ENVIRONMENTAL PROTECTION DIVISION

MINISTRY OF ENVIRONMENT AND CLIMATE CHANGE STRATEGY

Water Quality Assessment and Proposed Objectives for Sooke Watersheds, Inlet, Harbour and Basin

TECHNICAL REPORT

January 2019

Prepared by:

Rosie Barlak
Environmental Impact Assessment Biologist
Environmental Protection Division

EXECUTIVE SUMMARY

This document presents a summary of the ambient water quality of Sooke Inlet, Harbour and Basin, and the streams in the surrounding watersheds that drain into these marine areas, near the District of Sooke, British Columbia (BC). The water quality assessment conducted here forms the basis for proposed water quality objectives (WQOs) to protect existing and future water uses. The WQOs have recently been approved and can be found in the following document "*Water Quality Objectives for Sooke Inlet, Harbour, and Basin, and Tributary Streams*" (BC ENV, 2019).

There are 12 major watersheds that drain into the Sooke Inlet, Harbour and Basin. Nine are designated community watersheds, including four that are part of the Greater Victoria Water Supply Area (GVWSA). The T'Sou-ke Nation traditionally used to harvest shellfish in the Sooke marine areas; however the area has been closed to harvesting for many years. The designated water values/uses to be protected are shellfish harvesting, recreation and wildlife in the marine waters of the inlet/harbour/basin; and drinking water, aquatic life, recreation, irrigation and wildlife in the freshwater rivers and streams. There are many activities that can potentially affect water quality both in the marine and freshwater environments, such as rural and urban development, industry, agriculture, forestry, recreation and wildlife.

Water quality monitoring in the marine areas and the freshwater streams (downstream of the protected GVWSA) was conducted in 2008 and 2009, respectively. The results of this monitoring indicated that the overall state of the water quality is good. All chemical, physical and biological parameters met provincial water quality guidelines with the exception of temperature, turbidity, total organic carbon, fecal coliforms, enterococci and *Escherichia coli*, which exceeded the drinking water guidelines on occasion; dissolved aluminum, total copper, and total zinc also exceeded the aquatic life guideline on occasion. In order to maintain and protect the water quality in the Sooke watersheds and marine areas, ambient water quality objectives were proposed for fecal coliforms and enterococci in the marine areas, and for temperature, dissolved oxygen, turbidity, total phosphorus, and *E. coli* in the freshwater rivers and streams. Future monitoring is recommended to ensure protection of the environment.

Proposed Water Quality Objectives for Sooke Inlet/Harbour/Basin

Time Period	Variable	Objective Value	Use
Short-term (5-10 years)	Enterococci	≤ 35 CFU/100 mL (geometric mean based on a minimum 5 weekly samples collected over a 30-day period) 70 CFU/100 mL (single sample maximum value)	primary contact recreation and cultural uses
Long-term (>10years)	Fecal Coliform	≤ 14 CFU/100 mL (median based on a minimum 5 weekly samples collected over a 30-day period) ≤43 CFU/100 mL (90th percentile based on a minimum 5 weekly samples collected over a 30-day period)	aquatic life – shellfish harvesting
	Enterococci	≤ 4 CFU/100 mL (median based on a minimum 5 weekly samples collected over a 30-day period)	aquatic life – shellfish harvesting

Designated water uses: aquatic life – shellfish harvesting, recreation and wildlife

Proposed Water Quality Objectives for Sooke Watersheds

Variable	Objective Value	Use
Temperature	Sooke River: ≤17°C (max) Any water intake: ≤ 15 °C (max)	aquatic life, drinking water supply
Dissolved oxygen	≥5 mg/L (min) ≥8 mg/L (average)	aquatic life
Turbidity	At any intake: <5 NTU maximum Oct – Dec <2 NTU maximum Jan – Sept 95% of samples ≤1 NTU at intake	drinking water
Total phosphorus	0.010 mg/L max 0.005 mg/L avg (based on a minimum of monthly samples collected from May – Sept)	aquatic life, aesthetics
Escherichia coli	Any water intake: Jan-Sept: ≤10 CFU/100 mL (90th percentile) Oct-Dec: ≤40 CFU/100 mL (90th percentile) To protect recreational and cultural uses: ≤200 CFU/100 mL (geomean of five weekly samples in 30 days) 400 CFU/100 mL (single sample maximum value)	raw drinking water – disinfection only, recreation and culture

Designated water uses: drinking water, aquatic life – shellfish harvesting, recreation, irrigation and wildlife

Note: all calculations are based on a minimum of 5 samples in 30 days, unless stated otherwise. Parameters apply at all freshwater sites downstream of the GVWSA in the lower Sooke watersheds, unless stated otherwise.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

The author would like to thank Laura Hooper and staff (District of Sooke), Anna Colangeli, Tony Dorling and their students (Camosun College), Mark Gaudy (T'Sou-ke First Nation), Jady Tyers (Environment Canada), and Barri Rudolph, Dalia Hull-Thor, Heather Sinnott and Dean Lacey (Capital Regional District) for assistance in the collection of samples. I would also like to thank all who provided information and additional site data for this project, as well as the stakeholders who reviewed and provided comments, including T'Sou-ke First Nation, the District of Sooke, Capital Regional District, Island Health, TimberWest and Environment Canada, and Geneen Russo, Environmental Stewardship Division. Financial contributions from the District of Sooke, the Capital Regional District, and in kind contributions, including boats and time by all our sample collectors, and analysis of caffeine by Sergei Verenitch's lab at the University of Victoria made us able to maximize our sampling budget. Special thanks go out to Deb Epps, Environmental Protection Division, for her assistance in field sampling and providing comments, and to Tom Eng and Doug Fetherston (Ministry of Forests, Lands and Natural Resource Operations) who helped with land use information and mapping.

Rosie Barlak, Environmental Impact Assessment Biologist
Environmental Protection Division
Ministry of Environment and Climate Change Strategy

1.0 INTRODUCTION

1.1 PROGRAM BACKGROUND

The British Columbia (BC) Ministry of Environment and Climate Change Strategy (ENV) is conducting a program to assess water quality in priority watersheds. The purpose of this program is to accumulate the baseline data necessary to assess both the current state of water quality and long-term trends, and to propose ambient water quality objectives on a watershed specific basis.

Water quality objectives provide goals that need to be met to ensure protection of designated water uses. The inclusion of water quality objectives into planning initiatives can help protect watershed values, mitigate impacts of land-use activities, and protect water quality in the context of both acute and chronic impacts to human and aquatic ecosystem health. Water quality objectives provide direction for resource managers, serve as a guide for issuing permits, licenses, and orders by ENV, and establish benchmarks for assessing the Ministry's performance in protecting water quality. Water quality objectives and attainment monitoring results are reported both to local stakeholders and on a province-wide basis through forums such as State of the Environment reporting.

Vancouver Island's topography is such that the many watersheds of the ENV's Vancouver Island Region are generally small ($<500\ km^2$). As a result the stream response times can be relatively short and opportunities for dilution or settling are often minimal. Rather than developing water quality objectives for these watersheds on an individual basis, an ecoregion approach has been implemented. The ecoregion areas are based on the ecosections developed by Demarchi (1996). However, for ease of communication with a wide range of stakeholders the term "ecoregion" has been adopted by Vancouver Island ENV regional staff. Thus, Vancouver Island has been split into six terrestrial ecoregions, based on similar climate, geology, soils and hydrology (Figure 1).

Fundamental baseline water quality should be similar in all streams and all lakes throughout each ecoregion. However, the underlying physical, chemical and biological differences between streams and lakes must be recognized. Representative lake and stream watersheds within each ecoregion are selected (initially stream focused) and a three year monitoring program is implemented to collect water quality and quantity data, as well as biological data. Standard base monitoring programs have been established for use in streams and lakes to maximize data comparability between watersheds and among ecoregions, regardless of location. Water quality objectives will be developed for each of the representative lake and stream watersheds, and these objectives will also be applied on an interim basis to the remaining lake and stream watersheds within that ecoregion. Over time, other priority watersheds within each ecoregion will be monitored for one year to verify the validity of the objectives developed for each ecoregion and to determine whether the objectives are being met for individual watersheds.

Figure 1. Map of Vancouver Island Ecoregions.

Partnerships formed between the ENV, local municipalities and stewardship groups are a key component of the water quality network. Water quality sampling conducted by the public works departments of local municipalities and stewardship groups has enabled the Ministry to significantly increase the number of watersheds studied and the sampling regime within these watersheds. These partnerships have allowed the Ministry to study watersheds over a greater geographic range and in more ecoregions across Vancouver Island, have resulted in strong relationships with local government and interest groups, provided valuable input and local support and, ultimately, resulted in a more effective monitoring program.

1.2 SITE SPECIFIC BACKGROUND

The community of Sooke is located to the north of Sooke Inlet, Harbour and Basin, about 30 km west of the City of Victoria, on southwest Vancouver Island. The area has approximately 13 000 residents and is a popular destination for eco-tourists, fisherman and visitors. Marine waters of the Sooke Inlet, Harbour and Basin contain valuable shellfish resources that, prior to shellfish harvesting closures, were a key food staple for the T'Sou-ke Nation, whose traditional territory surrounds the current day community of Sooke. The Sooke River salmon run was historically a mainstay of the Sooke economy, along with a thriving forestry economy in the 1900's and a brief history of mining. Though the economy has shifted to an eco-tourism driven economy, the community of Sooke values its current way of life with a close connection to the natural environment. However, many residents live in Sooke and commute daily to Victoria, and the demand for more development in the area is a constant pressure (Hooper, *pers. comm*. 2012).

Within the12 major watersheds (covering an area of 46 476 ha) flowing into the Sooke Inlet Harbour and Basin are 26 smaller watersheds. These include nine designated community watersheds (totaling 20910 ha (BC Gov, 2017)) and ten watersheds that provide habitat for important fish populations. Of the nine community watersheds, four (totaling 18243 ha – and referred to as the Leech and Sooke Water Supply Areas) are protected from anthropogenic uses as part of the Greater Victoria Water Supply Area

(GVWSA), and provide a significant source of drinking water to the local communities, serving a population of approximately 350 000 people (CRD, 2017).

The community watersheds received this designation in 1995, as defined under the *Forest Practices Code of British Columbia Act* ("the drainage area above the downstream point of diversion and which are licensed under the *Water Act* for waterworks purposes"). This designation was grandparented and continued under the *Forest and Range Practices Act* (FRPA) in 2004 and infers a level of protection. In addition, the ENV uses other tools, such as water quality objectives, and legislation, such as the *Private Managed Forest Land Act* and the *Drinking Water Protection Act* (BC Gov, 2011), to ensure that water quality within community watersheds is protected and managed in a consistent manner.

The BC *Drinking Water Protection Act* sets minimum disinfection requirements for all surface supplies as well as requiring drinking water to be potable. Island Health (formerly Vancouver Island Health Authority) (VIHA) determines the level of treatment and disinfection required based on both source and end of tap water quality. As such, VIHA requires all surface water supply systems to provide two types of treatment processes. The Capital Regional District (CRD) treats GVWSA water using ultra violet light, chlorine and then ammonia addition to form chloramine (CRD, 2017) to effectively treat the water for bacteria, viruses and parasites, such as *Cryptosporidium* and *Giardia*. As the four GVWSA watersheds are protected and managed by the CRD, with strict limits set for drinking water quality, these upper watersheds will be minimally discussed in this report to provide an understanding of influences to water quality throughout the watershed. Only the lower portions of the watersheds (which include other community watersheds) will be considered for applicability of water quality objectives.

Rapid development and changing land use in the lower portions of the watersheds put the health of these streams at risk. Impacts to water quality have been studied in this area since the late 1980's (CRD, 1990; Cross *et al,* 1990). Anthropogenic land uses within the lower, non-protected portions of the watersheds include urban and rural development, agriculture, timber harvesting, industrial uses, and recreation. These activities, as well as natural erosion and the presence of wildlife, all potentially affect water quality in the lower Sooke watersheds and in the marine areas of the harbour, inlet and basin. Maintenance of the microbiological quality and safety of waterbodies for recreational use and shellfish harvesting is essential to prevent risks to human health and economic losses due to shellfish harvesting closures. Section 3.0 of this report demonstrates that designated water uses to be protected should include shellfish, recreation, aquatic life, and wildlife in both marine and freshwaters, and drinking water and irrigation in freshwater only.

This report examines the existing water quality of the lower Sooke watersheds and marine area and recommends water quality objectives based on designated water uses, potential impacts and water quality parameters of concern. The ENV Environmental Protection Division worked in partnership with the CRD, District of Sooke, Environment Canada, T'Sou-ke Nations, Camosun College and the University of Victoria in 2008 and 2009 to collect marine and freshwater monitoring data in the Sooke area. These data were considered with historical data (1980's, 1990's), ongoing data collection from the CRD and Environment Canada, and 2007 ENV benthic invertebrate data to propose Water Quality Objectives for Sooke Inlet, Harbour and Basin and the freshwater streams entering these waters.

The CRD and the District of Sooke have taken a proactive approach to rainwater management within the Sooke Liquid Waste Management Planning (LWMP) process. The LWMP addresses maximizing rainwater retention through development guidelines and designed site works. Monitoring of the marine and freshwater environment is critical to a risk assessment approach that will guide watershed prioritization and planning processes, while assessing both existing impacts and the effectiveness of rainwater management activities. Integrated into the Sooke LWMP, and possibly a local rainwater bylaw, water quality objectives can be used as a tool to help reduce contamination and potentially improve water quality to the point that would allow for re-opening of shellfish beds in the Sooke Harbour and Basin.

1.3 WATER QUALITY OBJECTIVES

Water quality objectives are prepared for specific bodies of fresh, estuarine and coastal marine surface waters of British Columbia as part of ENV's mandate to manage water quality. Objectives are prepared only for those waterbodies and water quality characteristics that may be affected by human activity now or in the future.

Water quality objectives are based on scientific guidelines (BC ENV water quality guidelines available at http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html) that are safe limits of the physical, chemical or biological characteristics of water, biota (plant and animal life) or sediment, which protect water use. Objectives are established in British Columbia for waterbodies on a site-specific basis. They are derived from the guidelines by considering local water quality, water uses, water movement, and waste discharges.

Water quality objectives are set to protect the most sensitive designated water use at a specific location. For marine waters, designated uses include: shellfish harvesting; aquatic life and wildlife; and recreation and aesthetics. For freshwater, designated uses include: drinking water, aquatic life and wildlife, recreation and irrigation. By protecting the most sensitive water use, all designated uses for a given waterbody are also protected.

Water quality objectives have no legal standing at this time and are not directly enforced. However, they do provide policy direction for resource managers for the protection of water uses in specific waterbodies. Objectives guide the evaluation of water quality, the issuing of permits, licenses and orders, and the management of fisheries and the province's land base. They also provide a reference against which the state of water quality in a particular water body can be checked, and help to determine whether basin-wide water quality studies should be initiated. Water quality objectives are also a standard for assessing the Ministry's performance in protecting water uses, and can be integrated into an overall fundamental water protection program.

Monitoring is undertaken to determine if all the designated water uses are being protected. The monitoring usually takes place at a critical time, when the water quality objective may not be met, that is generally determined as part of the water quality objective setting exercise. It is assumed that if all designated water uses are protected at the critical time, then they will also be protected at other times when the threat is less. For practical reasons, the monitoring usually takes place during a five-week period, which allows the specialists to measure the worst, as well as the average condition in the water. For some waterbodies, the monitoring period and frequency may vary, depending upon the nature of the problem, severity of threats to designated water uses, and the way the objectives are expressed (*e.g.* mean and/or maximum values).

2.0 WATERSHED PROFILE AND HYDROLOGY

2.1 BASIN PROFILE

The community of Sooke lies between the Sooke Hills and the Sooke Inlet, Harbour and Basin. Most of the land development is in the lower parts of the watersheds only on the north side of Sooke Basin, while there is very little development in the upper watersheds or the land south of the basin (Figure 2). The Sooke Harbour and Basin are protected from exposure to the open ocean with Whiffin Spit jutting out between Sooke Harbour and Sooke Inlet, which is slightly more exposed. Sooke Inlet flows into Juan de Fuca Strait.

The drainage area ranges from sea level at Sooke Inlet/Harbour/Basin to 954m in elevation at Survey Mountain in the upper Leech River and Cragg Creek watersheds. There are twelve major (1:50 000 mapping) watersheds in the drainage area (Figure 2) that include numerous lakes (Table 1). Of the 26 minor watersheds within the major watersheds, twelve flow into the inlet/harbour/basinfrom the north, ten flow into the inlet/harbour basin from the south and four flow into Sooke Bay. As mentioned in Section 1, there are nine designated community watersheds in the drainage area (Table 2), four of which make up the GVWSA. Note the GVWSA boundaries for the CRD's Leech and Sooke Water Supply Areas (CRD, 2017) (Figure 3) vary slightly from the 1:50 000 watershed mapping boundaries shown in Figure 2.

The drainage area falls within three ecoregions. Watersheds to the south, west and most of the developed area of Sooke itself is in the Southern Gulf Islands (SGI) ecoregion; the northeastern part of the Sooke River watershed is considered part of the Nanaimo Lowlands (NAL) ecoregion and the remainder of the drainage area (northwestern watersheds) is part of the Leeward Island Mountains (LIM) ecoregion. One of the community watersheds in the LIM ecoregion, the Kemp Lake Community Watershed, has its own site specific water quality objectives (Obee and Phippin, 2012); these can be applied to other small lakes within the LIM ecoregion.

The entire drainage area falls into the Coastal Western Hemlock biogeoclimatic zone (CWH). Most of the drainage area is classified as eastern and western very dry maritime subzone (CWHxm1 and CWHxm2); however, the northwestern upper watersheds above approximately 600 m in elevation are classified as montane and submontane moist maritime subzones (CWHmm2 and CWHmm1).

Glaciation during the Pleistocene epoch was the most influential mechanism in forming the local geological landscape. Unconsolidated sands, gravel and tills (boulder clays) are commonly found within the area. The area varies from low-lying agricultural land in the east to hilly in the western and northern regions with materials consisting mostly of thin colluvial veneers overlying bedrock outcrops. Dominating bedrock types are Sooke Gabro and Metchosin volcanic (Jackson and Blecic, 1996; Goff and Hicock, 1991).

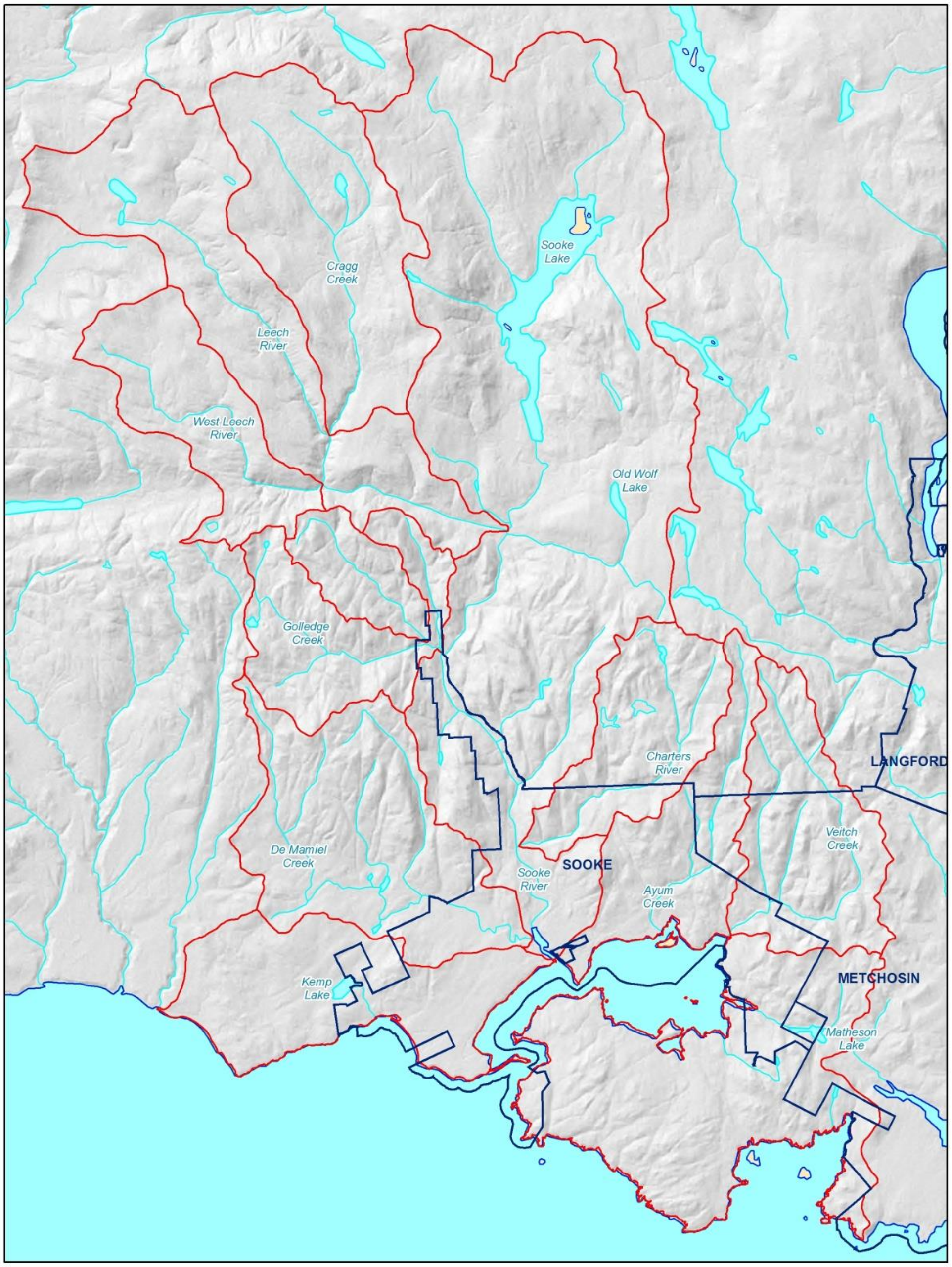


Figure 2. Map of the watersheds that drain into the Sooke Inlet, Harbour and Basin, including jurisdictional boundaries. Areas not included in labeled municipal boundaries are under the jurisdiction of the Juan de Fuca Electoral area.

Table 1. Major (1:50 000) watersheds draining into Sooke Inlet, Harbour and Basin. Lakes within each watershed are listed.

Watershed	Watershed size (ha)	Lake	Lake size (ha)
Sooke River	14926	Horton Lake	5.4
		Begbie Lake	< 3
		Sooke Lake/Reservoir	594
		Council Lake	13.3
		Old Wolf Lake	24.9
		Macdonald Lake	2.9
		Deception Reservoir	59.5
		Peden Lake	2.8
		Boneyard	2.3
		unnamed lake	7.9
		2 unnamed lakes	< 3
Cragg Creek	3732	Jarvis Lake	14.2
		48 unnamed lakes	< 3
Leech River	4515	Weeks Lake	27.6
		unnamed	3.4
		unnamed	3.9
		14 unnamed lakes	< 3
West Leech River	2104	5 unnamed lakes	< 3
		Boulder Lake	5.7
Golledge Creek	2030	5 unnamed	< 3
		Butler Lake	1.6
		Tugwell Lake	5.4
Tributary to Golledge Creek	849	3 unnamed lakes	< 3
DeMamiel Creek	3817	McKenzie Lake	2.4
		Young Lake	7.2
		Poirier Lake	2.7
		unnamed lake	3.4
		6 unnamed lakes	< 3
West of Sooke marine area	2978	Kemp Lake	24.7
		10 unnamed lakes	< 3
South of Sooke marine area	4963	Matheson Lake	22.3
		Quarantine Lake	2.3
		7 unnamed lakes	< 3
Charters River	2027	Crabapple Lake	5.4
		Shields Lake	14.7
		Grass Lake	3.5
		1 unnamed lake	< 3
Ayum Creek	2057	Glinz Lake	3
		1 unnamed	< 3
Veitch Creek	2466	Blinkhorn Lake	1.6
		7 unnamed lakes	< 3

Table 2. Community Watersheds within the Sooke Inlet, Harbour and Basin drainage area (BC Gov, 2017)

Community Watershed Name	Size (ha)
Wilfred Brook (near Matheson Lake)	2
William Brook (drains into Doerr Creek near Matheson Lake)	7
Charters River	1927
Mary Vine Creek (Drains into Sooke River above Sooke potholes)	308
Council Creek (drains into Sooke river below Sooke Lake)	1034
Sooke Lake (drains into Sooke River)	6982
Deception Gulch (drains into Sooke Reservoir)	744
Leech River (drains into Sooke River below Sooke Lake)	9357
Kemp Lake (drains into Juan de Fuca Strait)	549

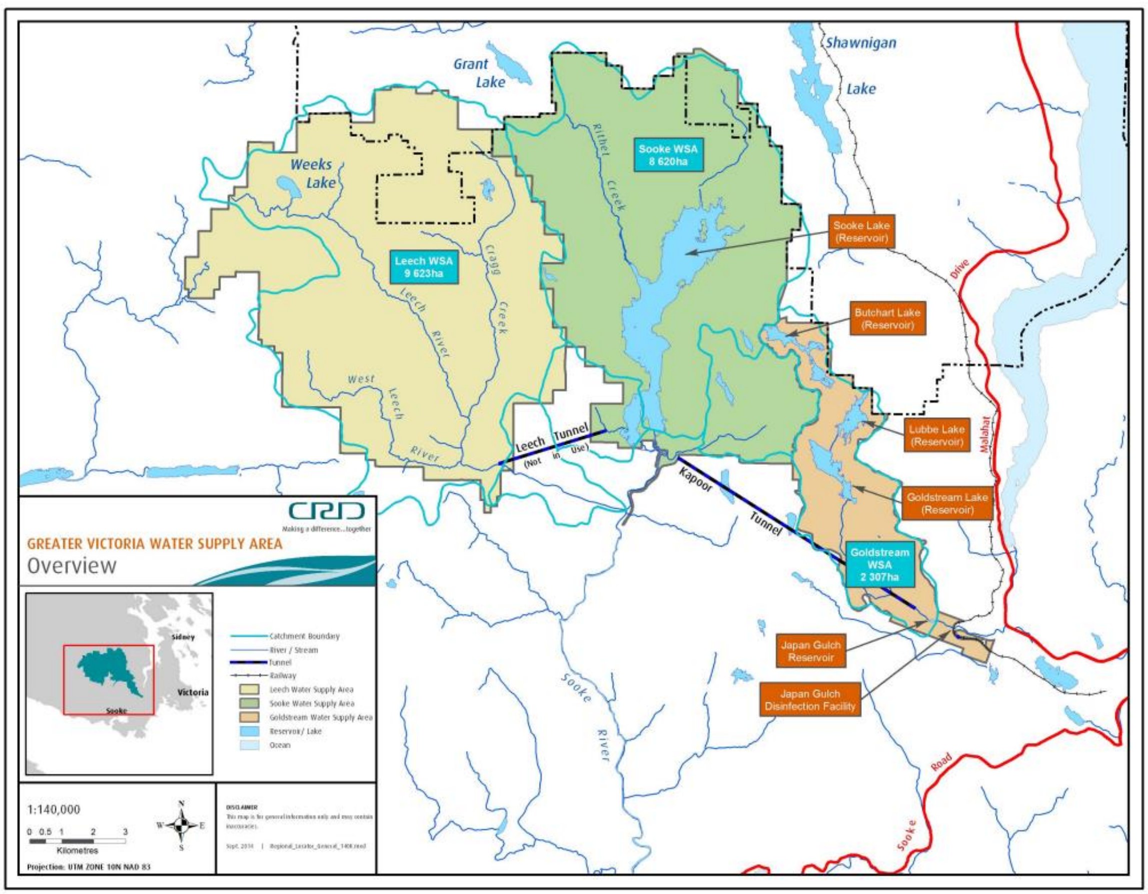


Figure 3. Greater Victoria Water Supply Area boundaries (CRD, 2017)

2.2 HYDROLOGY AND PRECIPITATION

The nearest climate station to the Sooke area for which climate normal data are available is the Victoria Marine station (elevation 31 m) (Environment Canada Climate Station 1018642), located approximately 6 km west of Sooke. Average daily temperatures between 1971 and 2000 ranged from 4.4°C in January to 14.3°C in August. Average total annual precipitation between 1971 and 2000 was 1236 mm, with only 27 mm (water equivalent) (2%) of this falling as snow (Figure 4). This average precipitation value of 1236 mm in the lower watersheds is likely not a good representation of the relatively higher precipitation that falls in the upper Sooke watershed (data not presented here), where site specific data are collected at weather stations by the CRD's Watershed Protection Division (Ussery, *pers. comm*. 2015). Temperatures at higher elevations in the watershed would be cooler than recorded at sea level. A larger portion of the annual total precipitation occurred as snowfall in the higher-elevation terrain of the watershed. Most of the precipitation (986 mm, or 80%) fell between October and March. The driest months are July and August. Winds are strongest from November through April and blow predominantly in a westerly direction.

Water Survey Canada (WSC) operated a hydrometric station on the Sooke River for a total of 9 years between 1989 and 1997 upstream of the confluence with Charters River, periodically for 50 years between 1916 and 1966 at two stations near Sooke Lake, and briefly for 2 years between 1963 and 1965 at Sooke River above Todd Creek. The CRD Watershed Protection Division also operates a hydrometric station in the Sooke River (Ussery, *pers. comm*. 2015). For this report only the data for the Sooke River upstream of Charters River are shown. Minimum, maximum and average daily flows for this period are shown in Figure 5. Peak flows measured between 1989 and 1997 were 228 m^3/s, while minimum flows were 0.04 m^3/s (Figure 5).

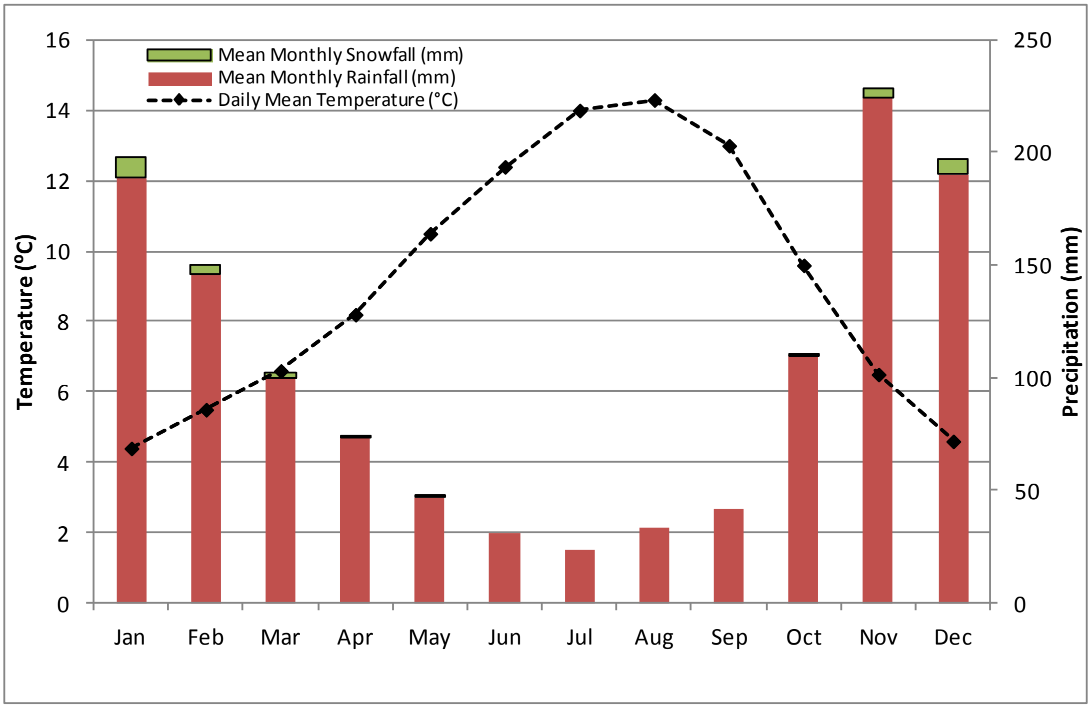


Figure 4. Climate data (1971 – 2000) for Victoria Marine (Environment Canada Climate Station 1018642).

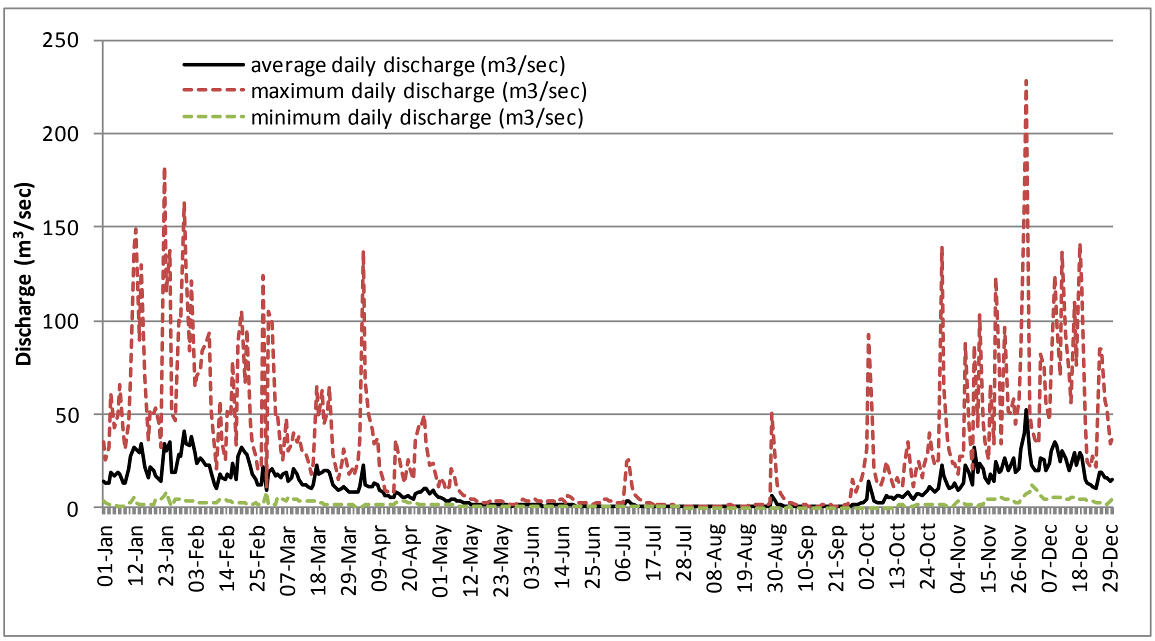


Figure 5. Minimum, maximum and average daily discharge data for Sooke River upstream of Charters River (Water Survey Canada Station 08HA059) between 1989 and 1997 (Water Survey Canada, 2011).

2.3 OCEANOGRAPHY

The Sooke marine area consists of the inner Sooke Basin, the inner Harbour and outer Sooke Inlet, separated by Whiffin Spit (Figure 6). Predominant features of the shoreline in Sooke Inlet are rocky headlands, while in the harbour and basin small bays and rock outcrops are common. The Sooke Basin, with a length of about 3 km, has an average depth of approximately17 m (Thompson, 1981) and maximum depth of 37 m (Canadian Hydrographic Service, 1995) near its seaward end. Sooke River flows into the head of Sooke Harbour, delineating it from Sooke Basin. The Sooke Harbour area is very shallow with an average depth of 3 m over its 3km length, accumulates fine sand from the outflow of the Sooke River and has been dredged to allow ships to pass through a narrow channel with a maximum depth of 13 m. A wide range of soft sediments is found intertidally in the inlet, harbour and basin, including sand, mud and gravel. Sooke Inlet is characterized by the presence of coarse sediment stratified on top of bedrock (Schurer, 1979). Whiffin Spit blocks the harbour and basin allowing an entry passage into Sooke harbour of only about 0.5 km wide. Historically, this spit would periodically break on its west side where it connects to the shore, contributing to some flushing in the inlet (Planes, *pers. comm*. 2009); however, the spit is now reinforced so that this will not happen. Sooke Inlet is a short channel that connects the area to Juan de Fuca Strait.

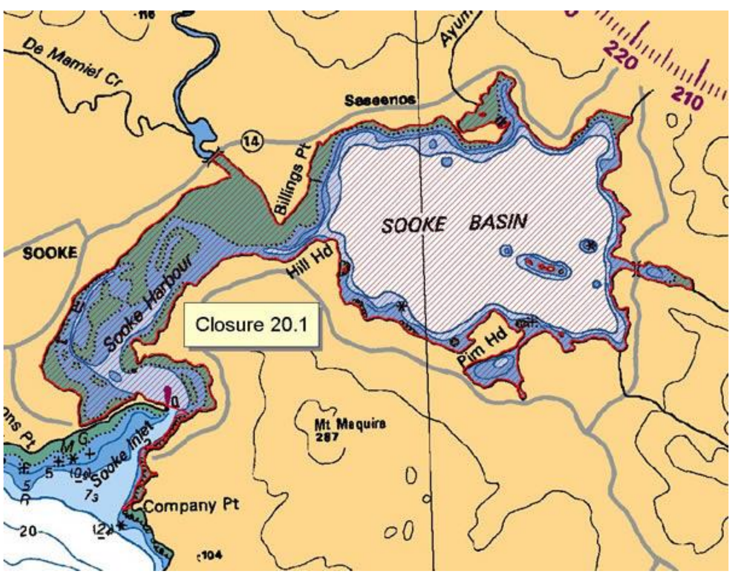


Figure 6. Map of Sooke Inlet, Harbour and Basin, showing shallow areas and shellfish closure boundaries (Fisheries and Oceans, 2013)

Maximum currents occur midway through tidal cycles off Whiffin Spit (up to 100cm/s during maximum tides) and Billings Point (up to150cm/s during maximum tides), with slack water near the times of low and high tides (Thompson, 1981). In the entrance to the Sooke Basin, the depth increases rapidly and large tidal currents can occur (up to 500cm/sec recorded). These currents are much stronger during flood than during ebb tides, and inhibit deposition of fine grain sediment, resulting in the flat-topped gravel ridges found at the entrance to the basin (Schurer, 1979). Maximum currents in the harbour are typically 15cm/s up to 50 cm/s at maximum tides (Thompson, 1981). The mean flow in the basin is a clockwise gyre with its centre in the deep part near the entrance of the basin (Elliott, 1969) and currents are always weak (<20cm/s). These confined weak circulation pattern makes the basin favourable for oyster cultivation (Thompson, 1981). Incoming water on a flooding tide keeps mainly to the north of the basin and water leaving on the ebbing tide comes mainly from the south side, suggesting that deposition of fine grain sediment takes place mainly in the east and southwest part of the basin. When the slope of the basin levels off at the bottom there is coarse sediment (silt, sand, gravel). The southwest part of the basin close to shore has rock outcrops between which lies stratified fine-grained sediment. Near Goodridge Peninsula the bottom is bedrock and course grained sediment (Schurer, 1979).

The Sooke River is the primary freshwater inflow to the area, which is maximized in winter and has very low flow in summer. This input and tidal exchange with Juan de Fuca Strait largely determine water properties throughout the area. Surface salinities in the winter are lowest (approx 20 ‰) due to river discharge, while near the bottom of Sooke basin winter salinity values are around 31‰. In winter temperatures are similar (7-10 $^{\circ}$C) through the entire area. As river flows decrease in the spring and into the summer, salinities are more uniform (around 31‰) throughout the area. Surface temperatures increase and stratification occurs in the Sooke Basin (surface up to 20°C decreasing to around 14°C at depth), while the harbour stays mixed at around 10-13°C, getting progressively cooler to about 9°C the closer the water is to Juan de Fuca straight (Thompson, 1981).

Tides in Sooke are classified as mixed, predominantly diurnal (with two unequal cycles per day) (Thompson, 1981). In the Sooke basin the highest tides are 3.3 m and the lowest 0.5 m; in the Sooke Harbour highest is 3.6 m and lowest is 0.3 m (Canadian Hydrographic Service, 1995).

3.0 WATER USES

3.1 WATER LICENSES

There are 216 current points of diversions that have been licensed for the entire drainage area on 82 different freshwater waterbodies including springs. License uses are variable and include: camps (4 points of diversion), conservation (14), domestic (91), fire protection (1), irrigation (34), land improvement (17), ponds (4), power (2), stock watering (1), non-power storage (31), and waterworks (13).

The largest withdrawals of water are for domestic use under several “Waterworks – Local Authority” licenses and are by the CRD, totaling 100 651 dam^3/year (cubic decametres/year, where 1 dam^3 = 1,000 m^3) (GeoBC, 2013). These withdrawals are from various reservoirs and dams that are part of the GVWSA, supplying water to approximately 350 000 users. GVWSA water is treated with ultraviolet disinfection, chlorinated, then ammonia addition to form chloramine prior to consumption (CRD, 2012). The CRD protects and manages the upper watersheds to meet their own drinking water treatment objectives for the Greater Victoria Water Supply system (CRD, 2012a). More detailed information on water allocation in the Sooke area can be found in the 1996 Sooke Water Allocation Plan (Jackson and Blecic, 1996).

