COMMUNITY WATERSHED MONITORING NETWORK DATA ANALYSIS (2011-2020)

Prepared For:
Regional District of Nanaimo

Prepared By:
Ecoscape Environmental Consultants Ltd.

April 2021
File No. 21-3702

ERRATA.

Regional District of Nanaimo Community Watershed Monitoring Network Data Analysis (2011-2020)

Appendices.

Report Date: April 2021 Errata Data: May 2021

Explanation: Due to data entry errors that were caught following the issuance of the report, there are some incorrect data points presented in the following map and graphs. The corrections are listed below, and the data has been corrected in the provincial Environmental Monitoring System database.

Appendix	Water Region	Map / Graph / Table Name	Site Identifier	Correction
A	5 – 2	Fall Exceedance Assessment Map	E290480	Temperature quadrant should be blue for no exceedance recorded in the fall sample period from 2012 – 2020.
B	5 – 2a	Figure B81: Fall Conductivity	Millstone River @ East Wellington	2020 fall conductivity readings should be within range of the box plot as were in line with results recorded in previous years.
B	5 – 2a	Figure B83: Fall Dissolved Oxygen	Millstone River @ East Wellington	2020 fall dissolved oxygen readings should be within range of the box plot as were in line with results recorded in previous years.
B	5 – 2a	Figure B85: Fall Temperature	Millstone River @ East Wellington	2020 fall temperature readings should be within range of the box plot as were in line with results recorded in previous years.
B	5 – 2a	Figure B87: Fall Turbidity	Millstone River @ East Wellington	Oct. 20, 27, and Nov. 10, 2020 fall turbidity readings should be within range of the box plot as were in line with results recorded in previous years. On Oct. 13 and Nov. 3, 2020 exceedances of turbidity guideline were experience, 18.8 NTU and 10.78 NTU, respectively.

COMMUNITY WATERSHED MONITORING NETWORK DATA ANALYSIS (2011-2020)

BRIEF SUMMARY REPORT

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1.0 INTRODUCTION

Ecoscape Environmental Consultants Ltd. (Ecoscape) was retained by the Regional District of Nanaimo (RDN) to conduct trend analyses on the Community Watershed Monitoring Network (CWMN) surface water quality dataset. The RDN and the British Columbia Ministry of Environment and Climate Change Strategy (ENV) started the CWMN program in 2011. The CWMN program trains volunteers from over 14 stewardships organizations to conduct water quality sampling at local creek sites across the region. The objective of the CWMN is to track and define the state of the water quality in the region to assist in land use planning and restoration decisions (Barlak and Fegan, 2014).

The CWMN program consists of annual sampling in both the summer low flow period (August – September) and fall flush period (October – November). There are 87 total sample sites for which data are available over the years since the inception of the CWMN program; data collected at these sites include measurements of dissolved oxygen (DO), temperature, turbidity, and specific conductivity. Sixty-seven (67) CMWN sample sites in 26 watersheds are currently active. Of the CMWN sites, 47 have more than 6 years of data and 18 sites have 10 years of data. The monitoring program is designed to calculate the BC 30-day average guidelines (five grab samples taken within 30 days during the summer and fall sampling periods) (RDN, 2021).

Ecoscape conducted a comprehensive trend analysis of the CWWN water quality dataset using data from 2011-2020 sampling events. Trend analysis was used to determine whether watershed health (measured by dissolved oxygen, temperature, turbidity and specific conductivity) is stable or changing, either through improvement or decline in water quality parameters. In addition, Ecoscape conducted a brief assessment of quality assurance / quality control by evaluating turbidity measurements from 8 sites in 2019 where samples were assayed using both field and lab methods. Recommendations for improvements to the water quality sampling and future management actions are provided for the current monitoring program using the results of the trend analysis.

2.0 METHODS

2.1 CWMN Water Quality Sampling Program

The CWMN partnership collects water temperature, dissolved oxygen, specific conductivity and turbidity for streams in seven different Water Regions (WR) throughout the RDN (Figure 2-1).

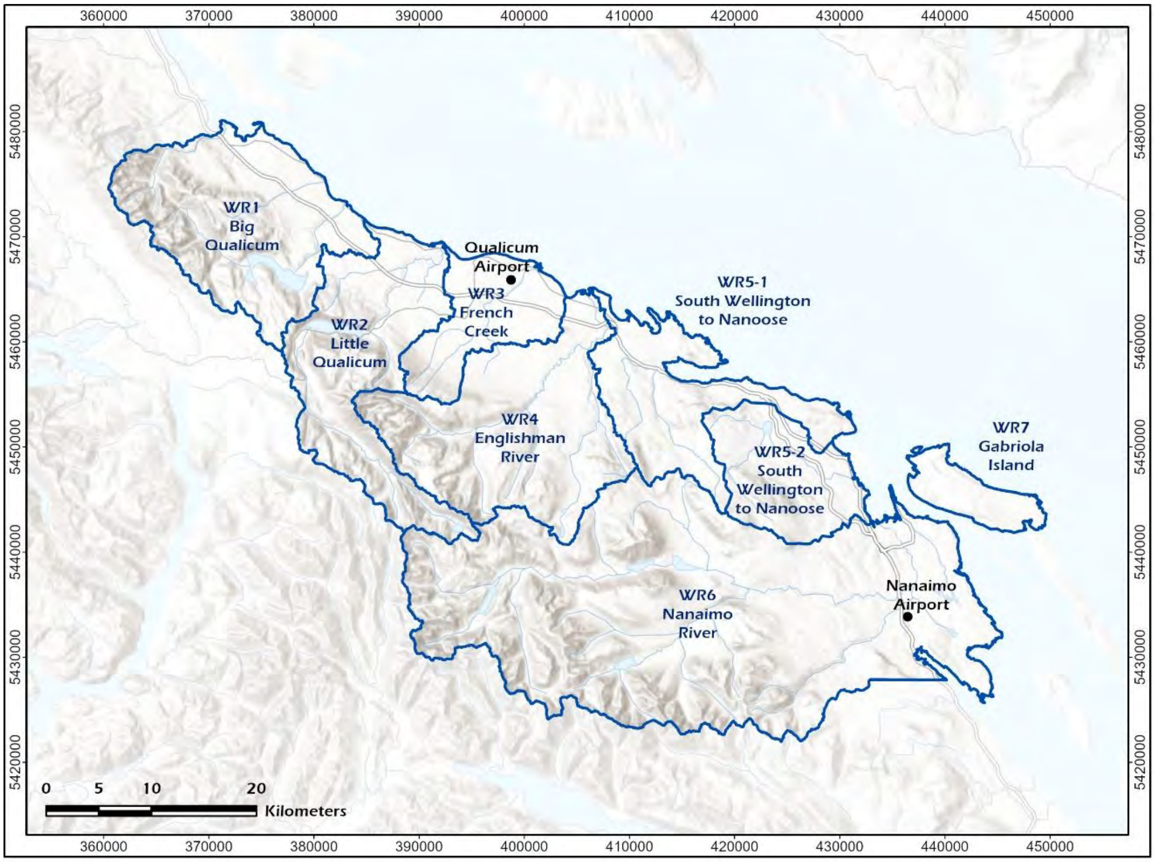

Figure 2-1: Water regions within the Regional District of Nanaimo.

The RDN provides the trained volunteers with equipment and overall program support, while Mosaic Forest Management provides land access and safety gear to the volunteers (Barlak and Fegan, 2014). The trained volunteers conduct water quality sampling five times in summer low flows and 5 times in fall flush flows. The RDN and ENV work together to ensure accurate data is uploaded into the provincial Environmental Monitoring System (EMS) database. Each water quality parameter sampled by the program is described below:

WATER TEMPERATURE can alter the physical and chemical properties of water, notably dissolved oxygen and carbon dioxide concentrations, pH, conductivity, and compound solubilities. Additionally, water temperature can directly affect the metabolic rates of aquatic organisms.

DISSOLVED OXYGEN The solubility of oxygen and other gases will decrease as temperature increases. So, for example, if stream water is too warm, it will not hold enough oxygen for fish and other aquatic organisms to survive. Many other factors also affect the oxygen concentration in water, including photosynthesis, water turbulence and the oxygen demand within the water. Thus, oxygen within water can be either above or below saturation, or the maximum concentration at any given temperature. Oxygen super-saturation (>100%) (rarely a problem for aquatic life) can occur during intense photosynthesis while dissolved oxygen below 5 mg/L can stress fish. Most pristine coastal streams average >8 mg/L.

CONDUCTIVITY is a measure of the amount of dissolved material in water. It is affected by the concentration, charge and mobility of dissolved ions. Conductivity is also affected by water temperature; therefore, specific conductance was measured (conductivity corrected to 25°C). Warm water can dissolve minerals and salts more easily than cold water, so conductivity usually increases with water temperature. Common causes of high conductivity in streams includes inflows of hard (high calcium carbonate) groundwater, natural flooding, evaporation or anthropogenic influences such as salinity from roads or man-made pollution. Most pristine coastal streams with no groundwater influence average <80 µS/cm.

TURBIDITY is the amount of suspended solids in water. Sources of turbidity include eroding stream banks, adjacent lands void of vegetation and stormwater. Increased turbidity will also increase water temperature because suspended particles absorb heat from the sun more efficiently than clear water. Turbidity is variable in pristine coastal streams but is generally <2 NTU.

2.2 Database Management and Analytical Methods

Water quality data was retrieved from the Environmental Monitoring System (EMS) which included *in situ* data collected by trained volunteers during 2011-2020. EMS numbers for the 67 active sites sampled as part of the CWMN program in 2020 are listed in Table 2-1. Gaps and data entry errors in the EMS dataset were identified and corrected by Ecoscape. Data exploration techniques including descriptive statistics (mean, minimum, maximum, standard deviation, etc.) and simple graphs such as box plots were used to compare analytes and sites. Box plots were prepared to visually display the results, and provide an understanding of the mean, median, and range in data or variability. Figure 2-2 shows how to interpret a box plot.

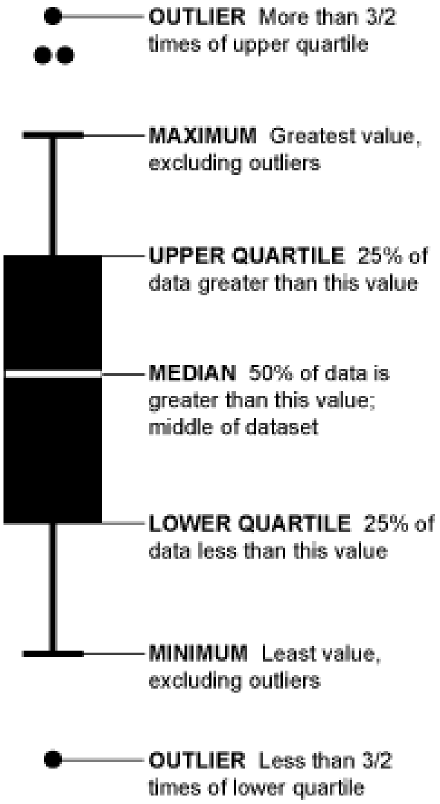

Figure 2-2: How to interpret a boxplot.

The water quality data was compared to applicable BC guidelines or to specific water quality objectives for the Englishman River (Barlak et al., 2010). The Englishman River Water Quality Objectives turbidity objective of 5 NTU was used for the fall flush period and 2 NTU was used for the summer low flow period. The Englishman River Objective was compared to each individual turbidity measurement. For temperature, the Englishman River has a short-term objective of 17°C and a long-term objective of 15°C. Thirty-day mean temperature averages over a sampling period were compared to the long-term objective. For dissolved oxygen, the BC Water Quality guidelines protective of aquatic life were used. The 30-day average is 8 mg/L and the instantaneous minimum is 5 mg/L. There is no guideline for specific conductivity, but typically coastal streams have conductance less than 80 µS/cm. If a stream has higher conductivity, it is usually indicative of groundwater or ocean influence.

Table 2-1: List of CWMN sites sampled in 2020 by Water Region with EMS numbers.

Water Region Code	Water Region	EMS ID	Location Description
WR1	Big Qualicum	E240141	Annie Creek
WR1	Big Qualicum	E286549	Thames Creek 200m u/s Old Island Hwy
WR1	Big Qualicum	E286553	Nile Creek 50m u/s Old Island Hwy
WR1	Big Qualicum	E298597	Big Qualicum u/s site
WR1	Big Qualicum	E298598	Big Qualicum River about 700m d/s hatchery
WR1	Big Qualicum	E306374	Rosewall Creek @ Rosewall Creek Park
WR1	Big Qualicum	E306375	Deep Bay Creek
WR1	Big Qualicum	E309086	Cook Creek at Old Island Hwy Connector
WR2	Little Qualicum	E220635	Cameron River (near the highway, just u/s of Cathedral Grove)
WR2	Little Qualicum	E256394	Little Qualicum River at Intake
WR2	Little Qualicum	E268993	Little Qualicum River 1.2 km d/s Cameron Lake
WR2	Little Qualicum	E285669	Upper Cameron River
WR2	Little Qualicum	E287697	Whiskey Creek on Hwy 4, TB Ave Save on Gas
WR2	Little Qualicum	E318150	Harris Creek on north/downstream side of Hwy 4
WR3	French Creek	E243021	French Creek at new highway
WR3	French Creek	E243022	French Creek at Barclay Bridge
WR3	French Creek	E243024	Fench Creek at Grafton Road
WR3	French Creek	E288090	Grandon Creek at West Crescent (Caissons)
WR3	French Creek	E288091	Grandon Creek at Laburnum Road
WR3	French Creek	E288092	Beach Creek near Chester Road at Hemsworth Road
WR3	French Creek	E288093	Beach Creek near Memorial Golf Course Pond
WR3	French Creek	E318151	Morningstar Creek 100m u/s Lee Rd W
WR4	Englishman River	0121580	Englishman River at Highway 19A
WR4	Englishman River	E248834	Englishman River U/S from Morison Creek
WR4	Englishman River	E248835	Morison Creek U/S from Englishman River
WR4	Englishman River	E248836	South Englishman River U/S from Englishman River
WR4	Englishman River	E282969	Upper Englishman River u/s Centre Fork Creek
WR4	Englishman River	E287131	Shelly Creek @ Hamilton Road
WR4	Englishman River	E290452	Shelly Creek @ end of Blower Rd
WR4	Englishman River	E299852	Centre Creek, just upstream of the confluence with S Englishman

Water Region Code	Water Region	EMS ID	Location Description
WR4	Englishman River	E308186	Swayne Creek d/s of Errington Road
WR5-1	S. Wellington to Nanoose	E290473	Cottle Creek @ Nottingham
WR5-1	S. Wellington to Nanoose	E290475	Cottle Creek @ Stephenson Pt Rd
WR5-1	S. Wellington to Nanoose	E294010	Bloods Creek just u/s Dickenson Rd
WR5-1	S. Wellington to Nanoose	E294013	Knarston Ck just u/s Lantzville Rd
WR5-1	S. Wellington to Nanoose	E309186	Cottle Creek downstream of Hammond Bay Rd
WR5-1	S. Wellington to Nanoose	E290469	Departure Ck @ Neyland Rd (Stn1)
WR5-1	S. Wellington to Nanoose	E290470	Joseph's Creek (trib to Departure Ck) off Newton St (Stn 2)
WR5-1	S. Wellington to Nanoose	E290471	Departure Ck at lower end of Woodstream Park (Stn 3)
WR5-1	S. Wellington to Nanoose	E290472	Departure Ck @ outlet (Stn 4)
WR5-1	S. Wellington to Nanoose	E306256	Walley Ck d/s Hammond Bay
WR5-1	S. Wellington to Nanoose	E306257	Walley Ck @ Morningside Dr
WR5-1	S. Wellington to Nanoose	E306434	Walley Creek 20m u/s beach
WR5-2	S. Wellington to Nanoose	E290478	Millstone River @ Biggs Road
WR5-2	S. Wellington to Nanoose	E290479	McGarrigle Ck @ Jingle Pot Rd
WR5-2	S. Wellington to Nanoose	E290480	Millstone River @ East Wellington
WR5-2	S. Wellington to Nanoose	E290481	Millstone River in Barsby Park
WR5-2	S. Wellington to Nanoose	E306294	Millstone River @ Jingle Pot Road
WR5-2	S. Wellington to Nanoose	E321394	Beaver Creek d/s Avonlea Rd bridge
WR5-2	S. Wellington to Nanoose	E290483	Chase River @ Aebig
WR5-2	S. Wellington to Nanoose	E290484	Chase River @Howard below colliery dam
WR5-2	S. Wellington to Nanoose	E290485	Chase River @ Park Ave
WR5-2	S. Wellington to Nanoose	E290486	Cat Stream @ Park above confluence with Chase River
WR5-2	S. Wellington to Nanoose	E309280	Chase River at Estuary Park
WR6	Nanaimo River	E318152	North Wexford Ck just d/s Douglas Ave
WR6	Nanaimo River	E318153	North Wexford Ck just d/s Tenth St
WR6	Nanaimo River	E318154	Wexford Ck ~20m d/s confluence of N and main arm
WR6	Nanaimo River	E318155	Wexford Ck at Community Park (Glenford Pl)
WR6	Nanaimo River	E318172	North Wexford Ck just u/s seniors complex
WR6	Nanaimo River	E215789	Nanaimo River at Cedar Rd bridge
WR6	Nanaimo River	E287699	Nanaimo River u/s Haslam Ck ~500m d/s hwy bridge

Water Region Code	Water Region	EMS ID	Location Description
WR6	Nanaimo River	E290487	Beck Creek @ Cedar Rd
WR6	Nanaimo River	E310147	Upper Holden Creek at Lazo Lane
WR6	Nanaimo River	E321392	UKNOWN TRIB (HALEY CREEK)15M D/S YELLOW POINT RD
WR6	Nanaimo River	E321393	Holden Creek 10m d/s Tiesu Rd
WR6	Nanaimo River	E321395	Richards Creek 5m u/s Frames Rd
WR7	Gabriola Island	E304070	Mallett Creek

2.2.1 *Turbidity and Rainfall Correlation*

Daily Environment Canada rainfall data was obtained from the Nanaimo and Qualicum airports located within the RDN (see Figure 2-1) to determine if a correlation exists between seasonal 2020 turbidity exceedances and rain events. Although some hourly parameters are available from the Nanaimo Airport Environment Canada monitoring station, hourly rainfall data are not included. Instead, daily rainfall data was used to compare turbidity and rain on the same sample day, the day before sampling, three days before sampling and one week prior to sampling. Sites were analyzed using the rainfall data from the nearest Environment Canada station. A Spearman's rank correlation coefficient (r_S) test was used to determine the strength of the relationship between turbidity and rainfall. Spearman's rank correlation is a non-parametric measure of correlation between ranks of two variables that do not meet assumptions needed to assess direct correlation between numeric values. The Spearman's rank correlation between two values is high when observations have a similar rank between the two variables, and low when observations have a dissimilar rank. r_S ranges from -1 to 1, where a value closer to -1 indicates a strong negative correlation and a value closer to 1 indicates a strong positive correlation. A p-value of <0.05 indicates a significant correlation.

2.2.2 *Identification of Exceedances*

Analyte exceedances for all Water Regions and sites are summarized in Appendix A and in Table C6-2 of Appendix C. Exceedances were assessed for each analyte at each site on a per-season basis; if a given analyte exceeded during any sampling event during a season, that season was flagged as exceeding. These seasonal exceedances were tallied and categorized as either low, moderate or high. For each analyte/site combination, Low indicates 1 or 2 seasons with exceedances, Moderate indicates 3 or 4 seasons with exceedances, and High indicates 5 or more seasons where exceedances occurred throughout the duration of sampling (i.e., 1-10 years). Exceedance categories were determined by a visual inspection of the distribution of exceedance counts; although groupings were not apparent in the distribution of the raw counts, a log transformation of the exceedance counts indicated groupings that ranged from 1 to 2, from 3 to 4, and from 5 and above. These breaks are suitable for the data assessed but would not necessarily translate to different regions or assessments. The raw exceedance counts for each analyte/site/season combination were also classified at the level of individual samples that exceeded the relevant guideline; these classifications are summarized in Table C6-5 in Appendix C.

2.2.3 Trend Analysis

Seasonal Mann-Kendall tests were used to identify and assess the direction and statistical significance of trends in water quality measurements over time (2011-2020). Mann-Kendall is a robust non-parametric regression analysis because it is easy to meet the assumptions needed for an accurate analysis and this test yields a result that is easy to interpret as either increasing, decreasing, or not changing. Further, seasonal Mann-Kendall tests account for seasonal variability by only comparing the same months from different years. Only sites that were sampled for at ***least six years*** in both summer and fall were included in the trend analysis. Water quality measures that had significant trends over time were graphed with Thiel-Sen estimator slope trend lines to aid in the visual interpretation of trend directions (Sen, 1968). Tests were performed using the “Kendall” package version 2.2 in R (McLeod, 2011).

Table 2-2 provides an interpretation summary for the trend analysis for each analyte. It assumes that if there are increasing trends in water temperature, turbidity and specific conductance, then the aquatic condition is degrading. In contrast, if there are increasing trends in DO, then the condition is improving. These assumptions are straight forward for temperature, turbidity and DO, however, specific conductance can be influenced by several factors, such as groundwater and ocean spray, which are not necessarily indicative of a degrading condition. Therefore, the assumption is that an increasing conductance is a worsening condition, however, the source that is driving the changes to specific conductance was also considered on a site-by-site basis.

Table 2-2: Interpretation summary for increasing, decreasing or stable trends of analytes.

Analyte	Trend	Condition
Water temperature (°C)	↑	Degrading
	↓	Improving
	_	Stable
Dissolved Oxygen (mg/L)	↑	Improving
	↓	Degrading
	_	Stable
Specific conductance (μS/cm)	↑	Degrading
	↓	Improving
	_	Stable
Turbidity (NTU)	↑	Degrading
	↓	Improving
	_	Stable

*Although an increasing trend for specific conductivity is denoted as a degrading condition, increasing specific conductance is not always reflective of degrading or worsening water quality.

Mann Kendall tests were also completed independently for summer and fall data. The results of this analysis are not discussed herein, however the significant trend graphs are included in Appendix B.

2.2.4 *Mapping Methods*

Maps of each Water Region with sampling points indicating trend directions were generated. Each sampling point visually displays whether individual analytes (temperature, dissolved oxygen, conductivity and turbidity) are stable, improving or degrading. Sites with fewer than six years of available data for trend analysis were labeled as "no trend assessed."

Maps of each Water Region with sampling points indicating the number of exceedances in a given analyte were also generated. These points indicate the exceedance class (as described in Section 2.2.2) for each analyte (dissolved oxygen, temperature and turbidity) if applicable. These maps were generated for both Fall and Summer seasons.

For both exceedance and trend map sets, maps are data-driven and show the areas of interest within each Water Region. To improve visualization, areas with few or no sites are not mapped at a small scale: map scale and extent focuses instead on regions of high sample site density.

3.0 RESULTS AND DISCUSSION

Maps of each WR and sites sampled in 2020 are available in Appendix A, detailed water quality plots are presented in Appendix B, and tabular summaries are presented in Appendix C. Results include all water quality data collected to date as part of the CWMN program. These data are displayed as box plots compared to relevant water quality guidelines or objectives. Other graphs and tables include trend analysis graphs, Spearman's rank correlation between turbidity and rainfall, and exceedance summaries.

The sections below provide an overview of the study's findings, relevant discussion, and our opinion as to why trends may be occurring for a limited number of the water regions. The scope of this reporting is focused on three priority water regions identified by the RDN based on previous data and related concurrent projects: French Creek (WR3), South Wellington to Nanoose (WR5) and Nanaimo River (WR6). In addition, sites that have not been previously analyzed for long-term trends are summarized, as well as sites that now have 10 years of data.

3.1 Turbidity and Precipitation Overview

Table 3-1 provides a summary of the Spearman's rank correlation test between turbidity and rainfall during the summer and fall. During the fall, the two variables were positively correlated for all four of the timing windows. The strongest association occurred with precipitation on the same day (r_S=0.508), with the association becoming least robust when precipitation occurred during the previous 7 days (r_S=0.238).

There was not a strong correlation between turbidity and rainfall during the summer (r_S ranged from -0.105 to 0.123), likely resulting from limited rainfall and from the occurrence of high turbidity spikes at certain sites during periods of no rain. A summary of correlation test results for each CWMN site for all four timing windows is available in Appendix C: Table C6-1.

Table 3-1: Summary of Spearman's rank correlation test between rainfall and turbidity in summer and fall for four different timing windows preceding sampling events.

Season	r_S	*p*-value	n	Turbidity correlation with
Fall	0.516	< 0.001	320	Precipitation on same day
Fall	0.482	< 0.001	320	Precipitation on previous day
Fall	0.486	< 0.001	320	Precipitation on previous 3 days
Fall	0.238	< 0.001	320	Precipitation on previous 7 days
Summer	0.091	0.1	330	Precipitation on same day
Summer	-0.105	0.058	330	Precipitation on previous day
Summer	0.123	0.026	330	Precipitation on previous 3 days
Summer	-0.031	0.577	330	Precipitation on previous 7 days

In 2019, a QA/QC evaluation of turbidity analysis was conducted at select CMWN sites. To assess consistency across samples, the percentage difference was calculated between turbidity measurements taken at the same sample location at the same time. The percentage difference was calculated as the absolute difference between two samples divided by the mean value of those two samples (Equation 1). This QA/QC evaluation revealed that the mean difference between samples varied across sites (Table 3-2).

$$Percentage\ Difference = \frac{|Turbidity_1 - Turbidity_2|}{\left(\frac{Turbidity_1 + Turbidity_2}{2}\right)} \qquad \text{Equation 1}$$

The maximum acceptable percentage difference between duplicate samples is 25% (Barlak et at., 2010). Of the 71 samples taken to the lab for analysis to compare to field in-situ samples of turbidity, 39 samples were less than 25% different from one another and 32 were greater. Of the 32 samples with greater than 25% difference between lab and field, only seven occurred for values over 1.0 NTU.

For the remaining 25 values below 1.0 NTU, variations of 0.1 NTU result in a much higher percent difference than at higher values. For instance, 2.73 NTU sampled in-situ compared to 2.22 NTU analyzed in lab is a difference of 0.51 NTU or 18.6%. Whereas, 0.34 NTU sampled in-situ vs. 0.46 NTU in lab is a difference of 0.14 NTU or 35.3% (Table C6-3). Therefore, the turbidity values less than 1.0 NTU with greater than 25% difference are not considered as big of a concern as those with values greater than 1 NTU.

The results of the 2019 turbidity QA/QC were evenly distributed across the sample season, with differences between field and lab occurring at similar amounts in summer and fall. The results of the 2019 QA/QC support the reliability of the sampling methodology; however, the seven values over 1.0 NTU with a percent difference greater than 25 are a reminder that field meter calibration, measuring techniques and field grab sampling techniques need to follow protocols closely for continued accuracy of samples.

Table 3-2: Summary of QA/QC assessment performed in 2019. Mean percentage difference is the average percentage value as calculated using Equation 1. Individual percentage differences between pairs are recorded in Table C6-3.

EMS Number	Site	n	Mean difference (NTU)	Mean percentage difference (%)	Variance of field samples	Variance of lab samples
E290469	Departure Ck @ Neyland Rd	4	0.0925	37.33	0.001	0.0164
E290470	Joseph's Ck (trib to Departure Ck)	5	0.1920	38.34	0.394	0.4689
E290471	Departure Ck at Woodstream Park	9	0.1011	21.32	1.274	1.1791
E290472	Departure Ck @ outlet	9	0.3411	39.42	3.690	2.5304
E290475	Cottle Creek @ Stephenson Pt Rd	9	0.1422	13.88	0.501	0.3402
E306256	Walley Ck d/s Hammond Bay	11	1.1164	24.78	9.840	0.2387
E306257	Walley Ck @ Morningside Dr	1	0.1000	47.62		
E309186	Cottle Creek d/s Hammond Bay Rd	8	0.0875	8.41	0.384	0.3035

3.2 Priority Water Region 3: French Creek

Water Region 3 encompasses 8 CWMN sites on four different creeks, including French Creek, Beach Creek, Grandon Creek and Morningstar Creek. Sampling has been undertaken at each of these creeks since 2011, except for Morningstar Creek, where there is two years of data.

3.2.1 2020 Conductivity Data

Conductivity in WR3 substantially varied between sites. The three French Creek sites (at Grafton Rd, New Highway and Barclay Bridge) had the lowest specific conductance of all creeks, averaging <75 µS/cm in fall (Figure B26). In the summer only French Creek at Grafton Rd remained that low, while all other WR3 sites were elevated (Figure B27). The mean conductivity of the elevated sites exceeded 160 µS/cm during summer low flows, suggesting groundwater influence or possibly salinized inflow from adjacent lands resulting from agriculture or hardscape.

3.2.2 2020 Dissolved Oxygen Data

All sites in WR3 had mean DO concentrations suitable for aquatic life in the fall of 2020 (Figure B28). Three stations with warmer summer water temperatures also had low DO during the summer (Figure B29). This included Grandon Creek at Laburnum Rd, French Creek at Grafton Rd and Morningstar Creek (Figure B29). All three sites had low summer DO concentrations well below saturation limits. The 2020 30-day average for DO at Grandon Creek at Laburnum Rd was below 5.0 mg/L, whereas French Creek at Grafton Rd and Morningstar Creek had a mean summer DO below 8 mg/L (Figure B29). We understand that Grandon Creek at Laburnum Rd has minimal flow in the summer months (Plewes et al., 2018); this may be a factor in the low DO, resulting from limited mixing.

3.2.3 2020 Water Temperature Data

All sample sites in WR3 had suitable water temperatures for aquatic life in the fall flush period with temperatures consistently occurring between 5-10°C (Figure B30). However, in the summer months of 2020, water temperatures at French Creek Barclay Bridge exceeded the 17°C Aquatic Life Guideline for Coho Rearing on two sampling occasions (Figure B31). Other sites with water temperatures that approached the guideline in the summer included Morningstar Creek, Beach Creek near Chester Road and Grandon Creek at West Crescent (Figure B31).

3.2.4 2020 Turbidity Data

In the fall of 2020, turbidity guideline exceedances occurred at all sites in WR3, except at French Creek at Barclay Bridge (Figure B32). The turbidity spikes, in almost all cases, were associated with storm events that resulted in additive accumulation of precipitation over 24, 72 and 168 hours prior to the sampling event. Sites with adjacent agriculture, roads and/or disturbed riparian habitats are expected to experience the greatest turbidity spikes (Plewes et al., 2018).

In the summer months, small turbidity spikes were recorded at Beach Creek near Memorial Golf Course Pond and at Grandon Creek at Laburnum Rd (Figure B33). These samples exceeded the 2 NTU guideline and although precipitation occurred between 72 and 168 hrs prior to the sampling events, there was no significant correlation between precipitation and turbidity at either of those sites (Table C6-1).

3.2.5 Summary of Exceedances by Analyte

Table 3-3 provides an overview of exceedance frequencies in WR3 categorized as low, moderate or high (as described in Section 2.2.2). Throughout the years of sampling (2011-2020), there have never been exceedances of DO or water temperature in the fall. High frequency of seasonal exceedances (≥5) have occurred at sites in the summer for DO and turbidity. The frequent seasonal exceedances of turbidity in the summer have occurred despite the lack of correlation between turbidity and rainfall data. Given this, sources of turbidity, such as high bacteria or algal counts, should be identified and mitigated.

Table 3-3: Summary of seasonal exceedance frequency by analyte in Water Region 3.

Site label	Dissolved oxygen		Temperature		Turbidity	
	Summer	Fall	Summer	Fall	Summer	Fall
Beach Creek near Chester Road	-	-	-	-	High	Low
Beach Creek near Memorial Golf	-	-	-	-	High	Moderate
French Creek at Barclay Bridge	-	-	Moderate	-	Low	Low
French Creek at Grafton Road	High	-	Low	-	-	Low
French Creek at new highway	-	-	-	-	-	Low
Grandon Creek at Laburnum Road	High	-	-	-	High	Moderate
Grandon Creek at West Crescent	-	-	Moderate	-	High	Moderate
Morningstar Creek u/s Lee Rd W	Low	-	-	-	-	Low

3.2.6 Trend Analysis

Seven of the eight sites in WR3 had suitable continuous datasets with 10 years of data for trend analysis (Appendix A). Three of those seven sites exhibited trends for either temperature or DO, while the remaining sites were stable for all four analytes.

Grandon Creek at Laburnum Road had an increasing trend in DO (Figure B35), suggesting that this site had improved water quality conditions. In contrast, Beach Creek near Chester Road at Hemsworth Road had a long-term trend of increasing water temperature (Figure B36) and French Creek at Barclay Bridge exhibited a decreasing trend in DO (Figure B34), suggesting that both sites had degrading water quality conditions.

The water temperature at Beach Creek near Chester Road at Hemsworth Road has increased over the last ten years (Figure B36). In 2011, the mean temperature was 14°C in the summer and in 2020 the mean temperature had increased to just over 15° C. Despite this long-term trend, the temperatures during the fall and summer were below the 17°C Aquatic Life Guideline for Coho Rearing.

Similarly, the 2020 mean DO values at French Creek at Barclay Bridge in the summer met the 8 mg/L Englishman River water quality objectives, despite the decreasing trend (Figure B34).

3.2.7 Sites of Concern in Water Region 3

A parameter with high seasonal exceedance frequency, in addition to a degrading condition, should be considered a site of concern. Of the three sites that exhibited long-term trends, none were flagged as sites of concern, given that each parameter fell within its respective guideline. There were other sites, however, that exhibited data in 2020 outside of the guidelines, specifically pertaining to summer DO:

- French Creek @ Grafton Road,
- Morningstar Creek, and
- Grandon Creek @ Laburnum Road

Previously, two of these three sites were identified as sites of concern (Plewes et al., 2018). These sites have >78% agricultural land use within the 500 m upstream buffer (Plewes et al., 2018). We understand that remedial planting was conducted at French Creek at Grafton Road because of compromised bank stability due to a lack of riparian vegetation (Clough, 2015a). This planting may have improved conditions at this site, as 2020 turbidity and temperature values were not elevated.

Plewes et al. (2018) reported that Grandon Creek at Laburnum Rd had depleted DO, high summer water temperatures and high summer turbidity. In 2020, the site continued to have high summer temperatures and turbidity, but summer DO had improved. We understand that previously recommended tree planting was undertaken (Clough, 2015b), and this could be a factor in the improved DO values.

3.3 Priority Water Region 5: South Wellington to Nanoose

Water Region 5 is divided into four subregions including: WR5-1A, WR5-1B, WR5-2A, and WR5-2B (Table 3-4). There are a total 26 CWMN sample sites across 13 different creeks and sampling has been ongoing at the various creeks between 1-9 years.

Table 3-4: Summary of watercourses, sample sites and years of data in Water Region 5.

Subregions	Creek Name	# of CWMN Sites	Years of Data
WR5-1A	Nanoose Creek	2	8
	Craig Creek	1	8
	Bloods Creek	1	5
	Knarston Creek	1	3
	Cottle Creek	3	4-9
WR5-1B	Walley Creek	3	5
	Departure Creek	3	9
	Joseph's Creek	1	9
WR5-2A	McGarrigle Creek	1	9
	Beaver Creek	1	1
	Millstone River	4	9
WR5-2B	Chase River	4	9
	Cat Stream	1	9

3.3.1 2020 Conductivity Data

In 2020, specific conductance in WR5 varied widely between 97 to 376 µS/cm in the fall (Figure B54, Figure B71, Figure B81) and between 69 to 794 µS/cm during summer low flows (Figure B55, Figure B72, Figure B82). Conductivity levels often increase during the summer due to lower flows and evaporation. Conversely, more rain in the fall can increase water volume and levels, lowering conductivity. This pattern of higher conductivity in the summer was observed at most of the WR5 sites. Many of the WR5 sites also had conductivity levels that were greater than 80 µS/cm, which is typical of coastal streams without groundwater influence. The higher conductivity levels may be indicative of a significant groundwater component (i.e., Nanoose, Departure, Cottle and Walley creeks), or higher conductivity values observed at sites close to the coast, may reflect ocean influence (i.e., Chase River at Park Avenue, Aebig Rd and Estuary Park). However, other anthropogenic influences, such as road salts and agricultural impacts may also be contributing to the elevated conductivity at these sites.

3.3.2 2020 Dissolved Oxygen Data

All sites in WR5 had DO measurements suitable for aquatic life in the fall sample period.

In the summer, there were seven sites that had mean summer DO below 8.0 mg/L (Figure B57, Figure B74, Figure B84). Because the solubility of oxygen decreases as water temperatures increase, higher water temperatures during the summer are likely a factor in the lower recorded DO values. The low mean summer DO could also be influenced by groundwater, which has low concentrations of DO, or the low DO may be due to low flows and lack of mixing water, or it could even be caused by the increased uptake of DO by aquatic organisms during the summer.

For example, all three Walley Creek sites had mean DO less than the 8 mg/L guideline in the summer (Figure B74). We understand that Walley Creek is ditched through a residential area, with some sections flowing through culverts. RDN reports issues with yard waste dumping and removal of riparian vegetation. Given this, likely causes of low DO include low flows and lack of mixing, as well as the possibility of algal blooms which can proliferate when there are increased nutrient sources (e.g., yard waste, fertilizers, etc.) and higher water temperatures. Low DO can result from excessive algae growth, with DO consumed as the algae die and decompose.

3.3.3 2020 Water Temperature Data

All sample sites in WR5 had suitable water temperatures for aquatic life in the fall monitoring period.

Water temperatures at sites in WR5 during the summer sample period ranged from 13 – 19°C, with the 30-day average temperatures exceeding the 17°C guideline at three sites including: Millstone River at Biggs Rd, Millstone River at East Wellington and Millstone River at Barsby Park (Figure B59, Figure B76, Figure B86).

3.3.4 *2020 Turbidity Data*

In 2020, turbidity exceedances occurred throughout WR5 in both seasons. During the fall flush, turbidity >5 NTU was periodically measured at most sites (Figure B60, Figure B77, Figure B87). Millstone River, Cat Stream and Chase River frequently exceeded the 2 NTU guideline during the summer sampling period (Figure B61, Figure B78, Figure B88). During summer low flows, turbidity exceedances were particularly evident at Cottle Creek D/S Hammond Bay Road, Cottle Creek at Stephenson Pt Rd, Millstone River at Jingle Pot Rd and Chase River at Aebig Rd (Figure B61 and Figure B88).

In almost all cases, increased turbidity was associated with a rain event occurring on one of the seven days prior to the sampling date. Turbidity values were highest when there were consecutive days of precipitation sometime within the 7 days prior to the sample date. For example, turbidity exceedances during sampling events on September 24/25, and October 13, 2020 were associated with rain events that resulted in precipitation occurring in all three intervals of 24, 72 and 168 hrs prior to the sampling event, and the turbidity on these sampling dates ranged from 4.6 – 26.8 NTU.

3.3.5 *Summary of Exceedances by Analyte*

Table 3-5 provides an overview of seasonal exceedance frequencies in WR5 categorized as low, moderate or high. Like WR3, there were no exceedances for water temperature in the fall. Fall DO values below the 5 mg/L guideline occurred at three sites. While there were many occurrences of low (1 - 2) and moderate (3 - 4) seasonal fall turbidity exceedances, there was only one site with a high (≥5) frequency. During the summer sample periods, high seasonal exceedances occurred for DO, water temperature and turbidity.

Table 3-5: Summary of exceedance frequency by analyte in Water Region 5.

Site label	Dissolved oxygen		Temperature		Turbidity	
	Summer	Fall	Summer	Fall	Summer	Fall
Beaver Creek d/s Avonlea Rd bridge	-	-	-	-	-	Low
Benson Creek @ Biggs Road	Moderate	-	-	-	-	-
Bloods Creek just u/s Dickenson Rd	-	-	-	-	-	Moderate
Cat Stream	Low	-	High	-	High	Moderate
Chase River @ Aebig	Moderate	-	High	-	Low	Moderate
Chase River @ Estuary Park	Low	-	Moderate	-	Low	Low
Chase River @ Howard	Low	-	High	-	Low	Low
Chase River @ Park Ave	-	-	High	-	Moderate	Moderate
Cottle Creek @ Landalt Rd	-	-	Low	-	Low	-
Cottle Creek @ Nottingham	High	-	High	-	Moderate	Moderate
Cottle Creek @ Stephenson Pt Rd	Low	-	High	-	Low	Low
Cottle Creek d/s Hammond Bay Rd	-	-	Moderate	-	Moderate	Low
Craig Creek u/s Northwest Bay Rd	Low	Low	-	-	Low	Low
Departure Ck @ Neyland Rd	-	-	-	-	Moderate	Moderate
Departure Ck @ outlet	-	-	-	-	High	Moderate
Departure Ck at Woodstream Park	-	-	-	-	Low	Low
Joseph's Ck (trib to Departure) off Newton	-	-	Low	-	High	-
Knarston Ck @ Hydro Bridge		-		-		-
Knarston Ck @ Superior Rd	-	-	-	-	-	-
Knarston Ck just u/s Lantzville Rd	-	-	Low	-	-	Moderate
McClure Creek at Montessori School	-	-	-	-	Moderate	-
McGarrigle Ck @ Jingle Pot Rd	-	-	Low	-	Low	Low
Millstone River @ Biggs Road	High	-	High	-	High	-
Millstone River @ East Wellington	High	-	High	-	High	Moderate
Millstone River @ Jingle Pot Road	-	-	Moderate	-	High	Low
Millstone River in Barsby Park	-	-	High	-	Moderate	High
Nanoose Creek @ Campground	Low	Low	-	-	-	Low
Nanoose Creek @ Matthew Crossing	High	Low	Low	-	-	Low
North Cottle Creek d/s Burma Rd.	-	-	-	-	-	-
Northfield Creek @ outlet	-	-	Moderate	-	Moderate	Moderate
Slogar Brook	-	-	-	-	-	-

Site label	Dissolved oxygen		Temperature		Turbidity	
	Summer	Fall	Summer	Fall	Summer	Fall
Upper McGarrigle Ck	-	-	-	-	-	-
Walley Ck @ Morningside Dr	Low	-	-	-	Low	Moderate
Walley Ck d/s Hammond Bay	-	-	Moderate	-	High	Moderate
Walley Creek 100m d/s McGuffie Rd	-	-	-	-	-	-
Walley Creek 20m u/s beach	Low	Low	Moderate	-	Low	Moderate

3.3.6 *Trend Analysis*

Seventeen of 41 sites in WR5 had suitable continuous datasets for trend analysis. These sites included the three Departure Creek sites, the Cottle Creek sites at Nottingham and Stephenson Pt Rd, three Millstone River sites, the three upper Chase River sites, Cat Stream, Craig Creek, Joseph's Creek, McGarrigle Creek and the two Nanoose Creek sites.

Of those seventeen datasets, four exhibited significant trends. There was an upward trend in DO at Nanoose Creek at Matthew Crossing (Figure B64) and at Craig Creek U/S Northwest Bay Road (Figure B65). Both of which indicated an improving condition in water quality.

In contrast, there was an increasing trend in conductivity at Cottle Creek at Stephenson Pt Rd (Figure B63) and at Cottle Creek at Nottingham (Figure B62). Increased conductivity at these sites indicates a degrading or worsening condition.

3.3.7 *Sites of Concern in Water Region 5*

Previously Plewes et al. (2018) identified Cat Stream and Walley Creek at Hammond Bay as sites of concern, both of which are located adjacent to stormwater outlets. The Walley Creek site had low DO and high turbidity and it was suspected that the stormwater outlet was a source of suspended sediment and possibly nutrients. The other site, Cat Stream, had high turbidity, warm summer temperatures and increasing conductivity. The results in 2020 at these sites were generally consistent with previous findings, therefore, these sites remain as sites of concern. However, it is positive that the conditions at these sites appear to be stable.

Two other sites that should continue to be sampled include Cottle Creek at Nottingham and Millstone River at Biggs Rd. Both sites had low DO in the summer, with Millstone River at Biggs Rd having lower DO in 2020 compared to previous years. During future sampling, RDN should encourage volunteers to take photos and detailed notes of the sampling sites to determine if the presence of algal blooms or aquatic vegetation may be contributing to the low DO.

3.4 Priority Water Region 6: Nanaimo River

Water Region 6 includes two subregions: WR6-a and WR6-b. WR6-a has 5 sampling sites on Wexford and North Wexford Creeks, while WR6-b has 7 active sampling sites across five creeks: Nanaimo River, Holden Creek, Beck Creek, Richards Creek and Unknown Trib (Haley Creek). Three of the 7 sites in WR6-b were first sampled in 2020, while the other WR6 sites have had data collected over the last 1-10 years. Two sites in WR6-b were subsurface for a portion of the summer and fall sample periods, Holden Creek D/S Tiesu Rd and Unknown Trib (Haley Creek). The results from these two sites cannot be compared to 30-day average guidelines.

3.4.1 2020 Conductivity Data

Historically, the specific conductance readings in WR6 were higher compared to other Water Regions at several sites in both seasons (Plewes et al., 2018). For example, during summer low flows, Beck Creek averaged 500 µS/cm, possibly due to historical coal mining in this watershed (Plewes et al., 2018).

In fall 2020, conductivity values at the Wexford Creek sites were lower compared to 2019 (Figure B103). The specific conductance had also declined at Holden Creek off Lazo Lane, while Nanaimo River U/S Haslam Creek and Nanaimo River at Cedar Rd Bridge remained similar to previous years (Figure B111). Three sites were sampled for the first time in 2020. They included Holden Creek 10m D/S Tiesu Rd, Richards Creek 5m U/S Frames Rd and Unknown Trib (Haley Creek). The conductivity at these sites fell within the range of other WR6 sites.

In the summer, declines in specific conductance were also noted at Holden Creek off Lazo Lane, North Wexford Creek D/S of Tenth Street and at Wexford Creek D/S of Confluence (Figure B104, Figure B112). The remaining sites in WR6 were consistent with previous years.

3.4.2 2020 Dissolved Oxygen Data

All sample sites in WR6 had DO concentrations suitable for aquatic life during the fall, except for newly sampled site, Holden Creek 10m D/S Tiesu Rd (Figure B113, Figure B114). This site had values outside of the 5 mg/L guideline in the fall and summer sample periods. During summer low flows, 3 sample sites had 30-day averages of less than 8 mg/L (Figure B106, Figure B114). This included Holden Creek off Lazo Lane, North Wexford Creek D/S of Douglas Ave and North Wexford Creek D/S of Tenth Street. The summer 30-day average for DO at North Wexford Creek D/S of Tenth Street was by far the lowest at just over 5 mg/L (Figure B106). This site also had enhanced turbidity that was not associated with rainfall.

3.4.3 2020 Water Temperature Data

All sample sites in WR6 had suitable water temperatures for aquatic life during the fall (Figure B107, Figure B115). However, during summer low flows, the 30-day average water temperature exceeded the 17°C Coho rearing guideline at the Nanaimo River U/S Haslam Ck and at Nanaimo River at Cedar Rd Bridge (Figure B108, Figure B116). The higher water temperatures at the Nanaimo River sites are likely a result of the wide and shallow nature of the river near these sites.

3.4.4 2020 Turbidity Data

In the fall, individual samples exceeded 5 NTU at 7 of the twelve sites in WR6. The exceeding sites include Beck Creek at Cedar Rd, North Wexford Creek D/S of Douglas Ave, North Wexford Creek D/S of Tenth Street, North Wexford Creek u/s Seniors Complex, Wexford Creek d/s of confluence, Holden Creek 10m D/S Tiesu Rd and Unknown Trib (Haley Creek) 15m d/s Yellow Point Rd (Figure B109, Figure B117).

In the summer, values exceeded 2 NTU at 5 of the WR6 sites sampled, including Beck Creek at Cedar Rd, North Wexford Creek D/S of Douglas Ave, North Wexford Creek D/S of Tenth Street, Wexford Creek d/s of confluence and Holden Creek 10m D/S Tiesu Rd (Figure B110, Figure B118).

Interestingly, some of the highest spikes in turbidity (17.8 and 24.8 NTU) occurred at North Wexford Creek D/S of Tenth Street on August 4 and August 18, 2020, respectively, and they were not associated with any precipitation up to 168 hrs prior to the sampling. The surrounding land uses, and potential sources of contamination should be investigated to understand and potentially mitigate these turbidity spikes.

Other turbidity spikes in WR6 were associated with rain events; the most predominant of which occurred on October 13, 2020. Rainfall causes mobilization of sediments which increases turbidity and can decrease conductivity resulting from stream flow dilution.

3.4.5 *Summary of Exceedances by Analyte*

Table 3-6 provides an overview of seasonal exceedances in WR6 categorized as low, moderate or high. The number of sites with high (≥5) exceedances in WR6 was limited to four and occurred only for water temperature and turbidity in the summer. Frequency of seasonal exceedances of DO were nil or low across all sites during the summer and fall. Like other Water Regions, there were no exceedances in the fall for water temperature.

Table 3-6: Summary of exceedance frequency by analyte in Water Region 6.

Site label	Dissolved oxygen		Temperature		Turbidity	
	Summer	Fall	Summer	Fall	Summer	Fall
Beck Creek @ Cedar Rd	Low	-	High	-	High	Moderate
Unknown Trib (Haley Creek)		-		-		Low
Haslam Ck u/s Nanaimo River	-	-	Low	-	-	-
Holden Creek 10m d/s Tiesu Rd	Low	Low	Low	-	Low	Low
Lower Holden Creek u/s Duke Pt Hwy	Low	Low	Low	-	Low	Low
Nanaimo River at Cedar Rd bridge	Low	-	High	-	Low	-
Nanaimo River u/s Haslam Ck	-	Low	High	-	-	-
North Wexford Creek d/s Douglas	Low	-	-	-	Low	Low
North Wexford Creek d/s Tenth St	Low	-	-	-	Low	Low
North Wexford Creek u/s Senior's	-	-	-	-	Low	Low
Richards Creek 5m u/s Frames Rd	-	-	Low	-	-	-
Holden Creek off Lazo Lane	-	-	Low	-	-	-
Wexford Creek @ Community Park	-	-	Low	-	-	-
Wexford Creek 20m d/s Confluence	-	-	-	-	Low	Low

3.4.6 *Trend Analysis*

The Nanaimo River upstream of Haslam Creek, Beck Creek and Nanaimo River at Cedar Creek Bridge were the only sites in WR6 that had suitable continuous datasets for trend analysis. The seasonal trend analysis did not identify significant trends for any of the analytes.

3.4.7 Sites of Concern in Water Region 6

The main site of concern is North Wexford Creek D/S of Tenth Street. This site had substantially depleted DO in the summer and multiple summer turbidity spikes that were not associated with rainfall events. This is the second year this site has been sampled and the low DO and high summer turbidity were also documented in 2019. North Wexford Creek D/S of Tenth Street is in a highly developed area and the creek is ditched along certain stretches; likely contributing to the depleted DO and high turbidity values.

Other sites of concern include Nanaimo River upstream of Haslam Creek, and Nanaimo River at Cedar Rd Bridge. These sites have consistently experienced high summer temperatures well above the Aquatic Life Guideline for Coho Rearing. Despite the elevated water temperatures at these sites, DO has remained above the 8 mg/L guideline and specific conductivity has remained low. Consistent with Plewes et al. (2018), we recommend that these sites continue to be sampled and closely monitored for changes in water quality. Because of their proximity to the Nanaimo Airport and to agriculture, both of which are known contributors of water with periodic excessive oxygen demand (Canadian Council of Ministers of the Environment, 1999).

Previously Plewes et al. (2018) included Lower Holden Creek and Holden Creek off Lazo Lane as sites of concern. Lower Holden Creek u/s Duke Pt Hwy was only sampled in 2017 and 2018 due to its tidal nature and thus was not included in this discussion. Holden Creek off Lazo Lane has been consistently sampled since 2017 and has not experienced a high frequency of exceedances, however it has several upstream land uses that have the potential to impact watershed health and should continued to be monitored. North Wexfrod Creek D/S Tenth Street and North Wexford Creek D/S Douglas Ave also had depleted DO in the summer. Sampling began at both sites in 2019. The later of the two had substantially lower summer DO values in 2020 compared to 2019.

3.5 Sites Not Previously Analyzed for Trends

Seasonal Mann-Kendall tests were used to identify and assess the direction and statistical significance of trends in water quality measurements over time. The test yields a result that is easy to interpret as either increasing, decreasing or not changing. There are nine sites that were not previously analyzed in 2018 that now have the required six years of water quality data for seasonal Mann-Kendall trend analysis. Eight significant trends were identified across seven of these nine sites (Table 3-7). Three of these significant trends occur in WR1, three occur in WR5 and one occurs in each of WR6b and WR7. Three of the sites had improving conditions with significant decreases in specific conductivity (Figure B11, Figure B12). Four of the sites had improving conditions with significant increases in dissolved oxygen (Figure B49, Figure B50, Figure B119, Figure B129). One site showed improving conditions with a significant decrease in turbidity (Figure B51).

Table 3-7: Sites not previously analyzed and associated trends.

Water Region	EMS ID	Location Name	Trend	Analyte	Condition
WR1	E298598	BIG QUALICUM RIVER ABOUT 700M D/S HATCHERY	↓	Specific conductance	Improving
WR1	E298597	BIG QUALICUM RIVER JUST U/S HWY 19 BRIDGE	↓	Specific conductance	Improving
WR1	E286549	THAMES CREEK 200M U/S OLD ISLAND HWY	↓	Specific conductance	Improving
WR4	E299852	CENTRE CREEK U/S SOUTH ENGLISHMAN RIVER	↑	Dissolved oxygen	Improving
WR4	E287131	SHELLEY CREEK AT HAMILTON RD	↑	Dissolved oxygen	Improving
WR4	E287131	SHELLEY CREEK AT HAMILTON RD	↓	Turbidity	Improving
WR6b	E215789	NANAIMO RIVER AT CEDAR RD BRIDGE	↑	Dissolved oxygen	Improving
WR7	E304070	MALLETT CREEK	↑	Dissolved oxygen	Improving

3.6 Sites With 10-years of Data

There are 18 sites where data has now been collected over a 10-year period (Table 3-8). Of those, four exhibited significant increasing or decreasing trends for either turbidity, DO or water temperature. These sites occurred within WR2 and WR3. Three of the trends indicate a degrading, or worsening condition in aquatic health, while the remaining site had an improving condition. No trends were observed for conductivity.

The seasonal Mann Kendall at Little Qualicum River at Intake (WR2) showed an increasing trend in turbidity (Figure B24). The greatest change occurred during the fall when turbidity measurements gradually increased from ~0.5 NTU to ~2.4 NTU. Despite the increasing trend, the 2020 fall turbidity remained below the 5 NTU guideline.

A discussion of the trends in WR3 are presented in Section 3.2.6. However, the take home message is that despite the degrading trends at two of the three sites (↑ water temperature, ↓ DO), the 2020 values remained within their respective guidelines.

Therefore, all three sites that had 10 years of data and a degrading condition fell within the specified guidelines. This indicates that although there may be degrading trends, these sites do not necessarily translate into Sites of Concern. Rather, the trend analysis tracks changes over time and can be used as a tool in concert with the exceedance analysis to identify problematic sites.

Table 3-8: Summary of sites with 10 years of data.

Water Region	EMS ID	Location Name	Trend	Analytes	Condition
WR1	E286553	NILE CREEK 50M U/S OLD ISLAND HWY	-	-	Stable
WR2	E285669	UPPER CAMERON RIVER	-	-	Stable
WR2	E220635	CAMERON RIVER	-	-	Stable
WR2	E256394	LITTLE QUALICUM RIVER AT INTAKE	↑	Turbidity	Degrading
WR2	E268993	LITTLE QUALICUM RIVER - 1.2KM D/S CAMERON LAKE	-	-	Stable
WR3	E243021	FRENCH CREEK AT NEW HIGHWAY	-	-	Stable
WR3	E243022	FRENCH CREEK AT BARCLAY BRIDGE	↓	DO	Degrading
WR3	E243024	FRENCH CREEK AT GRAFTON ROAD	-	-	Stable
WR3	E288090	GRANDON CREEK WEST CRESCENT (CAISSONS)	-	-	Stable
WR3	E288091	GRANDON CREEK AT LABURNUM ROAD	↑	DO	Improving
WR3	E288092	BEACH CREEK NEAR CHESTER ROAD AT HEMSWORTH ROAD	↑	Water Temperature	Degrading
WR3	E288093	BEACH CREEK NEAR MEMORIAL GOLF COURSE POND	-	-	Stable
WR4	E248834	ENGLISHMAN RIVER JUST UPSTREAM MORRISON CREEK	-	-	Stable
WR4	E248835	MORRISON CREEK JUST UPSTREAM ENGLISHMAN RIVER	-	-	Stable
WR4	E248836	SOUTH ENGLISHMAN RIVER JUST U/S ENGLISHMAN RIVER	-	-	Stable
WR4	0121580	ENGLISHMAN R. AT HIGHWAY 19A	-	-	Stable
WR4	E282969	UPPER ENGLISHMAN RIVER U/S CENTRE FORK CREEK	-	-	Stable
WR6	E287699	NANAIMO RIVER U/S HASLAM CK ~500 M D/S HWY 1 BRIDGE	-	-	Stable

4.0 RECOMMMEDATIONS

The following recommendations are meant to prioritize further efforts to improve and protect surface water quality.

4.1 Site Specific Recommendations within the Three Priority Water Regions

4.1.1 Water Region 3: French Creek

- French Creek at Barclay Bridge was the only site that exhibited a decreasing trend in DO. Despite the decreasing trend, the mean 2020 values were above the 8 mg/L guideline. Other sites, French Creek @ Grafton Road and Grandon Creek @ Laburnum Road had values outside the guideline. Additional sampling for ultra-low detection total and dissolved phosphorus, nitrogen and nitrates at these sites will help to confirm the potential cause of the decreasing DO. Ecoscape understands that phosphorus sampling was undertaken in 2019. If it has not already, this data should be reviewed and compared with CWMN data. We suspect there are high nutrient concentrations due to surrounding agricultural land use. The collection of nutrient data will assist in confirming this suspicion and it may help to target restoration efforts.

- Several sites in WR3 had turbidity that was approaching or exceeding the guideline in both summer and fall. Restoration efforts in the form of riparian planting should be explored to improve the riparian condition of these creeks and to ameliorate turbidity associated with rainfall.
- Given the high agricultural use in the French Creek watershed, we recommend that resources be provided to farmers to encourage sustainable practices and restoration efforts. Examples include ensuring that all farmers are aware of the provincial Environmental Farm Plan program, where farmers can gain access to funding for fencing riparian areas, seeding, and planting programs, etc.

4.1.2 Water Region 5: South Wellington to Nanoose

- There was a trend of increasing conductivity (i.e., degrading condition) at three sites in WR5. They included Cottle Creek @ Nottingham, Cottle Creek @ Stephenson Pt Road (WR5-1) and at Millstone River @ Biggs Road (WR5-2). The Cottle Creek sites occur downstream of an area that has experienced rapid development over the last decade. We suspect that this land use change likely contributed to the degrading condition in Cottle Creek. These sites should continue to be monitored as part of the CWMN program over the next several years to ensure that a stabilization in specific conductance occurs.

- The Millstone River @ Biggs Road occurs downstream of Brannon Lake. We understand that the lake is dammed, and the sampling site occurs downstream of the lake outflow. Therefore, the increasing conductivity is likely to do with influences on Brannon Lake. Efforts should be undertaken to identify activities that may be negatively influencing the water quality of Brannon Lake. It should also be determined if there is existing water quality data for Brannon Lake that could be reviewed.

4.1.3 *Water Region 6: Nanaimo River*

- The North Wexford Creek D/S of Tenth Street site should continue to be monitored as part of the CWMN program. This site had substantially depleted DO in the summer and multiple turbidity spikes that were not associated with rainfall events. This is the second year this site has been sampled and the low DO and high summer turbidity were also documented in 2019. Potential sources of turbidity should also be investigated.

- Plewes et al. (2018) had recommended re-running the trend analysis at Nanaimo River U/S Haslam Creek. There were 10 years of data at this site and all analytes were stable. Nevertheless, summer temperatures were elevated above the guideline at this site, as well as at Nanaimo River @ Cedar Rd Bridge. They have been consistently high throughout the monitoring program. These sites should be investigated to see if there are restoration opportunities that could improve the riparian condition along these stretches of the river.

4.2 Broader Recommendations

Several of these recommendations were provided by Plewes et al. (2018), but are included again, as they remain relevant and are important to properly document water quality conditions and to ensure watershed health.

- Conduct sampling outside of significant rainfall events, as the existing data has outliers attributable to storm events, and they can complicate statistical analyses and interpretation.
- Future analysis of the relationship between turbidity and precipitation may benefit from the use of hourly precipitation data in place of daily total precipitation. Potentially suitable networks that provide such data include: the BC Ministry of Forests, Lands, and Natural Resource Operations and Rural Development – Wild Fire Management Branch (Beaver Creek, Bowser and Cedar stations); the Ministry of Transportation and Infrastructure (Cochrane and North Courtenay stations); and the Environment Canada Qualicum Beach Airport station, which is a source of daily precipitation data assessed in this report. Any data from the listed networks would need to be assessed for accuracy, but hourly data would allow the relationship between precipitation and turbidity to be evaluated at a more granular level.

- Sample for ultra-low detection (0.002 mg/L RDL) Total and Dissolved Phosphorous, Nitrogen and Nitrates during the summer low flow period for watersheds and/or sites that have high agricultural land use, show evidence of excessive algae growth, and/or exhibit depleted DO. High agricultural use and depleted DO suggest a potential for high nutrient concentrations. Sampling for nutrients will help to confirm potential causes of low DO and will assist in the identification of critical areas for restoration and enhancement.
- Conductivity values greater than 230 µS/cm have been shown to alter fish communities (Morgan et al., 2012). Conductivity may be naturally high due to estuary or groundwater influence; however, another source of elevated conductivity is salt from paved roads/parking lots. Sites with elevated conductivity should be sampled for Chloride to determine if impervious surfaces are contributing to elevated conductivity and the potential impairment of aquatic ecosystems.
- Soil survey data from the Ministry of Environment online Soil Information Finder Tool should be utilized to better understand the natural variance in conductivity. It is expected that sites with watersheds that have more gleysols will naturally have higher conductance.
- A functional riparian habitat is critical for improved aquatic habitat values. Riparian restoration should be undertaken at all sites where the riparian habitat has been compromised and where CWMN analyte values occur outside of their respective guidelines. This is especially important for creeks that have modified adjacent land use such as agriculture and/or urban development.
- Policies for land use should consider ensuring effective implementation of agricultural buffers to separate farms from streams, where the buffers are based upon the risks associated with the farm type and the size of the watercourse. For example, a minimum 5 m buffer is often recommended between streams and cropland and a 15 m buffer for grazing. Larger buffers are encouraged for rivers and larger creeks.
- We understand that benthic invertebrate sampling following CABIN methodology has been undertaken within the various Water Regions. An assessment of the CABIN sites and how they may or may not overlap with CWMN sites would be useful. If there are overlapping sampling sites, we recommend reviewing both datasets. Together they will provide additional insights into the health of the aquatic ecosystems.
- Further to the previous point, we recommend establishing a long-term benthic monitoring program to further evaluate changes in creeks over time. Benthic sampling must occur in riffle habitat, but otherwise site selection should overlap CWMN sites, so that both datasets can be utilized. RDN should prioritize creeks for the benthic monitoring program considering key creeks that flow through a

variety of land uses (e.g., agricultural, industrial, residential), the inclusion of sampling locations that are located near areas of proposed growth, as well as considerations of CWMN sites that have been identified as Sites of Concern.

The City of Surrey has undertaken this type of program since the 1980s, and it has been informative to evaluate the effects of land use changes on stream health (Plewes and Olson-Russello, 2020). Their program integrates a Benthic Index of Biological Integrity (B-IBI) as a measure of biological condition. This index has been calibrated for northwestern coastal areas (e.g., Seattle and Vancouver) and it is sensitive to changes in human disturbances, but has limited inter-annual variability (Page et al., 2008).

- Trend analysis using the seasonal Mann-Kendall test should be repeated as additional years of data are added. At least six years of data is needed to look for specific trends and more data will improve the accuracy of the analysis.
- Targeted public education could be offered for areas where stormwater impacts are probable. This could involve an info mailer, adding a stencilled fish symbol to stormwater grates that report to fish-bearing streams, incentives for rain gardens, etc.
- Perform an analysis of where rain gardens would provide the greatest benefit to reduce the amount of stormwater from impervious surfaces such as roofs and parking lots. Rain gardens are an easy way to reduce the stormwater inputs to surrounding waterbodies and provide an aesthetically appealing garden that helps conserve water. Rain gardens at the municipal scale can include swales. Swales can gather and slow the infiltration of stormwater to the surrounding area. Additionally, swales can be used to direct water to rain gardens or other gardens. Rain gardens at commercial and industrial properties are also viable and can be used to adsorb or redirect runoff from large parking lots.
- Support physical assessments and stream mapping, to expand upon existing Fisheries and Oceans Canada Sensitive Habitat Inventory and Mapping (SHIM), to determine and document locations of erosion, point sources of contamination (i.e., outfalls) and priority restoration sites. This mapping is also useful for determining the quantity and quality of fish habitat and it provides a useful tool for effective long-term adaptive management. Streams should be prioritized for this mapping based on the highest level of surrounding disturbance/land uses and value of the watercourses as fish habitat.
- The provincial Riparian Areas Protection Regulation (RAPR) applies to industrial and residential development on properties within 30 m of a watercourse. Development applications via RAPR can present opportunities for riparian restoration. RDN should work with the Province to understand where riparian restoration works are occurring/proposed and how that restoration may be reflected in future CWMN sampling.