Most “domestic” licenses occur downstream of the GVWSA in the lower portions of the watersheds not managed by the CRD. Though these are generally for small amounts of water, and may not all be actively in use at any given time, the licenses are considered “current”; thus, drinking water is also a designated use downstream of the GVWSA.

3.2 RECREATION

Sooke Inlet, Harbour and Basin provide significant recreational values for both foreshore residents and visitors. It is an important part of the community's identity, as well as socio-economically. Boating and canoe/kayaking are popular recreational activities within the inlet/harbour/basin, and the area is used to access the fishing spots just outside in Juan de Fuca Strait. Swimming occurs during the summer months from the many docks located along the foreshore.

The protected upper watersheds within the CRD's GVWSA have controlled (gated) road access only. CRD Regional Parks owns and manages approximately 4000 ha of land in the Sooke Hills (CRD, 2010b) with varying levels of protection (see Section 4.0). CRD Regional Park land includes parts of the Sooke Hills Wilderness Regional Park Reserve within the Sooke Basin watershed (*e.g.* Upper Veitch Creek), Sooke Potholes Regional Park, as well as the Sea to Sea Regional Park. The Sea to Sea Regional Park includes parts of Sooke River and Ayum and Charter's Creeks and has designated hiking, mountain biking and equestrian trails (CRD, 2010b).

There is logging road access to most areas of the lower parts of the watersheds, and all accessible areas in the lower watersheds get high recreational use including hiking, mountain biking, swimming, fishing, rock climbing, hunting in the fall, and some ATV riding. The Juan de Fuca Community Trails Society is involved with encouraging sustainable use and a legacy of trail systems in the area. The Sooke River watershed (where Sooke Potholes Provincial Park and the Sooke Potholes Regional Park are located) and the watersheds directly accessible around the community (*e.g.* Ella Stream (biking), Broom Hill Stream) are particularly popular. There are three sanctioned camping areas (two private: Sunny Shores Resort and Sooke River Campground (The Flats); and two public: the Sooke Mountain Provincial Park and Sooke Potholes Regional Park) in the watershed, and no BC Forest Service recreation sites. However, the proximity of the watershed to the community of Sooke, coupled with the high number of tourists that visit the area during the summer, results in some unsanctioned camping.

3.3 FISHERIES

Many of the minor watersheds flowing into the Sooke Inlet/Harbour/Basin are first order streams, and are ephemeral with no known fish populations. Ten of the watersheds, mostly those flowing through the District of Sooke, are larger and still have the capability to support healthy fish stocks, including salmonids. The larger of the Sooke watersheds (Sooke River, Demamiel Creek, Charter Creek) have high fisheries values, and species present include chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), and chum (*O. keta*) salmon, as well as cutthroat trout (*O. clarkii*), rainbow trout (*O. mykiss*), and steelhead (*O. mykiss*) (FISS, 2013). As well, sockeye (*O. nerka*) have been observed only in the Sooke River, and anecdotal evidence suggests that resident Dolly Varden char (*Salvelinus malma*) inhabit the lower Sooke River. Some of the smaller watersheds also have fish observations: Lannon Creek and Ayum Creek have coho and chum salmon, steelhead and cutthroat trout; Throup Stream has coho and chum; Wildwood Creek has coho and cutthroat; and Veitch Creek and Alderbrook Stream both have observation of cutthroat trout.

Fishing is an attraction to the Sooke marine area. While most fishing activities are conducted out in Juan de Fuca Strait, there are people who fish, shrimp and crab from the docks, as well as commercial crabbers and shrimpers in the harbour and basin.

3.3.1 Shellfish Harvesting

Numerous shellfish species are found in the inlet/harbour/basin. The area is currently closed for direct harvesting of bivalves (DFO, 2013) (Figure 6) but is approved for depuration harvesting (maintaining live bivalves in purified seawater to purge them of contamination) (Environment Canada, 2009a). Some commercial harvesting occurs with depuration only (Cooper's Cove Oyster Farm Ltd.). A stringent standard for shellfish growing water is necessary due to the filter feeding mechanism of bivalve shellfish that can concentrate bacteria. Improvements in bacteriological levels were seen in the marine areas since the sewer system came online in the Sooke town centre 2005; however, bacteriological contamination in shellfish is still an issue. The direct harvesting sanitary closure is still in place due to identified pollution sources such as septic seepage, urban and agricultural runoff and wildlife. There are five current prohibited areas surrounding marinas and some large docks including the large dock near the former industrial site on Goodridge Pensinsula (Environment Canada, 2009b).

Environment Canada has stated that, prior to re-assessment of the closure classification, pollution source identification and remediation must be addressed, as well as DFO enforcement concerns. Environment Canada has begun preliminary work with the T'Sou-ke Nation to re-classify an area of Closure 20.1 that T'Sou-ke Nation would like to utilize. If this project was successful, the lease would operate under a Conditional Management Plan based on rainfall and the ability to predict bacteriological conditions when rainfall events occur.

3.4 FLORA AND FAUNA

The foreshore areas of the Sooke Inlet/Harbour/Basin and the Sooke watersheds provide habitat to a variety of species typical of west coast Vancouver Island, including blacktail deer (*Odocoileus hemionus columbianus*), black bear (*Ursus americanus*), cougar (*Puma concolor*), and numerous other small mammals and birds. The BC Conservation Data Centre shows numerous at risk species occurrences within the watershed boundaries (BCCDC, 2013). Some general locations are described.

Blue listed:

Fauna: Ermine *Mustela erminea anguinae* (Auguinae subspecies, found at low elevation sites near the marine and fresh waters), Warty Jumping-slug *Hemphillia glandulosa* (Galloping Goose Trail, Sooke), Marbled Murrelet *Brachyramphus marmoratus* (Sooke Lake).

Flora: Common bluecup *Githopsis specularioides* (moist seepages around the Sooke River and Sooke Hills), Fleshy jaumea *Jaumea carnosa* (moist tidal beaches and salt marshes in the lowland zone), Macoun's groundsel *Packera macounii* (dry open forests, disturbed areas and rock outcrops), heterocodon *Heterocodon rariflorum*, slender woolly-heads *Psilocarphus tenellus*, nodding semaphoregrass *Pleuropogon refractus*.

Red-listed:

Fauna: Keen's myotis *Myotis keenii* (bat found in tree cavities, rock crevices and small caves), painted turtle - Pacific Coast Population *Chrysemys picta pop. 1,* blue-grey taildropper *Prophysaon coeruleum* (Sooke River, Matheson Lake).

Flora: Nevada marsh fern *Thelypteris nevadensis*, Roemer's fescue – junegrass *Festuca roemeri - Koeleria macrantha* ecological community, streambank lupine *Lupinus rivularis* (Sooke Potholes Provincial Park), pacific waterleaf *Hydrophyllum tenuipes* (widely dispersed in moist woodlands and stream banks), coast microseris *Microseris bigelovii* (East Sooke Regional Park), fungi seaside bone *Hypogymnia heterophylla*, Douglas-fir / dull Oregon-grape *Pseudotsuga menziesii / Mahonia nervosa* ecological community, prairie lupine *Lupinus Lepidus*, American water shrew, *brooksi* subspecies *Sorex palustris brooksi* (Veitch Creek).

In addition, the marine area of the inlet, harbour and basin has abundant bird, marine mammal and other marine life. Seals and sea otters are commonly sighted and the occasional whale has been seen in the area.

3.5 DESIGNATED WATER USES

Designated water uses are those identified for protection in a watershed or waterbody. Water quality objectives are designed for the substances or conditions of concern in a watershed so that, by protecting the most sensitive designated use, their attainment will protect all designated uses.

Sooke Inlet/Harbour/Basin

The preceding discussion demonstrates that water uses to be protected in the Sooke Inlet/Harbour/Basin should include shellfish, recreation, aquatic life, and wildlife. Currently for Sooke Inlet/Harbour/Basin, the most sensitive use is shellfish harvesting and consumption by humans. It is a goal of local residents and First Nations to re-open all or parts of the area for future shellfish harvesting (Planes, *pers.comm.* 2009; Hooper, *pers. comm*. 2012). Human health also needs to be considered with people spending time in or on the water, swimming, boating or fishing. The water should also be protected for aquatic life and wildlife. Protecting the shellfish resources would protect all other marine water uses in the area.

Sooke Watersheds

The preceding discussion demonstrates that water uses to be protected in Sooke's freshwater watersheds should include aquatic life, drinking water, wildlife, recreation and irrigation. The most sensitive uses of the freshwater streams is aquatic life or drinking water, depending on which water quality parameter is being considered; protecting for aquatic life or drinking water (as applicable) would protect all the other freshwater uses in the watersheds. As the streams flow directly into the marine areas, protecting the freshwater streams for the uses in the marine areas (*i.e.* shellfish, in addition to those listed above) is also important.

4.0 INFLUENCES ON WATER QUALITY

4.1 LAND OWNERSHIP

The area is within the traditional territories of the T'Sou-ke Nation and sections of Crown and private residential and industrial land. There are four First Nation Reserves in the drainage area. The District of Sooke has jurisdiction over the non-reserve areas on the north side of Sooke Basin where most of the development is (lower parts of the watersheds only), while the Juan de Fuca Electoral area has jurisdiction over the land to the south of the basin, and the upper parts of all the watersheds on the north side of the basin, where there is very little development (Figure 2). A small area to the east of Sooke Basin is under the jurisdiction of the District of Metchosin and a small area at the very top of the Sooke River watershed is under the jurisdiction of the Cowichan Valley Regional District.

Land ownership and zoning in the area draining into the Sooke Inlet, Harbour and Basin is summarized in Tables 3 and 4. Note that the land zoning in Table 4 is for the Juan de Fuca Electoral area only and does not include the District of Sooke or Metchosin where rural, urban and industrial zoning make up the majority of the zoning for those areas; nor does it include the small area of the Cowichan Valley Regional District that is part of the protected upper Sooke watershed GVWSA. While zoning does not always reflect use (*e.g.* all land zoned for agriculture is not necessarily actively used agricultural lands), it is clear there is a diversity of current and potential land uses in the area.

Table 3. Land use summary for the area draining into Sooke Inlet, Harbour and Basin.

LAND USE	Net Area (ha)
Total Project (Watershed) Area	**46475.57**
First Nation Reserve (Becher Bay 1 &2, Long Neck Island 9, T'Souke 1 &2)	428.64
Agricultural Reserve	1053.27
Provincial Parks (Sooke Mountain Park)	460.12
Prov Forest	1180.55
Private Ownership (Approximate)	24460.1
Crown Ownership (Approximate - Municipal) (18243 GVWSA and approx. 4000 park)	22423.00
Crown Ownership (Approximate - Provincial)	1074.6
Crown Land Tenures (122 Crown Tenures)	11503.01
Private Lands owned by Forest Companies (TimberWest)	9298
Tree Farm Licenses (TFL Schedule A)	3387.11
Tree Farm Licenses (TFL Deletions)	3707.38
Mineral Tenures (32 Tenures)	4953.11
Mineral Placers (93 Mineral Placers)	3112.57
Municipality (District of Metchosin)	2550.38
Municipality (District of District of Sooke)	5804.22
Juan De Fuca Official Community Plan Areas:	
East Sooke	3104.7
Malahat	1591.6
Otter Point	3195.33
Rural Resource Lands	27998.73

Table 4. Zoning for the Juan de Fuca Electoral Area

Juan de Fuca Zoning	Net Area (ha)
Rural A + Rural A-1	1767.47
Forestry	619.91
Agriculture	437.63
Rural Watershed	290.41
Neighbourhood Commercial	5.57
Greenbelt 2	1601.73
General Industrial	23.12
No Zone	19.52
Park	3499.43
Community Facilty	181.27
Gordon Beach Recreational Residential	1.79
Resource Land	10751.72
Mobile Home Park	9.63
Apartment	0.27
Rural Residential (various)	1256.09
Water Supply Area	15132.23

The GVWSA community watersheds have no private households within their boundaries and are protected with gated access; thus, potential sources of contamination associated with households (such as runoff, septic fields, fertilizers and pesticides) are not an issue in the GVWSA. In the areas of CRD regional park land, the CRD parks management plan places high priority on ecological protection and managing the land as wilderness; thus they also play a significant role in protecting and enhancing water quality in the Sooke watersheds (CRD, 2010b). However, the lower portions of the watersheds, where rural and urban residential and industrial development occurs, are subject to household contamination risks, agricultural runoff, as well as industrial runoff and discharges.

The District of Sooke has approved an agricultural plan for the 531 ha of Agricultural Reserve (ALR) lands and other land with agricultural potential within the District of Sooke (District of Sooke, 2012). Generally most ALR areas in Sooke do not have a lot of self-sustaining agriculture but mainly consist of hobby farms. Many hobby farms can be found outside of ALR land as well (Hooper *pers.comm*., 2012).

Areas of industrial development include the lower Alderbrook Stream and Alderbrook foreshore, the Demamiel watershed outside of District of Sooke boundaries, the lower Baker Creek watershed and the Broomhill watershed. There are currently 122 crown tenures in the drainage area, including various commercial and industrial leases in the inlet, harbour and basin such as marina and wharf complexes (13), boat repairs and maintenance or other commercial tenures (five) and shellfish tenures (14), one of which includes shellfish processing.

The primary concern with regards to potential impacts on water quality in Sooke Inlet/Harbour/Basin are associated with anthropogenic activities, specifically failing septic fields and rainwater runoff carrying contaminants from the freshwater streams and stormdrains into the marine waters (Cameron and Green, 2007; CRD, 2008; Environment Canada, 2005; Cross, 1996; CRD, 2010; CRD, 2011; CRD, 2012; CRD, 2013). The CRD has conducted stormwater discharge studies and upstream investigations to help determine sources of various contaminants. While the CRD has sampled freshwater sediment for metals at selected rainwater/stormwater discharge points, these data have not been linked to metal levels in water in streams in the area.

There are also 58 private moorages in the marine area (GeoBC, 2013). Marine vessels in the area may contribute to metals (specifically zinc, copper and arsenic, and to a lesser extent cadmium, lead and mercury) (Cross, 1996) and hydrocarbons in defined areas where moorage and maintenance of boats takes place. Historical hydrocarbon sampling noted presence in point source areas only (Cross, 1993). Antifoulants are also associated with boating but have not been monitored enough to confirm their presence.

Historically there were more industrial uses in or near the inlet, harbour and basin, including marine aquaculture operations (two salmon net pen operations), fish processing and forestry operations (log storage and booming and wood treatment by Lamford Forest Products Ltd. on Goodridge Peninsula) (Cross, 1993). Though these three industries are no longer in operation, there may be legacy impacts remaining in buried sediments in the areas where these industries were located; in particular, near the Lamford site where terrestrial chlorophenol, polycyclic aromatic hydrocarbons (PAHs), hydrocarbon, metals and poly-chlorinated biphenyls (PCBs) contamination was confirmed (ENV files, Environment Canada, 2009b). A long term study undertaken in the 1990s on PAHs around creosote pilings in the marine environment showed that under worst case conditions, significant PAH contamination was restricted to an area within 7.5 m from the perimeter of a significant structure over a 384 day exposure period, and significant adverse biological effects were found within 0.65 m of the structure (Goyette and Brooks, 1998).

A 2009 Health Canada analysis was inconclusive in regards to shellfish contamination near Goodridge Peninsula (Environment Canada, 2009b) and, at the time of writing this report, no other known studies had been conducted since. There also may have been other historical use of PCBs in the Sooke area but these have not been monitored enough to confirm their presence (Cross, 1993).

Foreshore development has been a longstanding concern for its potential to affect fish habitat in the Sooke marine area, and studies have been completed regarding fish habitat, bivalve, kelp, and eelgrass beds (Feakins, 1991, Archipelago Marine Research Ltd., 2012). Early recommendations included that uplands uses be compatible with foreshore designations, since land-based and marine activities are necessarily interrelated (Feakins, 1991). The Sooke Harbour, Basin and Inlet Management Plan (CRD, 1990) provided early guidelines for management and development of upland areas; the District of Sooke's most recent Official Community Plan (OCP) (District of Sooke, 2010a) and the OCP for East Sooke (CRD, 2012b) continue to provide guidelines intended to help protect water quality of the Sooke watersheds and marine areas.

4.2 PERMITTED DISCHARGES

There are seven authorized industrial and eight authorized municipal discharges in the Sooke drainage area. All but four are in the lower DeMamiel, Sooke and Ayum watersheds. Most discharges are to ground or air, not to surface waters, thus, when operating correctly, are unlikely to have a direct effect on water quality. Industrial discharge authorizations include: permits for an inactive wood waste landfill and open burning associated with a dryland log sort (Upper DeMamiel Creek watershed), an active woodwaste landfill and open burning associated with a shake and shingle mill, discharge of wood waste refuse to a landfill in association with a sawmill; three registered sites under the Vehicle Dismantling and Recycling Industry Environmental Planning Regulation; and one registration under the Code of Practice for Concrete and Concrete Products. Municipal discharge authorizations include four permits for wastewater effluent discharge (two stratas, one school and one summer camp (Upper Veitch watershed)), one inactive registration under the Land-Based Finfish Waste Control Regulation, and three registrations under the Municipal Waste Regulation. One of these registrations under the Municipal Waste Regulation discharges to ground within the lower Sooke watershed, and the other two discharge to marine waters outside of Sooke Inlet. The larger of the two discharges is the District of Sooke treated wastewater discharge.

As a part of their LWMP process, the District of Sooke has required any new developments to hook into the existing sewage treatment system which currently covers only the main part of town between West Coast Road and the Sooke River; it also requires that sewage disposal cannot occur directly or indirectly into the Sooke Harbour or Basin (District of Sooke, 2010b). The Juan de Fuca Electoral Area does not have a LWMP or these same requirements. Outside of the town, some of the larger developments have small, independent sewage treatment systems, but the majority of homes and businesses use septic tank and tile field treatment. Existing residences not connected to the sewage treatment area may potentially cause fecal contamination to nearby waterways if their septic fields are failing, not properly located, or not maintained. There are several (exact numbers are not available) small modular home park or multi-home onsite septic areas that, if septic systems are failing, may contribute to high bacteriological counts in nearby creeks. These fall under the jurisdiction of Island Health, who orders the owner(s) to repair any failing systems (Dyck, *pers. comm*., 2012). Onsite sewage treatment on Reserve lands is covered by Health Canada through the First Nations and Inuit Health Branch. Historically, fecal contamination at marine water quality sampling stations has coincided with high fecal coliform counts in the creeks and heavy rainfall (Environment Canada, 2009).

The many vessels that dock in the Sooke marine waters are another source of human fecal contamination. Vessels traveling to the area are not allowed to directly discharge to the marine environment while in port. However, control of these non-permitted discharges is limited and, until the opening of the public boat launch in late 2011, there were no pump out stations for boats in the area. The District of Sooke's public boat launch located on West Coast Road has one sani-dump station for vessels and connects directly to the sewage system.

4.3 LICENSED WATER WITHDRAWALS

There is a maximum licensed water withdrawal from the GVWSA of 100 651 dam^3/year (GeoBC, 2013). Water withdrawals are likely to impact downstream flows in the Sooke River (or other watersheds) only during summer low-flow periods when water consumption is highest, emphasizing the need to reservoirs in winter to be held for summer water demand. Flows are managed at the Sooke Reservoir in response to water demand, seasonal variations and to enhance fish and fish habitat in the Sooke River and Charter's River. These water releases for fish and fish habitat enhancement are carried out under the terms of an expired agreement with the T'Sou-ke First Nation, Fisheries and Oceans Canada, and the Province of British Columbia. Fisheries releases from Sooke Reservoir average about 5.5 million m^3 per year, of which about 0.36 million m^3 are released to the Charters River between June and October. An additional 3.0 million m^3 are released from Deception Reservoir (licensed by the Province of BC for conservation) to the Sooke River to reduce the demand on Sooke Reservoir for fisheries releases (CRD, 2012a).

Reservoir construction, channel building, inter-basin water transfers, dam building, road construction, firefighting and other anthropogenic activities in the watersheds have controlled many natural events in the watershed (*e.g.* stream flows, lake levels, and forest fires) (CRD, 2017). Despite best practices followed for dam safety within the GVWSA, all dams still come with safety risks and have the potential to influence downstream water quality in the event of dam failure.

4.4 FOREST HARVESTING AND FOREST ROADS

Forestry activities can impact water quality both directly and indirectly in several ways. The removal of trees can decrease water retention times within the watershed and result in a more rapid response to precipitation events and earlier and higher rain on snow events in spring. The improper construction of roads can change drainage patterns, destabilize slopes, and introduce high concentrations of sediment to streams. Potential impacts from forestry decrease as roads are deactivated and reclaimed, and as timber stands grow back in harvested areas.

In the Sooke watersheds timber harvesting began in the 1920s; logging activities were accompanied by railways, roads and camps being built throughout the watersheds. By 1949 in the GVWSA, approximately 45% of the watersheds had been logged; From 1949 to 1993 (when logging activities ceased) the Greater Victoria Water District (now the CRD Water Department) carried out a sustained yield harvesting program with silviculture programs designed for short rotation timber production. As a result, extensive second growth, even-aged plantations cover about 60% of the forested watershed lands in the GVWSA (CRD, 2017).

TimberWest owns approximately 20% (9298 ha) of the entire area (46476 ha) draining into the Sooke Inlet, Harbour and Basin (Table 5). Of this ownership, the weighted equivalent clearcut area (ECA) in 2012 was 8% (Iannidinardo, *pers. comm*. 2012). A small area of approximately 51 ha in the upper Sooke Lake basin is owned by Island Timberlands LP; the only non-forestry use on this land is a BC Hydro easement. Another smaller area (size not available) is owned and managed by Kapoor Lumber. There were no Coastal Watershed Assessment Procedure or similar reports available for more information on forest harvesting in the Sooke watersheds.

Table 5. Summary of TimberWest ownership in watersheds draining into the Sooke Inlet, Harbour and Basin (this table does not include all watersheds draining into Sooke Inlet, Harbour and Basin) (Iannidinardo, *pers. comm.*, 2012).

Sooke Watershed Basin	Gross Area (ha)	Net Area (TimberWest) - (ha)	TimberWest Ownership (%)
Sooke CW	6932	641	9%
Sooke Residual	6776	1963	29%
Sooke Council CW	1039	0	0%
Sooke Cragg CW	3705	115	3%
Leech Upper CW	3504	269	8%
Leech West CW	2132	396	19%
Sooke Deception CW	819	447	55%
Sooke Golledge CW	2727	2718	100%
Sooke Mary Vine CW	306	119	39%
Sooke Rock	720	667	93%
Sooke Demamiel	3296	1817	55%
Sooke Charters	1926	139	7%
Total	33883	9290	27%
Outside of Sooke River Watershed	**Gross Area (ha)**	**Net Area (TimberWest) - (ha)**	**TimberWest Ownership (%)**
Kemp CW	581	8	1%
Ayum	488	0	0%
Veitch	457	0	0%
Total	1526	8	0.52%
Total Combined	**35409**	**9298**	**26%**

4.5 RECREATION

Recreational activities can affect water quality in a number of ways. Erosion associated with 4-wheel drive and ATV vehicles, direct contamination of water from vehicle fuel, and fecal contamination from human and domestic animal wastes (*e.g.*, dogs or horses) are typical examples of potential effects. Some recreation concerns are identified in the CRD's Regional Parks Management Plan, such as: risks from fires, impacts to sensitive environmental features such as riparian zones or at risk species, and interactions between pets and wildlife (CRD, 2010b). While no specific or quantitative studies are available on recreation within the Sooke watersheds, impacts (especially during the summer months) are likely but would probably be less significant than other impacts that have occurred.

4.6 WILDLIFE

Wildlife can influence water quality through the deposition of fecal material which may include pathogens such as *Giardia lamblia*, which causes giardiasis or “beaver fever”, and *Cryptosporidium* oocysts which cause the gastrointestinal disease, cryptosporidiosis (Health Canada, 2004). Microbiological indicators, such as *E. coli* and enterococci, are used to assess the risk of fecal contamination to human health. Fecal contamination of water by animals is generally considered to be less of a concern to human health than contamination by humans because there is less risk of inter-specific transfer of pathogens. However, without specific source tracking methods, it is impossible to determine the origins of coliforms.

The Sooke watersheds contain significant valuable wildlife habitat (particularly in the upper watersheds) and provide a home for a wide variety of warm-blooded species. In addition, the marine waters are home to many marine mammals such as seals, otters and mink. Therefore, a risk of fecal contamination from natural wildlife populations within the entire watershed area does exist.

4.7 MINING

Mining activities can potentially impact water quality by introducing high concentrations of metals and other contaminants (*e.g.* sulphate) to waterbodies. The leaching of waste rock or adit discharges can also contribute to acidification of the water. Mining activities generally include road construction and land-clearing, which can change water movement patterns and result in increased turbidity levels.

There are 93 mineral placers and 32 mineral tenures in the Sooke Watersheds. Most of the tenures are in the Leech and West Leech watersheds, as well as Charters River and the land to the south of the Sooke Basin. Most of the placers are in the Leech and West Leech watersheds, with a few in the southern portion of the Sooke River, Golledge Creek and Demamiel Creek (GeoBC, 2013). There are three past producing claims, one prospect and nine showings in the Sooke watersheds (MINFILE, 2013). Names of these and the commodities present are shown in Table 6. Some of the old active claims are used to enable land clearing and to get gravel (Hooper, *pers. comm*. 2012). There are also numerous gravel extraction facilities (Eddy Taje, *pers. comm*., 2012). Future developments of these or other mineral claims within the watershed would be subject to environmental impact assessments to ensure that they do not adversely affect water quality.

Table 6. Mineral claims in the Sooke watersheds (MINFILE, 2013)

Name (secondary name)	Latitude	Longitude	Elevation (m)	Status	Commodity	Watershed
EAGLE (Old Wolfe)	48.49056	-123.69972	267	Past Producer (1923)	Talc (Carbonate-hosted talc)	Sooke
WOLFE CREEK (Old Wolf Creek)	48.48806	-123.68611	220	Past Producer (~1850-1900, 1930-1940)	Gold (Surficial placers)	Sooke
LEECH RIVER PLACER (Martin's Gulch)	48.50028	-123.74583	200	Past Producer (1860-1945)	Gold (Surficial placers)	Leech
INVERECK (Gold Bar)	48.51639	-123.71805	180	Prospect	Talc	Deception
PERMIT 85	48.46917	-123.72388	300	Showing	Copper	Sooke
FLORENCE (L.77) (Sooke Ochre)	48.39694	-123.76611	70	Showing	Aluminum (Bauxite), Ochre	DeMamiel
EASTERN STAR	48.49556	-123.71138	160	Showing	Talc (Carbonate-hosted talc), Gold	Sooke
SUNBEAM 1	48.49472	-123.70638	160	Showing	Talc, Gold	Sooke
SUN (Sunbeam)	48.49556	-123.72638	170	Showing	Talc	Leech
OTTER	48.3925	-123.74444	90	Showing	Copper	DeMamiel
JILL	48.49139	-123.76888	620	Showing	Copper	Golledge
BLOCK 811	48.42361	-123.77861	350	Showing	Copper	DeMamiel
SM (Susie M)	48.44167	-123.64222	533	Showing	Copper, Gold, Silver	Charters

5.0 STUDY DETAILS AND METHODOLOGY

This study focused on the water quality of the lower Sooke watersheds and Sooke Inlet/Harbour/Basin in order to recommend water quality objectives based on water uses, potential impacts and water quality parameters of concern. To complete the study, ENV partnered with the CRD, Environment Canada, District of Sooke, T'Sou-ke Nations and Camosun College to determine common objectives, provide an opportunity for public input, and assist with field work. The project consisted of four phases: gathering information on water use, collecting water quality data, determining land use activities that may influence water quality, and proposing water quality objectives.

Multiple studies have been done in the freshwater and marine waters of Sooke since 1988 that focused on rainwater runoff and various contaminants (including: Cameron & Green, 2007; Chambers & Rodenkirschen, 2003; CRD, 1990; CRD, 2008; Cross *et al*, 1990; Cross, 1991; Cross, 1993; Cross, 1995; Cross, 1996; Environment Canada, 2005; Environment Canada,2009a; Environment Canada,2009b; Environment Canada, 2012; Feakins, 1991; Hull & Miller, 1998; IEC, 1999; Roxborough, *pers. comm.* 2009; Roxborough *et al*., 2010; CRD, 2010; CRD, 2011; CRD, 2012; CRD, 2013). Due to the large amount of information considered, varying data collection methodologies and detection limits in older data, these data, along with ongoing data collection by the CRD and Environment Canada, are not summarized in this report but information within them was considered in the development of proposed objectives for the Sooke Watersheds, Inlet, Harbour and Basin.

5.1 SAMPLING SITES AND SCHEDULE

Water quality sampling at Sooke marine sites was conducted in 2008, while freshwater sampling was conducted in 2007 (benthic only) and 2009. Detailed site, date and parameters are given below for all sampling. Existing CRD sample sites were used in this study to maximize historical data comparability.

Sooke Inlet/Harbour/Basin

Marine sampling occurred weekly between August 7, 2008 to September 3, 2008 (summer low flow period, five sample dates) and October 20, 2008 to November 20, 2008 (fall flush period, five sample dates) at 28 sample sites throughout Sooke Inlet, Harbour and Basin (Figure 7). This includes one control site SO-1 (away from stream influences), located at the entrance to Sooke Inlet. Table 7 provides a list of each sample site and parameters sampled. All sites were sampled for bacteriology (fecal coliform and enterococci) and caffeine (first four summer dates only). Metals were sampled only at nine sample sites where historical data showed past metals concerns and only on August 7, 2008. Water samples for caffeine analysis were collected during the summer low flow sampling period only, due to limited resources. Any oily films that could indicate presence of hydrocarbons on water were noted if present. Water column profiles were conducted for temperature, dissolved oxygen, pH and salinity using a Hydrolab Surveyor 4 sonde at SO-27, SO-28 and at the deepest point of Sooke Basin (E275003, where no other analysis were conducted). Most sample collection was completed on a rising tide, while three sets of samples (August 7, November 12 and November 20, 2008) were collected through a falling tide, and one set on August 19, 2008 was collected through a falling tide, reaching the low and starting to rise again. Tide tables from the sample periods are provided in Appendix I.

Figure 7. Marine sample locations in the Sooke Inlet, Harbour and Basin, 2008.

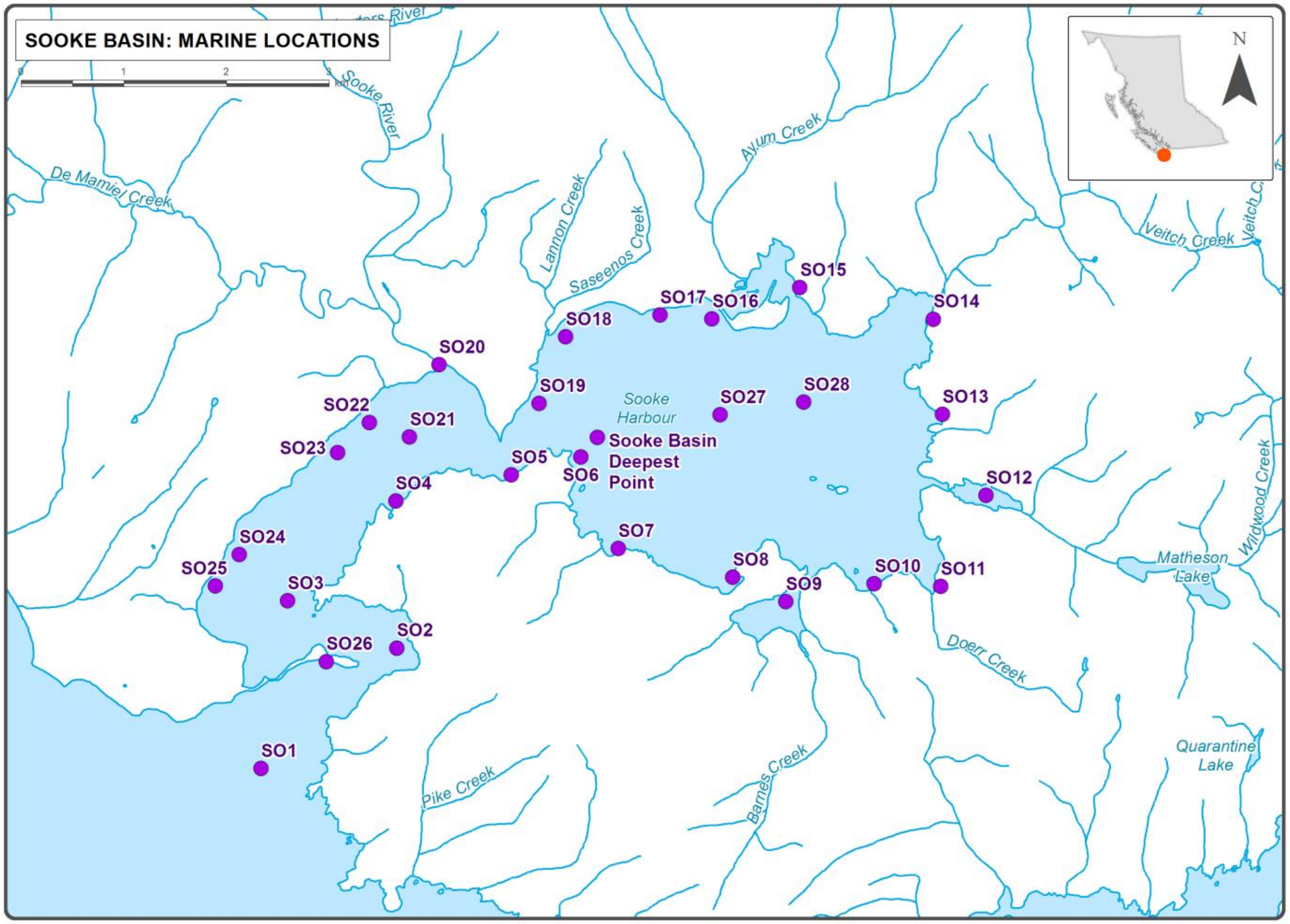


Table 7. Sooke marine (Inlet, Harbour and Basin) weekly (Aug 7 – Sep 3, 2008; Oct 20- Nov 20, 2008) sample sites and parameters sampled at each.

MOE SITE NAMES	**CRD ID**	**EMS#**	**UTM Northing**	**UTM Easting**	**Latitude**	**Longitude**	**depth profile (temp, DO, pH, salinity)** (Aug 12 and Oct 15, 2008 only)	**metals** (Aug 7, 2008 only)	**fecal coliform/ Enterococci** (all dates)	**caffeine** (first four summer dates only)
SOOKE INLET MID-INLET (CRD SO-1) (control)	SO-1	E272569	5355410.185	446213.313	48.349578087696	-123.725964905709			y	y
SOOKE INLET NEARSHORE (CRD SO-2)	SO-2	E272570	5356471.328	447856.647	48.359261908387	-123.703917897313			y	y
SOOKE HARBOUR MID-HARBOUR (CRD SO-3)	SO-3	E272571	5357037.499	446527.948	48.364243979965	-123.721925399602			y	y
SOOKE HARBOUR NEARSHORE (CRD SO-4)	SO-4	E272572	5357929.685	447716.707	48.372369608834	-123.705988194236			y	y
SOOKE HARBOUR NEARSHORE (CRD SO-5)	SO-5	E272573	5358137.089	448786.368	48.374323128333	-123.691570793773		y	y	y
SOOKE BASIN NEARSHORE (CRD SO-6)	SO-6	E272574	5358253.705	449486.565	48.375428647363	-123.682130296445		y	y	y
SOOKE BASIN NEARSHORE (CRD SO-7)	SO-7	E272575	5357410.678	449816.179	48.367871103260	-123.677578905633			y	y
SOOKE BASIN NEARSHORE (CRD SO-8)	SO-8	E272576	5357011.09	450921.577	48.364363338885	-123.662608306138			y	y
SOOKE BASIN NEARSHORE (CRD SO-9)	SO-9	E272577	5356772.152	451393.848	48.362250393105	-123.656204995563			y	y
SOOKE BASIN NEARSHORE (CRD SO-10)	SO-10	E272578	5356941.823	452235.525	48.363841013132	-123.644861998581			y	y
SOOKE BASIN NEARSHORE (CRD SO-11)	SO-11	E272579	5356929.399	452898.629	48.363779078506	-123.635908703370			y	y
SOOKE BASIN NEARSHORE (CRD SO-12)	SO-12	E272580	5357768.946	453510.712	48.371377080656	-123.627738394762			y	y
SOOKE BASIN NEARSHORE (CRD SO-13)	SO-13	E272581	5358484.212	453068.089	48.377778882009	-123.633794551908			y	y
SOOKE BASIN NEARSHORE (CRD SO-14)	SO-14	E272582	5359556.245	452957.821	48.387414712117	-123.635403602297			y	y
SOOKE BASIN NEARSHORE (CRD SO-15)	SO-15	E272583	5360008.404	451585.238	48.391378451304	-123.653994105483		y	y	y
SOOKE BASIN NEARSHORE (CRD SO-16)	SO-16	E272584	5359690.44	450879.757	48.388463495635	-123.663486005411		y	y	y
SOOKE BASIN NEARSHORE (CRD SO-17)	SO-17	E272585	5359644.247	450285.139	48.388001350084	-123.671511701662			y	y
SOOKE BASIN NEARSHORE (CRD SO-18)	SO-18	E272586	5359410.236	449328.204	48.385820039189	-123.684408096124		y	y	y
SOOKE BASIN NEARSHORE (CRD SO-19)	SO-19	E272587	5358764.255	449062.492	48.379987431550	-123.687918402394		y	y	y
SOOKE HARBOUR NEARSHORE (CRD SO-20)	SO-20	E272588	5359099.246	448420.963	48.382948856023	-123.696622802491			y	y
SOOKE HARBOUR MID-HARBOUR (CRD SO-21)	SO-21	E272589	5358607.509	447908.388	48.378483111298	-123.703484105747			y	y
SOOKE HARBOUR NEARSHORE (CRD SO-22)	SO-22	E272590	5358623.744	447207.174	48.378570868636	-123.712955106236		y	y	y
SOOKE HARBOUR NEARSHORE (CRD SO-23)	SO-23	E272591	5358196.186	446777.636	48.374688513526	-123.718701305932		y	y	y
SOOKE HARBOUR NEARSHORE (CRD SO-24)	SO-24	E272592	5357562.737	446187.449	48.368940022804	-123.726589298587		y	y	y
SOOKE HARBOUR NEARSHORE (CRD SO-25)	SO-25	E272593	5356895.821	445946.911	48.362919968727	-123.729751106274			y	y
SOOKE INLET NEARSHORE (CRD SO-26)	SO-26	E272594	5356375.04	446836.008	48.358310580305	-123.717682903197			y	y
SOOKE BASIN MID-BASIN (CRD SO-27)	SO-27	E272595	5358459.069	450775.938	48.377378013392	-123.664743968956	y		y	y
SOOKE BASIN MID-BASIN (CRD SO-28)	SO-28	E272596	5358445.343	451698.569	48.377325847648	-123.652283613510	y		y	y
SOOKE BASIN DEEPEST POINT	N/A	E275003	5358490.96	449736.93	48.377583000000	-123.678778000000	y			

Sooke Watersheds

Freshwater sampling occurred in 2009 at a total 17 sites to address potential sources of contamination (Table 8, Figure 8). Six of these (identified in Table 8) were considered reference sites. Freshwater sites chosen include the stream sampling priorities (identified in Table 8) as identified in the draft Stage 2 LWMP for rainwater (Miller *et al*., 2010), and focus on the area of greatest development within the District of Sooke. To represent the worst case scenario, water samples were collected at the sites on a weekly basis for five consecutive weeks during the summer low flow and fall high flow periods. Only 12 of the17 sites were sampled during summer low flow (weekly from August 5, 2009 to September 3, 2009), as not all streams were flowing at that time; 15 of 17 sites were sampled during fall flush (weekly from October 19, 2009 to November 18, 2009) (Table 8).

Most of the streams had very low flows or were without riffle/run habitat in late August/early September to enable benthic invertebrate sampling. Benthic invertebrate samples were collected at one reference site (Charters) and one test site (Demamiel) in 2007 and two reference sites (Charters and Upper Sooke River) and two test sites (Demamiel and Ayum) in 2009 (Table 8). Note the Demamiel and Charters sites were new sites, not the regular sites sampled in the summer and fall, as stream conditions at the regular sites precluded biological sampling. Sampling also occurred at two additional reference sites in the protected Sooke Lake area in 2011: Jones Creek and Council Creek; as well as at the test sites Demamiel and Charters (note the status of this site changed from reference to test) in 2012. At the time of 2009 sampling at the Sooke River site, summer recreational activity disturbing river substrate could potentially have reduced numbers/variety of benthic invertebrates available for collection in a localized area.

Based on current knowledge of water uses (Section 3) and potential anthropogenic impacts to the watersheds (Section 4), the following water quality variables were included in the summer and fall monitoring:

- Physical: pH, true color, specific conductance, turbidity, total suspended solids (TSS), temperature, dissolved oxygen;
- Carbon: total organic carbon;
- Nutrients: total phosphorus, ortho-phosphate, nitrate and nitrite;
- Microbiological indicators: fecal coliforms and *E. coli;*
- Total and dissolved metals concentrations (13 sites only);
- Biological: benthic invertebrate community.

Biological sampling was conducted according to CABIN (Canadian Aquatic Biomonitoring Network) protocols (Environment Canada, 2011b). These protocols include benthic invertebrate collection, general water chemistry (true colour, pH, total dissolved solids, specific conductivity, turbidity, total organic carbon, total suspended solids), nutrient (nitrate, nitrite, ammonia, total organic nitrogen, total kjeldahl nitrogen, total nitrogen, total dissolved orthophosphate, total phosphorous), and metals (ICPMS) sampling, as well as habitat assessments. Benthic invertebrate samples were sent to Sue Salter at Cordillera Consulting for taxonomic identification following CABIN laboratory methods (Environment Canada, 2014).

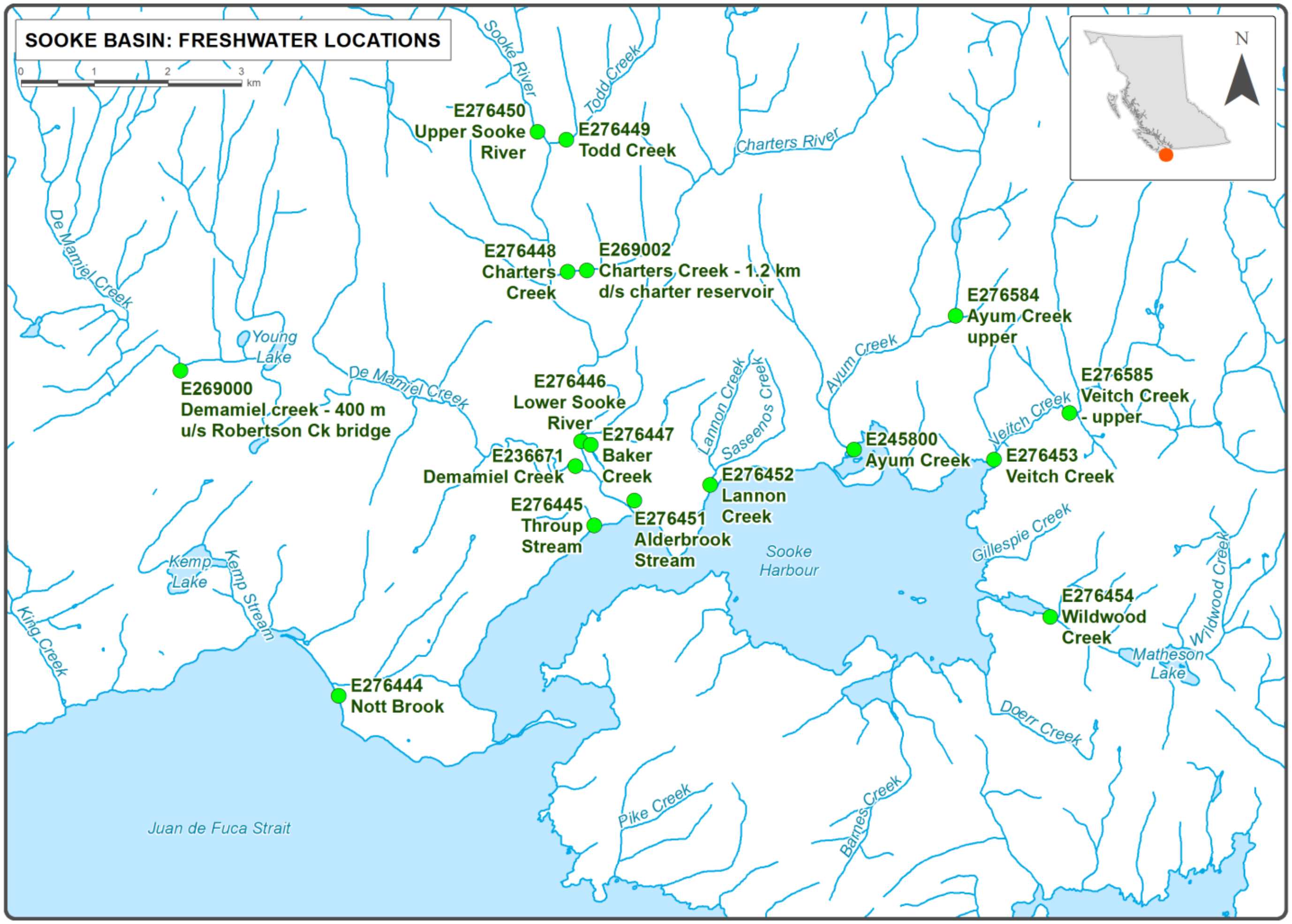
Marine and freshwater grab samples were collected at the water surface using plastic bottles provided by the lab conducting the analyses. Water samples were collected in strict accordance with Resource Inventory Standards Committee (RISC) standards (BC MOE, 2003), by trained personnel. Grab samples were sent to North Island Labs in Courtenay, B.C., and Cantest Laboratories in Burnaby, BC, for marine and freshwater bacteriological analysis, respectively; to the University of Victoria Water Quality Lab for caffeine analysis (following standard methodologies (Verenitch, *pers. comm*. 2011)); and to Maxxam Analytics in Burnaby, BC for water chemistry analysis. Field data for temperature and dissolved oxygen were collected using a YSI Pro Plus hand held meter.

Summary statistics were calculated on all available data, and geometric means and 90th percentiles were calculated using data from a minimum of five weekly samples in 30 consecutive days for each site. When duplicate samples were collected, the results were incorporated into the 30 day average, thus some averages may be based on six samples in 30 days, rather than five. Data are summarized in Appendices I-IV.

Table 8. Freshwater sample sites, including parameters monitored in streams draining into Sooke Basin, Inlet and Harbour. Fish presence in brackets has not been confirmed.

When sampled			EMS #	Drainage Location (Harbour, Inlet, Basin or Bay)	Name	UTMNorthing	UTMEasting	CRD site name (E=ephemeral)	CRD Priority (high, medium, low)	summer flow range (L/min)	Fish (no, non-salmonid, trout, salmon)	Reference site?	Benthic Inverts	Metals	Bacterological/ Turbidity/DO	Total Phosphorous
	fall flush		E276444	Bay	Nott Brook	5356912.212	444138.931	2100-1	h	0-5	not any more	n		x	x	x
summer low flow	fall flush		E276445	Harbour	Throup Stream	5359089.334	447696.155	2046-1	h	10-15	s	n		x	x	x
summer low flow	fall flush		E236671	Harbour	Demamiel Creek	5359903.978	447474.15	2043-1a	h	20-40	(s, t, ns)	n		x	x	x
summer low flow	fall flush		E276446	Harbour	Lower Sooke River	5360244.374	447568.362	2043-1	m	20-270	s, t, ns	n		x	x	x
summer low flow	fall flush		E276447	Harbour	Baker Creek	5360187.663	447690.733	2043-1b	m	0-20	(s, t, ns)	n		x	x	x
summer low flow	fall flush		E276448	Harbour	Charters Creek	5362556.37	447481.013	2043-2	l	60-100	(s, t, ns)	y		x	x	x
summer low flow	fall flush		E276449	Harbour	Todd Creek	5364357.281	447536.52	2043-3	l	0-30	(s, t, ns)	y		x	x	x
summer low flow	fall flush	september	E276450	Harbour	Upper Sooke River	5364481.655	447147.568	2043-4	l	10-60	s,t	y	reference	x	x	x
summer low flow	fall flush		E276451	Harbour	Alderbrook Stream	5359405.506	448250.693	2042a-1	m	0-10	t	n		x	x	x
summer low flow	fall flush		E276452	Basin	Lannon Creek	5359572.866	449290.274	2039-1	m	0-10	s, t, ns	n		x	x	x
summer low flow	fall flush	september	E245800	Basin	Ayum Creek	5359972.46	451259.482	2036-1	l	0-5	s, t, ns	n	test	x	x	x
	fall flush		E276584	Basin	Ayum Creek upper	5361737.254	452709.0649	2036-2 (E)	l			y			x	
summer low flow	fall flush		E276453	Basin	Veitch Creek	5359759.765	453151.532	2030-1	l	15-30	t	n			x	
summer low flow	fall flush		E276585	Basin	Veitch Creek - upper	5360349.886	454198.3064	2030-2 (E)				n			x	
	fall flush		E276454	Basin	Wildwood Creek	5357586.654	453821.656	2027-1		0-20	s, t, ns	y			x	
		september	E269000	Harbour	Demamiel creek - 400 m u/s Robertson Ck bridge	5361430.46	442177.9756	none		0-?	(s, t, ns)	n	test	x	x	x
		september	E269002	Harbour	Charters Creek - 1.2 km d/s charter reservoir	5362564.78	447741.262	none				y	reference	x	x	x

Figure 8. Map of freshwater sample locations in the Sooke watersheds draining into Sooke Inlet, Harbour and Basin.



5.2 QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance and quality control was verified by collecting duplicate samples from randomly chosen sites on each five weekly samples in 30 days sample date. For 2008 marine sampling three duplicate bacteriological samples per date were collected; for 2009 freshwater sampling one bacteriological sample, one chemical physical sample (including metals and nutrients) and one field meter reading sample per date were collected. Duplicate grab samples were collected by filling two sample bottles in as close to the same time period as possible (one right after the other) at a monitoring location.

The maximum acceptable percentage difference between duplicate samples is 25% (RISC, 1997). However, this interpretation only holds true if the results are at least 10 times the detectable limits for a given parameter, as the accuracy of a result close to the detectable limit shows more variability than results well above detectable limits. As well, some parameters (notably bacteriological indicators that are constantly changing concentrations of living organisms) are not homogeneous throughout the water column and therefore a higher degree of variability is expected between replicate samples.

5.2.1 Quality Assurance / Quality Control Results

Sooke Inlet/Harbour/Basin

Twenty-four sets of duplicate samples were collected for enterococci and 21 for fecal coliforms during the 2008 marine sampling program (Appendix II). Relative percent mean differences were not calculated for most duplicate pairs as 96% of the enterococci and 90% of fecal coliform results were less than 10 times the detection limits (<2CFU/100ml), and therefore the guidelines for interpreting acceptability do not apply. There were a few exceptions when the results for duplicate pairs were higher and thus relative percent differences could be calculated. For example on October 20, 2008 at SO-20, the duplicate fecal coliform results were 220 MPN/100 mL and 240 MPN/100 mL (relative percent difference of 10% or acceptable difference); however, enterococci results for the same date and location were 27 MPN/100 mL and 79 MPN/100 mL (relative percent difference of 26% and considered different). In these instances, contamination may have occurred during collection or analysis, but it is more likely the result of environmental conditions that were highly variable, as both these analyses (fecal coliform and enterococci) came from the same bottle.

Sooke Watersheds

For the 2009 freshwater duplicate sampling (Appendix II), relative percent mean differences of *E. coli* and fecal coliforms could be calculated for all but two duplicate pairs that were less than 10 times the detection limit. Three fecal coliform and one *E. coli* duplicate pair had greater than 25% relative percent mean difference and thus were considered different. Similar to the marine results, relative percent mean differences greater than 25% for freshwater microbiological results were likely a result of environmental conditions that were highly variable.

All freshwater duplicate pair readings taken with the field meter were identical, thus meeting the acceptability criteria for quality control. Relative percent mean differences were not calculated for most duplicate pairs of freshwater grab samples (chemical/ physical parameters) as 58% of the results (267 of 458 values) were less than 10 times the applicable detection limits, and therefore the guidelines for interpreting acceptability do not apply. Of those specific parameter results that were greater than 10 times the applicable detection limits, eight duplicate pairs had a greater than 25% relative percent difference between their values (Appendix II). All of these occurred on the same two dates, October 19 and 26, 2009, coinciding with the first fall flush sampling events, and seven of them were for various total metals values (one was for a dissolved metal). Corresponding dissolved metals for the same parameters did not show a 25% difference between the values in the duplicate pairs. As total metals measures metals bound to particles in the water and those dissolved in the water (as opposed to only dissolved metals in the water), these results were likely a result of highly variable environmental conditions (including particles in the water) during the first rain events.

6.0 WATER QUALITY ASSESSMENT

The following sections describe the characteristics considered in assessing the water quality of the Sooke watersheds, harbour, inlet and basin.

6.1 PH

pH measures the concentration of hydrogen ions (H^+) in water. The concentration of hydrogen ions in water can range over 14 orders of magnitude, so pH is defined on a logarithmic scale between 0 and 14. A pH between 0 and 7 is acidic (the lower the number, the more acidic the water) and a pH between 7 and 14 is alkaline (the higher the number, the more basic the water). The aesthetic objective for drinking water is a pH between 6.5 and 8.5 (McKean and Nagpal, 1991). Corrosion of metal plumbing may occur at both low and high pH outside of this range, while scaling or encrustation of metal pipes may occur at high pH. The effectiveness of chlorine as a disinfectant is also reduced outside of this range. In marine waters the BC aquatic life guideline for pH is 7.0 to 8.7.

Sooke marine pH profiles on Aug 12, 2008 and October 15, 2008 ranged from 7.34 to 8.27 pH units with an average of 7.83 pH units for 91 measurements (Appendix III, Table 21). pH in all the Sooke watersheds (including 1999-2000 data) ranged from 6.9 to 7.8 pH units with a mean of 7.3 pH units (Appendix IV, Table 26) for 23 samples collected. No obvious trends were observed between seasons or watershed location. This suggests (as supported by other reports and non-ENV data collected) that pH is not presently a concern in the Sooke watersheds, inlet, harbour or basin; thus, no water quality objective is proposed for pH.

6.2 DISSOLVED OXYGEN

Dissolved oxygen levels are important for the survival of aquatic organisms, especially species sensitive to low oxygen levels, such as salmonids. Oxygen becomes dissolved in water on the surface of waterbodies as a result of diffusion from the atmosphere, as well as from photosynthetic activity from plants and algae. When deeper waters no longer mix with surface waters due to stratification or restricted circulation, concentrations of dissolved oxygen can decrease. In streams, low flows can result in lower oxygen levels in the water. In marine waters with restricted circulation, such as some inlets, deep waters can remain anoxic. Low oxygen can also occur as a result of decomposition of organic materials in the water body and can be exaggerated by high water temperatures. If the euphotic zone lies above the thermocline, no photosynthesis occurs in deeper waters, and therefore oxygen depletion occurs as a result of decomposition. The aquatic life guideline for the minimum instantaneous dissolved oxygen concentration is 5 mg/L and for the 30 day mean is 8 mg/L (BC MOE, 1997).

Sooke Inlet/Harbour/Basin

Historically, the oxygen content of the Sooke marine system was considered excellent with good mixing in the water column, but was also identified as potentially at risk if the amount of industrial and commercial activity continued to increase in the Sooke Basin. In the basin in the early 1990s there were fish processing wastes, salmon farming wastes and wood debris from log booming and storage activities (Cross, 1993). These activities are no longer occurring in the area, and high DO levels have been maintained.

DO levels in the Sooke Harbour and Basin ranged from 5.48 to 10.4 mg/L (91 measurements) (Appendix III), with the lowest values observed at the deepest point (35m depth) of the basin in August (Figure 9) when the water column was slightly thermally stratified (see Section 6.3). Relatively high DO levels in the harbour and basin, with the exception of the lower summer levels at depth in the basin, suggest that the area is generally well flushed and oxygenated; however, summer stratification can result in reduced DO at depth. If commercial or industrial activities associated with organic matter deposition are revived in the basin, there is the potential for further reduced oxygen during this higher risk summer period. In the event of revival of any activities in the basin, establishment of a water quality objective for dissolved oxygen at the deepest point in the basin could be considered and would serve as an early warning sign for impact from future activities. ***No objective is proposed for DO in the Sooke marine areas at this time.***

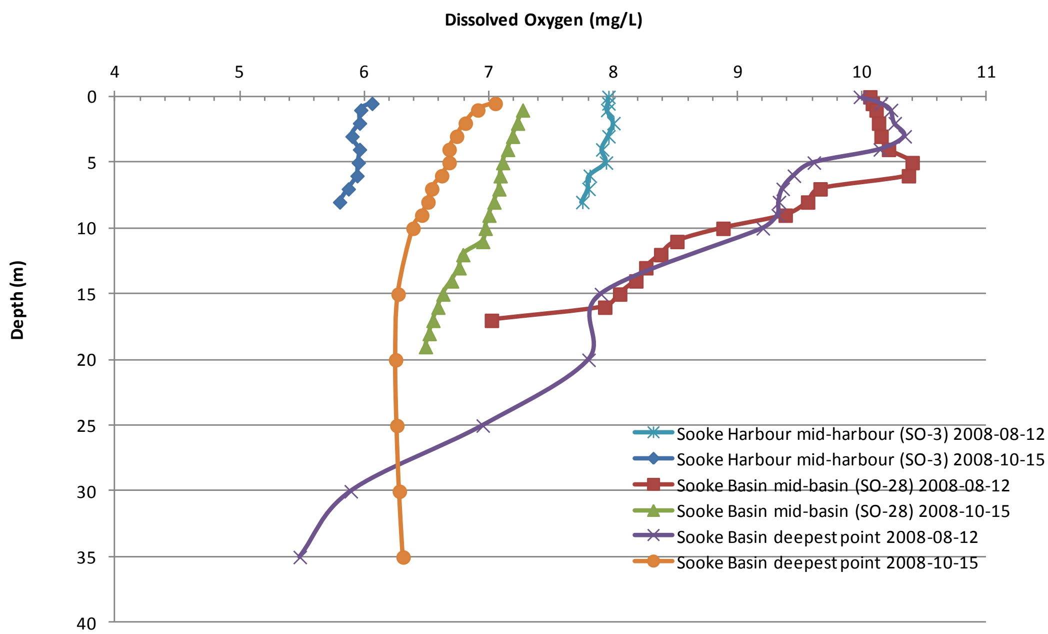


Figure 9. Dissolved oxygen data collected in 2008 from Sooke Harbour and Basin.

Sooke Watersheds

DO values from the Sooke watersheds measured with a handheld meter were generally high in both summer (ranging from 5.43mg/L to 14.23 mg/L for 65 measurements) and fall (ranging from 11.0 mg/L to 16.79 mg/L for 76 measurements), with the lowest values occurring at both Veitch Creek sites during the summer (ranging from 5.43 mg/L to 8.79 mg/L) (Figure 10). Though no quantifiable flow data were available for Veitch Creek, lower summer DO values are typically associated with visual observations of low flow or stagnant water. As there is potential for freshwater streams in Sooke to approach the minimum instanteous DO guideline, a DO guideline is recommended for the Sooke watersheds***. The proposed objective is that the minimum instantaneous dissolved oxygen concentration remain above 5 mg/L or and the average of five weekly samples collected in a 30 day period remain above 8 mg/L.***

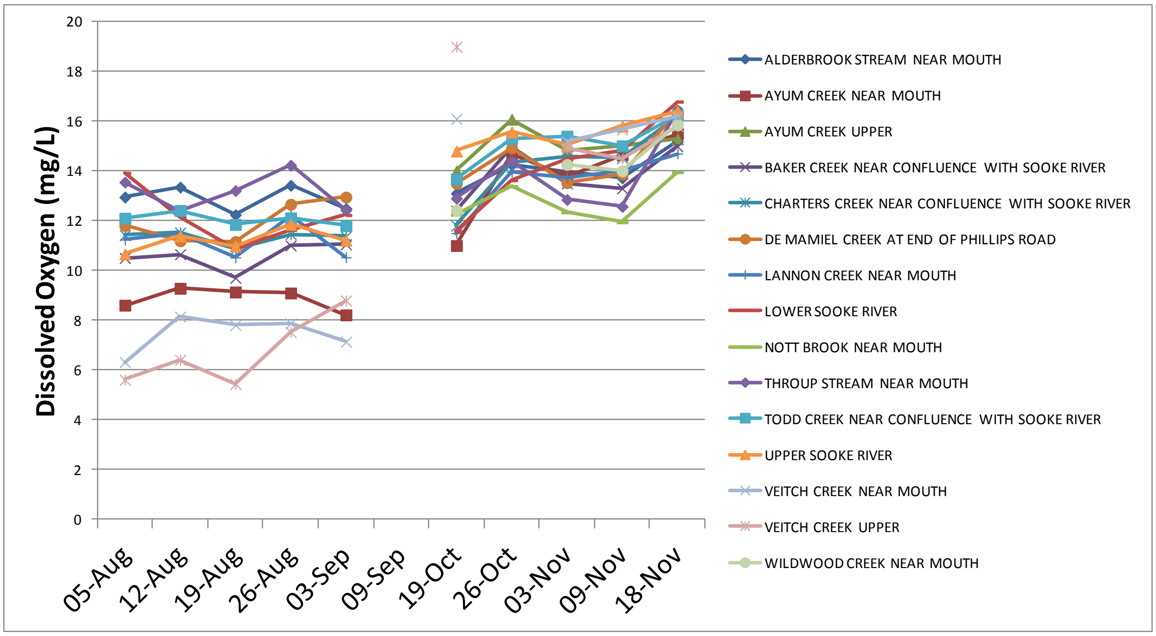


Figure 10. Dissolved oxygen data collected in 2009 from Sooke watersheds.

6.3 TEMPERATURE

Temperature is considered in drinking water for aesthetic reasons. The aesthetic guideline is 15°C; temperatures above this level are considered to be too warm to be aesthetically pleasing (Oliver and Fidler, 2001). For the protection of aquatic life in streams, the allowable change in temperature is +/-1°C from naturally occurring levels. The optimum temperature ranges for salmonids and other coldwater species are based on species-specific life history stages such as incubation, rearing, migration, and spawning, and each species has its own optimum temperature range. Of the species of fish present in the Sooke watersheds (see Section 3.3), chum are the most sensitive to warmer temperatures (12-14 °C for rearing). Chum juveniles, however, are not present in the river during the summer months. Coho, steelhead and cutthroat trout all have similar temperature thresholds (Oliver and Fidler, 2001), and are the species in the watersheds for the longest periods of time, including the summer.

Sooke Inlet/Harbour/Basin

Temperatures in the Sooke Harbour and Basin ranged from 9.39 to 16.99°C (91 measurements) (Appendix III), with no defined thermocline (the plane of maximum rate of decrease of temperature with respect to depth, with a rate of change greater than 1°C per metre (Wetzel, 2001)) but weak stratification occurring in the top 6 m of the Sooke Basin during the summer (Figure 11). Temperatures at the surface of the Sooke Basin are occasionally higher than the most sensitive guideline for salmonid migration of 15.6°C. Temperatures between the Sooke Basin surface and the bottom (about 35 m) did not vary by more than 4°C even during the middle of summer, while the Sooke Harbour was well mixed in both summer and fall (less than 1°C difference between top and bottom (about 8m), suggesting the area is generally well flushed. During the summer months when surface temperatures increase, fish in the Sooke Basin would be able to retreat to lower temperature and well oxygenated water, ***therefore no temperature objective is proposed for the Sooke marine areas.***

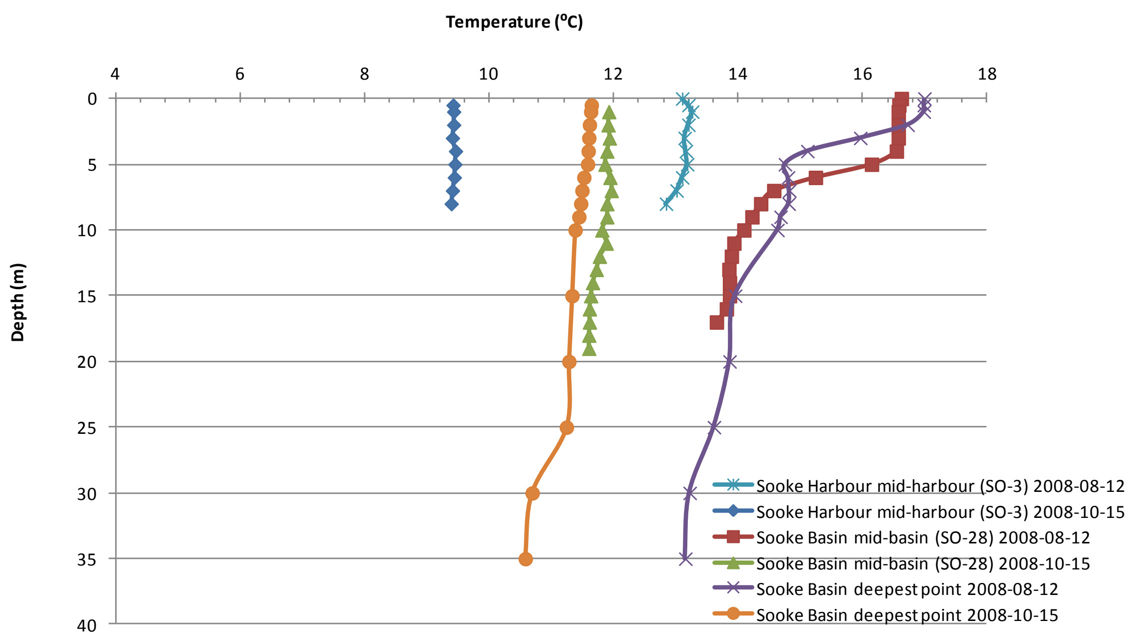


Figure 11. Water temperature data collected in 2008 from Sooke Harbour and Basin.

Sooke Watersheds

Water temperatures in the Sooke watershed ranged from 9.8 to 21.9 °C in the summer sample period (65 samples), and from 6.19 to 11.7 °C in the fall sample period (76 samples), with the highest temperatures in both the upper (16.1 to 18.6 °C) and lower

(17.1 to 21.9 °C) mainstem of the Sooke River (Figure 12). At these two sites, and at the Demamiel site, guidelines (optimum maximum temperature plus a change of 1 degree Celsius) for both coho (17°C) and steelhead (19°C) rearing were occasionally exceeded in the summer 2009 sample period. While adult steelhead typically return to the ocean after spawning, most juveniles spend one to two years in freshwater maturing into smolts before entering the ocean. Some salmon species, including coho, also utilize freshwater for up to three years before entering the ocean. Water temperatures remained consistently below the aquatic life guidelines for the incubation and spawning period for salmonids. ***Due to the high summer temperatures and the high fisheries values of the Sooke River, a water quality objective is proposed to protect juvenile salmonids, in particular coho (the most sensitive species at this time). The maximum temperature at any location in the river should not exceed 17°C at any time during the year.*** While maximum temperatures may exceed the guideline in the lower portion of the river, as long as refuges remain with average temperatures below the guideline, juvenile fish should protected during periods of elevated temperatures.

At the Sooke River, Demamiel Creek and Charters Creek sites, temperatures exceeded the aesthetic guideline of 15°C in the summer 2009 sample period. Temperature data were only collected for one summer period, but it is likely that the aesthetic drinking water guideline is exceeded occasionally each year in these larger steams that drain large land areas. Many watersheds on the east coast of Vancouver Island, as well as throughout the Southern Interior, typically have elevated summer water temperatures. It is therefore likely that higher summer temperatures are, for the most part, a natural occurrence. However, it is possible that activities such as forest harvesting, agriculture or urban development, activities that have the potential to decrease stream shading if removal of vegetation occurs in riparian areas, and climate change, could exacerbate peak summer water temperature to the point where this guideline is occasionally exceeded.

As the provincial drinking water guideline is occasionally exceeded in the larger of the Sooke streams (Sooke River, Demamiel Creek and Charters Creek) where the streams are wider, flatter and more exposed, this guideline is appropriate for all of the lower Sooke watersheds. To protect the creek from future activities in the watershed ***a water quality***

objective is proposed for water temperature in the lower Sooke watersheds. It is recommended that maximum instantaneous water temperatures at any water intake should not exceed 15°C during the summer months. As the streambank along any creeks subject to forestry activities or development recover from vegetation clearing, maximum summer temperatures should begin to decrease as the amount of sunlight reaching the water decreases. However, where land clearing from development occurs efforts should be made to protect riparian areas to retain vegetative cover over streams and keep stream temperatures from increasing.

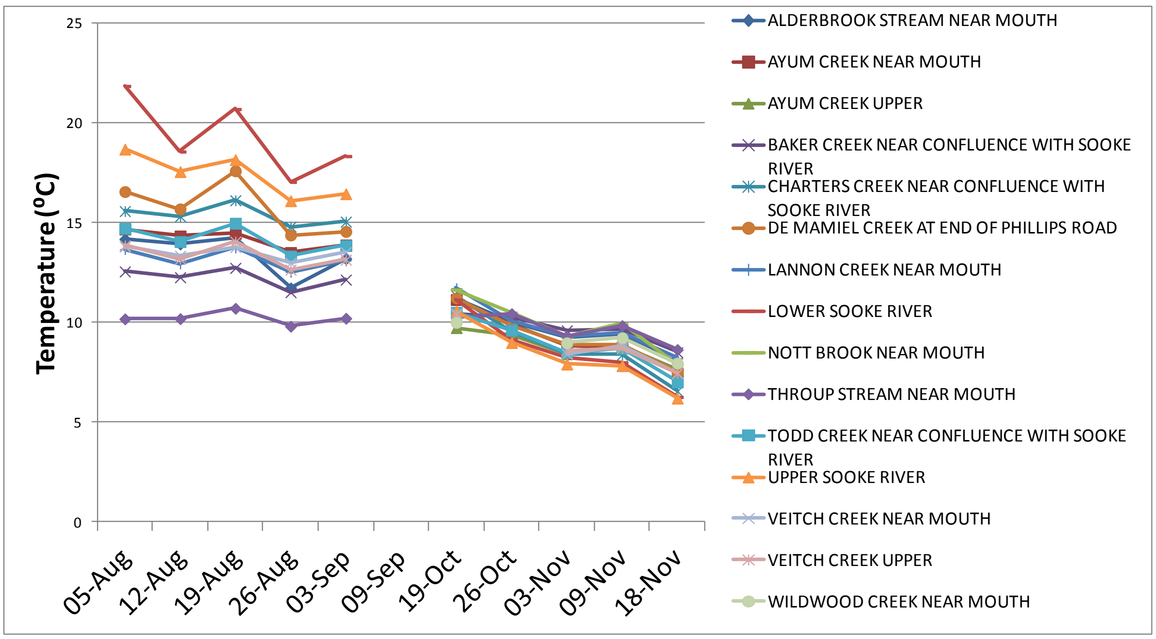


Figure 12. Water temperature data collected in 2009 from Sooke watersheds.

6.1 CONDUCTIVITY

Conductivity refers to the ability of a substance to conduct an electric current. The conductivity of a water sample gives an indication of the amount of dissolved ions in the water. The more ions dissolved in a solution, the greater the electrical conductivity. As temperature affects the conductivity of water (a 1ºC increase in temperature results in approximately a 2% increase in conductivity), specific conductance is used (rather than simply conductivity) to compensate for temperature.

Coastal systems, with high annual rainfall values and typically short water retention times, generally have low specific conductance (<80 microsiemens/centimeter (μS/cm)), while interior watersheds generally have higher values. Increased flows resulting from precipitation events or snowmelt tends to dilute the ions, resulting in decreased specific conductance levels with increased flow levels. Therefore, water level and specific conductance tend to be inversely related. However, in situations such as landslides, where high levels of dissolved and suspended solids are introduced to the stream, specific conductance levels tend to increase. As such, significant changes in specific conductance can be used as an indicator of potential impacts.

Sooke Watersheds

Specific conductance was not measured in the marine environment. In the Sooke watersheds, specific conductance values in the grab samples (sampled only when benthic invertebrates were collected and in the 1999-2000 data) ranged from 36 μS/cm to 85 μS/cm, with an average of 52 μS/cm for seven samples collected at five sites (Appendix IV). The field values collected with a meter on only one date (November 9, 2009) during the fall sample period (fall flush) ranged from 25 μS/cm to 578 μS/cm (Figure 13), with an average of 178 μS/cm for 13 samples at 12 sites; the maximum observed at the four sites sampled for conductivity in the fall that were considered to be reference was 217 uS/cm with an average of 130 uS/cm. It should be noted that in some streams spawning salmon and salmon carcasses were also present at time of sampling and may have contributed to high specific conductance levels at sites considered to be reference. Groundwater influences may also have contributed to these higher values at reference sites.

There were not enough seasonal data to determine if values were correlated with flows; this is typically observed, with the highest conductivity occurring during low summer flows (when dilution was lowest) and conductivity values dropping during the winter (when dilution from rainfall was highest). Not enough data were available to determine if turbidity events influenced higher fall values for some streams (Figure 13). For these reasons, though there were some observations of higher specific conductance than that typically observed in coastal streams, no objectives is proposed for specific conductance in the Sooke watersheds. However, this parameter should be included in future attainment monitoring to obtain a better understanding of trends.

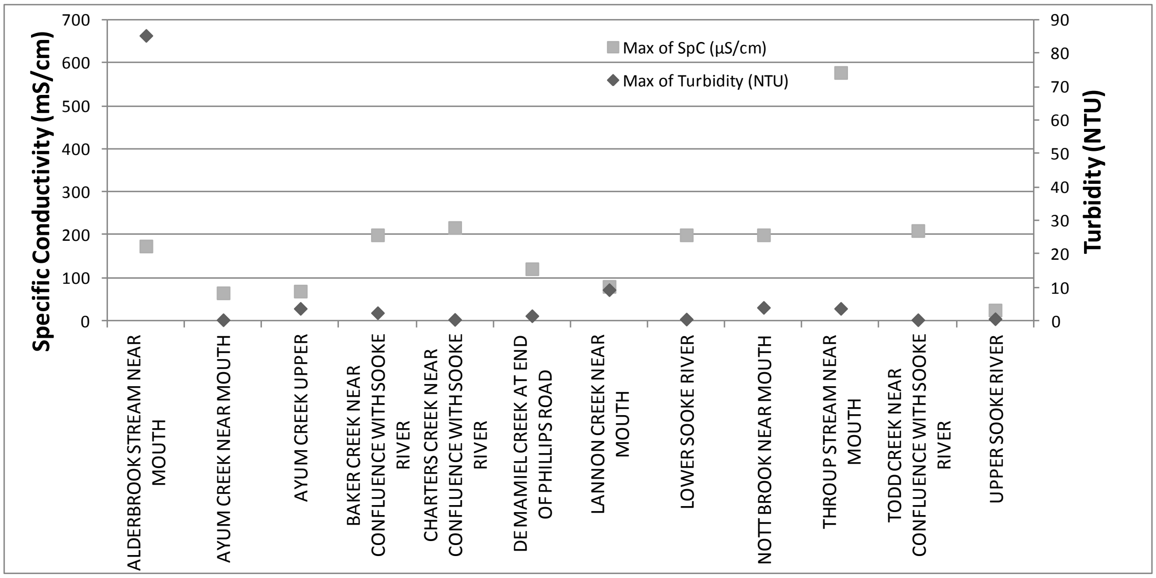


Figure 13. Specific conductivity and turbidity data collected on November 9, 2009 from Sooke watersheds (figure includes only sites where both parameters were collected).

6.2 TURBIDITY

Turbidity is a measure of the clarity or cloudiness of water, and is measured by the amount of light scattered by the particles in the water as nephelometric turbidity units (NTU). Elevated turbidity levels can decrease the efficiency of disinfection, allowing microbiological contaminants to enter the water system. As well, there are aesthetic concerns with cloudy water, and particulate matter can clog water filters and leave a film on plumbing fixtures. The guideline for drinking water that does not receive treatment to remove turbidity is an induced turbidity over background of 1 NTU when background is less than 5 NTU, and a maximum of 5 NTU (during turbid flow periods) (Caux *et al.*, 1997). VIHA's goal for surface source drinking water for systems that do not receive filtration, such as the GVWSA, is that it demonstrate 1 NTU turbidity or less (95% of days) and not above 5 NTU on more than 2 days in a 12 month period (min. 4 hr frequency of monitoring) when sampled immediately before disinfection (Enns, *pers. comm.*, 2009).

Sooke Watersheds

At the sites considered to be in reference condition (seven sites), turbidity values based on grab samples ranged from 0.1 NTU to 6.8 NTU, with a summer average of 0.4NTU (36 samples at five sites) and a fall average of 1.4 NTU (28 samples at five sites) for samples collected in 2009 (Figures 14-16 and Appendix IV). When considering all sample locations, the maximum value (86.2 NTU) occurred November 9, 2012 in Alderbrook Stream. With the exception of Lannon, Baker and Alderbrook, all sites were at or below 1.0 NTU throughout the summer sample period. On 4 of the 5 dates when turbidity exceeded 1.0 NTU at any of the reference sites, there had been significant rainfall within the past 24 hours (Environment Canada, 2012). The exception to this was October 19, 2009, when a turbidity value of 2.7 NTU was measured. However, rainfall had occurred less than 48 hours prior to that sample being collected. Therefore it can be stated that elevated turbidity levels in the Sooke watersheds are almost invariably associated with rain events, which flush material into the creek. Future monitoring should focus on collecting water samples following significant rain events, in order to try and capture these occasional elevated turbidity levels.

Turbidity values measured over the course of this study reflect impacts of urban and rural development in the lower parts of the Sooke watersheds. Two of the sites considered to be in reference condition (Upper Sooke River and Demamiel Creek 400 m upstream of Robertson Rd bridge) do have some timber harvesting occurring, but at low enough density (<20% of watershed) to be considered reference for this parameter. Low turbidity at these sites even during fall flush suggests recovery from historical timber harvesting practices; therefore, it is anticipated that as the estimated clear-cut area decreases, turbidity events will continue to decrease in both frequency and severity.

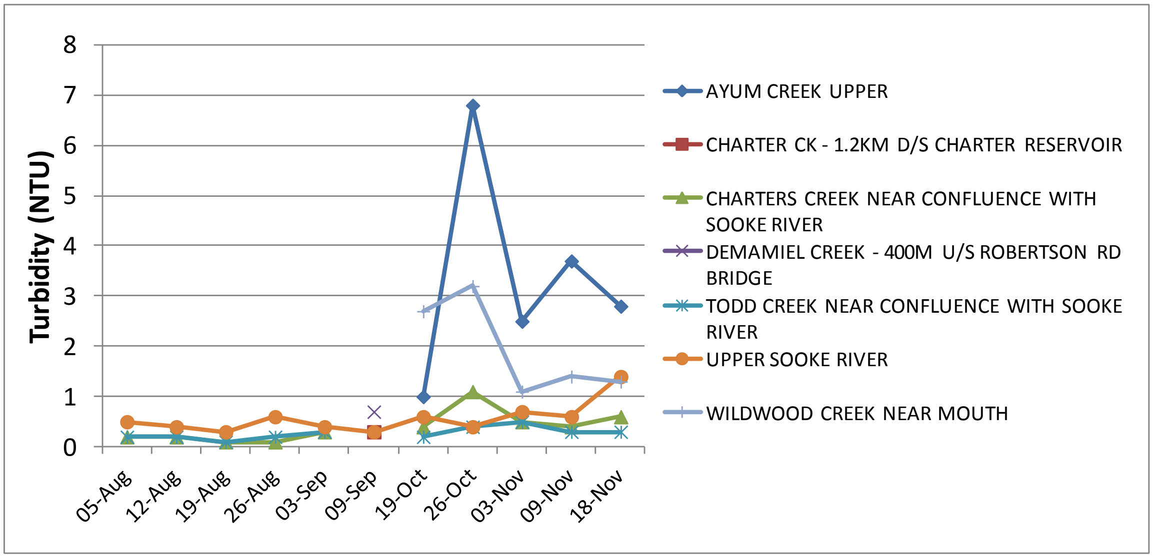


Figure 14. Turbidity levels in 2009 grab samples taken at Sooke sample sites considered to be reference.