5.0 CLOSURE

This report has been prepared for the exclusive use of the Regional District of Nanaimo.

If you have any questions pertaining to this report, you may contact the undersigned at your convenience.

Respectfully Submitted,
ECOSCAPE Environmental Consultants

Prepared By:

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Appendix A

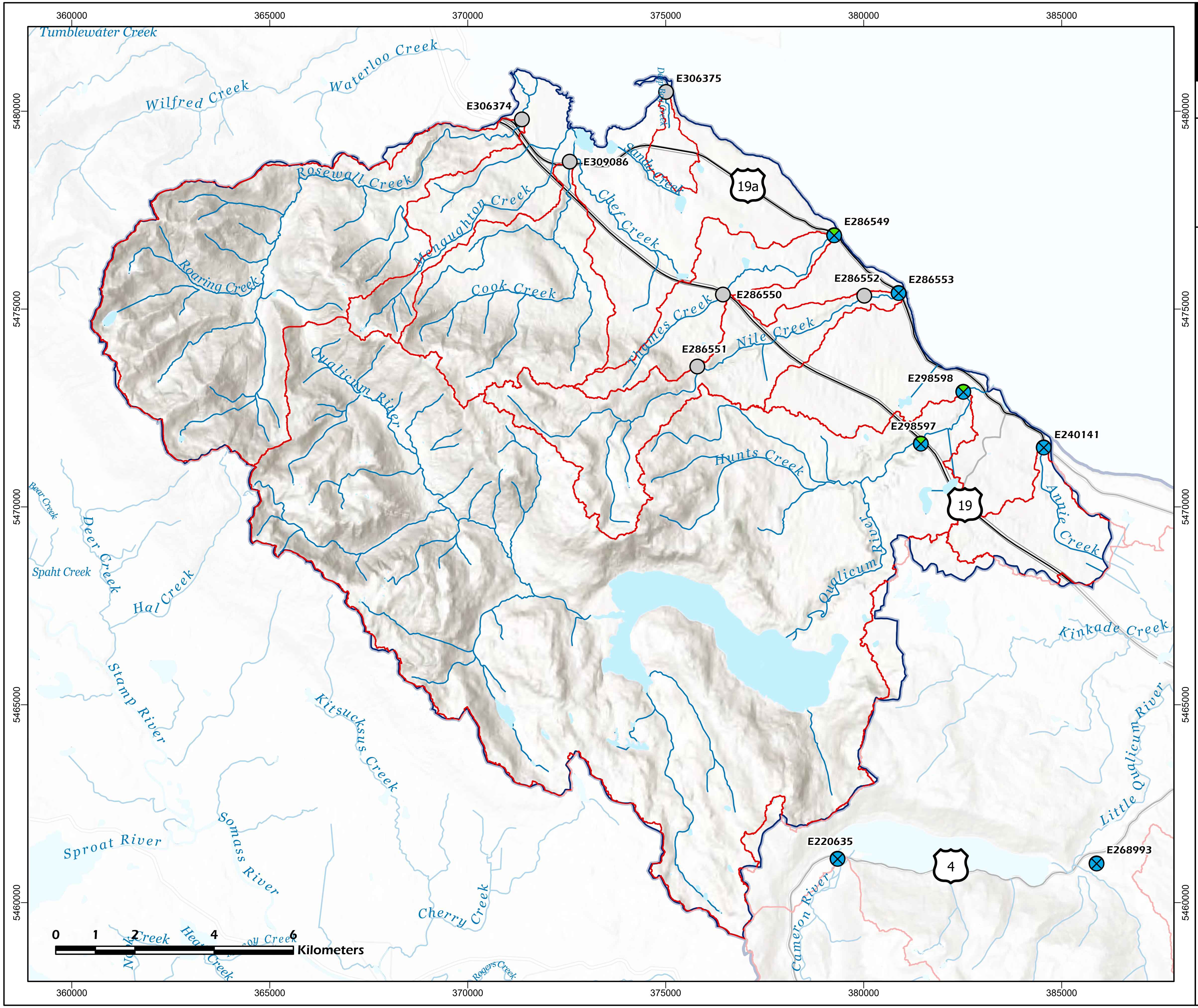
Water Region Maps with Trends

Regional District of Nanaimo

CMMN Water Quality Trend Analysis 2011-2020

WR1: Big Qualicum

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada



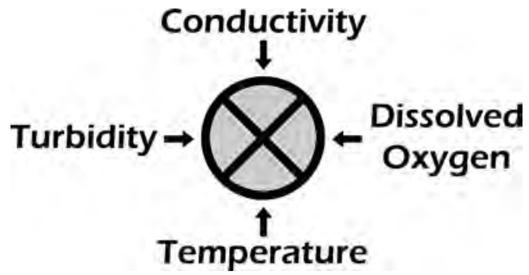
LEGEND

- ● Sample Site - No Trend Assessed
- ⊗ Sample Site - Trend Assessed
- — Highway
- ▭ Watershed
- ▭ Water Region
- ▬ Lake

Trend Color Code

- 🟩 Improving
- 🟦 Stable
- 🟥 Degrading

SAMPLE SITE KEY



Conductivity can be influenced by factors such as groundwater and ocean spray that are not necessarily indicative of a degrading condition. For simplicity, an increase in conductivity is categorized here as degrading.

MAP INDEX

Solid blue lines indicate entire water region; extent of main view map may be scaled to better visualize sample -site-dense regions.

DISCLAIMER

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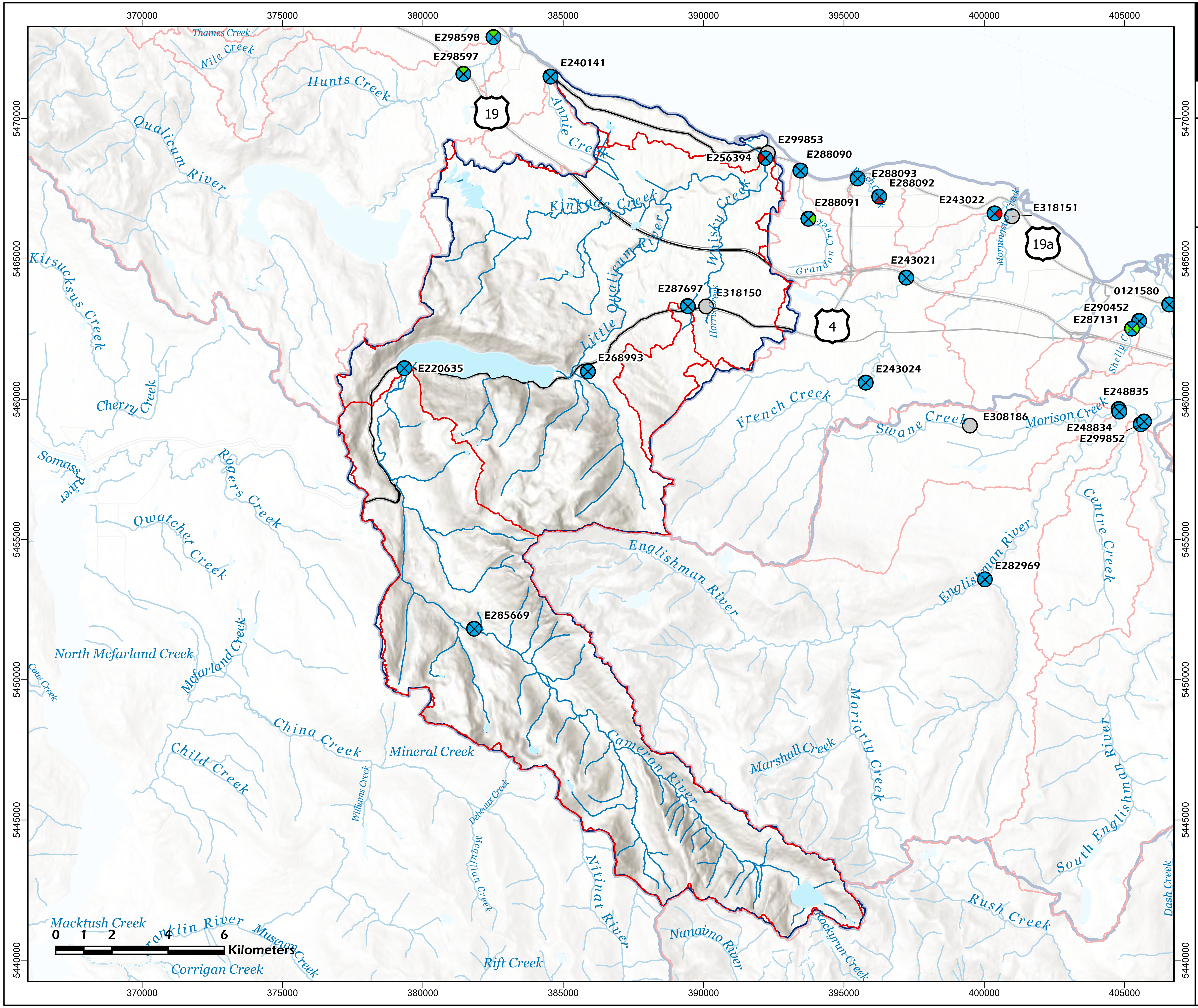


Regional District of Nanaimo

CMMN Water Quality Trend Analysis 2011-2020

WR2: Little Qualicum

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

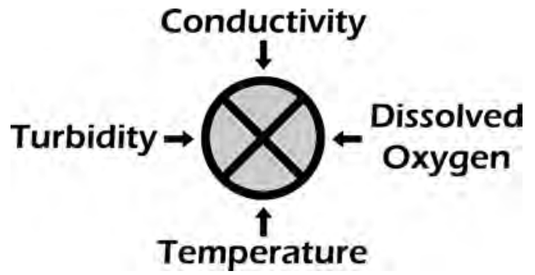
LEGEND

●	Sample Site - No Trend Assessed
⊗	Sample Site - Trend Assessed
—	Highway
▭	Watershed
▭	Water Region
▬	Lake

Trend Color Code

🟩	Improving
🟦	Stable
🟥	Degrading

SAMPLE SITE KEY



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MAP INDEX

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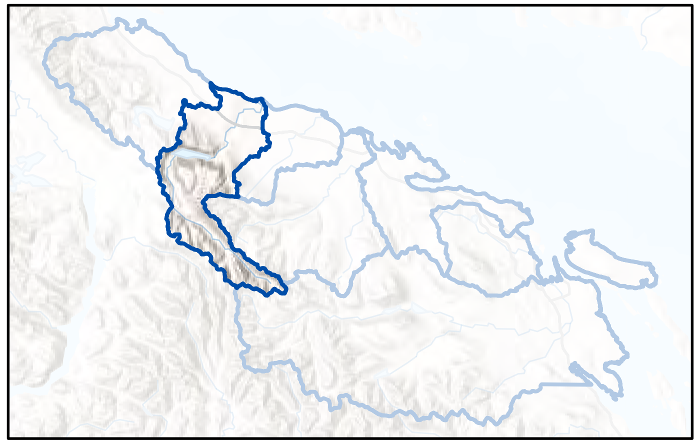

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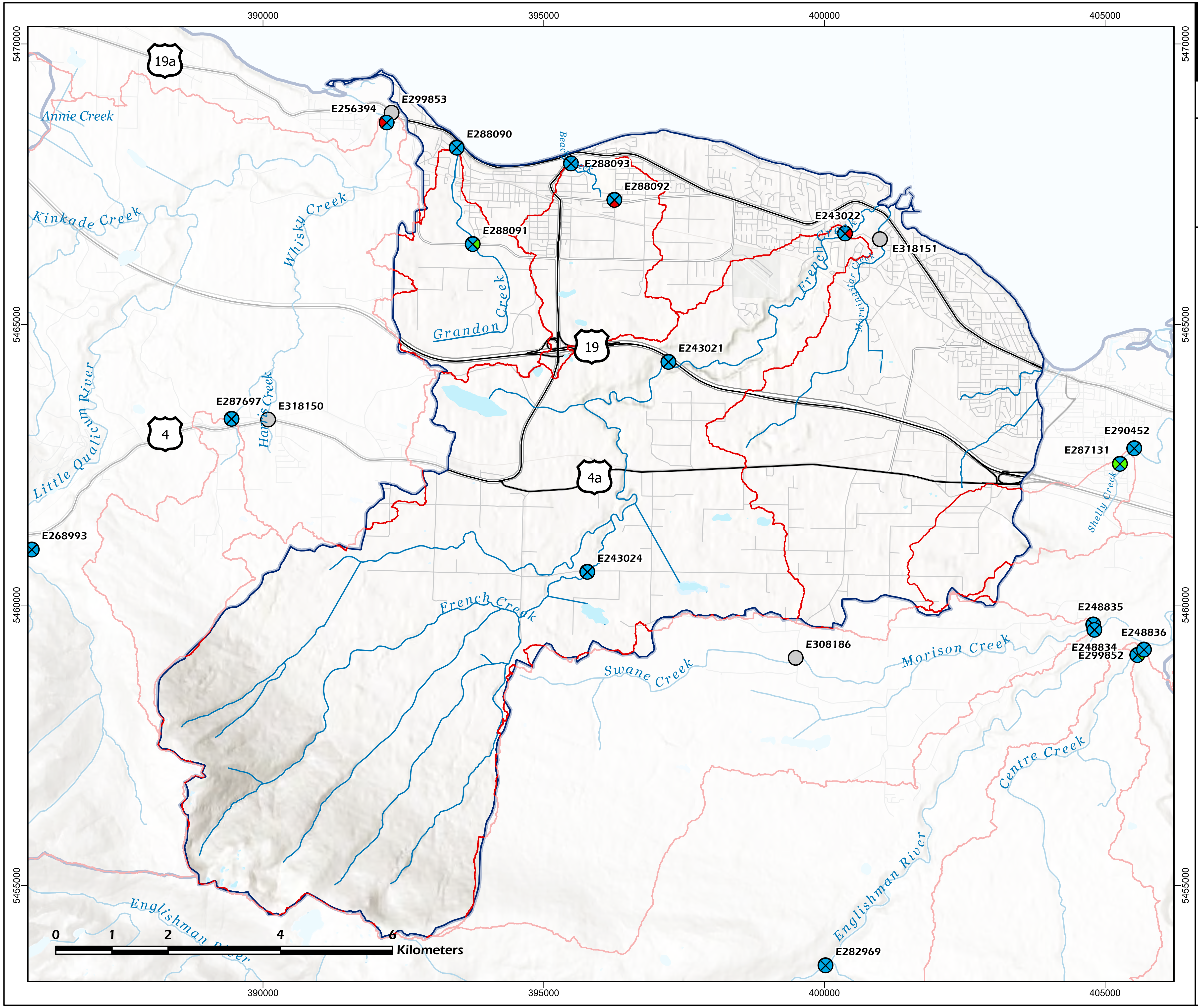


Regional District of Nanaimo

CMMN Water Quality Trend Analysis 2011-2020

WR3: French Creek

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

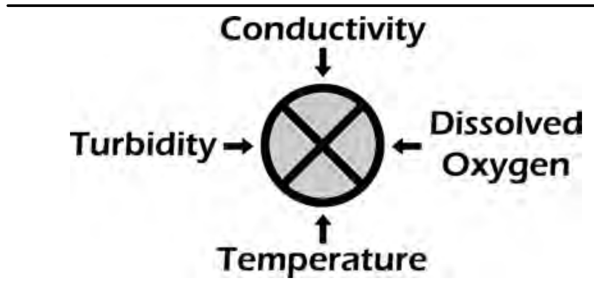
LEGEND

- ● Sample Site - No Trend Assessed
- ⊗ Sample Site - Trend Assessed
- — Highway
- ▭ Watershed
- ▭ Water Region
- ▭ Lake

Trend Color Code

- 🟩 Improving
- 🟦 Stable
- 🟥 Degrading

SAMPLE SITE KEY



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MAP INDEX

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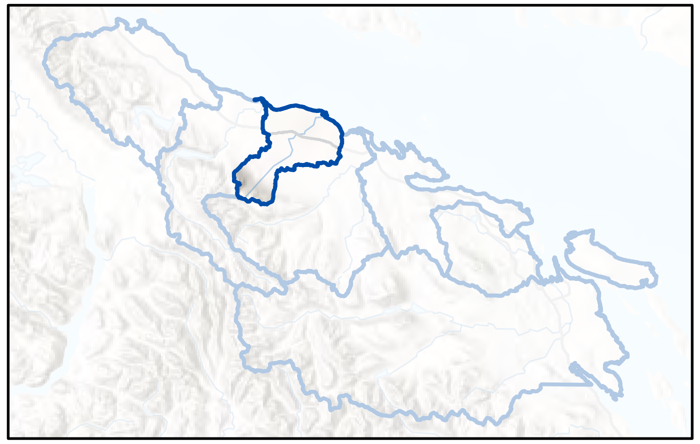

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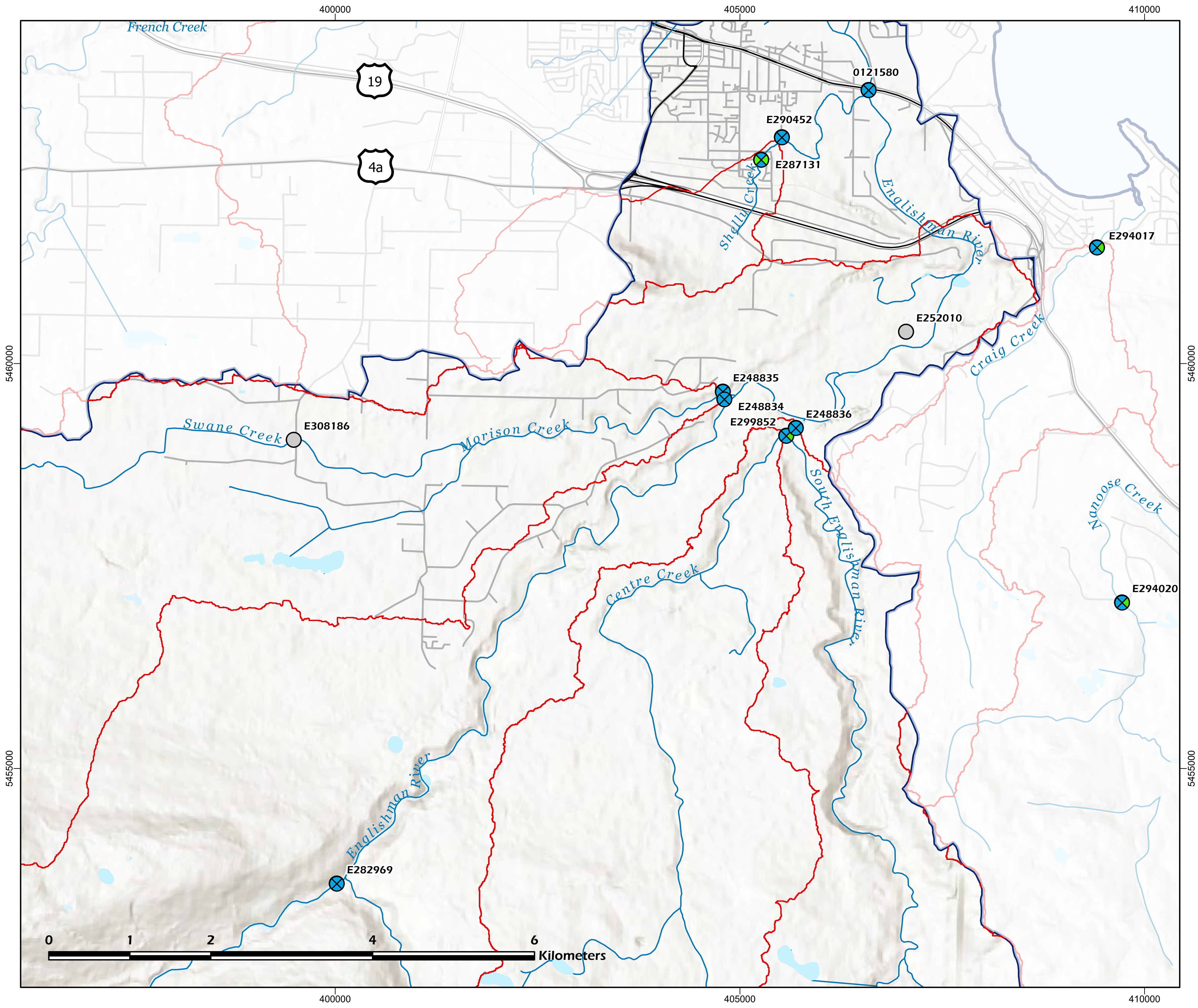


Regional District of Nanaimo

CMMN Water Quality Trend Analysis 2011-2020

WR4a: Englishman River

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

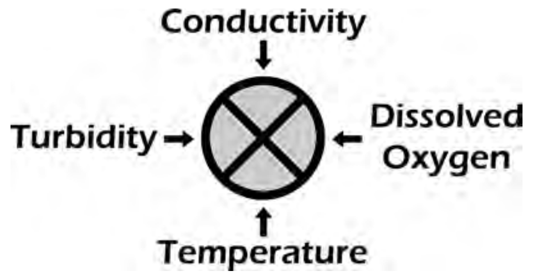
LEGEND

●	Sample Site - No Trend Assessed
⊗	Sample Site - Trend Assessed
—	Highway
▭	Watershed
▭	Water Region
▭	Lake

Trend Color Code

🟩	Improving
🟦	Stable
🟥	Degrading

SAMPLE SITE KEY



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MAP INDEX

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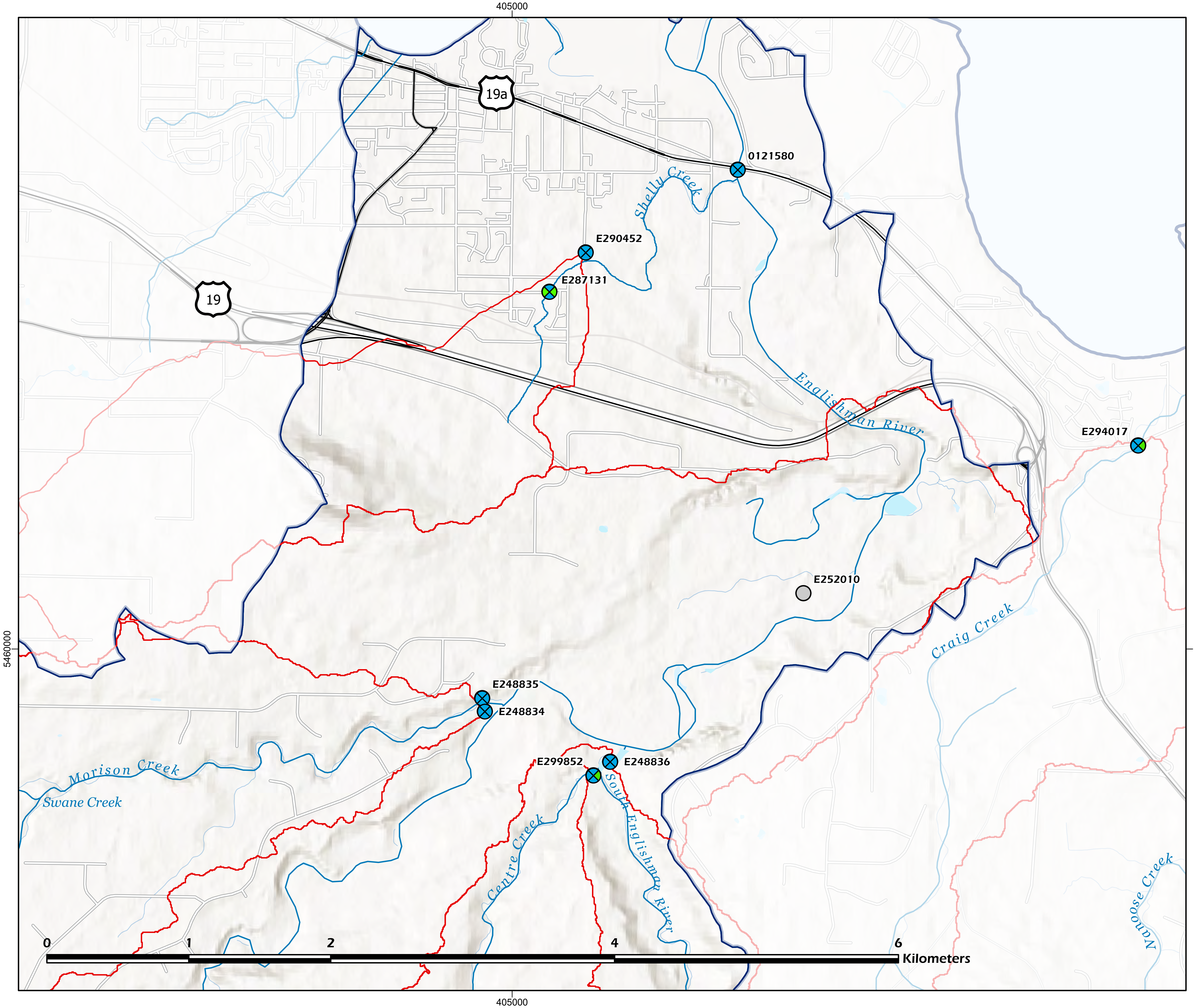


Regional District of Nanaimo

CMMN Water Quality Trend Analysis 2011-2020

WR4b: Englishman River

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

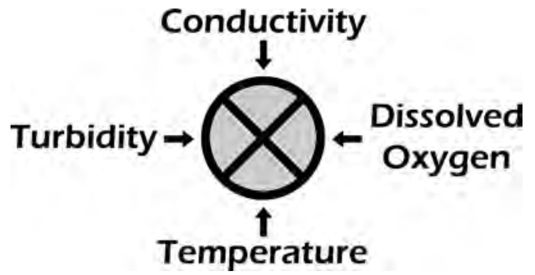
LEGEND

●	Sample Site - No Trend Assessed
⊗	Sample Site - Trend Assessed
—	Highway
▭	Watershed
▭	Water Region
■	Lake

Trend Color Code

🟩	Improving
🟦	Stable
🟥	Degrading

SAMPLE SITE KEY



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MAP INDEX

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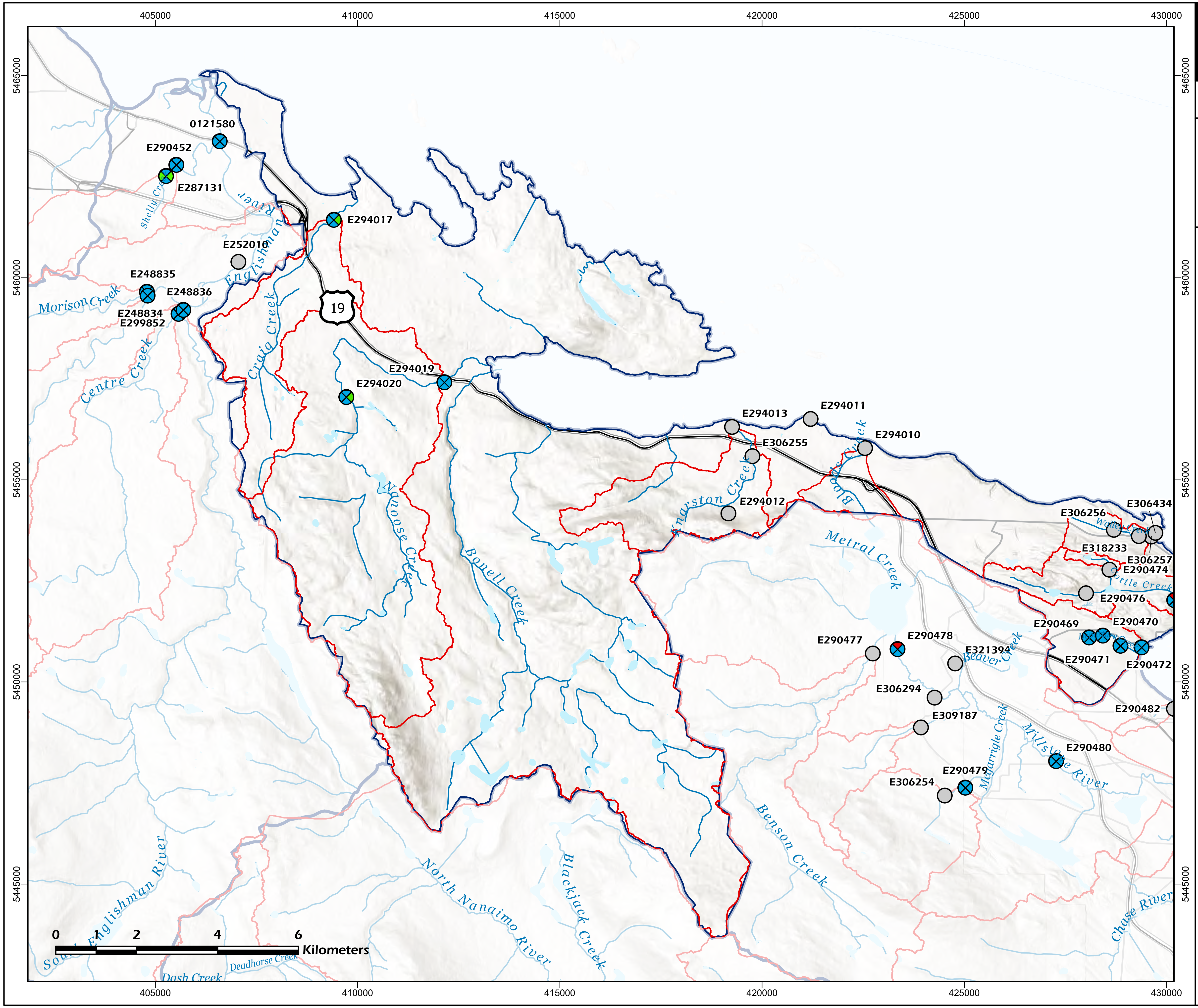


Regional District of Nanaimo

CMMN Water Quality Trend Analysis 2011-2020

WR5-1a: South Wellington to Nanoose

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

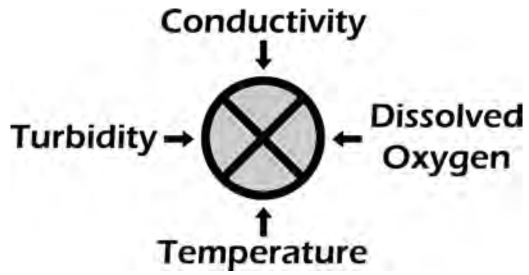
LEGEND

- ● Sample Site - No Trend Assessed
- ⊗ Sample Site - Trend Assessed
- — Highway
- ▭ Watershed
- ▭ Water Region
- ▬ Lake

Trend Color Code

- 🟩 Improving
- 🟦 Stable
- 🟥 Degrading

SAMPLE SITE KEY



Conductivity can be influenced by factors such as groundwater and ocean spray that are not necessarily indicative of a degrading condition. For simplicity, an increase in conductivity is categorized here as degrading.

MAP INDEX

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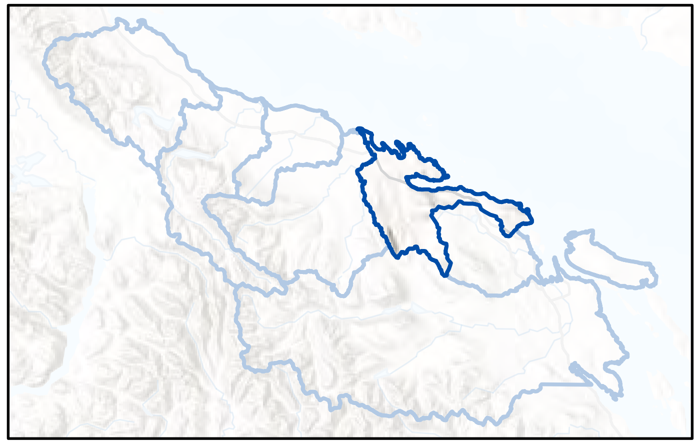

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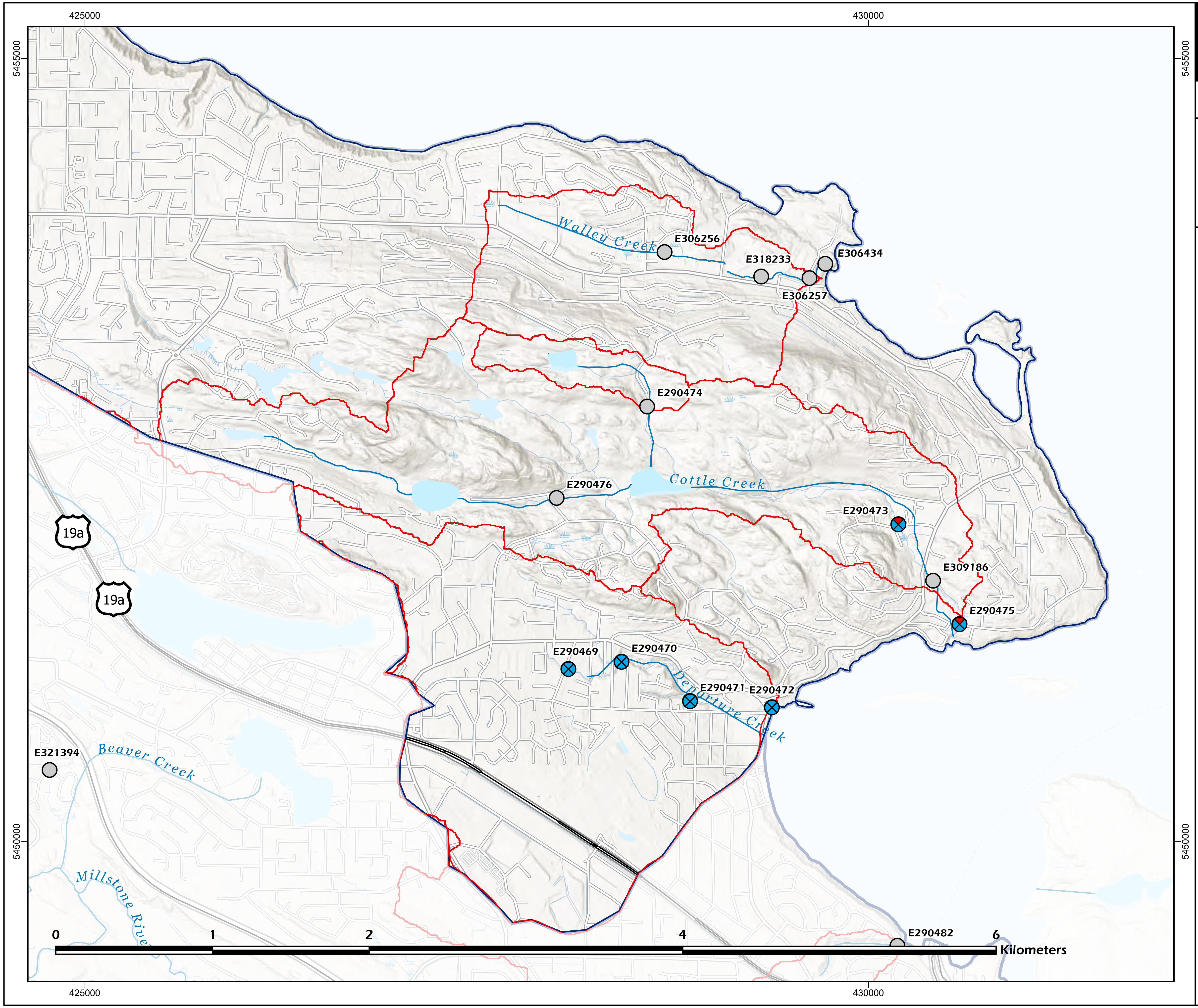


Regional District of Nanaimo

CMMN Water Quality Trend Analysis 2011-2020

WR5-1b: South Wellington to Nanoose

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

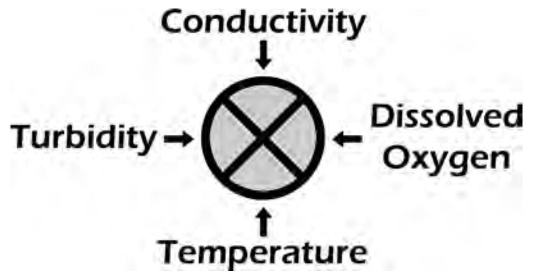
LEGEND

- ● Sample Site - No Trend Assessed
- ⊗ Sample Site - Trend Assessed
- — Highway
- ▭ Watershed
- ▭ Water Region
- ▭ Lake

Trend Color Code

- 🟩 Improving
- 🟦 Stable
- 🟥 Degrading

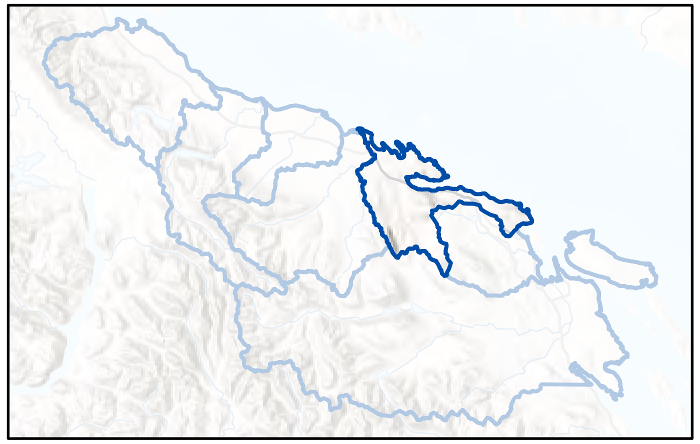
SAMPLE SITE KEY



Conductivity can be influenced by factors such as groundwater and ocean spray that are not necessarily indicative of a degrading condition. For simplicity, an increase in conductivity is categorized here as degrading.

MAP INDEX

Solid blue lines indicate entire water region; extent of main view map may be scaled to better visualize sample -site-dense regions.



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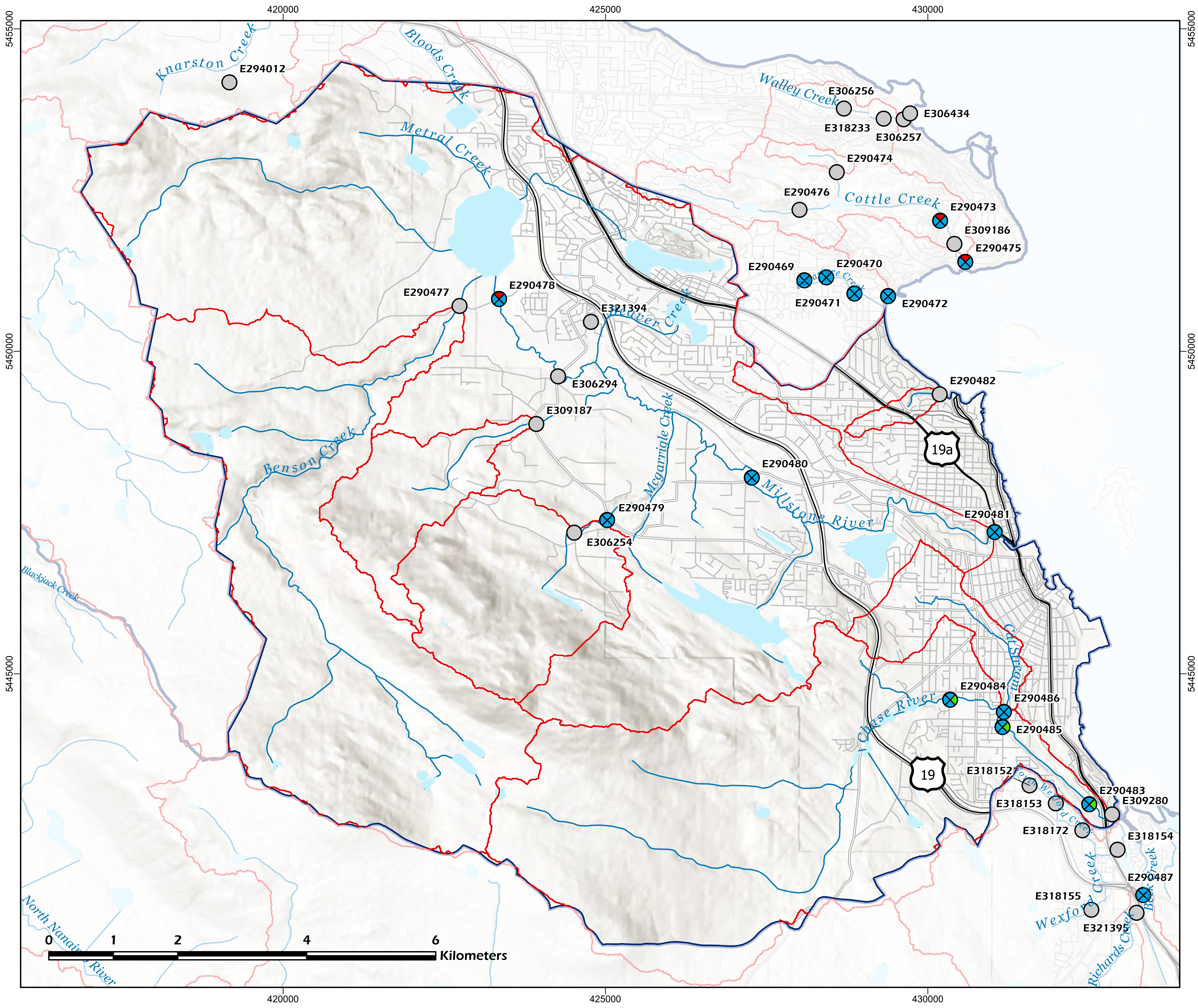


Regional District of Nanaimo

CMMN Water Quality Trend Analysis 2011-2020

WR5-2: South Wellington to Nanoose

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

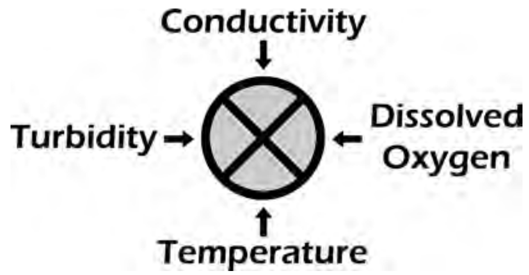
LEGEND

●	Sample Site - No Trend Assessed
⊗	Sample Site - Trend Assessed
—	Highway
▭	Watershed
▭	Water Region
▭	Lake

Trend Color Code

🟩	Improving
🟦	Stable
🟥	Degrading

SAMPLE SITE KEY



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MAP INDEX

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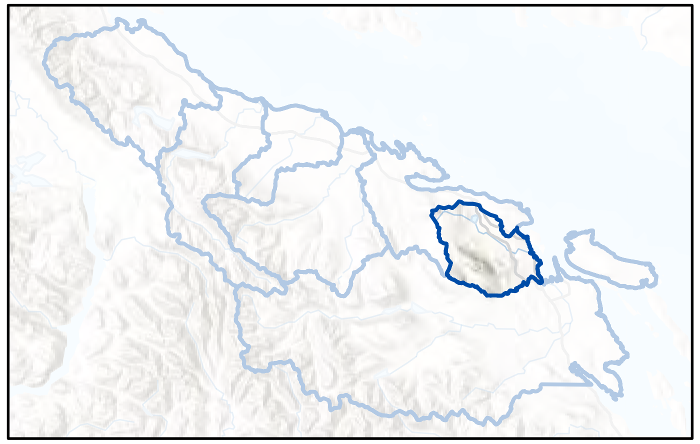

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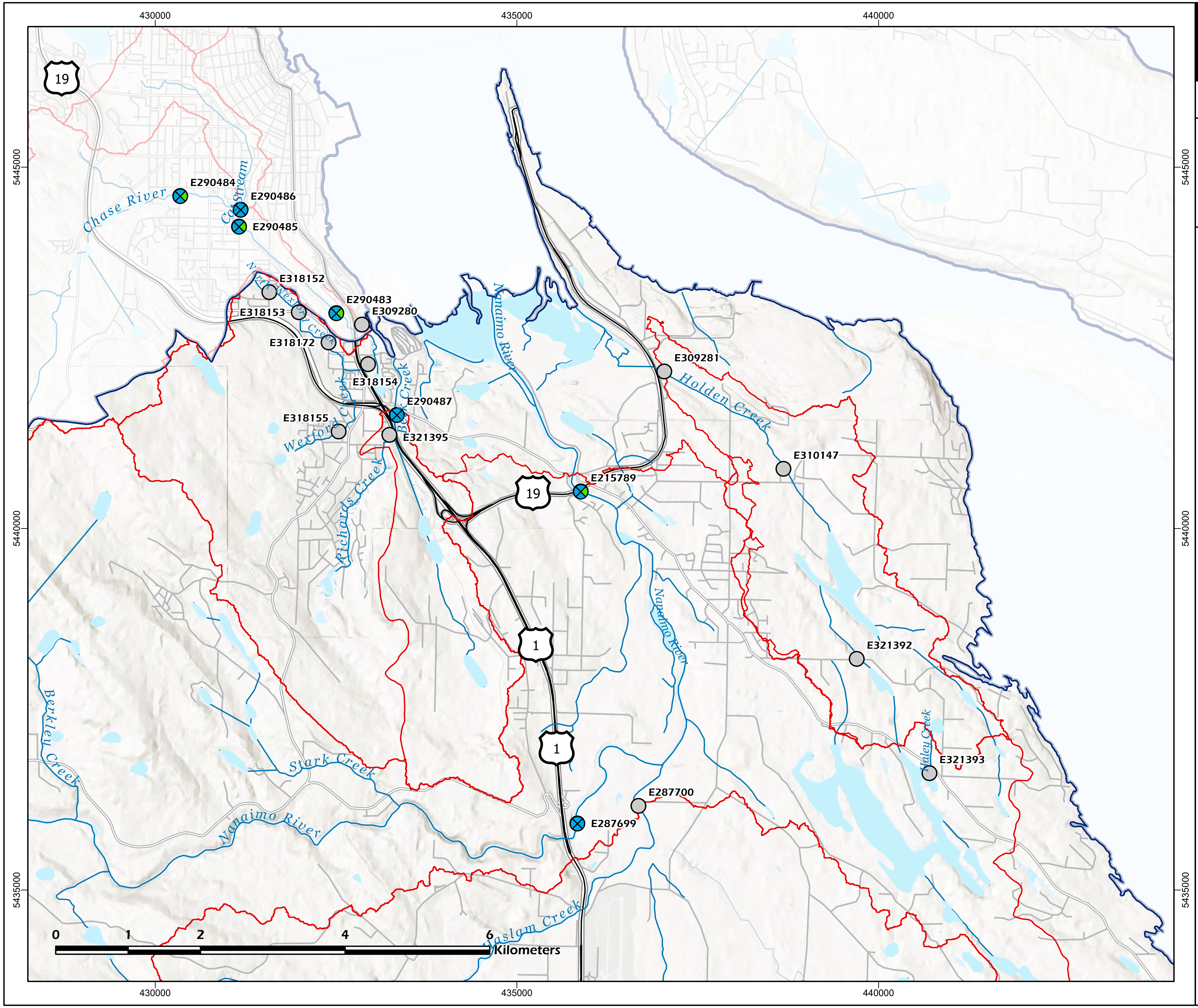


Regional District of Nanaimo

CMMN Water Quality Trend Analysis 2011-2020

WR6: Nanaimo River

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

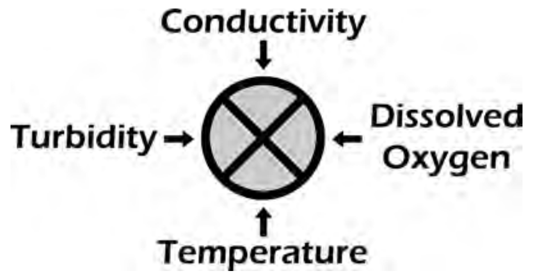
LEGEND

- ● Sample Site - No Trend Assessed
- ⊗ Sample Site - Trend Assessed
- — Highway
- ▭ Watershed
- ▭ Water Region
- ▭ Lake

Trend Color Code

- 🟩 Improving
- 🟦 Stable
- 🟥 Degrading

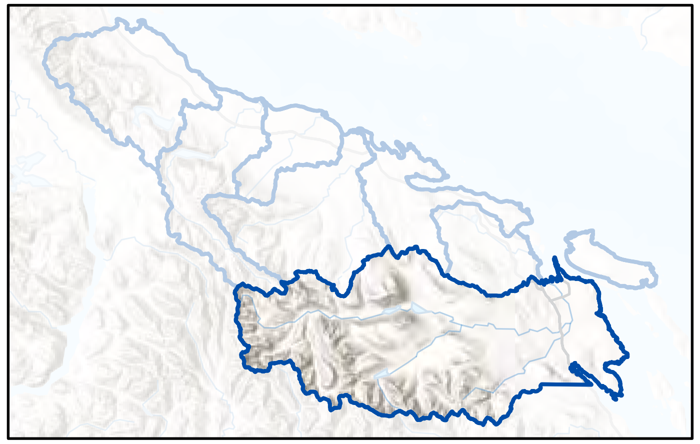
SAMPLE SITE KEY



Conductivity can be influenced by factors such as groundwater and ocean spray that are not necessarily indicative of a degrading condition. For simplicity, an increase in conductivity is categorized here as degrading.

MAP INDEX

Solid blue lines indicate entire water region; extent of main view map may be scaled to better visualize sample -site-dense regions.



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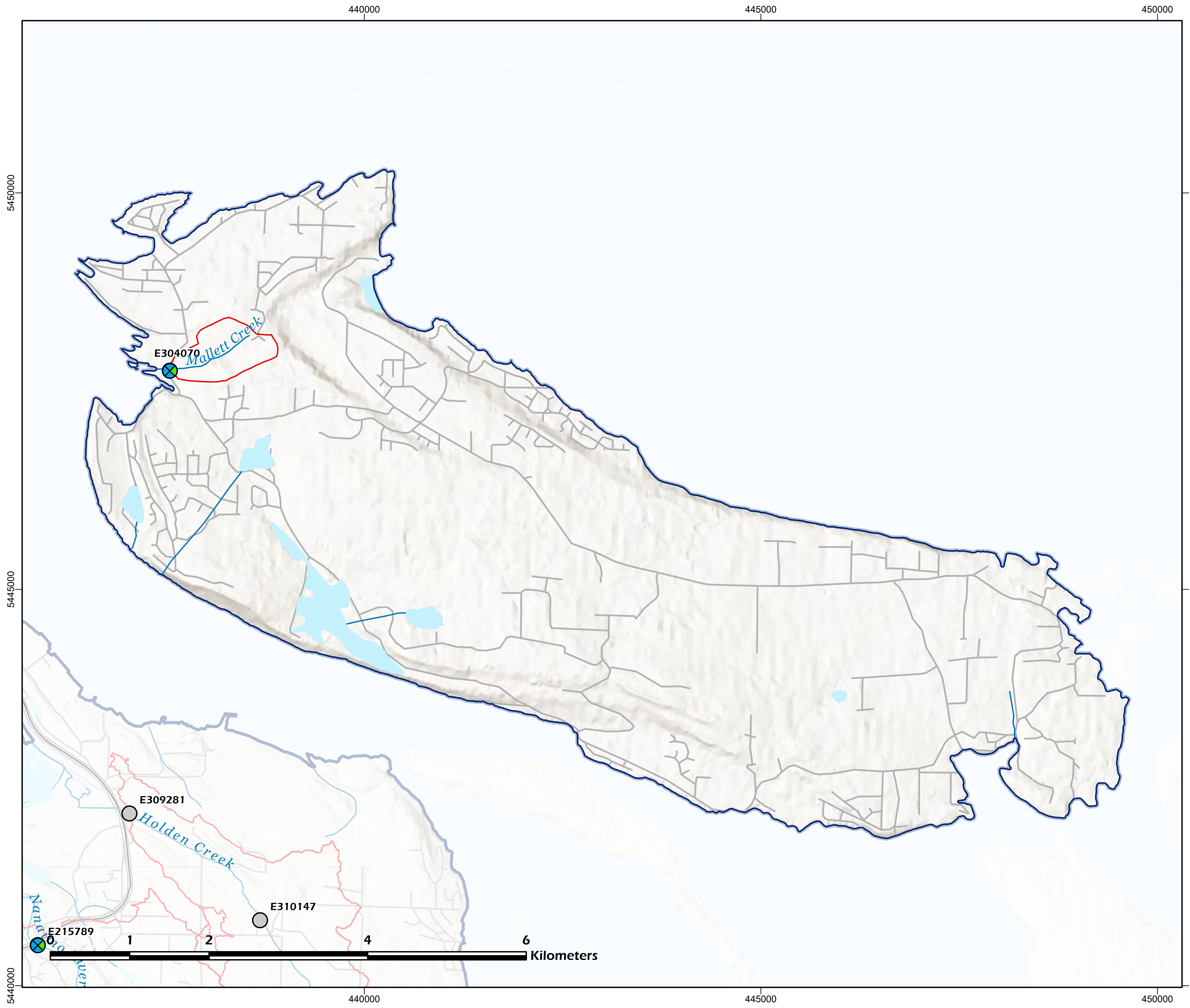


Regional District of Nanaimo

CMMN Water Quality Trend Analysis 2011-2020

WR7: Gabriola Island

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

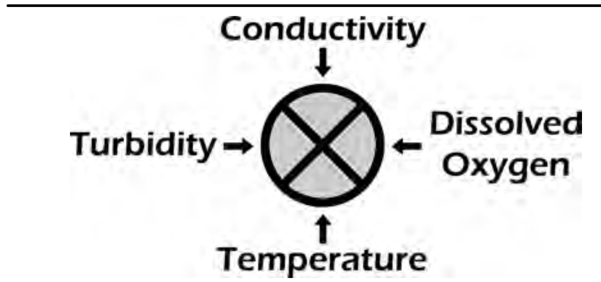
LEGEND

●	Sample Site - No Trend Assessed
⊗	Sample Site - Trend Assessed
—	Highway
▭	Watershed
▭	Water Region
▬	Lake

Trend Color Code

🟩	Improving
🟦	Stable
🟥	Degrading

SAMPLE SITE KEY



Conductivity can be influenced by factors such as groundwater and ocean spray that are not necessarily indicative of a degrading condition. For simplicity, an increase in conductivity is categorized here as degrading.

MAP INDEX

Solid blue lines indicate entire water region; extent of main view map may be scaled to better visualize sample -site-dense regions.

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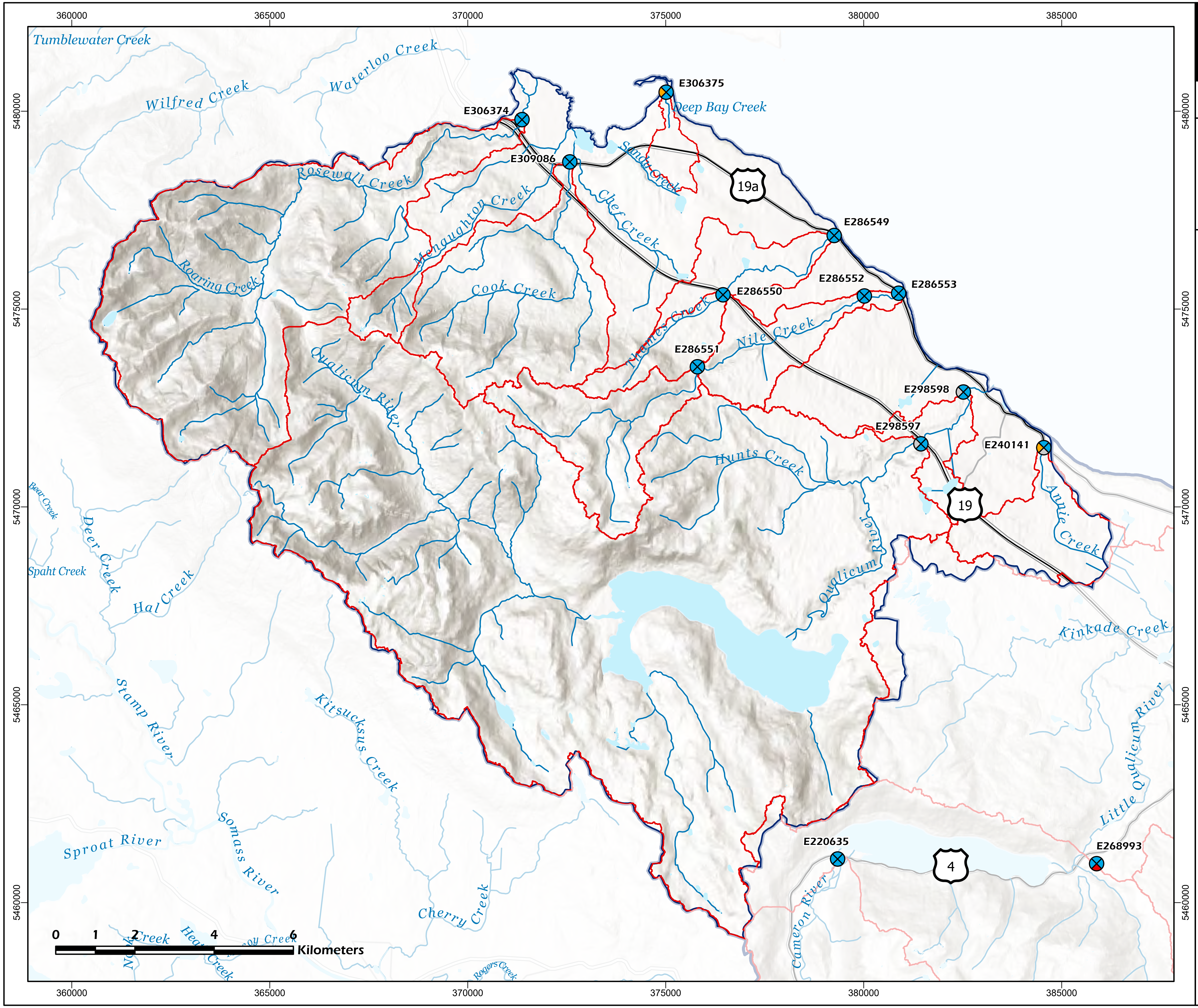


Regional District of Nanaimo

CMMN 2011-2020 Summer Exceedance Assessment

WR1: Big Qualicum

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

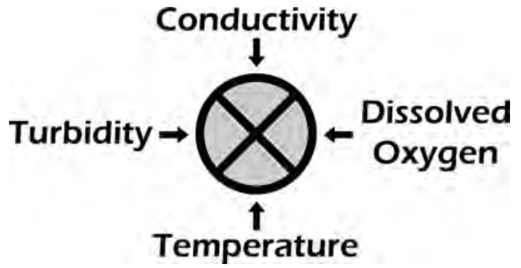
LEGEND

⊗	Sample Site
—	Highway
—	Stream
▭	Watershed
▭	Water Region
▭	Lake

Exceedance colour key

🟦	No exceedance recorded
⬜	Low exceedance frequency
🟧	Moderate exceedance frequency
🟥	High exceedance frequency

SAMPLE SITE KEY



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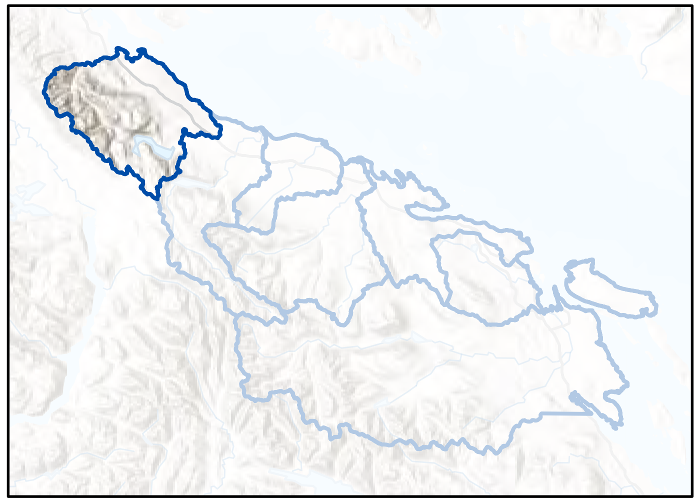

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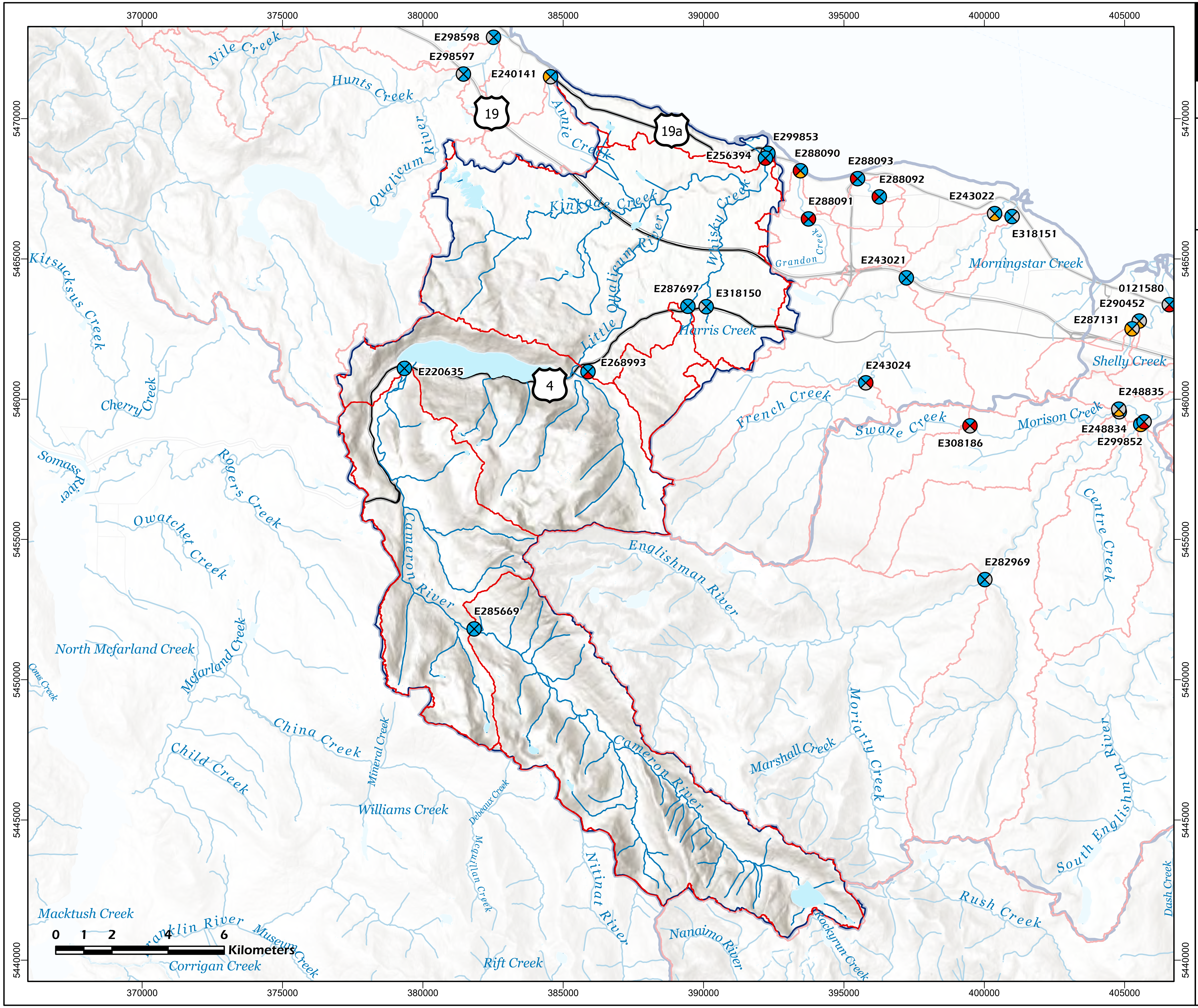


Regional District of Nanaimo

CMMN 2011-2020 Summer Exceedance Assessment

WR2: Little Qualicum

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

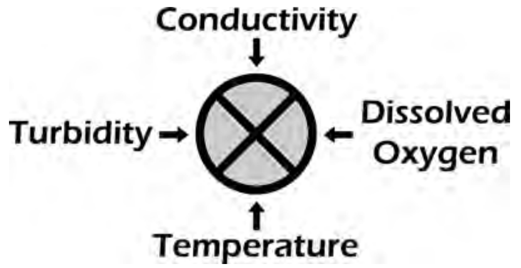
LEGEND

⊗	Sample Site
—	Highway
—	Stream
▭	Watershed
▭	Water Region
▭	Lake

Exceedance colour key

🟦	No exceedance recorded
⬜	Low exceedance frequency
🟧	Moderate exceedance frequency
🟥	High exceedance frequency