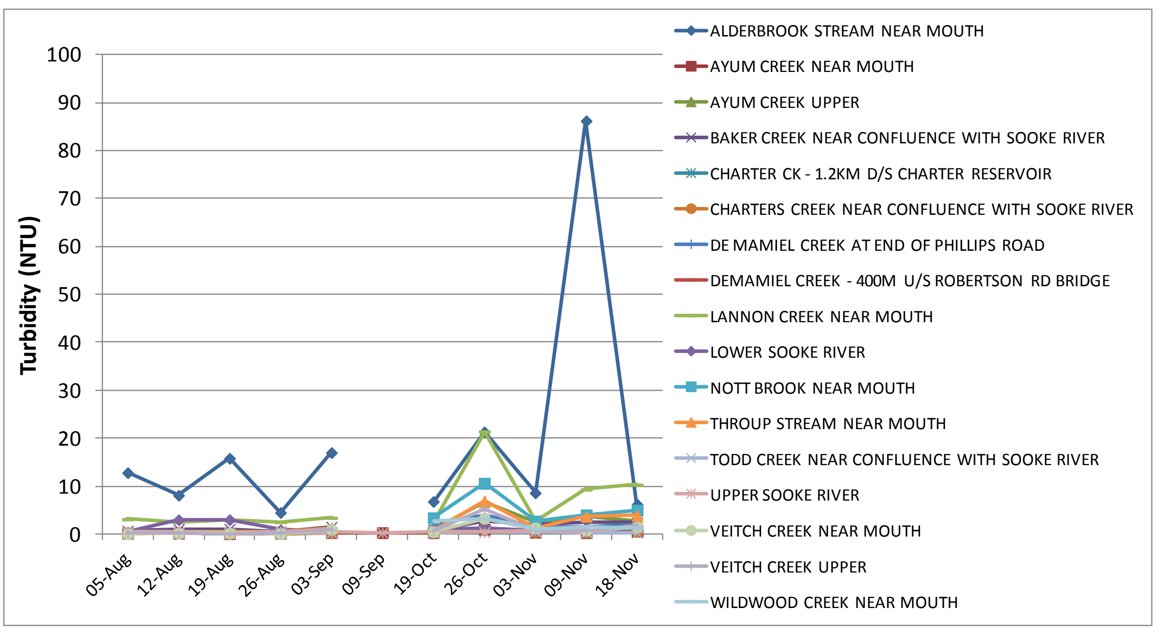


Figure 15. Turbidity levels in 2009 grab samples taken at all Sooke sample sites.

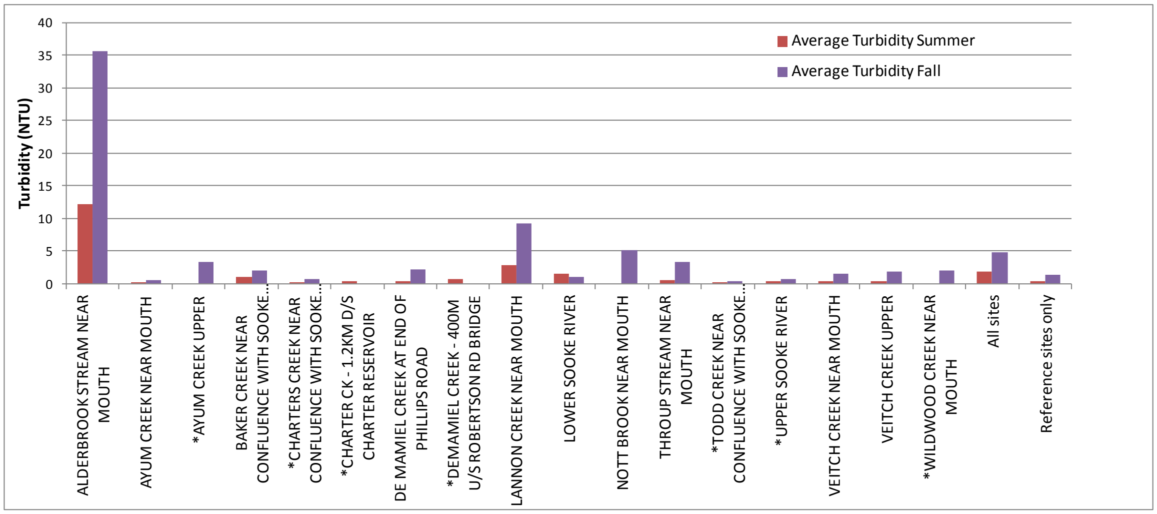


Figure 16. Average 2009 summer and fall turbidity levels from grab samples taken at all Sooke sample sites. Sites with an asterisk are considered to be reference sites.

Water quality objectives can be developed using a background concentration approach, where the mean summer and fall turbidity (1 NTU or less, as measured in the lower Sooke watersheds) at reference condition sites is used to calculate the water quality objective as per the guideline. To protect drinking water quality at domestic intakes in the lower watersheds only (not the GVWSA, as it is strictly protected and managed by the CRD) a water quality objective for turbidity is proposed. ***It is recommended that from October to December (when turbid flows can occur) turbidity at any drinking water intake in the lower Sooke watersheds should not exceed a maximum of 5.0 NTU at any time; during the remainder of the year (clear flow periods), turbidity should not exceed 2.0 NTU (1 NTU above ambient levels, as measured in the Sooke watersheds). To align with VIHA criteria, turbidity at any intake in the watershed should be <1 NTU 95% of the time.*** An alternative to the objective of 2 NTU would be to treat the raw water prior to disinfection to remove some of the turbidity and increase treatment efficiency.

6.3 TOTAL SUSPENDED SOLIDS

Total suspended solids (TSS), or non-filterable residue (NFR), include all of the undissolved particulate matter in a sample. This value should be closely correlated with the turbidity value, however, unlike turbidity, it is not an optical measurement. Instead, a quantity of the sample is filtered, and the residue is dried and weighed so that a weight of residue per volume is determined. No guideline has been established for drinking water sources at this time. For the protection of aquatic life, the maximum concentration allowed is an induced TSS concentration over background of 25 mg/L at any one time in 24 hours when background is less than or equal to 25 mg/L (clear flows) and an induced TSS concentration of 5 mg/L over background concentrations at any one time for a duration of 30 days (clear flows). Initially, less frequent monitoring may be appropriate to determine the need for more extensive monitoring (Caux *et al.* 1997).

Sooke Watersheds

Concentrations of total suspended solids were only measured on September 9, 2009 and only at the four sites sampled for benthic invertebrates. All values were below detectable limits (< 1 mg/L) (three samples at four sites, three of which were considered background).

As background data are limited, no objective is proposed for TSS at this time. However, given that turbidity in some of the watersheds can be elevated, TSS should be included in future attainment monitoring to obtain a better understanding of trends. To determine average levels, a minimum of five weekly samples within 30 days should be collected in both summer and fall in future sampling. Means of five weekly samples in 30 days should be used (rather than maximum values of 30 samples in a 30 day period, as recommended in the guideline) considering the practicality of, and resources available for, monitoring, as well as local hydrology and the fact that Vancouver Island streams have clear flows for most of the year.

6.4 COLOUR AND TOTAL ORGANIC CARBON

Colour in water is caused by dissolved and particulate organic and inorganic matter. True colour is a measure of the dissolved colour in water after the particulate matter has been removed, while apparent colour is a measure of the dissolved and particulate matter in water. Colour can affect the aesthetic acceptability of drinking water, and the aesthetic water quality guideline is a maximum of 15 true colour units (TCU) (Moore and Caux, 1997). Colour is also an indicator of the amount of organic matter in water. When organic matter is chlorinated it can produce disinfection by-products such as trihalomethanes (THMs), which may pose a risk to human health.

Sooke Watersheds

Colour was only measured on September 9, 2009 and only at the four sites sampled for benthic invertebrates (Appendix IV). Values ranged from <5 TCU at the Upper Sooke River site to 15 TCU at the Demamiel Creek 400 m upstream Robertson Rd bridge. The average value was 7.5 TCU. This measurement was below the provincial guideline; however, Demamiel Creek results suggest that occasional high colour levels are observed in this ecoregion. While the source of this colour is likely natural processes within the watershed, it can be exacerbated by anthropogenic activities.

As background data are limited, no objective is proposed for colour at this time; however, this parameter should be included in future attainment monitoring to obtain a better understanding of trends. If colour levels are found to be consistently high during some periods of the year, THMs should also be measured in the finished water (after chlorination) to determine if disinfection byproducts (DBP) are a concern.

Elevated total organic carbon (TOC) levels (above 4.0 mg/L) can result in higher levels of THMs in finished drinking water if chlorination is used to disinfect the water (Moore, 1998). It is not known what types of disinfection, if any, are used for the many domestic intake licenses in the lower Sooke watersheds. During the study period, TOC concentrations were measured only on September 9, 2009 and only at the four sites sampled for benthic invertebrates (Appendix IV). Values ranged from 2.7 to 8.9 mg/L (at Charter Creek 1.2 km downstream of Charter reservoir) with an average of 4.3 mg/L.

Some of these levels may be natural, but more background data are needed to understand trends in TOC in the Sooke watersheds. ***Thus, no objective is proposed for TOC at this time*** and it is recommended that TOC be included in attainment monitoring.

6.5 NUTRIENTS (NITRATE, NITRITE AND PHOSPHORUS)

The concentrations of nitrogen (including nitrate and nitrite) and phosphorus are important parameters, since they tend to be the limiting nutrients in biological systems. Productivity is therefore directly proportional to the availability of these parameters. Nitrogen is usually the limiting nutrient in terrestrial systems, while phosphorus tends to be the limiting factor in freshwater aquatic systems. In watersheds where drinking water is a priority, it is desirable that nutrient levels in surface water remain low to avoid algal blooms and foul tasting water. Similarly, to protect aquatic life, nutrient levels should not be too high or the resulting plant and algal growth can deplete oxygen levels when it dies and begins to decompose, as well as during periods of low productivity when plants consume oxygen (*i.e*., at night and during the winter under ice cover).

The guideline for the maximum concentration for nitrate in drinking water is 10 mg/L as nitrogen and the guideline for nitrite is a maximum of 1 mg/L as nitrogen. When both nitrate and nitrite are present, their combined concentration must not exceed 10 mg /L as N. For the protection of freshwater aquatic life, the nitrate guidelines are a maximum concentration of 31.3 mg/L and an average concentration of 3 mg/L. Nitrite concentrations are dependent on chloride; in low chloride waters (*i.e*., less than 2 mg/L) the maximum concentration of nitrite is 0.06 mg/L and the average concentration is 0.02 mg/L. Allowable concentrations of nitrite increase with ambient concentrations of chloride (Meays, 2009).

Sooke Watersheds

Nitrogen concentrations were measured in terms of dissolved nitrite (NO_2) and dissolved nitrate (NO_3). Dissolved nitrate concentrations for all sample sites (including 1999-2000 data from Demamiel Creek) ranged from 0.12 mg/L to a maximum of 0.98 mg/L (at Ayum Creek at mouth) as N for 7 samples, with an average of 0.33 mg/L. Concentrations of total nitrite were consistently low, with almost half of the 7 measured values below detectable limits (< 0.002 mg/L) and a maximum of only 0.005 mg/L. All values of both nitrate and nitrite species were well below the existing aquatic life guidelines (Appendix IV). For these reasons, no objective is proposed for this parameter.

The BC ENV has proposed a phosphorus objective for Vancouver Island. This objective takes into consideration the fact that elevated phosphorus is primarily a concern during the summer low flow period when elevated nutrient levels are most likely to lead to deterioration in aquatic life habitat and aesthetic problems. The proposed total phosphorus objective applies from May to September and is an average of 0.005 mg/L and a maximum of 0.010 mg/L, based on a minimum of five monthly samples (BCMOE, *in press*).

Summary statistics for all total phosphorus data are in Appendix IV. Considering just May to September data, samples in 2009 were not collected each month to enable direct comparison to the average objective but instead were collected weekly for 5 weeks from mid-August to mid-September. These summer low flow data are presented to show watershed trends. Total phosphorus concentrations ranged from below detectable limits (< 0.002 mg/L) to a maximum of 0.065 mg/L (Lower Sooke River on August 19, 2009) with an average of 0.010 mg/L for 59 values (Figure 17). The next highest value (below the maximum observed of 0.065 mg/L) in the Lower Sooke River was 0.006 mg/L, and the next highest maximum value at all sites was 0.036 mg/L at Alderbrook Stream near mouth. This suggests such a high value in the Lower Sooke River may not be typical; however, in this case it was associated with higher microbiological counts. If considering just the reference sites, the maximum was 0.006 mg/L and the average was 0.004 mg/L, below the phosphorous objective for Vancouver Island. All data were collected in the summer when solar inputs were at their highest, therefore the higher than objective values at non-reference sites are a concern. As watersheds with the most development have the highest phosphorous values (Alderbrook, Baker, Lannon,and Lower Sooke) it is likely that the higher values are related to inputs from rural and urban development. Higher average phosphorous values are usually associated with higher average turbidity values (Figure 17). For these reasons, ***a water quality objective for total phosphorous is proposed. The objective is that the May through September (based on a minimum of five monthly samples) average total phosphorous at any location in the lower Sooke Watersheds should not exceed 0.005 mg/L and maximum values should not exceed 0.010 mg/L.***

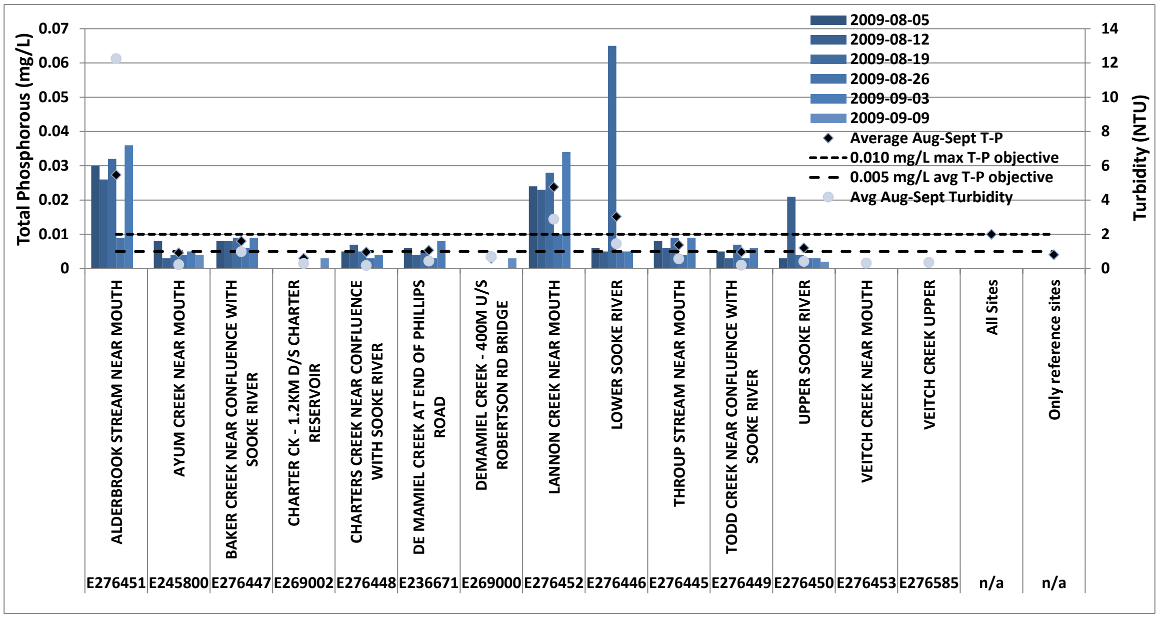


Figure 17. Summer low flow (Aug-Sept) 2009 maximum and average total phosphorous values and average turbidity in the Sooke watersheds.

6.6 METALS

Sooke Inlet/Harbour/Basin

Marine total metals data collected at 9 sites on August 7, 2008 (Appendix III) showed a few metals observations were worth noting. Total boron ranged from 3620 to 3880 ug/L while the aquatic life guidelines specifies 1200 ug/L. Though in exceedence of marine guidelines, these values are typical for Canadian coastal marine waters (Health Canada 1990). Total cadmium ranged from 0.12 to 0.19 ug/L while the working aquatic life guideline specifies a maximum of 0.12 ug/L. Cadmium levels may be naturally slightly elevated for this area as there is not much variation in values between sites, but more data should be collected to find reference cadmium levels and determine if the values observed in the inlet, harbour and basin are a problem. Total copper and total iron show more variability from site to site; copper ranged from <0.5 ug/L to1.1 ug/L (at SO-5, the site directly across from where the Sooke River enters the basin) while the maximum marine aquatic life guideline for total copper is 3 ug/L and the 30 day average is 2ug/L. Total iron ranged from 4 to 45 ug/L (at SO-5) with highest levels at SO-5. There is no marine guideline for total iron, but there appear to be inputs at five of the sites (SO-5, SO-15, SO-22, SO-23, SO-24), notably higher than the other sites sampled, that should not be ignored. Generally, the sites near the output of the Sooke River, Goodridge Peninsula and along the north side of Sooke Harbour where most of the population lives tend to have the highest metals levels.

Sampling done by the CRD has found metals in storm drain and creek sediments in the populated areas of Sooke (Cameron and Green, 2007; CRD, 2008; CRD, 2010; CRD, 2011; CRD, 2012; CRD, 2013); though these data are not representative of loadings to the marine environment via dissolved metals or particulates carried by stormwater flows, they do show that metals inputs from populated areas are occurring. Metals inputs are also potentially occurring from docks (Cross, 1996). Data from this study have found elevated fall flush microbiological results and likehood of additional contaminants associated with rainwater runoff. Considering the above data and information, fall metals sampling should be included in future marine monitoring. Background marine metals levels should also be established.

Sooke Watersheds

Total and dissolved metals concentrations in 2009 were measured in the fall only in the Sooke watersheds, with the exception of the four benthic invertebrate sites, where total metals were collected only on September 9, 2009. The concentrations of most metals were below detection limits, and well below guidelines for drinking water and aquatic life. The exceptions were aluminum, copper and zinc.

Guideline levels for these metals are quite low because they are hardness-dependent (higher hardness levels may ameliorate the toxicity of some metals) and water in the Sooke watersheds is very soft, with hardness levels between 8 mg/L and 22 mg/L $CaCO_3$ at reference sites. Considering background conditions, a hardness of 22 mg/L $CaCO_3$ was used to calculate all guidelines requiring hardness values. Average fall 2009 five weekly samples in 30 days hardness values of 22 mg/L to 66 mg/L were observed at Alderbrook, Baker, Lannon, Nott and Throup sites. These results support that anthropogenic influences occur at these sites.

The provincial guideline for dissolved aluminum is a maximum of 0.1 mg/L for aquatic life or a maximum of 0.2 mg/L for drinking water and an average of 0.05 mg/L for aquatic life. Dissolved aluminum was measured 60 times in the Sooke watersheds, with values ranging from 0.0175 mg/L to a maximum of 0.2 mg/L (Nott Brook on October 26, 2009) with an all site average of 0.08 mg/L (Figure 18); when considering fall data from reference sites only the five weekly samples in 30 days average was 0.07 mg/L. This suggests that aluminum levels above the average guideline are a result of the natural geology of the area in this area, which is typical on some areas of Vancouver Island (Barlak *et al*,. 2010). The 95th percentile of all fall reference site values was 0.09 mg/L, lower than the maximum guideline value of 0.1 mg/L. Eleven results exceeded the maximum aquatic life guideline, while none exceeded the drinking water guideline. With the exception of one sample in Todd Creek (0.011 mg/L) during a rainstorm even on October 26, 2009, all sites at which the maximum was exceeded were not considered to be in reference condition. Dissolved aluminum averages of a minimum of five weekly samples within 30 days (fall only) at all sites sampled for dissolved metals exceeded the aquatic life guideline of 0.05 mg/L (Table 9). The elevated concentrations of dissolved aluminum in most the Sooke watersheds are almost certainly a result of the natural geography of the area rather than any anthropogenic activities. However, when combined with anthropogenic soil disturbances and development, these naturally high values may lead to values elevated above acceptable levels and thus be a cause for concern. Average dissolved aluminum at the Alderbrook (0.14 mg/L) and Nott Brook (0.13 mg/L) sites were markedly higher than the other sites. As a better understanding of metals in the watersheds is needed, ***no dissolved aluminum objective is proposed for the Sooke watersheds*** at this time, and it is recommended that five weekly samples in 30 days metals data should be collected during the fall flush (Oct-Nov).

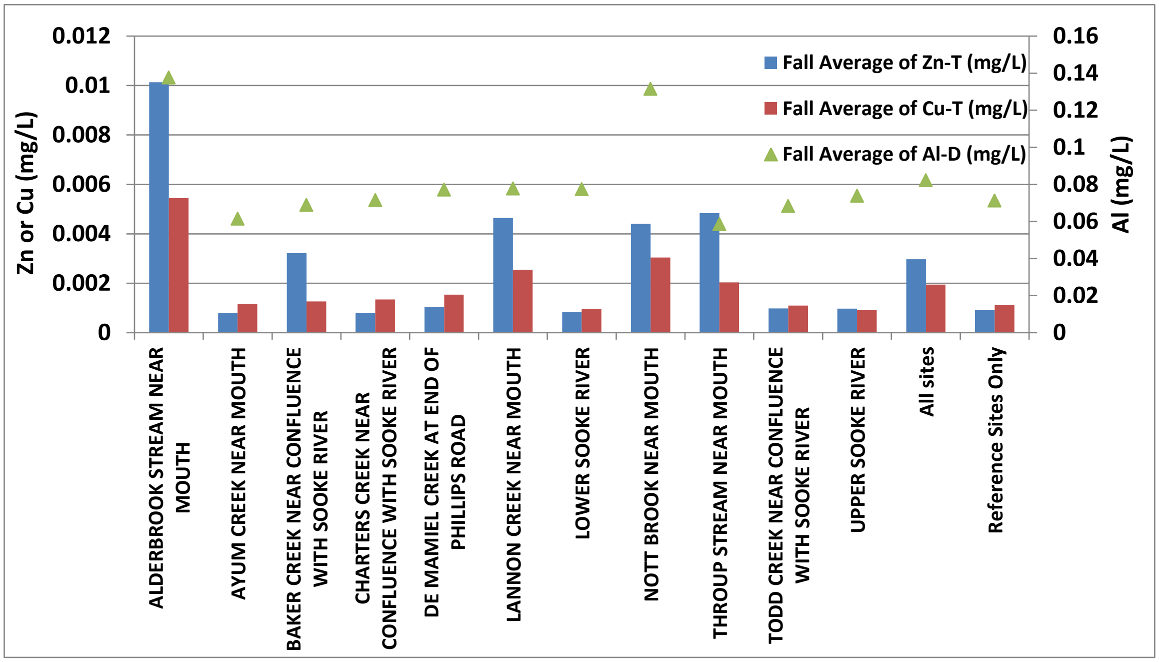


Figure 18. Average fall zinc, copper and aluminum levels in the Sooke watersheds.

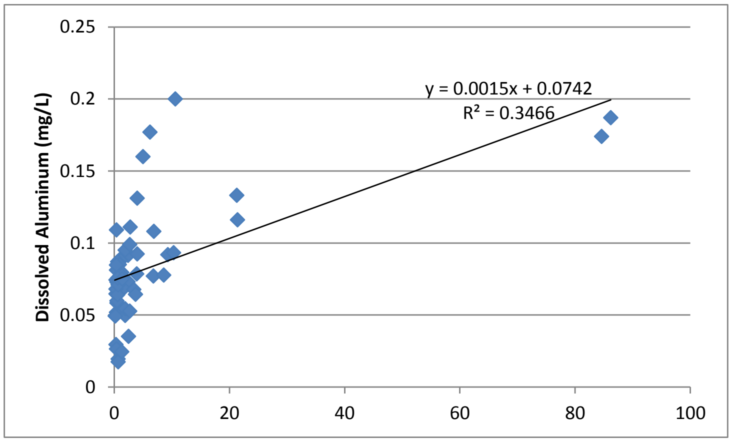
Table 9. Fall 2009 five weekly samples in 30 days averages for zinc, copper and aluminum levels in the Sooke watersheds. Bold indicates exceedences of average water quality guidelines. * indicates reference site.

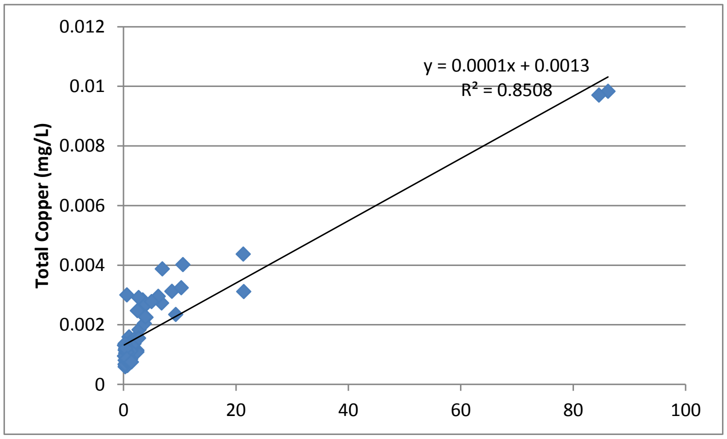
EMS ID	LOCATION NAME	Al-D (mg/L)	Cu-T (mg/L)	Hardness (mg/L)	Zn-T (mg/L)
E276451	ALDERBROOK STREAM NEAR MOUTH	**0.138**	**0.0055**	66	**0.0101**
E245800	AYUM CREEK NEAR MOUTH	**0.062**	0.0012	19	0.0008
E276447	BAKER CREEK NEAR CONFLUENCE WITH SOOKE RIVER	**0.069**	0.0013	25	0.0032
E276448	*CHARTERS CREEK NEAR CONFLUENCE WITH SOOKE RIVER	**0.072**	0.0013	13	0.0008
E236671	DE MAMIEL CREEK AT END OF PHILLIPS ROAD	**0.077**	0.0015	14	0.0010
E276452	LANNON CREEK NEAR MOUTH	**0.078**	**0.0025**	42	0.0046
E276446	LOWER SOOKE RIVER	**0.077**	0.0010	20	0.0008
E276444	NOTT BROOK NEAR MOUTH	**0.132**	**0.0030**	56	0.0044
E276445	THROUP STREAM NEAR MOUTH	**0.059**	**0.0020**	60	0.0048
E276449	*TODD CREEK NEAR CONFLUENCE WITH SOOKE RIVER	**0.068**	0.0011	13	0.0010
E276450	*UPPER SOOKE RIVER	**0.074**	0.0009	10	0.0010
n/a	*Reference sites only	**0.071**	0.0011	12	0.0009

Total copper levels ranged from 0.0005 mg/L to 0.009 mg/L (Alderbrook on November 9, 2009) with an average of 0.0019 mg/L for all sites sampled (64 samples); considering fall data from reference sites only the five weekly samples in 30 day average was 0.0011 mg/L (Figure 18, Table 9). Average fall copper values at Alderbrook (0.0054 mg/L), Lannon (0.0025 mg/L), Nott (0.003 mg/L) and Throup (0.002 mg/L) sites were at or in exceedence of the average aquatic life guideline for copper of 0.002 mg/L. Four samples exceeded the maximum aquatic life guideline for copper (0.004 mg/L); three of these were at the Alderbrook site and the other was at the Nott Brook site. As a better understanding of metals in the watersheds is needed, ***no total copper objective is proposed for the Sooke watersheds*** at this time, and it is recommended that five weekly samples in 30 days metals data should be collected during the fall flush (Oct-Nov).

Total zinc ranged from 0.0003 mg/L to 0.0146 mg/L with an average of 0.0028 mg/L for all sites (64 samples); considering only fall data for reference sites, the five weekly samples in 30 days average was 0.0009 mg/L (Figure 18, Table 9). Though the maximum aquatic life guideline (0.033 mg/L) for zinc was not exceeded in any of the samples, average fall total zinc levels at Alderbrook were higher than the average aquatic life guideline for zinc of 0.0075 mg/L. Also, noteably higher than background (but not in exceedence) total zinc values were observed at Baker, Lannon, Nott and Throup sites. As a better understanding of metals in the watersheds is needed, ***no total zinc objective is proposed for the Sooke watersheds*** at this time, and it is recommended that five weekly samples in 30 days metals data should be collected during the fall flush (Oct-Nov).

Nearly all elevated concentrations of metals occurred after rainfall events and appeared to be associated with elevated turbidity (Figures 19-21).





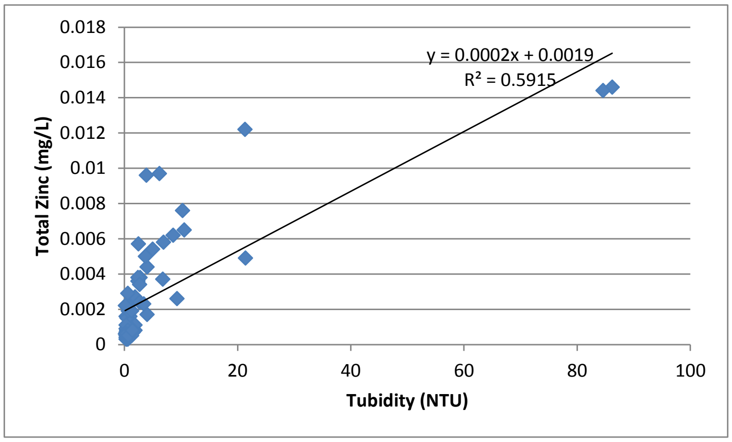


Figure 19, 20, and 21 - Individual fall 2009 aluminum, copper, zinc and levels plotted with turbidity in the Sooke watersheds.

Metal speciation determines the biologically available portion of the total metal concentration. Only a portion of the total metals level is in a form which can be toxic to aquatic life. Naturally occurring organics in the watershed can bind substantial proportions of the metals which are present, forming metal complexes that are not biologically available. The relationship will vary seasonally, depending upon the metal (*e.g.* copper has the highest affinity for binding sites in humic materials). Levels of organics as measured by dissolved organic carbon (DOC) vary from ecoregion to ecoregion. To aid in future development of metals objectives, DOC has been included in the Sooke watershed monitoring program. As increasing water hardness can decrease the toxicity of copper and some other metals to some organisms, hardness has also been included in the Sooke watershed monitoring program.

6.7 MICROBIOLOGICAL INDICATORS

The microbiological quality of marine waters used for recreating and harvesting of seafood, as well as freshwaters used for drinking and recreating, is imperative, as contamination of these systems can result in high risks to human health, as well as significant economic losses due to closure of beaches and shellfish harvesting areas (Scott *et al*., 2002). Water contaminated with human feces is generally regarded as a greater risk to human health, as the water is more likely to contain human-specific enteric pathogens, including *Salmonella enterica*, *Shigella* spp., Hepatitis A virus, and Norwalk-group viruses. The direct measurement and monitoring of pathogens in water, however, is difficult due to their low numbers, intermittent and generally unpredictable occurrence, and specific growth requirements (Krewski *et al*., 2004; Ishii and Sadowsky, 2008). To assess health risks, resource managers commonly measure fecal indicator bacteria levels (Field and Samadpour, 2007; Ishii and Sadowsky, 2008), whose presence is used to indicate the fecal contamination of water.

There are a number of characteristics that suitable indicator organisms should possess. They should be present in the intestinal tracts of warm-blooded animals, not multiply outside the animal host, be nonpathogenic and have similar survival characteristics to the pathogens of concern. They should also be strongly associated with the presence of pathogenic microorganisms, be present only in contaminated samples and be detectable and quantifiable by easy, rapid, and inexpensive methods (Scott *et al*., 2002; Field and Samadpour, 2007; Ishii and Sadowsky, 2008). The most commonly used indicator organisms for assessing the microbiological quality of water are the total coliforms, fecal coliforms (a subgroup of the total coliforms more appropriately termed thermotolerant coliforms as they can grow at elevated temperatures), *E. coli*, a thermotolerant coliform considered to be specifically of fecal origin (Edberg *et al*., 2000; Kloot *et al*., 2006), and enterococcus, a subgroup of the fecal streptococci, normally found in the gastrointestical tract of warm-blooded animals (Yates, 2007).

Fecal coliforms have been used extensively for many years as indicators for determining the sanitary quality of surface, recreational, and shellfish growing waters. However, research in recent years has shown there are many differences between the coliforms and the pathogenic microorganisms they are a surrogate for, which limits the use of coliforms as an indicator of fecal contamination (Scott *et al*., 2002). For example, many pathogens, such as enteric viruses and parasites, are not as easily inactivated by water and wastewater treatment processes as coliforms are. As a result, disease outbreaks do occur when indicator bacteria counts are at acceptable levels (Yates, 2007; Haack *et al*., 2009). Additionally, some members of the coliform group, such as *Klebsiella*, can originate from non-fecal sources (Ishii and Sadowsky, 2008) adding a level of uncertainty when analyzing data. Waters contaminated with human feces are generally regarded as a greater risk to human health, as they are more likely to contain human-specific enteric pathogens (Scott *et al*., 2002). Measurement of total and fecal coliforms does not indicate the source of contamination, which can make the actual risk to human health uncertain; thus it is not always clear where to direct management efforts. Therefore, additional microbes such as *E. coli* and enterococci have been suggested for use as alternative indicators (Griffin *et al*., 2001). Studies have shown that *E. coli* is the main thermotolerant coliform species present in human and animal fecal samples (94%) (Tallon *et al*., 2005) and at contaminated bathing beaches (80%) (*Davis et al.*, 2005). Enterococci are considered especially reliable as indicators of health risk in marine environments (Cabelli, 1983).

It should be noted that Environment Canada still bases their shellfish harvesting designations on fecal coliform measurements. The monitoring programs of the BC ENV have traditionally measured total coliforms, fecal coliforms, *E. coli* and enterococci, either alone or in combination, depending on the specific program. In cases where fecal coliform counts were greater than *E. coli*, we can assume a high likelihood of contributions from non-fecal sources. Thus, the value added benefit of measuring both groups is limited. Given the uncertainty in linking thermotolerant (*i.e.* fecal) coliforms to human sources of sewage, this study uses *E. coli* as the microbiological indicator for Sooke watersheds and enterococci as the microbiological indicator for Sooke Inlet, Harbour and Basin.

The BC ENV water quality guidelines were used to assess water quality in Sooke Watersheds and Inlet, Harbour and Basin based on the designated use of the water, *i.e.*, drinking water, aquatic life – shellfish harvesting, and recreation (both primary and secondary contact) (Warrington, 1988; Warrington, 2010) (See Table 10). Primary contact refers to direct contact with water over most of the body's surface, to the point of complete submergence, or where there is substantial risk of ingestion or intimate contact with eyes, ears, nose, mouth or groin, such as swimming and scuba diving. Secondary contact refers to an activity where a person would have very limited direct contact with the water, usually only the feet and hands, and little risk of complete immersion, such as boating, kayaking, canoeing, and fishing. These water quality guidelines are set at levels intended to prevent health problems in healthy adults. Children, seniors and domestic animals may be more susceptible to illness. As small pieces of fecal matter in a sample can skew the overall results for a particular site, the 90th percentiles (for drinking water and aquatic life-shellfish harvesting), median (aquatic life – shellfish harvesting) and geometric means (for recreation) are used to determine if the water quality guideline is exceeded, as extreme values would have less effect on the data.

It should be noted that when Island Health posts primary contact recreation advisories to the public, they use Health Canada sourced microbiological guidelines (for enterococci in marine waters: geometric mean ≤ 35CFU /100mL or single sample maximum ≤ 70 CFU/100mL; for *E. coli* in freshwater: geometric mean ≤ 200 CFU /100mL or single sample ≤ 400 CFU/100mL). These are more sensitive than BC ENV water quality guidelines (Table 10).

Table 10. The BC ENV water quality guidelines for microbiological indicators (colony forming units (CFU)/100 mL) (Warrington, 1988)**.** Medians, geometric means and 90th percentiles are calculated from at least five samples in a 30-day period.

Water Use	*E. coli (freshwater only)*	Enterococci	Fecal coliforms
Raw Drinking Water - disinfection only	less than or equal to 10/100 mL 90th percentile	less than or equal to 3/100 mL 90th percentile	less than or equal to 10/100 mL 90th percentile
Aquatic Life - shellfish harvesting	less than or equal to 43/100 mL 90th percentile	less than or equal to 11/100 mL 90th percentile	less than or equal to 43/100 mL 90th percentile
Aquatic Life - shellfish harvesting	less than or equal to 14/100 mL median	less than or equal to 4/100 mL median	less than or equal to 14/100 mL median
Recreation - secondary contact - crustacean harvesting	less than or equal to 385/100 mL geometric mean	less than or equal to 100/100 mL geometric mean	None applicable
Recreation - primary contact	less than or equal to 77/100 mL geometric mean	less than or equal to 20/100 mL geometric mean	less than or equal to 200/100 mL geometric mean

Note that though the guidelines are given in colony forming units (CFU)/100mL, marine bacteriological samples were analyzed and reported as most probable number (MPN) while fresh water samples were analyzed using membrane filtration (MF) which gives results in CFU/100mL. These two different procedures do not give strictly comparable results, but the confidence limits at low coliform levels do overlap (Warrington, 1988).

6.7.1 Sooke Watersheds - Fecal coliforms and *E. coli*

To represent the worst case scenario, bacteriological samples were only collected during summer low flow and fall flush periods. For all freshwater data (including 36 samples from1999-2000) fecal coliform concentrations were measured 181 times in the Sooke watersheds, with values ranging from below detection limits (<1 CFU/100 mL) to a maximum of 1400 CFU/100 mL (Throup Stream near mouth on September 3, 2009) (Appendix IV). The 90th percentiles of five weekly samples in a 30 day period ranged from 9 CFU/100 mL (summer 2009 in Todd Creek) to 1200 CFU/100 mL (Fall 2009 at Baker Creek site) (Figure 22). The geometric means of five weekly samples in a 30 day period ranged from 5 CFU/100 mL (summer and fall 2009 in Todd Creek) to 335 CFU/100 mL (Fall 2009 at Lannon Creek site) (Figure 23). Fecal coliform 90th percentiles tended to be highest during the fall sampling period with the exception of at

Alderbrook, Lannon, Lower Sooke River and Throup sites, where they were highest in the summer. Geometric means also tended to be highest in fall, with the exception of Lower Sooke River and Throup sites. Fecal coliform guideline exceedences are discussed at the end of this section.

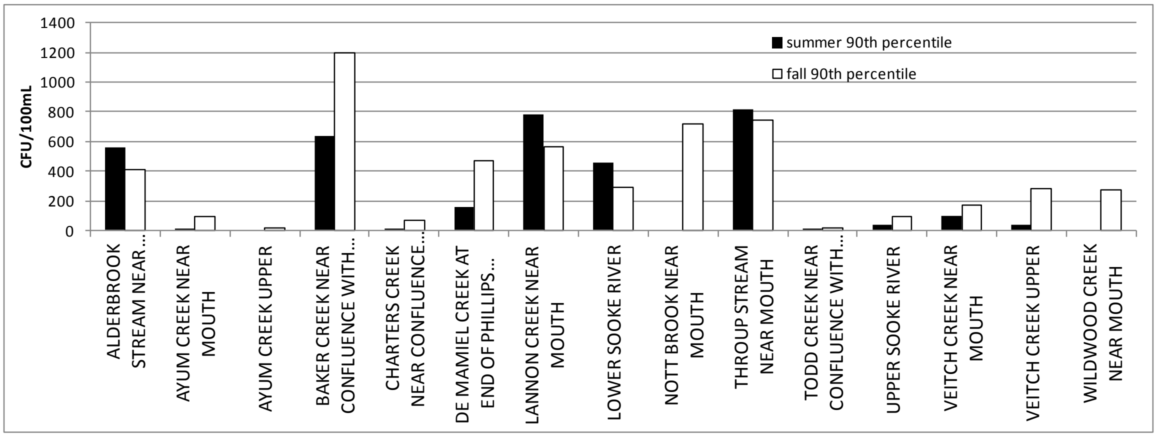


Figure 22. Fecal coliform 90th percentiles at all Sooke watersheds sampled in 2009. The drinking water guideline is < =10 CFU/100 mL, while the shellfish harvesting guideline is <=43 CFU/100mL..

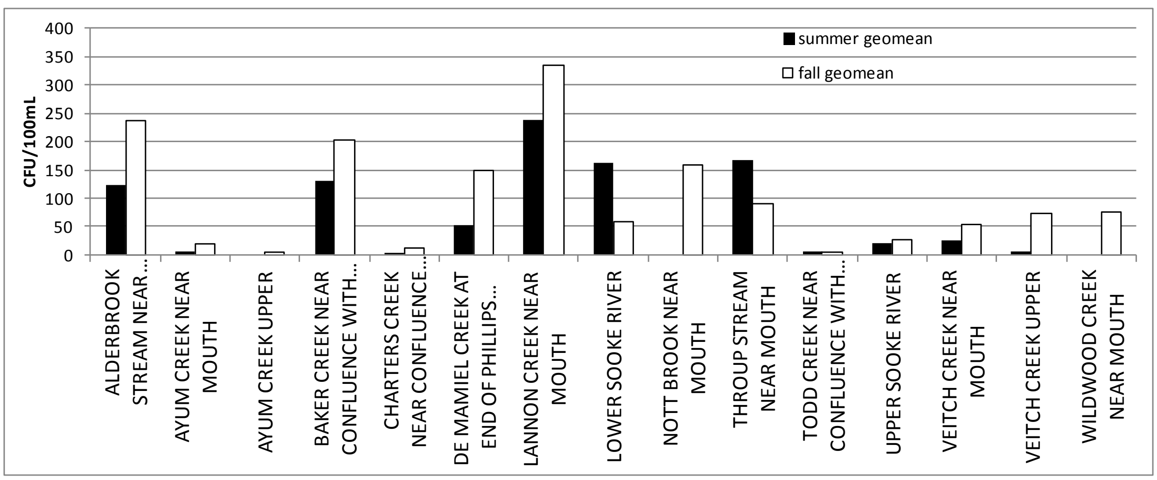


Figure 23. Fecal coliform geometric means at all Sooke watersheds sampled in 2009. The primary contact recreation guideline is < =200 CFU/100 mL.