SAMPLE SITE KEY



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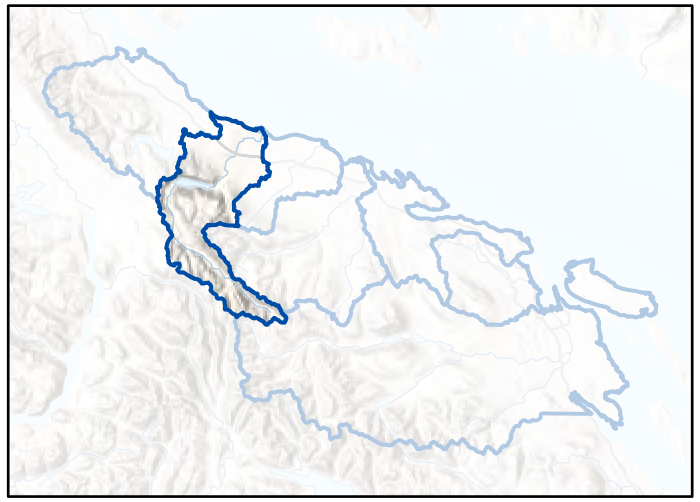

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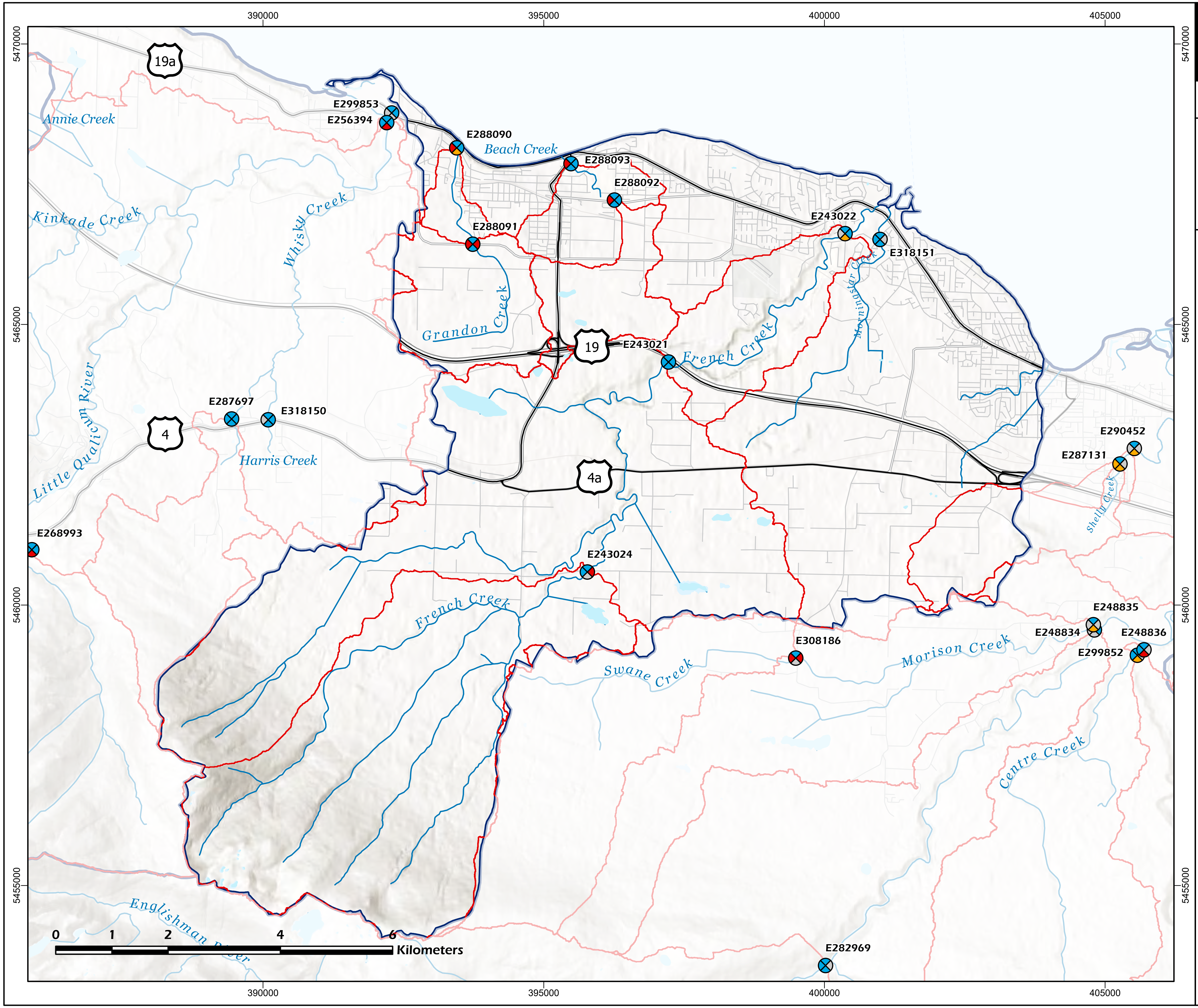


Regional District of Nanaimo

CMMN 2011-2020 Summer Exceedance Assessment

WR3: French Creek

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

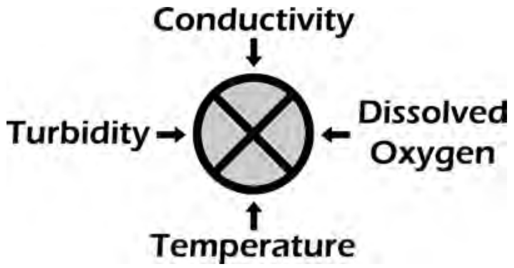
LEGEND

- ⊗ Sample Site
- — Highway
- — Stream
- ▭ Watershed
- ▭ Water Region
- ▭ Lake

Exceedance colour key

- 🟦 No exceedance recorded
- ⬜ Low exceedance frequency
- 🟧 Moderate exceedance frequency
- 🟥 High exceedance frequency

SAMPLE SITE KEY



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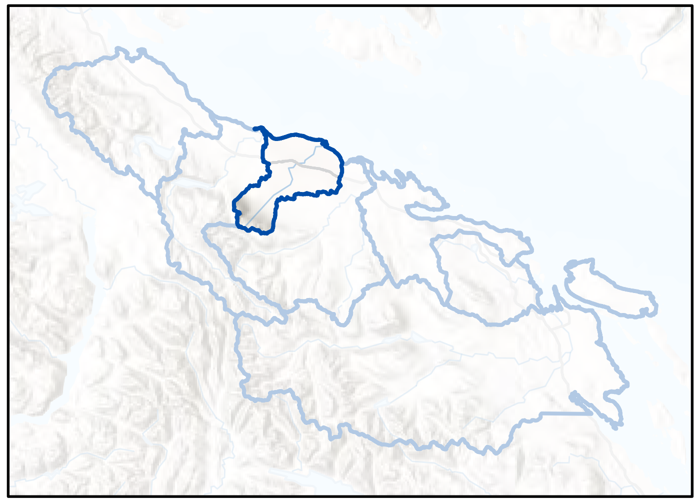

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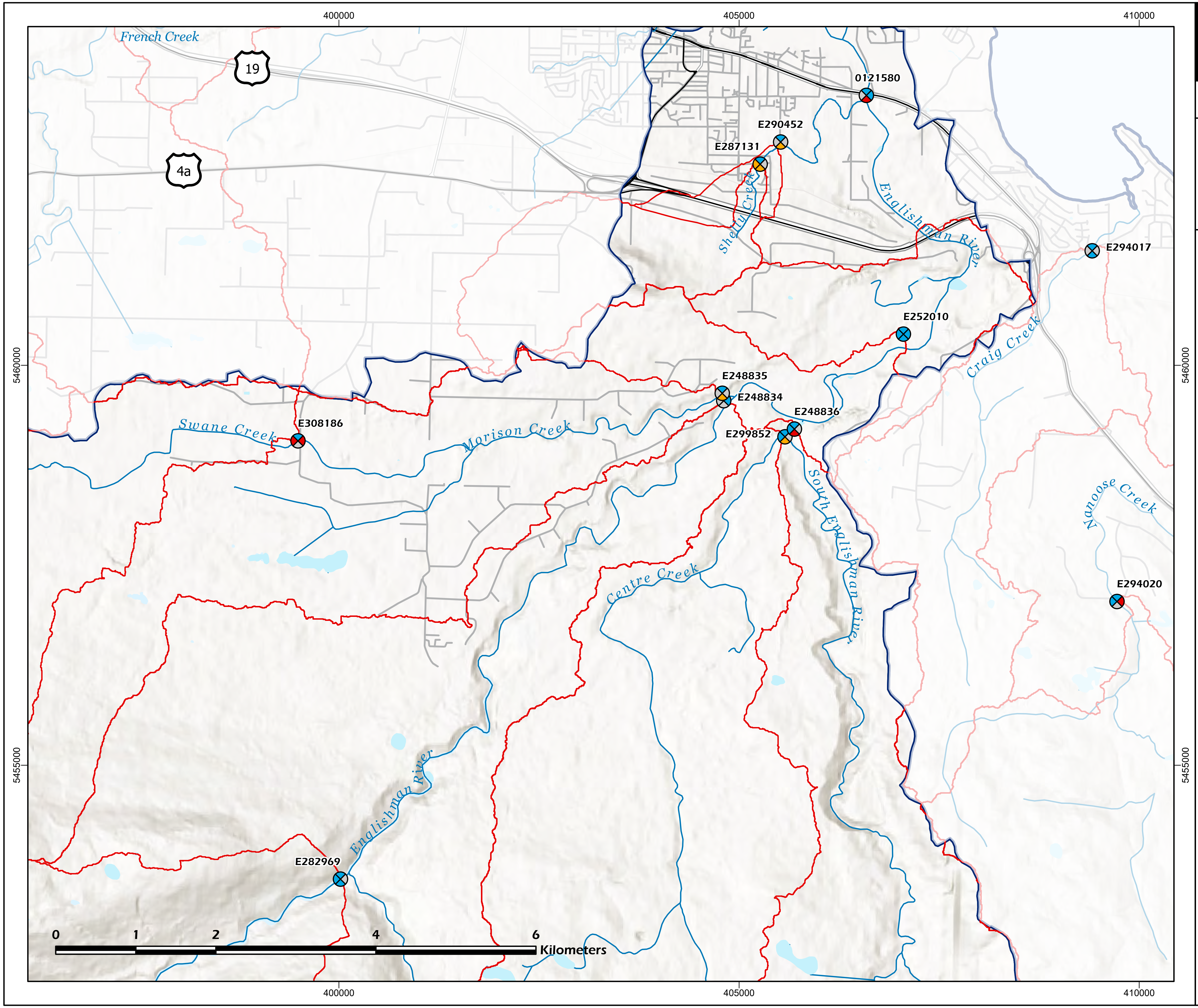


Regional District of Nanaimo

CMMN 2011-2020 Summer Exceedance Assessment

WR4a: Englishman River

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

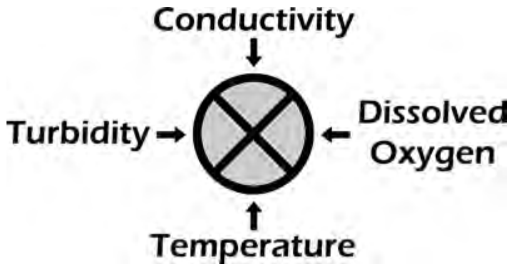
LEGEND

⊗	Sample Site
—	Highway
—	Stream
▭	Watershed
▭	Water Region
■	Lake

Exceedance colour key

🟦	No exceedance recorded
■	Low exceedance frequency
🟧	Moderate exceedance frequency
🟥	High exceedance frequency

SAMPLE SITE KEY



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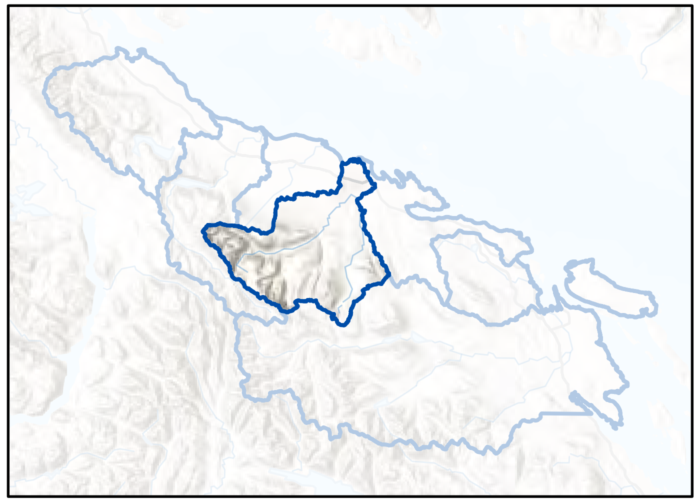

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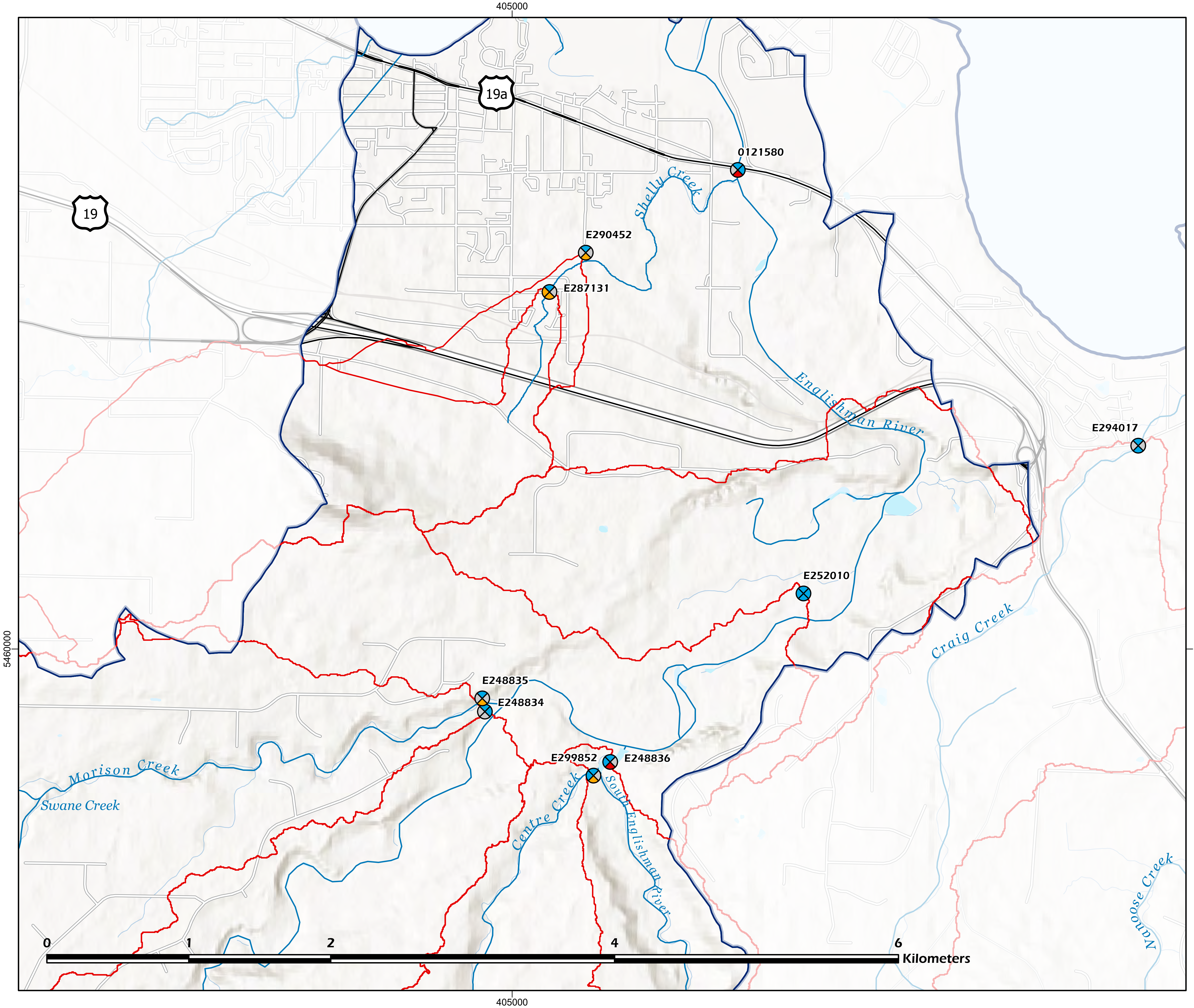


Regional District of Nanaimo

CMMN 2011-2020 Summer Exceedance Assessment

WR4b: Englishman River

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

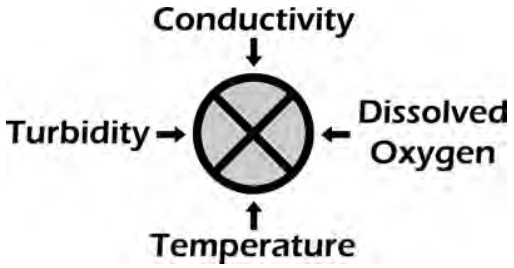
LEGEND

⊗	Sample Site
—	Highway
—	Stream
▭	Watershed
▭	Water Region
▬	Lake

Exceedance colour key

🟦	No exceedance recorded
⬜	Low exceedance frequency
🟧	Moderate exceedance frequency
🟥	High exceedance frequency

SAMPLE SITE KEY



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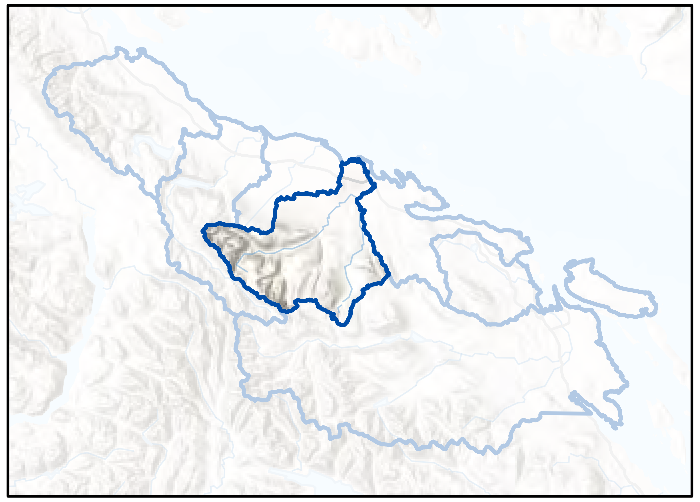

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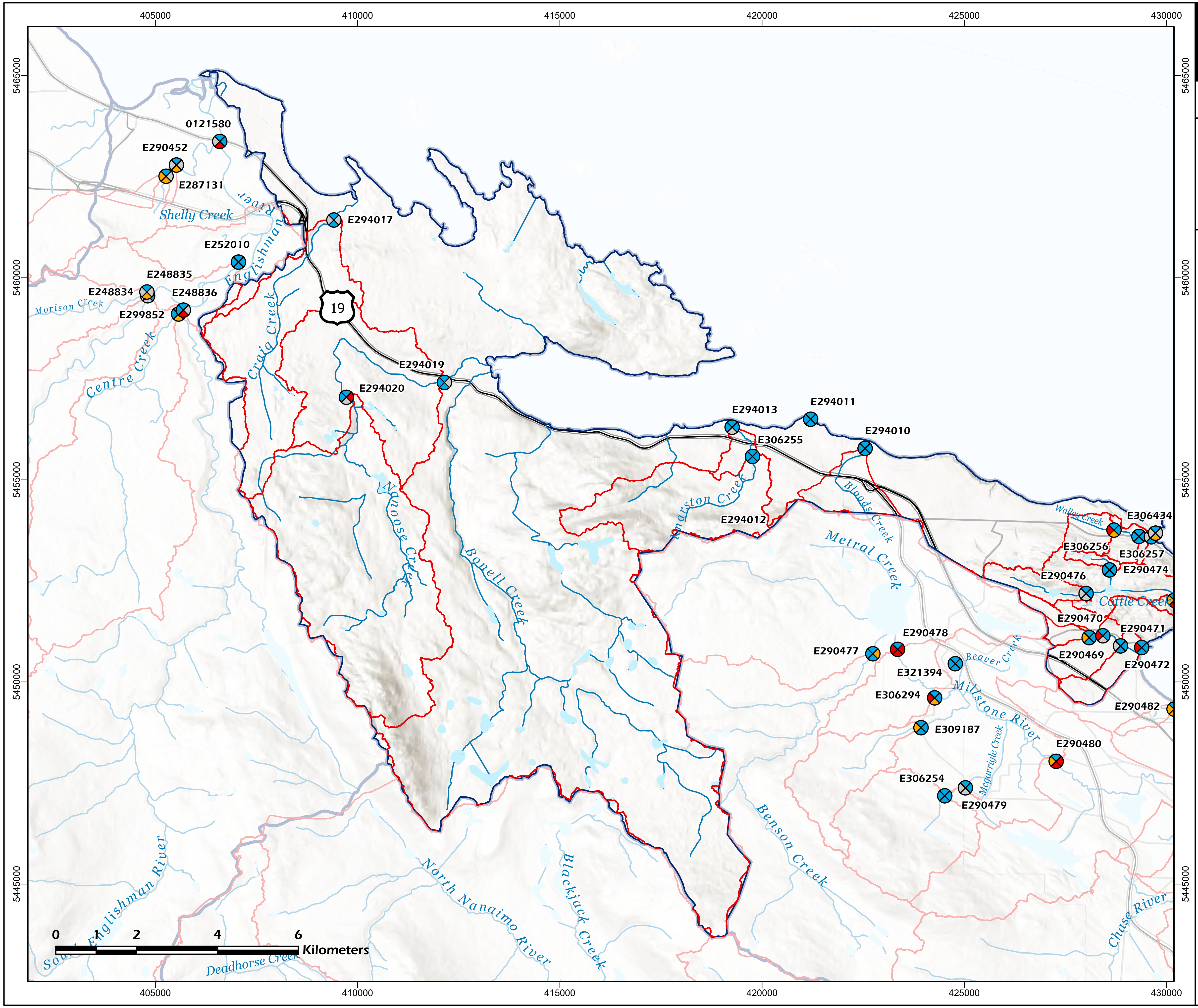


Regional District of Nanaimo

CMMN 2011-2020 Summer Exceedance Assessment

WR5-1a: South Wellington to Nanoose

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

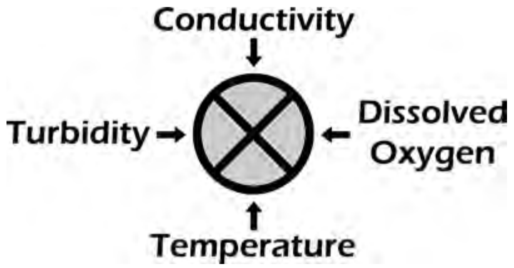
LEGEND

- ⊗ Sample Site
- — Highway
- — Stream
- ▭ Watershed
- ▭ Water Region
- ▭ Lake

Exceedance colour key

- 🟦 No exceedance recorded
- ⬜ Low exceedance frequency
- 🟧 Moderate exceedance frequency
- 🟥 High exceedance frequency

SAMPLE SITE KEY



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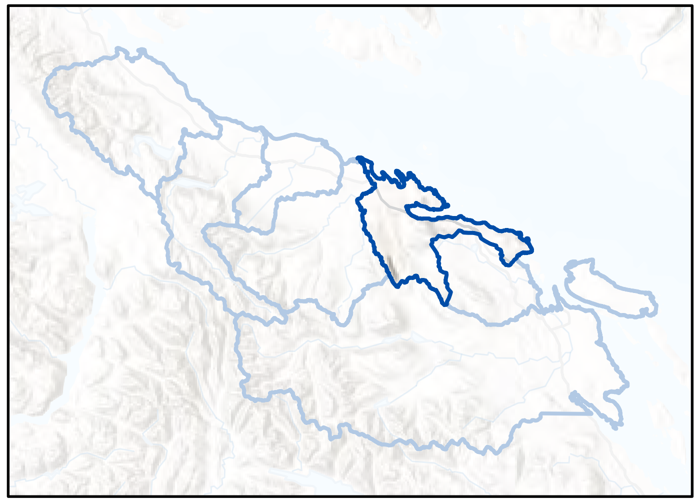

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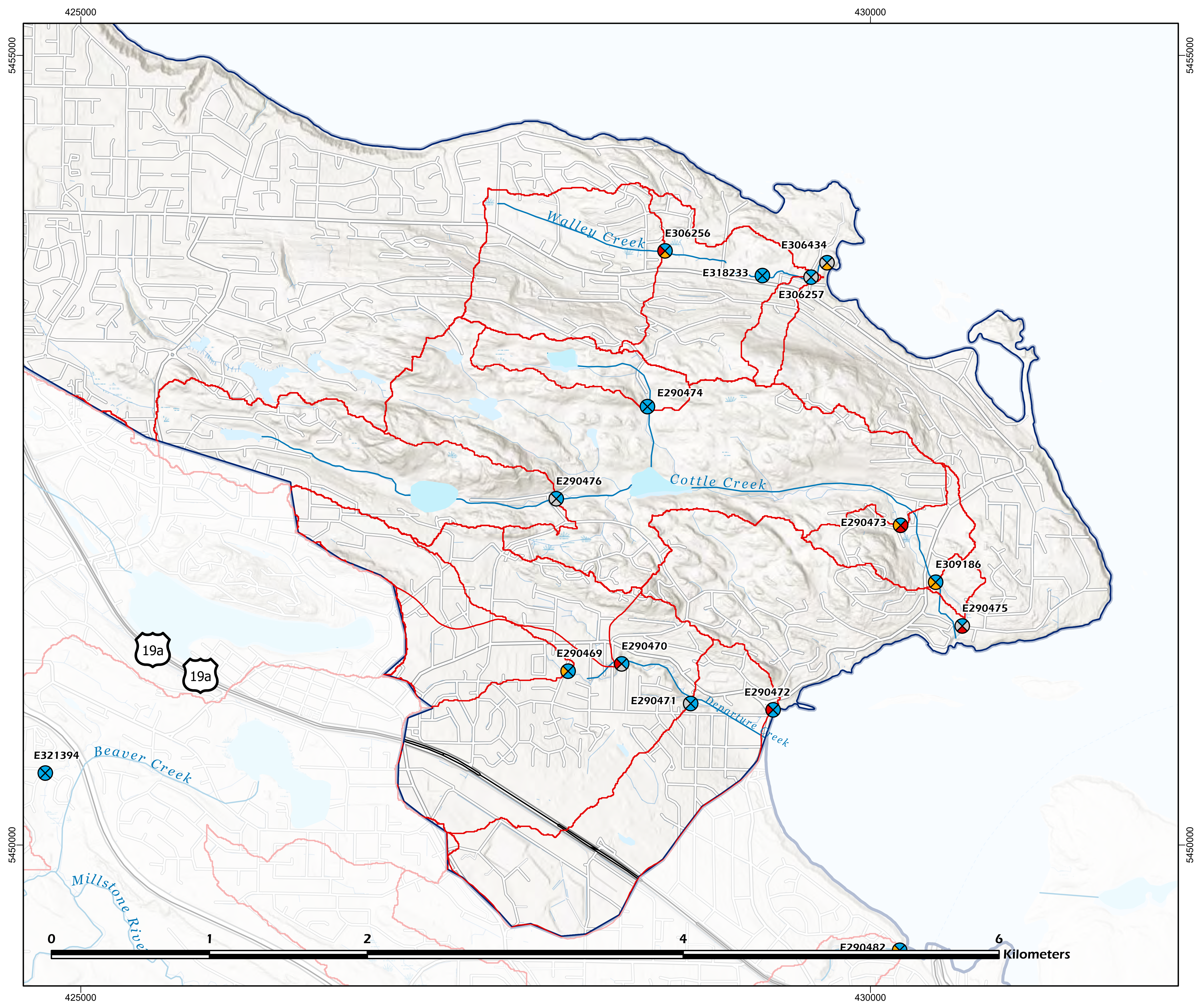


Regional District of Nanaimo

CMMN 2011-2020 Summer Exceedance Assessment

WR5-1b: South Wellington to Nanoose

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

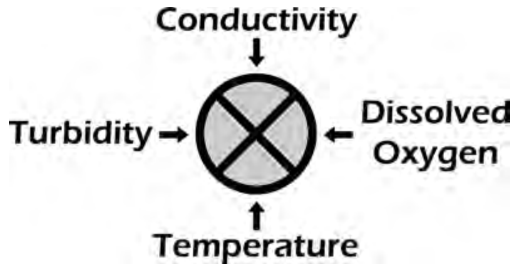
LEGEND

- ⊗ Sample Site
- — Highway
- — Stream
- ▭ Watershed
- ▭ Water Region
- ▭ Lake

Exceedance colour key

- 🟦 No exceedance recorded
- ⬜ Low exceedance frequency
- 🟧 Moderate exceedance frequency
- 🟥 High exceedance frequency

SAMPLE SITE KEY



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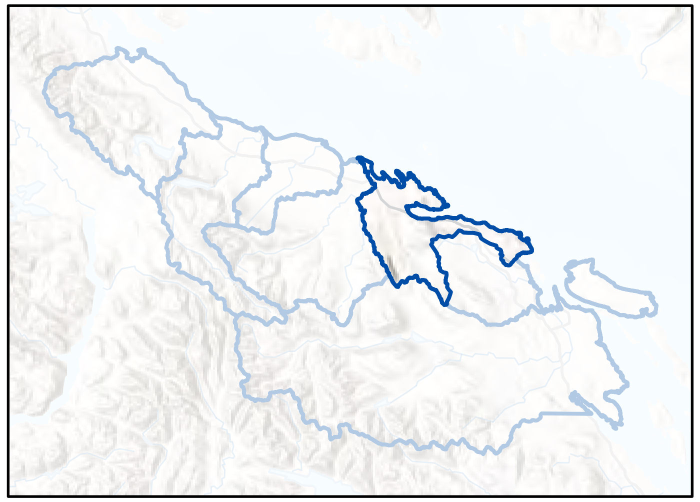

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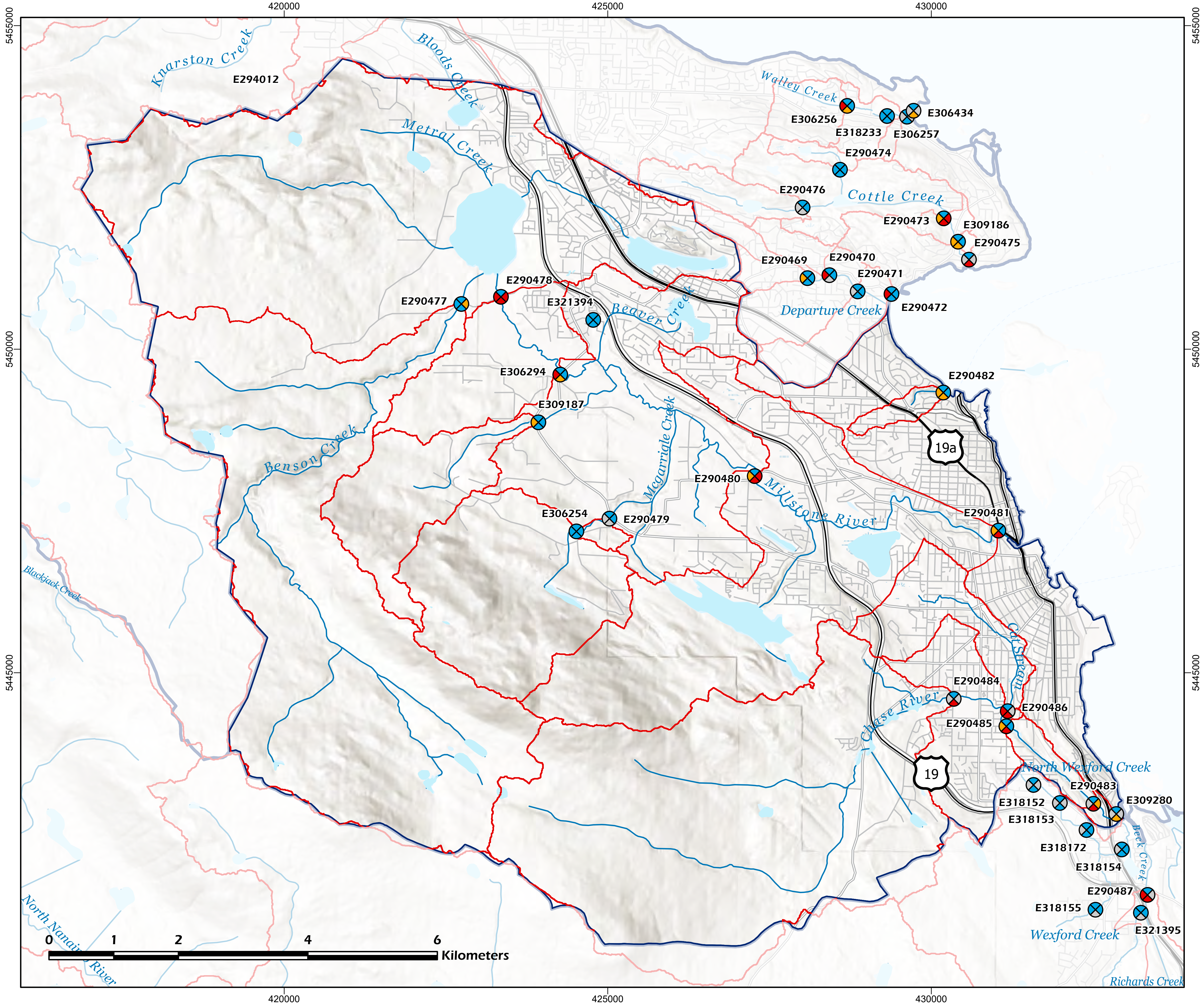


Regional District of Nanaimo

CMMN 2011-2020 Summer Exceedance Assessment

WR5-2: South Wellington to Nanoose

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

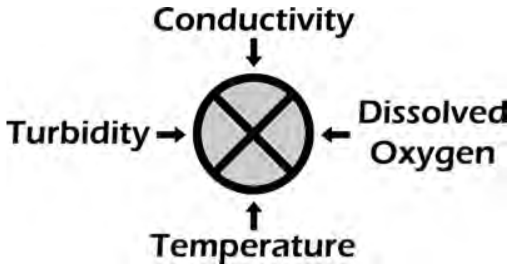
LEGEND

- ⊗ Sample Site
- — Highway
- — Stream
- ▭ Watershed
- ▭ Water Region
- ▭ Lake

Exceedance colour key

- 🟦 No exceedance recorded
- ⬜ Low exceedance frequency
- 🟧 Moderate exceedance frequency
- 🟥 High exceedance frequency

SAMPLE SITE KEY



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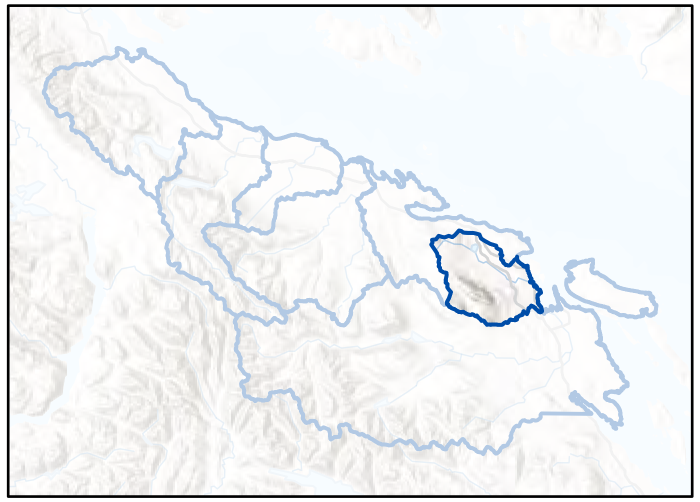

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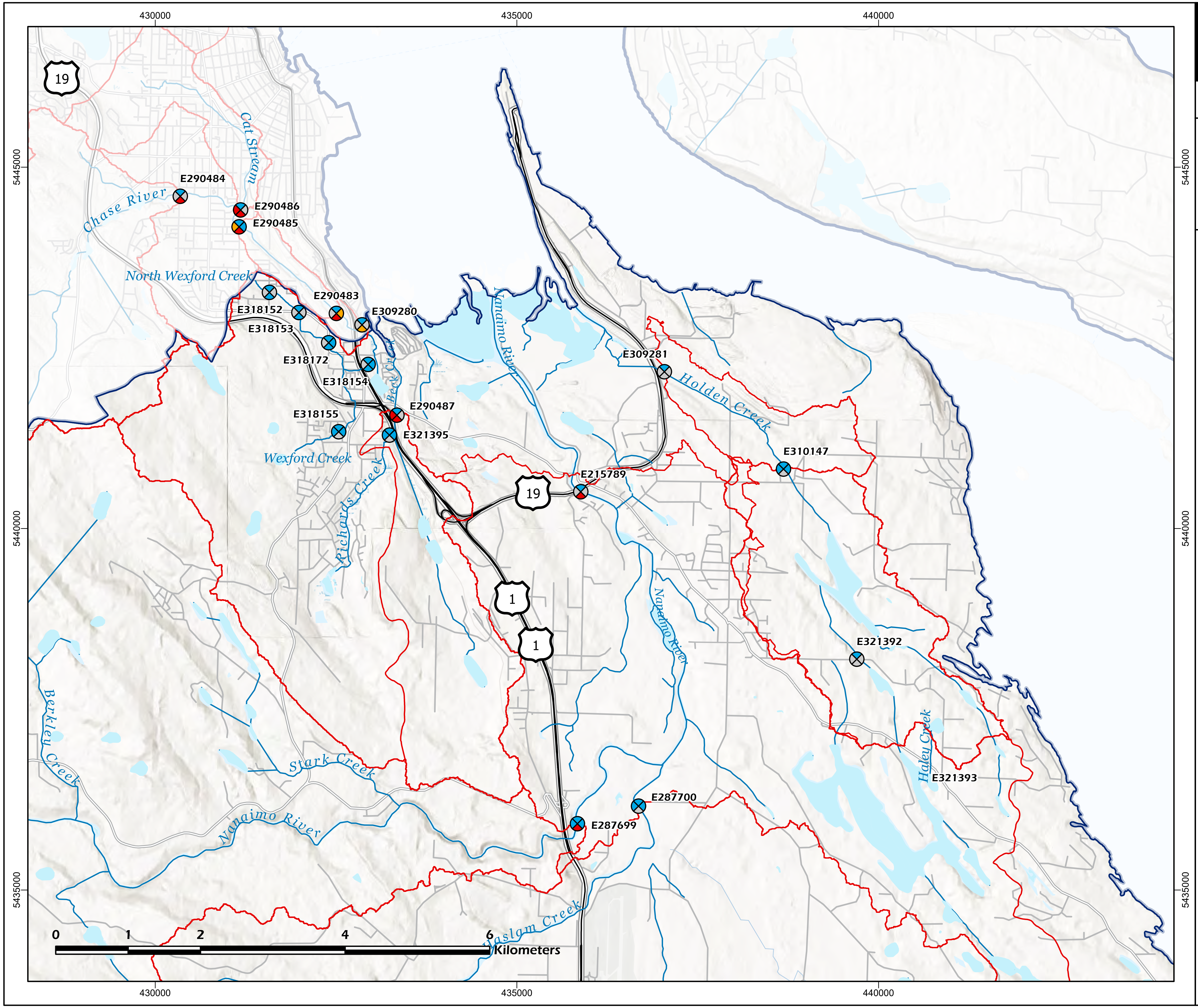


Regional District of Nanaimo

CMMN 2011-2020 Summer Exceedance Assessment

WR6: Nanaimo River

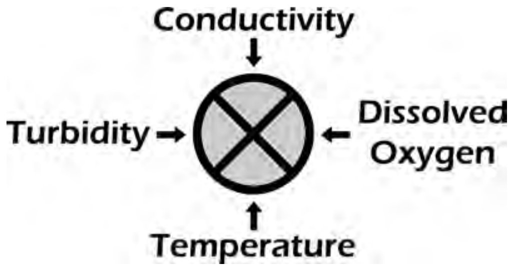
Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

LEGEND

⊗ Sample Site
— Highway
— Stream
▭ Watershed
▭ Water Region
▭ Lake

Exceedance colour key
🟦 No exceedance recorded
⬜ Low exceedance frequency
🟧 Moderate exceedance frequency
🟥 High exceedance frequency

SAMPLE SITE KEY



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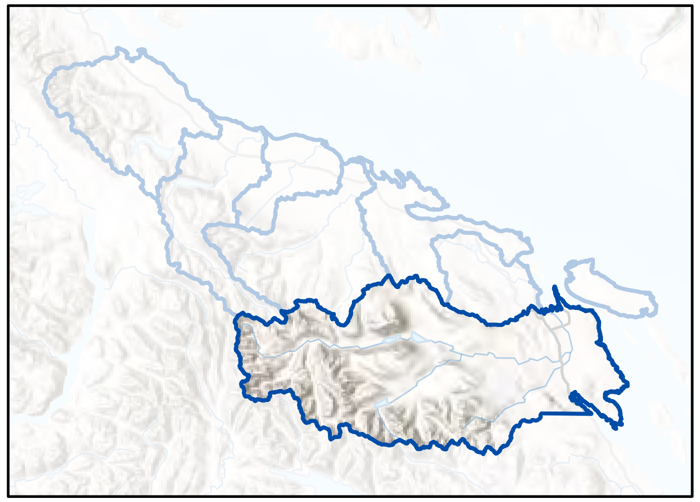

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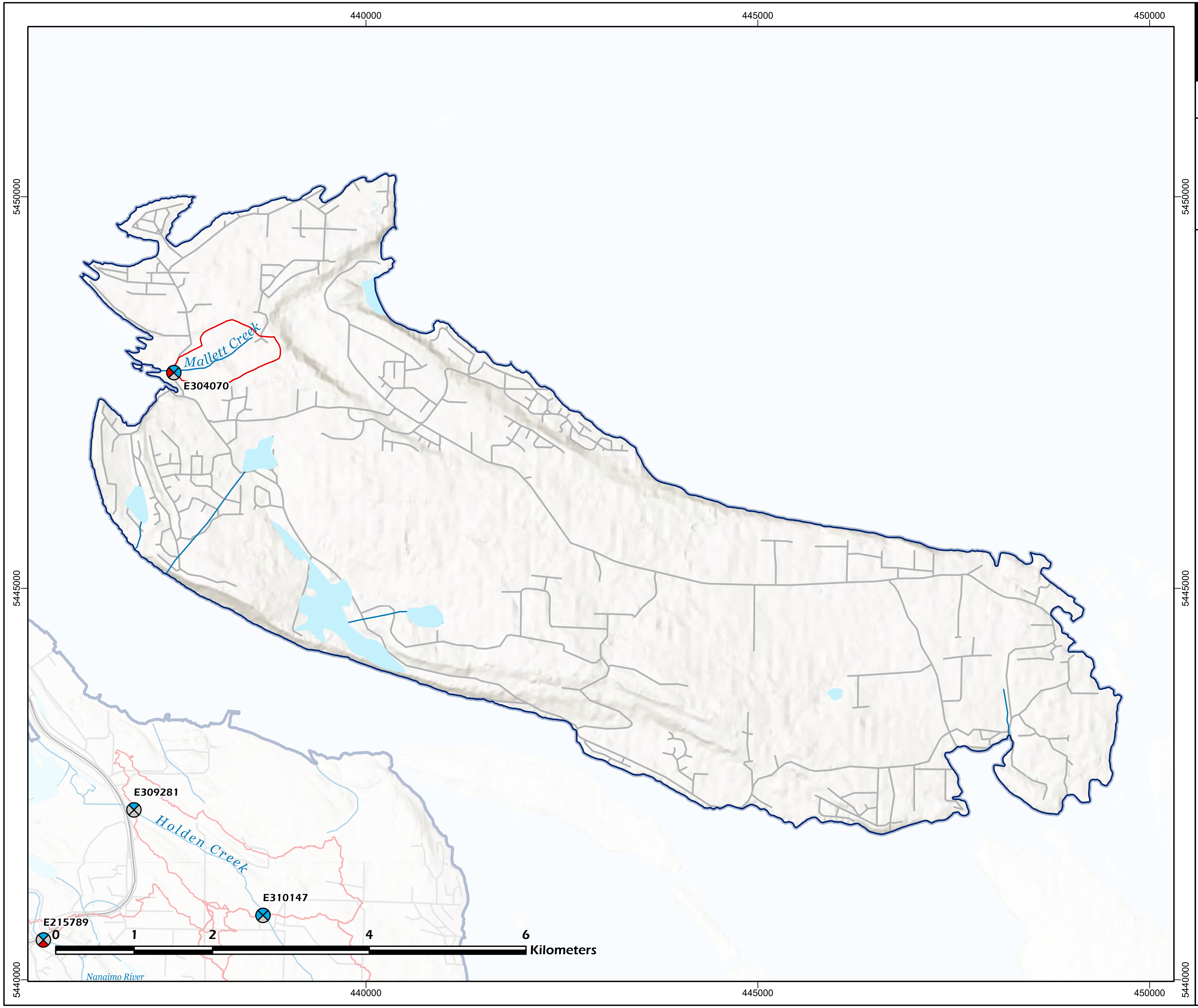


Regional District of Nanaimo

CMMN 2011-2020 Summer Exceedance Assessment

WR7: Gabriola Island

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

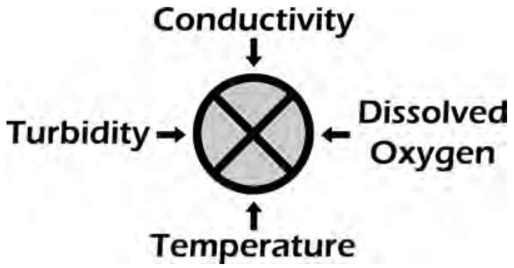
LEGEND

- ⊗ Sample Site
- — Highway
- — Stream
- ▭ Watershed
- ▭ Water Region
- ▬ Lake

Exceedance colour key

- 🟦 No exceedance recorded
- ⬜ Low exceedance frequency
- 🟧 Moderate exceedance frequency
- 🟥 High exceedance frequency

SAMPLE SITE KEY



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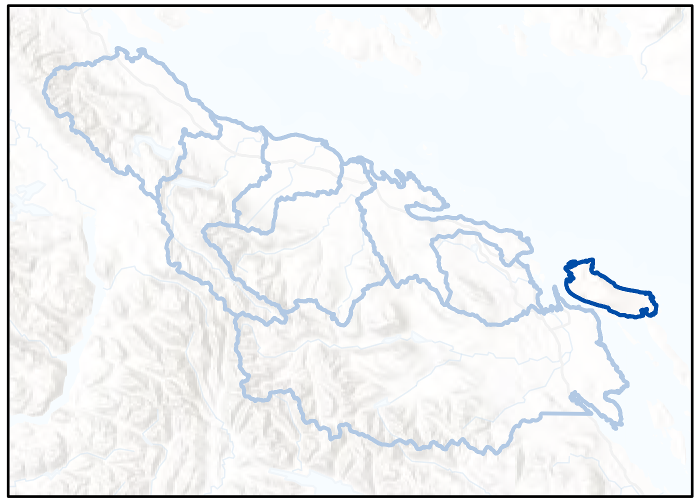

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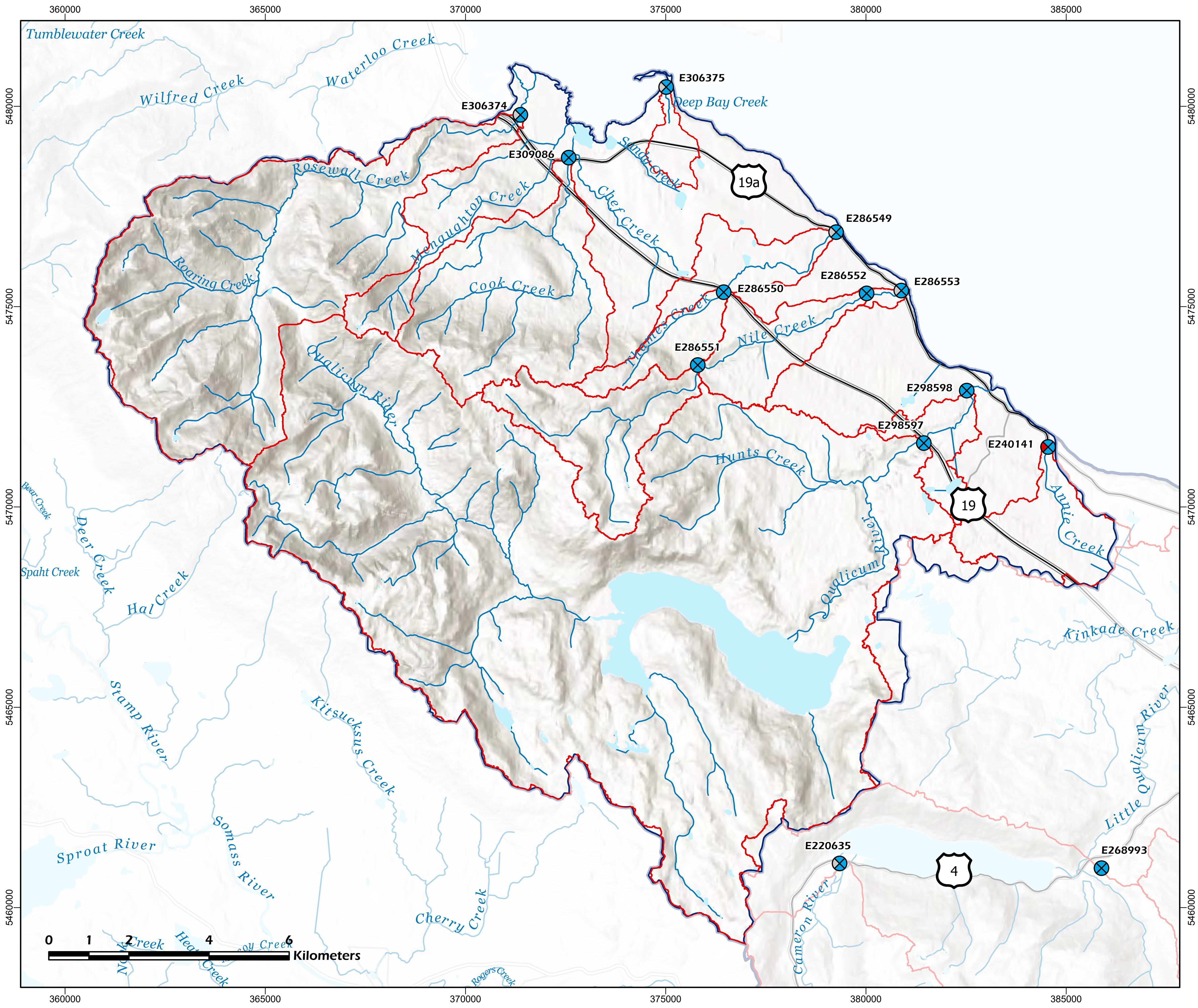


Regional District of Nanaimo

CMMN 2011-2020 Fall Exceedance Assessment

WR1: Big Qualicum

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

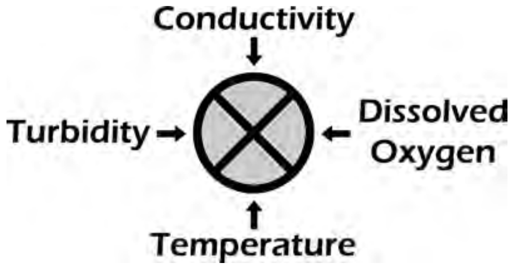
LEGEND

⊗	Sample Site
—	Stream
—	Highway
▭	Watershed
▭	Water Region
🟦	Lake

Exceedance colour key

🟦	No exceedance recorded
⬜	Low exceedance frequency
🟧	Moderate exceedance frequency
🟥	High exceedance frequency

SAMPLE SITE KEY



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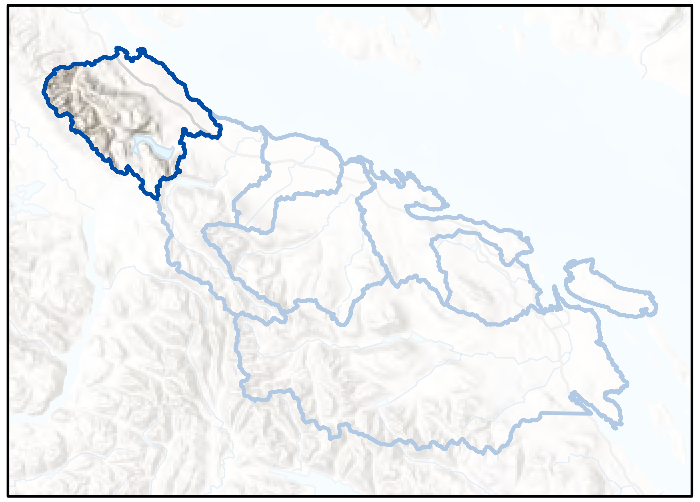

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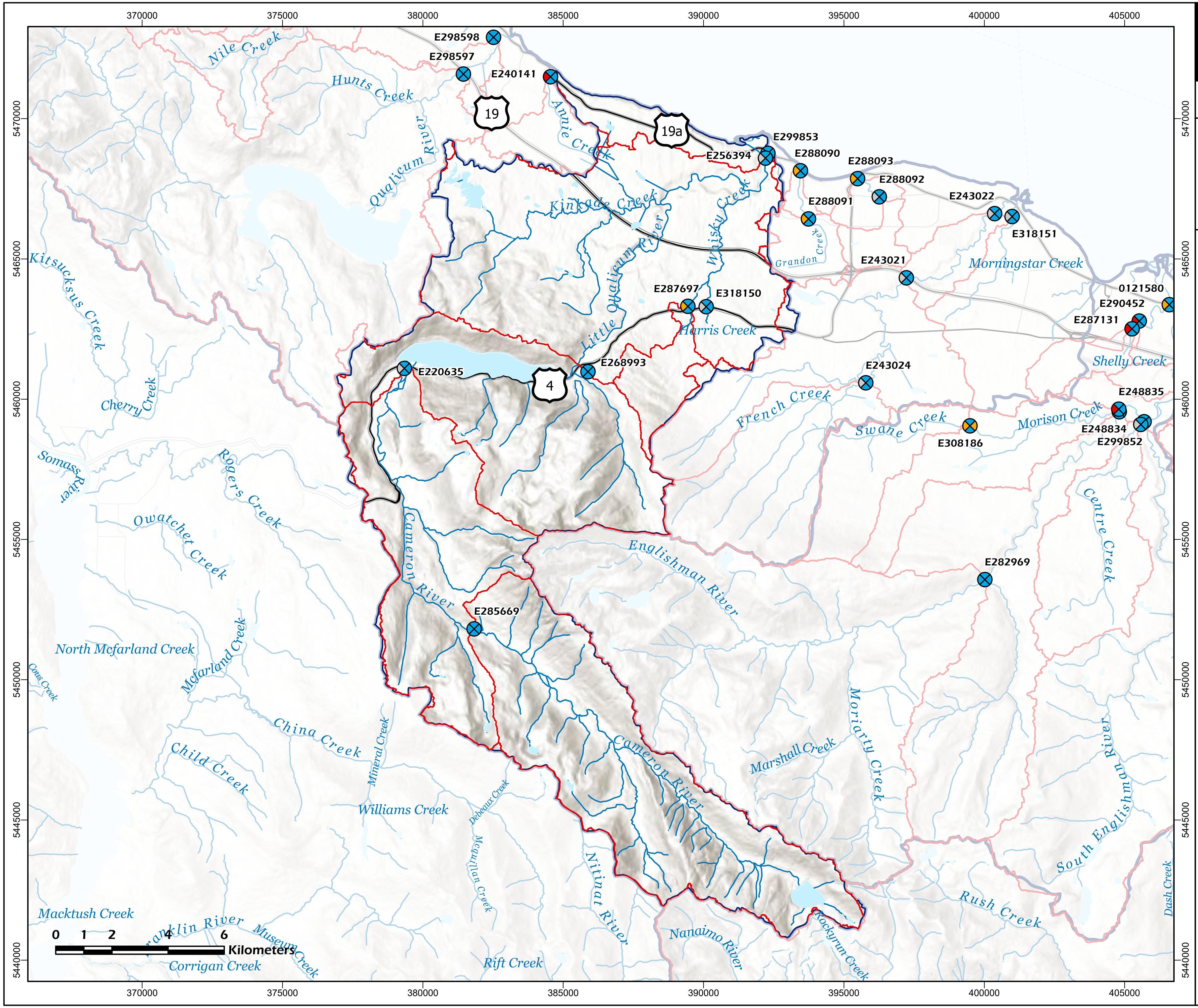


Regional District of Nanaimo

CMMN 2011-2020 Fall Exceedance Assessment

WR2: Little Qualicum

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

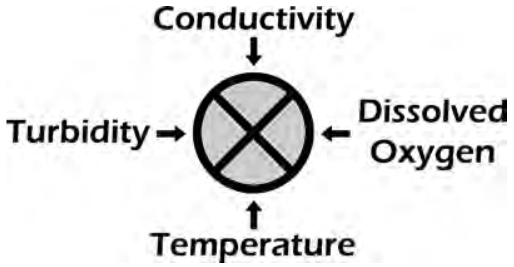
LEGEND

⊗	Sample Site
—	Stream
—	Highway
▭	Watershed
▭	Water Region
▭	Lake

Exceedance colour key

🟦	No exceedance recorded
⬜	Low exceedance frequency
🟧	Moderate exceedance frequency
🟥	High exceedance frequency

SAMPLE SITE KEY



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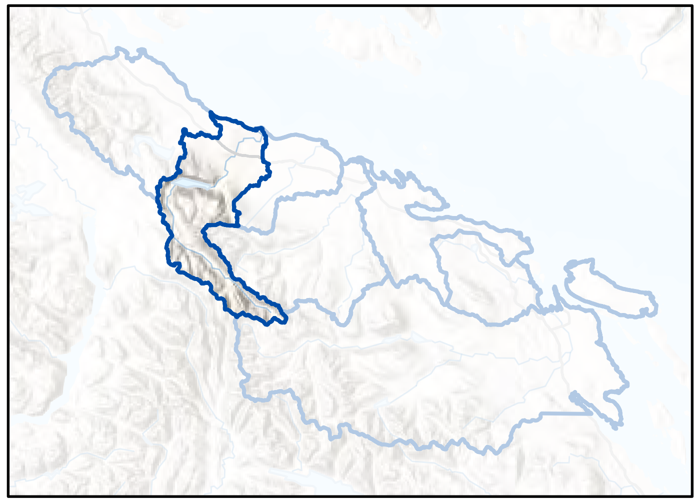

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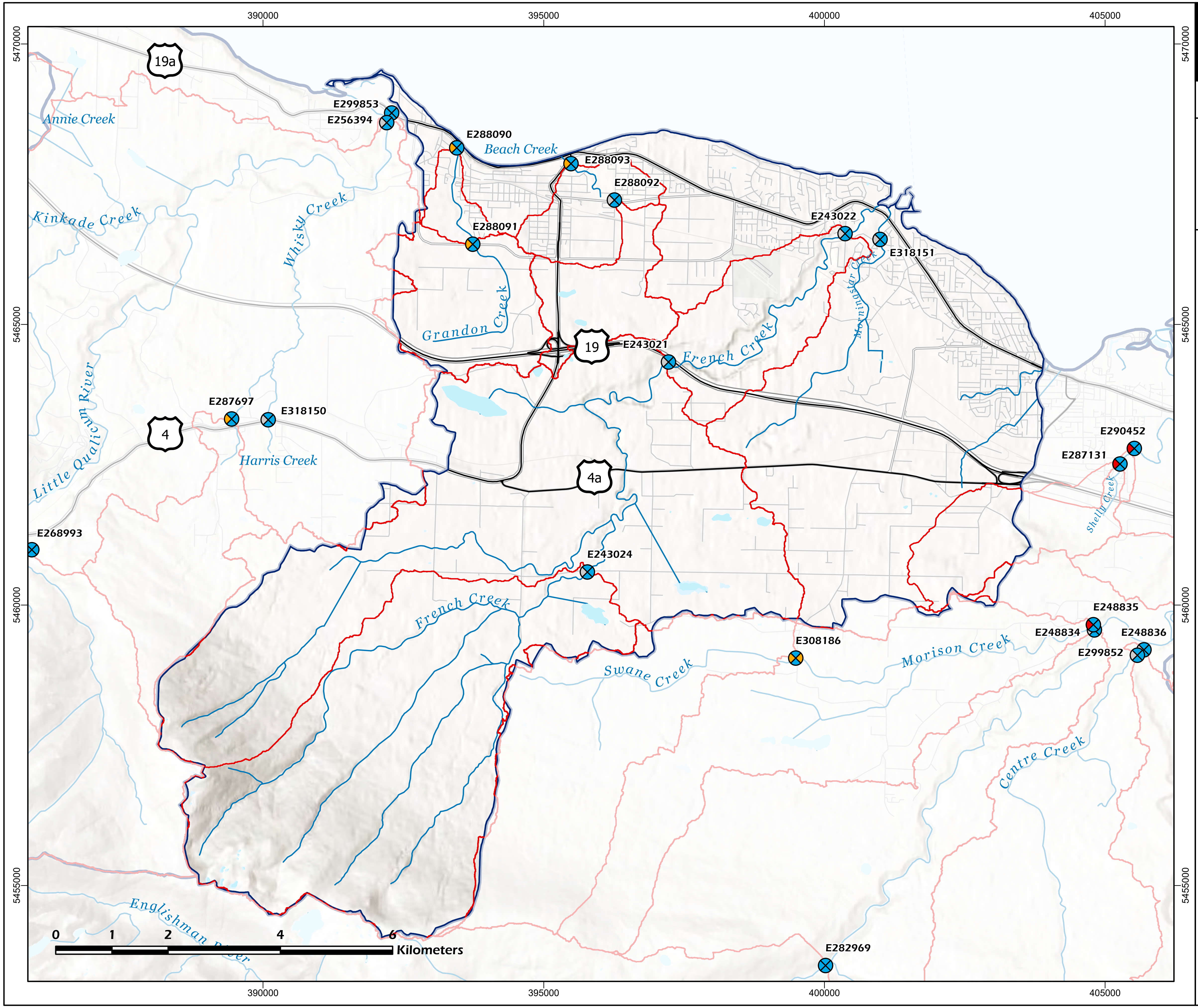


Regional District of Nanaimo

CMMN 2011-2020 Fall Exceedance Assessment

WR3: French Creek

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

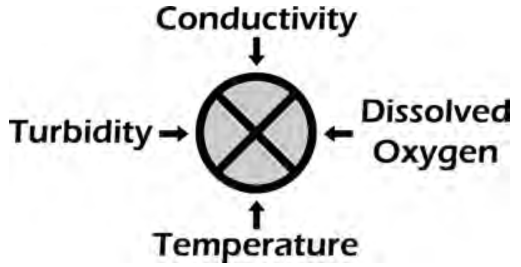
LEGEND

- ⊗ Sample Site
- Stream
- Highway
- Watershed
- Water Region
- Lake

Exceedance colour key

- 🟦 No exceedance recorded
- ⬜ Low exceedance frequency
- 🟧 Moderate exceedance frequency
- 🟥 High exceedance frequency

SAMPLE SITE KEY



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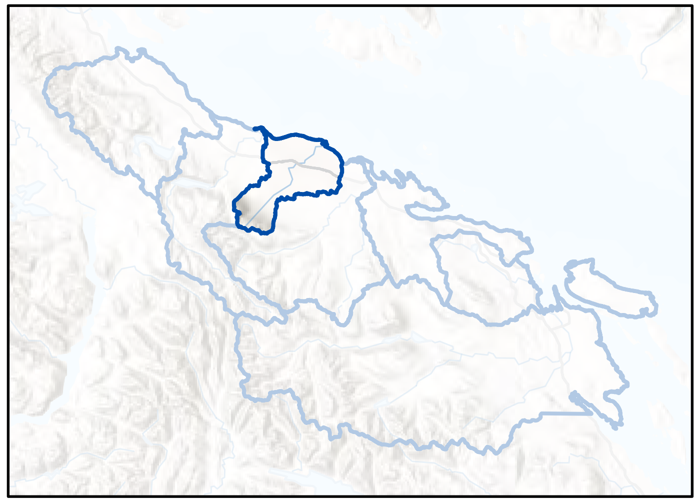

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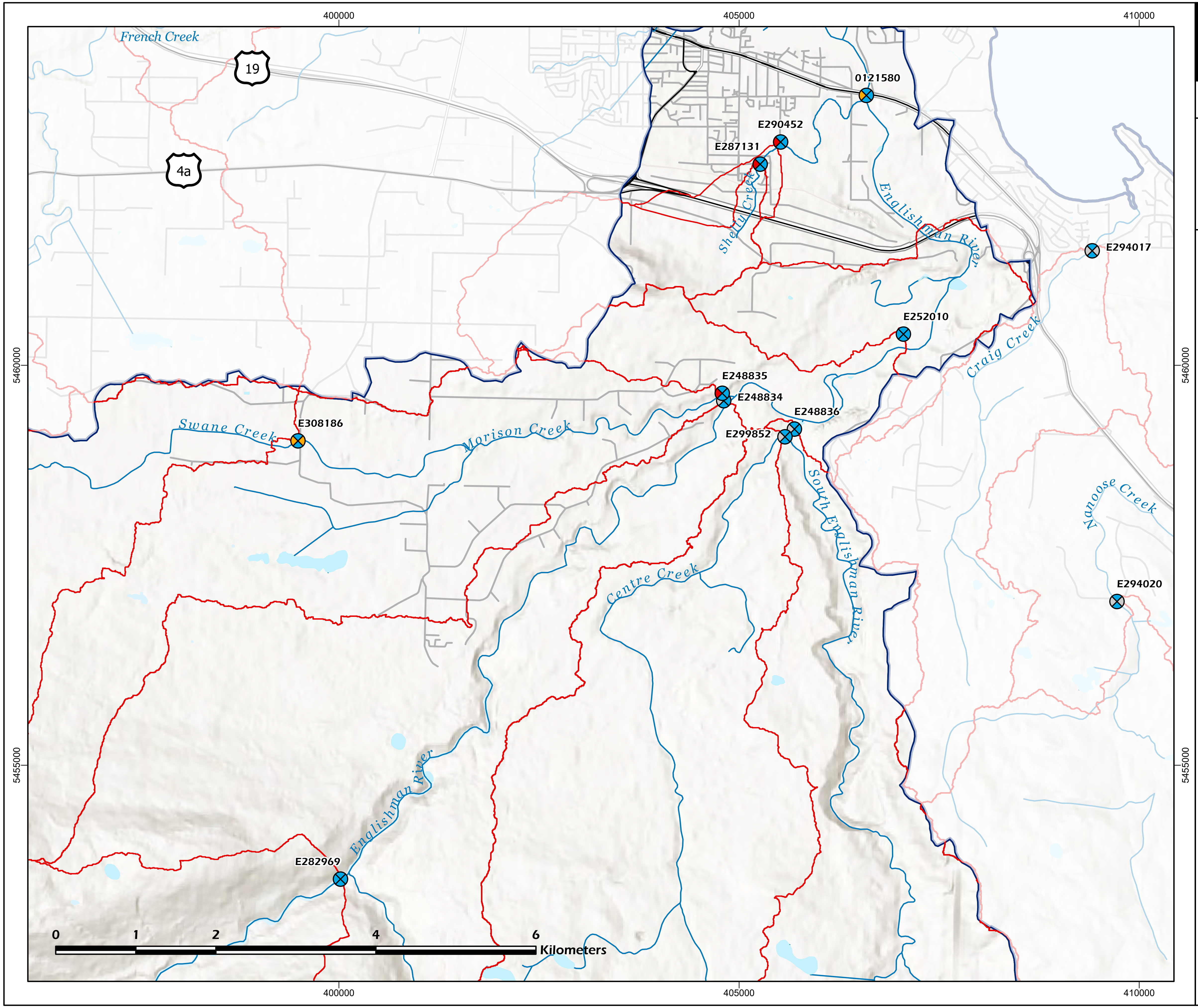


Regional District of Nanaimo

CMMN 2011-2020 Fall Exceedance Assessment

WR4a: Englishman River

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

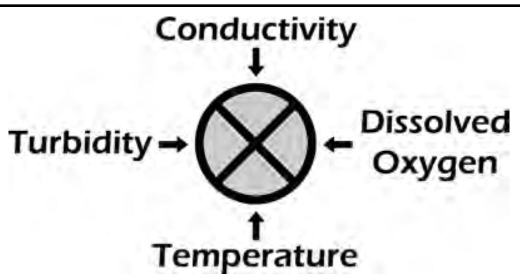
LEGEND

⊗	Sample Site
—	Stream
—	Highway
▭	Watershed
▭	Water Region
▭	Lake

Exceedance colour key

🟦	No exceedance recorded
⬜	Low exceedance frequency
🟧	Moderate exceedance frequency
🟥	High exceedance frequency

SAMPLE SITE KEY



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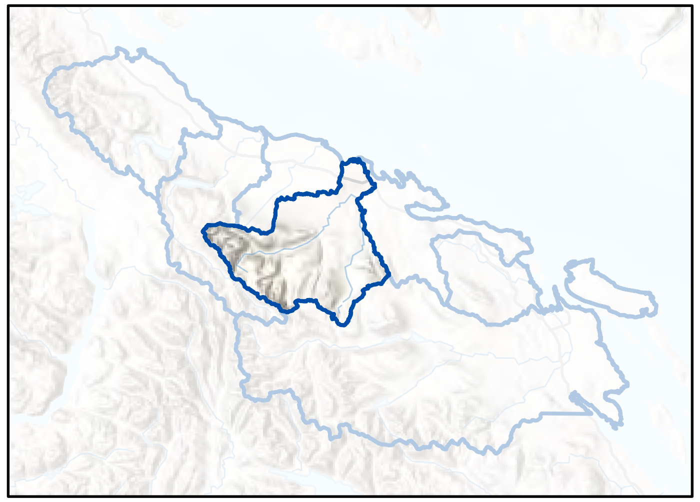

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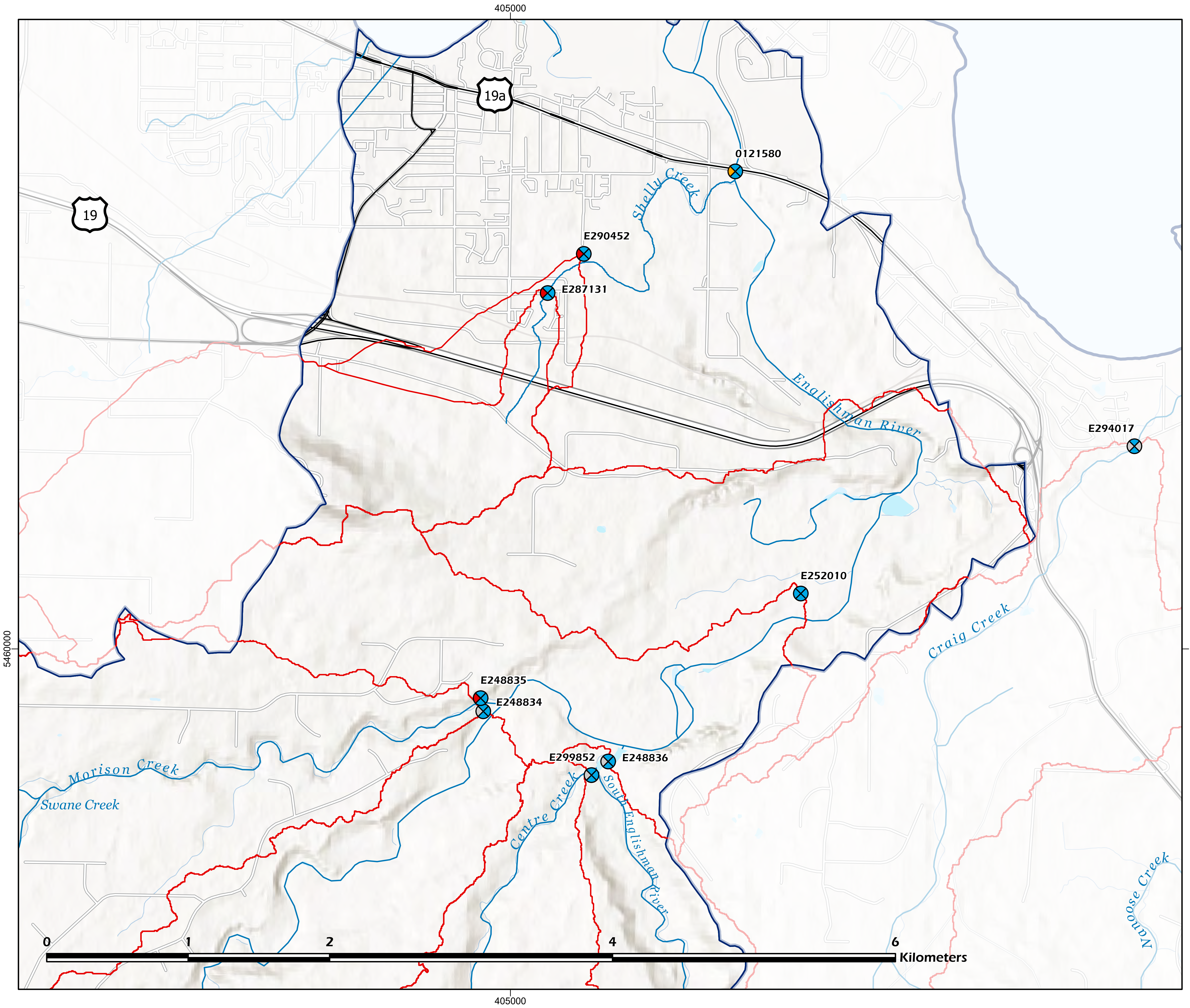


Regional District of Nanaimo

CMMN 2011-2020 Fall Exceedance Assessment

WR4b: Englishman River

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

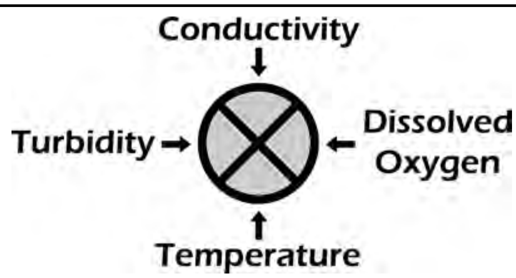
LEGEND

- ⊗ Sample Site
- — Stream
- — Highway
- ▭ Watershed
- ▭ Water Region
- ▭ Lake

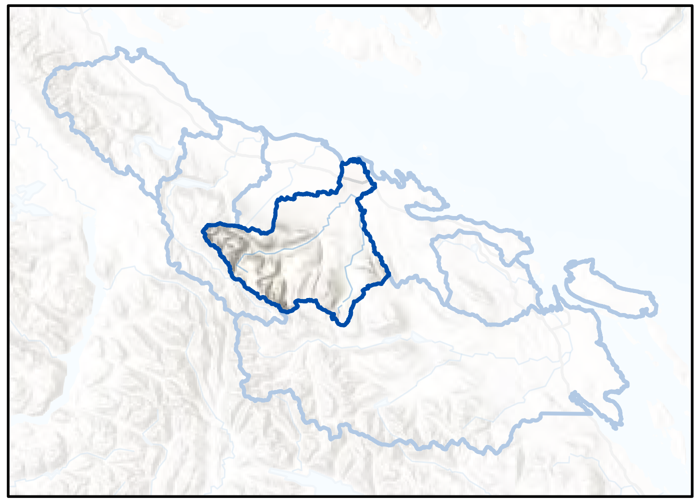
Exceedance colour key

- 🟦 No exceedance recorded
- ⬜ Low exceedance frequency
- 🟧 Moderate exceedance frequency
- 🟥 High exceedance frequency

SAMPLE SITE KEY



MAP INDEX



DISCLAIMER

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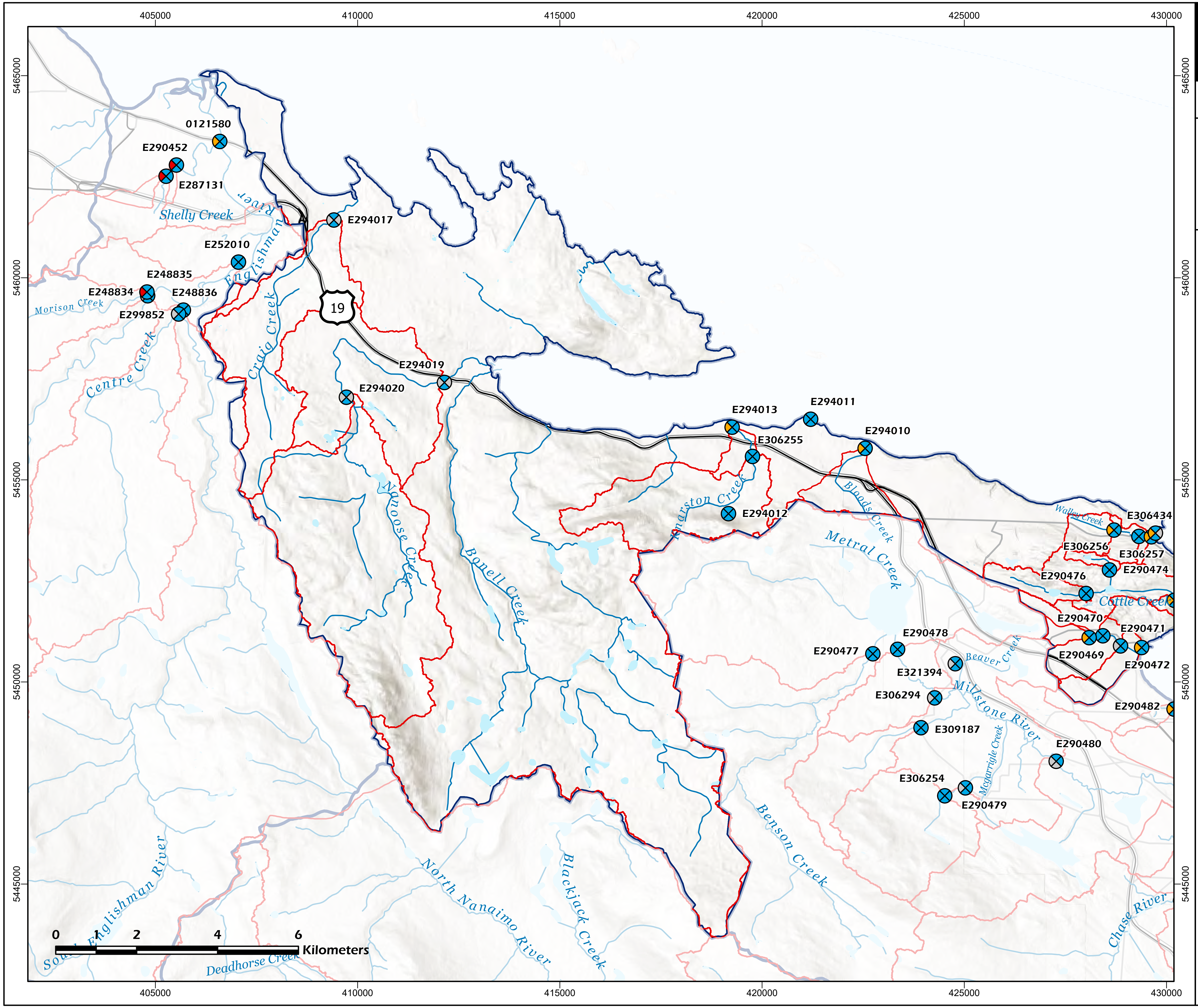


Regional District of Nanaimo

CMMN 2011-2020 Fall Exceedance Assessment

WR5-1a: South Wellington to Nanoose

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

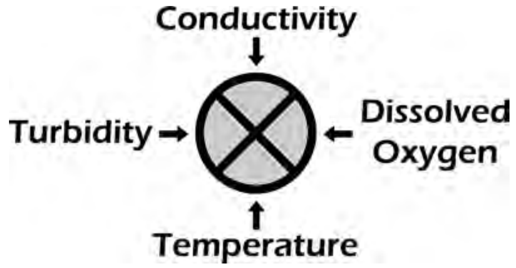
LEGEND

- ⊗ Sample Site
- — Stream
- — Highway
- ▭ Watershed
- ▭ Water Region
- ▭ Lake

Exceedance colour key

- 🟦 No exceedance recorded
- ⬜ Low exceedance frequency
- 🟧 Moderate exceedance frequency
- 🟥 High exceedance frequency

SAMPLE SITE KEY



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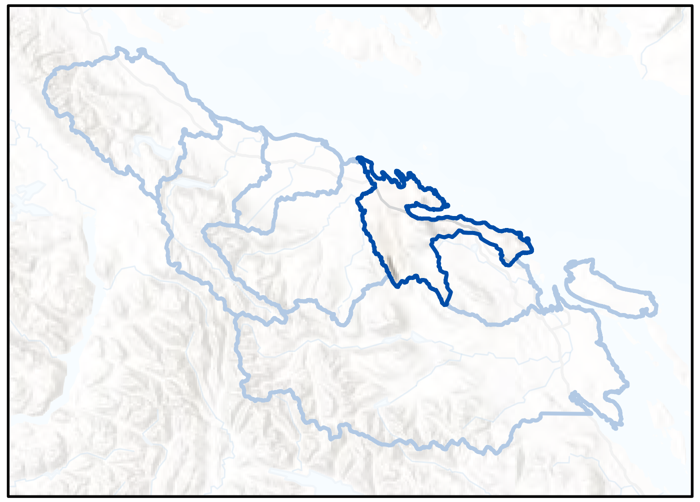

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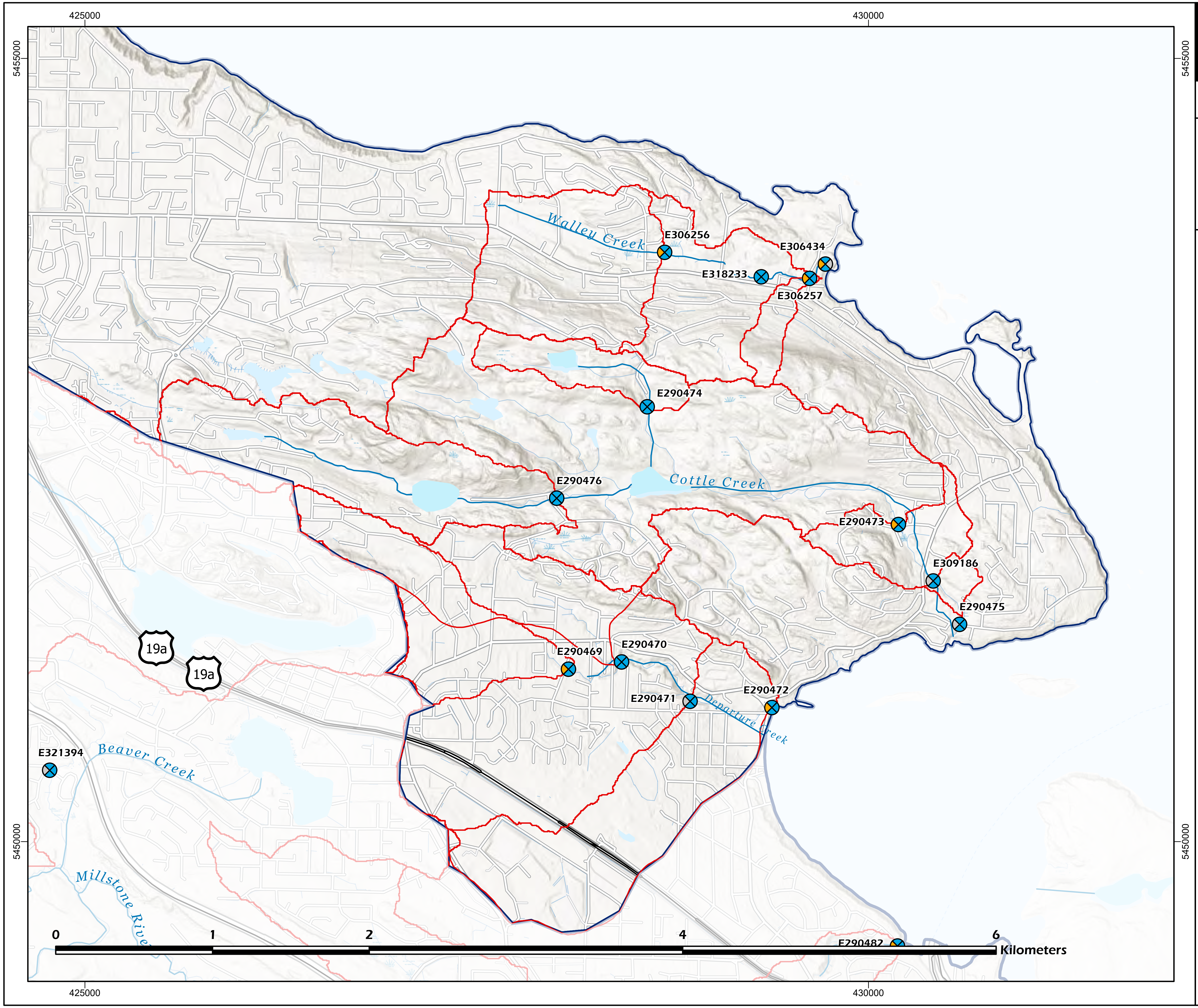
Regional District of Nanaimo

CMMN 2011-2020 Fall Exceedance Assessment

WR5-1b: South Wellington to Nanoose

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada



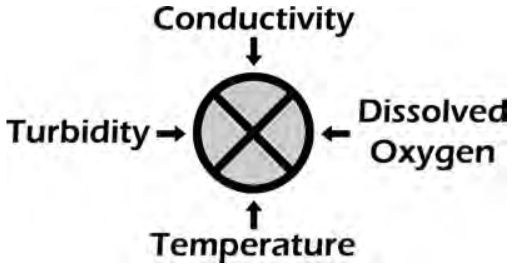
LEGEND

⊗	Sample Site
—	Stream
—	Highway
▭	Watershed
▭	Water Region
▭	Lake

Exceedance colour key

🟦	No exceedance recorded
⬜	Low exceedance frequency
🟧	Moderate exceedance frequency
🟥	High exceedance frequency

SAMPLE SITE KEY



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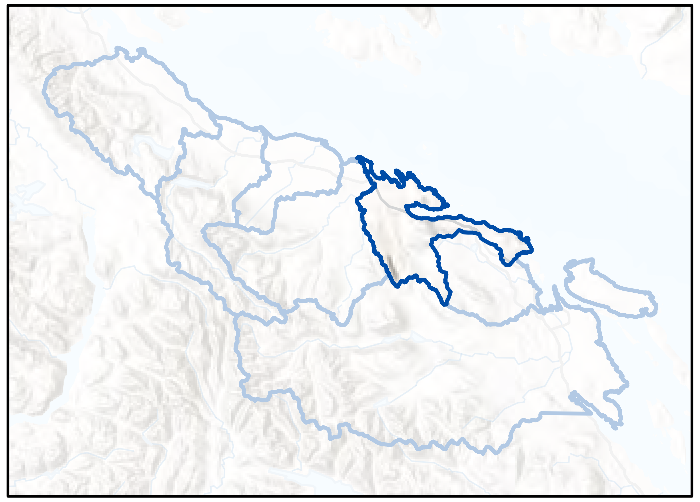

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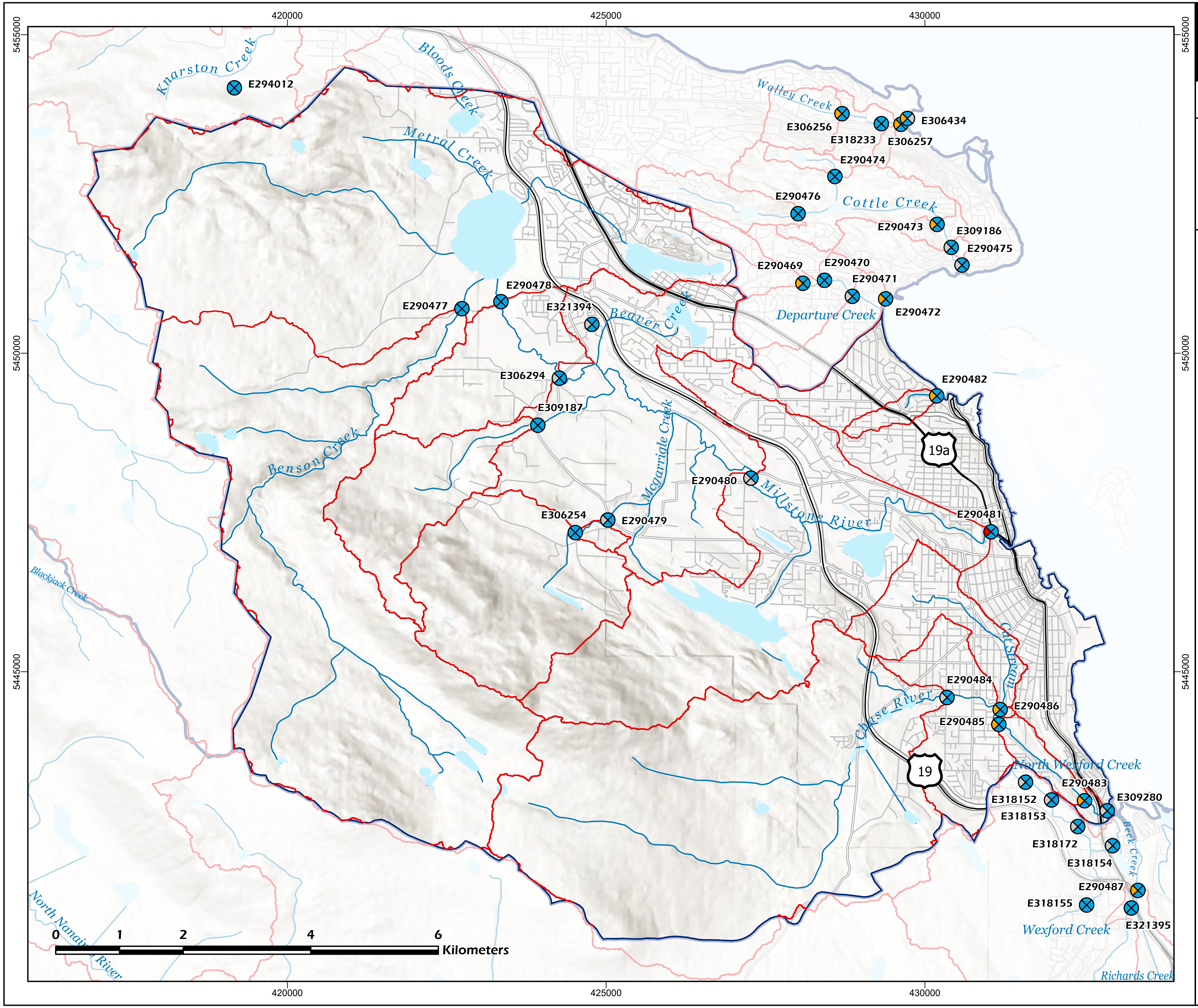


Regional District of Nanaimo

CMMN 2011-2020 Fall Exceedance Assessment

WR5-2: South Wellington to Nanoose

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

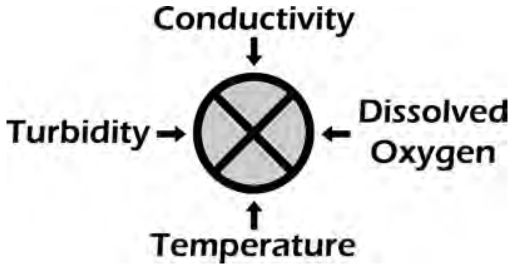
LEGEND

- ⊗ Sample Site
- Stream
- Highway
- Watershed
- Water Region
- Lake

Errata - site E290480 has no exceedance recorded for turbidity.

Exceedance colour key
- 🟦 No exceedance recorded
- ⬜ Low exceedance frequency
- 🟧 Moderate exceedance frequency
- 🟥 High exceedance frequency

SAMPLE SITE KEY



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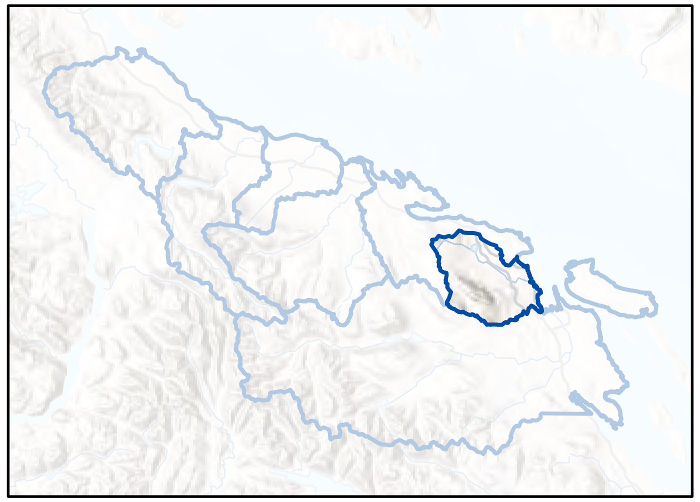
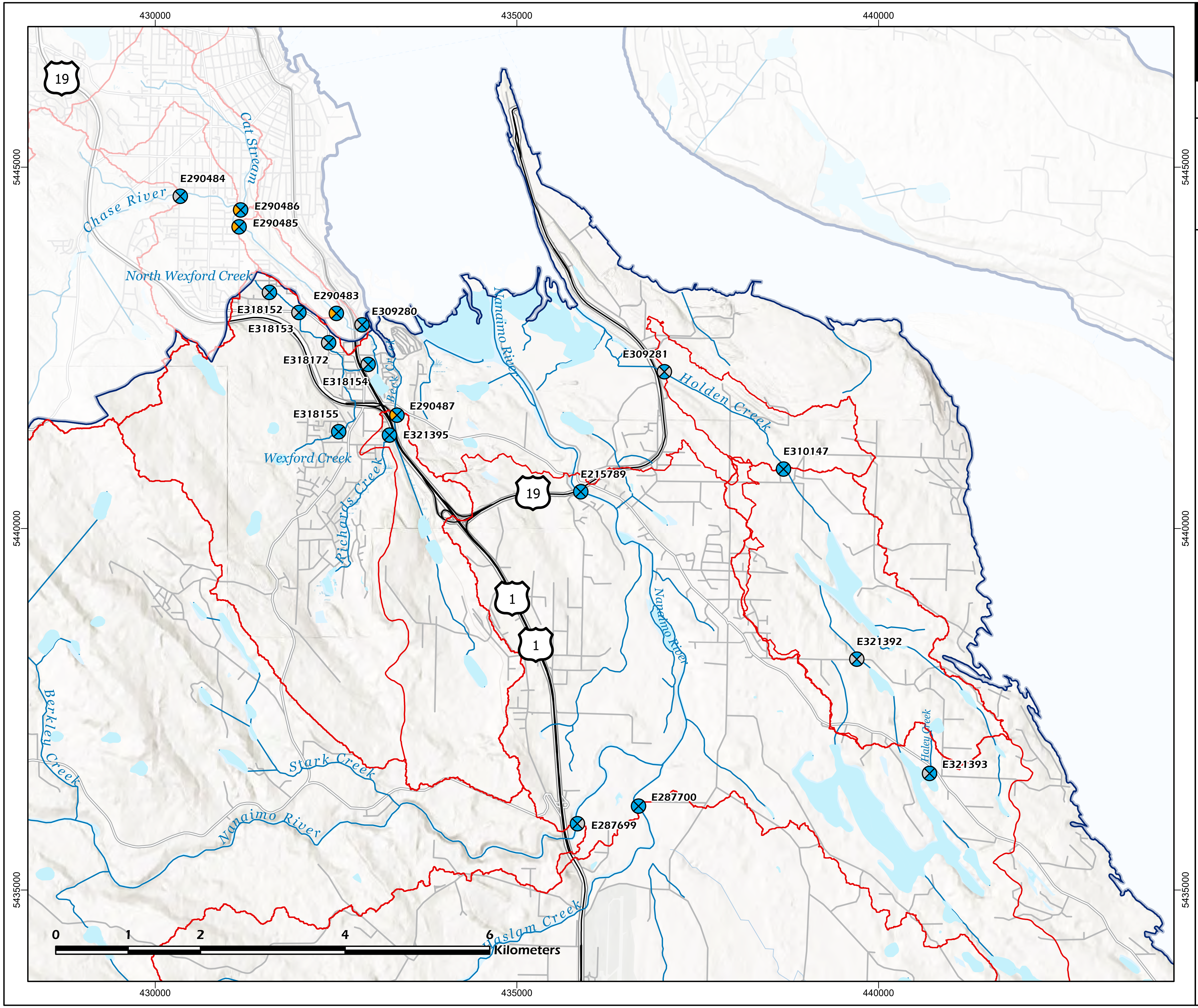


DISCLAIMER



Regional District of Nanaimo

CMMN 2011-2020 Fall Exceedance Assessment

WR6: Nanaimo River

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

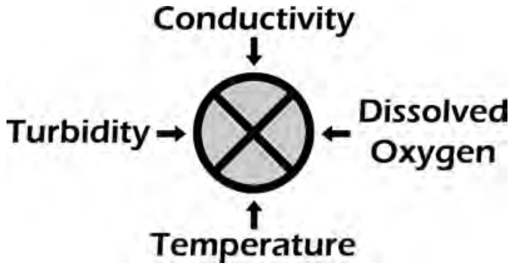
LEGEND

⊗	Sample Site
—	Stream
—	Highway
▭	Watershed
▭	Water Region
▨	Lake

Exceedance colour key

🟦	No exceedance recorded
⬜	Low exceedance frequency
🟧	Moderate exceedance frequency
🟥	High exceedance frequency

SAMPLE SITE KEY



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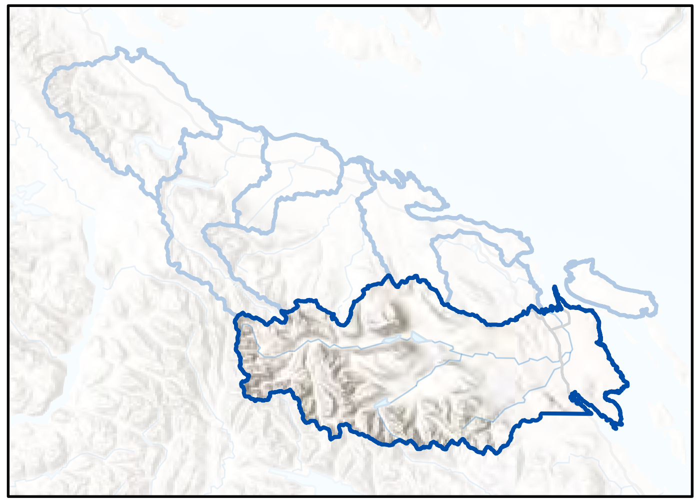

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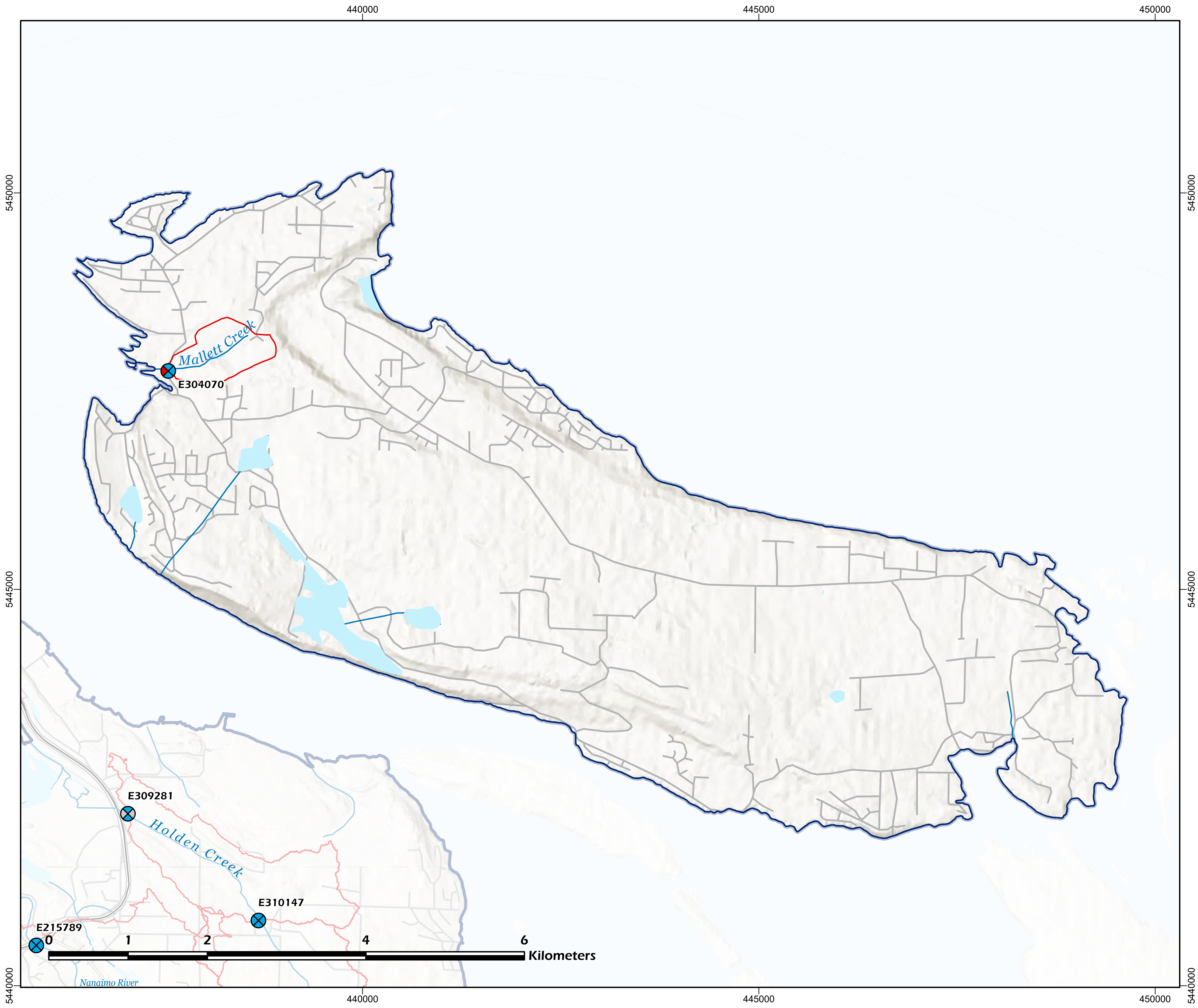


Regional District of Nanaimo

CMMN 2011-2020 Fall Exceedance Assessment

WR7: Gabriola Island

Location:	Nanaimo, BC
Project No.:	21-3702
Prepared for:	Regional District of Nanaimo
Prepared by:	Ecoscape Environmental Consultants Ltd.
Coordinate System:	NAD83-UTM Zone 10
Imagery:	ESRI Canada

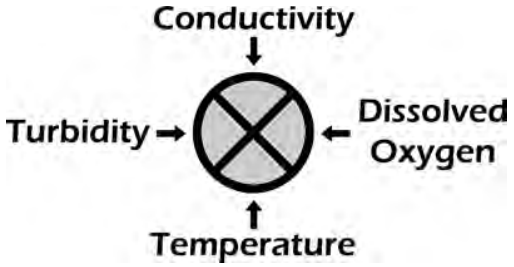
LEGEND

- ⊗ Sample Site
- — Stream
- — Highway
- ▭ Watershed
- ▭ Water Region
- 🟦 Lake

Exceedance colour key

- 🟦 No exceedance recorded
- ⬜ Low exceedance frequency
- 🟧 Moderate exceedance frequency
- 🟥 High exceedance frequency

SAMPLE SITE KEY



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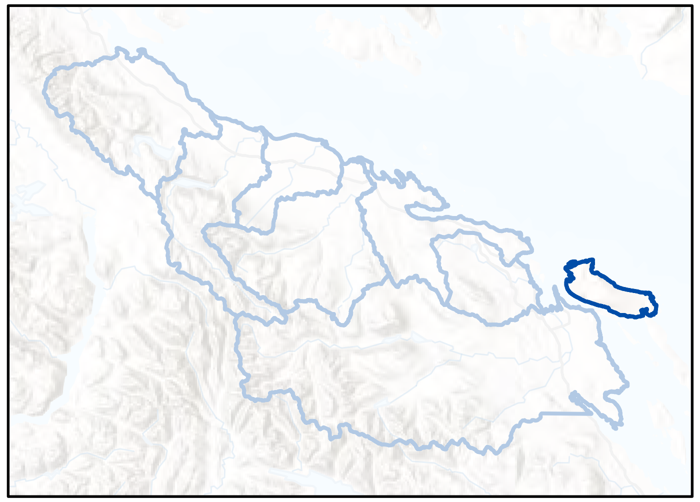

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Appendix B

Water Quality Summaries (Graphs)

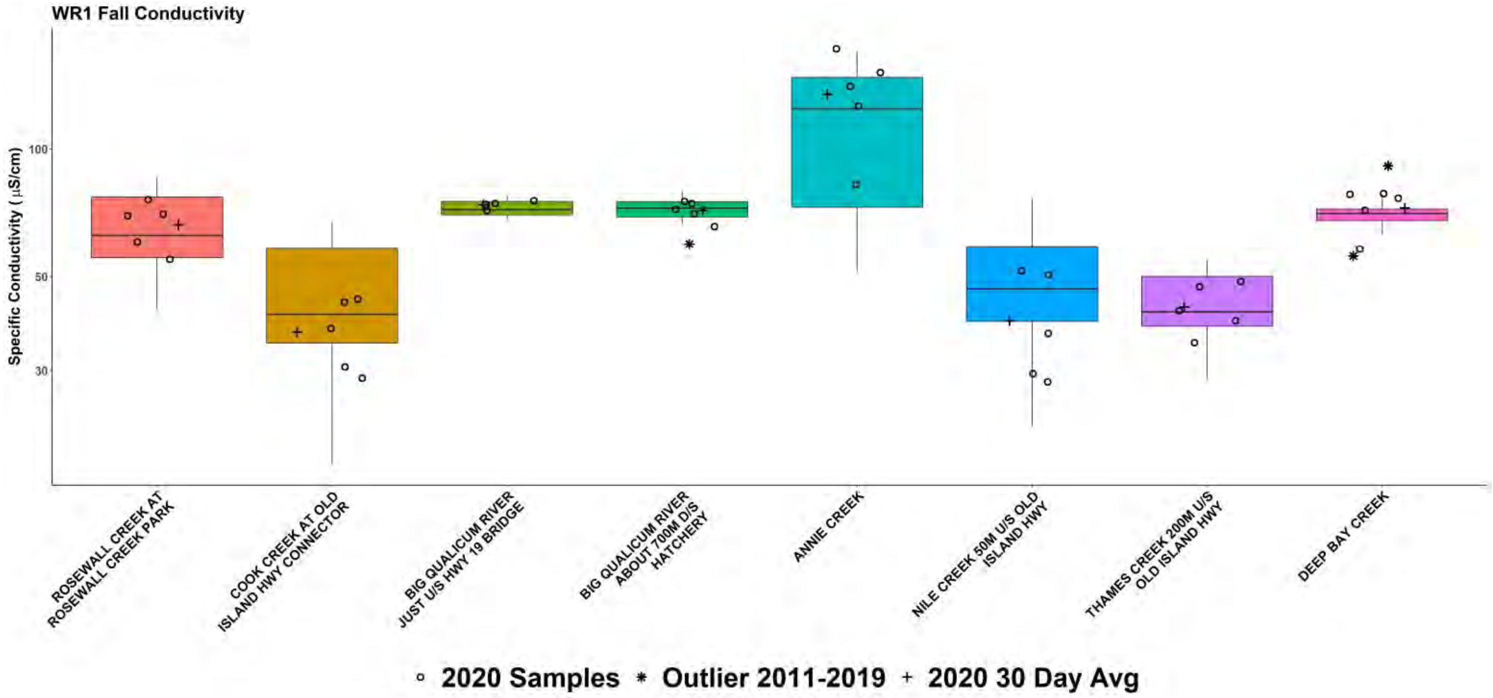

Figure B3: Fall 2011-2020 specific conductivity of CWMN sites in Water Region 1 (Big Qualicum).

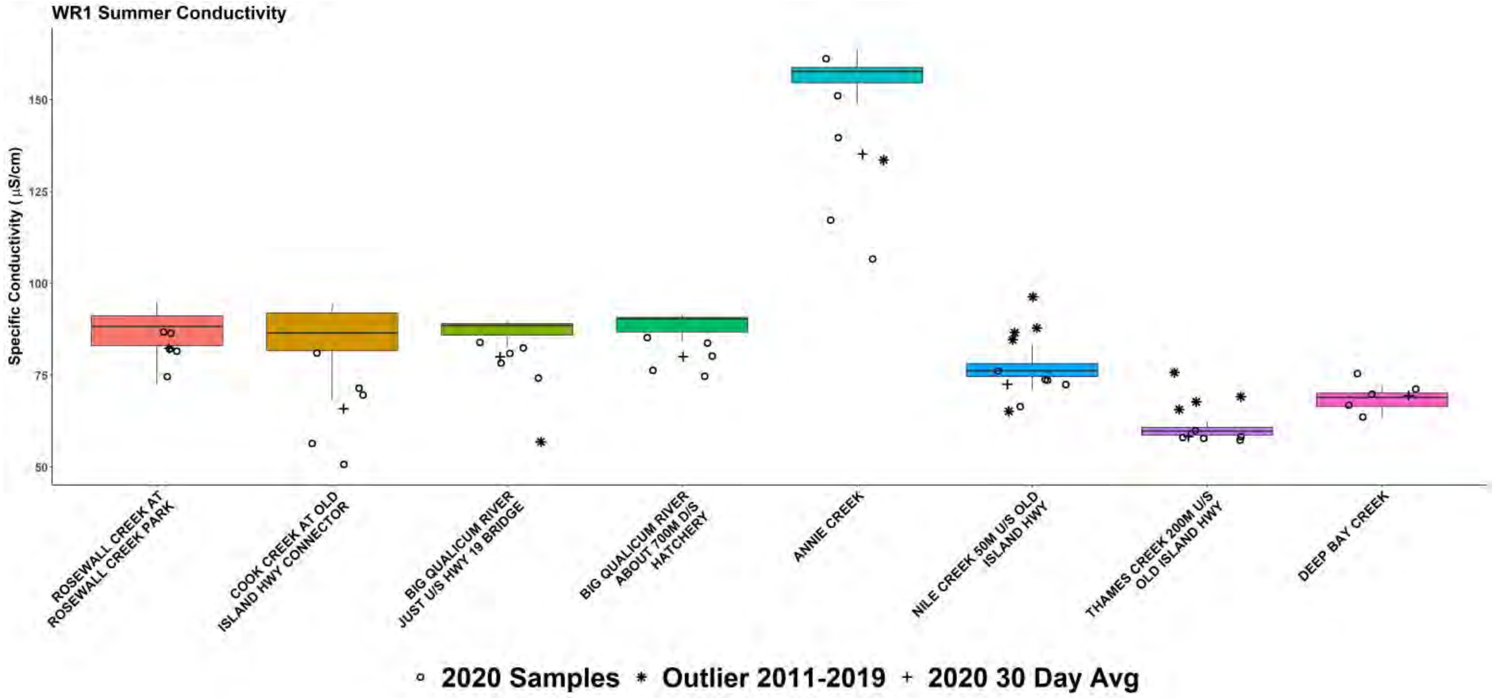

Figure B4: Summer 2011-2020 specific conductivity of CWMN sites in Water Region 1 (Big Qualicum).

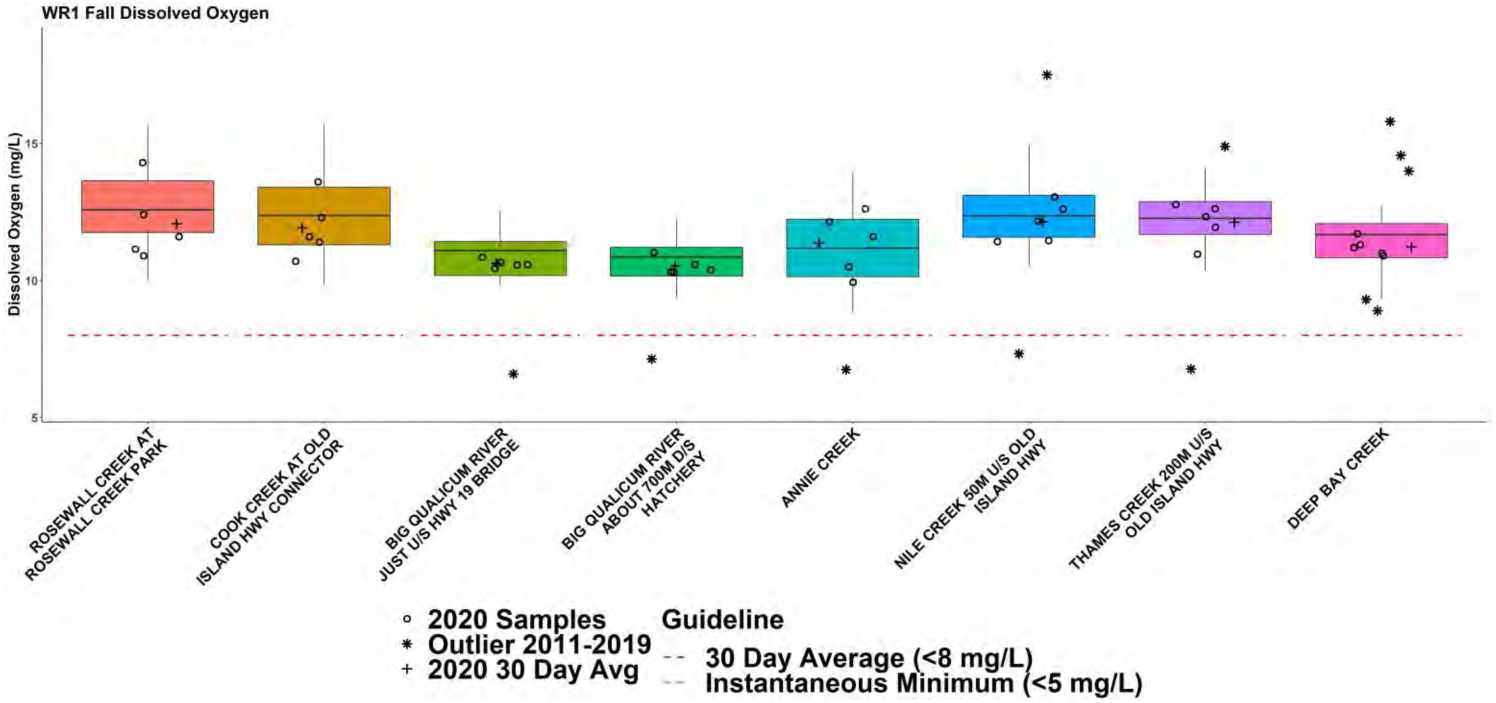

Figure B5: Fall 2011-2020 dissolved oxygen of CWMN sites in Water Region 1 (Big Qualicum) with Englishman River water quality objectives.

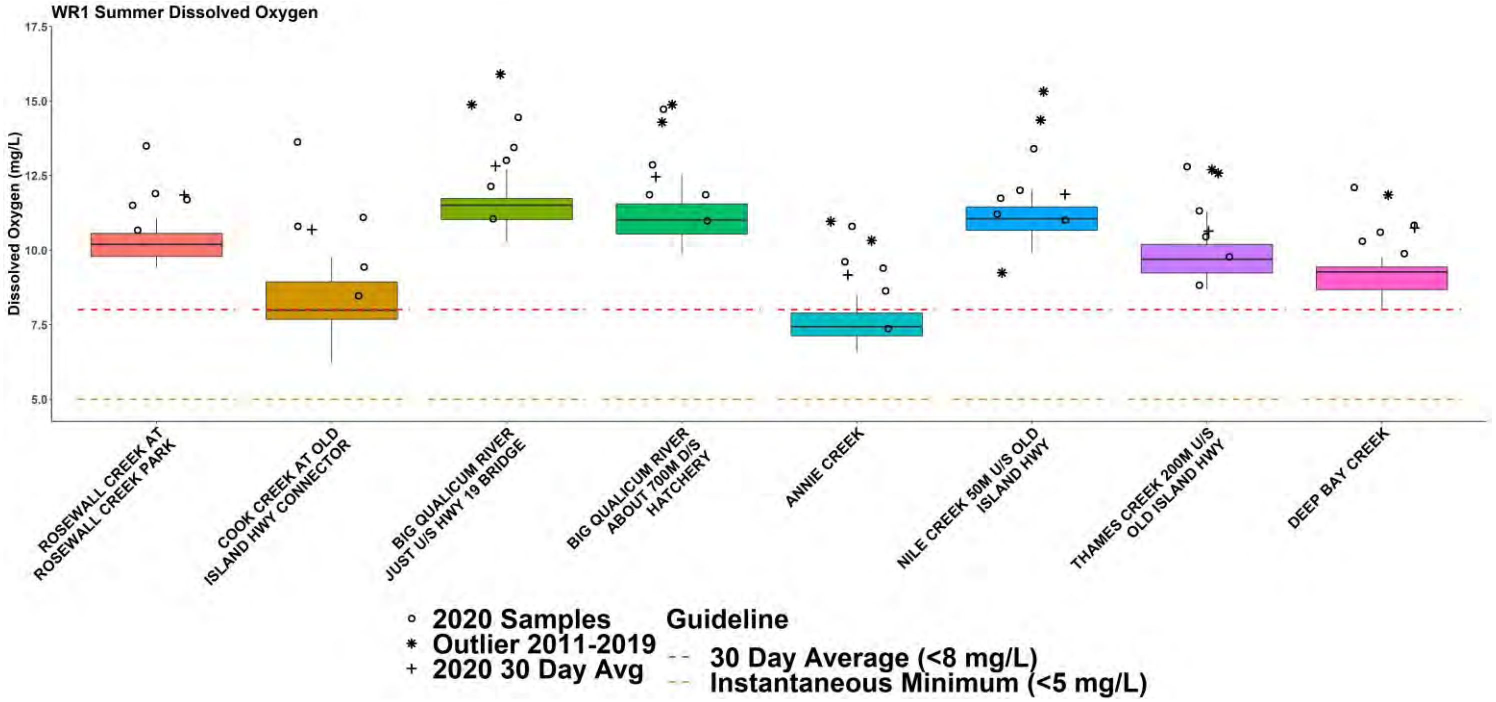

Figure B6: Summer 2011-2020 dissolved oxygen of CWMN sites in Water Region 1 (Big Qualicum) with Englishman River water quality objectives.

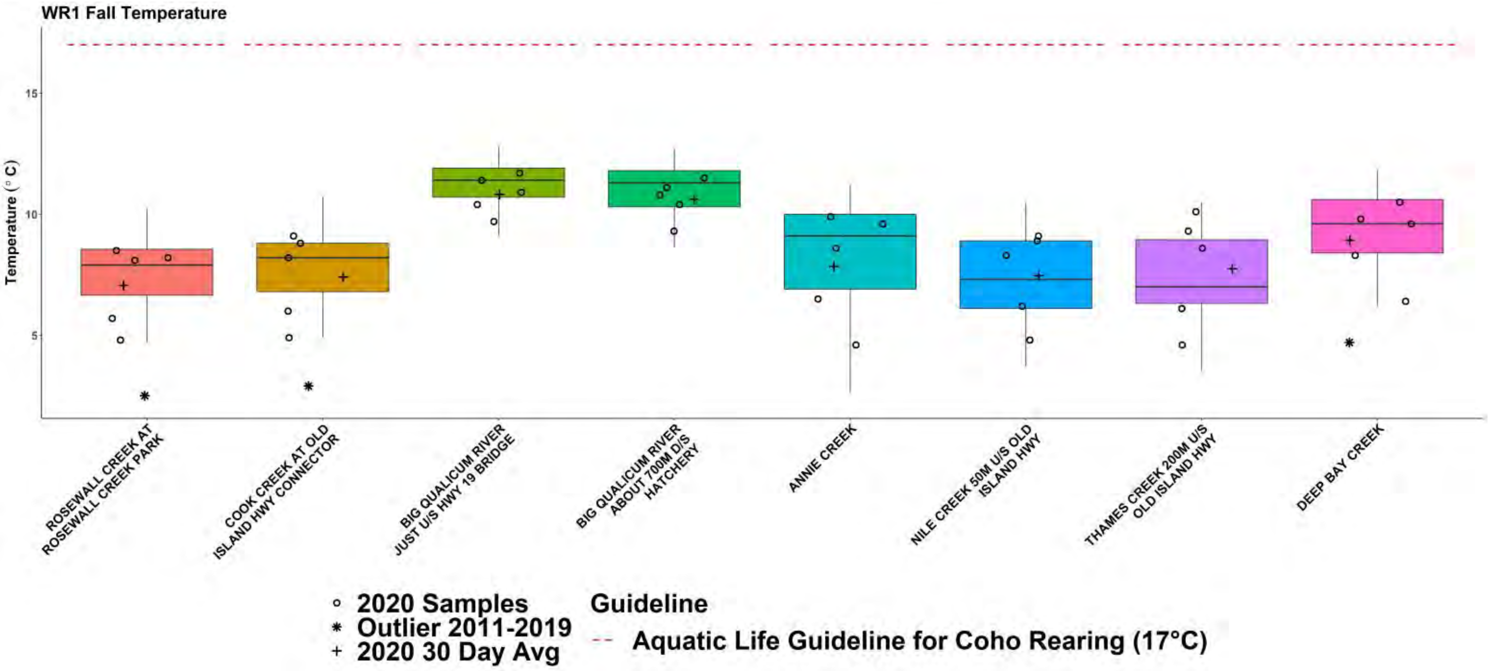

Figure B7: Fall 2011-2020 water temperature of CWMN sites in Water Region 1 (Big Qualicum) with BC Water Quality guidelines for Aquatic Life.

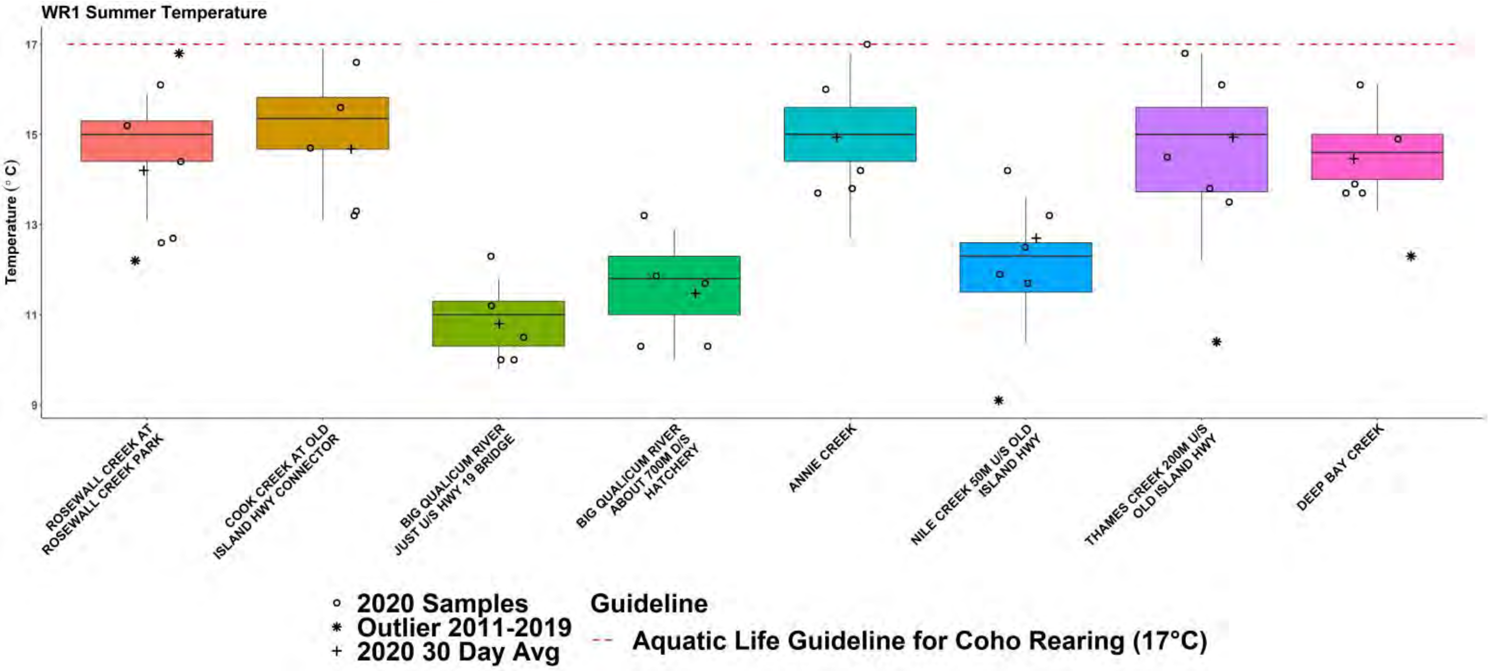

Figure B8: Summer 2011-2020 water temperature of CWMN sites in Water Region 1 (Big Qualicum) with BC Water Quality guidelines for Aquatic Life.

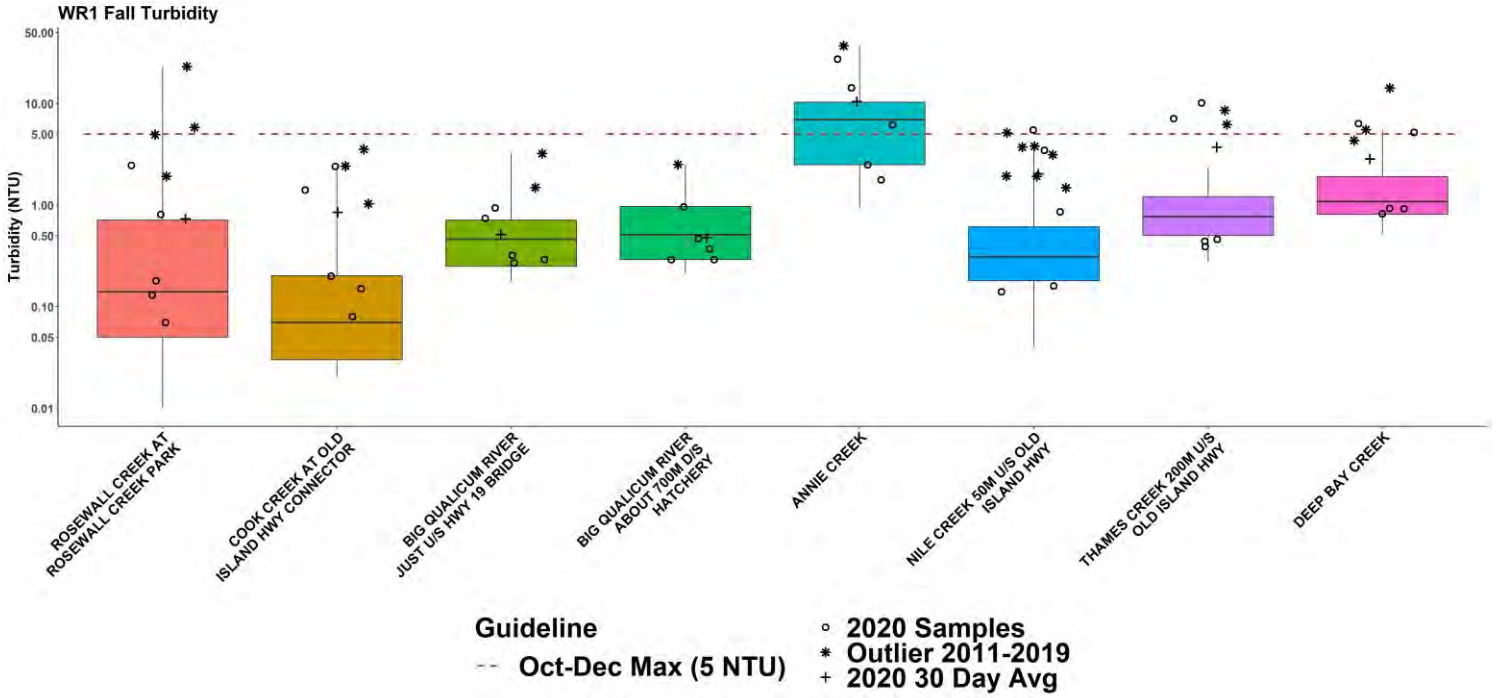

Figure B9: Fall 2011-2020 turbidity of CWMN sites in Water Region 1 (Big Qualicum) with BC Water Quality guidelines for Aquatic Life.