E. coli concentrations ranged from below detection limits (< 1 CFU/100 mL) (Ayum Creek near mouth August 26, 2009) to 1300 CFU/100 mL (Lannon Creek near mouth, on September 3, 2009) for 157 samples (17 of which were from 1999-2000). When the requisite sampling frequency was met (at least five weekly samples in 30 days), the 90th

percentiles ranged from 7 CFU/100 mL (Todd Creek site, summer 2009) to 1160 CFU/100 mL (Baker Creek site, fall 2009) (Figure 24); geometric means ranged from 3 CFU/100 mL (Upper Ayum Creek, fall 2009) to 243 CFU/100 mL (Lannon Creek site, fall 2009) (Figure 25). As with fecal coliforms, the highest 90th percentile values were seen in the fall, with the exception of Alderbrook, Lannon and Lower Sooke River sites which had higher summer 90th percentile values. Geometric means were also highest in the fall, with the exception of Lower Sooke River and Throup sites. Only three sites considered to be in reference condition were monitored for *E.coli* in the summer and only four in the fall; one of these, the Upper Sooke River above the Sooke potholes, may get summer recreational activity and therefore may not be suitable as a reference site for this parameter in summer; another, Wildwood Creek, is downhill from a popular walking trail and may not be suitable as a reference site for this parameter. Of the two remaining reference sites with summer data, the *E. coli* 90th percentile values were 7 and 13 CFU/100mLwith an 90th percentile mean of 10 CFU/100 mL; at the three remaining reference sites with fall data the 90th percentiles ranged from 10 to 60 CFU/100 mL with a 90th percentile mean of 40 CFU/100 mL.

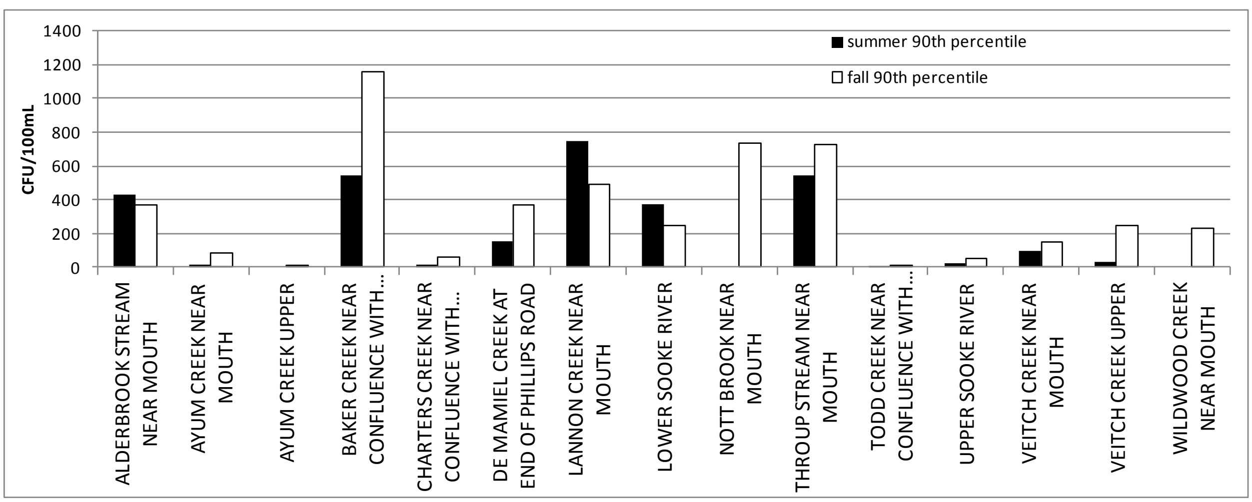


Figure 24. *E. coli* 90th percentiles at all Sooke watersheds sampled in 2009. The drinking water guideline is < =10 CFU/100 mL, while the shellfish harvesting guideline is <=43 CFU/100mL.

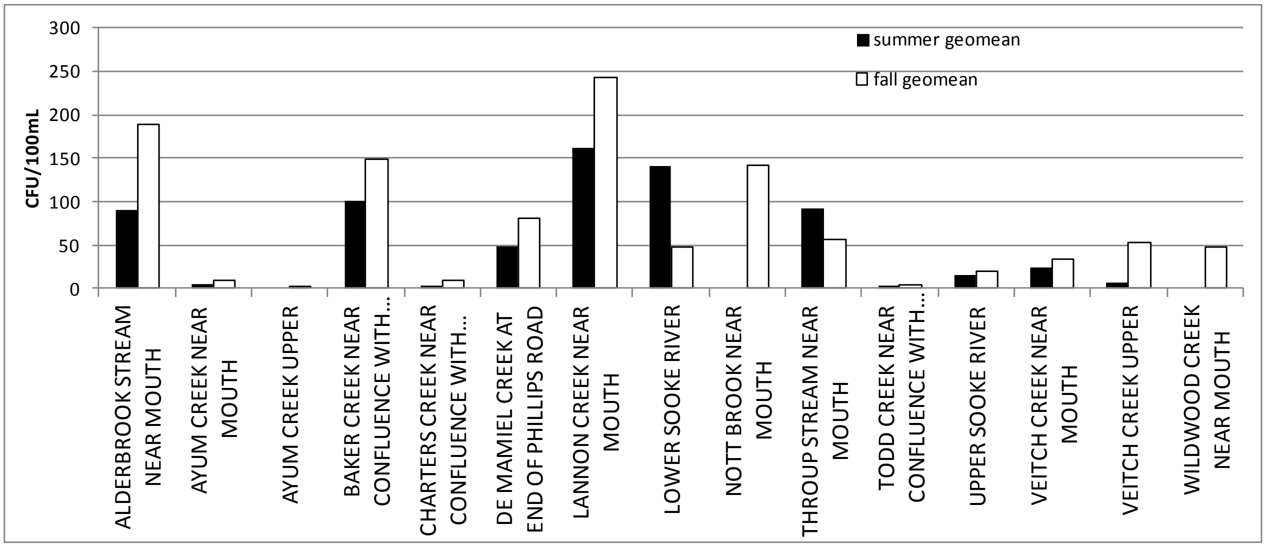


Figure 25. *E. coli* geometric means at all Sooke watersheds sampled in 2009. The primary contact recreation guideline is < =77 CFU/100 mL.

Overall the range of values for both fecal coliforms and *E. coli* were similar, however, in general, fecal coliform concentrations tended to be slightly higher than *E. coli* concentrations, likely due to the contribution of coliforms from non-fecal sources.

When comparing to BC water quality guidelines (Table 10), 2009 fecal coliform and *E.coli* 90^{th} percentiles exceeded the drinking water guideline of <10 CFU/100 mL at all but one (Todd Creek site summer only) site in the summer and fall, and exceeded the shellfish harvesting guideline of <43 CFU/100 mL at seven (Alderbrook, Baker, DeMamiel, Lannon, Lower Sooke, Throup and Veitch sites) of 12 sites sampled in the summer and 13 of 15 sites (only Todd and Ayum Creek Upper sites were not in exceedence) sampled in the fall (Table 11).

As bivalves are filter feeders and concentrate pathogens, the concentration of coliforms in the meat on a per 100 g basis can be expected to be 10 to 100 times the concentration in 100 mL of the water in which they grow (Warrington, 1988). For this reason, the quality of growing waters must be very high. Currently, there are no water quality shellfish harvesting guidelines for fresh water environments. While shellfish harvesting is not occurring in the freshwater environments, the shellfish harvesting guidelines were applied to the freshwater inputs as they are potential sources of fecal contamination into Sooke

Inlet, Harbour and Basin. The shellfish harvesting guideline of a median of <14 CFU/100mL was exceeded for both parameters at eight of 12 sites in the summer (only Ayum near mouth, Charters, Todd and Veitch Upper sites were not in exceedence) and 11 of 15 sites sampled in fall (only Ayum at mouth, Ayum upper, Charters and Todd sites were not in exceedence). This illustrates the potential for upland sources to contribute to fecal contamination in the marine environment. Sampling done by the CRD has also found microbiological inputs from populated areas (Cameron and Green, 2007; CRD, 2008; CRD, 2010; CRD, 2011; CRD, 2012; CRD, 2013).

Finally, the primary contact guideline of a geometric mean of <77 CFU/100 mL for *E.coli* was exceeded at five (Alderbrook, Baker, Lannon, Lower Sooke and Throup sites) of 12 sites sampled in summer and five (Alderbrook, Baker, DeMamiel, Lannon and Nott sites) of 15 sites sampled in fall; the geometric mean of <200 CFU for fecal coliforms was exceeded at one site (Lannon) in summer and at three sites (Alderbrook, Baker and Lannon sites) in fall.

When considering only the 1999-2000 data (collected only at the Demamiel Creek site), the required sampling frequency of five weekly samples within a 30 day period was met for four such periods in samples from November 1999 - March 2000 (Table 12). The 90th percentiles exceeded the drinking water guideline of 10 CFU/100 mL in all fecal coliform and *E.coli* samples; and exceeded the shellfish harvesting guideline of 43 CFU/100 mL for both parameters in three of the four sample periods. The shellfish harvest guideline of a median of <14 CFU/100mL was also exceeded in three of four sample periods. Enterococci and streptococci were also collected. No guideline exists for streptococci, but for enterococci two of three sample periods exceeded the shellfish harvesting guideline of a 90th percentile of <11 CFU/100mL and the shellfish harvesting guideline of a median of <4 CFU/100mL; one of three sample periods exceed the primary contact recreational guideline of <20 CFU/100 mL.

Table 11. Summary of 90th percentile, geometric mean and median values for fecal coliforms (CFU/100ml) and *E. coli* (CFU/100ml) at Sooke watersheds in 2009, calculated based on a minimum of five samples collected within a 30-day period. Boldfaced and highlighted values are in exceedence of applicable values.

		SUMMER			**FALL**		
	Water Quality Guideline to meet (CFU/100mL)	<10 drinking water, <43 shellfish harvesting (underlined)	<77 primary contact (*E.coli*), <200 primary contact (fecal coliforms)	<14 shellfish harvesting	<10 drinking water, <43 shellfish harvesting (underlined)	<77 primary contact (*E.coli*), <200 primary contact (fecal coliforms)	<14 shellfish harvesting
Location	**Parameter**	**summer 90th percentile**	**summer geomean**	**summer median**	**fall 90th percentile**	**fall geomean**	**fall median**
ALDERBROOK STREAM NEAR MOUTH	*E. coli*	**430**	**90**	**130**	**372**	**190**	**320**
ALDERBROOK STREAM NEAR MOUTH	Fecal coliforms	**560**	124	**195**	**412**	**238**	**350**
AYUM CREEK NEAR MOUTH	*E. coli*	**14**	6	8	**82**	10	5
AYUM CREEK NEAR MOUTH	Fecal coliforms	**15**	6	8	**97**	19	9
AYUM CREEK UPPER	*E. coli*				**13**	3	2
AYUM CREEK UPPER	Fecal coliforms				**14**	6	5
BAKER CREEK NEAR CONFLUENCE WITH SOOKE RIVER	*E. coli*	**542**	**101**	**73**	**1160**	**150**	**52**
BAKER CREEK NEAR CONFLUENCE WITH SOOKE RIVER	Fecal coliforms	**638**	131	**97**	**1200**	**203**	**80**
CHARTERS CREEK NEAR CONFLUENCE WITH SOOKE RIVER	*E. coli*	**13**	4	3	**60**	9	6
CHARTERS CREEK NEAR CONFLUENCE WITH SOOKE RIVER	Fecal coliforms	**16**	4	4	**65**	12	7
DE MAMIEL CREEK AT END OF PHILLIPS ROAD	*E. coli*	**156**	49	**37**	**368**	**81**	**170**
DE MAMIEL CREEK AT END OF PHILLIPS ROAD	Fecal coliforms	**156**	52	**41**	**472**	148	**210**
LANNON CREEK NEAR MOUTH	*E. coli*	**750**	**162**	**115**	**490**	**243**	**330**
LANNON CREEK NEAR MOUTH	Fecal coliforms	**780**	**238**	**225**	**568**	**335**	**510**
LOWER SOOKE RIVER	*E. coli*	**370**	**141**	**147**	**250**	48	**23**
LOWER SOOKE RIVER	Fecal coliforms	**455**	162	**151**	**292**	59	**26**
NOTT BROOK NEAR MOUTH	*E. coli*				**736**	**142**	**170**
NOTT BROOK NEAR MOUTH	Fecal coliforms				**720**	159	**110**
THROUP STREAM NEAR MOUTH	*E. coli*	**548**	**93**	**70**	**724**	56	**54**
THROUP STREAM NEAR MOUTH	Fecal coliforms	**820**	168	**155**	**748**	91	**84**
TODD CREEK NEAR CONFLUENCE WITH SOOKE RIVER	*E. coli*	7	4	4	10	4	4
TODD CREEK NEAR CONFLUENCE WITH SOOKE RIVER	Fecal coliforms	9	5	4	**18**	5	4
UPPER SOOKE RIVER	*E. coli*	**27**	16	**15**	**56**	21	**20**
UPPER SOOKE RIVER	Fecal coliforms	**35**	21	**17**	**96**	26	**23**
VEITCH CREEK NEAR MOUTH	*E. coli*	**93**	25	**20**	**149**	35	**36**
VEITCH CREEK NEAR MOUTH	Fecal coliforms	**100**	26	**20**	**171**	54	**57**
VEITCH CREEK UPPER	*E. coli*	**35**	7	5	**244**	53	**23**
VEITCH CREEK UPPER	Fecal coliforms	**36**	7	5	**280**	74	**34**
WILDWOOD CREEK NEAR MOUTH	*E. coli*				**228**	48	**30**
WILDWOOD CREEK NEAR MOUTH	Fecal coliforms				**272**	76	**52**

Table 12. Summary of 90th percentile values for fecal coliforms (CFU/100ml) and *E. coli* (CFU/100ml) at Sooke watersheds in1999-2000, calculated with a minimum of five samples were collected within a 30-day period. Boldfaced and highlighted values are in exceedence of applicable values.

Water Quality Guideline to meet (CFU/100mL)	***E.coli*, fecal coliform**	<10 drinking water, <43 shellfish harvesting (underlined)	<77 primary contact (*E.coli*), <200 primary contact (fecal coliforms)	<14 shellfish harvesting	<10 drinking water, <43 shellfish harvesting (underlined)	<77 primary contact (*E.coli*), <200 primary contact (fecal coliforms)	<14 shellfish harvesting	<10 drinking water, <43 shellfish harvesting (underlined)	<77 primary contact (*E.coli*), <200 primary contact (fecal coliforms)	<14 shellfish harvesting	<10 drinking water, <43 shellfish harvesting (underlined)	<77 primary contact (*E.coli*), <200 primary contact (fecal coliforms)	<14 shellfish harvesting
	Enterococci	<11 shellfish harvesting	<20 primary contact	<4 shellfish harvesting				<11 shellfish harvesting	<20 primary contact	<4 shellfish harvesting	<11 shellfish harvesting	<20 primary contact	<4 shellfish harvesting
Location	**Parameter**	**fall 1999 90th percentile**	**fall 1999 geomean**	**fall 1999 median**	**spring 1999 90th percentile**	**spring 1999 geomean**	**spring 1999 median**	**winter 2000 Jan 90th percentile**	**winter 2000 Jan geomean**	**winter 2000 Jan median**	**winter 2000 Feb 90th percentile**	**winter 2000 Feb geomean**	**winter 2000 Feb median**
DE MAMIEL CREEK AT END OF PHILLIPS ROAD	*E. coli*							**<u>103</u>**	17	14	**27**	10	8
DE MAMIEL CREEK AT END OF PHILLIPS ROAD	Fecal coliforms	**<u>91</u>**	67	**62**	**<u>240</u>**	18	**23**	**<u>130</u>**	29	**44**	**30**	13	14
DE MAMIEL CREEK AT END OF PHILLIPS ROAD	Enterococci	**98**	**40**	**74**				**581**	19	**10**	6	3	2
DE MAMIEL CREEK AT END OF PHILLIPS ROAD	Streptococci							154	21	14	8	3	2

Clearly there are issues with microbiological contamination in the Sooke watersheds, particularly those in the lowermost developed parts of the watersheds immediately draining into the Sooke Basin, Inlet and Harbour. Individuals with water intakes in the lower watersheds should ensure proper treatment of water before drinking. The Sooke watersheds and stormwater flows (Cameron and Green, 2007; CRD, 2008; CRD, 2010; CRD, 2011; CRD, 2012; CRD, 2013) are contributors of microbiological contamination higher than the shellfish harvesting guidelines to the marine waters. For these reasons, ***a seasonal water quality objective is proposed for* E. coli *in the lower Sooke watersheds based on the 90th percentile mean of reference sites only. The objective is that the 90th percentile of a minimum of five weekly samples collected within a 30-day period from January-September must not exceed 10 CFU/100ml and during fall flush (October-December) must not exceed 40 CFU at any intake for* E. coli.** While the proposed fall objective is higher than the provincial guideline it does represent the natural variability within the study area with respect to bacteriological values. This highlights the need for water purveyors to provide adequate treatment prior to consumption. Meeting these objectives will provide protection from most pathogens but not from parasites such as *Cryptosporidium* or *Giardia.* Sampling for these pathogens falls under the auspices of the water purveyors.

Recreational water users need also use caution given primary contact recreation guideline exceedences, particularly at the lower Sooke River site; though these are likely only a risk in the warmer summer season, higher fall values should not be overlooked. ***Thus, to protect recreational and cultural uses as required by Island Health, the proposed objective for* E. coli *is that the geomentric mean of a minimum of five weekly samples collected within a 30-day period must not exceed 200 CFU/100mL and the single sample maximum value must not exceed 400 CFU/100mL.***

6.7.2 Sooke Inlet/Harbour/Basin - Fecal coliforms and Enterococci

Individual values for fecal coliforms at the marine sites ranged from below detectable limits (<2 MPN/100 mL) to a maximum of 1,600 MPN/100 mL (Appendix III). It should be noted that due to dangerous sampling conditions, SO-01 and SO-26 were only sampled four times in 30 days in the fall of 2008. The sample date missed coincided with a large storm event and all other sites had elevated values; likely, SO-1 and SO-26 would have as well. Though statistics for these two sites are presented in Figures 26-29, they should not be considered representative.

The geometric mean for all marine sites in 2008 ranged from 2 MPN/100 mL (at 18 of the sites in the summer) to 140 MPN/100 mL at SO-20 in the fall (Figure 26). SO-01 (control site) was consistently low in both sample periods, though as mentioned above, these data did not include one large storm event. While fecal coliform geometric means were elevated in both seasons in the north side of Sooke Inlet where most of the population is, and especially where the Sooke River enters the inlet, all sites met the fecal coliform primary recreation guideline of 200 CFU/100ml.

The marine fecal coliform median values ranged from 2 MPN/100 mL (at 21 sites in the summer) to 110 MPN/100 mL at SO-20 in the fall (Figure 27). When comparing the fecal coliform median values for all sites against the shellfish harvesting (aquatic life) guideline (<u><</u>14 CFU/100 ml) there were some exceedances (SO-20, SO-22 and SO-23 in the summer and SO-05 and SO-20 in the fall). Again, these exceedances tended to occur in the north side of Sooke Inlet where most of the population is, and especially where the Sooke River enters the inlet. For the same reasons discussed above, the median value for SO-1 and SO-26 should not be considered representative.

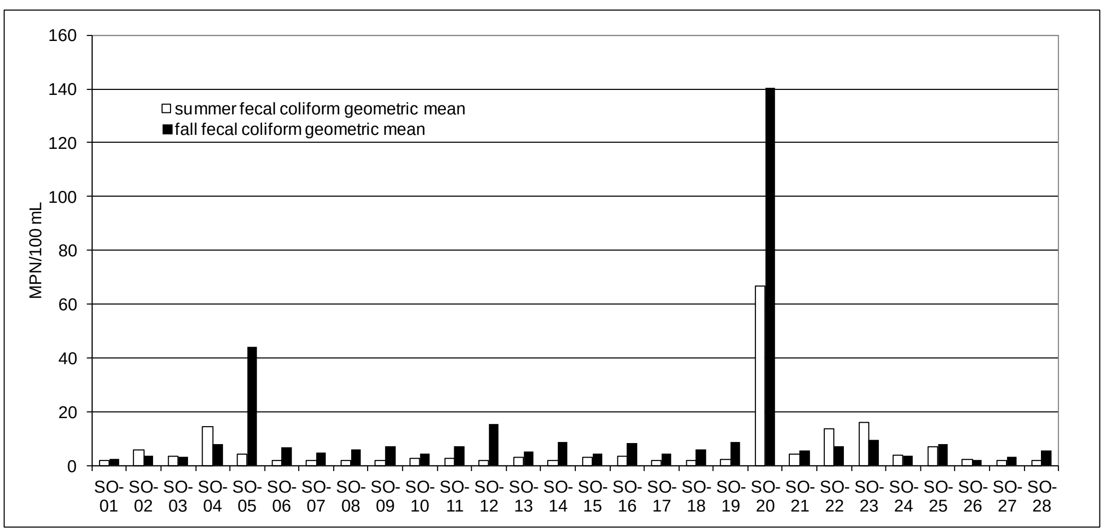


Figure 26. Marine fecal coliform geometric mean results for 2008. Note the geometric mean for S0-1 and SO-26 is based on only four values in 30 days and is not representative.

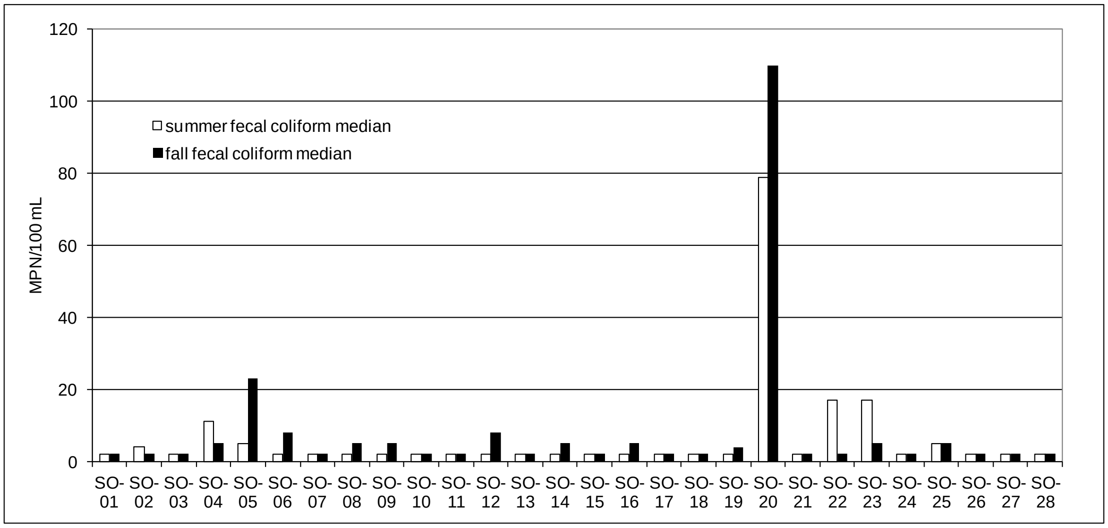


Figure 27. Fecal coliform median values for 2008. Note the median value for S0-1 and SO-26 is based on only four values in 30 days and is not representative.

Individual enterococci values ranged from below detectable limits (<2 CFU/100 mL) to a maximum of 180 CFU/100 mL (at SO-9 in the fall). The geometric mean for all sites ranged from 2 CFU/100mL at 25 sites in the summer to 28 CFU/100 mL at SO-20 in the fall (Figure 28). The SO-20 site is the only site at which the primary recreation guideline (20 CFU/100 mL) for enterococci was exceeded, and this site lies right at the outflow of the Sooke River. For the same reasons discussed above, the geometric mean value for SO-1 and SO-26 should not be considered representative.

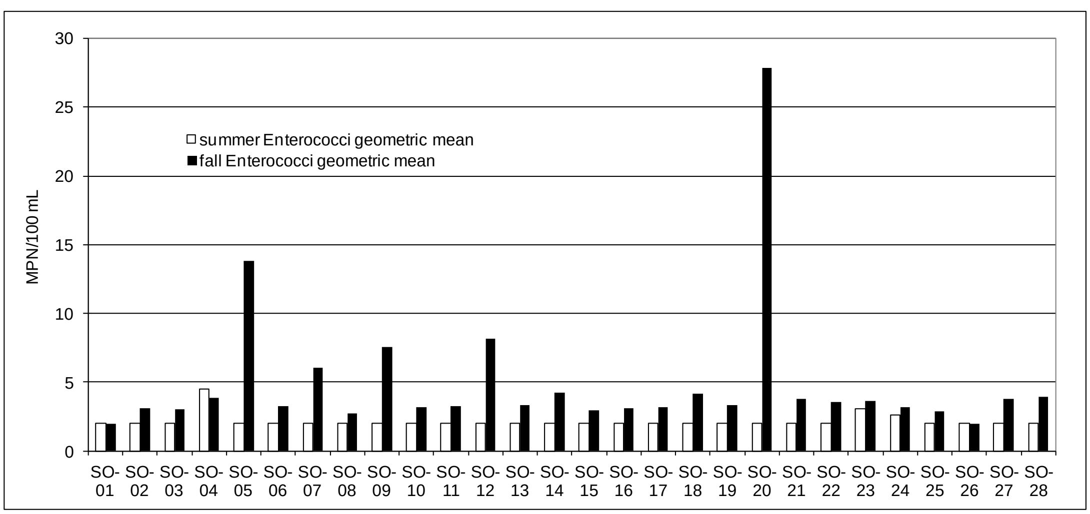


Figure 28. Enterococci geometric means for 2008. Note the median value for S0-1 and SO-26 is based on only four values in 30 days and is not representative.

The enterococci median values ranged from 2 MPN/100 mL (all sites in summer and 24 sites in the fall) to 49 MPN/100 mL (SO-20 in the fall) (Figure 29). There were four exceedances (at SO-5, SO-7, SO-12 and SO-20 in the fall) of the shellfish harvesting guideline for enterococci (4 CFU/100 mL). Enterococci concentrations were consistently at or below detection limits at SO-1, the control site, for all dates sampled (as noted above this site was not sampled during the Nov 12, 2008 storm event).

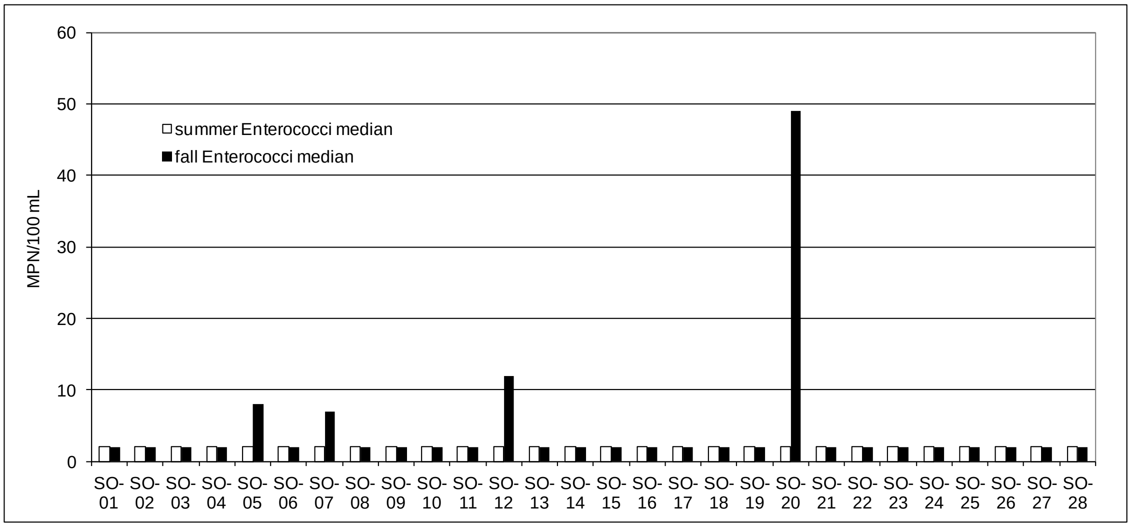


Figure 29. Enterococci median values for 2008. Note the median value for S0-1 and SO-26 is based on only four values in 30 days and is not representative.

Wildlife was often observed while sampling. Large groups of birds (usually Canada geese or gulls) or seals were regularly present near sample locations and may have contributed to elevated fecal coliforms in several samples. For example, at SO-25 all summer sites had fecal coliforms normally less than 10 MPN/mL with no wildlife observations, but on August 19, 2008 a value of 110 MPN/100mL was observed, coinciding with an observation of a large group of gulls near shore. Large enterococci increases were not observed, suggesting microbiological sources were not likely of human origin. A similar situation happened at SO-22 and SO-23 in the summer. There was a light rain August 19, 2008 which likely also contributed to higher microbiological levels and made it difficult to make conclusions regarding the origin of contaminants. This challenge is confounded in the fall samples as contaminants washed off the land by heavier fall rains (notably rainfall in the two days preceding all of the fall sample dates) were also microbiological sources. To identify sources of microbiological contaminants, it is recommended that microbial source tracking (see Section 6.8) sampling occur during the next sample period.

Microbiological data from this study showed that Sooke Basin, Inlet and Harbour are clearly subject to bacteriological contamination and exceedences of BC Water Quality Guideline levels for shellfish, particularly in the areas adjacent to the community of Sooke. Most elevated levels occurred in association with rainfall events. These results were consistent with earlier studies (Cross, 1996), CRD stormwater quality monitoring reports (Cameron and Green, 2007; CRD, 2008; CRD, 2010; CRD, 2011; CRD, 2012; CRD, 2013) and Environment Canada water quality reports (Environment Canada, 2005; Environment Canada, 2009a; Environment Canada, 2009b; Environment Canada, 2012).

During the fall only when lower temperatures make it unlikely that people are swimming in the ocean, enterococci at SO-20 exceeded primary contact criteria for recreation; thus it is not likely a concern for humans, but may still be for pets. The control site, SO-1, illustrates that natural or background concentrations of bacterial contamination are very low. The control site is not without its limitations, such as that water flushing out of the inlet, harbour and basin must pass it as they leave the inlet; however it was the best site within reasonable distance to the Sooke Basin and is generally well flushed with water from the open ocean.

While shellfish harvesting is closed in the inlet and surrounding area, it is a designated water use that local shellfish harvesters and residents would like to see re-established. Therefore, a short term and a long-term water quality objective are proposed for both fecal coliforms and enterococci. The short-term objectives are based on primary recreation uses, thus, Island Health/Health Canada guidelines are proposed (recently adopted by ENV); while the long-term objectives are proposed for future shellfish harvesting. While fecal coliforms do have their limitations as indicators (see Section 6.7), they were chosen in addition to enterococci, as they are more relative to the Environment Canada shellfish regulations. Objectives established for shellfish harvesting may only be applicable to portions of the inlet, harbour and basin as the area is potentially opened for harvesting through options such as conditional management plans, seasonal openings or depuration. However, any future shellfish harvesting would be dependent on the success of measures taken to reduce bacteriological contamination. ***Thus, the proposed short-term (5-10 years) water quality objective is that for enterococci the geometric mean of a minimum of five weekly samples collected within a 30-day period must not exceed 35 CFU/100 mL, and the single sample maximum value should not exceed 70 CFU/100 mL at all sites within Sooke Inlet, Basin and Harbour (primary contact recreation criteria). The proposed long-term (>10 years) water quality objective is that the median of a minimum of five weekly samples collected within a 30-day period must not exceed 4 CFU/100 mL for enterococci and must not exceed 14 CFU/100 mL for fecal coliforms, while the 90th percentile value of a minimum of ten weekly samples collected within a 30-day period must not exceed 43 CFU/100 mL for fecal coliforms at all sites within Sooke Inlet, Basin and Harbour (shellfish harvesting criteria).*** Note that 90th percentiles are ideally based on 10 samples collected in 30 days, which is not convenient or cost effective for the Sooke area; however if funds are available these data would provide useful results.

6.8 MICROBIAL SOURCE TRACKING

While elevated levels of fecal indicator bacteria, such as fecal coliforms and enterococci, can indicate a potential risk to human health, and provide evidence of fecal pollution, they cannot identify the contamination source(s). Over the last decade, researchers have developed a range of microbial source tracking (MST) tools that can be used to distinguish human-sourced fecal contamination from that of animals (Ahmed *et al*., 2010). Some current methodologies include ribotyping, pulse-field gel electrophoresis, denaturing-gradient gel electrophoresis, repetitive DNA sequences (Rep-PCR), host-specific 16S rDNA genetic markers (*Bacteroides*), and antibiotic resistance analysis (Scott *et al.*, 2002; Meays *et al*., 2004). Each method appears to have distinct advantages and disadvantages and currently there is no standard method that has been adopted for source tracking (Meays *et al*., 2004). Determining which method or combination of methods to use for any given situation will depend on a number of factors including: the goal of the project; the level of detail required (broad scale results -human /non-human versus detailed results – human, livestock species, wildlife species); availability of resources; time constraints; and access to a lab with expertise to analyze the samples.

Sooke Inlet/Harbour/Basin

In this study resources were not available for MST to determine if the contamination was of human origin. Studies from the CRD containing MST data were considered in this report and future work may involve more bacterial source tracking. This technique can be used to discriminate and identify the source of contamination if it is human, ruminant, horse, pig, or dog. CRD stormwater quality monitoring reports (Cameron and Green, 2007; CRD, 2008; CRD, 2010; CRD, 2011; CRD, 2012; CRD, 2013) confirmed human sources contributed to microbiological contaminants at some marine sites (SO-20, SO-21, SO-22, SO-23 in 2006) and have further investigated upstream sources of some of these contaminants.

6.9 CAFFEINE ANALYSIS

As mentioned above, there are certain shortcomings with relying solely on indicator bacteria to assess risks associated with pathogenic microorganisms in water. Methods for MST in aquatic environments have also been developed to distinguish animal from human sources, however, expense, reproducibility, and standardization have also been problems for these approaches (Scott *et al*., 2002). Recently, caffeine has been examined as a potential chemical marker for surveillance of human fecal input into source water (Peeler *et al*., 2006). As an active ingredient in many beverages, pharmaceuticals, and food products, and only being partially metabolized in the human body, caffeine has been found in many different aquatic ecosystems (Buerge *et al*., 2003). The stability of caffeine in the aquatic environment, and its source-specificity make caffeine an ideal surrogate of human-derived fecal pollution of source water (Weigel *et al*., 2002). In many instances, there appears to be an association between elevated caffeine concentrations and population densities.

Sooke Inlet/Harbour/Basin

Caffeine was above detection limits at all sites at some time during the four summer dates sampled with the exception of SO-27 (the middle of the Sooke Basin). Even the reference site (SO-01) showed caffeine above detection limits on two occasions. Observing caffeine at the reference site is not unusual and can be attributed to many things such as the natural occurrence of caffeine in the environment from plant species (Peeler *et al*., 2006), the presence of boaters in the area or tidal currents carrying caffeine from within the basin, inlet and harbour. Caffeine values ranged from the detection limit of <2 ng/L to 85.7 ng/L (SO-7 on Aug 3, 2008) (Appendix III). Caffeine values from first four sample dates of the summer 2008 sampling program showed no significant relationships with either fecal coliforms or *Enterococci* on those same dates. Elevated average caffeine values (Figure 30) above that observed at the reference site (12.9 ng/L at SO-1) were found at SO-3, SO-6, SO-7, SO-9, SO-11, SO-12, SO-23 and SO-26. Of these, SO-7, SO-9 and SO-12 also had elevated *Enterococci* values in the fall. However, two of the four sites (SO-5 opposite the river outlet and SO-20 at the river outlet) that exceeded the *Enterococci* shellfish guideline in the fall did not show elevated summer caffeine levels.

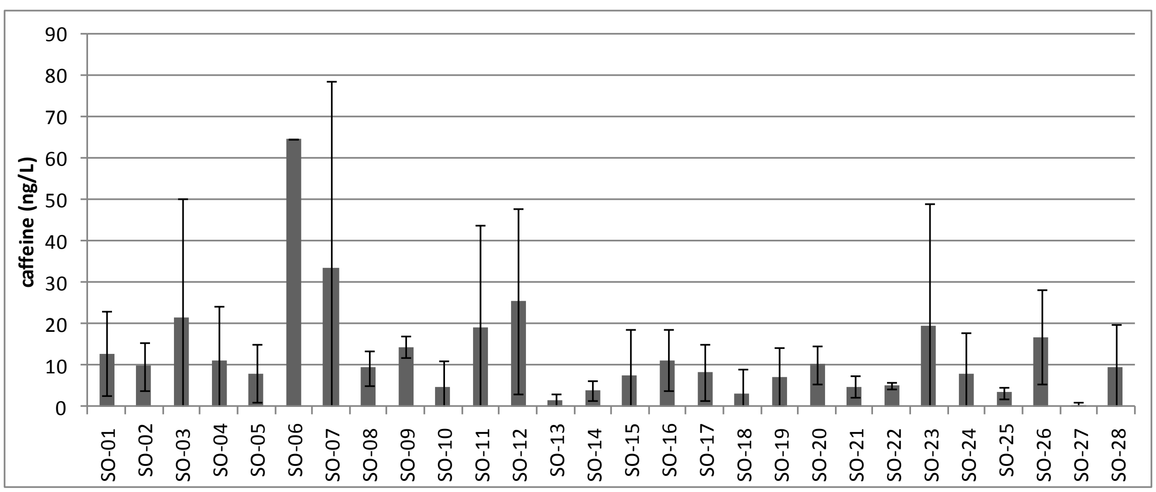


Figure 30. Average caffeine values for the summer of 2008 (based on first four sample dates only). Error bars show standard deviation of the mean.

The caffeine analytical tool has its limitations, as it is a relatively new technique and research is still being conducted. Each tool used in this study responds differently in the environment, due to varying stabilities and biological interactions. For example, fecal coliforms are relatively short lived in marine waters, while caffeine is relatively stable. Regardless, caffeine results confirm the presence and influence of human sewage contamination in the Sooke Inlet, Basin and Harbour. It is a valuable means to characterize the sewage inputs and should be considered in future monitoring work.

6.10 BIOLOGICAL MONITORING

Objectives development has traditionally focused on physical, chemical and bacteriological parameters. However, as aquatic life is typically the most sensitive use of water bodies and benthic macroinvertebrate communities provide a direct measure of the condition of aquatic biota, the inclusion of biological data into the overall objective development program is crucial.

In BC, ENV collaborates with Environment and Climate Change Canada (ECCC) to promote the use of the nationally standardized CABIN program. CABIN uses the reference condition approach (RCA), which requires a large database of biological and habitat data from sites across BC that are minimally affected by human activities. These data define what is expected for aquatic ecosystems in a natural, or reference, condition and are used to develop predictive models that explain the variability among the reference benthic communities based on environmental attributes. The models predict the benthic invertebrates expected at a test site if it were in reference condition and can then be used to evaluate the aquatic biota at sites of concern. The assumption is that if the benthic community is different from reference sites with similar environmental attributes, then it has been influenced by human activities. There is currently a preliminary CABIN Coastal model available to assess Vancouver Island watersheds (Gaber, 2012).

In the Sooke watersheds, low summer flows in most streams limited site selection, thus not all tributaries of interest could be sampled for benthic invertebrates. Additional GIS-based habitat is required for the Sooke area test sites (Demaniel (all years), Ayum (all years) and Charters (2012 data only)) before they can be analyzed using the preliminary CABIN Coastal model. Once available, these test sites should be analyzed to determine if the benthic communities are similar or divergent from conditions found at similar reference sites.

It is recommended that benthic invertebrate data be collected annually in the late summer-early fall for a minimum of three years at the test sites previously sampled in Demamiel Creek, Ayum Creek, Charters Creek. Frequency of future monitoring should be determined based on these results. Reference sites (Upper Sooke River, Jones Creek and Council Creek) should be evaluated for resampling if any new activities have occurred upstream that may affect their status as a reference site. Consideration will be given to including a water quality objective for benthic communities for tributary streams once test site data has been analyzed (e.g., stable or improving condition using applicable CABIN reference model and Benthic Assessment of Sediment (BEAST) ordination).

7.0 PROPOSED WATER QUALITY OBJECTIVES, MONITORING RECOMMENDATIONS AND SCHEDULE

In BC, water quality objectives are based mainly on approved or working water quality guidelines. These guidelines are established to prevent specified detrimental effects from occurring with respect to a designated water use. Designated water uses for the Sooke watersheds that are sensitive and should be protected are shellfish, recreation, aquatic life, and wildlife in both marine and freshwaters, and drinking water and irrigation in freshwater only. The water quality objectives proposed here (Table 14 (marine), Table 15 (freshwater)) take into account background conditions, impacts from current land use and any known potential future impacts that may arise within the watershed. These proposed objectives should be periodically reviewed and revised to reflect any future improvements or technological advancements in water quality assessment and analysis. It should be noted that this assessment report forms the basis of approved WQOs that can be found in BC ENV (2019).