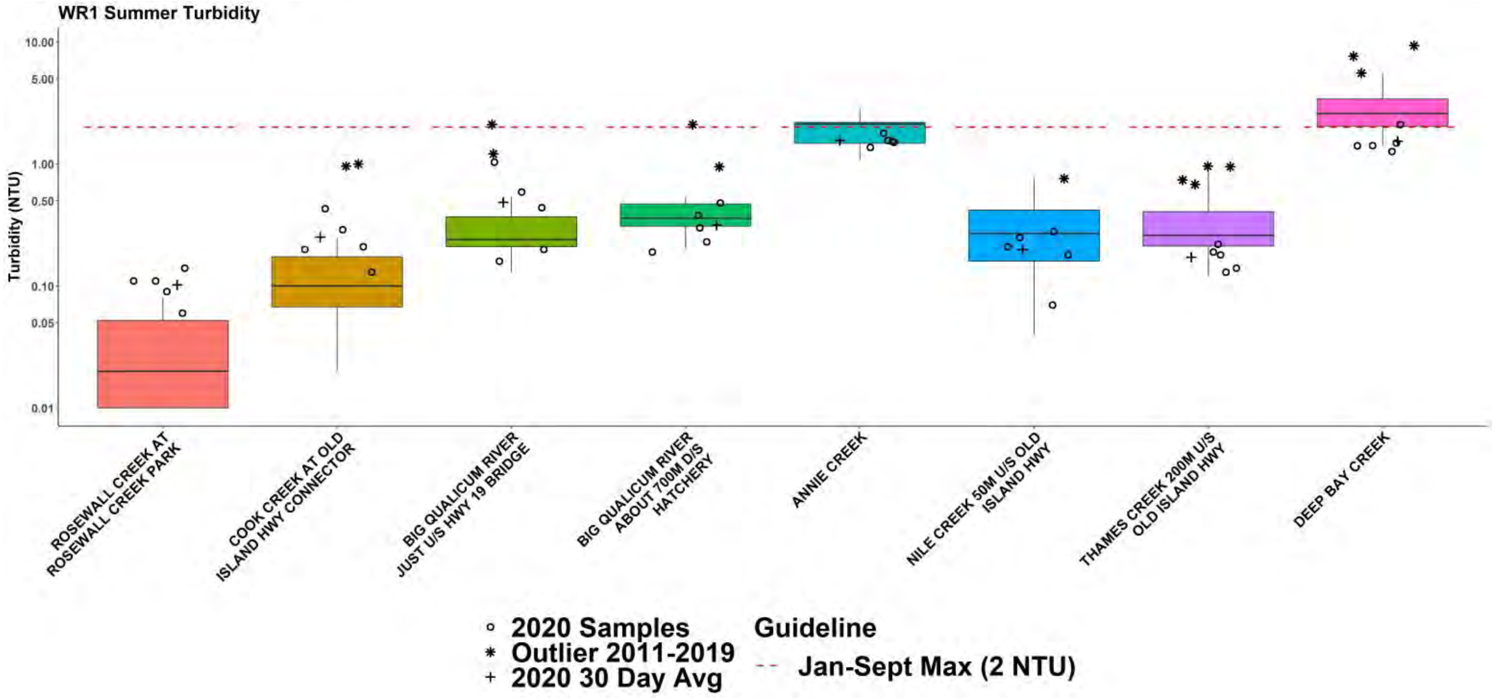

Figure B10: Summer 2011-2020 turbidity of CWMN sites in Water Region 1 (Big Qualicum) with BC Water Quality guidelines for Aquatic Life.

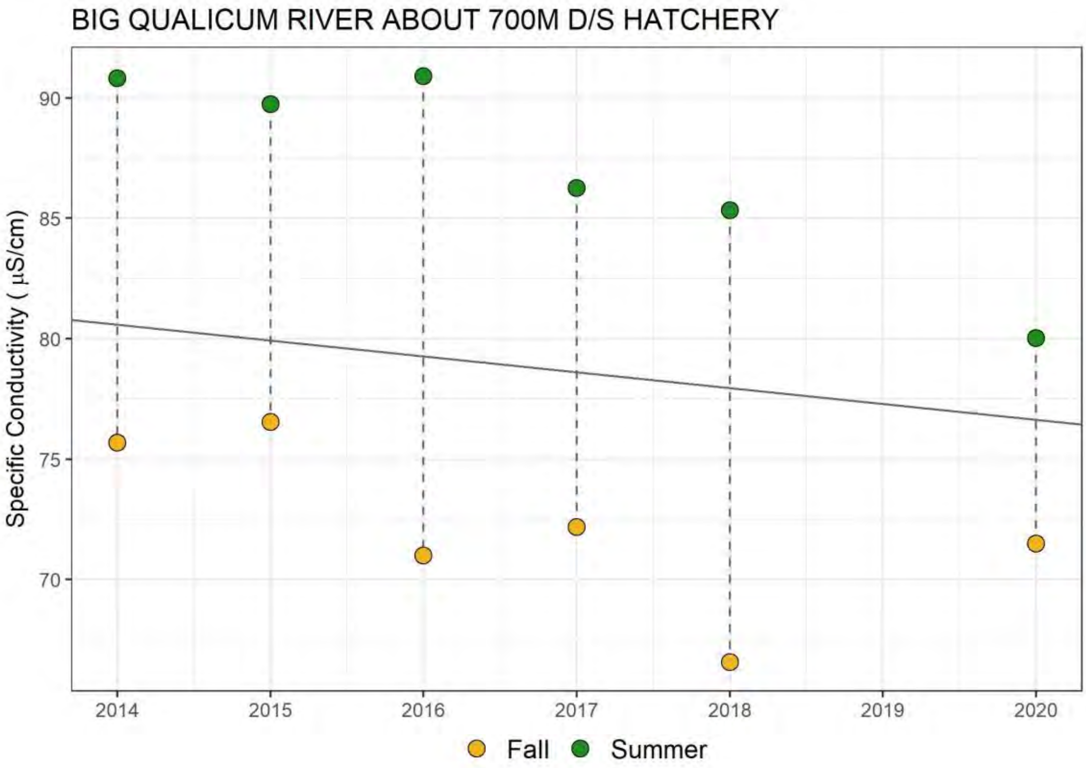

Figure B11: 2011-2020 Seasonal Mann-Kendall analysis plot for specific conductivity at the CMWN site: Big Qualicum River about 700m downstream of hatchery

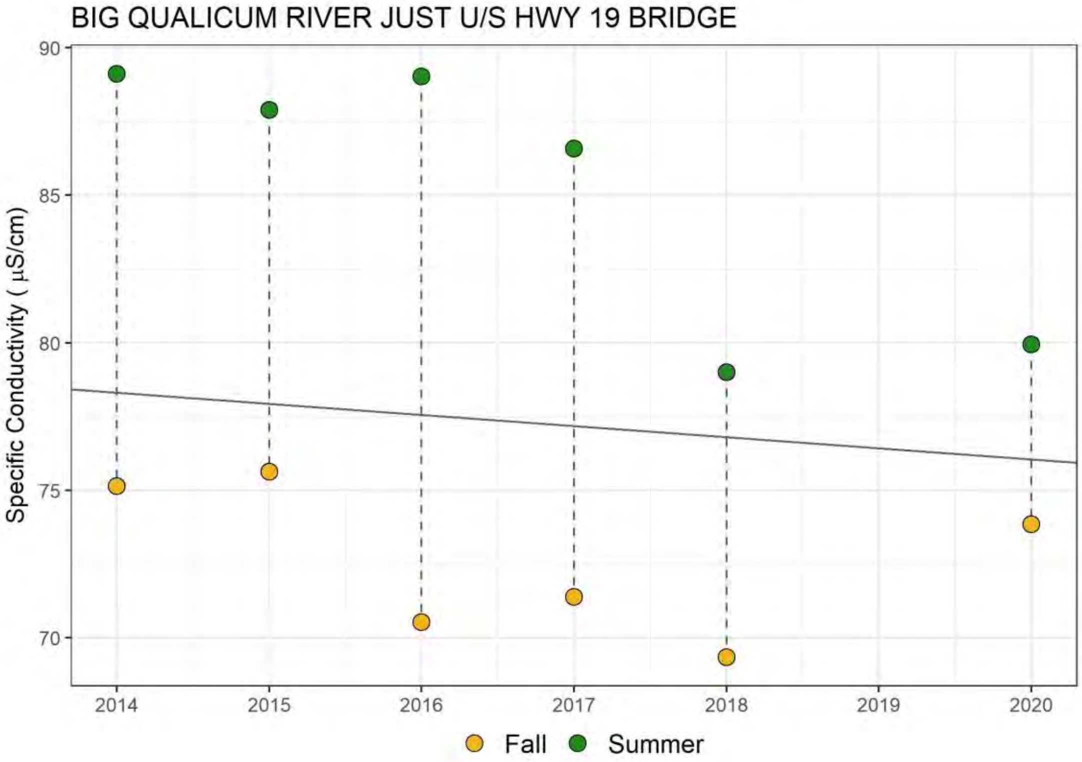

Figure B12: 2011-2020 Seasonal Mann-Kendall analysis plot for specific conductivity at the CMWN site: Big Qualicum upstream of HWY 19

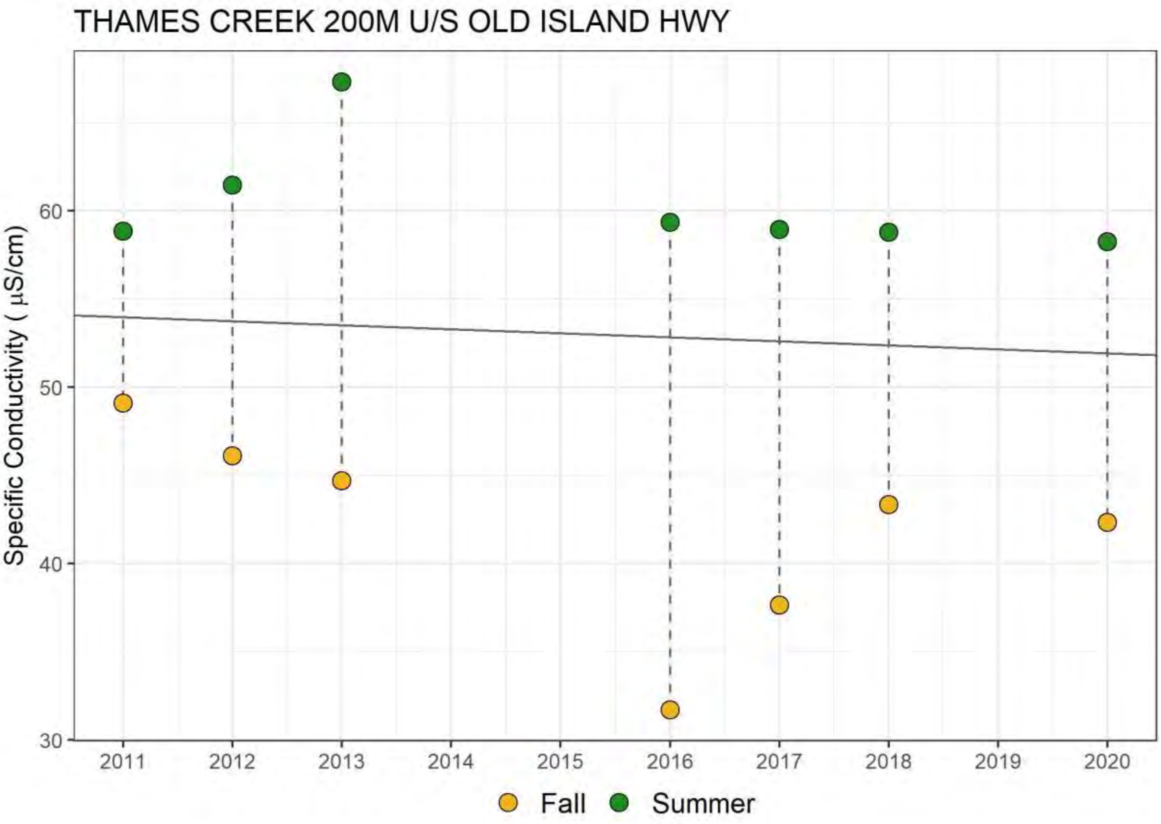

Figure B13: 2011-2020 Seasonal Mann-Kendall analysis plot for specific conductivity at the CMWN site: Thames Creek 200m upstream of Old Island Hwy

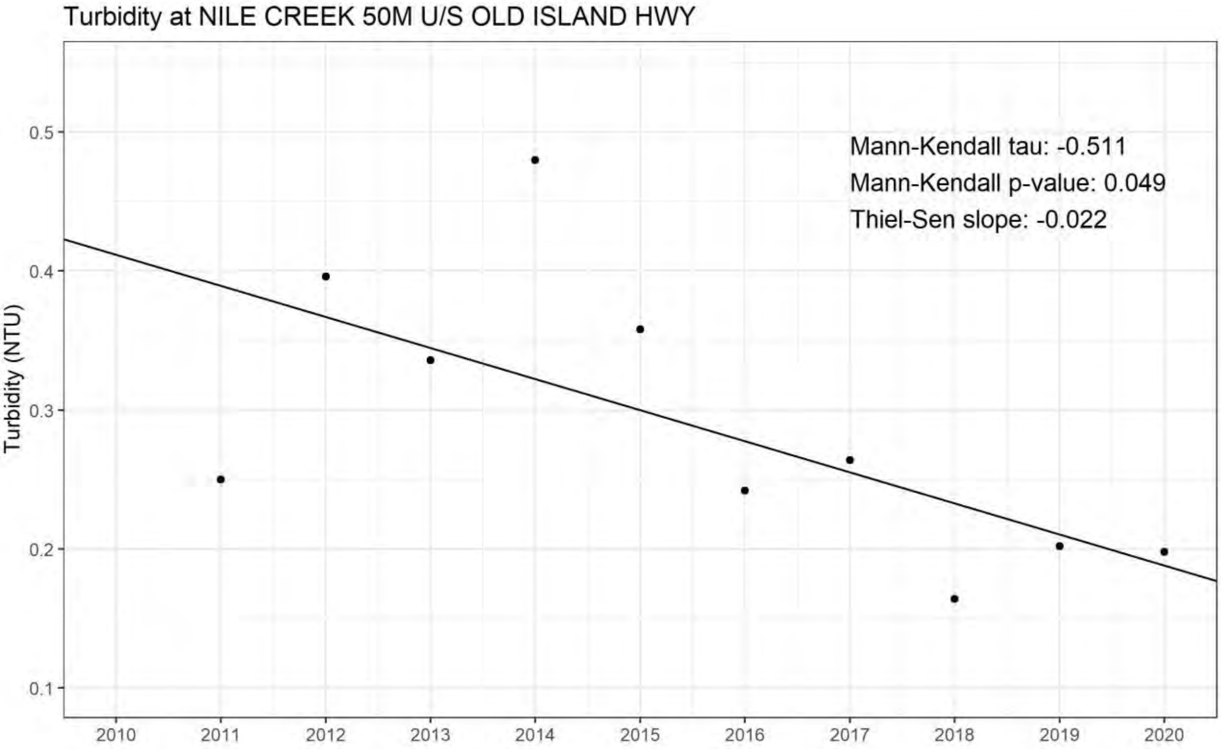

Figure B14: 2011-2020 Mann-Kendall analysis plot for turbidity in the summer at the CMWN site: Nile Creek 50m u/s Old Island Hwy

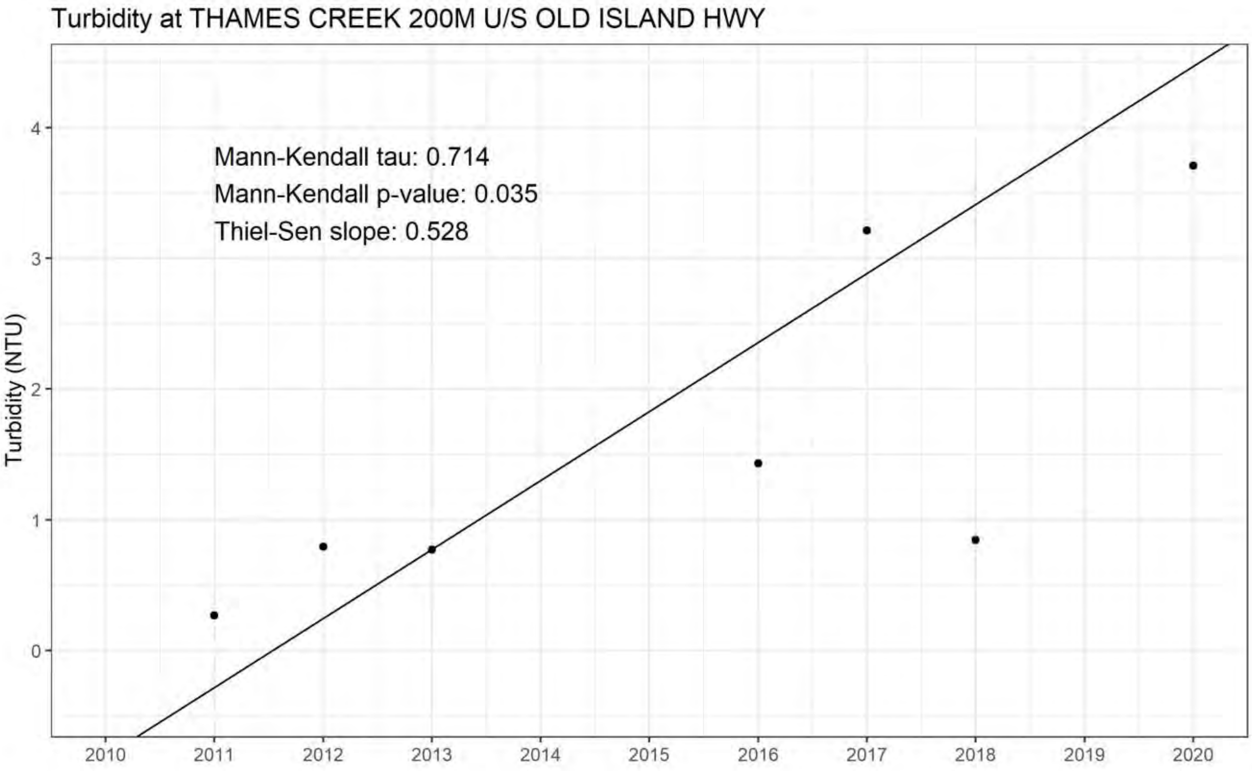

Figure B15: 2011-2020 Mann-Kendall analysis plot for turbidity in the fall at the CMWN site: Thames Creek 200m u/s Old Island Hwy

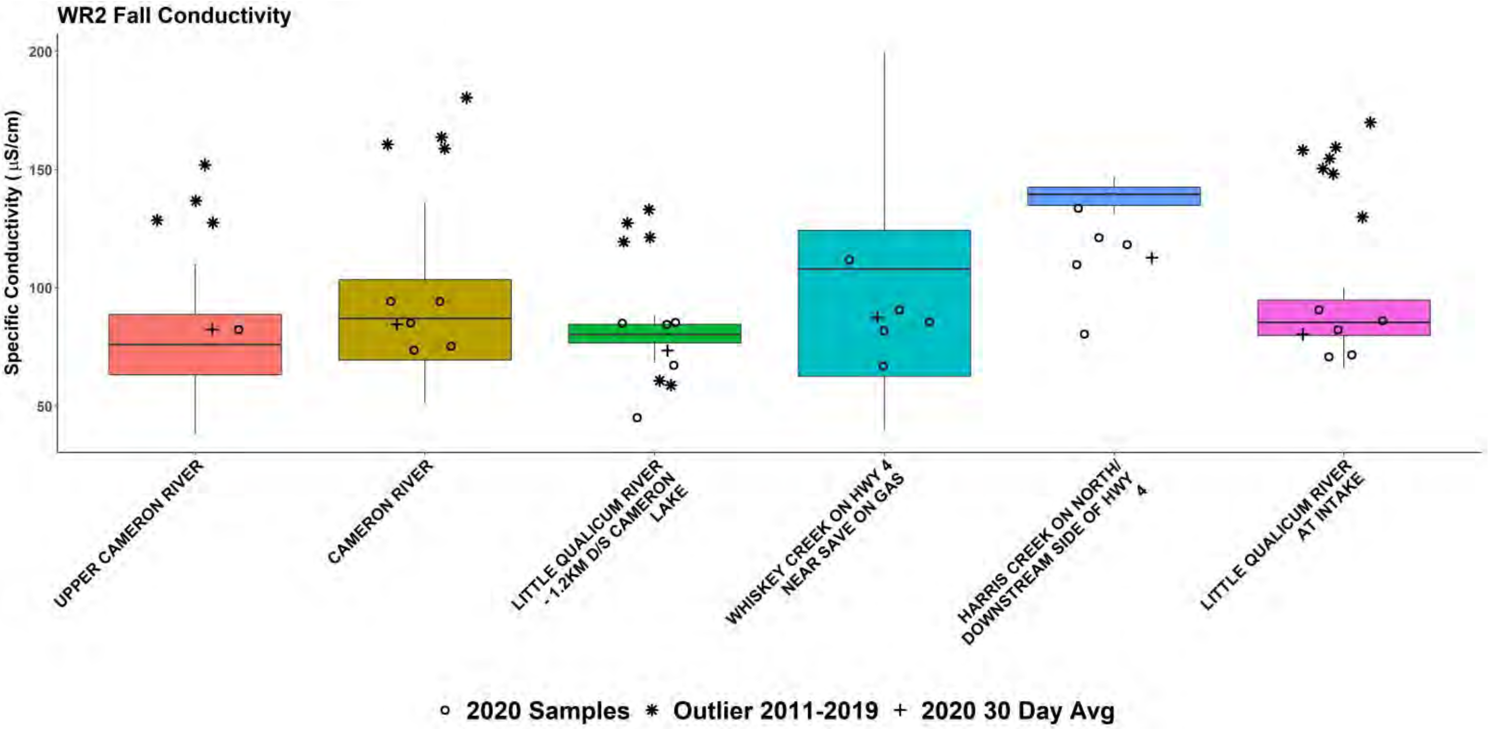

Figure B16: Fall 2011-2020 specific conductivity of CWMN sites in Water Region 2 (Little Qualicum).

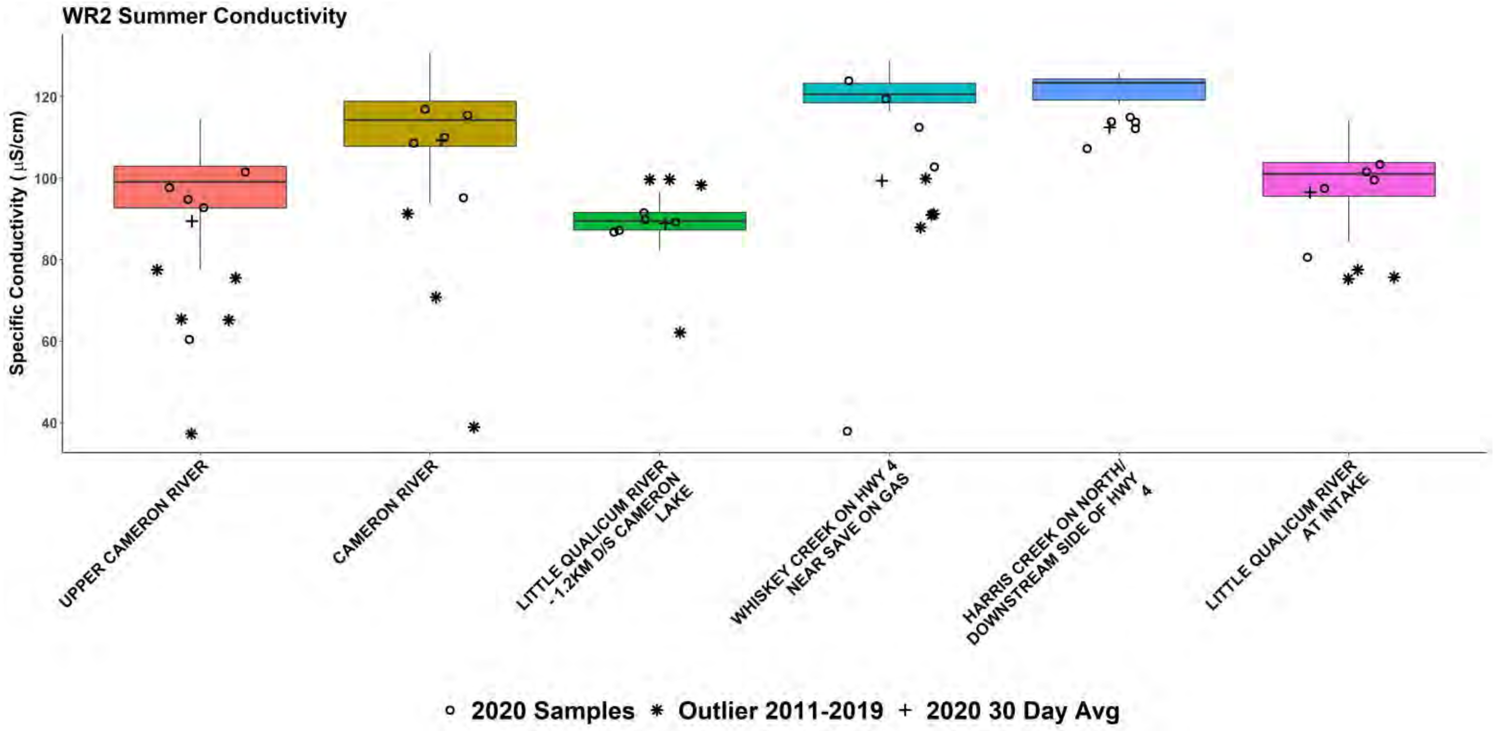

Figure B17: Summer 2011-2020 specific conductivity of CWMN sites in Water Region 2 (Little Qualicum).

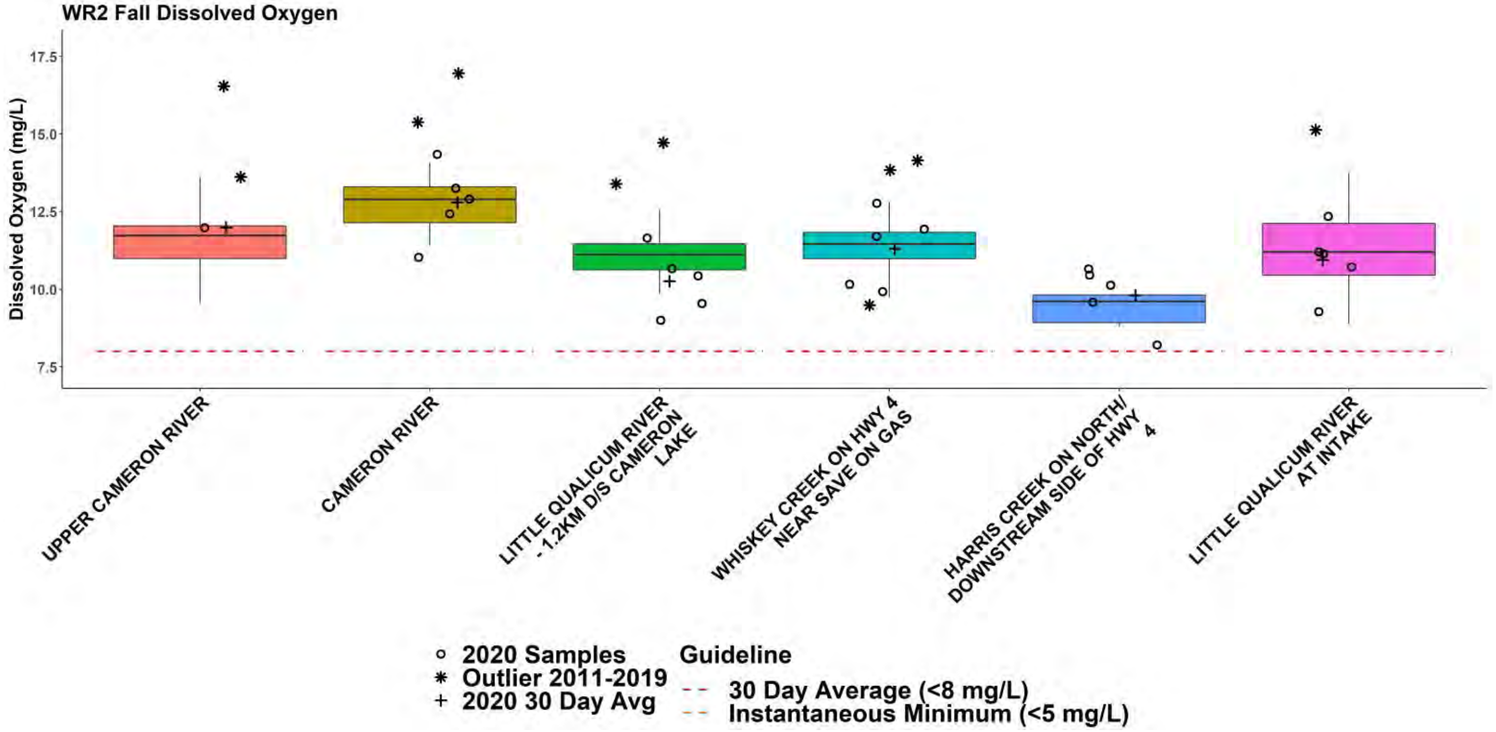

Figure B18: Fall 2011-2020 dissolved oxygen of CWMN sites in Water Region 2 (Little Qualicum) with Englishman River water quality objectives.

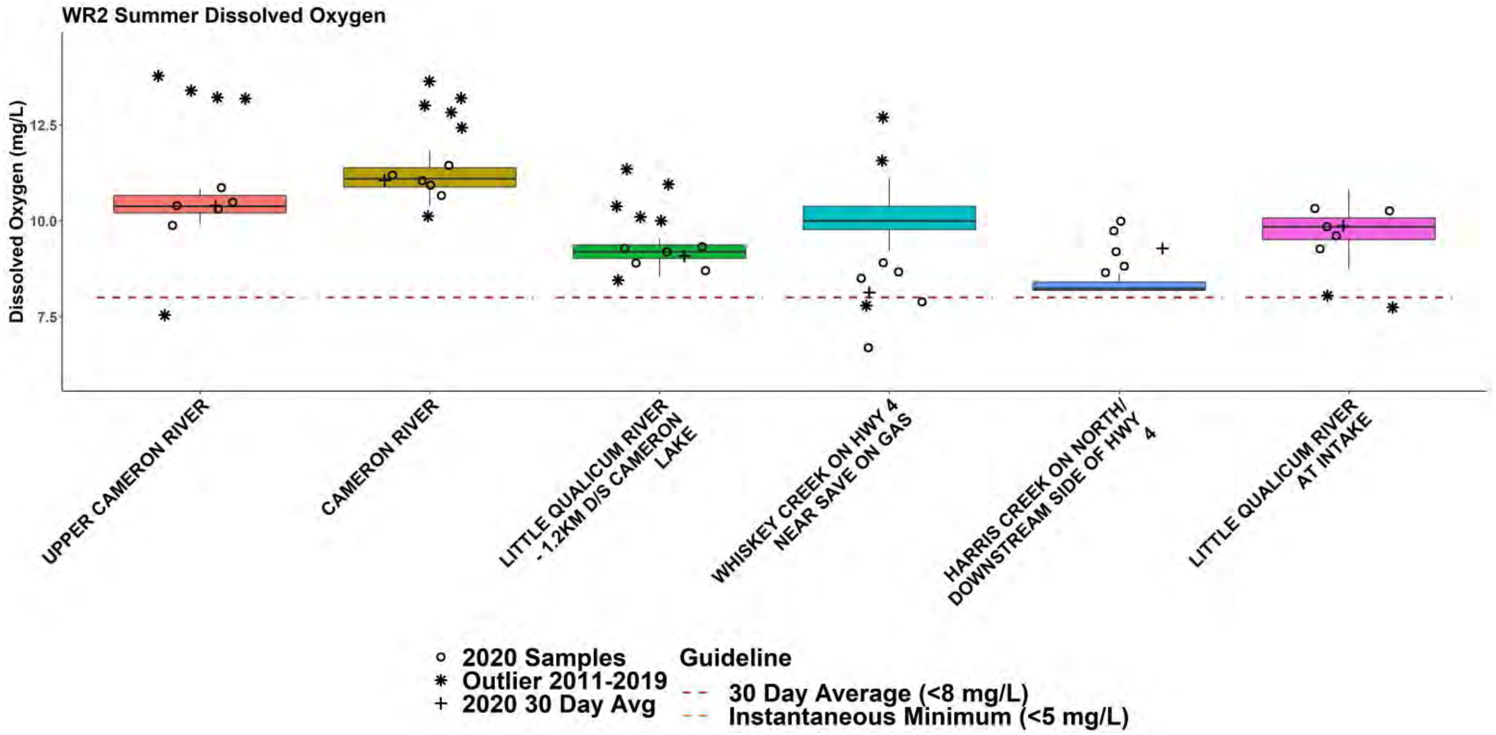

Figure B19: Summer 2011-2020 dissolved oxygen of CWMN sites in Water Region 2 (Little Qualicum) with Englishman River water quality objectives.

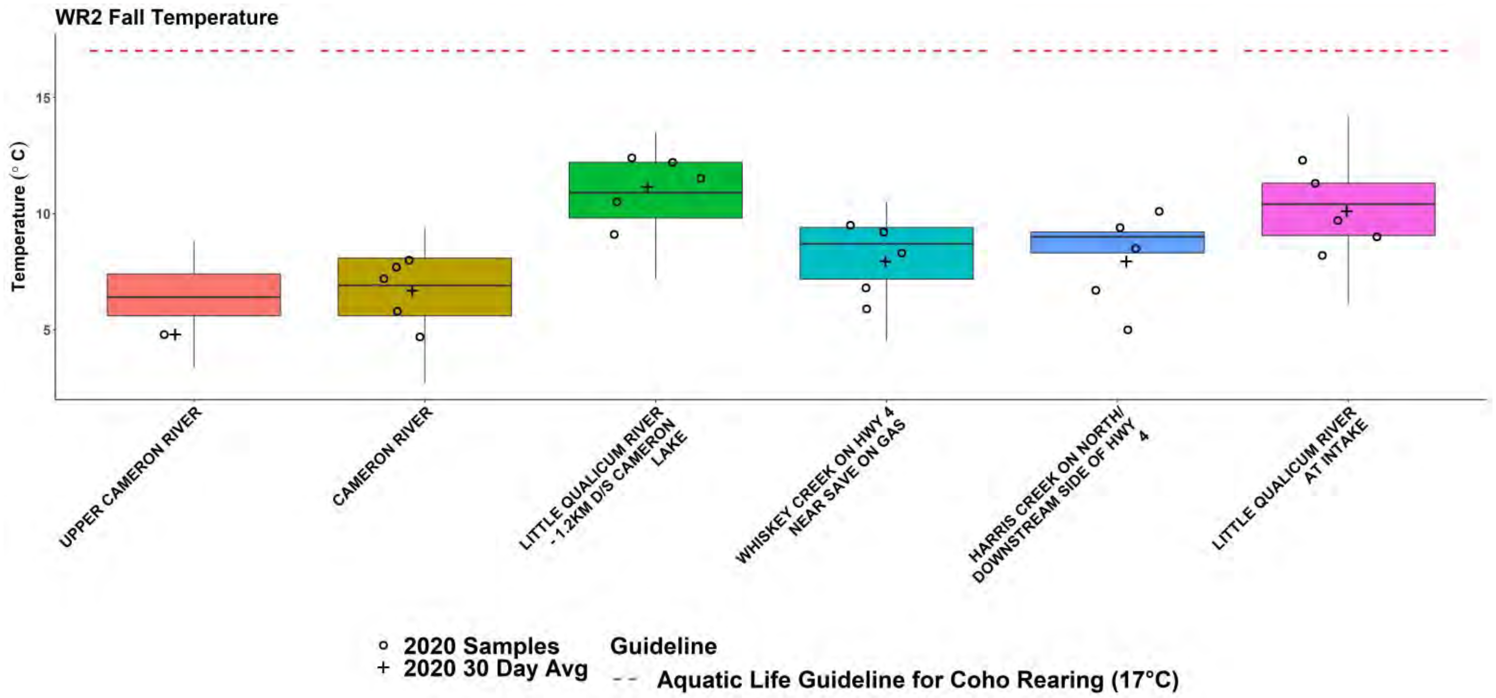

Figure B20: Fall 2011-2020 water temperature of CWMN sites in Water Region 2 (Little Qualicum) with BC Water Quality guidelines for Aquatic Life.

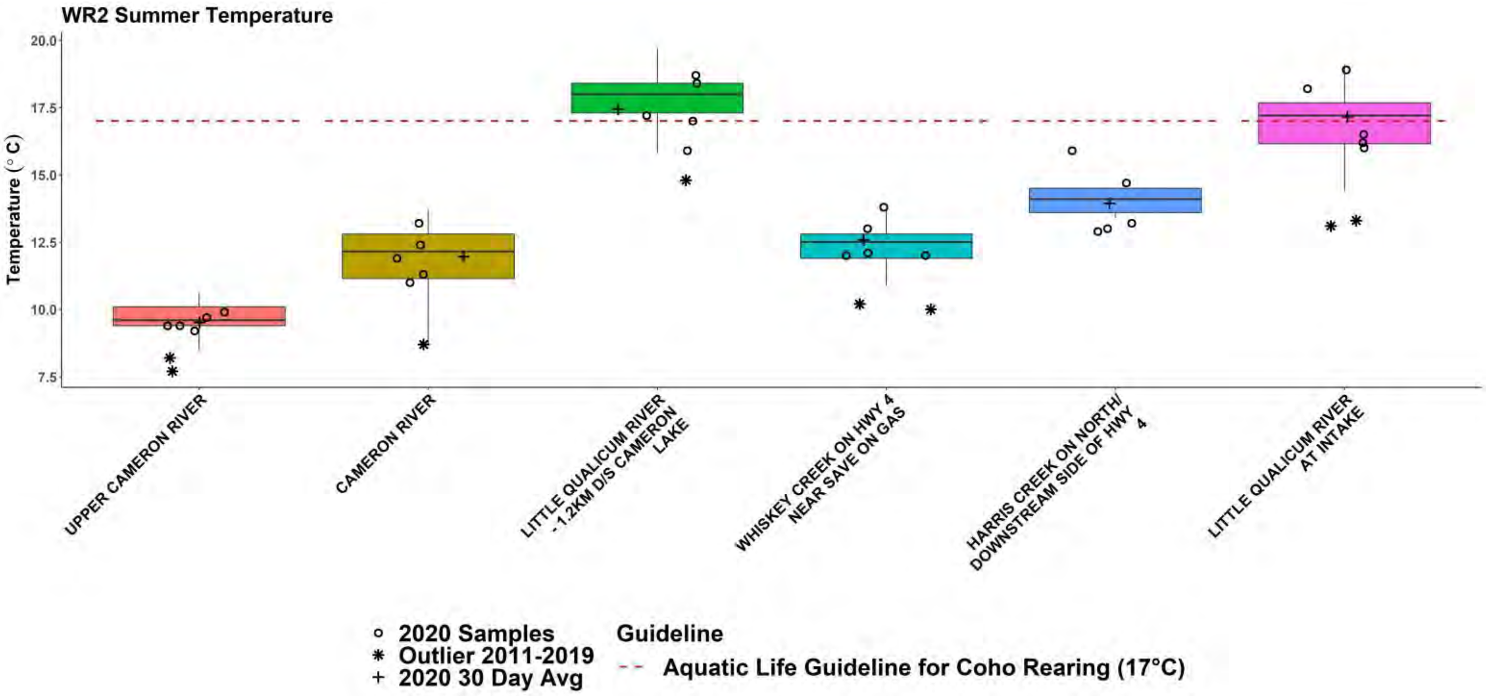

Figure B21: Summer 2011-2020 water temperature of CWMN sites in Water Region 2 (Little Qualicum) with BC Water Quality guidelines for Aquatic Life.

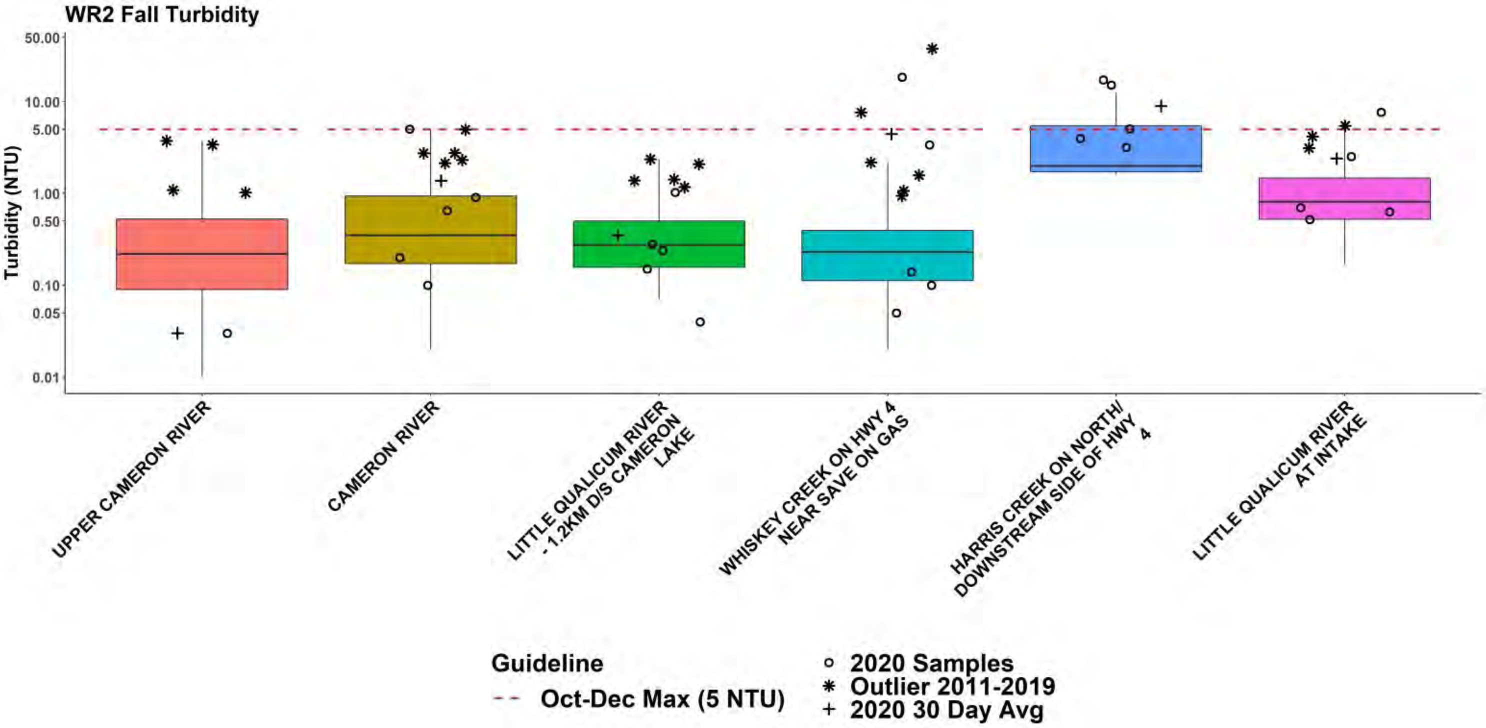

Figure B22: Fall 2011-2020 turbidity of CWMN sites in Water Region 2 (Little Qualicum) with BC Water Quality guidelines for Aquatic Life.

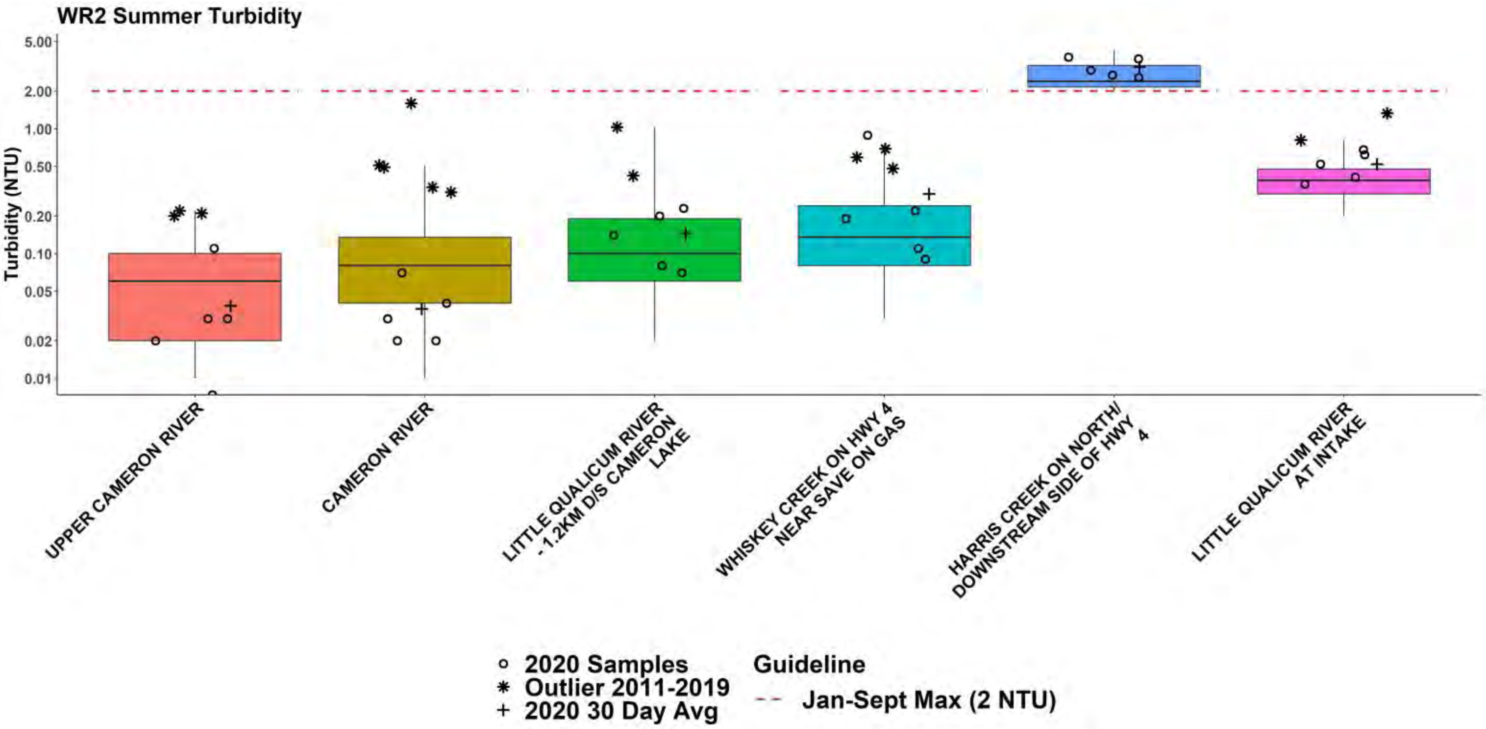

Figure B23: Summer 2011-2020 turbidity of CWMN sites in Water Region 2 (Little Qualicum) with BC Water Quality guidelines for Aquatic Life.

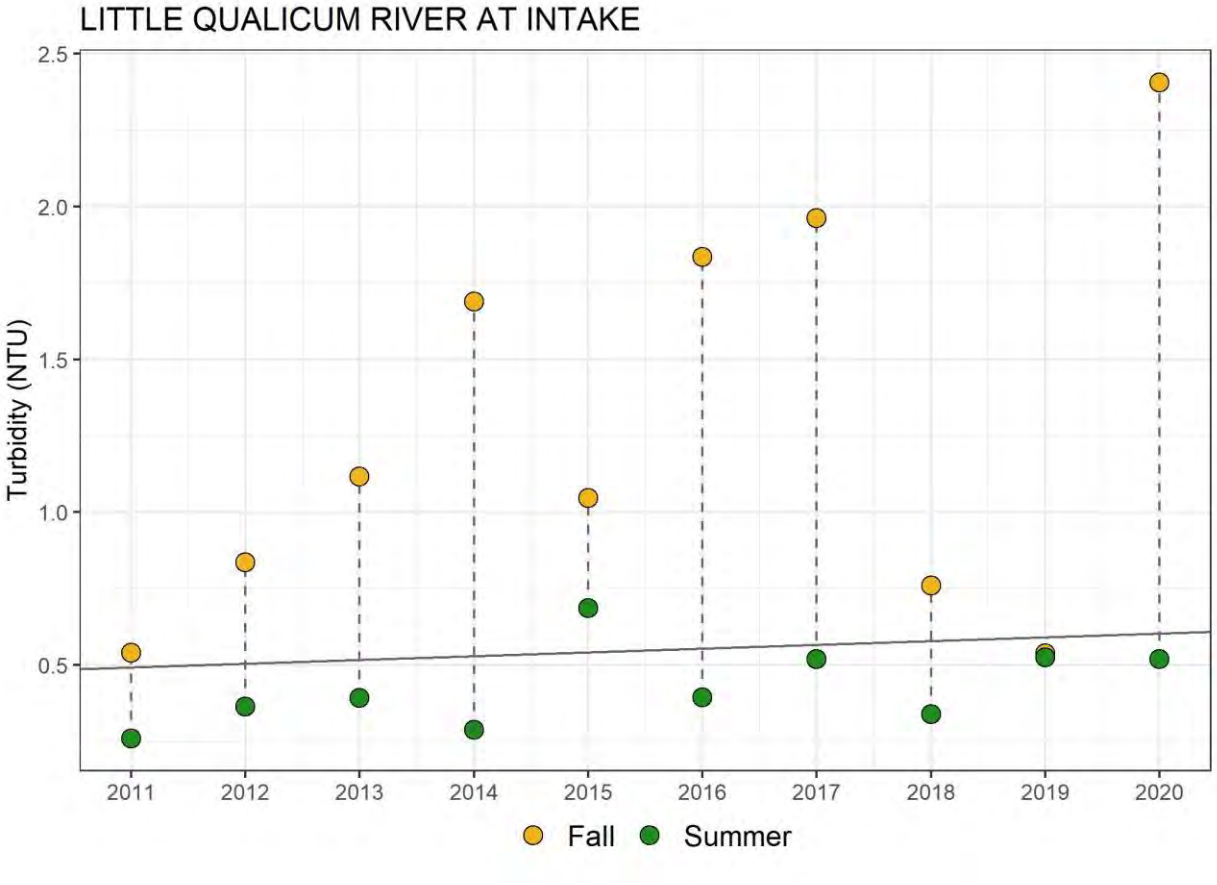

Figure B24: 2011-2020 Seasonal Mann-Kendall analysis plot for turbidity at the CMWN site: Little Qualicum River at Intake

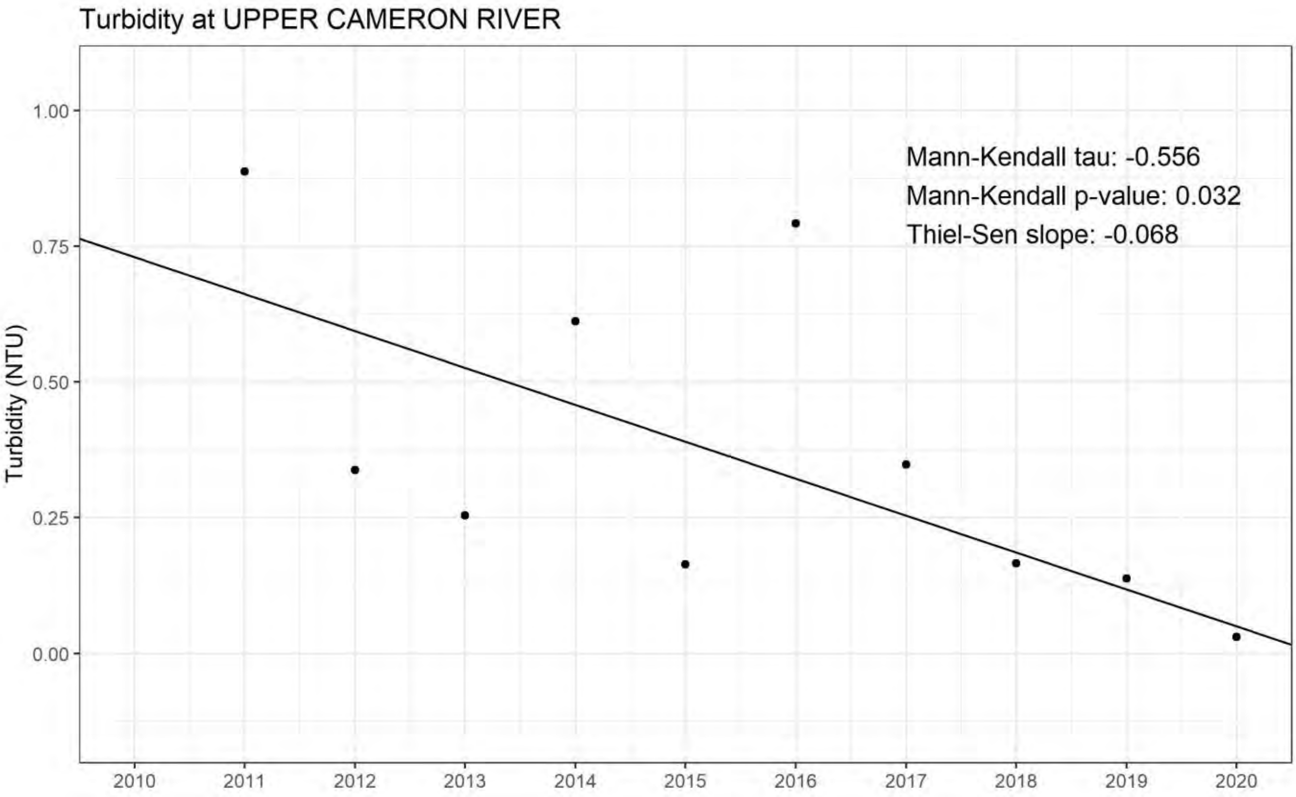

Figure B25: 2011-2020 Mann-Kendall analysis plot for turbidity in the fall at the CMWN site: Upper Cameron River

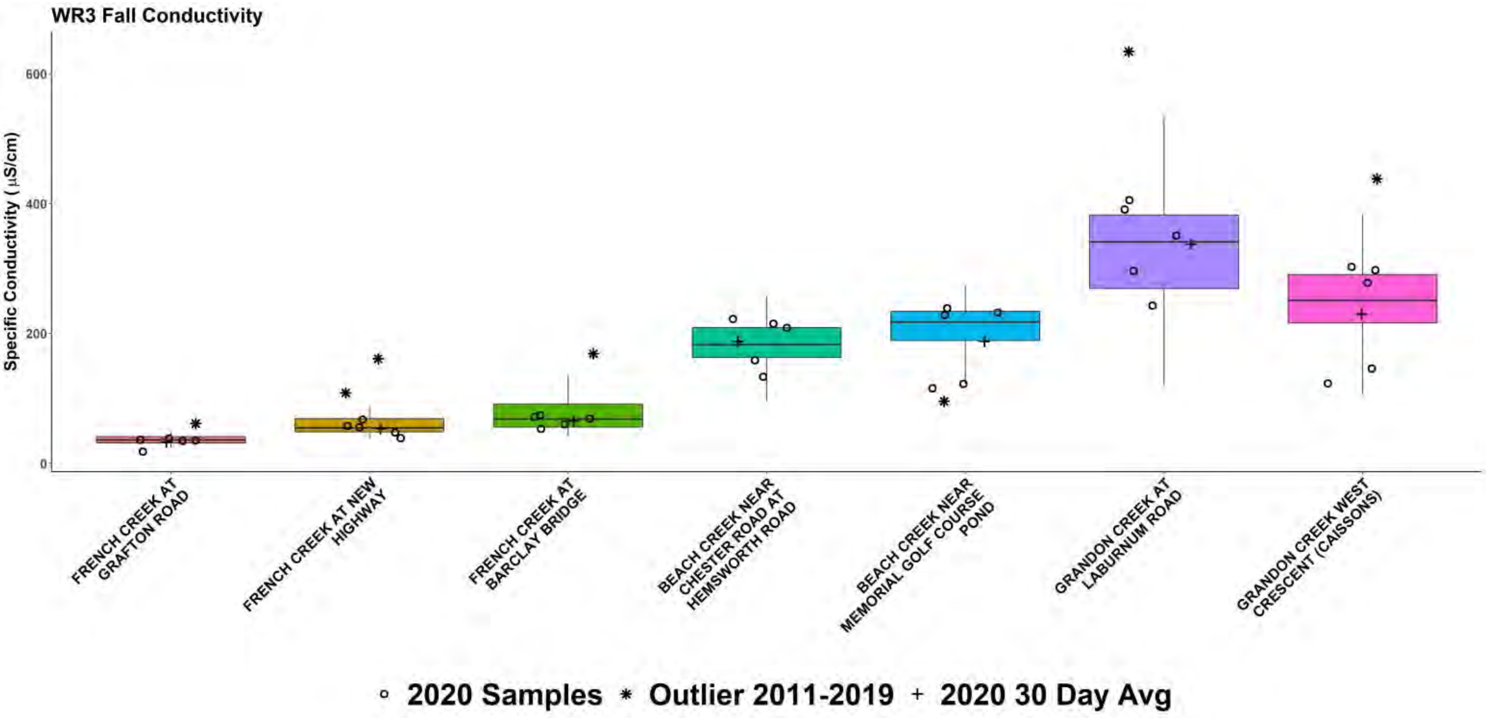

Figure B26: Fall 2011-2020 specific conductivity of CWMN sites in Water Region 3 (French Creek).

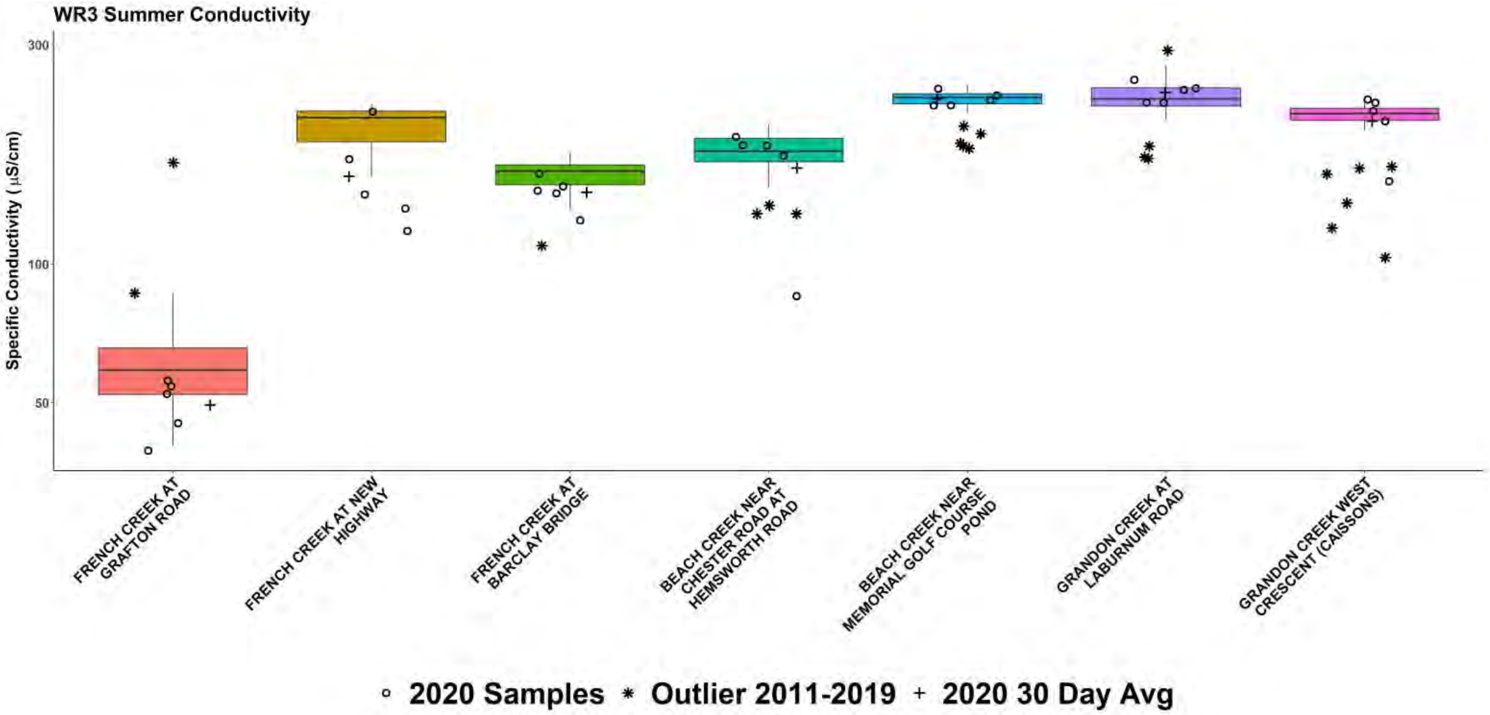

Figure B27: Summer 2011-2020 specific conductivity of CWMN sites in Water Region 3 (French Creek).

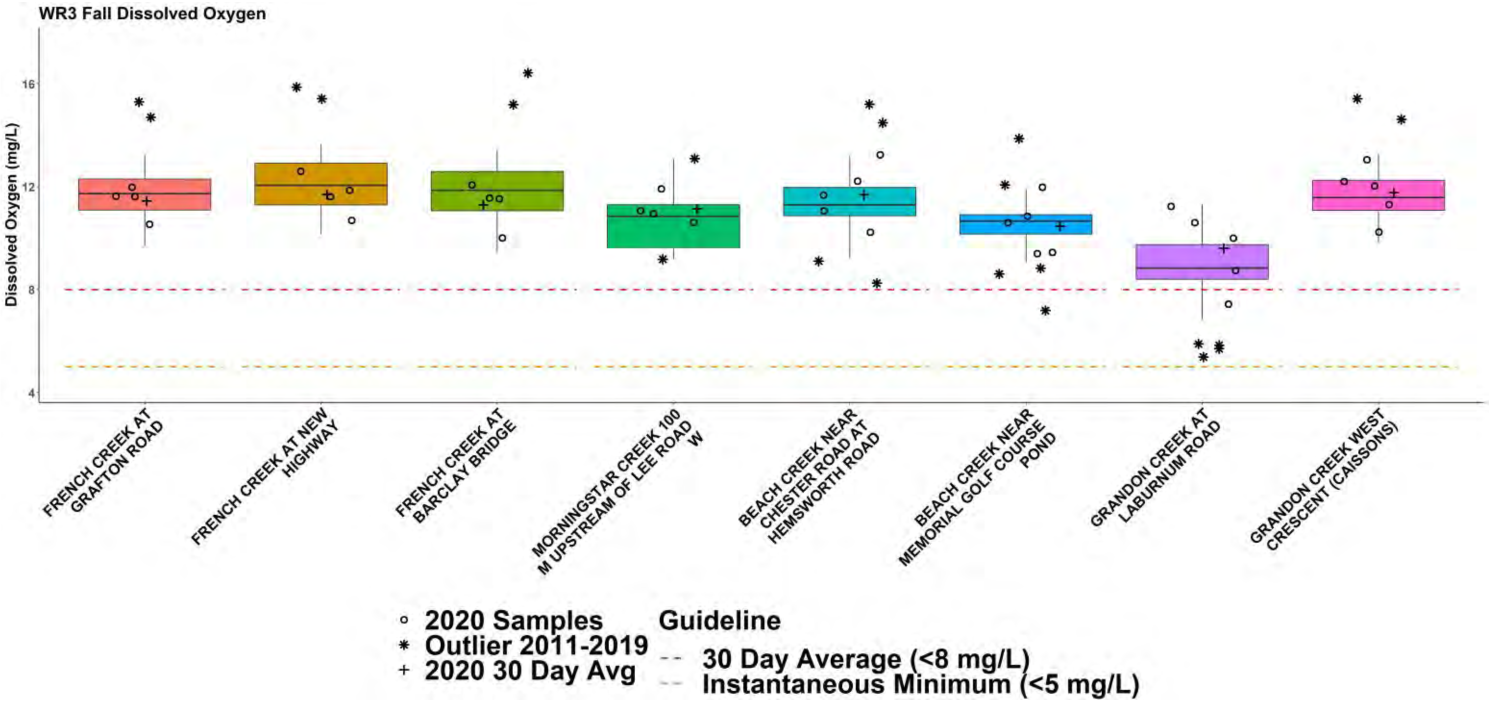

Figure B28: Fall 2011-2020 dissolved oxygen of CWMN sites in Water Region 3 (French Creek) with Englishman River water quality objectives.

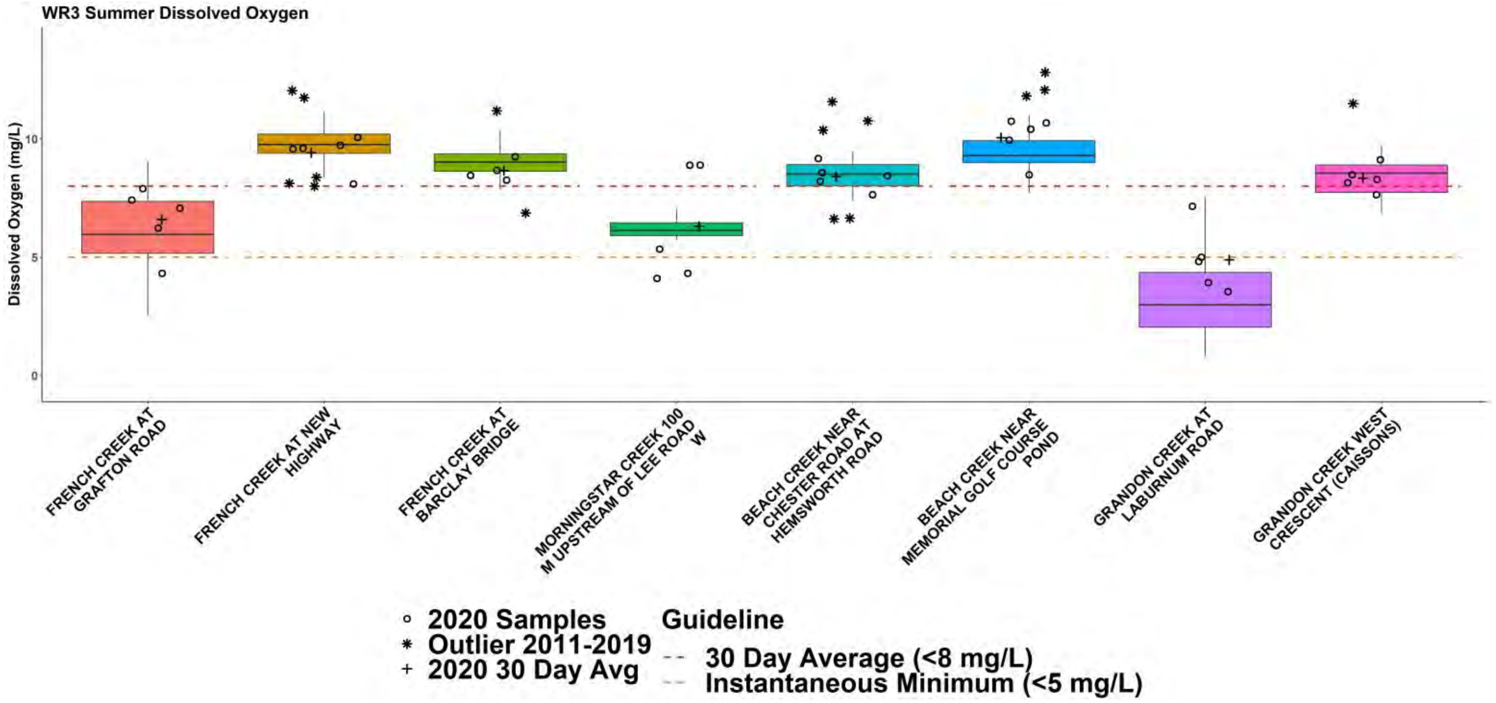

Figure B29: Summer 2011-2020 dissolved oxygen of CWMN sites in Water Region 3 (French Creek) with Englishman River water quality objectives.

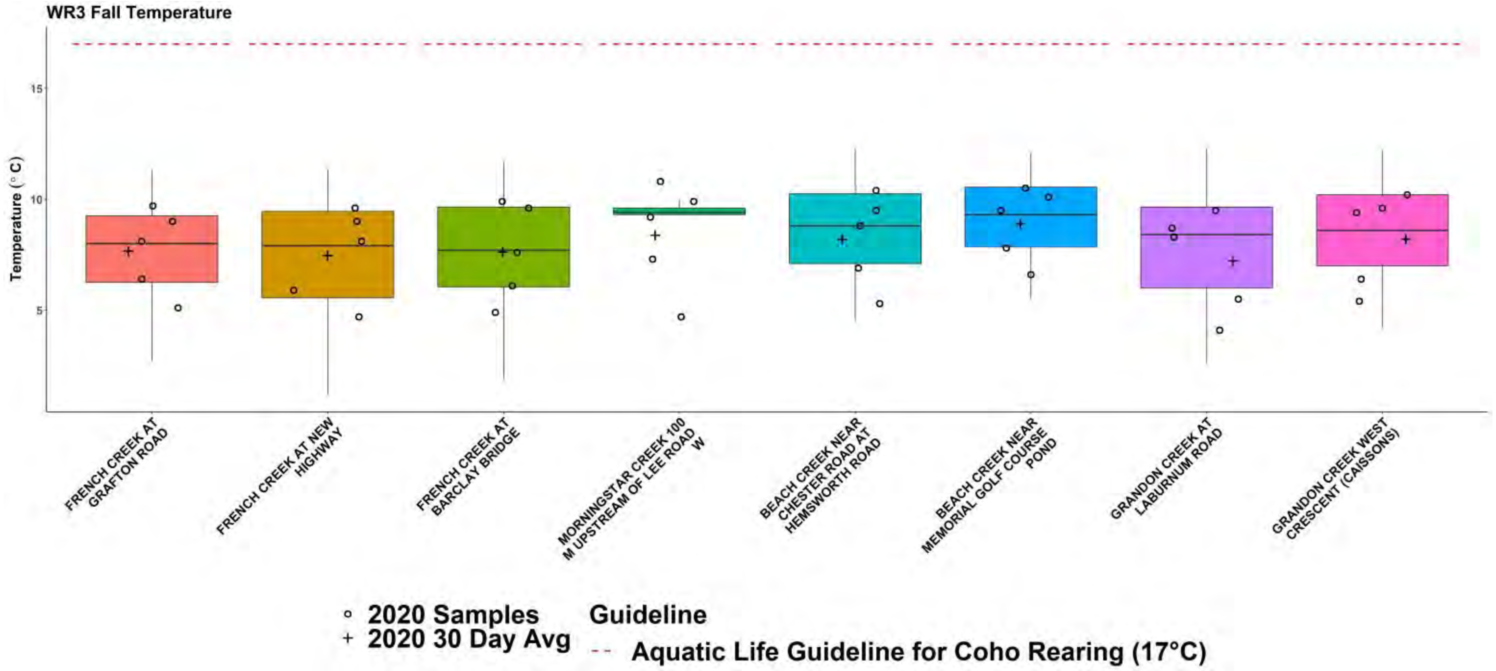

Figure B30: Fall 2011-2020 water temperature of CWMN sites in Water Region 3 (French Creek) with BC Water Quality guidelines for Aquatic Life.

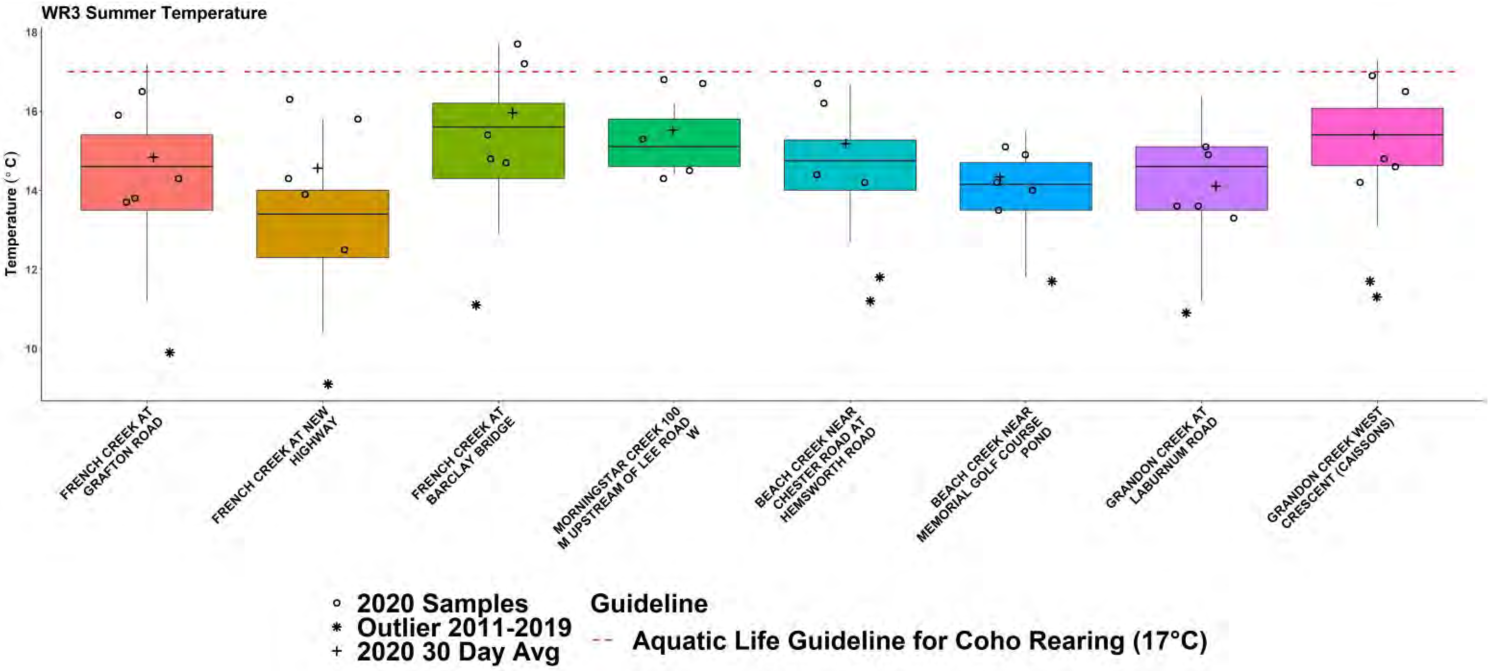

Figure B31: Summer 2011-2020 water temperature of CWMN sites in Water Region 3 (French Creek) with BC Water Quality guidelines for Aquatic Life.

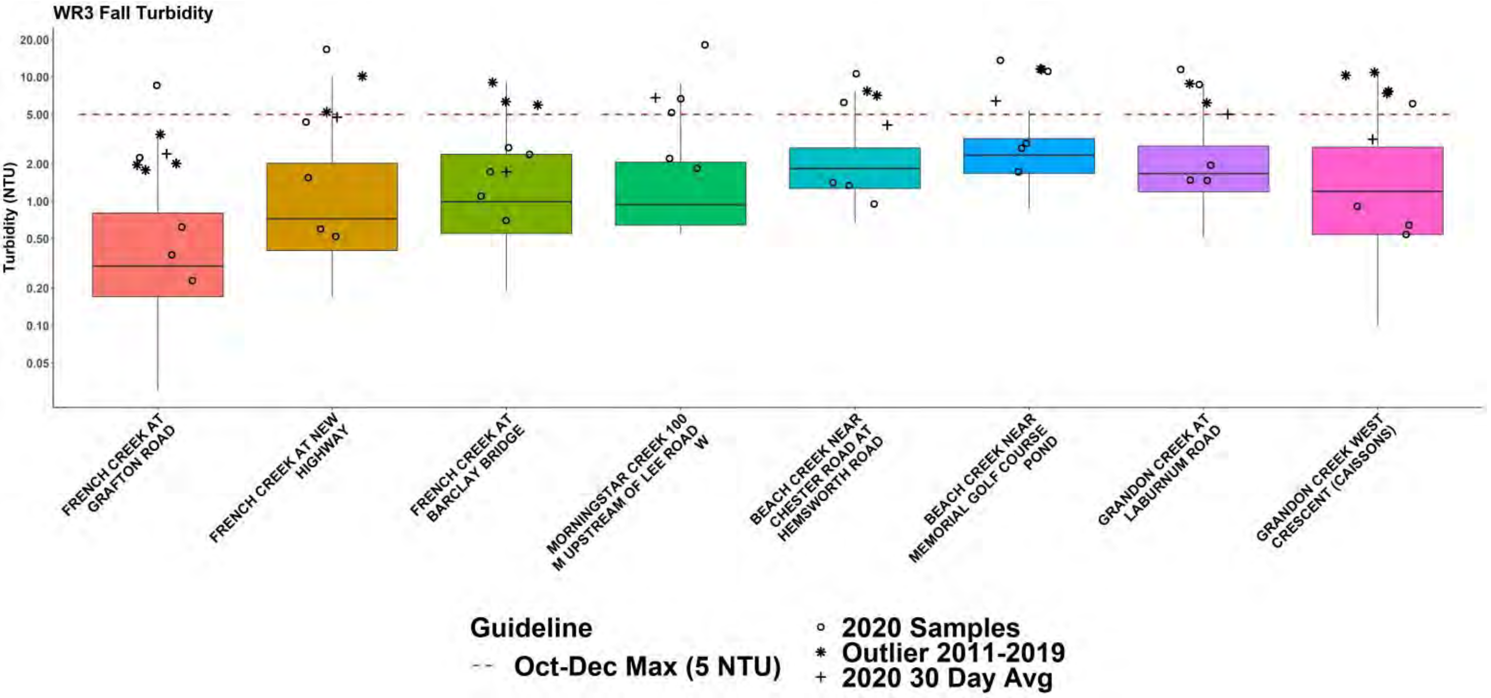

Figure B32: Fall 2011-2020 turbidity of CWMN sites in Water Region 3 (French Creek) with BC Water Quality guidelines for Aquatic Life.

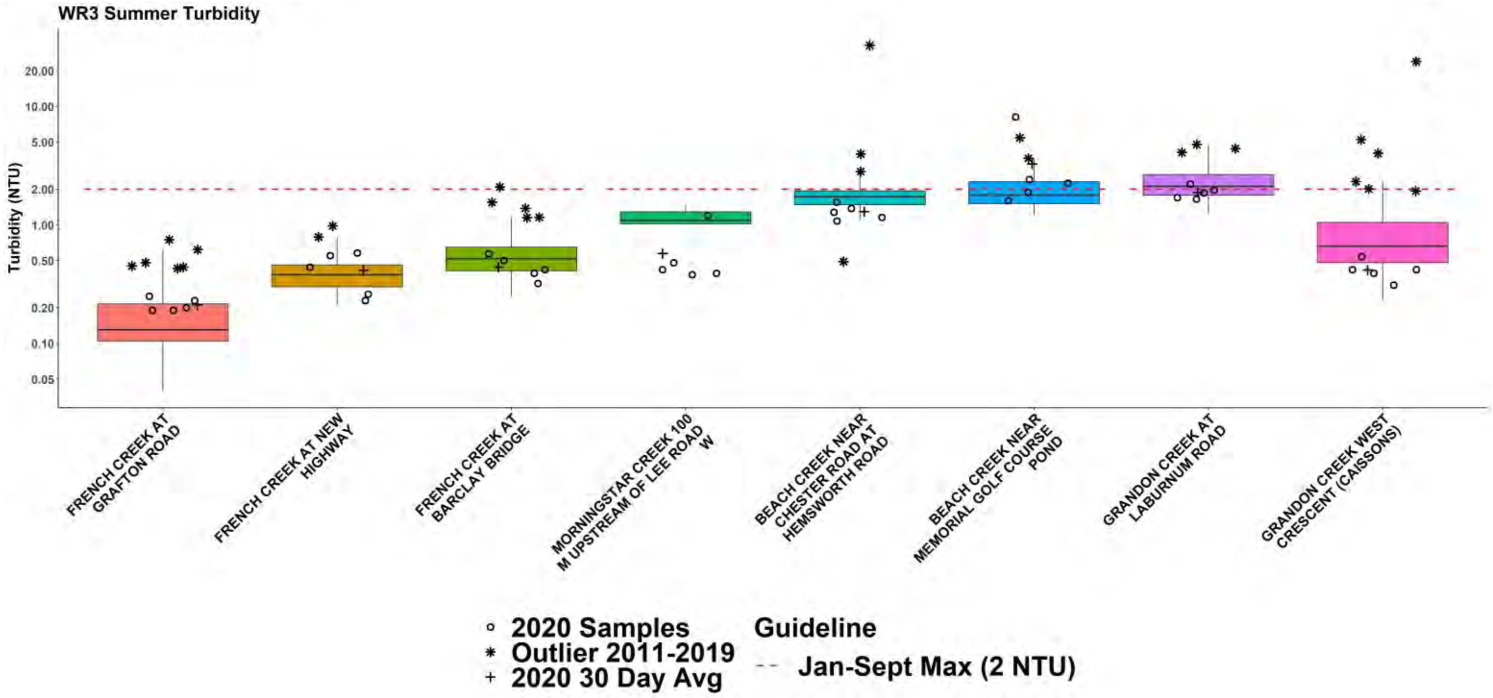

Figure B33: Summer 2011-2020 turbidity of CWMN sites in Water Region 3 (French Creek) with BC Water Quality guidelines for Aquatic Life.

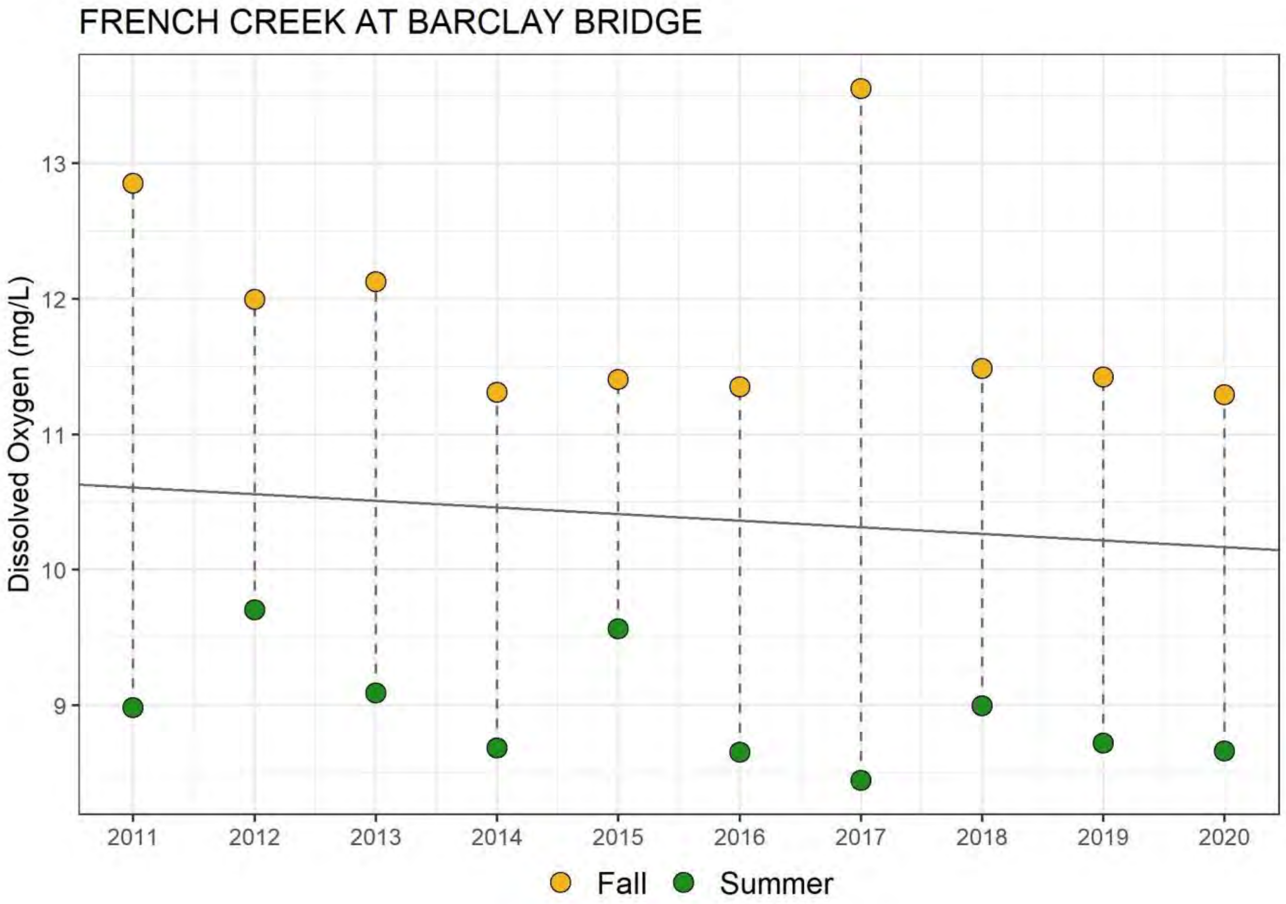

Figure B34: 2011-2020 Seasonal Mann-Kendall analysis plot for dissolved oxygen at the CMWN site: French Creek at Barclay Bridge

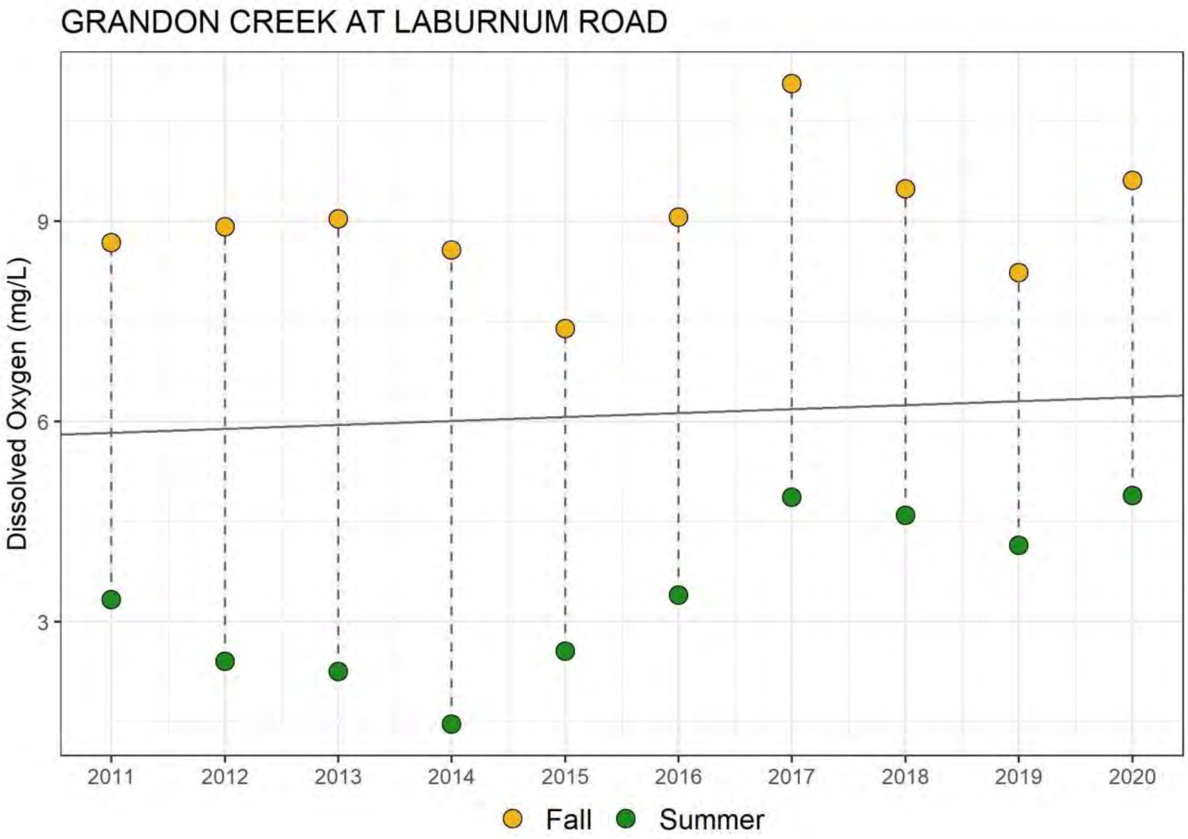

Figure B35: 2011-2020 Seasonal Mann-Kendall analysis plot for dissolved oxygen at the CMWN site: Grandon Creek at Laburnum Road

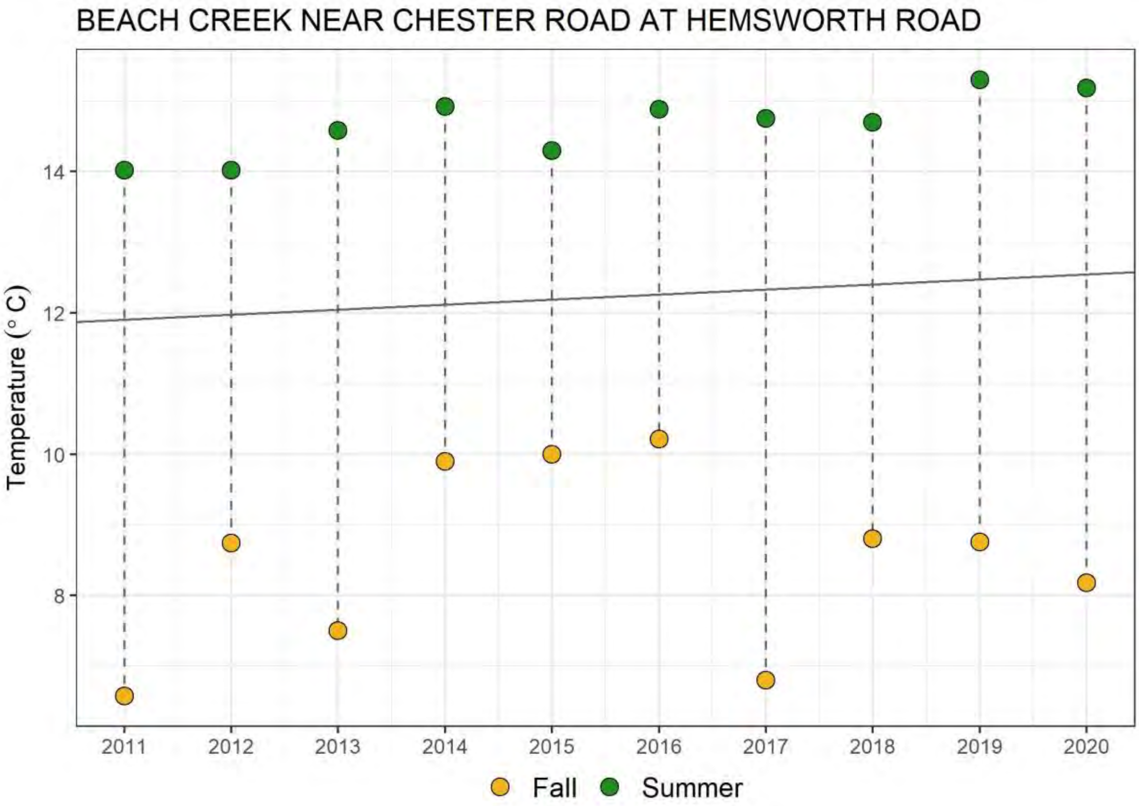

Figure B36: 2011-2020 Seasonal Mann-Kendall analysis plot for water temperature at the CMWN site: Beach Creek near Chester Road at Hemsworth Road

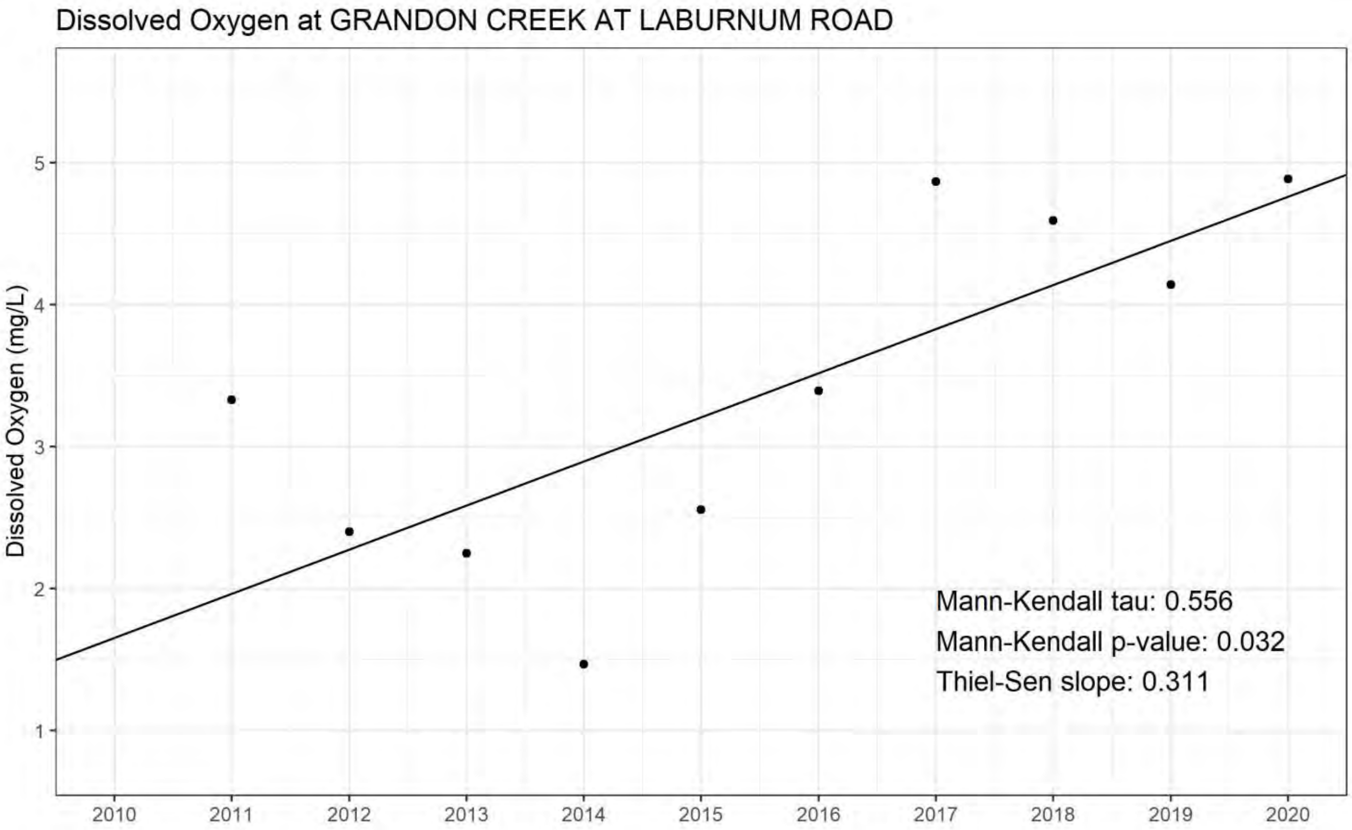

Figure B37: 2011-2020 Mann-Kendall analysis plot for dissolved oxygen in the summer at the CMWN site: Grandon Creek at Laburnum Road

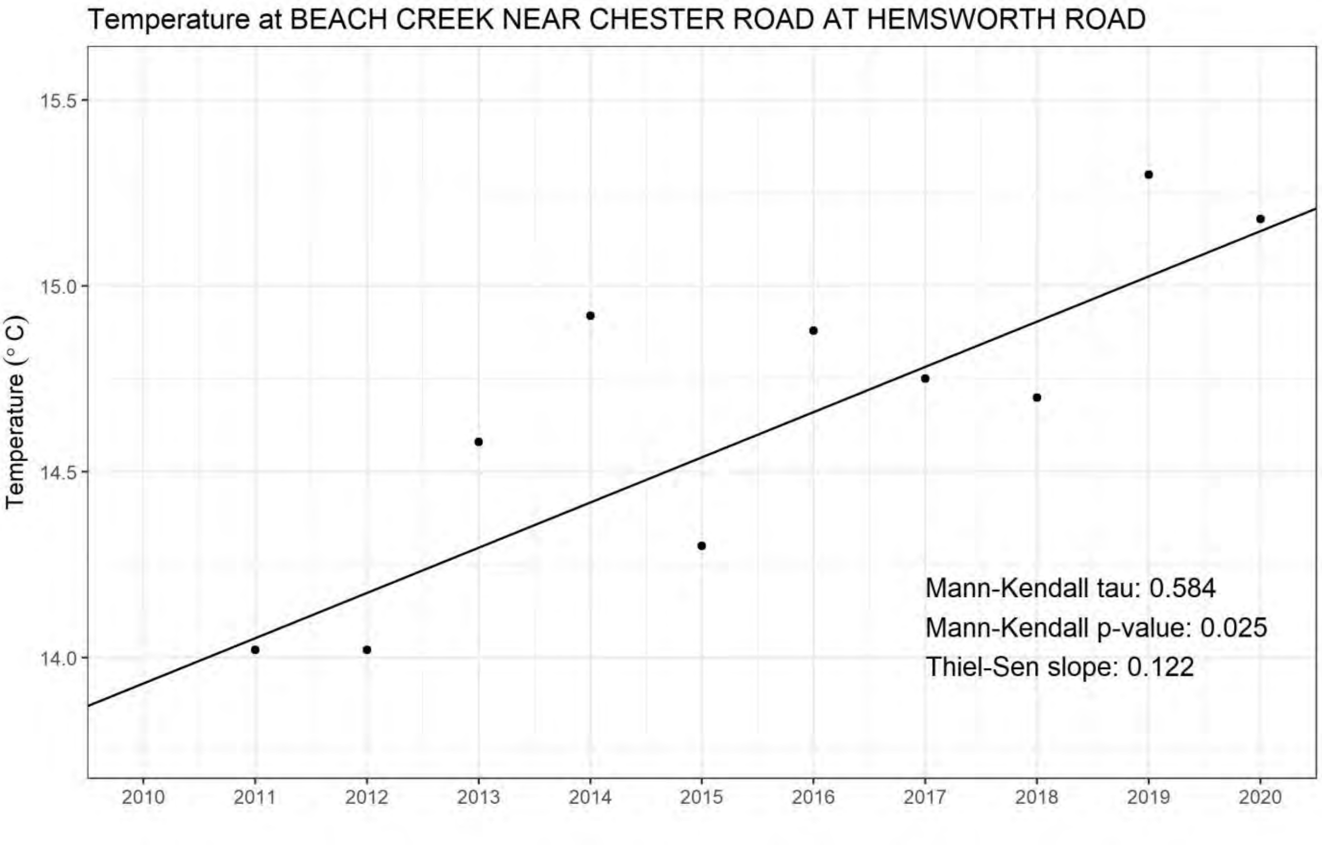

Figure B38: 2011-2020 Mann-Kendall analysis plot for water temperature in the summer at the CMWN site: Beach Creek near Chester Road at Hemsworth Road

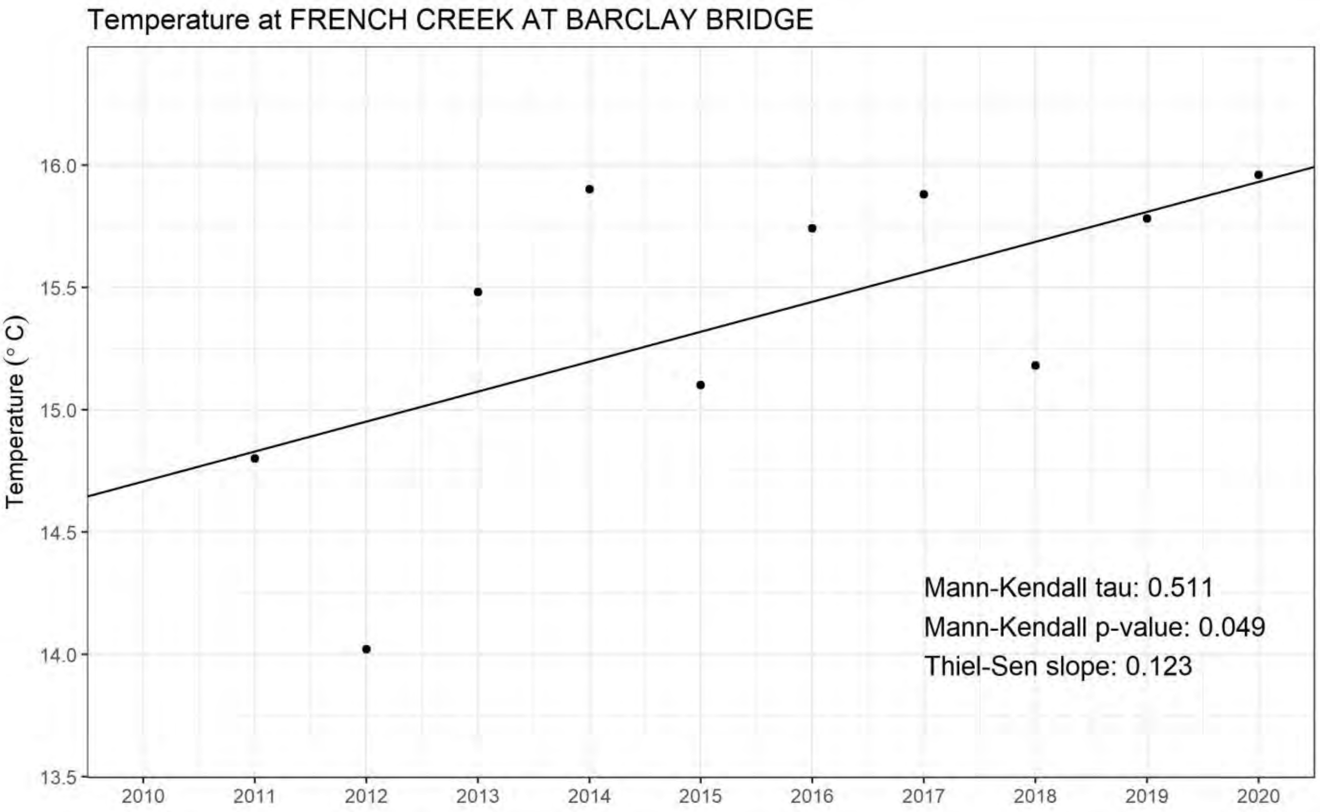

Figure B39: 2011-2020 Mann-Kendall analysis plot for water temperature in the summer at the CMWN site: French Creek at Barclay Bridge

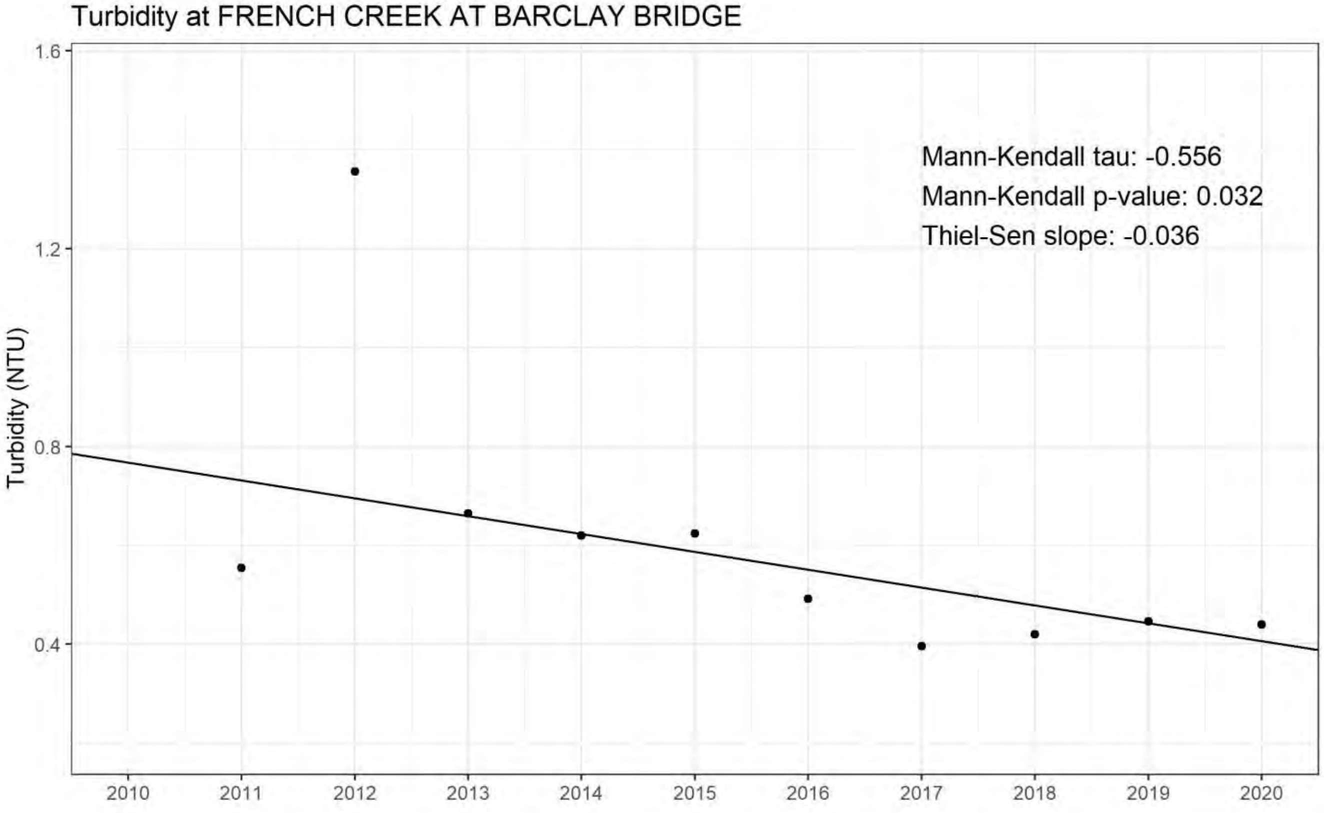

Figure B40: 2011-2020 Mann-Kendall analysis plot for turbidity in the summer at the CMWN site: French Creek at Barclay Bridge

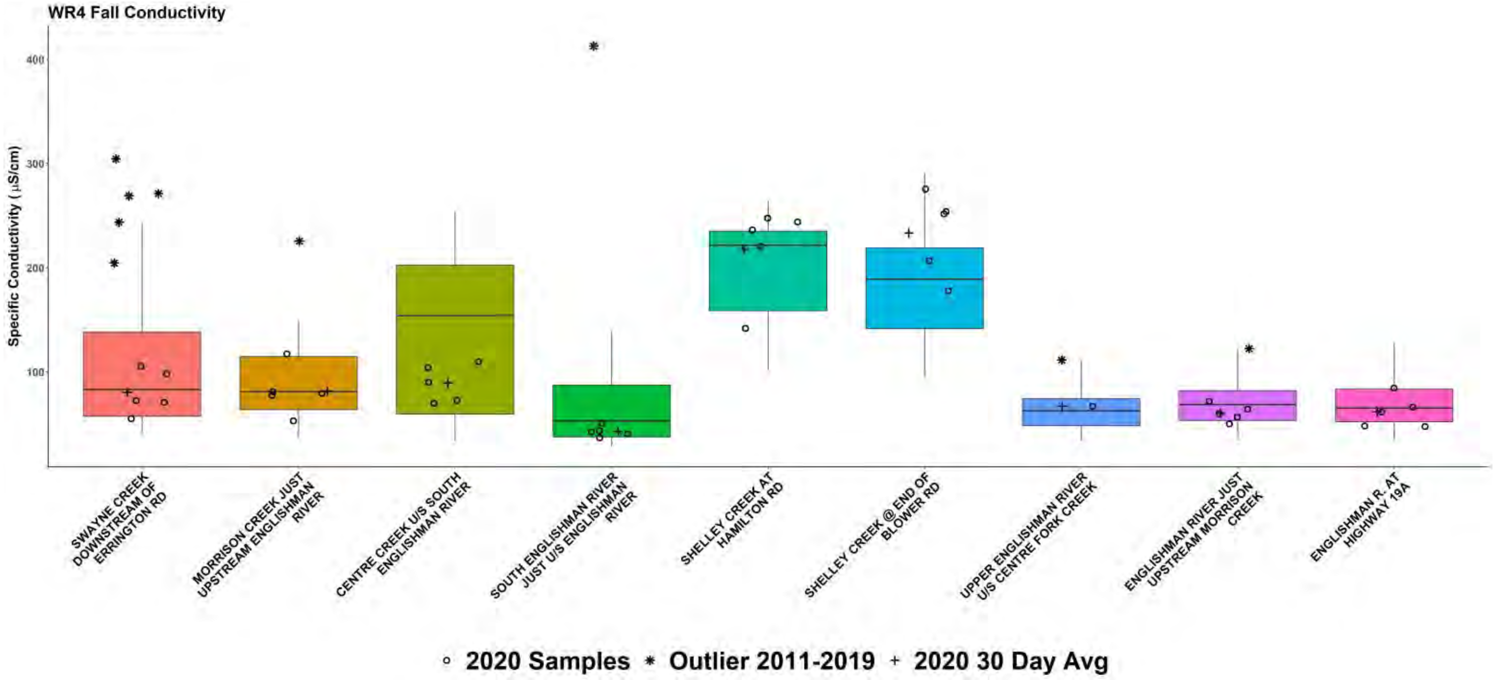

Figure B41: Fall 2011-2020 specific conductivity of CWMN sites in Water Region 4 (Englishman River).

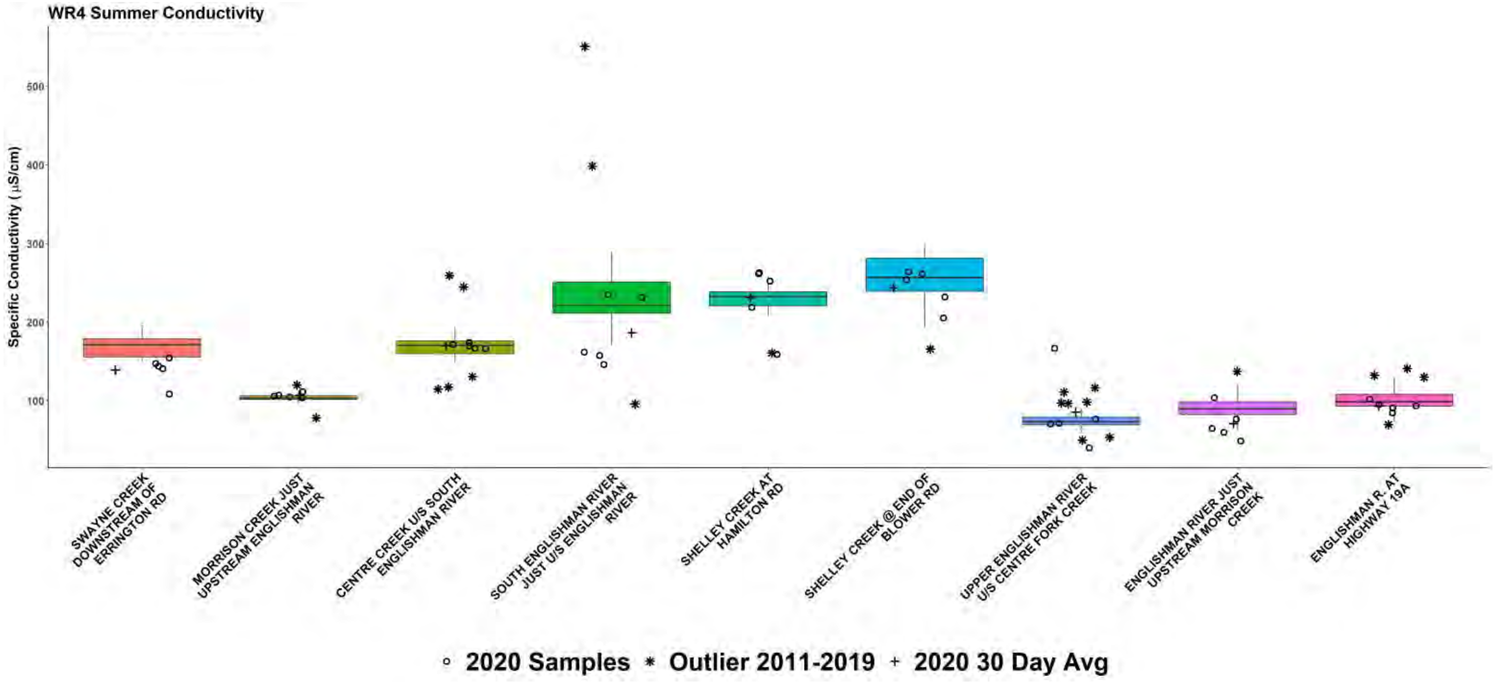

Figure B42: Summer 2011-2020 specific conductivity of CWMN sites in Water Region 4 (Englishman River).

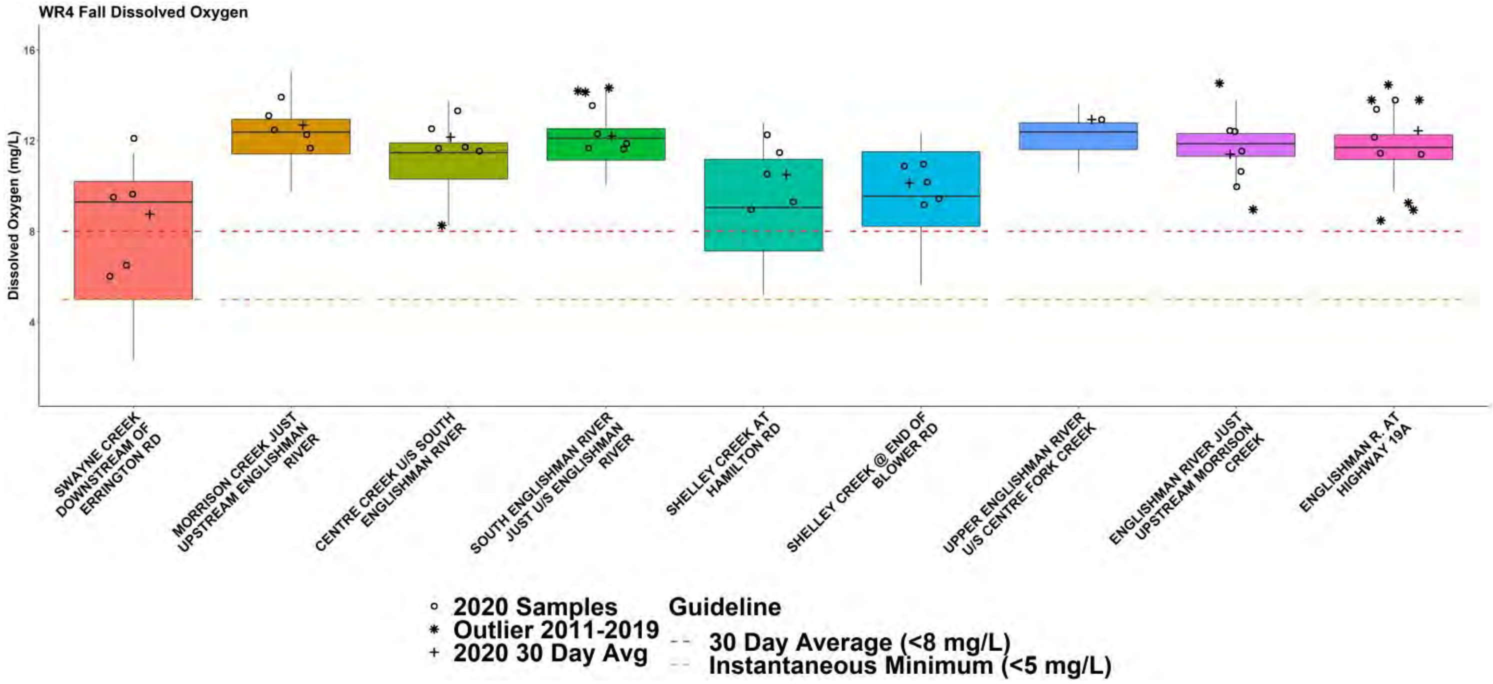

Figure B43: Fall 2011-2020 dissolved oxygen of CWMN sites in Water Region 4 (Englishman River) with Englishman River water quality objectives.

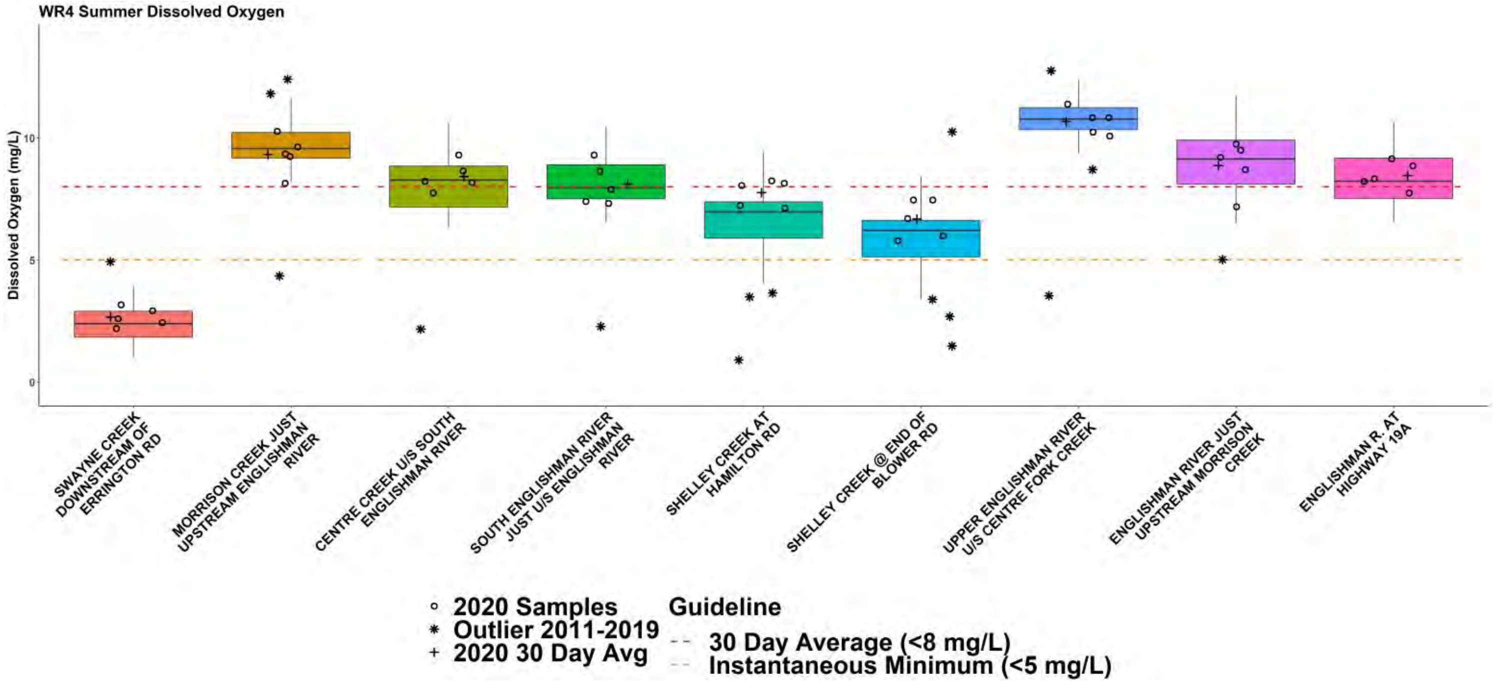

Figure B44: Summer 2011-2020 dissolved oxygen of CWMN sites in Water Region 4 (Englishman River) with Englishman River water quality objectives.

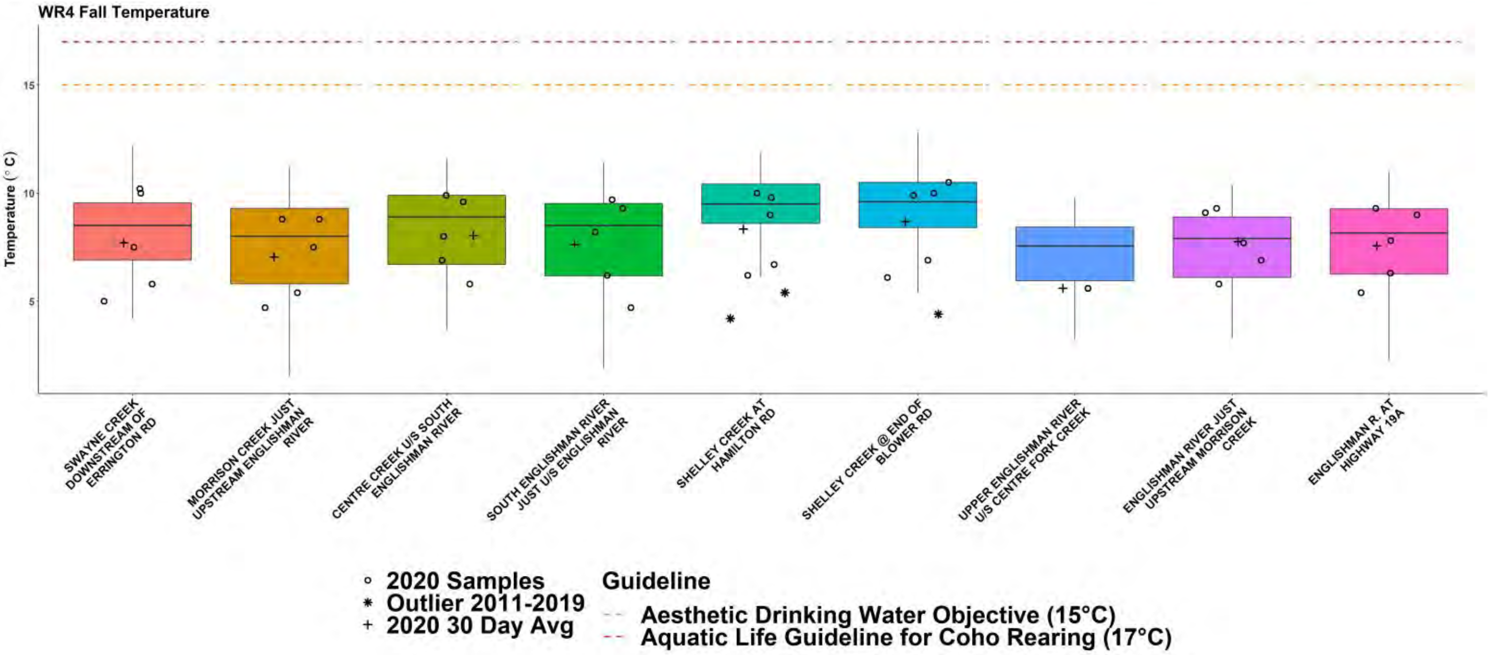

Figure B45: Fall 2011-2020 water temperature of CWMN sites in Water Region 4 (Englishman River) with BC Water Quality guidelines for Aquatic Life.

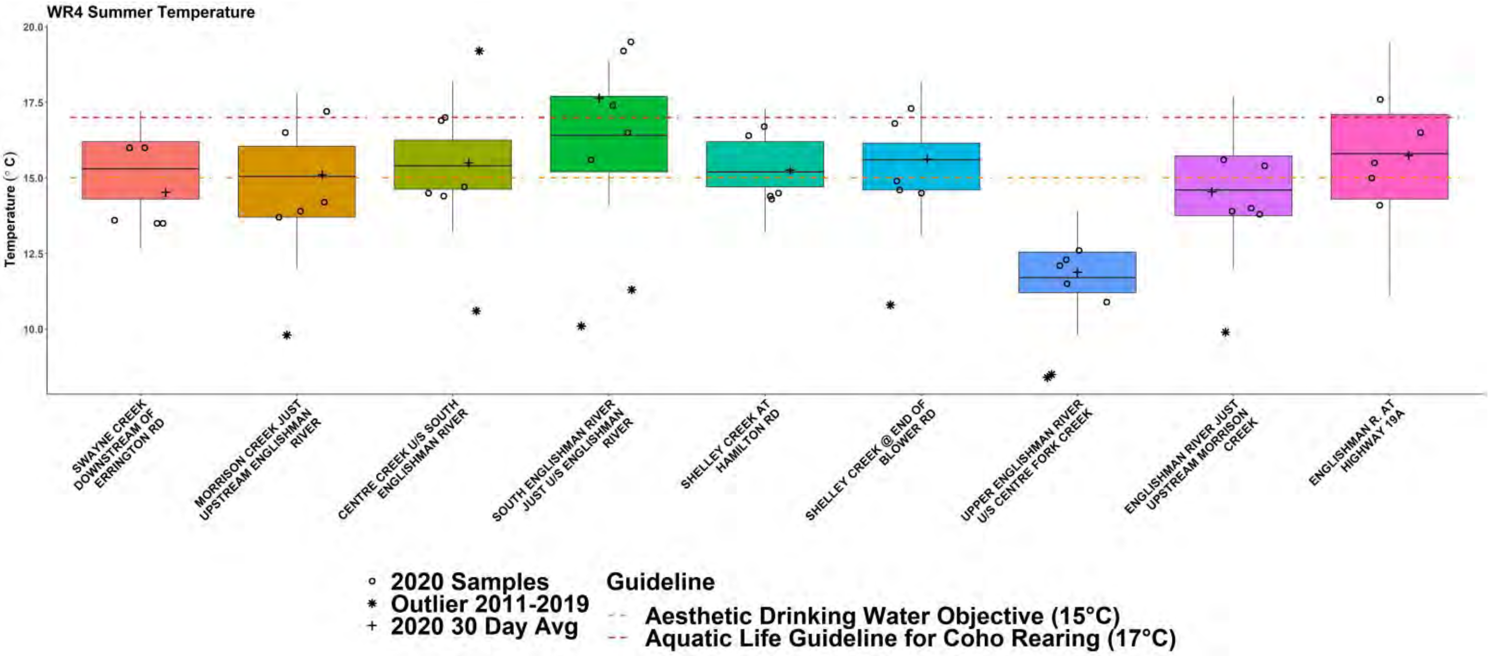

Figure B46: Summer 2011-2020 water temperature of CWMN sites in Water Region 4 (Englishman River) with BC Water Quality guidelines for Aquatic Life.

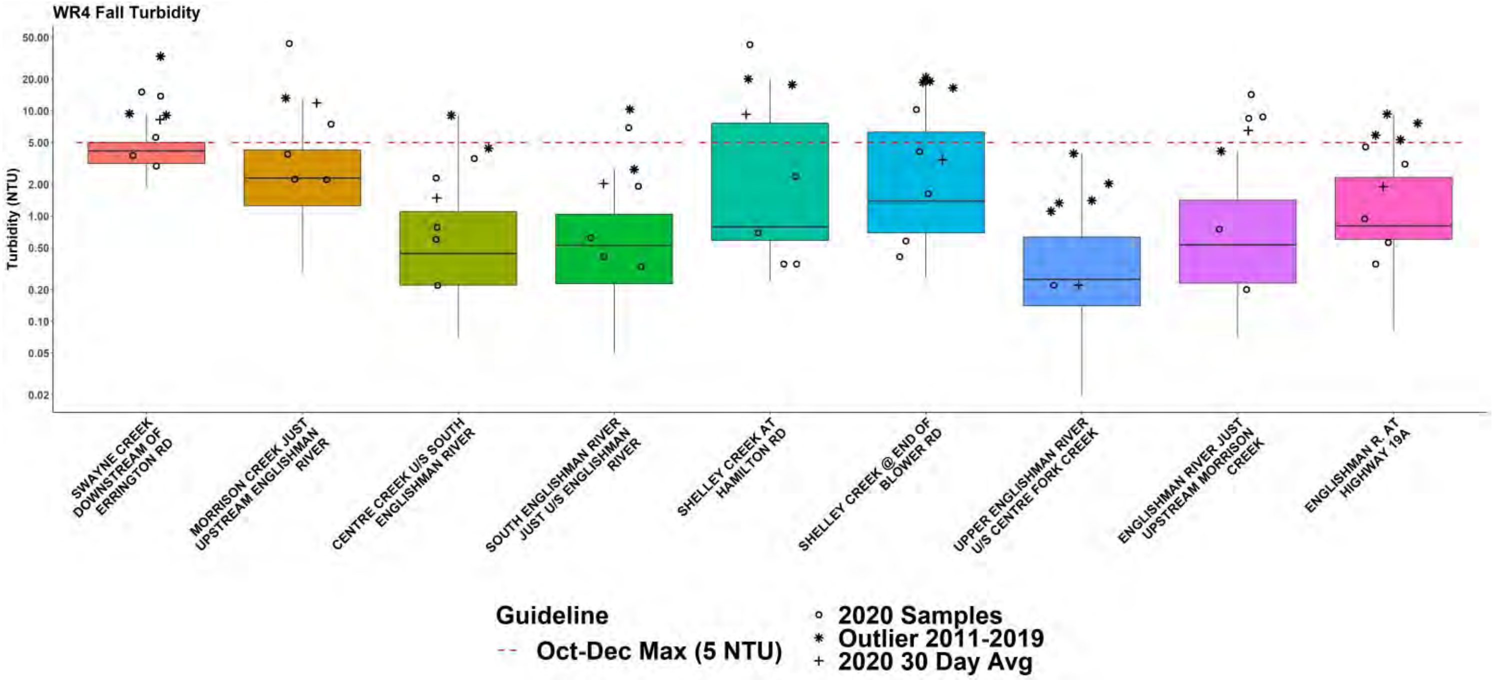

Figure B47: Fall 2011-2020 turbidity of CWMN sites in Water Region 4 (Englishman River) with BC Water Quality guidelines for Aquatic Life.