Table 13. Summary of proposed water quality objectives for Sooke Inlet, Harbour and Basin.

Time Period	Variable	Objective Value	Use
Short-term (5-10 years)	Enterococci	≤ 35 CFU/100 mL (geometric mean based on a minimum 5 weekly samples collected over a 30-day period) 70 CFU/100 mL (single sample maximum value)	primary contact recreation and cultural uses
Long-term (>10years)	Fecal Coliform	≤ 14 CFU/100 mL (median based on a minimum 5 weekly samples collected over a 30-day period) ≤43 CFU/100 mL (90th percentile based on a minimum 5 weekly samples collected over a 30-day period)	aquatic life – shellfish harvesting
	Enterococci	≤ 4 CFU/100 mL (median based on a minimum 5 weekly samples collected over a 30-day period)	aquatic life – shellfish harvesting

Designated water uses: aquatic life – shellfish harvesting, recreation and wildlife

Table 14. Summary of proposed water quality objectives for the Sooke watersheds draining into Sooke Basin/Harbour and Inlet.

Variable	Objective Value	Use
Temperature	Sooke River: ≤17°C (max) Any water intake: ≤ 15 °C (max)	aquatic life, drinking water supply
Dissolved oxygen	≥5 mg/L (min) ≥8 mg/L (average)	aquatic life
Turbidity	At any intake: <5 NTU maximum Oct – Dec <2 NTU maximum Jan – Sept 95% of samples ≤1 NTU at intake	drinking water
Total phosphorus	0.010 mg/L max 0.005 mg/L avg (based on a minimum of monthly samples collected from May – Sept)	aquatic life, aesthetics
Escherichia coli	Any water intake: Jan-Sept: ≤10 CFU/100 mL (90th percentile) Oct-Dec: ≤40 CFU/100 mL (90th percentile) To protect recreational and cultural uses: ≤200 CFU/100 mL (geomean of five weekly samples in 30 days) 400 CFU/100 mL (single sample maximum value)	raw drinking water – disinfection only, recreation and culture

Designated water uses: drinking water, aquatic life – shellfish harvesting, recreation, irrigation and wildlife

Note: all calculations are based on a minimum of 5 samples in 30 days, unless stated otherwise. Parameters apply at all freshwater sites downstream of the GVWSA in the lower Sooke watersheds, unless stated otherwise.

The recommended water quality monitoring program for Sooke Inlet, Harbour and Basin is summarized in Table 16. Once WQOs are approved, the attainment monitoring should be conducted every three to five years based on staff and funding availability, and whether activities, such as land use or upgrades to sewage discharges, are underway within the area. In order to capture the periods where water quality concerns are most likely to occur (*i.e.*, highest population use of the area and lack of dilution – summer, and rainwater runoff in the fall flush period) we recommend that a minimum of five weekly samples be collected within a 30-day period between August and September and between October and November. In this way, the two critical periods (minimum dilution and maximum turbidity), will be monitored. Samples should be collected at all 28 marine sites as well as the 17 freshwater sites. Monthly samples should occur between May and September for total phosphorous at the freshwater sites only.

Table 15. Proposed schedule for attainment water quality monitoring in Sooke Watersheds, Inlet, Harbour and Basin.

Sample Sites	Frequency and timing	Parameters to be measured
Marine: Sooke Inlet, Harbour and Basin (28 sites)	August – September and October-November: five weekly samples in a 30-day period	Field: Temperature, DO, pH, salinity (SO-3, SO-28 and deepest point in basin only). Lab: total metals (fall only), hardness, fecal coliforms and *enterococci*, Microbial Source Tracking
Freshwater: watersheds draining in the Sooke Inlet, Harbour and Basin (17 sites)	August – September and October-November: five weekly samples in a 30-day period	Field: Temperature, DO, pH, specific conductivity. Lab: TSS, turbidity, true colour, DOC, TOC, total and dissolved metals, hardness *E. coli* (freshwater only)
Freshwater: watersheds draining in the Sooke Inlet, Harbour and Basin (17 sites)	May-September (minimum one monthly sample)	Total phosphorus
Freshwater: 3 test sites (Ayum Creek, Demamiel Ck 400 m u/s Robertson Ck, Charters Ck 1.2 km d/s Charter Reservoir)	Annually (late summer-early fall) for a minimum of three years. Frequency of future monitoring to be determined.	Benthic invertebrate sampling as per CABIN protocols

8.0 MANAGEMENT OPTIONS

The most significant influences on bacteriological contamination in Sooke Inlet, Harbour and Basin are likely a combination of rainwater runoff from populated areas (road, impervious area, pet and hobby farm runoff), natural wildlife populations and populated areas that have septic only and are not connected to the sewage system. These areas include the two T'Sou-ke Nations Reserves. Chambers and Rodenkirchen (2003) investigated some potential sources of contamination into the Hutchinson, Roche and Anderson Cove areas; while the CRD has a comprehensive stormwater water monitoring program and reports out on stormwater contamination sources regularly (Cameron and Green, 2007; CRD, 2008; CRD, 2010; CRD, 2011; CRD, 2012; CRD, 2013).

The following sections briefly discuss management options that are in place to protect human health and overall water quality of Sooke Inlet, Harbour and Basin.

8.1 OFFICIAL COMMUNITY PLANS

There is a clear link between land-use planning required of local governments in the *Municipal Act* (sections 944, 945) and waste management plans in the *Environmental Management Act* (*EMA*) (part 3, section 24). An official community land-use plan (OCP) is a statement of objectives and policies regarding future land-use patterns in incorporated municipalities or in designated areas of regional districts. The official plan provides a clear statement to the public and the province about local government's growth management objectives and provides the rationale for subsequent land-use regulations. In most cases where official land use plans are in place, the local government planning statement (bylaw) will form the basis of waste management plans. The Liquid Waste Management Plan (LWMP) minimizes the adverse environmental impact of the official plan and ensures that development is consistent with ENV waste management objectives. Sooke has a comprehensive OCP that examines rainwater and septic sources of contamination (District of Sooke, 2010a). East Sooke also has an OCP (currently under review) that includes requirements for management of rainwater and maintenance of water quality (CRD, 2012b).

8.2 LIQUID WASTE MANAGEMENT PLANS (LWMP)

The *Environmental Management Act (EMA)* allows municipalities and regional districts to develop LWMPs for approval by the Minister of Environment. The LWMP is a strategy to reduce pollution and plan for the future. It applies to existing facilities with primary treatment or no treatment, and can be implemented in stages, taking into account the assimilative capacity of the receiving environment, the ability to finance the upgraded sewage facilities, and public input to the waste management planning process. Estimates of waste quantity and quality should be based on long-term growth projections. For waste management planning areas where official land use plans are not in place or where it is deemed the background information of a land use plan is inadequate, growth projections must be developed. Wastes to be addressed in the LWMP should include, but are not necessarily limited to:

- municipal sewage;
- urban storm water runoff;
- combined sewer overflows;
- septic tank pumpage;
- pump station overflows;
- sewage treatment plant sludge;
- industrial or commercial wastes discharged to municipal sewers;
- septic tanks and other sewage disposal systems not connected to the community sewer system; and
- any other effluent specified by a manager.

Sooke has a comprehensive LWMP addressing local concerns and priorities that includes a rainwater component. This LWMP was signed off in 2011 and includes a rainwater management component. Through an agreement with the District of Sooke, the CRD conducts detailed rainwater discharge studies and upstream investigations to help determine sources of various contaminants within the Sooke watersheds (Cameron and Green, 2007; CRD, 2008; CRD, 2010; CRD, 2011; CRD, 2012; CRD, 2013). The District of Sooke also has a draft bylaw to Regulate Discharges to the Municipal Stormwater Drainage System incorporating water quality limits. Once approved by the local government, this bylaw will serve as an enforceable protective measure for water quality in the Sooke watersheds, thereby also protecting and ultimately improving water quality in the marine areas.

LITERATURE CITED

Ahmed, W., R. Yusuf, I. Hasan, A. Goonetilleke, and T. Gardner. 2010. Quantitative PCR assay of sewage-associated *Bacteroides* markers to assess sewage pollution in an urban lake in Dhaka, Bangladesh. Can. J. Microbial. 56: 838-845.

Anderson, G. 2006. Personal communication. Vancouver Island Health Authority, Landuse – Water Consultant, North Vancouver Island Health Service Delivery Area.

Archipelago Marine Research Ltd. 2012. Marine intertideal inventory of clam beds and higher level eelgrass and kelp survey in Sooke Basin and Harbour, Sooke, B.C. In Ministry of Forests, Lands and Natural Resource Operations files, Nanaimo, B.C.

Barlak, R., Epps, D. and Phippen, B. 2010. Water quality assessment and objectives for the Englishman River Community Watershed: technical report. Ministry of Environment. Victoria B.C. Available online at: http://www.env.gov.bc.ca/wat/wq/englishman/wqo-technical-englishman.pdf

Berhard, A.E. and Field, K.G. 2000. A PCR assay to discriminate human and ruminant feces on the basis of host differences in *Bacteroides-Precotella* genes encoding 16S rRNA. Applied and Environ. Microbiol. 66(4): 1587-1594.

Brettar, I. and M.G. Höfle. 1992. Influence of ecosystematic factors on survival of *Escherichia coli* after large-scale release into lake water mesocosms. Applied and Environmental Microbiology 58(7): 2201 – 2210.

BC MOE (British Columbia Ministry of Environment). 1994. Environmental Lab Manual for the Analysis of Water, Wastewater, Sediment and Biological Materials, Province of BC.

BC MOE (British Columbia Ministry of Environment). 1997. Ambient water quality criteria for dissolved oxygen. Available online at: http://www.env.gov.bc.ca/wat/wq/BCguidelines/do/index.html

BC MOE (British Columbia Ministry of Environment). 2003. British Columbia field sampling manual for continuous monitoring and the collection of air, air-emission, water, wastewater, soil, sediment, and biological samples. Available online at: http://www.env.gov.bc.ca/epd/wamr/labsys/field_man_03.html.

British Columbia Ministry of Environment and Climate Change Strategy (ENV). 2019. Water Quality Objectives for Sooke Inlet, Harbour, and Basin, and Tributary Streams. Water Science Series, WSS2019-01. Prov. B.C., Victoria B.C.

BCCDC (British Columbia Conservation Data Centre): Conservation Data Centre Mapping Service [web application] (BCCDC). 2013. Victoria, British Columbia, Canada. Available: http://www.env.gov.bc.ca/cdc/

British Columbia Government (BC Gov). 2001. Drinking Water Protection Act – Drinking Water Protection Regulation. 2005. Available online at: http://www.qp.gov.bc.ca/statreg/reg/D/200_2003.htm

British Columbia Government (BC Gov). 2017. Community Watersheds Query. Available online at: http://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/community-watersheds

British Columbia Ministry of Aboriginal Relations and Reconciliation (BC MARR). 2008. Maa-nulth First Nations Final Agreement. Appendices. Available online at: http://www.gov.bc.ca/arr/firstnation/maa_nulth/down/maa_nulth_appendices_to_final_agreement_english_version_june_2008.pdf

British Columbia Ministry of Environment (BCMOE). *In press*. Guidance Document for Phosphorus Management in Vancouver Island Streams. Environmental Protection Division, British Columbia Ministry of Environment, Nanaimo, B.C.

British Columbia Ministry of Environment, Lands and Parks (BC MELP). 1998. Guidelines for Interpreting Water Quality Data. Available online at: http://www.ilmb.gov.bc.ca/risc/pubs/aquatic/interp/index.htm

Buerge, I.J., T. Poiger, M.D. Muller, and H.R. Buser. 2003. Caffeine, an anthropogenic marker for wastewater contamination of surface waters. Environ. Sci. Technol. 37:691-700.

Hooper, L. 2012. Parks and Environmental Sciences Coordinator. District of Sooke. Personal communications.

Cabelli, V.J. 1983. Health effects for marine recreation waters. USEPA 600/1-80-031. Health Effects Research Laboratory, Research Triangle Park, N.C.

Canadian Hydrographic Service. 1995. Nautical Chart 3411.

Cameron, R. and Green, D. 2007. Stormwater Quality Report District of Sooke 2005/2006. Capital Regional District, Victoria, BC.

Caux, P.-Y., D.R.J. Moore, and D. MacDonald. 1997. Ambient Water Quality Guidelines (Criteria) for Turbidity, Suspended and Benthic Sediments. Prepared for the Ministry of Environment, Lands and Parks. Victoria, B.C.

Cavanaugh, N., R.N. Nordin, L.W. Pommen, L.G. Swain. 1998. Guidelines for Designing and Implementing a Water Quality Monitoring Program in British Columbia. Ministry of Environment, Lands and Parks, Victoria, BC.

Chambers, K and Rodenkirchen, K. 2003. An Assessment of Hutchinson Cove, Roche Cove and Anderson Cove for Suitability for Open Shellfish Harvesting. Veins of Life Watershed Society, Victoria, BC.

CRD (Capital Regional District), 1990. Sooke Harbour, Basin and Inlet Management Plan (1990). Municipal Services Department, Victoria, BC.

CRD (Capital Regional District), 2008. Stormwater Quality Report Juan de Fuca Electoral Area 2005-2006. Stormwater, Harbours and Watersheds Program. Victoria, BC.

CRD (Capital Regional District). 2010. District of Sooke Stormwater Quality 2009 Annual Report. Stormwater, Harbours and Watersheds Program. Victoria, BC.

CRD (Capital Regional District). 2010b. Ayum Creek, Kapoor, Sea to Sea, Sooke Potholes Regional Parks Management Plans. Regional Parks. Victoria, BC.

CRD (Capital Regional District). 2011. District of Sooke Stormwater Quality 2010 Annual Report. Stormwater, Harbours and Watersheds Program. Victoria, BC.

CRD (Capital Regional District). 2012. District of Sooke Stormwater Quality 2011 Annual Report. Stormwater, Harbours and Watersheds Program. Victoria, BC.

CRD (Capital Regional District). 2013. District of Sooke Stormwater Quality 2012 Annual Report. Stormwater, Harbours and Watersheds Program. Victoria, BC.

CRD (Capital Regional District), 2012a. 2012 Strategic Plan for the Greater Victoria Water Supply System. Victoria, B.C.

CRD (Capital Regional District), 2012b. Capital Regional District Bylaw No. 3718, Official Community Plan for East Sooke Bylaw No.1, 2012. Victoria, B.C.

CRD (Capital Regional District), 2017. Capital Regional District Integrated Water Services Website. Available online at: http://www.crd.bc.ca/water/

Cross, S.F., Morrison, T.O., Gregory, L.A., and Dobbs, F.A. 1990. A Water Quality Assessment and Provisional Water Quality Objectives for Sooke Harbour and Basin. Aquametrix Research Ltd on behalf of Capital Regional Distric, Victoria, BC.

Cross, S.F. 1991. 1990 Sooke Harbour and Basin Water Quality Monitoring Program – summary report. Aquametrix Research Ltd on behalf of Capital Regional Distric, Victoria, BC.

Cross, S.F. 1993. Recommended Sooke Harbour and Basin Water Quality Objectives – DRAFT. Aquametrix Research Ltd. on behalf of Ministry of Environment, Lands and Parks. Victoria B.C.

Cross, S.F. 1995. 1994 Sooke Harbour and Basin Water Quality Monitoring Program – summary report. Aquametrix Research Ltd on behalf of Capital Regional Distric, Victoria, BC.

Cross, S.F. 1996. 1995 Sooke Harbour and Basin Water Quality Monitoring Program – summary report. Aquametrix Research Ltd on behalf of Capital Regional Distric, Victoria, BC.

Davis, K., M.A. Anderson, and M.V. Yates. 2005. Distribution of indicator bacteria in Canyon Lake, California. Water Res., 39:1277-1288.

Demarchi, D.A. 1996. An Introduction to the Ecoregions of British Columbia. Ministry of Environment, Lands and Parks, Victoria. B.C. Available online at: http://www.env.gov.bc.ca/ecology/ecoregions/intro.html

DFO (Fisheries and Oceans Canada). 2013. Mapster 3.0. Available online at: http://www.pac.dfo-mpo.gc.ca/gis-sig/maps-cartes-eng.htm

District of Sooke, 2010a. District of Sooke Bylaw No. 400, Official Community Plan, 2010, Sooke, B.C.

District of Sooke, 2010b. Liquid Waste Management Plan, Stage 3 Sanitary, Stage 2 & 3 Rainwater, Sooke, B.C.

District of Sooke. 2012. Community Roots An Agricultural Plan for Sooke. Sooke, B.C. Available online at: http://www.sooke.ca/EN/main/government/devservices/planning/ag_plan.html

Dyck, Erwin. 2012. Supervisor, Health Protection. Vancouver Island Health Authority. Personal Communication, 2009.

Edberg, S.C., E.W. Rice, R.J. Karlin, and M.J. Allen. 2000. *Escherichia coli*: the best biological drinking water indicator for public health protection. J. Appl. Microbiol., 88:106S-116S.

Elliott, J.A. 1969. A synoptic study of Sooke Basin. Institute of Oceanography, University of British Columbia. Report No. 22. 32 p.

Enns, Charmaine. Chief Medical Health Officer. Vancouver Island Health Authority. Personal Communication, 2009.

Environment Canada, 2005. File Report, Growing Area 30: Sooke Harbour and Basin (SK). Survey dates March 2002 to March 2005. Shellfish Water Quality Protection Program. Environmental Protection Branch. Vancouver, BC.

Environment Canada. 2009a. File Report – Growing Area 30: Sooke Harbour and Basin (SK). Survey Dates: November 2005 to June 2009. Marine Water Quality Section. Science and Technology Branch. Vancouver B.C.

Environment Canada. 2009b. Contaminated Area Report – Growing Area 30: Sooke (SK) Sector 02: Sooke Basin. Information: Chemical Contamination at Cooper Cove/ Goodridge Peninsula. June 2009. Marine Water Quality Section. Science and Technology Branch. Vancouver B.C.

Environment Canada. 2011. National Climate Data and Information Archive. Available online at http://www.climate.weatheroffice.gc.ca/climateData/

Environment Canada. 2011b. Canadian Aquatic Biomonitoring Network Field Manual – wadeable streams. Science and Technology Branch. Ottawa, Ontario. Available online at http://publications.gc.ca/site/eng/422979/publication.html

Environment Canada. 2012. File Report – Growing Area 30: Sooke Harbour and Basin (SK). Survey Dates: April 2009 to March 2012. Marine Water Quality Section. Science and Technology Branch. Vancouver B.C.

Environment Canada. 2014. CABIN Laboratory Methods: Processing, Taxonomy, and Quality Control of Benthic Macroinvertebrate Samples. Environment Canada, May 2014.

Epps, D. 2007. Water quality assessment and objectives for the McKelvie Creek community watershed: technical report. Ministry of Environment. Victoria B.C. Available online at: http://www.env.gov.bc.ca/wat/wq/mckelvie-creek/mckelvie-tech.pdf

Feakins, T.L. 1991. Sooke Harbour and Basin Fish Habitat Inventory. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2131. Department of Fisheries and Oceans, Nanaimo, BC.

Field, K.G. and M. Samadpour. 2007. Fecal source tracking, the indicator paradigm, and managing water quality. Water Res., 41:3517-3538.

Fisheries and Oceans Canada (DFO), 2013. http://www.pac.dfo-mpo.gc.ca/fm-gp/contamination/biotox/index-eng.htm

FISS (Fisheries Information Summary System Database). 2013. Ministry of Environment and Department of Fisheries and Oceans. Available online at: http://www.bcfisheries.gov.bc.ca/fishinv/fiss.html

Gaber, L. 2012. A predictive model for bioassessment of streams in coastal British Columbia using the reference condition approach: 2011. Report prepared by Water Protection and Sustainability Branch, B.C. Ministry of Environment, Victoria, B.C. 28p plus appendices.

Gartner, A., P. Lavery, and A.J. Smit. 2002. Use of δ15N signatures of different functional forms of macroalgae and filter-feeders to reveal temporal and spatial patterns in sewage dispersal. Mar Ecol Prog Ser 235: 63–7

GeoBC. 2013. Province of British Columbia mapping tool. Available online at: http://geobc.gov.bc.ca/

Goff, J.R. and Hicock, S.R. 1991. An Evaluation of the Potential Aggregate Resources for Sooke Land District, B.C. (92B/5). British Columbia Geological Survey Branch. Geological Fieldwork 1991.

Goyette, D. and Brooks, K.M. 1998. Creosote Evaluation: Phase II, Sooke Basin Study - Baseline to 535 Days Post Construction 1995-1996. Prepared fro Creosote Evaluation Steering Committee, Regional Program Report PR98-04. Environment Canada Pacific and Yukon Region.

Griffin, D.W., E.K. Lipp, M.R. McLaughlin, and J.B. Rose. 2001. Marine recreation and public health microbiology: quest for the ideal indicator. BioScience 51: 817-825.

Haack, S.K., J.W. Duris, L.R., Fogarty, D.W. Kolpin, M.J. Focazio, E.T. Furlong, and M.T. Meyer. 2009. Comparing wastewater chemicals, indicator bacteria concentrations, and bacterial pathogen genes as fecal pollution indicators. J. Environ. Qual., 38:248-258.

Health Canada. 1990. Guidelines for Canadian Drinking Water Quality. Supporting Documentation. Part III. Boron. Edited May 1991

Health Canada. 2004. Guidelines for Canadian drinking water quality: Supporting documentation – Protozoa: *Giardia* and *Cryptosporidium*. Water Quality and Health Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.

Health Canada. 2012. Guidelines for Canadian Recreational Water Quality. Third Edition. Water, Air and Climate Change Bureau, Healthy Environments and Consumer Safety Branch,

Health Canada, Ottawa, Ontario. (Catalogue No H129-15/2012E).

Howell, J.M., M.S. Coyne and P.L. Cornelius. 1996. Effect of sediment particle size and temperature on fecal bacteria morality rates and the fecal coliform/fecal streptococci ratio. J. Environ. Qual. 25: 1216 – 1220.

Hull, D.J. and Miller, R.A. 1998. Stormwater Quality Survey, Sooke – 1998. Capital Regional District, Victoria, BC.

Iannidinardo, Domenico. 2012. Manager, Environment and Resource Integration. TimberWest Forest Corp. Nanaimo, B.C. Personal communications.

IEC (Integrated Environmental Consultants). 1999. Lower Sooke River Watershed Non-point Source Assessment: Impact on the Sooke River Estuary. Victoria, BC.

Ishii, S. and M.J. Sadowsky. 2008. *Escherichia coli* in the environment: Implications for water quality and human health. Microbes Environ., 23(**2**): 101-108.

Jackson, C. and Blecic, B. 1996. Sooke Water Allocation Plan. Regional Water Management, Ministry of Environment, Lands and Parks. Available online at: http://www.env.gov.bc.ca/wsd/water_rights/wap/vi/sooke/sooke_wap.pdf

Jawson, M.D., L.F. Elliott, K.E. Saxton, and D.H. Fortier. 1982. The effect of cattle grazing on indicator bacteria in runoff from a Pacific Northwest watershed. J. Environ. Qual. 11: 621 - 627.

Kloot, R.W., B. Radakovich, X. Huang, and D. Brantley. 2006. A comparison of bacterial indicators and methods in rural surface water. Environ. Monior. Assess. 121: 275-287.

Krewski, D., J. Balbus, D. Butler-Jones, C.N. Haas, J. Isaac-Renton, K.J. Roberts, and M. Sinclair. 2004. Managing microbiological risks of drinking water. J. Toxicol. Environ. Health Part A, 67:1591-1617.

Lyngby, J. and M. Mortensen. 1994. Assessment of nutrient availability and limitation using macroalgae. J Aquat. Ecosyst. Health 3: 27-34.

McKean, C. and N. Nagpal. 1991. Ambient Water Quality Criteria for pH, Technical Appendix. Province of British Columbia. Ministry of Environment. Victoria. Available online at: http://www.env.gov.bc.ca/wat/wq/BCguidelines/phtech.pdf

McKinney, R.A., W.G. Nelson, M.A. Charpentier, and C. Wigand. 2001. Ribbed mussel nitrogen isotope signatures reflect nitrogen sources in coastal salt marshes. Ecol, Applications 11(1):203-214.

Meays, C. 2009. Water Quality Guidelines for Nitrogen (Nitrate, Nitrite, Ammonia). Water Stewardship Division. British Columbia Ministry of Environment, Victoria, BC.

Meays, C.L., K. Broersma, R. Nordin, and A. Mazumder. 2004. Source tracking fecal bacteria in water: a critical review of current methods. J. Environ. Man. 73: 71-79.

MINFILE 2013. Ministry of Energy and Mines Mineral Inventory. Available online at: http://www.em.gov.bc.ca/mining/geolsurv/minfile/

Miller, R.M., Lloyd, R., Malmkvist, L. and Evans, A. 2010. District of Sooke Liquid Waste Management Plan (Rainwater), Stage 2&3. District of Sooke, Sooke, BC.

Moore, D.R.J. and P.-Y. Caux. 1997. Ambient Water Quality Criteria for Colour in British Columbia, Technical Appendix. Province of British Columbia. Ministry of

Environment, Lands and Parks. Victoria. Available online at: http://www.env.gov.bc.ca/wat/wq/BCguidelines/colour/index.html

Moore, D.R. J. 1998. Ambient Water Quality Criteria for Organic Carbon in British Columbia. Province of British Columbia. Ministry of Environment, Lands and Parks. Victoria. Available online at: http://www.env.gov.bc.ca/wat/wq/BCguidelines/orgcarbon/index.html

Obee, N and Phippen, B. 2012. Water Quality Assessment and Objectives for Kemp Lake Community Watershed: Technical Report. Available online at: http://www.env.gov.bc.ca/wat/wq/objectives/kemp_lk/wqo_kemp_lk_technical.pdf

Oliver and Fidler, 2001. Towards a Water Quality Guideline for Temperature in the Province of British Columbia. Ministry of Environment, Lands and Parks. Victoria BC. Available online at: http://www.env.gov.bc.ca/wat/wq/BCguidelines/temptech/index.html

Peeler, K.A., S.P. Opsahl, and J.P. Chanton. 2006. Tracking anthropogenic inputs using caffeine, indicator bacteria, and nutrients in rural freshwater and urban marine systems. Environ. Sci. Technol. 40: 7616-7622.

PESC (Pacific Environmental Science Centre), 2006. Bacterial Source Tracking results submitted to ENV.

Planes, G. 2009. Chief . T'Sou-ke First Nations. Personal communications.

RISC (Resource Inventory Standards Committee). 1994. Ambient Freshwater and Effluent Sampling Manual. Available online at: http://ilmbwww.gov.bc.ca/risc/pubs/aquatic/ambient/index.htm

RISC. 1997. Guidelines for Interpreting Water Quality Data. Available online at: http://www.ilmb.gov.bc.ca/risc/pubs/aquatic/interp/index.htm

Rogers, K.M. 1999. Effects of sewage contamination on macroalgae and shellfish at Moa Point, New Zealand using stable carbon and nitrogen isotopes. NZ J Marine Freshwater Res. 33:181-188.

Rogers, K.M. 2003. Stable carbon and nitrogen isotope signatures indicate recovery of marine biota from sewage pollution at Moa Point, New Zealand. Mar. Pollul. Bulletin 46:821-827.

Roxborough, M. 2009. Laboratory Manager. Environmental Sustainability. Capital Regional District. Victoria, B.C. Personal communication.

Roxborough, M., Pennimpede, J., McEachern, B. and Irwin, S. 2010. 2009 Annual overview of Greater Victorias Drinking Water Quality. Capital Regional District. Victoria, B.C.

Schurer, P.J., MacFarlane, W.T. and Duffus, H.J. 1979. Sub-bottom survey of harbours near Victoria, B.C. Royal Roads University, Victoria, B.C.

Scott, T.M., Rose, J.B., Jenkins, T.M., Farrah, S.R., and Lukasik, J. 2002. Microbial cource tracking: current methodology and future directions. Appl. Environ. Microbiol. 68(12): 5796-5803.

Stephenson, G.R. and R.C. Rychert. 1982. Bottom sediment: a reservoir of *Escherichia coli* in rangeland streams. J. Range Manage. 35: 119-123.

Taje, E. 2012. Senior Inspector of Mines U/G Coal. Ministry of Energy and Mines. Personal Communication, 2012.

Tallon, P., B. Magajna, C. Lofranco, and K.T. Leung. 2005. Microbial indicators of faecal contamination in water: A current perspective. Water Air Soil Pollut., 166:139-166.

Tiedemann, A.R., D.A. Higgins, T.M. Quigley, H.R. Sanderson and D.B. Marx. 1987. Responses of fecal coliform in streamwater to four grazing strategies. J. Range Manage. 40(4): 322 – 329.

Thompson, R.E.1981. Oceanography of the British Columbia Coast. Can. Spec. Publ. Fish. Aquat. Sci. 56: 291 p.

Triton Environmental Consultants Ltd. 1996. Overview Assessment: Mercantile Creek. Triton Environmental Consultants Ltd. Richmond, B.C.

Tucker, J., N. Sheats, A.E. Giblin, C.S. Hopkinson and J.P. Montoya. 1999. Using stable isotopes to trace sewage-derived material through Boston Harbour and Massachusetts Bay. Mar. Environ. Res. 48: 353-375.

Ussery, J. 2015. Manager, Resource Planning, Watershed Protection, Capital Regional District Integrated Water Services. Personal communications.

Verenitch, S. 2011. Senior Lab Manager. Water and Aquatic Sciences Research Program. University of Victoria. Personal Communication, 2011.

Warrington, P.D. 1988. Water quality criteria for microbiological indicators, technical document. British Columbia Ministry of Environment. Victoria, BC.

Warrington, P.D. 2001 Update. Water quality criteria for microbiological indicators: Overview Report. BC Ministry of Environment. Victoria, BC. Available online at: http://www.env.gov.bc.ca/wat/wq/BCguidelines/microbiology/microbiology.html

Water Survey Canada (WSC). 2005. Environment Canada Hydat Online Database. Available online at: http://www.wsc.ec.gc.ca/hydat/H2O/

Wetzel, R.G. 2001. Limnology, Lake and River Ecosystems. Third Edition. Academic Press. San Diego. 1006 pp.

Yates, M.V. 2007. Classical indicators in the 21st century – far and beyond the coliform. Water Environ. Res., 79 (3):279-286.

APPENDIX I

Table 16. Tide information for Sooke Inlet, Harbour and Basin on marine sample dates in 2008.

Date	Tide Time	Tide Height	High/Low
2008-08-07	01:43 AM PDT	4.87 feet	Low Tide
2008-08-07	07:00 AM PDT	6.26 feet	High Tide
2008-08-07	11:19 AM PDT	5.34 feet	Low Tide
2008-08-07	06:46 PM PDT	8.97 feet	High Tide
2008-08-12	06:40 AM PDT	2.56 feet	Low Tide
2008-08-12	10:22 PM PDT	9.05 feet	High Tide
2008-08-19	03:24 AM PDT	7.8 feet	High Tide
2008-08-19	10:19 AM PDT	3.11 feet	Low Tide
2008-08-19	04:43 PM PDT	8.17 feet	High Tide
2008-08-19	11:14 PM PDT	4.74 feet	Low Tide
2008-08-23	02:26 AM PDT	3.05 feet	Low Tide
2008-08-23	06:23 PM PDT	9.72 feet	High Tide
2008-09-03	04:48 AM PDT	7 feet	High Tide
2008-09-03	10:24 AM PDT	4.72 feet	Low Tide
2008-09-03	04:38 PM PDT	8.67 feet	High Tide
2008-10-20	01:27 AM PDT	1.06 feet	Low Tide
2008-10-20	05:12 PM PDT	9.29 feet	High Tide
2008-10-29	03:45 AM PDT	6.7 feet	High Tide
2008-10-29	07:48 AM PDT	6.17 feet	Low Tide
2008-10-29	01:42 PM PDT	9.24 feet	High Tide
2008-10-29	09:46 PM PDT	1.97 feet	Low Tide
2008-11-04	12:19 AM PST	2.39 feet	Low Tide
2008-11-04	03:21 PM PST	8.24 feet	High Tide
2008-11-12	01:49 AM PST	6.74 feet	High Tide
2008-11-12	05:25 AM PST	6.13 feet	Low Tide
2008-11-12	11:39 AM PST	9.91 feet	High Tide
2008-11-12	07:52 PM PST	0.88 feet	Low Tide
2008-11-20	01:36 AM PST	2.62 feet	Low Tide
2008-11-20	09:15 AM PST	8.14 feet	High Tide
2008-11-20	03:02 PM PST	6.52 feet	Low Tide
2008-11-20	06:57 PM PST	7.03 feet	High Tide

APPENDIX II

Table 17. Duplicate marine microbiological samples collected during the study period. Relative percent difference were calculated only for those results greater than 10 times the minimum detection limit of <2 MPN/100mL. Percent differences above the acceptable level (25%) are boldfaced.

Marine Sample Station	Date	Enterococci (MPN/100 ml) Sample #1	Enterococci (MPN/100 ml) Sample #2	**Enterococci (MPN/100 ml) % difference**	Fecal Coliforms (MPN/100 ml) Sample #1	Fecal Coliforms (MPN/100 ml) Sample #2	**Fecal Coliforms (MPN/100 ml) % difference**
SO-22	12-Aug-08	<2	2		23	11	
SO-08	19-Aug-08	2	<2		<2	<2	
SO-26	19-Aug-08	<2	<2		<2	2	
SO-01	28-Aug-08	<2	<2		<2	<2	
SO-06	28-Aug-08	<2	<2		<2	<2	
SO-14	28-Aug-08	<2	<2		<2	2	
SO-15	28-Aug-08	2	<2		2	2	
SO-03	03-Sep-08	<2	<2		<2	<2	
SO-10	03-Sep-08	<2	<2		<2	<2	
SO-18	03-Sep-08	<2	<2		<2	<2	
SO-19	20-Oct-08	2	<2		<2	<2	
SO-20	20-Oct-08	27	79	**26**	220	240	10
SO-03	20-Oct-08	<2	<2		<2	2	
SO-21	29-Oct-08	<2	<2				
SO-27	29-Oct-08	<2	<2				
SO-05	29-Oct-08	4	7				
SO-27	04-Nov-08	2	<2		2	2	
SO-28	04-Nov-08	5	<2		5	2	
SO-03	12-Nov-08	17	14		11	33	
SO-24	12-Nov-08	17	22		13	23	
SO-08	12-Nov-08	11	7		33	49	
SO-01	20-Nov-08	2	<2		5	<2	
SO-22	20-Nov-08	2	<2		7	<2	
SO-20	20-Nov-08	11	2		33	130	**48.5**

Table 18. Duplicate freshwater microbiological samples collected during the study period. Relative percent difference were calculated only for those results greater than 10 times the minimum detection limit of <1CFU/100mL. Percent differences above the acceptable level (25%) are boldfaced.

EMS ID	Location Name	Date	Fecal Coliforms (CFU/100 ml) Sample #1	Fecal Coliforms (CFU/100 ml) Sample #2	**Fecal Coliforms (CFU/100 ml) % difference**	*E. coli* (CFU/100 ml) Sample #1	*E. coli* (CFU/100 ml) Sample #2	***E. coli* (CFU/100 ml) % difference**
E236671	DE MAMIEL CREEK AT END OF PHILLIPS ROAD	5-Aug-09	40	25	**38**	33	25	24
E245800	AYUM CREEK NEAR MOUTH	3-Sep-09	16	14	13	15	13	13
E276448	CHARTERS CREEK NEAR CONFLUENCE WITH SOOKE RIVER	26-Oct-09	75	54	**28**	70	50	**29**
E276449	TODD CREEK NEAR CONFLUENCE WITH SOOKE RIVER	19-Oct-09	4	10		4	6	
E276450	UPPER SOOKE RIVER	3-Nov-09	23	22	4	20	19	5
E276451	ALDERBROOK STREAM NEAR MOUTH	19-Aug-09	180	160	11	130	110	15
E276451	ALDERBROOK STREAM NEAR MOUTH	9-Nov-09	440	350	20	380	320	16
E276445	THROUP STREAM NEAR MOUTH	12-Aug-09	100	210	**-110**	95	80	16
E276446	LOWER SOOKE RIVER	26-Aug-09	82	80	2	72	73	-1

Table 19. Duplicate freshwater chemical physical parameter samples collected during the study period. Relative percent differences were calculated only for those results greater than 10 times the applicable minimum detection limit for a given parameter. Percent differences above the acceptable level (25%) are boldfaced.

EMS ID	LOCATION NAME	START DATE	Al-T (mg/L)	Co-T (mg/L)	Cu-T (mg/L)	Mn-T (mg/L)	Ni-T (mg/L)	Pb-D (mg/L)	Pb-T (mg/L)
E276451	MOUTH	2009-08-19							
E276451	MOUTH	2009-08-19							
		% difference	no samples > 10 times the minimum detection limit and greater than 25% difference						
E245800	AYUM CREEK NEAR MOUTH	2009-09-03							
E245800	AYUM CREEK NEAR MOUTH	2009-09-03							
		% difference	no samples > 10 times the minimum detection limit and greater than 25% difference						
E276448	CHARTERS CREEK NEAR CONFLUENCE WITH SOOKE RIVER	2009-10-26	0.115	0.000098	0.00124	0.00614	0.00035	0.000027	0.000072
E276448	CHARTERS CREEK NEAR CONFLUENCE WITH SOOKE RIVER	2009-10-26	0.157	0.000147	0.00141	0.00891	0.00031	0.000029	0.000108
		% difference	**-36.5**	**-50.0**	-13.7	**-45.1**	11.4	-7.4	**-50.0**
E236671	DE MAMIEL CREEK AT END OF PHILLIPS ROAD	2009-08-05							
E236671	DE MAMIEL CREEK AT END OF PHILLIPS ROAD	2009-08-05							
		% difference	no samples > 10 times the minimum detection limit and greater than 25% difference						
E276446	LOWER SOOKE RIVER	2009-08-26							
E276446	LOWER SOOKE RIVER	2009-08-26							
		% difference	no samples > 10 times the minimum detection limit and greater than 25% difference						
E276445	THROUP STREAM NEAR MOUTH	2009-08-12							
E276445	THROUP STREAM NEAR MOUTH	2009-08-12							
		% difference	no samples > 10 times the minimum detection limit and greater than 25% difference						
E276449	TODD CREEK NEAR CONFLUENCE WITH SOOKE RIVER	2009-10-19	0.0468	0.000047	0.00095	0.00054	0.00012	0.000051	0.000046
E276449	TODD CREEK NEAR CONFLUENCE WITH SOOKE RIVER	2009-10-19	0.0495	0.000047	0.00131	0.00055	0.00019	0.000037	0.00009
		% difference	-5.8	0.0	**-37.9**	-1.9	**-58.3**	**27.5**	**-95.7**
E276450	UPPER SOOKE RIVER	2009-11-03	0.0759	0.000068	0.00077	0.00135	0.00049	0.000018	0.000025
E276450	UPPER SOOKE RIVER	2009-11-03	0.077	0.00006	0.0008	0.00137	0.00046	0.000015	0.000024
		% difference	no samples > 10 times the minimum detection limit and greater than 25% difference						
E276450	UPPER SOOKE RIVER	2009-11-18	0.12	0.00009	0.00075	0.00333	0.00043	0.00002	0.000064
E276450	UPPER SOOKE RIVER	2009-11-18	0.121	0.000085	0.00089	0.00314	0.0004	0.000024	0.000077
		% difference	no samples > 10 times the minimum detection limit and greater than 25% difference						

APPENDIX III

Table 20. Depth profile data for Sooke Harbour and Basin collected August 12, 2008 and October 15, 2008.

Statistic	Diss Oxy (mg/L)	ORP (mV)	Salinity (ppt)	Temp (C)	pH (pH units)
MIN	5.48	209	31.03	9.39	7.34
MAX	10.4	442	31.98	16.99	8.27
AVG	7.71	381.98	31.53	12.90	7.83
STDDEV	1.46	38.80	0.23	2.07	0.28
Number of samples	91	91	91	91	91

Table 21. Summary statistics for caffeine samples in the Sooke Inlet, Basin and Harbour in the summer of 2008.