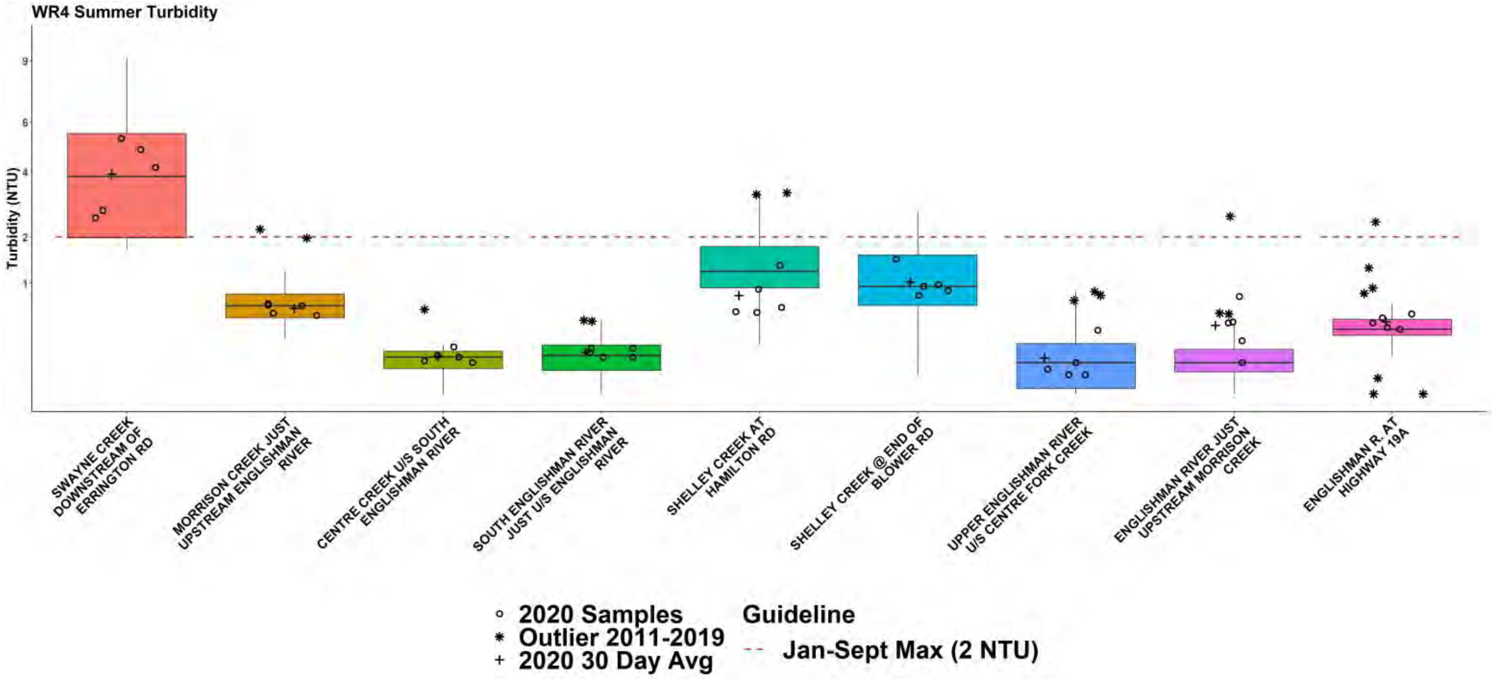

Figure B48: Summer 2011-2020 turbidity of CWMN sites in Water Region 4 (Englishman River) with BC Water Quality guidelines for Aquatic Life.

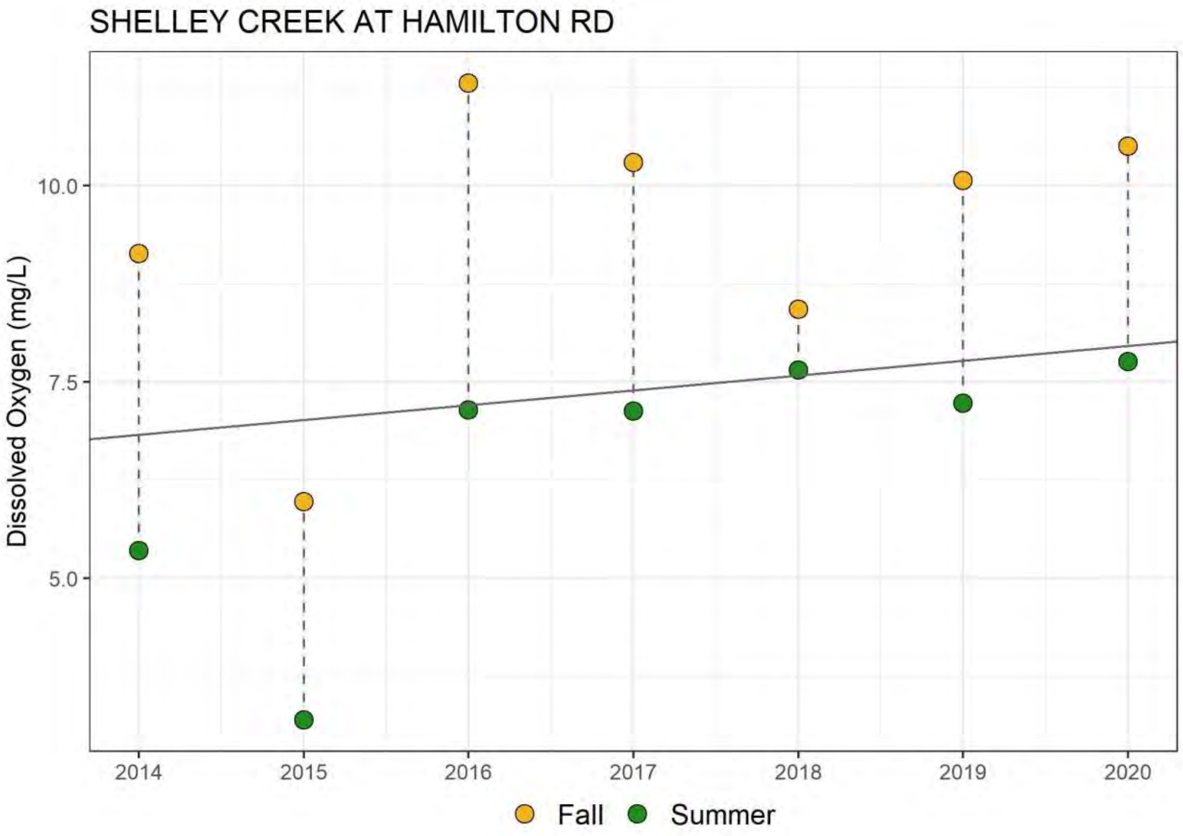

Figure B49: 2014-2020 Seasonal Mann-Kendall analysis plot for dissolved oxygen at the CMWN site: Shelly Creek at Hamilton Road

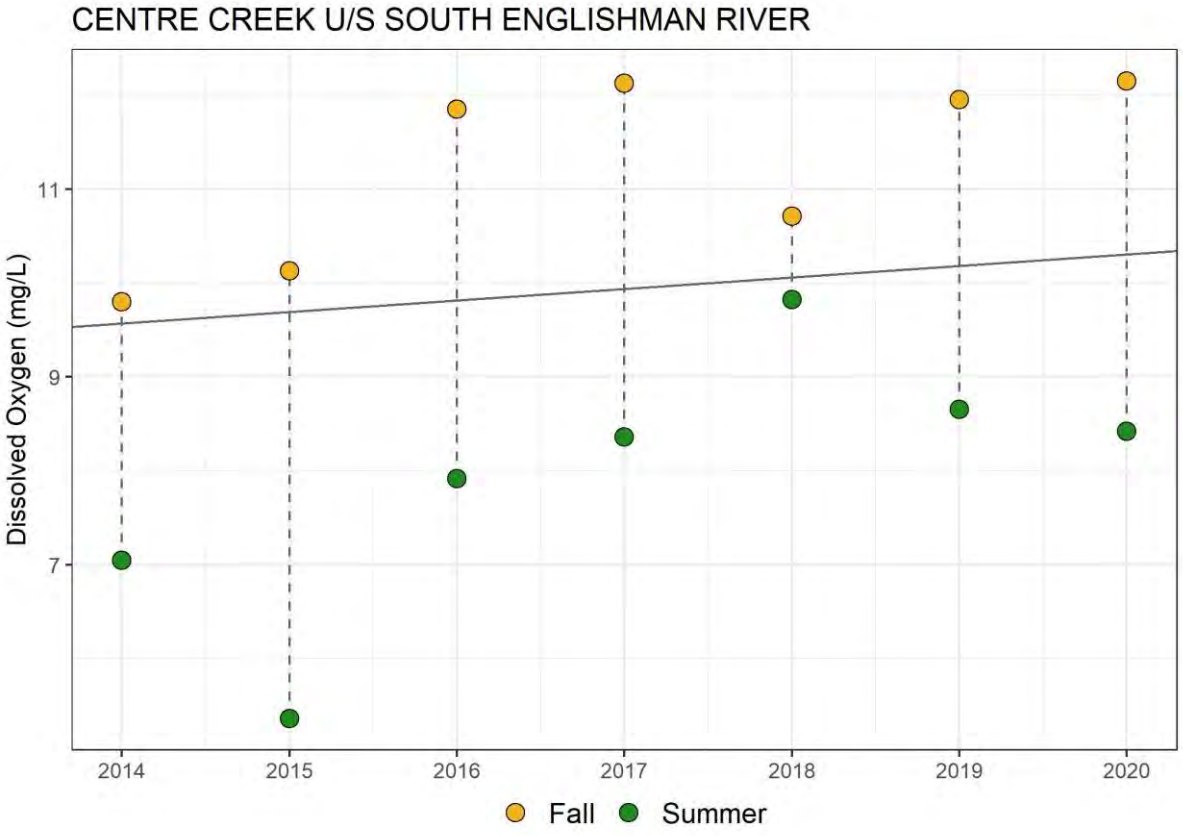

Figure B50: 2011-2020 Seasonal Mann-Kendall analysis plot for dissolved oxygen at the CMWN site: Centre Creek

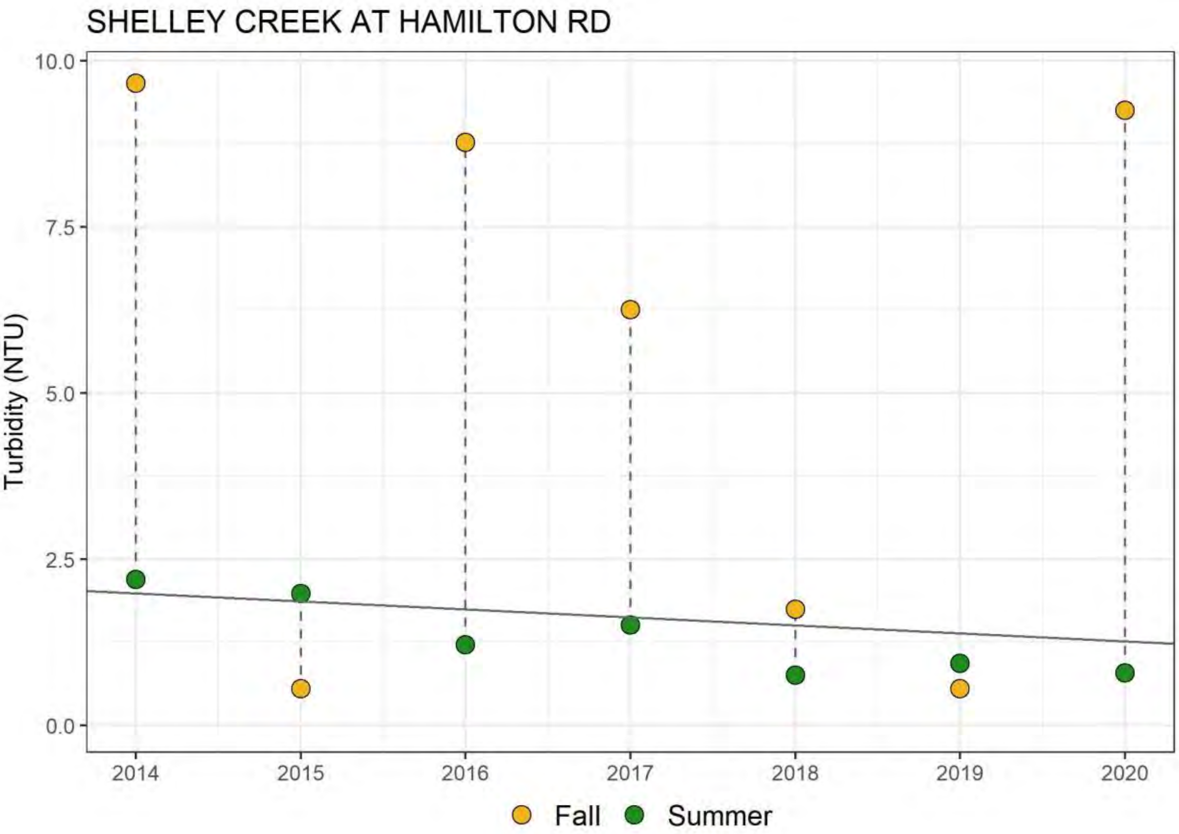

Figure B51: 2014-2020 Seasonal Mann-Kendall analysis plot for turbidity at the CMWN site: Shelly Creek at Hamilton Road

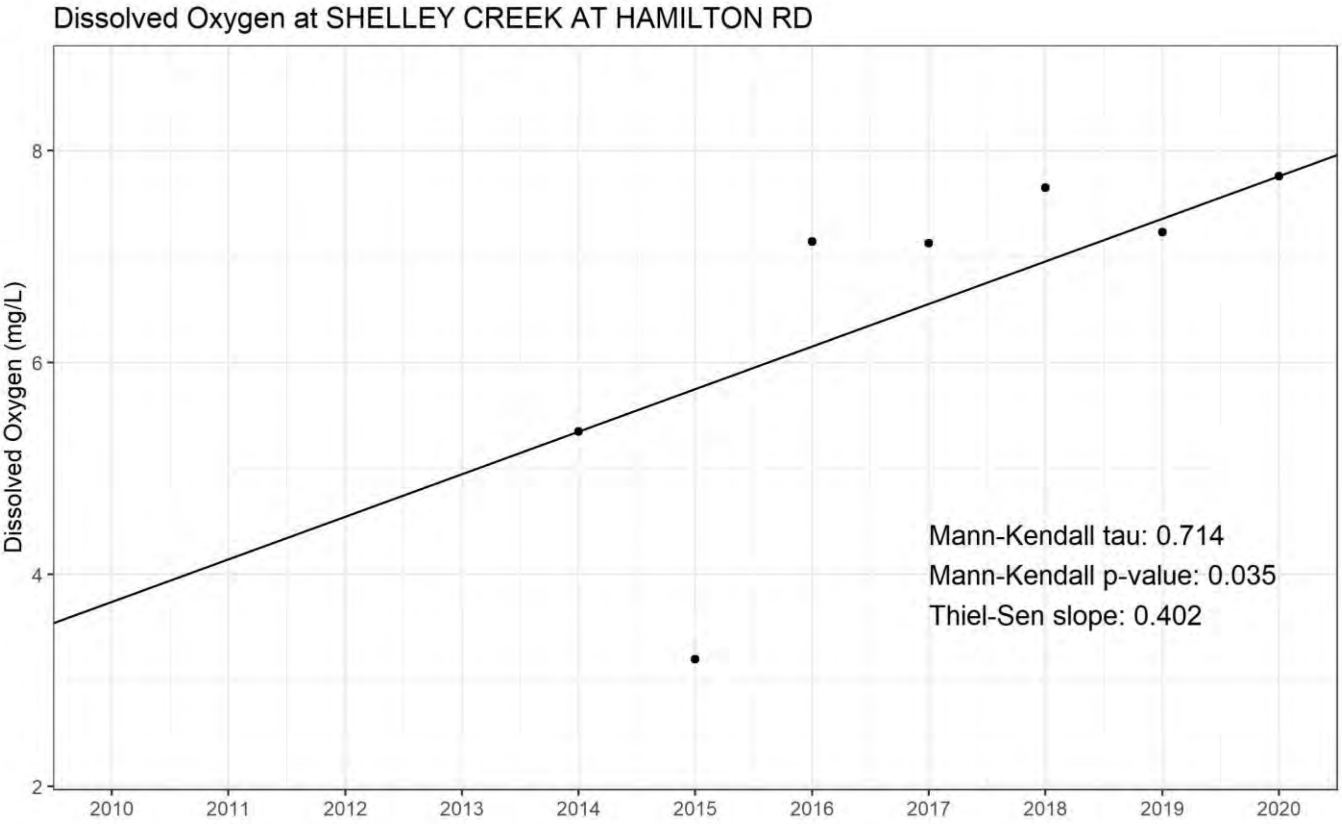

Figure B52: 2014-2020 Mann-Kendall analysis plot for dissolved oxygen in the summer at the CMWN site: Shelly Creek at Hamilton Road

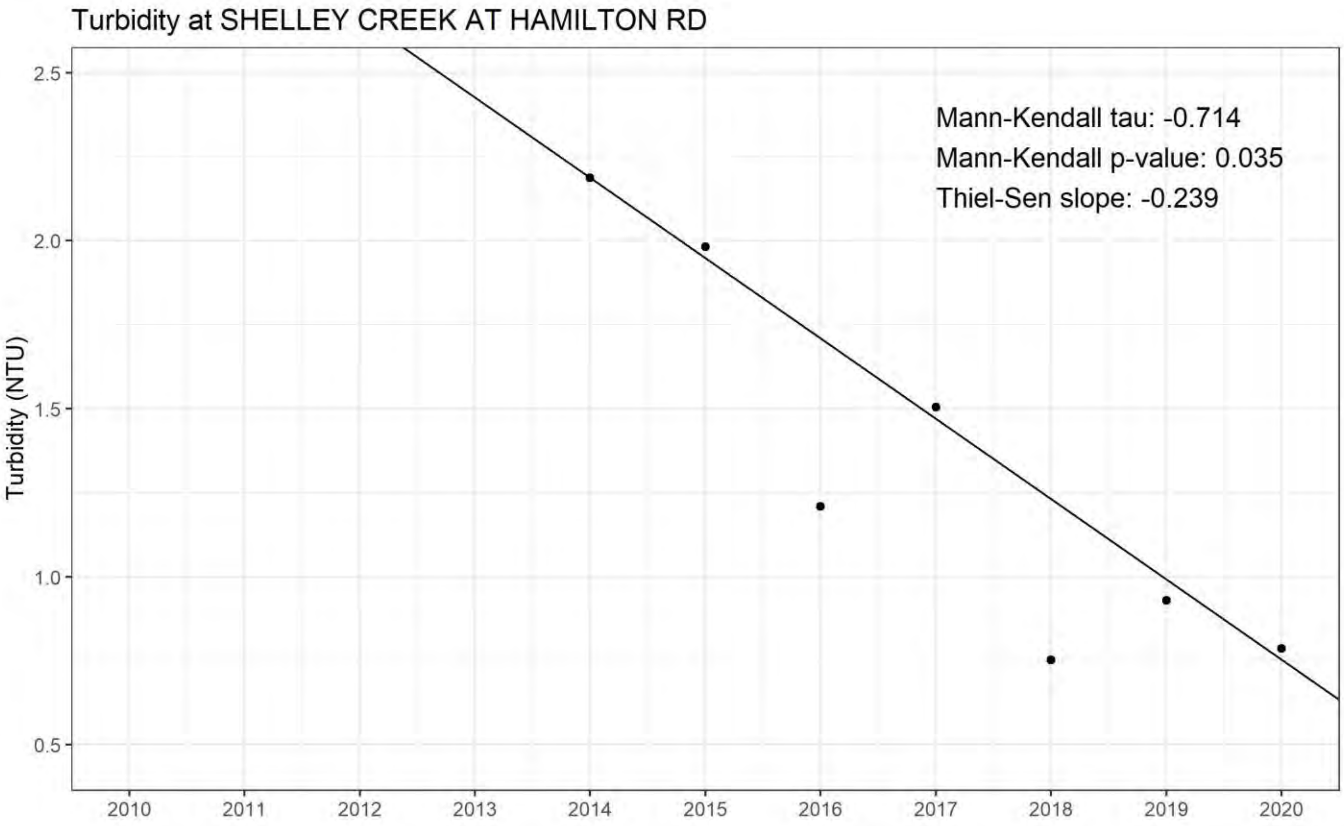

Figure B53: 2014-2020 Mann-Kendall analysis plot for turbidity in the summer at the CMWN site: Shelly Creek at Hamilton Road

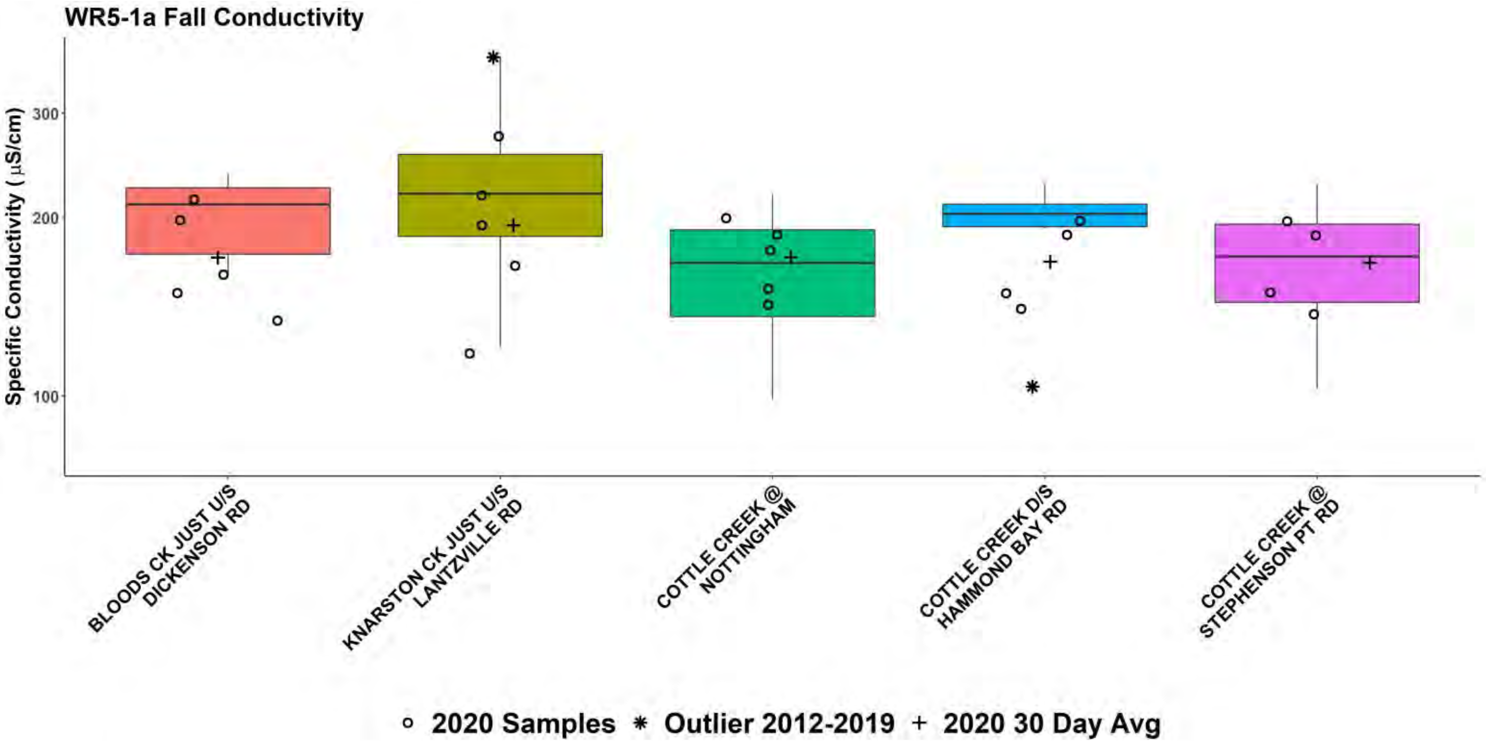

Figure B54: Fall 2012-2020 specific conductivity of CWMN sites in Water Region 5-1A (South Wellington to Nanoose).

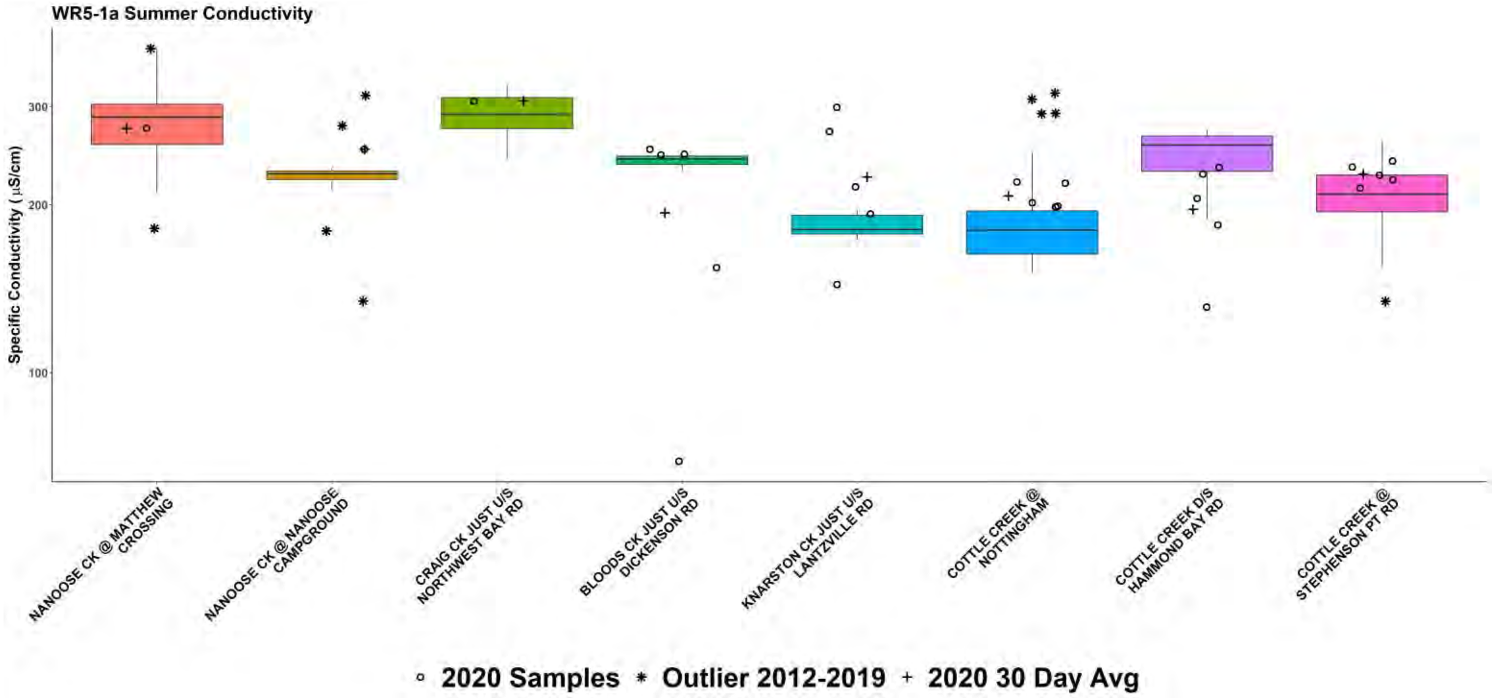

Figure B55: Summer 2012-2020 specific conductivity of CWMN sites in Water Region 5-1A (South Wellington to Nanoose).

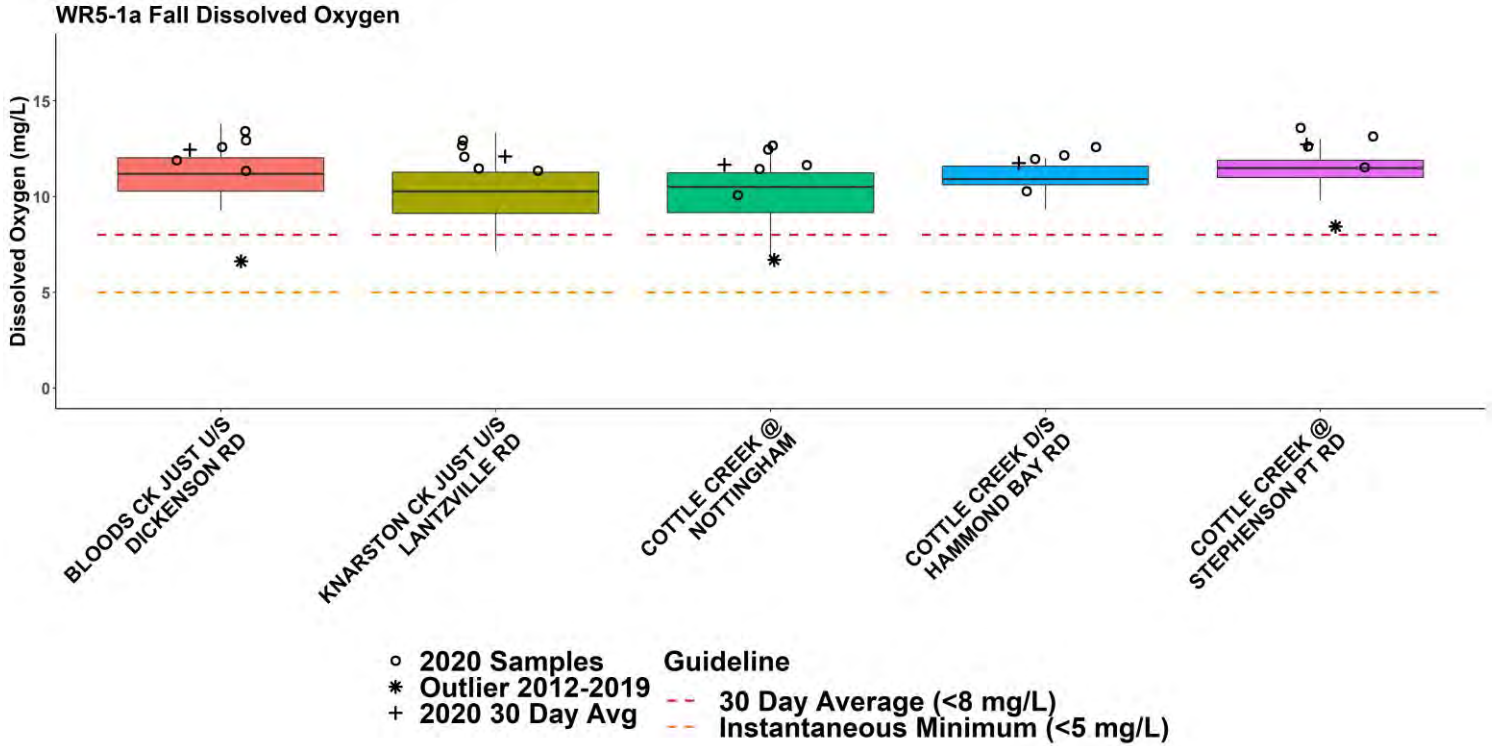

Figure B56: Fall 2012-2020 dissolved oxygen of CWMN sites in Water Region 5-1A (South Wellington to Nanoose) with Englishman River water quality objectives.

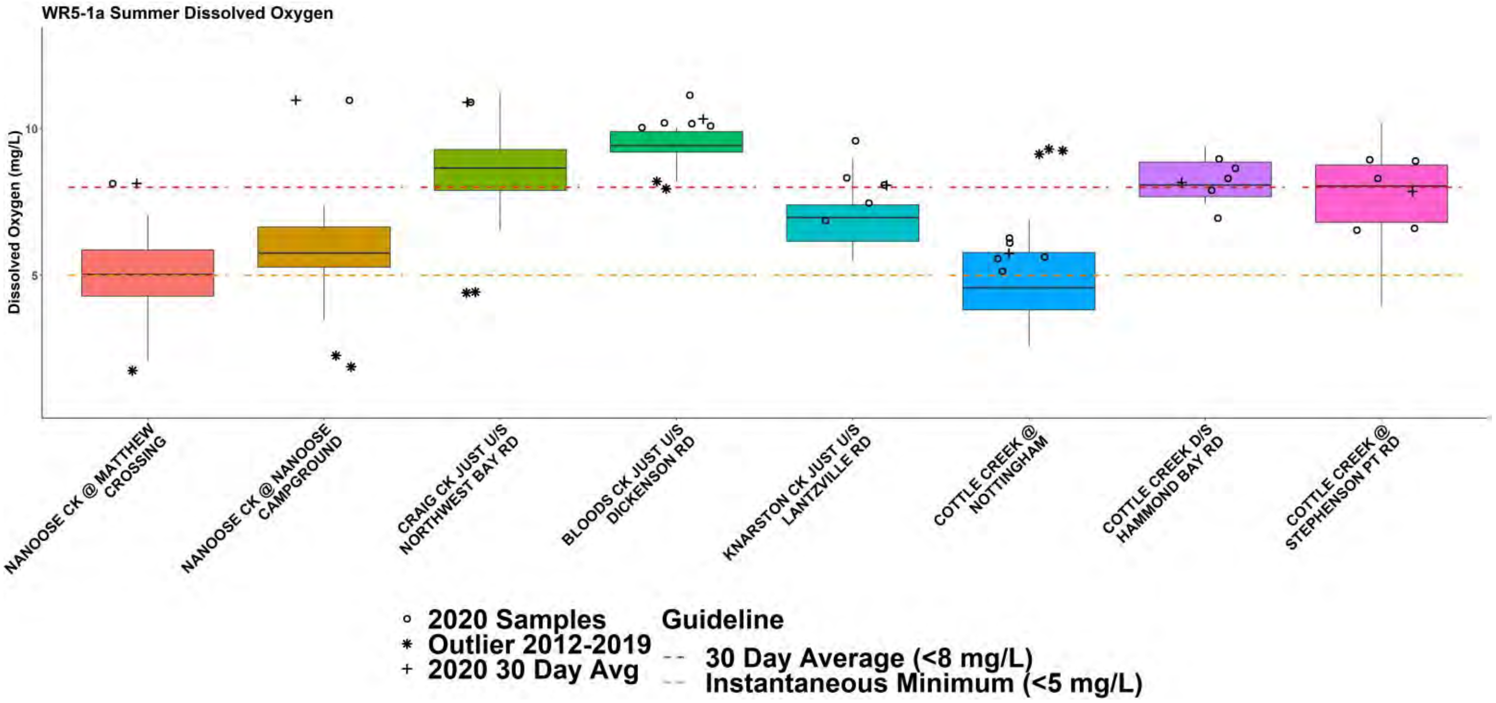

Figure B57: Summer 2012-2020 dissolved oxygen of CWMN sites in Water Region 5-1A (South Wellington to Nanoose) with Englishman River water quality objectives.

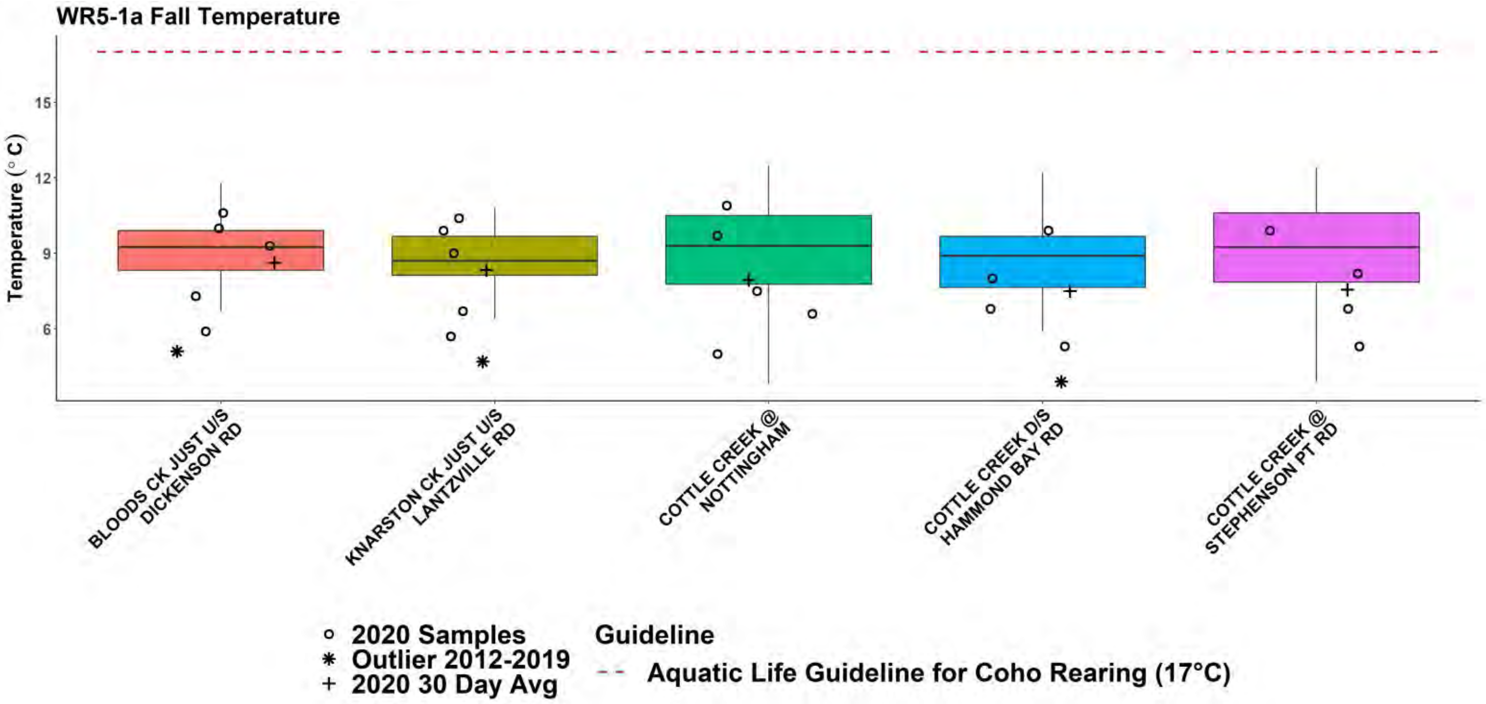

Figure B58: Fall 2012-2020 water temperature of CWMN sites in Water Region 5-1A (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

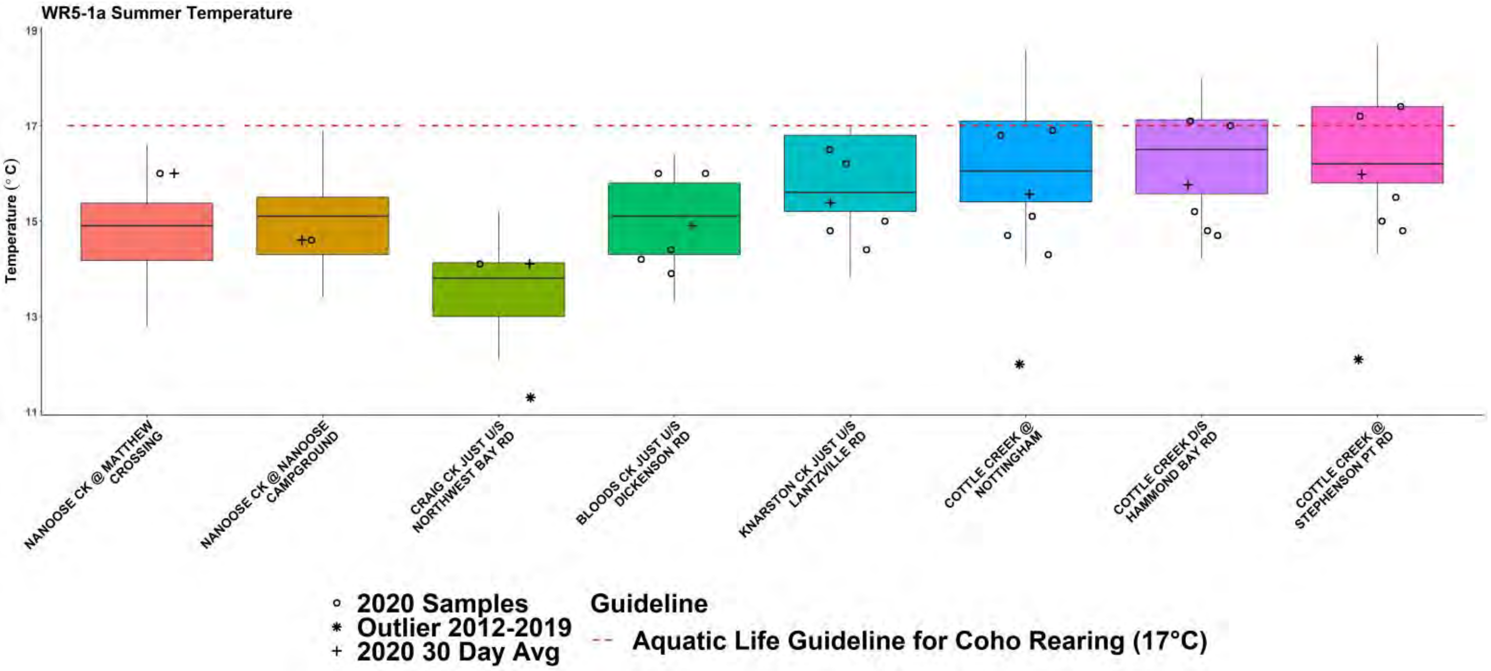

Figure B59: Summer 2012-2020 water temperature of CWMN sites in Water Region 5-1A (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

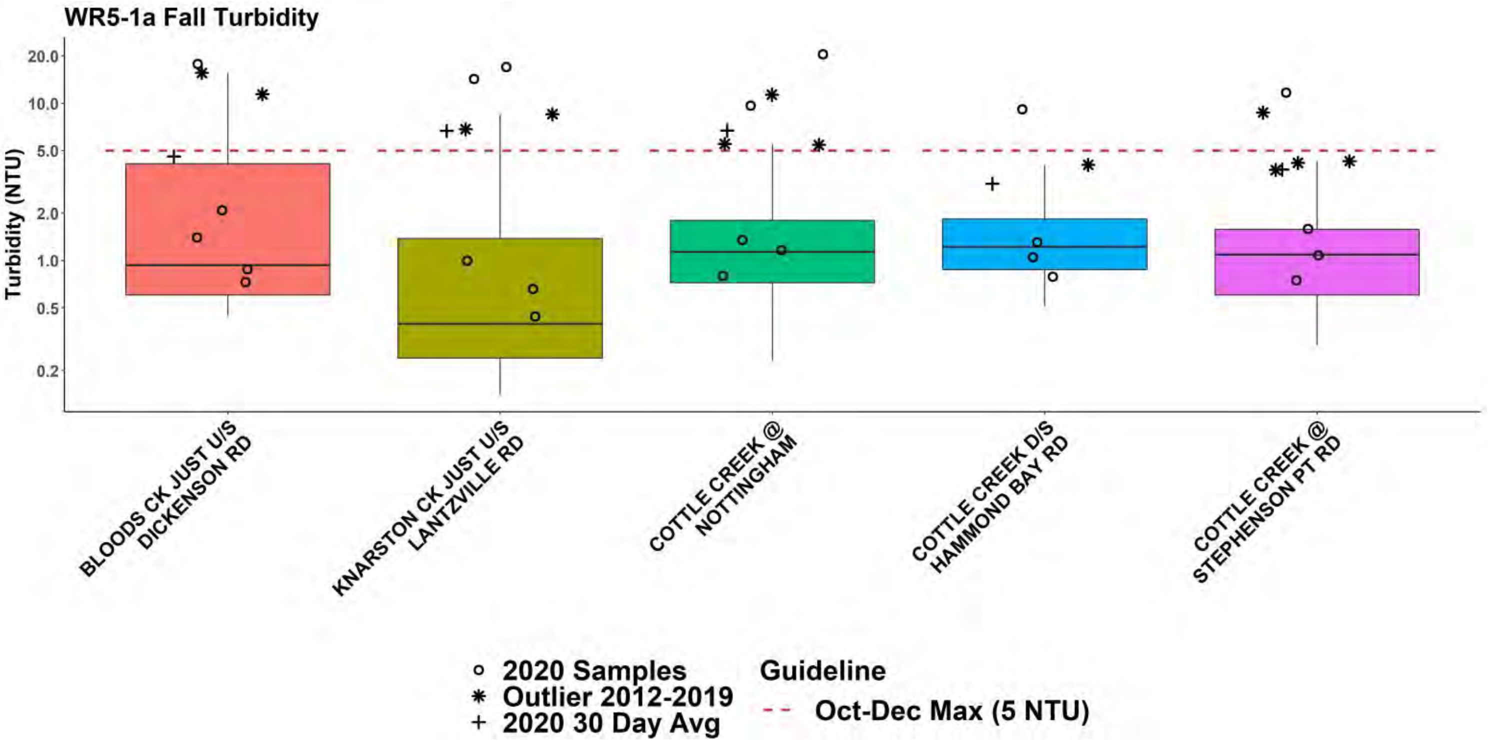

Figure B60: Fall 2012-2020 turbidity of CWMN sites in Water Region 5-1A (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

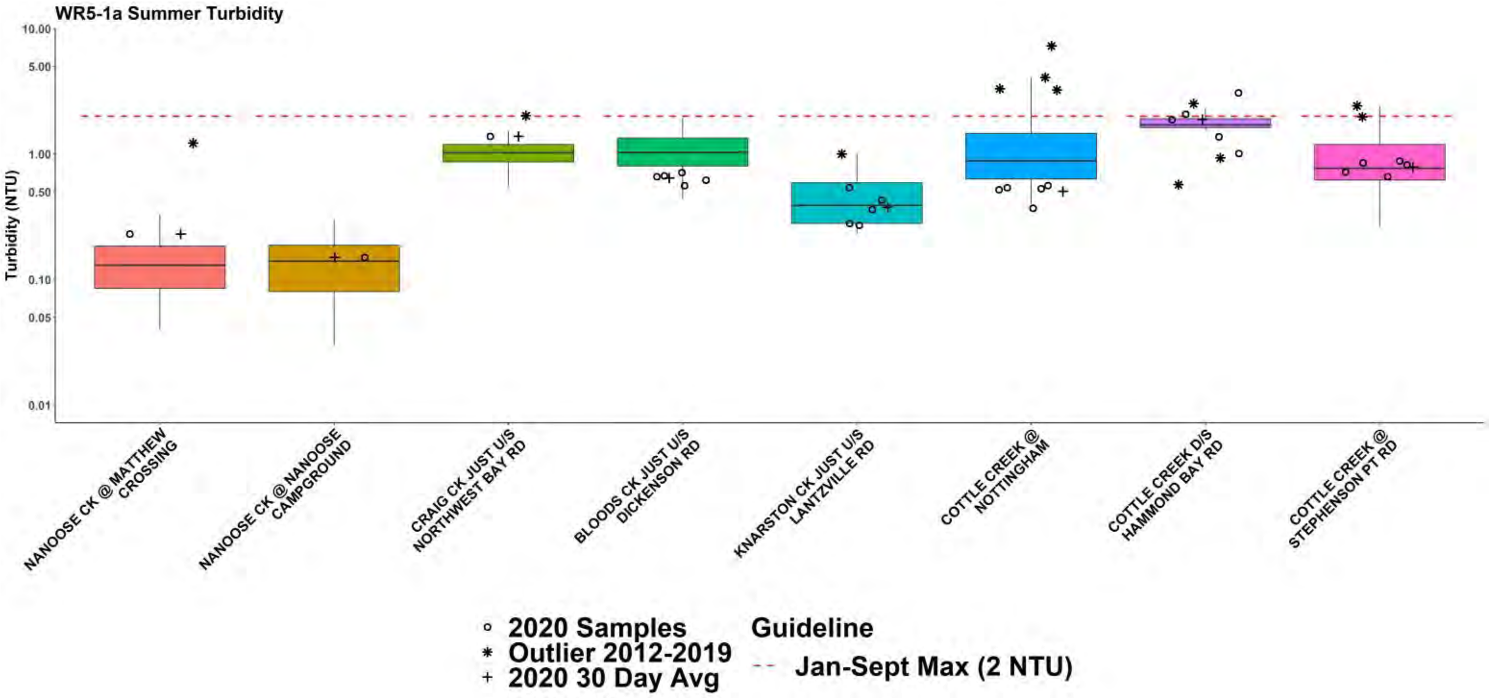

Figure B61: Summer 2012-2020 turbidity of CWMN sites in Water Region 5-1A (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

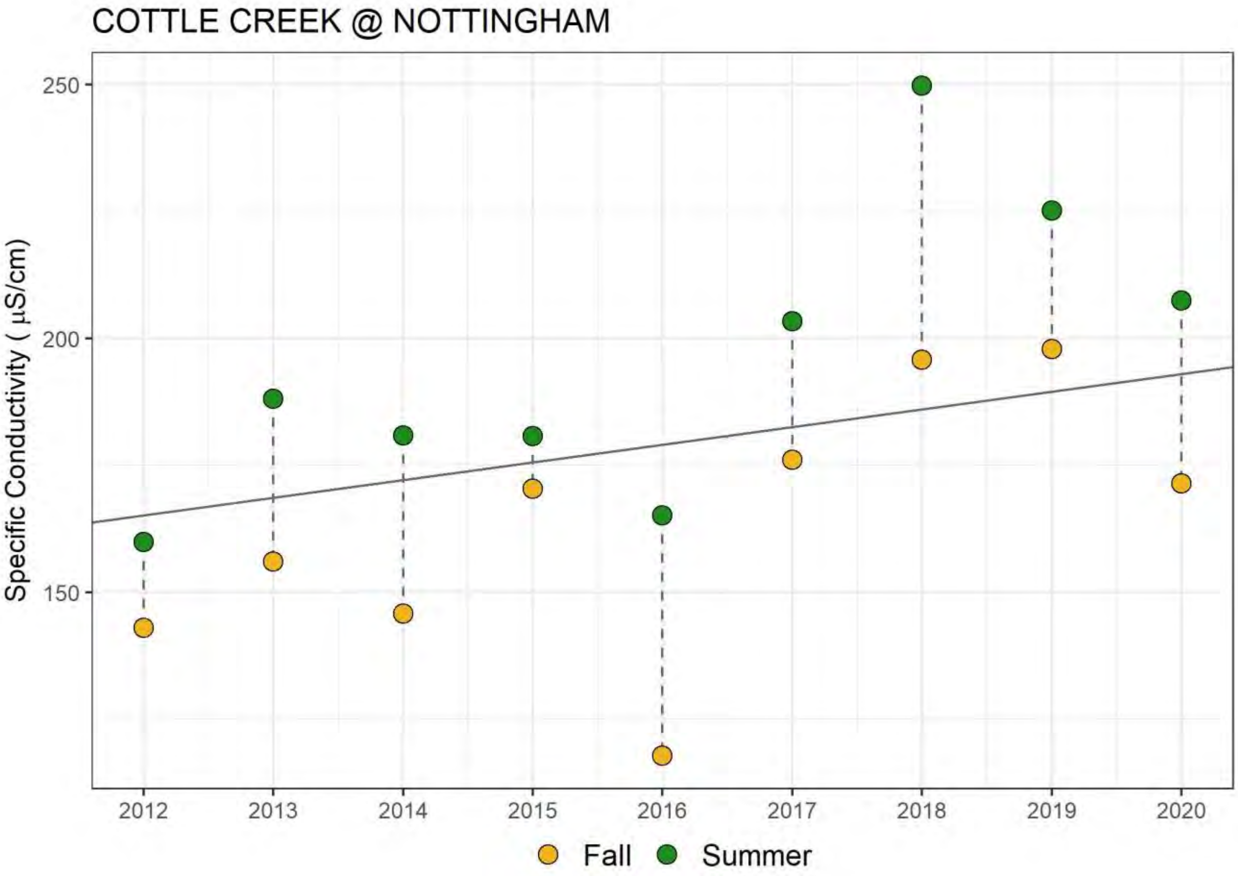

Figure B62: 2012-2020 Seasonal Mann-Kendall analysis plot for specific conductivity at the CMWN site: Cottle Creek at Nottingham

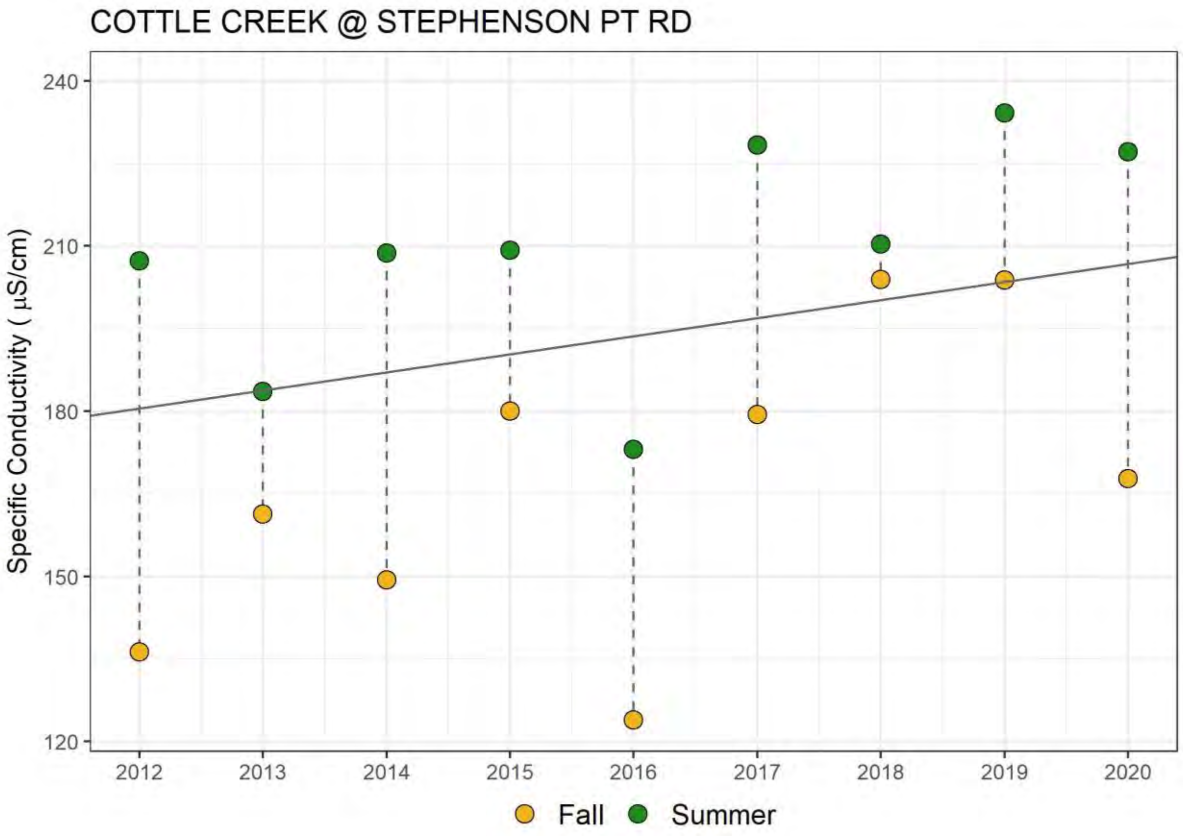

Figure B63: 2012-2020 Seasonal Mann-Kendall analysis plot for specific conductivity at the CMWN site: Cottle Creek at Stephenson Point Road

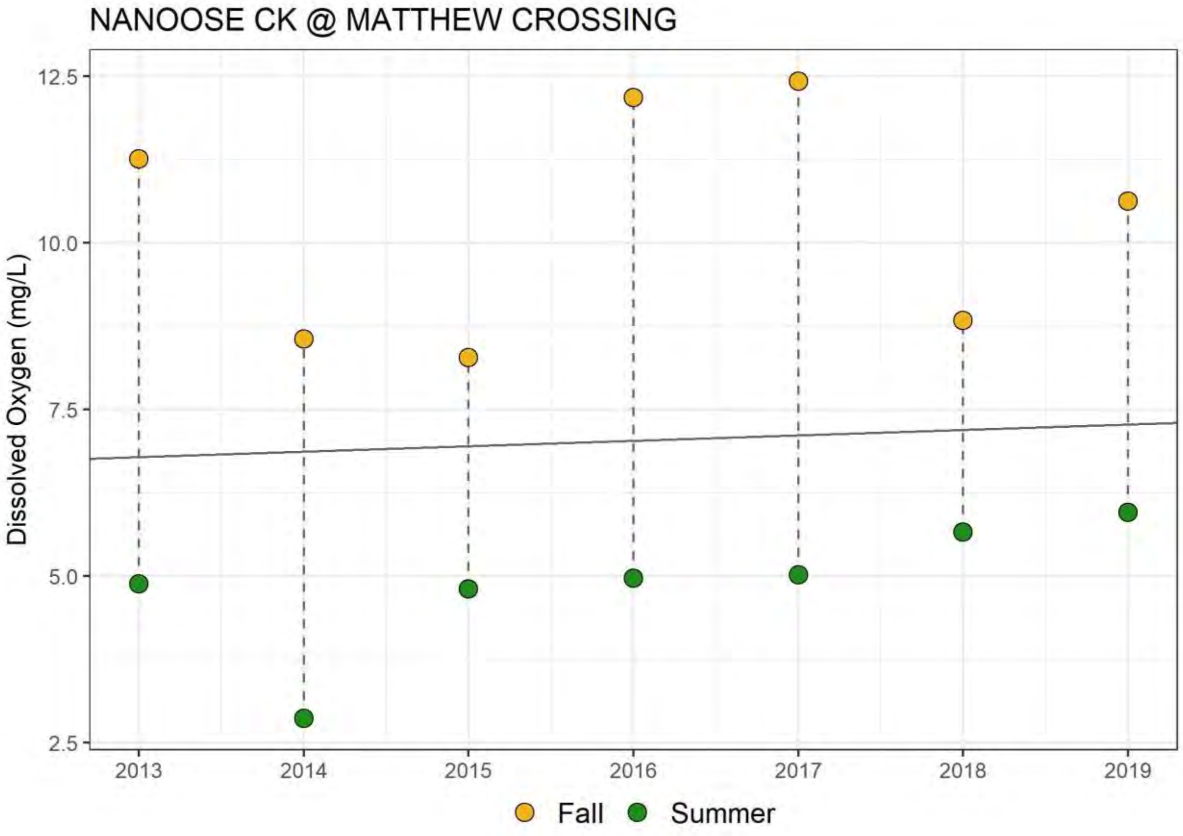

Figure B64: 2013-2020 Seasonal Mann-Kendall analysis plot for dissolved oxygen at the CMWN site: Nanoose Creek at Matthew Crossing

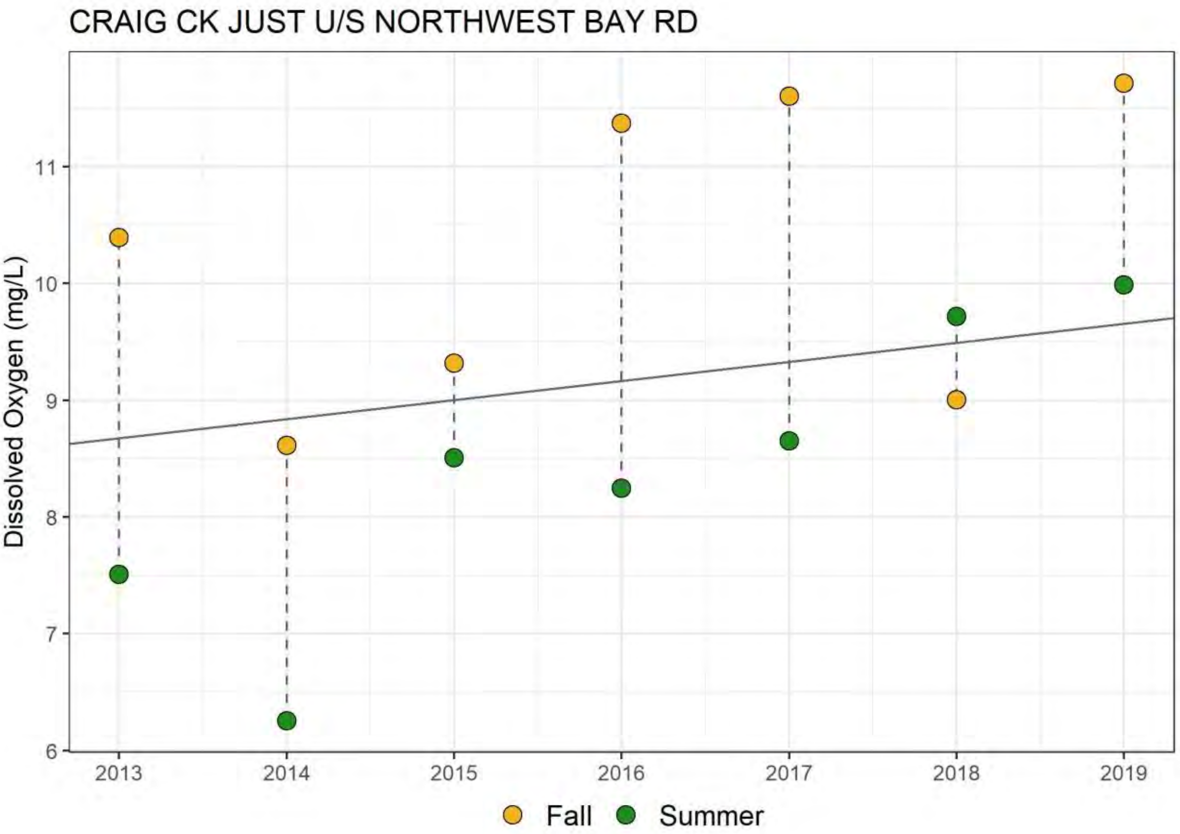

Figure B65: 2012-2020 Seasonal Mann-Kendall analysis plot for dissolved oxygen at the CMWN site: Craig Creek just upstream of Northwest Bay Road

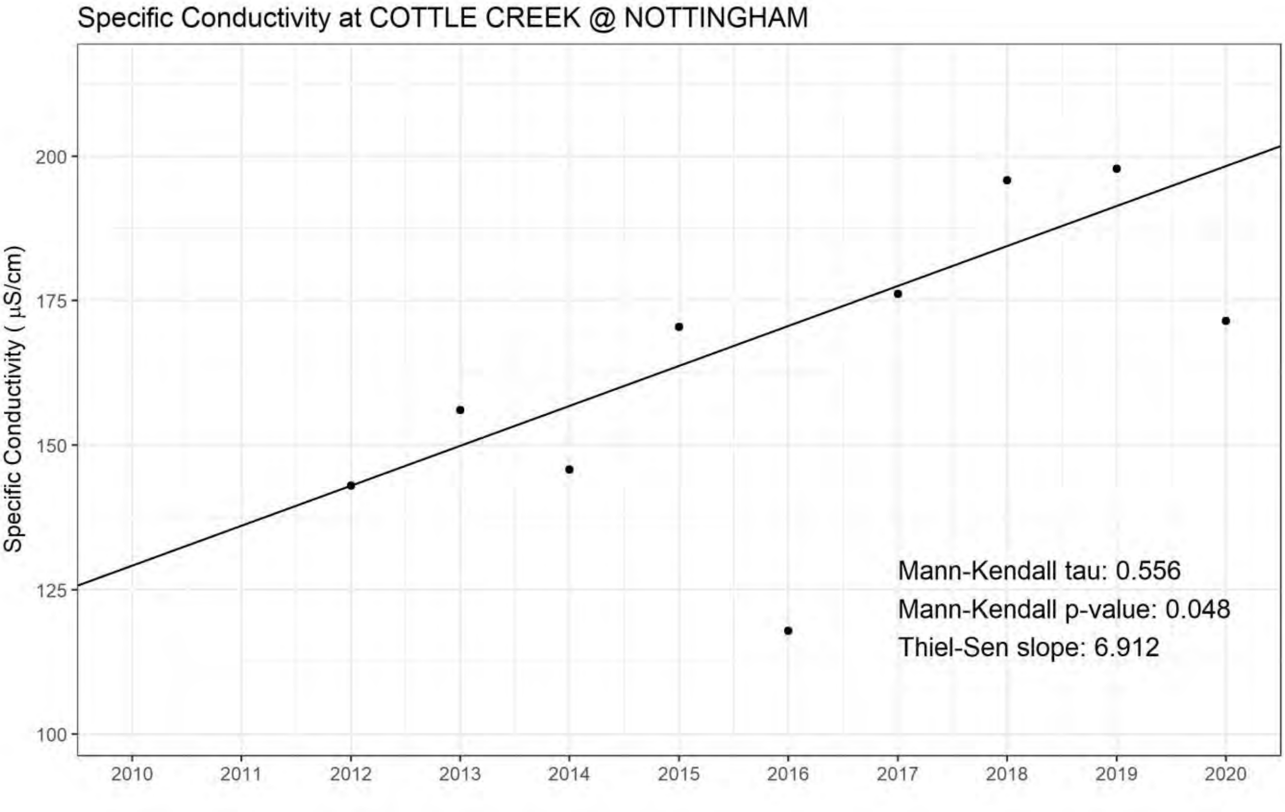

Figure B66: 2012-2020 Mann-Kendall analysis plot for specific conductivity in the fall at the CMWN site: Cottle Creek at Nottingham