Site	Min (ng/L)	Max (ng/L)	Average (ng/L)	Standard Deviation (ng/L)	Number of Samples
SO-1	1.4	20.0	12.9	10.1	3
SO-2	6.4	18.5	9.8	5.9	4
SO-3	4.2	55.0	21.5	29.0	3
SO-4	1.8	20.5	11.2	13.2	2
SO-5	1.6	15.6	8.1	7.1	3
SO-6	64.5	64.5	64.5	n/a	1
SO-7	6.2	85.7	33.6	45.1	3
SO-8	5.8	15.2	9.4	4.1	4
SO-9	12.0	17.1	14.5	2.6	3
SO-10	0.3	9.4	4.9	6.4	2
SO-11	3.7	47.6	19.0	24.7	3
SO-12	3.9	48.6	25.6	22.4	3
SO-13	0.0	2.7	1.4	1.9	2
SO-14	1.1	5.4	3.9	2.4	3
SO-15	1.3	20.5	7.7	11.0	3
SO-16	3.9	18.7	11.3	7.4	3
SO-17	3.6	13.1	8.3	6.7	2
SO-18	-1.4	7.5	3.1	6.3	2
SO-19	2.3	12.2	7.2	7.0	2
SO-20	7.0	13.4	10.2	4.5	2
SO-21	2.0	7.3	5.0	2.7	3
SO-22	3.8	5.5	5.0	0.8	4
SO-23	3.3	63.6	19.6	29.4	4
SO-24	-0.5	19.3	7.9	10.2	3
SO-25	1.9	4.7	3.5	1.5	3
SO-26	3.8	24.0	16.9	11.3	3
SO-27	-0.1	1.0	0.5	0.6	3
SO-28	0.5	20.5	9.8	10.1	3

Table 22. Marine metals data from 9 sites in the Sooke Inlet, Basin and Harbour on August 8, 2008.

	Units	Minimum Detection Limit	CRD SO-5	CRD SO-6	CRD SO-15	CRD SO-16	CRD SO-18	CRD SO-19	CRD SO-22	CRD SO-23	CRD SO-24
EMS ID			E272573	E272574	E272583	E272584	E272586	E272587	E272590	E272591	E272592
Sampling Date			2008-08-12 9:53	2008-08-12 11:28	2008-08-12 12:47	2008-08-12 12:52	2008-08-12 9:40	2008-08-12 9:47	2008-08-12 11:18	2008-08-12 10:18	2008-08-12 10:28
Sample Start Date			20080812	20080812	20080812	20080812	20080812	20080812	20080812	20080812	20080812
Sample Start Time			9:53:00 AM	11:28:00 AM	12:47:00 PM	12:52:00 PM	9:40:00 AM	9:47:00 AM	11:18:00 AM	10:18:00 AM	10:28:00 AM
Total Hardness (CaCO3)	mg/L	0.5	6950	6830	6740	6910	6940	6910	6810	6730	6820
Total Aluminum (Al)	ug/L	10	21	<10	10	<10	<10	<10	17	16	13
Total Antimony (Sb)	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Arsenic (As)	ug/L	0.5	1.8	2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Total Barium (Ba)	ug/L	1	8	8	8	8	8	8	8	8	8
Total Beryllium (Be)	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Bismuth (Bi)	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Boron (B)	ug/L	50	3620	3680	3690	3690	3880	3660	3760	3690	3670
Total Cadmium (Cd)	ug/L	0.05	0.13	0.14	0.12	0.19	0.14	0.12	0.12	0.14	0.15
Total Chromium (Cr)	ug/L	0.5	0.9	1.0	0.9	0.7	0.8	0.5	0.8	0.7	1.0
Total Cobalt (Co)	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Copper (Cu)	ug/L	0.5	1.1	0.9	0.9	0.6	<0.5	0.6	0.5	<0.5	0.7
Total Iron (Fe)	ug/L	2	45	12	24	7	4	8	20	19	13
Total Lead (Pb)	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Lithium (Li)	ug/L	20	177	198	195	186	210	188	189	178	189
Total Manganese (Mn)	ug/L	0.5	2.5	2.0	4.9	1.8	1.9	2.0	2.8	2.6	2.5
Total Molybdenum (Mo)	ug/L	1	10	10	10	10	11	10	10	10	10
Total Nickel (Ni)	ug/L	0.2	0.5	0.5	0.5	0.4	0.6	0.4	0.5	0.8	0.7
Total Phosphorus (P)	ug/L	50	76	53	73	<50	54	63	73	80	87
Total Selenium (Se)	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Silicon (Si)	ug/L	100	324	134	240	214	159	304	646	676	691
Total Silver (Ag)	ug/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Strontium (Sr)	ug/L	10	6920	6890	7050	7060	7270	6860	7170	6790	6940
Total Thallium (Tl)	ug/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Tin (Sn)	ug/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Titanium (Ti)	ug/L	10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total Uranium (U)	ug/L	0.05	2.74	2.69	2.78	2.74	2.82	2.73	2.81	2.78	2.72
Total Vanadium (V)	ug/L	10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total Zinc (Zn)	ug/L	1	1	<1	2	<1	<1	<1	<1	<1	<1
Total Calcium (Ca)	mg/L	1	453	448	455	445	449	445	438	432	457
Total Magnesium (Mg)	mg/L	1	1410	1390	1360	1410	1410	1410	1390	1370	1380
Total Potassium (K)	mg/L	1	421	419	426	416	415	416	407	403	425
Total Sodium (Na)	mg/L	1	8520	8730	9110	8990	8740	8750	8930	8990	9090
Total Sulphur (S)	mg/L	20	1100	1080	1120	1100	1100	1090	1080	1070	1120

Table 23. 2008 marine fecal coliform data from 28 sites in the Sooke Inlet, Basin and Harbour.

Summer Fecal Coliforms														
	SO-01	*SO-02*	*SO-03*	*SO-04*	*SO-05*	*SO-06*	*SO-07*	*SO-08*	*SO-09*	*SO-10*	*SO-11*	*SO-12*	*SO-13*	*SO-14*
Mean	2.0	13.0	4.2	32.8	4.8	2.0	2.0	2.0	2.0	3.4	3.8	2.0	5.0	2.0
Geomean	2.0	6.0	3.0	14.0	4.0	2.0	2.0	2.0	2.0	3.0	3.0	2.0	3.0	2.0
Standard Error	0.0	9.1	1.4	20.0	1.2	0.0	0.0	0.0	0.0	1.4	1.8	0.0	3.0	0.0
Median	2.0	4.0	2.0	11.0	5.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Mode	2.0	2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Standard Deviation	0.0	20.3	3.0	44.7	2.8	0.0	0.0	0.0	0.0	3.1	4.0	0.0	6.7	0.0
Sample Variance	0.0	411.0	9.2	1999.7	7.7	0.0	0.0	0.0	0.0	9.8	16.2	0.0	45.0	0.0
Kurtosis		4.7	-3.0	3.6	-2.7					5.0	5.0		5.0	
Skewness		2.2	0.7	1.9	0.0					2.2	2.2		2.2	
Range	0.0	47.0	6.0	108.0	6.0	0.0	0.0	0.0	0.0	7.0	9.0	0.0	15.0	0.0
Minimum	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Maximum	2.0	49.0	8.0	110.0	8.0	2.0	2.0	2.0	2.0	9.0	11.0	2.0	17.0	2.0
Sum	10.0	65.0	21.0	164.0	24.0	10.0	10.0	10.0	10.0	17.0	19.0	10.0	25.0	10.0
Count	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	SO-15	*SO-16*	*SO-17*	*SO-18*	*SO-19*	*SO-20*	*SO-21*	*SO-22*	*SO-23*	*SO-24*	*SO-25*	*SO-26*	*SO-27*	*SO-28*
Mean	4.2	4.4	2.0	2.0	2.6	440.0	7.4	42.2	21.6	5.4	25.4	2.4	2.0	2.0
Geomean	3.0	3.0	2.0	2.0	2.0	67.0	4.0	14.0	16.0	4.0	7.0	2.0	2.0	2.0
Standard Error	2.2	1.7	0.0	0.0	0.6	387.1	4.1	32.1	7.2	2.4	21.2	0.4	0.0	0.0
Median	2.0	2.0	2.0	2.0	2.0	79.0	2.0	17.0	17.0	2.0	5.0	2.0	2.0	2.0
Mode	2.0	2.0	2.0	2.0	2.0	79.0	2.0	17.0		2.0	2.0	2.0	2.0	2.0
Standard Deviation	4.9	3.9	0.0	0.0	1.3	774.2	9.1	71.8	16.1	5.3	47.4	0.9	0.0	0.0
Sample Variance	24.2	15.3	0.0	0.0	1.8	599362.0	82.8	5150.7	257.8	27.8	2242.8	0.8	0.0	0.0
Kurtosis	5.0	2.7			5.0	4.0	3.3	4.8	-1.7	1.5	4.9	5.0		
Skewness	2.2	1.7			2.2	2.0	1.8	2.2	0.5	1.5	2.2	2.2		
Range	11.0	9.0	0.0	0.0	3.0	1598.0	21.0	168.0	39.0	12.0	108.0	2.0	0.0	0.0
Minimum	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	4.0	2.0	2.0	2.0	2.0	2.0
Maximum	13.0	11.0	2.0	2.0	5.0	1600.0	23.0	170.0	43.0	14.0	110.0	4.0	2.0	2.0
Sum	21.0	22.0	10.0	10.0	13.0	1760.0	37.0	211.0	108.0	27.0	127.0	12.0	10.0	10.0
Count	5.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Fall Fecal coliforms														
	SO-01	*SO-02*	*SO-03*	*SO-04*	*SO-05*	*SO-06*	*SO-07*	*SO-08*	*SO-09*	*SO-10*	*SO-11*	*SO-12*	*SO-13*	*SO-14*
Mean	2.4	8.2	6.0	51.2	126.4	13.8	18.0	11.6	25.6	23.6	20.8	88.2	45.6	110.8
Geomean	2.0	4.0	3.0	8.0	44.0	7.0	5.0	6.0	7.0	4.0	7.0	15.0	5.0	9.0
Standard Error	0.4	6.2	4.0	47.2	71.0	8.9	15.3	7.4	21.1	21.6	11.5	67.1	43.6	107.3
Median	2.0	2.0	2.0	5.0	23.0	8.0	2.0	5.0	5.0	2.0	2.0	8.0	2.0	5.0
Mode	2.0	2.0	2.0	2.0		8.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Standard Deviation	0.8	13.9	8.9	105.6	158.8	19.9	34.1	16.6	47.3	48.3	25.7	149.9	97.5	239.9
Sample Variance	0.6	192.2	80.0	11143.7	25232.3	396.2	1164.5	276.3	2234.3	2332.8	662.7	22479.2	9504.8	57568.7
Kurtosis	4.0	5.0	5.0	5.0	-1.8	4.6	5.0	4.5	4.9	5.0	-3.3	4.0	5.0	5.0
Skewness	2.0	2.2	2.2	2.2	0.9	2.1	2.2	2.1	2.2	2.2	0.6	2.0	2.2	2.2
Range	1.5	31.0	20.0	238.0	342.0	47.0	77.0	39.0	108.0	108.0	47.0	348.0	218.0	538.0
Minimum	2.0	2.0	2.0	2.0	8.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Maximum	3.5	33.0	22.0	240.0	350.0	49.0	79.0	41.0	110.0	110.0	49.0	350.0	220.0	540.0
Sum	9.5	41.0	30.0	256.0	632.0	69.0	90.0	58.0	128.0	118.0	104.0	441.0	228.0	554.0
Count	4.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	SO-15	*SO-16*	*SO-17*	*SO-18*	*SO-19*	*SO-20*	*SO-21*	*SO-22*	*SO-23*	*SO-24*	*SO-25*	*SO-26*	*SO-27*	*SO-28*
Mean	27.6	38.4	27.6	36.2	52.2	202.1	18.6	110.1	30.6	5.8	17.8	2.0	6.2	35.9
Geomean	5.0	8.0	5.0	6.0	9.0	140.0	6.0	7.0	9.0	4.0	8.0	2.0	3.0	5.0
Standard Error	25.6	33.0	25.6	33.5	47.0	89.8	15.1	107.5	24.9	3.1	9.5	0.0	4.2	33.5
Median	2.0	5.0	2.0	2.0	4.0	110.0	2.0	2.0	5.0	2.0	5.0	2.0	2.0	2.0
Mode	2.0	2.0	2.0	2.0	2.0		2.0	2.0	5.0	2.0	2.0	2.0	2.0	2.0
Standard Deviation	57.2	73.7	57.2	74.8	105.1	200.9	33.9	240.3	55.7	6.9	21.3	0.0	9.4	75.0
Sample Variance	3276.8	5432.3	3276.8	5596.2	11042.2	40355.3	1146.8	57755.6	3098.3	48.2	452.7	0.0	88.2	5620.1
Kurtosis	5.0	4.9	5.0	5.0	5.0	2.6	4.9	5.0	4.9	4.3	-1.1		5.0	5.0
Skewness	2.2	2.2	2.2	2.2	2.2	1.7	2.2	2.2	2.2	2.1	1.0		2.2	2.2
Range	128.0	168.0	128.0	168.0	238.0	491.0	77.0	538.0	128.0	16.0	47.0	0.0	21.0	168.0
Minimum	2.0	2.0	2.0	2.0	2.0	49.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Maximum	130.0	170.0	130.0	170.0	240.0	540.0	79.0	540.0	130.0	18.0	49.0	2.0	23.0	170.0
Sum	138.0	192.0	138.0	181.0	261.0	1010.5	93.0	550.5	153.0	29.0	89.0	8.0	31.0	179.5
Count	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0

Table 24. 2008 marine enterococci data from 28 sites in the Sooke Inlet, Basin and Harbour.

Summer Enterococci

	SO-01	*SO-02*	*SO-03*	*SO-04*	*SO-05*	*SO-06*	*SO-07*	*SO-08*	*SO-09*	*SO-10*	*SO-11*	*SO-12*	*SO-13*	*SO-14*
Mean	2.0	2.0	2.0	7.6	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Geomean	2.0	2.0	2.0	5.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Standard Error	0.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Median	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Mode	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Standard Deviation	0.0	0.0	0.0	8.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sample Variance	0.0	0.0	0.0	71.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kurtosis				0.7										
Skewness				1.3										
Range	0.0	0.0	0.0	19.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Minimum	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Maximum	2.0	2.0	2.0	21.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Sum	10.0	10.0	10.0	38.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Count	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0

	SO-15	*SO-16*	*SO-17*	*SO-18*	*SO-19*	*SO-20*	*SO-21*	*SO-22*	*SO-23*	*SO-24*	*SO-25*	*SO-26*	*SO-27*	*SO-28*
Mean	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.6	3.2	2.0	2.0	2.0	2.0
Geomean	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	2.0	2.0	2.0	2.0
Standard Error	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.2	0.0	0.0	0.0	0.0
Median	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Mode	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Standard Deviation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.7	0.0	0.0	0.0	0.0
Sample Variance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	7.2	0.0	0.0	0.0	0.0
Kurtosis									-1.0	5.0				
Skewness									1.0	2.2				
Range	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	6.0	0.0	0.0	0.0	0.0
Minimum	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Maximum	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	7.0	8.0	2.0	2.0	2.0	2.0
Sum	10.0	10.0	10.0	10.0	10.0	8.0	10.0	10.0	18.0	16.0	10.0	10.0	10.0	8.0
Count	5.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.0

Fall Enterococci

	SO-01	*SO-02*	*SO-03*	*SO-04*	*SO-05*	*SO-06*	*SO-07*	*SO-08*	*SO-09*	*SO-10*	*SO-11*	*SO-12*	*SO-13*	*SO-14*
Mean	2.0	5.0	4.7	6.4	24.3	6.0	9.0	3.4	40.6	5.8	6.0	14.4	6.8	18.0
Geomean	2.0	3.0	3.0	4.0	14.0	3.0	6.0	3.0	8.0	3.0	3.0	8.0	3.0	4.0
Standard Error	0.0	3.0	2.7	3.7	12.6	4.0	3.4	1.4	35.0	3.8	4.0	6.1	4.8	16.0
Median	2.0	2.0	2.0	2.0	8.0	2.0	7.0	2.0	2.0	2.0	2.0	12.0	2.0	2.0
Mode	2.0	2.0	2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Standard Deviation	0.0	6.7	6.0	8.3	28.1	8.9	7.6	3.1	78.2	8.5	8.9	13.5	10.7	35.8
Sample Variance	0.0	45.0	36.5	68.3	789.0	80.0	57.5	9.8	6114.8	72.2	80.0	183.3	115.2	1280.0
Kurtosis		5.0	5.0	4.5	1.4	5.0	-3.1	5.0	4.9	5.0	5.0	-1.6	5.0	5.0
Skewness		2.2	2.2	2.1	1.5	2.2	0.3	2.2	2.2	2.2	2.2	0.5	2.2	2.2
Range	0.0	15.0	13.5	19.0	65.0	20.0	15.0	7.0	178.0	19.0	20.0	31.0	24.0	80.0
Minimum	2.0	2.0	2.0	2.0	5.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Maximum	2.0	17.0	15.5	21.0	70.0	22.0	17.0	9.0	180.0	21.0	22.0	33.0	26.0	82.0
Sum	8.0	25.0	23.5	32.0	121.5	30.0	45.0	17.0	203.0	29.0	30.0	72.0	34.0	90.0
Count	4.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0

	SO-15	*SO-16*	*SO-17*	*SO-18*	*SO-19*	*SO-20*	*SO-21*	*SO-22*	*SO-23*	*SO-24*	*SO-25*	*SO-26*	*SO-27*	*SO-28*
Mean	4.4	5.0	5.8	17.4	6.8	45.5	11.2	8.4	9.6	5.5	4.2	2.0	11.4	8.5
Geomean	3.0	3.0	3.0	4.0	3.0	28.0	4.0	4.0	4.0	3.0	3.0	2.0	4.0	4.0
Standard Error	2.4	3.0	3.8	15.4	4.8	18.8	9.2	6.4	7.6	3.5	2.2	0.0	9.4	6.1
Median	2.0	2.0	2.0	2.0	2.0	49.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Mode	2.0	2.0	2.0	2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Standard Deviation	5.4	6.7	8.5	34.4	10.7	42.1	20.6	14.3	17.0	7.8	4.9	0.0	21.0	13.7
Sample Variance	28.8	45.0	72.2	1185.8	115.2	1770.5	423.2	204.8	288.8	61.3	24.2	0.0	441.8	188.0
Kurtosis	5.0	5.0	5.0	5.0	5.0	0.5	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Skewness	2.2	2.2	2.2	2.2	2.2	0.9	2.2	2.2	2.2	2.2	2.2		2.2	2.2
Range	12.0	15.0	19.0	77.0	24.0	103.5	46.0	32.0	38.0	17.5	11.0	0.0	47.0	31.0
Minimum	2.0	2.0	2.0	2.0	2.0	6.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Maximum	14.0	17.0	21.0	79.0	26.0	110.0	48.0	34.0	40.0	19.5	13.0	2.0	49.0	33.0
Sum	22.0	25.0	29.0	87.0	34.0	227.5	56.0	42.0	48.0	27.5	21.0	8.0	57.0	42.5
Count	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0

APPENDIX IV

Table 25. Freshwater site summary statistics from the Sooke watersheds (highlighted indicates values are less than detection limit).

EMS ID	E236671					E245800					E276444				
LOCATION NAME	DE MAMIEL CREEK AT END OF PHILLIPS ROAD (2009)					AYUM CREEK NEAR MOUTH					NOTT BROOK NEAR MOUTH				
Parameter	Standard Deviation	Minimum	Maximum	Average	# of samples	Standard Deviation	Minimum	Maximum	Average	# of samples	Standard Deviation	Minimum	Maximum	Average	# of samples
Ag-D (mg/L)	0	0.000005	0.000005	0.000005	5	0.00000	0.000005	0.000006	0.00001	5	0	0.000005	0.000005	0.00001	5
Ag-T (mg/L)	0	0.000005	0.000005	0.000005	5	0	0.000005	0.000005	0.000005	6	0.00000	0.000005	0.000007	0.00001	5
Al-D (mg/L)	0.0170	0.0543	0.095	0.0772	5	0.0217	0.0295	0.0842	0.0615	5	0.0516	0.0677	0.2	0.1315	5
Al-T (mg/L)	0.0689	0.0653	0.239	0.1248	5	0.0406	0.0116	0.106	0.0660	6	0.0858	0.0759	0.281	0.1846	5
Amonia Dissolved (mg/L)							0.005	0.005	0.005	1					
As-D (mg/L)	0.00001	0.00006	0.00008	0.00007	5	0.00002	0.00004	0.00008	0.00006	5	0.00002	0.00019	0.00025	0.00022	5
As-T (mg/L)	0.00002	0.00005	0.00009	0.00007	5	0.00001	0.00006	0.00009	0.00007	6	0.00004	0.0002	0.00028	0.00024	5
B--D (mg/L)	0	0.05	0.05	0.05	5	0.00	0.05	0.05	0.05	5	0	0.05	0.05	0.05	5
B--T (mg/L)	0	0.05	0.05	0.05	5	0.00	0.05	0.05	0.05	6	0	0.05	0.05	0.05	5
Ba-D (mg/L)	0.00011	0.00107	0.00136	0.00120	5	0.00058	0.00118	0.00263	0.00162	5	0.00077	0.00675	0.00845	0.00758	5
Ba-T (mg/L)	0.0004	0.0012	0.0022	0.0015	5	0.0005	0.00117	0.00264	0.0017	6	0.0011	0.00704	0.00997	0.0082	5
Be-D (mg/L)	0	0.00001	0.00001	0.00001	5	0	0.00001	0.00001	0.00001	5	0	0.00001	0.00001	0.00001	5
Be-T (mg/L)	0	0.00001	0.00001	0.00001	5	0	0.00001	0.00001	0.00001	6	0	0.00001	0.00001	0.00001	5
Bi-D (mg/L)	0	0.000005	0.000005	0.000005	5	0	0.000005	0.000005	0.000005	5	0	0.000005	0.000005	0.000005	5
Bi-T (mg/L)	0	0.000005	0.000005	0.000005	5	0.00005	0.000005	0.000121	0.000025	6	0.000001	0.000005	0.000006	0.000005	5
Ca-D (mg/L)	0.22	2.72	3.28	3.07	5	1.76	3.05	7.54	4.53	5	4.71	9.56	21.5	13.57	5
Ca-T (mg/L)	0.18	2.82	3.23	3.07	5	1.38	3.32	6.89	4.83	6	4.78	9.92	22.1	13.88	5
Carbon Total Organic (mg/L)							2.7	2.7	2.7	1					
Cd-D (mg/L)	0.000004	0.000005	0.000013	0.000009	5	0.000014	0.000005	0.000039	0.000019	5	0.000006	0.000006	0.000021	0.000012	5
Cd-T (mg/L)	0.000002	0.000005	0.000009	0.000006	5	0.000063	0.000005	0.000167	0.000041	6	0.000004	0.000005	0.000014	0.000010	5
Co-D (mg/L)	0.00001	0.00005	0.000071	0.00006	5	0.00000	0.000043	0.000054	0.00005	5	0.00002	0.000124	0.000165	0.00014	5
Co-T (mg/L)	0.000085	0.000083	0.000284	0.000142	5	0.000019	0.00002	0.000079	0.000051	6	0.000059	0.00014	0.000294	0.000196	5
Coli:Fec (CFU/100mL)	171	25	540	150	11	40	1	140	22	11	401	42	1000	305	5
Color True (Col.unit)							5	5	5	1					
Cr-D (mg/L)	0.0000	0.0002	0.0002	0.0002	5	0.0001	0.0001	0.0004	0.0002	5	0.0001	0.0003	0.0005	0.0004	5
Cr-T (mg/L)	0.0002	0.0002	0.0007	0.0004	5	0.0001	0.0001	0.0002	0.0001	6	0.0001	0.0002	0.0005	0.0003	5
Cu-D (mg/L)	0.00028	0.00097	0.00172	0.00134	5	0.00044	0.00005	0.00123	0.00078	5	0.00048	0.00233	0.00356	0.00280	5
Cu-T (mg/L)	0.00041	0.0012	0.00225	0.00154	5	0.00031	0.00081	0.00159	0.00111	6	0.00055	0.00269	0.00402	0.00305	5
Dissolved Oxygen (mg/L) (field)	1.62	11.16	16.4	13.07	11	2.94	8.21	15.5	11.11	11	0.86	11.94	13.96	12.78	5
E Coli (CFU/100mL)	144	8	480	120	11	37	1	130	18	11	370	12	900	327	5
Entercoc (CFU/100mL)															
Hardness Total (D) (mg/L)	1.04	12.5	15.4	14.10	5	7.27	12.7	31.2	18.78	5	19.97	39.5	89.9	55.94	5
Hardness Total (T) (mg/L)	1.26	12.9	16	14.08	5	5.67	13.4	28.5	19.98	6	19.72	41.2	91	56.92	5
Li-D (mg/L)	0	0.0005	0.0005	0.0005	5	0	0.0005	0.0005	0.0005	5	0	0.0005	0.0005	0.0005	5
Li-T (mg/L)	0	0.0005	0.0005	0.0005	5	0	0.0005	0.0005	0.0005	6	0	0.0005	0.0005	0.0005	5
Mg-D (mg/L)	0.16	1.39	1.8	1.56	5	0.70	1.22	3.01	1.81	5	2.01	3.79	8.82	5.37	5
Mg-T (mg/L)	0.23	1.4	1.94	1.56	5	0.55	1.24	2.74	1.92	6	1.90	3.99	8.7	5.41	5
Mn-D (mg/L)	0.00071	0.00211	0.00403	0.00285	5	0.00081	0.00009	0.00215	0.00090	5	0.01302	0.00846	0.0401	0.01764	5
Mn-T (mg/L)	0.00792	0.00376	0.0218	0.00953	5	0.00125	0.00047	0.00381	0.00154	6	0.01251	0.0159	0.0411	0.02702	5
Mo-D (mg/L)	0	0.00005	0.00005	0.00005	5	0	0.00005	0.00005	0.00005	5	0.00005	0.00006	0.00017	0.00009	5
Mo-T (mg/L)	0	0.00005	0.00005	0.00005	5	0	0.00005	0.00005	0.00005	6	0.00003	0.00006	0.00013	0.00008	5
N.Kjel:T (mg/L)							0.09	0.09	0.09	1					
NO2+NO3 (mg/L)							0.98	0.98	0.98	1					
Ni-D (mg/L)	0.00007	0.00017	0.00034	0.00025	5	0.00002	0.00012	0.00016	0.00014	5	0.00014	0.00043	0.00081	0.00061	5
Ni-T (mg/L)	0.00348	0.0002	0.00805	0.00183	5	0.00007	0.00009	0.00025	0.00016	6	0.00010	0.00054	0.0008	0.00065	5
Nitrate (NO3) Dissolved (mg/L)							0.983	0.983	0.983	1					
Nitrate + Nitrite Diss. (mg/L)							0.983	0.983	0.983	1					
Nitrogen - Nitrite Diss. (mg/L)							0.002	0.002	0.002	1					
Nitrogen Organic-Total (mg/L)							0.09	0.09	0.09	1					
Nitrogen Total (mg/L)							1.07	1.07	1.07	1					
Ortho-Phosphate Dissolved (mg/L)							0.001	0.001	0.001	1					
P--T (mg/L)	0.002	0.003	0.008	0.005	6	0.002	0.003	0.008	0.005	7					
Pb-D (mg/L)	0.000011	0.000011	0.000037	0.000023	5	0.000008	0.000011	0.000031	0.000018	5	0.000030	0.000047	0.000116	0.000082	5
Pb-T (mg/L)	0.000023	0.000025	0.000081	0.000043	5	0.000027	0.00002	0.000084	0.000045	6	0.000064	0.000121	0.000271	0.000180	5
Phosphorus Tot. Dissolved (mg/L)															
Res:Tot (mg/L)							41	41	41	1					
Residue Filterable 1.0u (mg/L)							40	40	40	1					
Residue Non-filterable (mg/L)							1	1	1	1					
Sb-D (mg/L)	0	0.00002	0.00002	0.00002	5	0	0.00002	0.00002	0.00002	5	0.00001	0.00006	0.00009	0.00008	5
Sb-T (mg/L)	0	0.00002	0.00002	0.00002	5	0.00000	0.00002	0.00003	0.00002	6	0.00001	0.00006	0.00009	0.00007	5
Se-D (mg/L)	0.00000	0.00004	0.00005	0.00004	5	0.00001	0.00004	0.00006	0.00004	5	0.00082	0.00014	0.00201	0.00055	5
Se-T (mg/L)	0.00000	0.00004	0.00005	0.00004	5	0.00001	0.00004	0.00005	0.00005	6	0.00085	0.00013	0.00208	0.00057	5
Sn-D (mg/L)	0	0.00001	0.00001	0.00001	5	0	0.00001	0.00001	0.00001	5	0	0.00001	0.00001	0.00001	5
Sn-T (mg/L)	0	0.00001	0.00001	0.00001	5	0	0.00001	0.00001	0.00001	6	0	0.00001	0.00001	0.00001	5
Specific Conductance (uS/cm) (lab)							85	85	85	1					
Specific Conductance (uS/cm) (field)		121	121	121	1		65	65	65	1		200	200	200	1
Sr-D (mg/L)	0.00076	0.00854	0.0101	0.00930	5	0.00435	0.00748	0.0184	0.01092	5	0.01253	0.0371	0.0675	0.04560	5
Sr-T (mg/L)	0.00128	0.00846	0.0113	0.00942	5	0.00365	0.00717	0.0175	0.01139	6	0.01066	0.0375	0.0637	0.04496	5
Strepcoc (CFU/100mL)															
Temperature (C) (field)	3.68	7.49	17.6	12.88	11	2.73	7.45	14.68	11.89	11	1.40	7.88	11.64	9.84	5
Tl-D (mg/L)	0	0.000002	0.000002	0.000002	5	0	0.000002	0.000002	0.000002	5	0	0.000002	0.000002	0.000002	5
Tl-T (mg/L)	0	0.000002	0.000002	0.000002	5	0	0.000002	0.000002	0.000002	6	0	0.000002	0.000002	0.000002	5
Turbidit (NTU)	1.13	0.2	4	1.23	11	0.24	0.1	1	0.35	12	3.17	2.7	10.6	5.14	5
U--D (mg/L)	0.000001	0.000002	0.000005	0.000003	5	0.000001	0.000002	0.000004	0.000002	5	0.000001	0.000008	0.000011	0.000010	5
U--T (mg/L)	0.000003	0.000002	0.000008	0.000004	5	0.000001	0.000002	0.000005	0.000003	6	0.000003	0.000007	0.000015	0.000012	5
V--D (mg/L)	0.0001	0.0005	0.0008	0.0006	5	0.0002	0.0002	0.0007	0.0004	5	0.0002	0.0009	0.0013	0.0010	5
V--T (mg/L)	0.0004	0.0005	0.0014	0.0007	5	0.0002	0.0004	0.0007	0.0005	6	0.0002	0.0009	0.0015	0.0012	5
Zn-D (mg/L)	0.0007	0.0001	0.0018	0.0008	5	0.0005	0.0001	0.0014	0.0005	5	0.0010	0.0023	0.0048	0.0036	5
Zn-T (mg/L)	0.0004	0.0007	0.0017	0.0010	5	0.0005	0.0003	0.0016	0.0007	6	0.0016	0.0023	0.0065	0.0044	5
pH (pH units)		7.1	7.1	7.1	1	0.28	7	7.4	7.2	2		7.5	7.5	7.5	1

EMS ID	E276445					E276446					E276447				
LOCATION NAME	THROUP STREAM NEAR MOUTH					LOWER SOOKE RIVER					BAKER CREEK NEAR CONFLUENCE WITH SOOKE RIVER				
Parameter	Standard Deviation	Minimum	Maximum	Average	# of samples	Standard Deviation	Minimum	Maximum	Average	# of samples	Standard Deviation	Minimum	Maximum	Average	# of samples
Ag-D (mg/L)	0	0.000005	0.000005	0.000005	5	0	0.000005	0.000005	0.000005	5	0	0.000005	0.000005	0.000005	5
Ag-T (mg/L)	0	0.000005	0.000005	0.000005	5	0	0.000005	0.000005	0.000005	5	0	0.000005	0.000005	0.000005	5
Al-D (mg/L)	0.0379	0.0175	0.108	0.0586	5	0.0054	0.0719	0.0851	0.0774	5	0.0357	0.0195	0.111	0.0689	5
Al-T (mg/L)	0.1043	0.0273	0.278	0.1319	5	0.0196	0.074	0.118	0.0963	5	0.0633	0.0216	0.185	0.1036	5
Amonia Dissolved (mg/L)															
As-D (mg/L)	0.00004	0.00013	0.00022	0.00017	5	0.00004	0.00009	0.00019	0.00012	5	0.00005	0.00007	0.0002	0.00011	5
As-T (mg/L)	0.00006	0.00011	0.00027	0.00019	5	0.00004	0.00009	0.00018	0.00012	5	0.00005	0.00008	0.0002	0.00014	5
B--D (mg/L)	0.00	0.05	0.056	0.05	5	0	0.05	0.05	0.05	5	0	0.05	0.05	0.05	5
B--T (mg/L)	0.00	0.05	0.059	0.05	5	0	0.05	0.05	0.05	5	0	0.05	0.05	0.05	5
Ba-D (mg/L)	0.00093	0.00706	0.00959	0.00803	5	0.00051	0.00227	0.00347	0.00272	5	0.00097	0.00233	0.00482	0.00322	5
Ba-T (mg/L)	0.0015	0.00712	0.0105	0.0087	5	0.00037	0.00231	0.0033	0.00273	5	0.00086	0.0026	0.00466	0.00351	5
Be-D (mg/L)	0	0.00001	0.00001	0.00001	5	0	0.00001	0.00001	0.00001	5	0	0.00001	0.00001	0.00001	5
Be-T (mg/L)	0	0.00001	0.00001	0.00001	5	0	0.00001	0.00001	0.00001	5	0	0.00001	0.00001	0.00001	5
Bi-D (mg/L)	0	0.000005	0.000005	0.000005	5	0	0.000005	0.000005	0.000005	5	0	0.000005	0.000005	0.000005	5
Bi-T (mg/L)	0	0.000005	0.000005	0.000005	5	0	0.000005	0.000005	0.000005	5	0	0.000005	0.000005	0.000005	5
Ca-D (mg/L)	2.39	10.4	16	13.34	5	1.79	2.24	6.63	3.49	5	2.46	3.91	10.1	5.94	5
Ca-T (mg/L)	1.63	11	14.7	13.10	5	1.71	2.29	6.51	3.50	5	2.43	3.94	10.2	6.00	5
Carbon Total Organic (mg/L)															
Cd-D (mg/L)	0.000003	0.000005	0.000011	0.000008	5	0.000005	0.000006	0.000019	0.000011	5	0.000007	0.000005	0.000021	0.000010	5
Cd-T (mg/L)	0.000004	0.000005	0.000014	0.000009	5	0.000008	0.000005	0.000023	0.000009	5	0.000004	0.000005	0.000015	0.000008	5
Co-D (mg/L)	0.00004	0.000084	0.000196	0.00012	5	0.000017	0.000031	0.00008	0.000055	5	0.000026	0.000068	0.000134	0.000092	5
Co-T (mg/L)	0.000081	0.000096	0.000264	0.000190	5	0.000019	0.00005	0.000099	0.000075	5	0.000038	0.000106	0.000198	0.000132	5
Coli:Fec (CFU/100mL)	470	5	1400	321	11	170	13	470	181	11	513	38	1200	392	10
Color True (Col.unit)															
Cr-D (mg/L)	0.0000	0.0002	0.0003	0.0003	5	0.0000	0.0001	0.0001	0.0001	5	0.0000	0.0002	0.0002	0.0002	5
Cr-T (mg/L)	0.0002	0.0002	0.0007	0.0004	5	0.0000	0.0001	0.0002	0.0001	5	0.0001	0.0002	0.0004	0.0002	5
Cu-D (mg/L)	0.00093	0.00086	0.00328	0.00185	5	0.00010	0.00075	0.00103	0.00088	5	0.00026	0.00087	0.00156	0.00113	5
Cu-T (mg/L)	0.00118	0.00088	0.00387	0.00203	5	0.00017	0.00079	0.00116	0.00096	5	0.00033	0.00101	0.00183	0.00126	5
Dissolved Oxygen (mg/L) (field)	1.23	12.41	16.45	13.40	11	1.81	10.86	16.79	13.06	11	1.90	9.7	14.99	12.20	10
E Coli (CFU/100mL)	402	2	1100	241	11	143	12	430	153	11	489	28	1200	352	10
Entercoc (CFU/100mL)															
Hardness Total (D) (mg/L)	16.88	41.5	82.1	59.84	5	20.27	8.5	56.4	20.38	5	10.34	16.4	42.7	25.28	5
Hardness Total (T) (mg/L)	17.32	43.7	87.1	59.40	5	19.10	8.6	54	20.04	5	10.00	16.3	42.4	25.20	5
Li-D (mg/L)	0.0003	0.0005	0.0012	0.0006	5	0.0005	0.0005	0.0016	0.0007	5	0	0.0005	0.0005	0.0005	5
Li-T (mg/L)	0.0002	0.0005	0.001	0.0006	5	0.0004	0.0005	0.0013	0.0007	5	0	0.0005	0.0005	0.0005	5
Mg-D (mg/L)	3.08	3.81	11.4	6.46	5	3.84	0.7	9.67	2.83	5	1.01	1.62	4.22	2.53	5
Mg-T (mg/L)	3.47	3.93	12.4	6.46	5	3.60	0.7	9.16	2.74	5	0.97	1.57	4.13	2.49	5
Mn-D (mg/L)	0.01979	0.00486	0.052	0.01966	5	0.00065	0.00087	0.00246	0.00132	5	0.00732	0.0057	0.0229	0.00989	5
Mn-T (mg/L)	0.01677	0.0133	0.0544	0.02546	5	0.0010	0.00139	0.00384	0.0024	5	0.0081	0.00815	0.0265	0.0147	5
Mo-D (mg/L)	0.00003	0.00007	0.00015	0.00010	5	0.00002	0.00005	0.00009	0.00006	5	0.00000	0.00005	0.00005	0.00005	5
Mo-T (mg/L)	0.00002	0.00008	0.00013	0.00009	5	0.00001	0.00005	0.00007	0.00005	5	0.00000	0.00005	0.00005	0.00005	5
N.Kjel:T (mg/L)															
NO2+NO3 (mg/L)															
Ni-D (mg/L)	0.00015	0.00024	0.00062	0.00041	5	0.00010	0.00037	0.00062	0.00046	5	0.00002	0.00019	0.00025	0.00021	5
Ni-T (mg/L)	0.00022	0.00025	0.00076	0.00048	5	0.00010	0.00036	0.00063	0.00045	5	0.00004	0.00023	0.00032	0.00026	5
Nitrate (NO3) Dissolved (mg/L)															
Nitrate + Nitrite Diss. (mg/L)															
Nitrogen - Nitrite Diss. (mg/L)															
Nitrogen Organic-Total (mg/L)															
Nitrogen Total (mg/L)															
Ortho-Phosphate Dissolved (mg/L)															
P--T (mg/L)	0.002	0.004	0.009	0.007	6	0.024	0.005	0.065	0.015	6	0.001	0.006	0.009	0.008	5
Pb-D (mg/L)	0.000056	0.000007	0.000142	0.000048	5	0.000006	0.000017	0.00003	0.000027	5	0.000010	0.000015	0.000037	0.000025	5
Pb-T (mg/L)	0.000064	0.000021	0.00016	0.000093	5	0.000035	0.000018	0.000116	0.000061	5	0.000022	0.000039	0.000096	0.000059	5
Phosphorus Tot. Dissolved (mg/L)															
Res:Tot (mg/L)															
Residue Filterable 1.0u (mg/L)															
Residue Non-filterable (mg/L)															
Sb-D (mg/L)	0.00002	0.00005	0.0001	0.00007	5	0	0.00002	0.00002	0.00002	5	0.00001	0.00002	0.00003	0.00002	5
Sb-T (mg/L)	0.00002	0.00004	0.0001	0.00007	5	0	0.00002	0.00002	0.00002	5	0	0.00002	0.00002	0.00002	5
Se-D (mg/L)	0.00001	0.00005	0.00008	0.00007	5	0.000004	0.00004	0.00005	0.00004	5	0.00001	0.00004	0.00006	0.00005	5
Se-T (mg/L)	0.00001	0.00005	0.00009	0.00007	5	0.00001	0.00004	0.00005	0.00004	5	0.00001	0.00004	0.00007	0.00005	5
Sn-D (mg/L)	0	0.00001	0.00001	0.00001	5	0	0.00001	0.00001	0.00001	5	0	0.00001	0.00001	0.00001	5
Sn-T (mg/L)	0	0.00001	0.00001	0.00001	5	0	0.00001	0.00001	0.00001	5	0	0.00001	0.00001	0.00001	5
Specific Conductance (uS/cm) (lab)															
Specific Conductance (uS/cm) (field)		578	578	578	1		200	200	200	1		200	200	200	1
Sr-D (mg/L)	0.01605	0.0401	0.0815	0.0549	5	0.0236	0.0103	0.0659	0.0240	5	0.0089	0.0134	0.0355	0.0202	5
Sr-T (mg/L)	0.01751	0.0404	0.0846	0.0544	5	0.0267	0.0101	0.0731	0.0256	5	0.0076	0.0129	0.0326	0.0196	5
Strepcoc (CFU/100mL)															
Temperature (C) (field)	0.57	8.63	10.7	9.97	11	5.71	6.25	21.86	14.21	11	1.47	8.49	12.73	10.96	10
Tl-D (mg/L)	0.0000000	0.000002	0.000002	0.000002	5	0.0000000	0.000002	0.000002	0.000002	5	0.0000000	0.000002	0.000002	0.000002	5
Tl-T (mg/L)	0.0000004	0.000002	0.000003	0.000002	5	0.0000004	0.000002	0.000003	0.000002	5	0.0000000	0.000002	0.000002	0.000002	5
Turbidit (NTU)	2.13	0.4	6.9	1.81	11	0.93	0.4	3	1.22	11	0.81	0.6	2.8	1.51	10
U--D (mg/L)	0.000003	0.000004	0.000012	0.000007	5	0.000005	0.000002	0.000014	0.000006	5	0.0000004	0.000002	0.000003	0.000002	5
U--T (mg/L)	0.000005	0.000002	0.000013	0.000009	5	0.000005	0.000002	0.000016	0.000007	5	0.0000012	0.000002	0.000005	0.000003	5
V--D (mg/L)	0.0001	0.0005	0.0007	0.0006	5	0.0001	0.0002	0.0003	0.0002	5	0.0001	0.0005	0.0007	0.0006	5
V--T (mg/L)	0.0004	0.0004	0.0013	0.0008	5	0.0001	0.0002	0.0004	0.0003	5	0.0002	0.0004	0.001	0.0006	5
Zn-D (mg/L)	0.0026	0.0019	0.0084	0.0042	5	0.0003	0.0001	0.0008	0.0004	5	0.0012	0.0005	0.0036	0.0023	5
Zn-T (mg/L)	0.0032	0.0019	0.0096	0.0048	5	0.0004	0.0005	0.0015	0.0008	5	0.0007	0.0022	0.0038	0.0032	5
pH (pH units)		7.4	7.4	7.4	1		7.1	7.1	7.1	1		7.3	7.3	7.3	1

EMS ID	E276448					E276449					E276450				
LOCATION NAME	CHARTERS CREEK NEAR CONFLUENCE WITH SOOKE RIVER					TODD CREEK NEAR CONFLUENCE WITH SOOKE RIVER					UPPER SOOKE RIVER				
Parameter	Standard Deviation	Minimum	Maximum	Average	# of samples	Standard Deviation	Minimum	Maximum	Average	# of samples	Standard Deviation	Minimum	Maximum	Average	# of samples
Ag-D (mg/L)	0.000000	0.000005	0.000006	0.000005	6	0	0.000005	0.000005	0.000005	6	0	0.000005	0.000005	0.000005	7
Ag-T (mg/L)	0	0.000005	0.000005	0.000005	6	0	0.000005	0.000005	0.000005	6	0	0.000005	0.000005	0.000005	8
Al-D (mg/L)	0.0249	0.0264	0.0885	0.0716	6	0.0223	0.0493	0.109	0.0683	6	0.0063	0.064	0.0847	0.0739	7
Al-T (mg/L)	0.0408	0.0402	0.157	0.0961	6	0.0241	0.0468	0.0998	0.0736	6	0.0355	0.0112	0.121	0.0857	8
Amonia Dissolved (mg/L)												0.005	0.005	0.005	1
As-D (mg/L)	0.00001	0.00005	0.00007	0.00006	6	0.00002	0.00003	0.00007	0.00004	6	0.00003	0.00005	0.00013	0.00010	7
As-T (mg/L)	0.00001	0.00005	0.00008	0.00007	6	0.00001	0.00004	0.00006	0.00005	6	0.00003	0.00009	0.0002	0.00013	8
B--D (mg/L)	0.00	0.05	0.05	0.05	6	0.00	0.05	0.05	0.05	6	0.00	0.05	0.05	0.05	7
B--T (mg/L)	0.00	0.05	0.05	0.05	6	0.00	0.05	0.05	0.05	6	0.00	0.05	0.05	0.05	8
Ba-D (mg/L)	0.00040	0.00141	0.00248	0.00195	6	0.00024	0.00116	0.00175	0.00150	6	0.00045	0.00232	0.00354	0.00281	7
Ba-T (mg/L)	0.00060	0.00148	0.00279	0.00214	6	0.00025	0.00118	0.00183	0.00150	6	0.00138	0.00264	0.0064	0.00349	8
Be-D (mg/L)	0	0.00001	0.00001	0.00001	6	0	0.00001	0.00001	0.00001	6	0	0.00001	0.00001	0.00001	7
Be-T (mg/L)	0	0.00001	0.00001	0.00001	6	0	0.00001	0.00001	0.00001	6	0	0.00001	0.00001	0.00001	8
Bi-D (mg/L)	0	0.000005	0.000005	0.000005	6	0	0.000005	0.000005	0.000005	6	0	0.000005	0.000005	0.000005	7
Bi-T (mg/L)	0.000000	0.000005	0.000006	0.000005	6	0	0.000005	0.000005	0.000005	6	0.000001	0.000005	0.000007	0.000005	8
Ca-D (mg/L)	0.96	2.17	4.86	3.27	6	0.83	2.2	4.22	3.26	6	0.47	2.19	3.49	2.70	7
Ca-T (mg/L)	0.97	2.13	4.88	3.28	6	0.72	2.17	4.02	3.09	6	1.33	2.2	6.27	3.06	8
Carbon Total Organic (mg/L)												2.7	2.7	2.70	1
Cd-D (mg/L)	0.000002	0.000005	0.000008	0.000006	6	0.000008	0.000005	0.000023	0.000011	6	0.000036	0.000005	0.000103	0.000020	7
Cd-T (mg/L)	0.000003	0.000005	0.000013	0.000008	6	0.000015	0.000005	0.000045	0.000014	6	0.000040	0.000005	0.000121	0.000021	8
Co-D (mg/L)	0.000011	0.000035	0.000063	0.000047	6	0.000005	0.000033	0.000048	0.000042	6	0.000009	0.000043	0.000068	0.000053	7
Co-T (mg/L)	0.000042	0.000041	0.000147	0.000073	6	0.000005	0.000043	0.000058	0.000049	6	0.000021	0.000026	0.000092	0.000069	8
Coli:Fec (CFU/100mL)	25	2	75	17	11	7	1	25	7	11	34	7	120	34	11
Color True (Col.unit)											#DIV/0!	5	5	5	1
Cr-D (mg/L)	0.0000	0.0001	0.0002	0.0001	6	0	0.0001	0.0001	0.0001	6	0.0001	0.0001	0.0003	0.0001	7
Cr-T (mg/L)	0.0001	0.0001	0.0002	0.0001	6	0	0.0001	0.0001	0.0001	6	0.0000	0.0001	0.0002	0.0001	8
Cu-D (mg/L)	0.00023	0.00052	0.00106	0.00079	6	0.00018	0.00062	0.00108	0.00079	6	0.00020	0.00056	0.00104	0.00074	7
Cu-T (mg/L)	0.00087	0.00062	0.003	0.00134	6	0.00025	0.00068	0.00137	0.00109	6	0.00018	0.00066	0.00121	0.00088	8
Dissolved Oxygen (mg/L) (field)	1.85	10.86	16.2	12.95	11	1.66	11.8	16.26	13.60	11	2.26	10.66	16.4	13.52	11
E Coli (CFU/100mL)	23	2	70	15	11	3	1	13	5	11	18	7	69	23	11
Entercoc (CFU/100mL)															
Hardness Total (D) (mg/L)	3.40	8.8	18.3	12.85	6	3.35	8.9	17.1	13.25	6	1.56	7.8	12.2	9.57	7
Hardness Total (T) (mg/L)	3.34	8.7	18.2	12.85	6	2.98	8.9	16.2	12.63	6	4.27	7.7	20.9	10.69	8
Li-D (mg/L)	0	0.0005	0.0005	0.0005	6	0	0.0005	0.0005	0.0005	6	0	0.0005	0.0005	0.0005	7
Li-T (mg/L)	0	0.0005	0.0005	0.0005	6	0	0.0005	0.0005	0.0005	6	0.0001	0.0005	0.0007	0.0005	8
Mg-D (mg/L)	0.25	0.82	1.5	1.14	6	0.31	0.84	1.6	1.24	6	0.10	0.56	0.84	0.69	7
Mg-T (mg/L)	0.22	0.82	1.45	1.13	6	0.29	0.84	1.59	1.20	6	0.23	0.54	1.27	0.75	8
Mn-D (mg/L)	0.00063	0.00016	0.00167	0.00088	6	0.00023	0.00028	0.00092	0.00048	6	0.00038	0.00091	0.00201	0.00120	7
Mn-T (mg/L)	0.0033	0.00087	0.00891	0.0035	6	0.00036	0.00045	0.00142	0.00071	6	0.00088	0.00135	0.00333	0.00220	8
Mo-D (mg/L)	0	0.00005	0.00005	0.00005	6	0	0.00005	0.00005	0.00005	6	0.00000	0.00005	0.00005	0.00005	7
Mo-T (mg/L)	0	0.00005	0.00005	0.00005	6	0	0.00005	0.00005	0.00005	6	0.00000	0.00005	0.00005	0.00005	8
N.Kjel:T (mg/L)												0.11	0.11	0.11	1
NO2+NO3 (mg/L)												0.17	0.17	0.17	1
Ni-D (mg/L)	0.00004	0.0001	0.00022	0.00015	6	0.00002	0.00011	0.00016	0.00013	6	0.00005	0.00037	0.00052	0.00045	7
Ni-T (mg/L)	0.00010	0.0001	0.00035	0.00021	6	0.00003	0.00009	0.00019	0.00013	6	0.00008	0.00033	0.00058	0.00046	8
Nitrate (NO3) Dissolved (mg/L)												0.171	0.171	0.171	1
Nitrate + Nitrite Diss. (mg/L)												0.171	0.171	0.171	1
Nitrogen - Nitrite Diss. (mg/L)												0.002	0.002	0.002	1
Nitrogen Organic-Total (mg/L)												0.11	0.11	0.11	1
Nitrogen Total (mg/L)												0.28	0.28	0.28	1
Ortho-Phosphate Dissolved (mg/L)												0.001	0.001	0.001	1
P--T (mg/L)	0.001	0.003	0.007	0.005	5	0.002	0.003	0.007	0.005	5	0.007	0.002	0.021	0.006	6
Pb-D (mg/L)	0.000009	0.000013	0.000038	0.000025	6	0.000018	0.000013	0.000057	0.000034	6	0.000088	0.000015	0.000251	0.000052	7
Pb-T (mg/L)	0.000110	0.000026	0.000314	0.000098	6	0.000024	0.000036	0.00009	0.000068	6	0.000099	0.000019	0.000315	0.000076	8
Phosphorus Tot. Dissolved (mg/L)															
Res:Tot (mg/L)												25	25	25	1
Residue Filterable 1.0u (mg/L)												24	24	24	1
Residue Non-filterable (mg/L)												1	1	1	1
Sb-D (mg/L)	0.00002	0.00002	0.00007	0.00003	6	0.000000	0.00002	0.00002	0.00002	6	0.000023	0.00002	0.00008	0.00003	7
Sb-T (mg/L)	0	0.00002	0.00002	0.00002	6	0.000000	0.00002	0.00002	0.00002	6	0.000007	0.00002	0.00004	0.00002	8
Se-D (mg/L)	0.000004	0.00004	0.00005	0.00004	6	0.000000	0.00004	0.00004	0.00004	6	0.000004	0.00004	0.00005	0.00004	7
Se-T (mg/L)	0.00001	0.00004	0.00006	0.00005	6	0.000005	0.00004	0.00005	0.00005	6	0	0.00004	0.00004	0.00004	8
Sn-D (mg/L)	0.00000	0.00001	0.00002	0.00001	6	0.000000	0.00001	0.00001	0.00001	6	0	0.00001	0.00001	0.00001	7
Sn-T (mg/L)	0.00005	0.00001	0.00014	0.00003	6	0.000004	0.00001	0.00002	0.00001	6	0	0.00001	0.00001	0.00001	8
Specific Conductance (uS/cm) (lab)															
Specific Conductance (uS/cm) (field)		217	217	217	1		210	210	210	1		25	25	25	1
Sr-D (mg/L)	0.0029	0.00574	0.0135	0.0091	6	0.00165	0.00494	0.00881	0.00677	6	0.00264	0.00999	0.0173	0.01251	7
Sr-T (mg/L)	0.0031	0.00571	0.0143	0.0091	6	0.00155	0.00497	0.00884	0.00674	6	0.00825	0.0101	0.0344	0.01550	8
Strepcoc (CFU/100mL)															
Temperature (C) (field)	3.55	6.55	16.12	11.87	11	2.84	7	14.97	11.42	11	4.95	6.19	18.69	12.39	11
Tl-D (mg/L)	0.0000000	0.000002	0.000002	0.000002	6	0	0.000002	0.000002	0.000002	6	0	0.000002	0.000002	0.000002	7
Tl-T (mg/L)	0.0000000	0.000002	0.000002	0.000002	6	0	0.000002	0.000002	0.000002	6	0.000000	0.000002	0.000003	0.000002	8
Turbidit (NTU)	0.34	0.1	1.1	0.45	11	0.11	0.1	0.5	0.26	11	0.30	0.3	1.4	0.58	12
U--D (mg/L)	0.0000004	0.000002	0.000003	2.17E-06	6	0.000001	0.000002	0.000005	0.000003	6	0.000001	0.000002	0.000005	0.000003	7
U--T (mg/L)	0.0000005	0.000002	0.000003	2.33E-06	6	0.000001	0.000002	0.000003	0.000002	6	0.000001	0.000002	0.000005	0.000003	8
V--D (mg/L)	0.0001	0.0002	0.0005	0.0004	6	0.0001	0.0002	0.0005	0.0003	6	0.0000	0.0002	0.0003	0.0002	7
V--T (mg/L)	0.0002	0.0002	0.0007	0.0004	6	0.0001	0.0002	0.0004	0.0003	6	0.0001	0.0002	0.0004	0.0003	8
Zn-D (mg/L)	0.0002	0.0001	0.0007	0.0003	6	0.0002	0.0001	0.0006	0.0003	6	0.0008	0.0002	0.0025	0.0008	7
Zn-T (mg/L)	0.0005	0.0003	0.0016	0.0008	6	0.0006	0.0005	0.0022	0.0010	6	0.0008	0.0004	0.0029	0.0009	8
pH (pH units)		7.3	7.3	7.3	1		7.1	7.1	7.1	1	0.49	7.1	7.8	7.45	2

EMS ID	E276451					E276452					E269000				
LOCATION NAME	ALDERBROOK STREAM NEAR MOUTH					LANNON CREEK NEAR MOUTH					DEMAMIEL CREEK - 400M U/S ROBERTSON RD BRIDGE				
Parameter	Standard Deviation	Minimum	Maximum	Average	# of samples	Standard Deviation	Minimum	Maximum	Average	# of samples	Standard Deviation	Minimum	Maximum	Average	# of samples
Ag-D (mg/L)	0	0.000005	0.000005	0.000005	6	0	0.000005	0.000005	0.000005	5					
Ag-T (mg/L)	0.000001	0.000005	0.000007	5.67E-06	6	0	0.000005	0.000005	0.000005	5		0.000005	0.000005	0.000005	1
Al-D (mg/L)	0.0502	0.0771	0.187	0.1376	6	0.0330	0.0351	0.116	0.0778	5					
Al-T (mg/L)	0.4841	0.0835	1.16	0.4914	6	0.1506	0.0984	0.475	0.2401	5		0.0288	0.0288	0.0288	1
Amonia Dissolved (mg/L)												0.005	0.005	0.005	1
As-D (mg/L)	0.00012	0.00066	0.00095	0.00078	6	0.00007	0.00009	0.00026	0.00016	5					
As-T (mg/L)	0.00016	0.00079	0.00123	0.00100	6	0.00010	0.00015	0.00036	0.00025	5		0.00005	0.00005	0.00005	1
B--D (mg/L)	0.00	0.05	0.05	0.05	6	0	0.05	0.05	0.05	5					
B--T (mg/L)	0.00	0.05	0.05	0.05	6	0	0.05	0.05	0.05	5		0.05	0.05	0.05	1
Ba-D (mg/L)	0.00173	0.00941	0.0146	0.01220	6	0.00127	0.0021	0.00512	0.00303	5					
Ba-T (mg/L)	0.00424	0.00971	0.0201	0.01539	6	0.00164	0.00256	0.00606	0.00461	5		0.00124	0.00124	0.00124	1
Be-D (mg/L)	0	0.00001	0.00001	0.00001	6	0	0.00001	0.00001	0.00001	5					
Be-T (mg/L)	0.00001	0.00001	0.00002	0.00001	6	0.00000	0.00001	0.00002	0.000012	5		0.00001	0.00001	0.00001	1
Bi-D (mg/L)	0	0.000005	0.000005	0.000005	6	0	0.000005	0.000005	0.000005	5					
Bi-T (mg/L)	0.000004	0.000005	0.000016	0.000007	6	0.000001	0.000005	0.000007	0.000005	5		0.000005	0.000005	0.000005	1
Ca-D (mg/L)	2.39	13.9	19.7	16.85	6	5.07	6.16	18.5	9.55	5					
Ca-T (mg/L)	2.00	14.2	19.8	17.22	6	4.23	6.76	16.8	9.32	5		2.45	2.45	2.45	1
Carbon Total Organic (mg/L)												3	3	3	1
Cd-D (mg/L)	0.000021	0.000015	0.000069	0.000032	6	0.000007	0.000005	0.000022	0.000010	5					
Cd-T (mg/L)	0.000044	0.000011	0.000129	0.000049	6	0.000007	0.000011	0.000028	0.000015	5		0.000005	0.000005	0.000005	1
Co-D (mg/L)	0.000189	0.000225	0.000751	0.000473	6	0.000073	0.000075	0.000257	0.000136	5					
Co-T (mg/L)	0.000458	0.000228	0.0013	0.000779	6	0.000188	0.000159	0.000616	0.000346	5		0.000027	0.000027	0.000027	1
Coli:Fec (CFU/100mL)	242	3	900	287	12	352	97	1300	381	11					
Color True (Col.unit)												15	15	15	1
Cr-D (mg/L)	0.0001	0.0007	0.0008	0.0007	6	0.0001	0.0001	0.0003	0.0002	5					
Cr-T (mg/L)	0.0003	0.0007	0.0014	0.0010	6	0.0002	0.0003	0.0009	0.0005	5		0.0001	0.0001	0.0001	1
Cu-D (mg/L)	0.00099	0.00246	0.00461	0.00328	6	0.00041	0.00132	0.00228	0.00184	5					
Cu-T (mg/L)	0.00339	0.00273	0.00983	0.00545	6	0.00068	0.00155	0.00324	0.00254	5		0.00063	0.00063	0.00063	1
Dissolved Oxygen (mg/L) (field)	0.87	12.24	15.2	13.39	12	1.57	10.52	14.7	12.39	10					
E Coli (CFU/100mL)	210	3	730	236	12	364	69	1300	310	11					
Entercoc (CFU/100mL)															
Hardness Total (D) (mg/L)	11.09	52.6	80	65.72	6	25.34	25.4	86.9	42.08	5					
Hardness Total (T) (mg/L)	9.75	53.4	79.9	68.05	6	21.91	27.6	80.1	41.36	5		11.3	11.3	11.3	1
Li-D (mg/L)	0	0.0005	0.0005	0.0005	6	0	0.0005	0.0005	0.0005	5					
Li-T (mg/L)	0	0.0005	0.0005	0.0005	6	0.0000	0.0005	0.0006	0.00052	5		0.0005	0.0005	0.0005	1
Mg-D (mg/L)	1.25	4.33	7.47	5.75	6	3.08	2.44	9.89	4.43	5					
Mg-T (mg/L)	1.17	4.34	7.37	6.09	6	2.77	2.59	9.29	4.39	5		1.27	1.27	1.27	1
Mn-D (mg/L)	0.06451	0.0606	0.249	0.12310	6	0.03189	0.00611	0.0815	0.02583	5					
Mn-T (mg/L)	0.07078	0.0594	0.273	0.14223	6	0.04287	0.0163	0.108	0.06154	5		0.00086	0.00086	0.00086	1
Mo-D (mg/L)	0.00004	0.00012	0.00023	0.00018	6	0.00002	0.00005	0.0001	0.00006	5					
Mo-T (mg/L)	0.00003	0.00012	0.0002	0.00017	6	0.00001	0.00005	0.00008	0.00006	5		0.00005	0.00005	0.00005	1
N.Kjel:T (mg/L)												0.13	0.13	0.13	1
NO2+NO3 (mg/L)												0.39	0.39	0.39	1
Ni-D (mg/L)	0.00010	0.00081	0.0011	0.00099	6	0.00012	0.00025	0.00055	0.00039	5					
Ni-T (mg/L)	0.00042	0.00085	0.00181	0.00127	6	0.00023	0.0003	0.0008	0.00058	5		0.0001	0.0001	0.0001	1
Nitrate (NO3) Dissolved (mg/L)												0.385	0.385	0.385	1
Nitrate + Nitrite Diss. (mg/L)												0.385	0.385	0.385	1
Nitrogen - Nitrite Diss. (mg/L)												0.002	0.002	0.002	1
Nitrogen Organic-Total (mg/L)												0.13	0.13	0.13	1
Nitrogen Total (mg/L)												0.52	0.52	0.52	1
Ortho-Phosphate Dissolved (mg/L)												0.001	0.001	0.001	1
P--T (mg/L)	0.010	0.009	0.036	0.027	6	0.009	0.01	0.034	0.024	5		0.003	0.003	0.003	1
Pb-D (mg/L)	0.000113	0.000072	0.000396	0.000195	6	0.000027	0.000015	0.000072	0.000048	5					
Pb-T (mg/L)	0.000451	0.000188	0.00111	0.000639	6	0.000145	0.000102	0.000444	0.000292	5		0.000017	0.000017	0.000017	1
Phosphorus Tot. Dissolved (mg/L)															
Res:Tot (mg/L)												33	33	33	1
Residue Filterable 1.0u (mg/L)												32	32	32	1
Residue Non-filterable (mg/L)												1	1	1	1
Sb-D (mg/L)	0.000031	0.00005	0.00013	0.00010	6	0.00002	0.00002	0.00007	0.00004	5					
Sb-T (mg/L)	0.000039	0.00005	0.00014	0.00010	6	0.00001	0.00002	0.00004	0.00003	5		0.00002	0.00002	0.00002	1
Se-D (mg/L)	0.000009	0.00006	0.00008	0.00007	6	0.00001	0.00005	0.00008	0.00006	5					
Se-T (mg/L)	0.000005	0.00006	0.00007	0.00007	6	0.00001	0.00005	0.00008	0.00007	5		0.00004	0.00004	0.00004	1
Sn-D (mg/L)	0.000000	0.00001	0.00001	0.00001	6	0	0.00001	0.00001	0.00001	5					
Sn-T (mg/L)	0.000009	0.00001	0.00003	0.00002	6	0	0.00001	0.00001	0.00001	5		0.00001	0.00001	0.00001	1
Specific Conductance (uS/cm) (lab)												45	45	45	1
Specific Conductance (uS/cm) (field)	0	174	174	174	2		80	80	80	1					
Sr-D (mg/L)	0.00619	0.0579	0.0727	0.06435	6	0.02328	0.0161	0.0712	0.03000	5					
Sr-T (mg/L)	0.00412	0.0567	0.0688	0.06195	6	0.02101	0.0167	0.066	0.02896	5		0.0082	0.0082	0.0082	1
Strepcoc (CFU/100mL)															
Temperature (C) (field)	2.33	7.96	14.25	11.56	12	2.04	8.19	13.75	11.48	10					
Tl-D (mg/L)	0	0.000002	0.000002	0.000002	6	0	0.000002	0.000002	0.000002	5					
Tl-T (mg/L)	0.000001	0.000002	0.000003	0.000002	6	0	0.000002	0.000002	0.000002	5		0.000002	0.000002	0.000002	1
Turbidit (NTU)	29.15	4.5	86.2	23.93	12	6.14	2.5	21.4	6.06	10		0.7	0.7	0.7	1
U--D (mg/L)	0.000005	0.000011	0.000022	0.000015	6	0.000004	0.000003	0.000011	0.000006	5					
U--T (mg/L)	0.000011	0.00001	0.000034	0.000020	6	0.000006	0.000003	0.000016	0.000011	5		0.000002	0.000002	0.000002	1
V--D (mg/L)	0.0001	0.0011	0.0015	0.0013	6	0.0002	0.0006	0.001	0.0008	5					
V--T (mg/L)	0.0009	0.0013	0.0034	0.0022	6	0.0008	0.0008	0.0026	0.0015	5		0.0004	0.0004	0.0004	1
Zn-D (mg/L)	0.0022	0.0041	0.0091	0.0065	6	0.0007	0.0012	0.0028	0.0020	5					
Zn-T (mg/L)	0.0045	0.0037	0.0146	0.0101	6	0.0022	0.0024	0.0076	0.0046	5		0.0006	0.0006	0.0006	1
pH (pH units)	0.07	7.6	7.7	7.65	2		7.5	7.5	7.5	1		7.6	7.6	7.6	1

EMS ID	E269002					E276453					E276454				
LOCATION NAME	CHARTER CK - 1.2KM D/S CHARTER RESERVOIR					VEITCH CREEK NEAR MOUTH					WILDWOOD CREEK NEAR MOUTH				
Parameter	Standard Deviation	Minimum	Maximum	Average	# of samples	Standard Deviation	Minimum	Maximum	Average	# of samples	Standard Deviation	Minimum	Maximum	Average	# of samples
Ag-D (mg/L)															
Ag-T (mg/L)		0.000005	0.000005	0.000005	1										
Al-D (mg/L)															
Al-T (mg/L)		0.0105	0.0105	0.0105	1										
Amonia Dissolved (mg/L)		0.005	0.005	0.005	1										
As-D (mg/L)															
As-T (mg/L)		0.00008	0.00008	0.00008	1										
B--D (mg/L)															
B--T (mg/L)		0.05	0.05	0.05	1										
Ba-D (mg/L)															
Ba-T (mg/L)		0.00242	0.00242	0.00242	1										
Be-D (mg/L)															
Be-T (mg/L)		0.00001	0.00001	0.00001	1										
Bi-D (mg/L)															
Bi-T (mg/L)		0.000005	0.000005	0.000005	1										
Ca-D (mg/L)															
Ca-T (mg/L)		4.9	4.9	4.9	1										
Carbon Total Organic (mg/L)		8.9	8.9	8.9	1										
Cd-D (mg/L)															
Cd-T (mg/L)		0.000005	0.000005	0.000005	1										
Co-D (mg/L)															
Co-T (mg/L)		0.000018	0.000018	0.000018	1										
Coli:Fec (CFU/100mL)						71	8	240	65	10	161	37	410	123	5
Color True (Col.unit)		5	5	5	1										
Cr-D (mg/L)															
Cr-T (mg/L)		0.0001	0.0001	0.0001	1										
Cu-D (mg/L)															
Cu-T (mg/L)		0.00059	0.00059	0.00059	1										
Dissolved Oxygen (mg/L) (field)						4.44	6.31	16.2	11.16	9	1.40	12.42	15.85	14.13	4
E Coli (CFU/100mL)						67	7	220	55	10	143	22	350	95	5
Entercoc (CFU/100mL)															
Hardness Total (D) (mg/L)															
Hardness Total (T) (mg/L)		18	18	18	1										
Li-D (mg/L)															
Li-T (mg/L)		0.0005	0.0005	0.0005	1										
Mg-D (mg/L)															
Mg-T (mg/L)		1.4	1.4	1.4	1										
Mn-D (mg/L)															
Mn-T (mg/L)		0.0006	0.0006	0.0006	1										
Mo-D (mg/L)															
Mo-T (mg/L)		0.00005	0.00005	0.00005	1										
N.Kjel:T (mg/L)		0.12	0.12	0.12	1										
NO2+NO3 (mg/L)		0.11	0.11	0.11	1										
Ni-D (mg/L)															
Ni-T (mg/L)		0.00013	0.00013	0.00013	1										
Nitrate (NO3) Dissolved (mg/L)		0.116	0.116	0.116	1										
Nitrate + Nitrite Diss. (mg/L)		0.116	0.116	0.116	1										
Nitrogen - Nitrite Diss. (mg/L)		0.002	0.002	0.002	1										
Nitrogen Organic-Total (mg/L)		0.12	0.12	0.12	1										
Nitrogen Total (mg/L)		0.23	0.23	0.23	1										
Ortho-Phosphate Dissolved (mg/L)		0.001	0.001	0.001	1										
P--T (mg/L)		0.003	0.003	0.003	1										
Pb-D (mg/L)															
Pb-T (mg/L)		0.000021	0.000021	0.000021	1										
Phosphorus Tot. Dissolved (mg/L)															
Res:Tot (mg/L)		11	11	11	1										
Residue Filterable 1.0u (mg/L)		10	10	10	1										
Residue Non-filterable (mg/L)		1	1	1	1										
Sb-D (mg/L)															
Sb-T (mg/L)		0.00002	0.00002	0.00002	1										
Se-D (mg/L)															
Se-T (mg/L)		0.00004	0.00004	0.00004	1										
Sn-D (mg/L)															
Sn-T (mg/L)		0.00001	0.00001	0.00001	1										
Specific Conductance (uS/cm) (lab)		51	51	51	1										
Specific Conductance (uS/cm) (field)															
Sr-D (mg/L)															
Sr-T (mg/L)		0.0134	0.0134	0.0134	1										
Strepcoc (CFU/100mL)															
Temperature (C) (field)						2.60	7.46	13.8	11.40	9	0.84	7.95	9.99	9.03	4
Tl-D (mg/L)															
Tl-T (mg/L)		0.000002	0.000002	0.000002	1										
Turbidit (NTU)		0.3	0.3	0.3	1	0.98	0.1	3.3	0.90	10	0.94	1.1	3.2	1.94	5
U--D (mg/L)															
U--T (mg/L)		0.000002	0.000002	0.000002	1										
V--D (mg/L)															
V--T (mg/L)		0.0003	0.0003	0.0003	1										
Zn-D (mg/L)															
Zn-T (mg/L)		0.0003	0.0003	0.0003	1										
pH (pH units)		7.7	7.7	7.7	1		7.4	7.4	7.4	1		7.3	7.3	7.3	1

EMS ID	E276584					E276585					E236671				
LOCATION NAME	AYUM CREEK UPPER					VEITCH CREEK UPPER					DE MAMIEL CREEK AT END OF PHILLIPS ROAD (1999-2000				
Parameter	Standard Deviation	Minimum	Maximum	Average	# of samples	Standard Deviation	Minimum	Maximum	Average	# of samples	Standard Deviation	Minimum	Maximum	Average	# of samples
Ag-D (mg/L)															
Ag-T (mg/L)															
Al-D (mg/L)															
Al-T (mg/L)															
Amonia Dissolved (mg/L)											0.002	0.005	0.01	0.007	8
As-D (mg/L)															
As-T (mg/L)															
B--D (mg/L)															
B--T (mg/L)															
Ba-D (mg/L)															
Ba-T (mg/L)															
Be-D (mg/L)															
Be-T (mg/L)															
Bi-D (mg/L)															
Bi-T (mg/L)															
Ca-D (mg/L)															
Ca-T (mg/L)															
Carbon Total Organic (mg/L)															
Cd-D (mg/L)															
Cd-T (mg/L)															
Co-D (mg/L)															
Co-T (mg/L)															
Coli:Fec (CFU/100mL)	7	3	20	8	5	112	2	360	69	10	61	1	250	43	36
Color True (Col.unit)															
Cr-D (mg/L)															
Cr-T (mg/L)															
Cu-D (mg/L)															
Cu-T (mg/L)															
Dissolved Oxygen (mg/L) (field)	0.76	14	16.08	15.03	5	5.16	5.43	19	10.88	9					
E Coli (CFU/100mL)	8	1	20	6	5	97	2	300	59	10	41	2	150	24	12
Entercoc (CFU/100mL)											229	2	960	80	17
Hardness Total (D) (mg/L)															
Hardness Total (T) (mg/L)															
Li-D (mg/L)															
Li-T (mg/L)															
Mg-D (mg/L)															
Mg-T (mg/L)															
Mn-D (mg/L)															
Mn-T (mg/L)															
Mo-D (mg/L)															
Mo-T (mg/L)															
N.Kjel:T (mg/L)															
NO2+NO3 (mg/L)															
Ni-D (mg/L)															
Ni-T (mg/L)															
Nitrate (NO3) Dissolved (mg/L)											0.105	0.152	0.348	0.228	3
Nitrate + Nitrite Diss. (mg/L)											0.103	0.156	0.366	0.249	7
Nitrogen - Nitrite Diss. (mg/L)											0.002	0.002	0.005	0.004	3
Nitrogen Organic-Total (mg/L)															
Nitrogen Total (mg/L)															
Ortho-Phosphate Dissolved (mg/L)															
P--T (mg/L)															
Pb-D (mg/L)															
Pb-T (mg/L)															
Phosphorus Tot. Dissolved (mg/L)											0.002	0.003	0.008	0.006	8
Res:Tot (mg/L)															
Residue Filterable 1.0u (mg/L)															
Residue Non-filterable (mg/L)															
Sb-D (mg/L)															
Sb-T (mg/L)															
Se-D (mg/L)															
Se-T (mg/L)															
Sn-D (mg/L)															
Sn-T (mg/L)															
Specific Conductance (uS/cm) (lab)											2	36	40	38	3
Specific Conductance (uS/cm) (field)		69	69	69	1										
Sr-D (mg/L)															
Sr-T (mg/L)															
Strepcoc (CFU/100mL)											67	2	240	28	12
Temperature (C) (field)	0.83	7.62	9.73	8.79	5	2.56	7.44	14.05	11.33	9					
Tl-D (mg/L)															
Tl-T (mg/L)															
Turbidit (NTU)	2.15	1	6.8	3.36	5	1.55	0.1	5.3	1.1	10	0.76	0.21	2.4	0.95	7
U--D (mg/L)															
U--T (mg/L)															
V--D (mg/L)															
V--T (mg/L)															
Zn-D (mg/L)															
Zn-T (mg/L)															
pH (pH units)		7.3	7.3	7.3	1		7.2	7.2	7.2	1	0.09	6.93	7.11	7.00	3

EMS ID	All Freshwater sites				
LOCATION NAME	GRAND TOTALS				
Parameter	Standard Deviation	Minimum	Maximum	Average	# of samples
Ag-D (mg/L)	0.0000002	0.000005	0.000006	0.000005	60
Ag-T (mg/L)	0.0000004	0.000005	0.000007	0.000005	64
Al-D (mg/L)	0.0383	0.0175	0.2	0.0824	60
Al-T (mg/L)	0.1927	0.0105	1.16	0.1483	64
Amonia Dissolved (mg/L)	0.002	0.005	0.01	0.006	12
As-D (mg/L)	0.00021	0.00003	0.00095	0.00018	60
As-T (mg/L)	0.00027	0.00004	0.00123	0.00021	64
B--D (mg/L)	0.001	0.05	0.056	0.050	60
B--T (mg/L)	0.001	0.05	0.059	0.050	64
Ba-D (mg/L)	0.00354	0.00107	0.0146	0.00418	60
Ba-T (mg/L)	0.00441	0.00117	0.0201	0.00472	64
Be-D (mg/L)	0.000000	0.00001	0.00001	0.00001	60
Be-T (mg/L)	0.000002	0.00001	0.00002	0.00001	64
Bi-D (mg/L)	0.000000	0.000005	0.000005	0.000005	60
Bi-T (mg/L)	0.000015	0.000005	0.000121	0.000007	64
Ca-D (mg/L)	5.53	2.17	21.5	7.11	60
Ca-T (mg/L)	5.39	2.13	22.1	6.98	64
Carbon Total Organic (mg/L)	3.05	2.7	8.9	4.33	4
Cd-D (mg/L)	0.000016	0.000005	0.000103	0.000014	60
Cd-T (mg/L)	0.000030	0.000005	0.000167	0.000018	64
Co-D (mg/L)	0.000138	0.000031	0.000751	0.000117	60
Co-T (mg/L)	0.000254	0.000018	0.0013	0.000183	64
Coli:Fec (CFU/100mL)	251	1	1400	135	181
Color True (Col.unit)	5	5	15	7.5	4
Cr-D (mg/L)	0.0002	0.0001	0.0008	0.0002	60
Cr-T (mg/L)	0.0003	0.0001	0.0014	0.0003	64
Cu-D (mg/L)	0.00097	0.00005	0.00461	0.00146	60
Cu-T (mg/L)	0.00171	0.00059	0.00983	0.00186	64
Dissolved Oxygen (mg/L) (field)	2.49	5.43	19	12.75	141
E Coli (CFU/100mL)	240	1	1300	124	157
Entercoc (CFU/100mL)	229	2	960	80	17
Hardness Total (D) (mg/L)	23.8	7.8	89.9	30.0	60
Hardness Total (T) (mg/L)	23.3	7.7	91	29.4	64
Li-D (mg/L)	0.0002	0.0005	0.0016	0.0005	60
Li-T (mg/L)	0.0001	0.0005	0.0013	0.0005	64
Mg-D (mg/L)	2.62	0.56	11.4	2.97	60
Mg-T (mg/L)	2.58	0.54	12.4	2.90	64
Mn-D (mg/L)	0.04194	0.00009	0.249	0.01909	60
Mn-T (mg/L)	0.04766	0.00045	0.273	0.02516	64
Mo-D (mg/L)	0.00004	0.00005	0.00023	0.00007	60
Mo-T (mg/L)	0.00004	0.00005	0.0002	0.00007	64
N.Kjel:T (mg/L)	0.02	0.09	0.13	0.11	4
NO2+NO3 (mg/L)	0.40	0.11	0.98	0.41	4
Ni-D (mg/L)	0.0003	0.0001	0.0011	0.0004	60
Ni-T (mg/L)	0.00101	0.00009	0.00805	0.00056	64
Nitrate (NO3) Dissolved (mg/L)	0.304	0.116	0.983	0.334	7
Nitrate + Nitrite Diss. (mg/L)	0.246	0.116	0.983	0.309	11
Nitrogen - Nitrite Diss. (mg/L)	0.001	0.002	0.005	0.003	7
Nitrogen Organic-Total (mg/L)	0.02	0.09	0.13	0.11	4
Nitrogen Total (mg/L)	0.38	0.23	1.07	0.53	4
Ortho-Phosphate Dissolved (mg/L)	0	0.001	0.001	0.001	4
P--T (mg/L)	0.012	0.002	0.065	0.010	59
Pb-D (mg/L)	0.000069	0.000007	0.000396	0.000054	60
Pb-T (mg/L)	0.000224	0.000017	0.00111	0.000147	64
Phosphorus Tot. Dissolved (mg/L)	0.002	0.003	0.008	0.006	8
Res:Tot (mg/L)	12.8	11	41	27.5	4
Residue Filterable 1.0u (mg/L)	12.8	10	40	26.5	4
Residue Non-filterable (mg/L)	0	1	1	1	4
Sb-D (mg/L)	0.00003	0.00002	0.00013	0.00004	60
Sb-T (mg/L)	0.00003	0.00002	0.00014	0.00004	64
Se-D (mg/L)	0.00025	0.00004	0.00201	0.00009	60
Se-T (mg/L)	0.00026	0.00004	0.00208	0.00009	64
Sn-D (mg/L)	0.00000	0.00001	0.00002	0.00001	60
Sn-T (mg/L)	0.00002	0.00001	0.00014	0.00001	64
Specific Conductance (uS/cm) (lab)	19	36	85	52	7
Specific Conductance (uS/cm) (field)	137	25	578	177	13
Sr-D (mg/L)	0.02242	0.00494	0.0815	0.02572	60
Sr-T (mg/L)	0.02144	0.00497	0.0846	0.02493	64
Strepcoc (CFU/100mL)	67	2	240	28	12
Temperature (C) (field)	3.21	6.19	21.86	11.55	141
Tl-D (mg/L)	0.000000	0.000002	0.000002	0.000002	60
Tl-T (mg/L)	0.000000	0.000002	0.000003	0.000002	64
Turbidit (NTU)	10.1	0.1	86.2	3.3	155
U--D (mg/L)	0.000005	0.000002	0.000022	0.000005	60
U--T (mg/L)	0.000007	0.000002	0.000034	0.000007	64
V--D (mg/L)	0.0004	0.0002	0.0015	0.0006	60
V--T (mg/L)	0.0007	0.0002	0.0034	0.0008	64
Zn-D (mg/L)	0.0023	0.0001	0.0091	0.0019	60
Zn-T (mg/L)	0.0033	0.0003	0.0146	0.0028	64
pH (pH units)	0.25	6.93	7.8	7.32	23