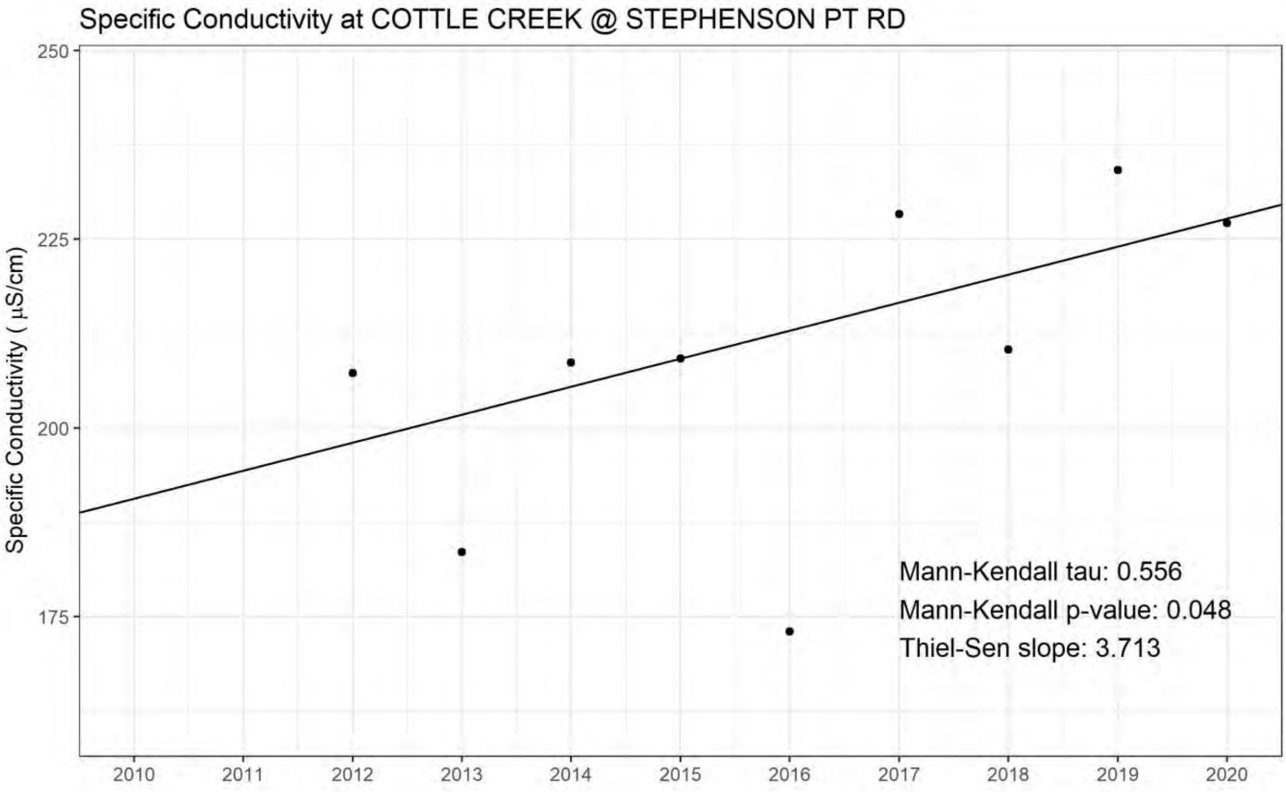

Figure B67: 2012-2020 Mann-Kendall analysis plot for specific conductivity in the summer at the CMWN site: Cottle Creek at Stephenson Point Road

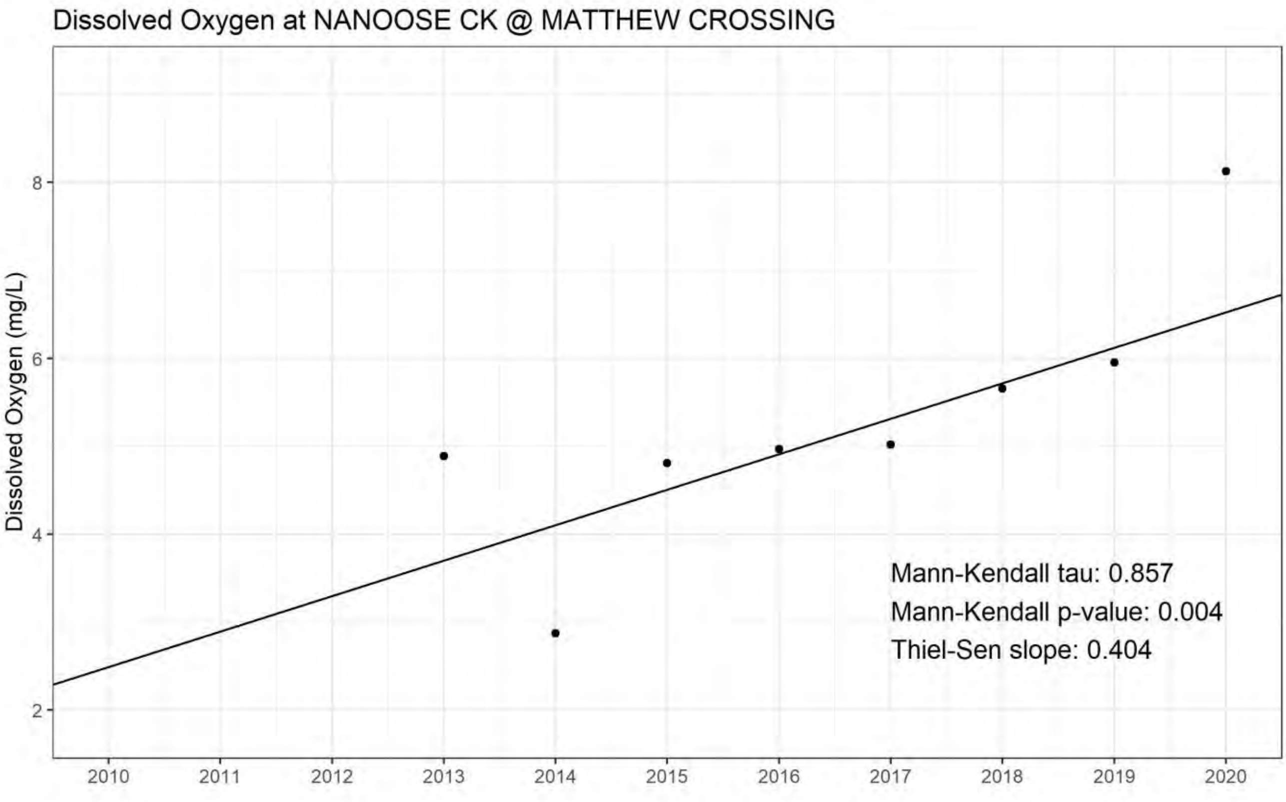

Figure B68: 2013-2020 Mann-Kendall analysis plot for dissolved oxygen in the summer at the CMWN site: Nanoose Creek at Matthew Crossing

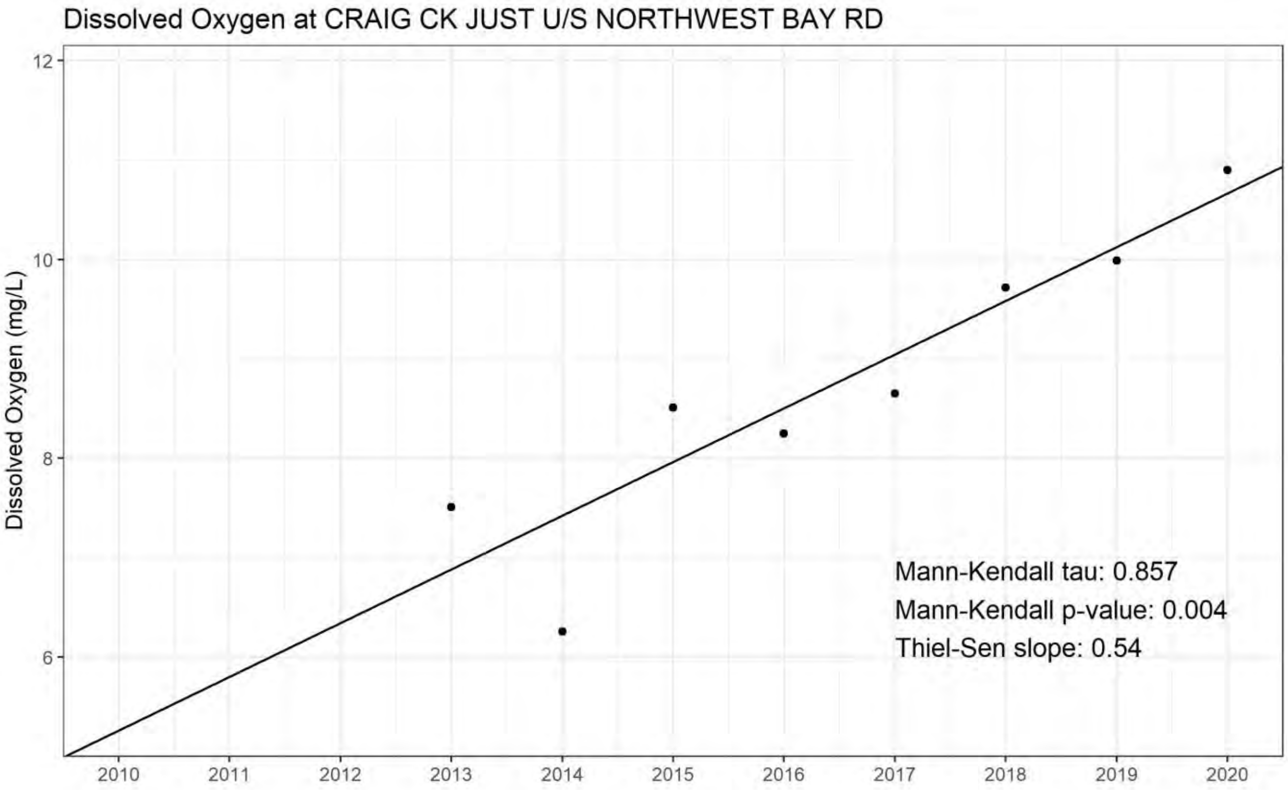

Figure B69: 2012-2020 Mann-Kendall analysis plot for dissolved oxygen in the summer at the CMWN site: Craig Creek just u/s Northwest Bay Rd

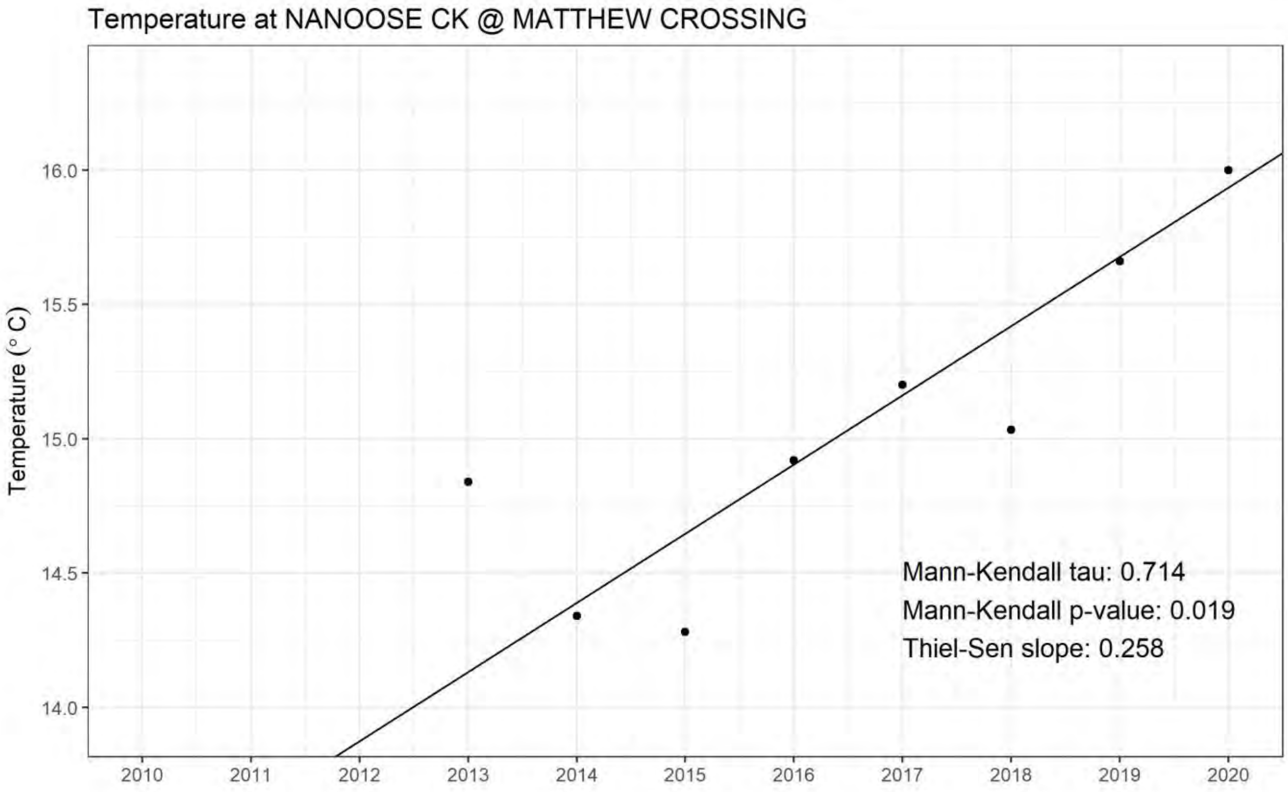

Figure B70: 2013-2020 Mann-Kendall analysis plot for water temperature in the summer at the CMWN site: Nanoose Creek at Matthew Crossing

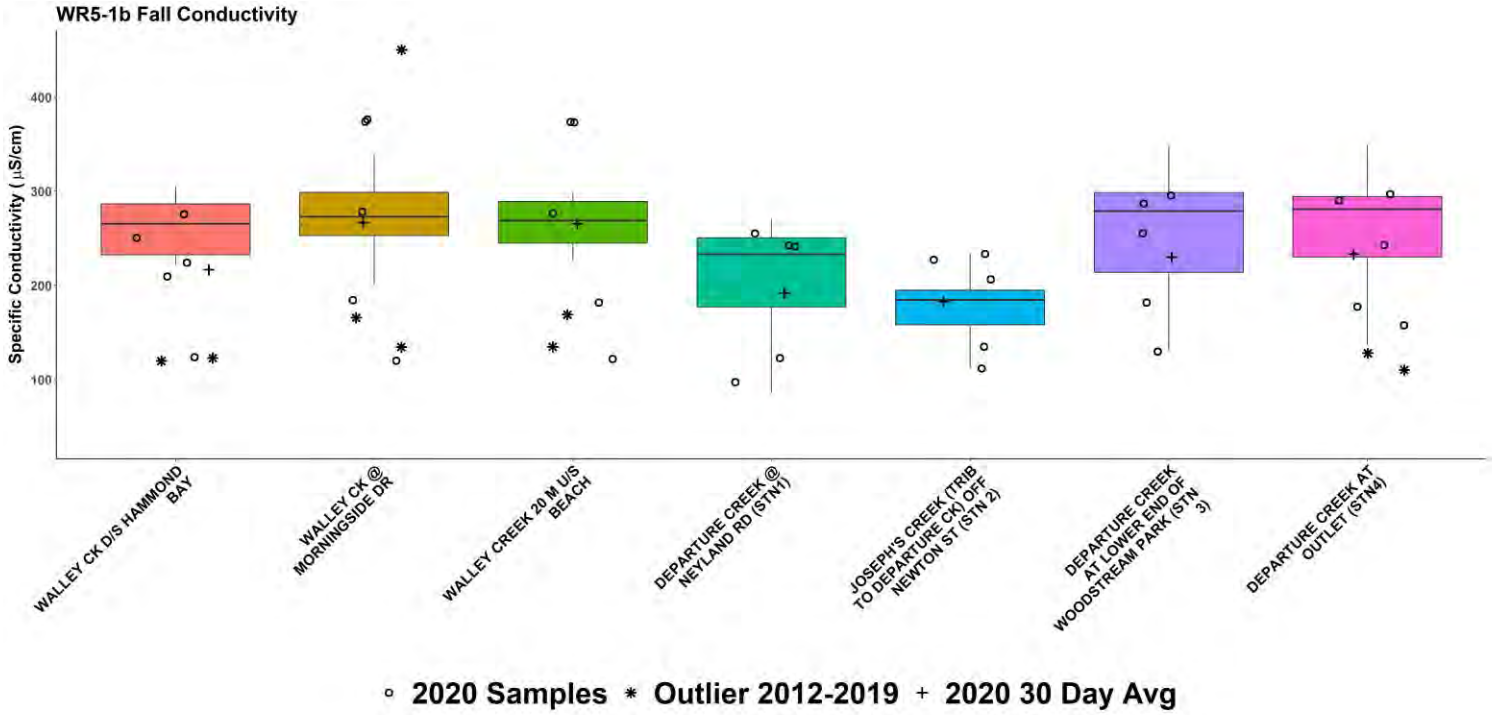

Figure B71: Fall 2012-2020 specific conductivity of CWMN sites in Water Region 5-1B (South Wellington to Nanoose).

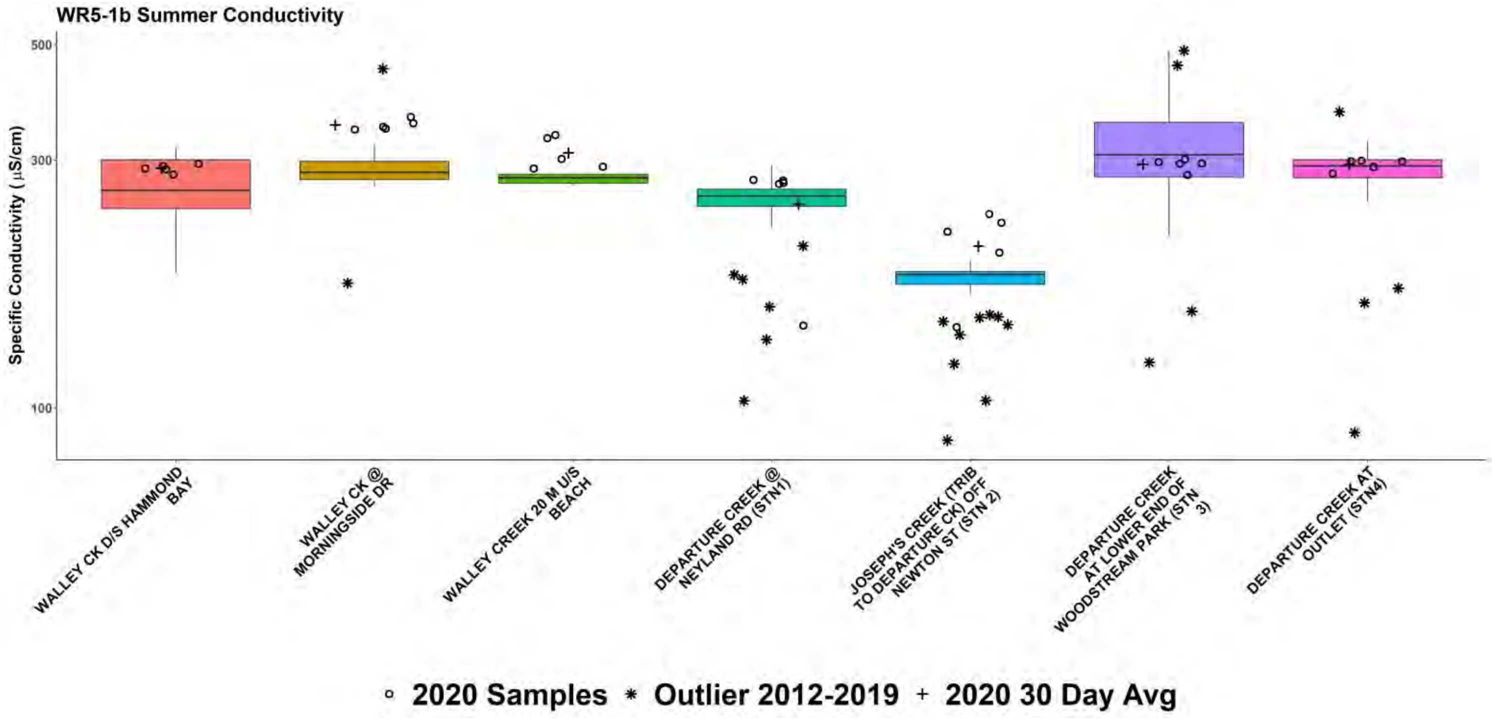

Figure B72: Summer 2012-2020 specific conductivity of CWMN sites in Water Region 5-1B (South Wellington to Nanoose).

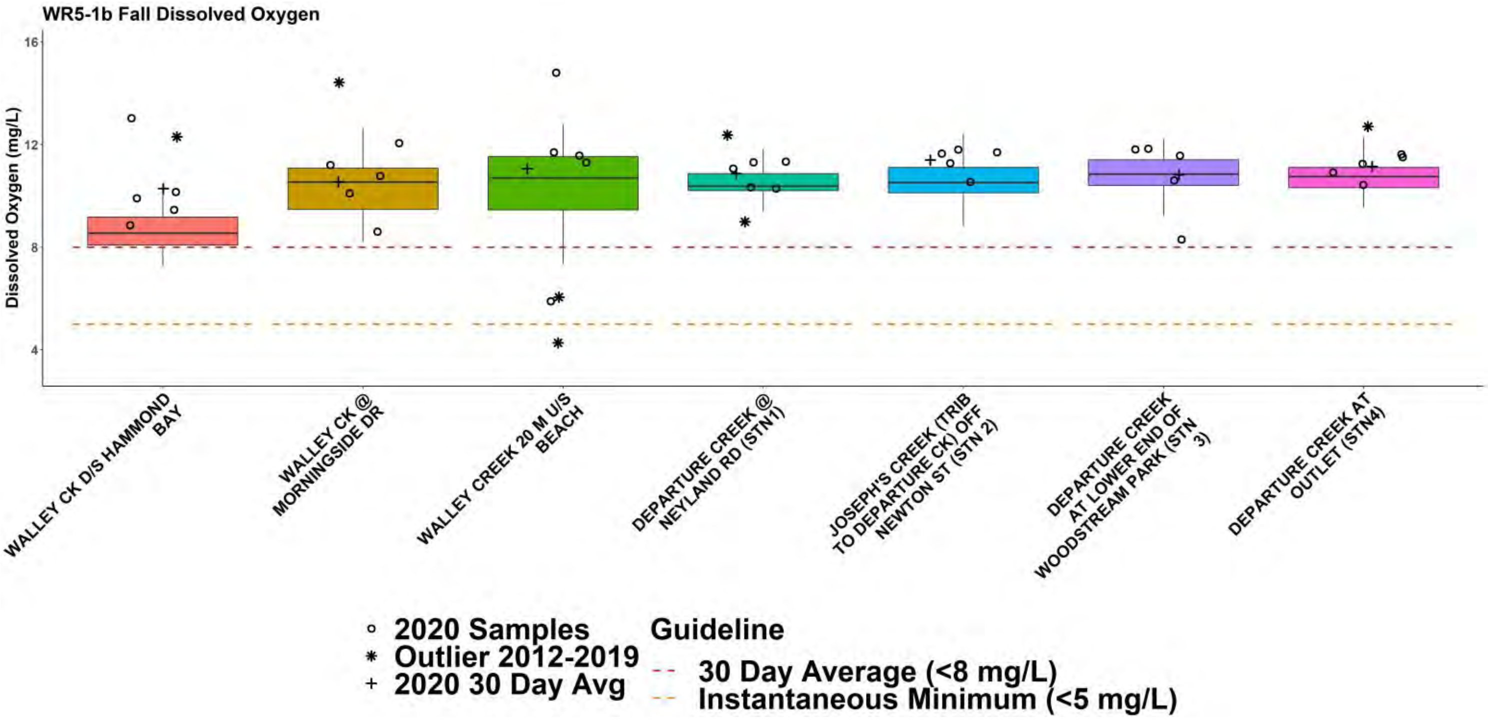

Figure B73: Fall 2012-2020 dissolved oxygen of CWMN sites in Water Region 5-1B (South Wellington to Nanoose) with Englishman River water quality objectives.

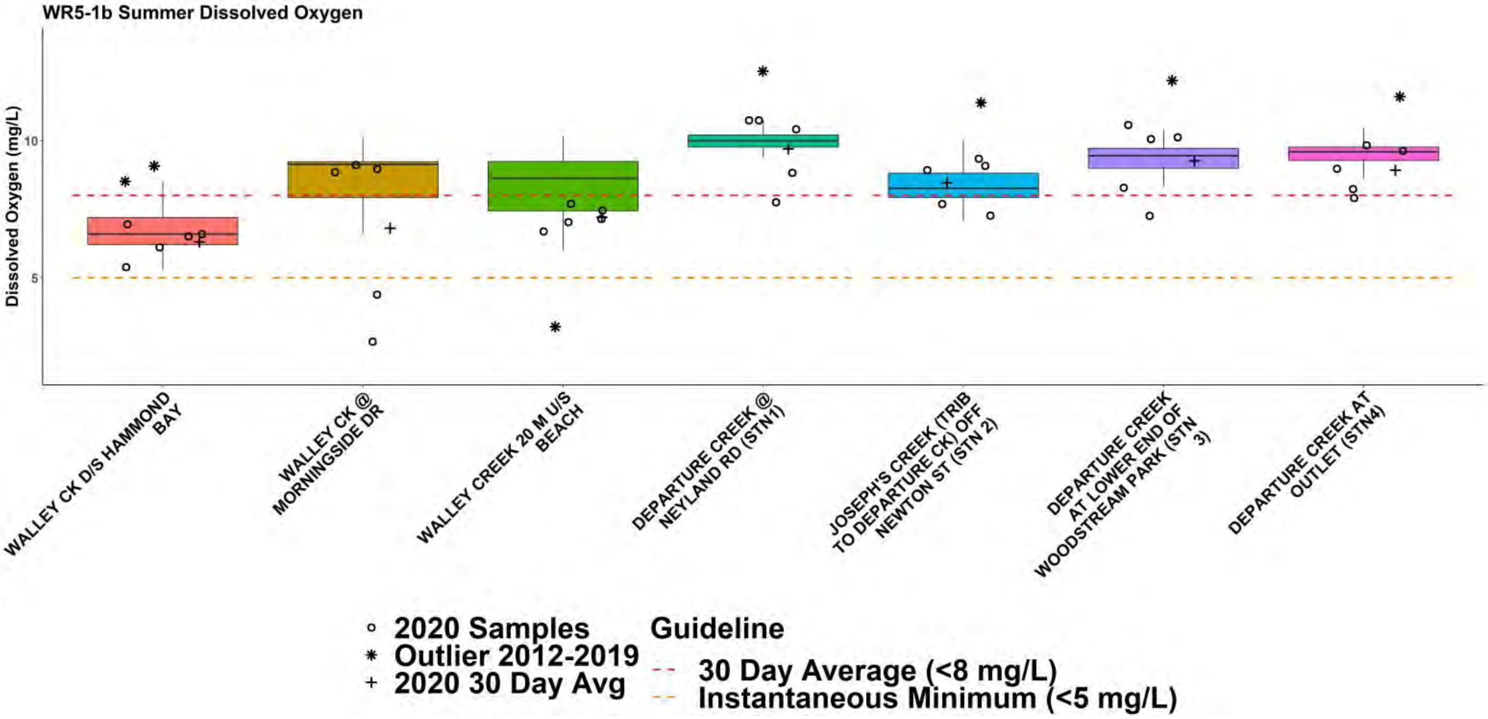

Figure B74: Summer 2012-2020 dissolved oxygen of CWMN sites in Water Region 5-1B (South Wellington to Nanoose) with Englishman River water quality objectives.

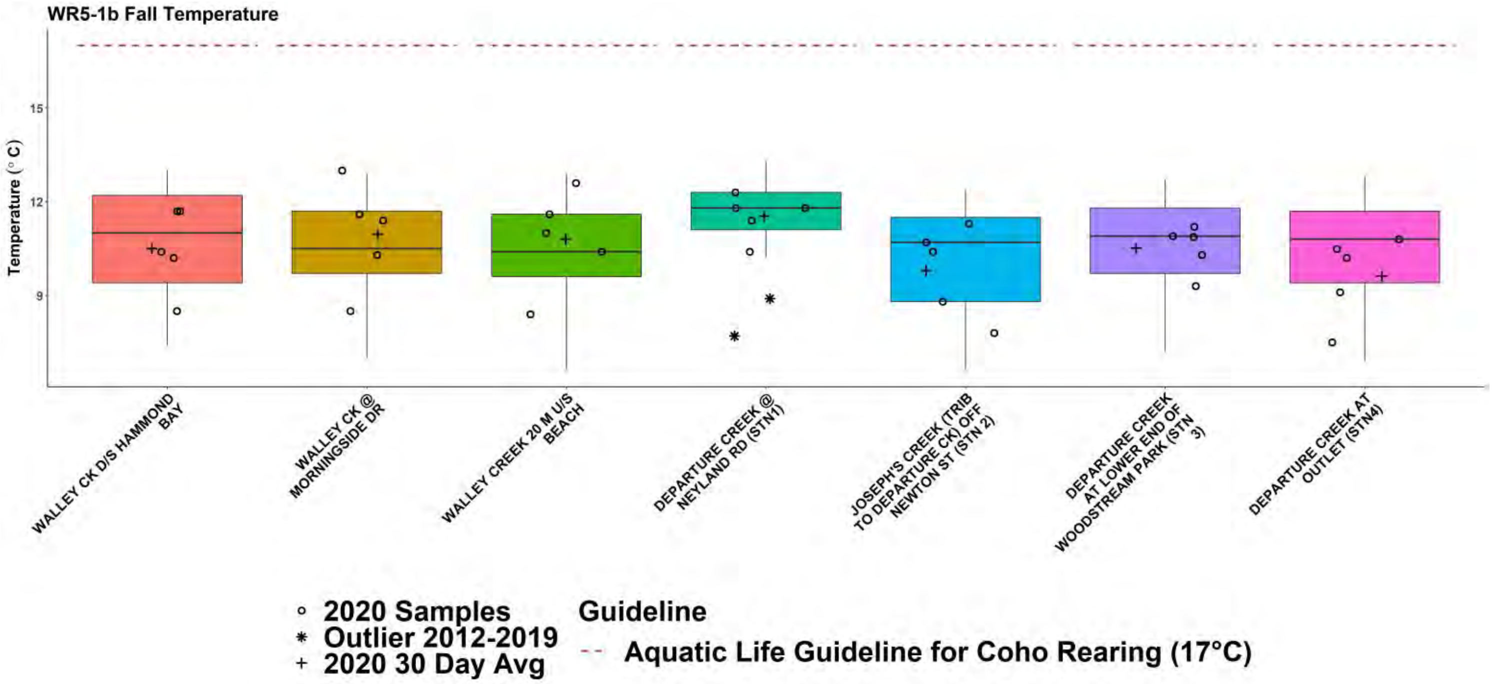

Figure B75: Fall 2012-2020 water temperature of CWMN sites in Water Region 5-1B (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

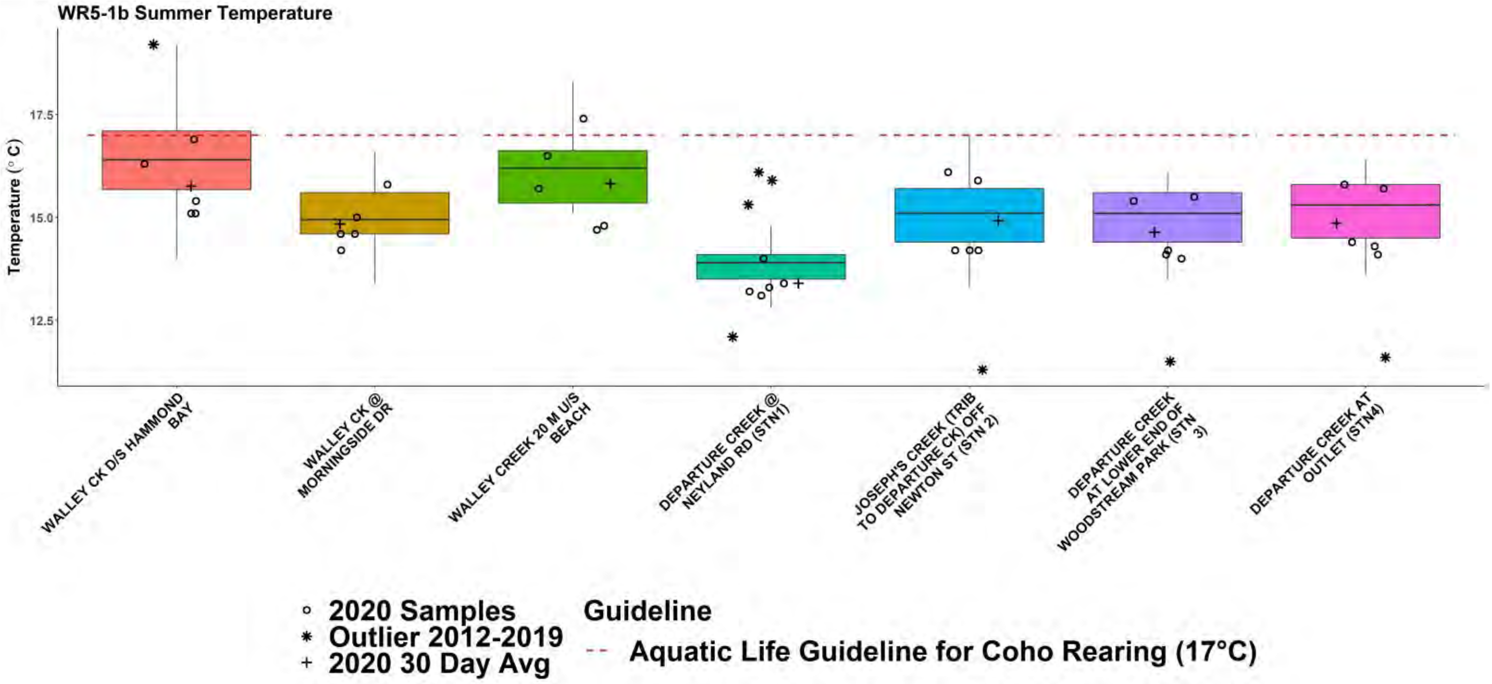

Figure B76: Summer 2012-2020 water temperature of CWMN sites in Water Region 5-1B (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

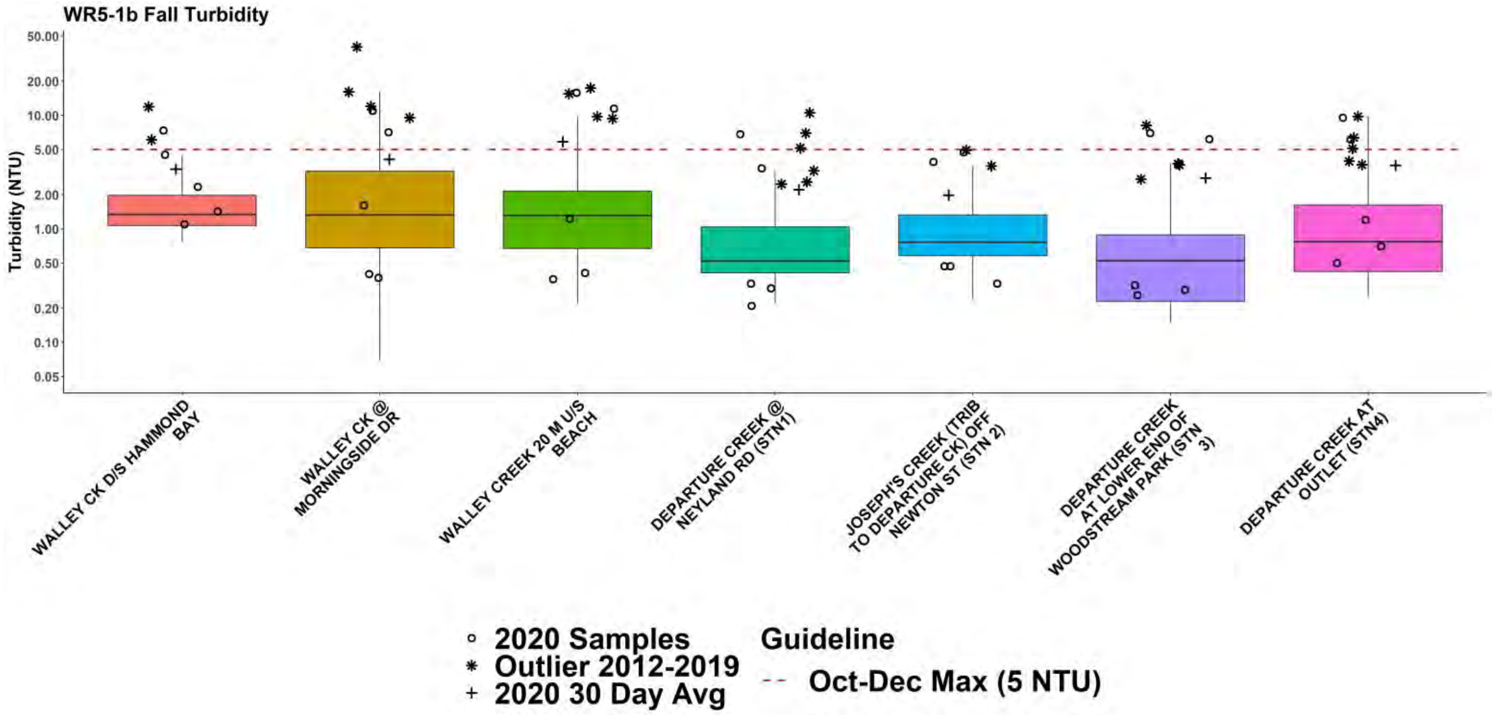

Figure B77: Fall 2012-2020 turbidity of CWMN sites in Water Region 5-1B (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

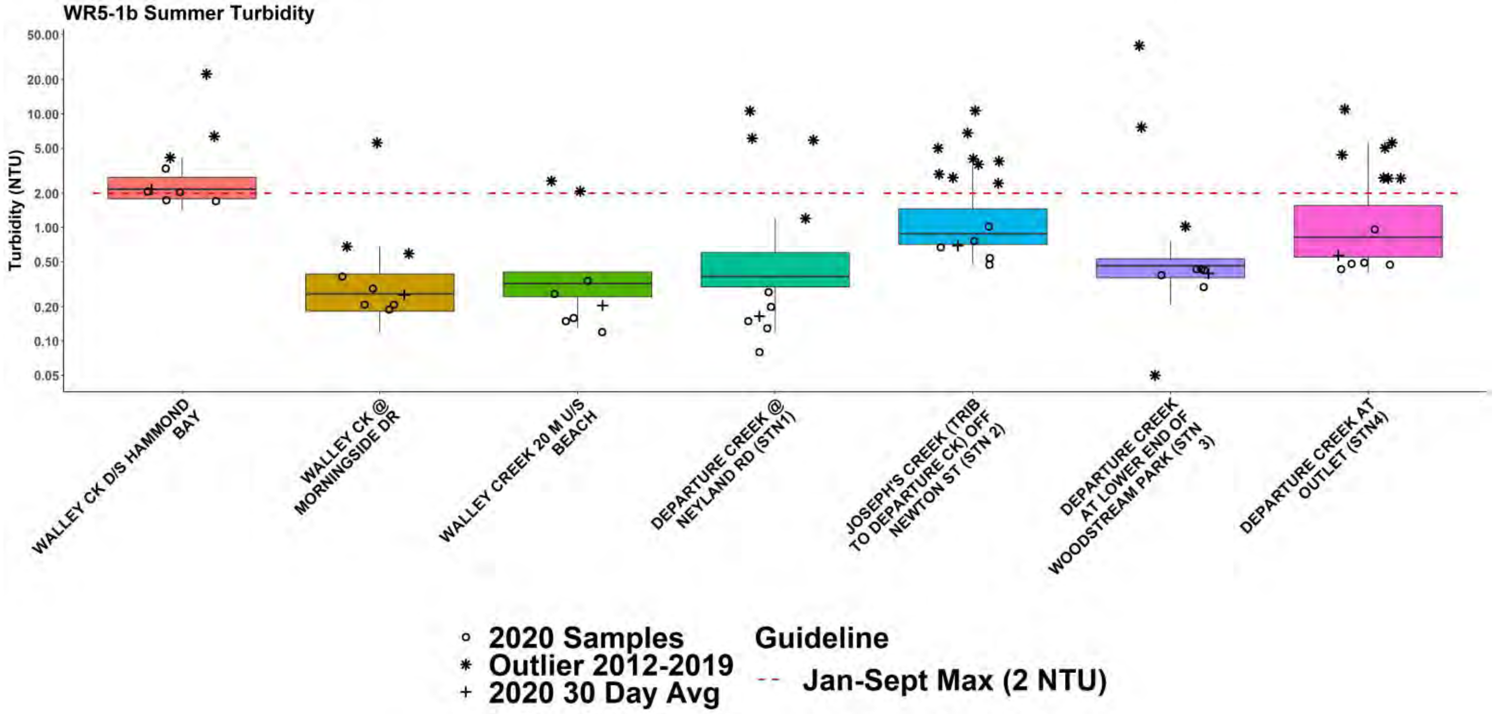

Figure B78: Summer 2012-2020 turbidity of CWMN sites in Water Region 5-1B (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

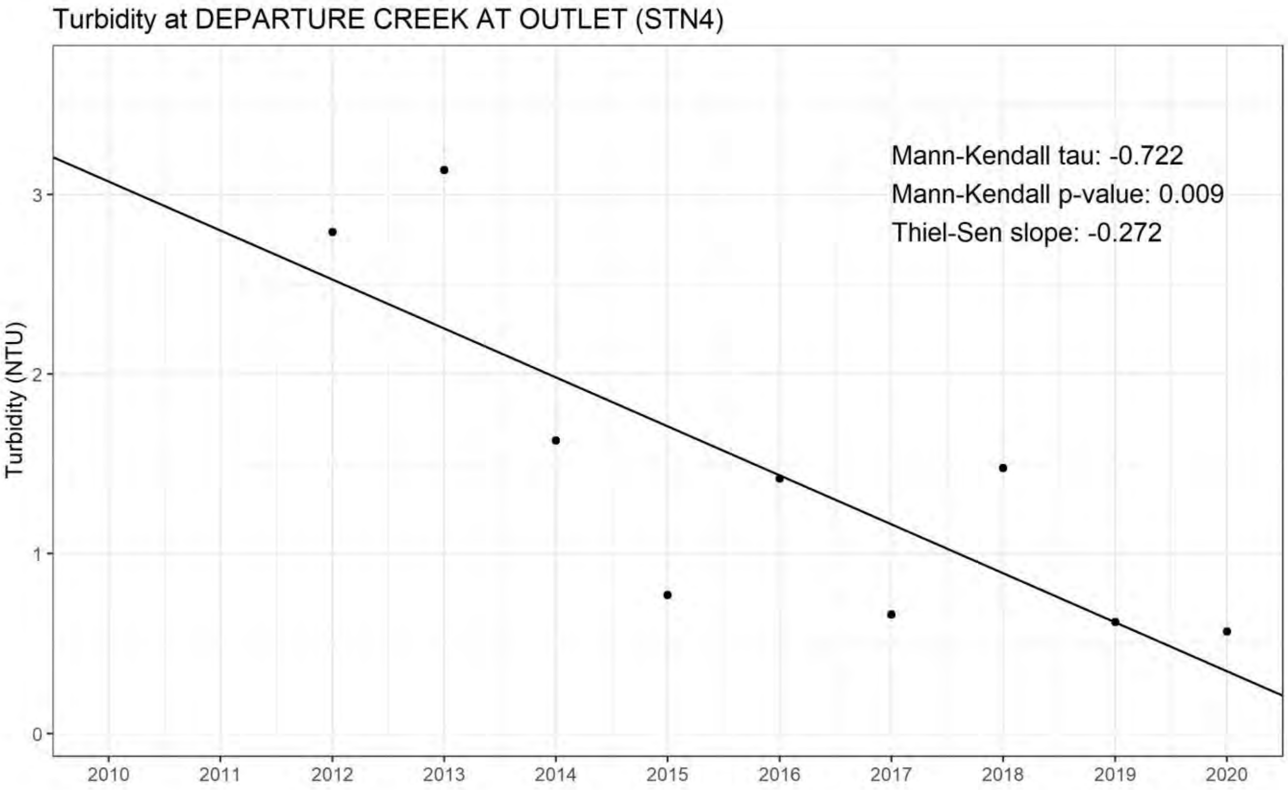

Figure B79: 2012-2020 Mann-Kendall analysis plot for turbidity in the summer at the CMWN site: Departure Ck @ outlet

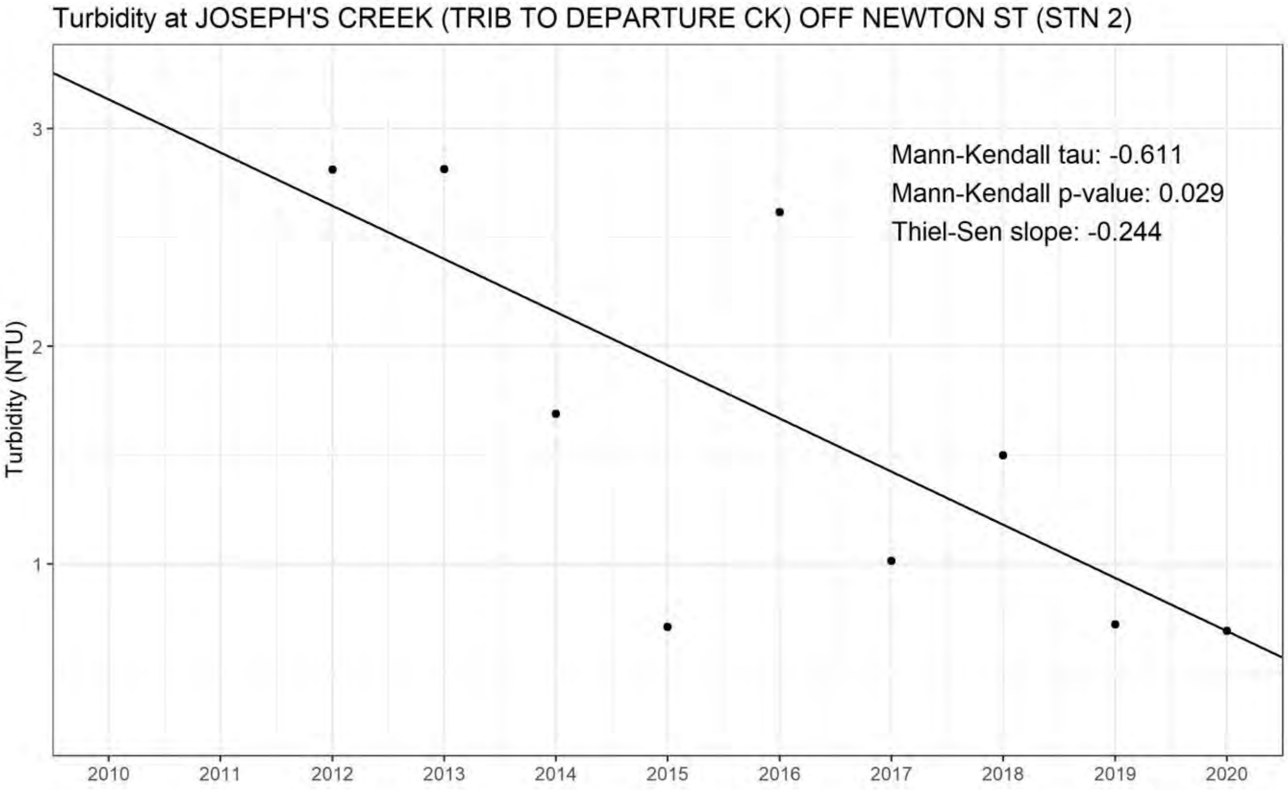

Figure B80: 2012-2020 Mann-Kendall analysis plot for turbidity in the summer at the CMWN site: Departure Ck off Newton St

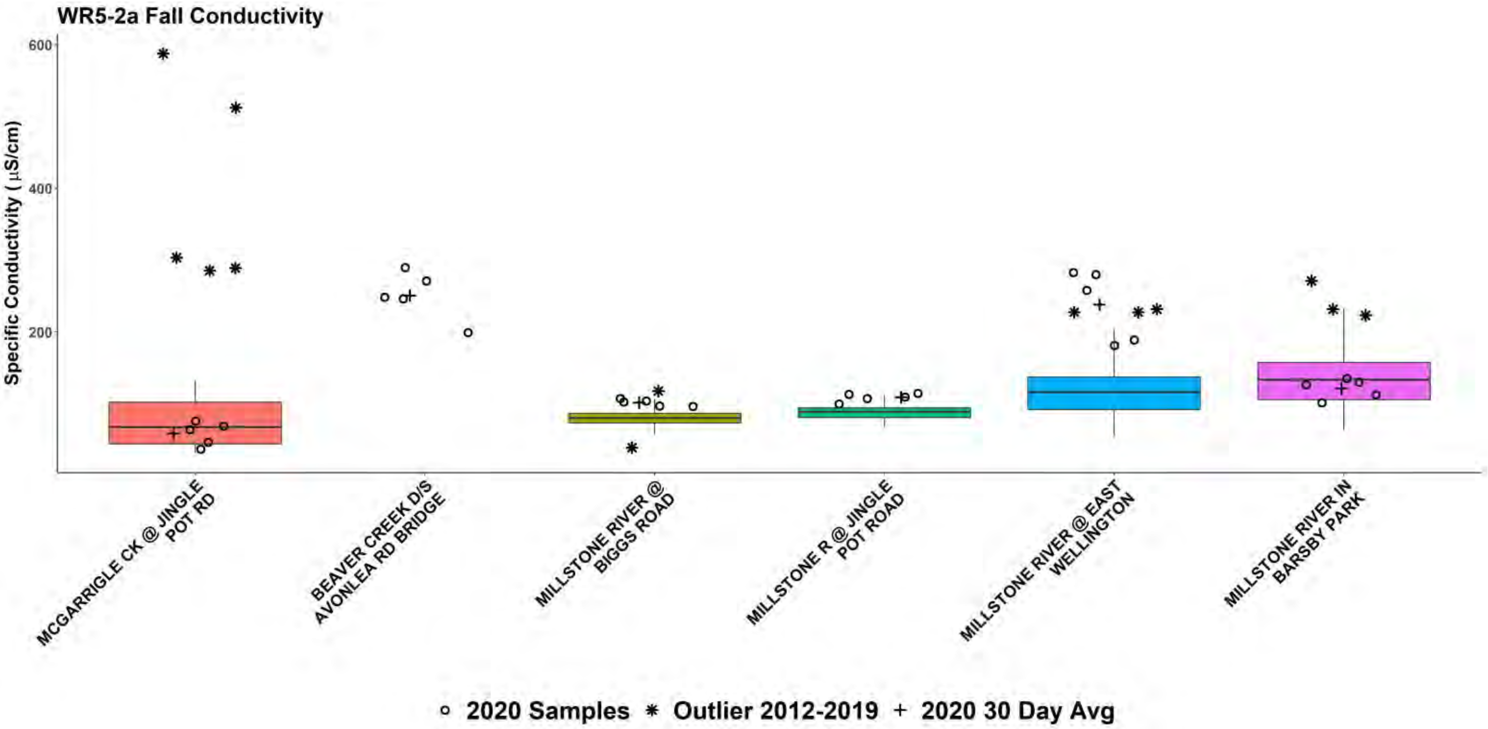

Figure B81: Fall 2012-2020 specific conductivity of CWMN sites in Water Region 5-2A (South Wellington to Nanoose).

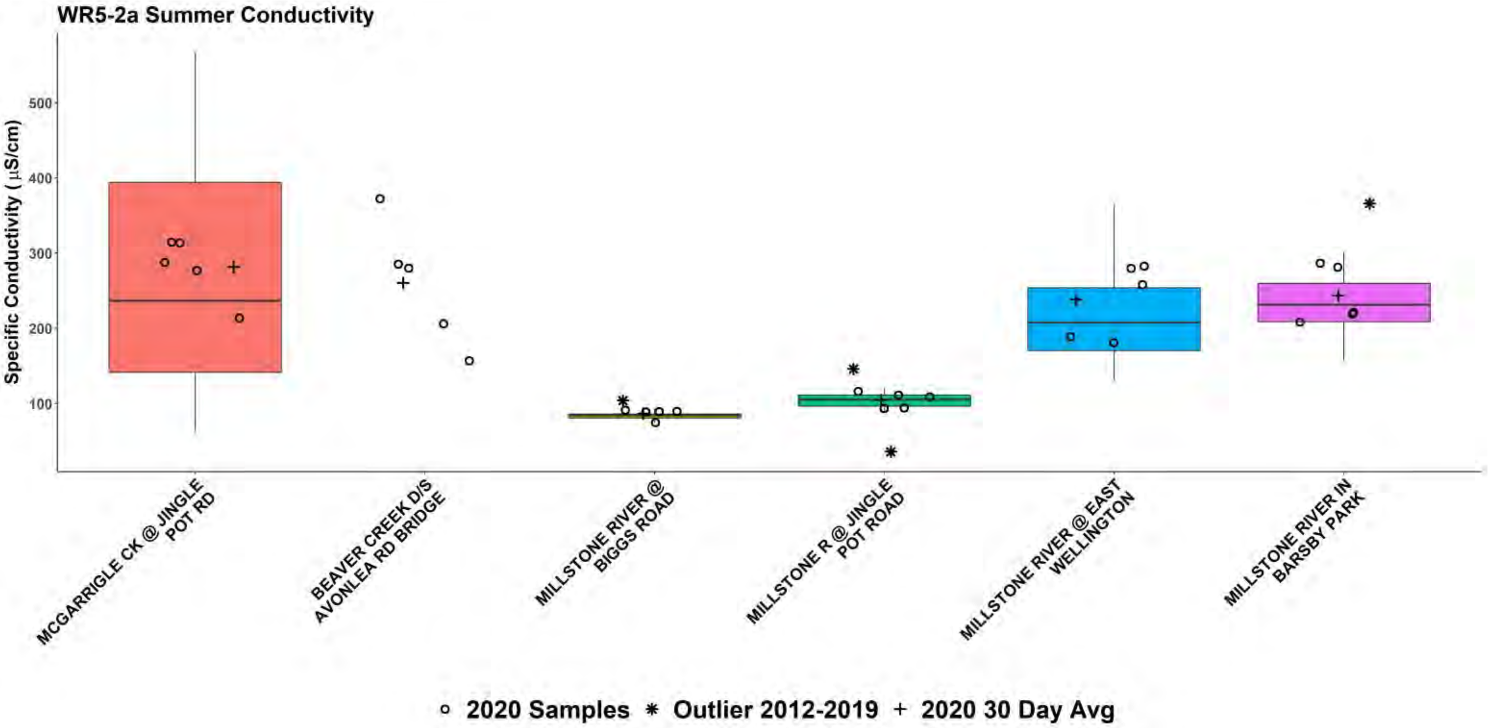

Figure B82: Summer 2012-2020 specific conductivity of CWMN sites in Water Region 5-2A (South Wellington to Nanoose).

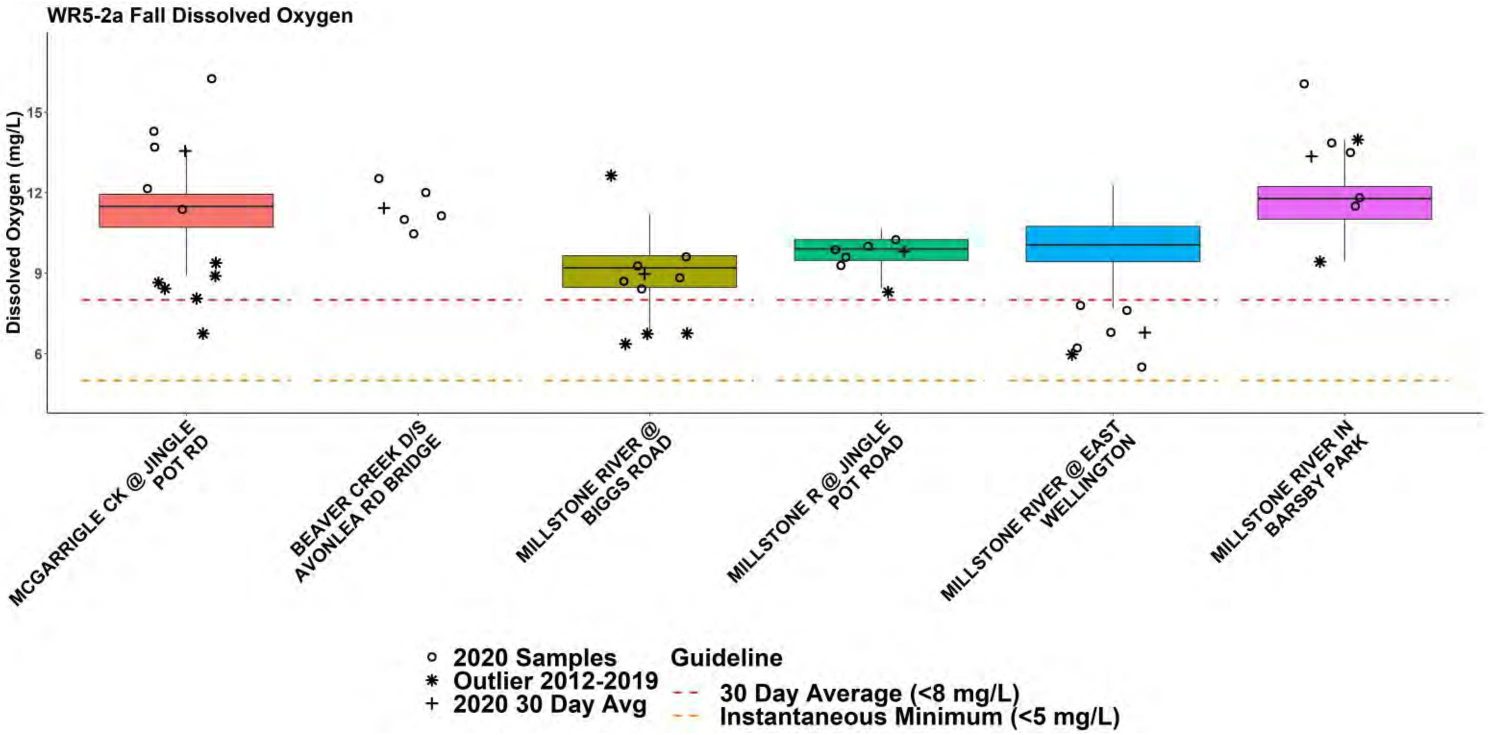

Figure B83: Fall 2012-2020 dissolved oxygen of CWMN sites in Water Region 5-2A (South Wellington to Nanoose) with Englishman River water quality objectives.

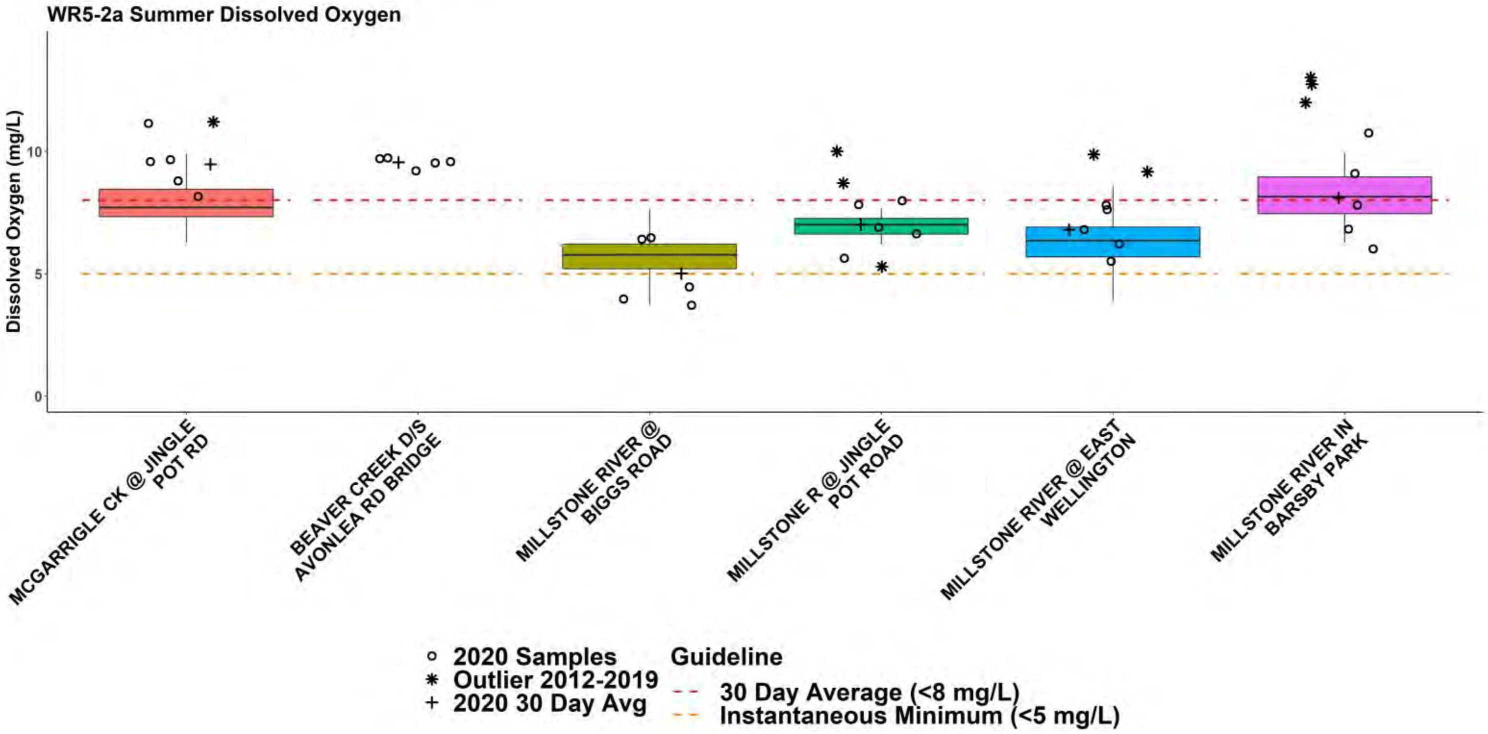

Figure B84: Summer 2012-2020 dissolved oxygen of CWMN sites in Water Region 5-2A (South Wellington to Nanoose) with Englishman River water quality objectives.

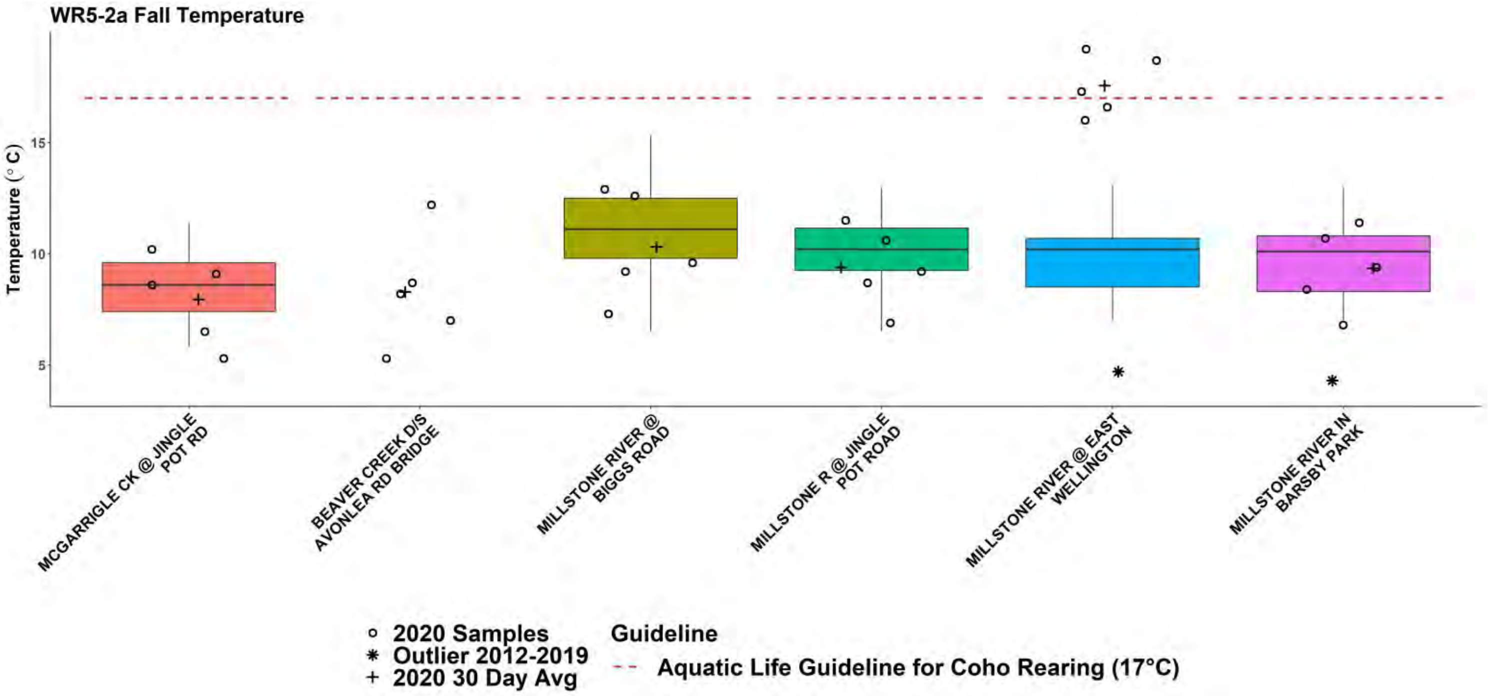

Figure B85: Fall 2012-2020 water temperature of CWMN sites in Water Region 5-2A (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

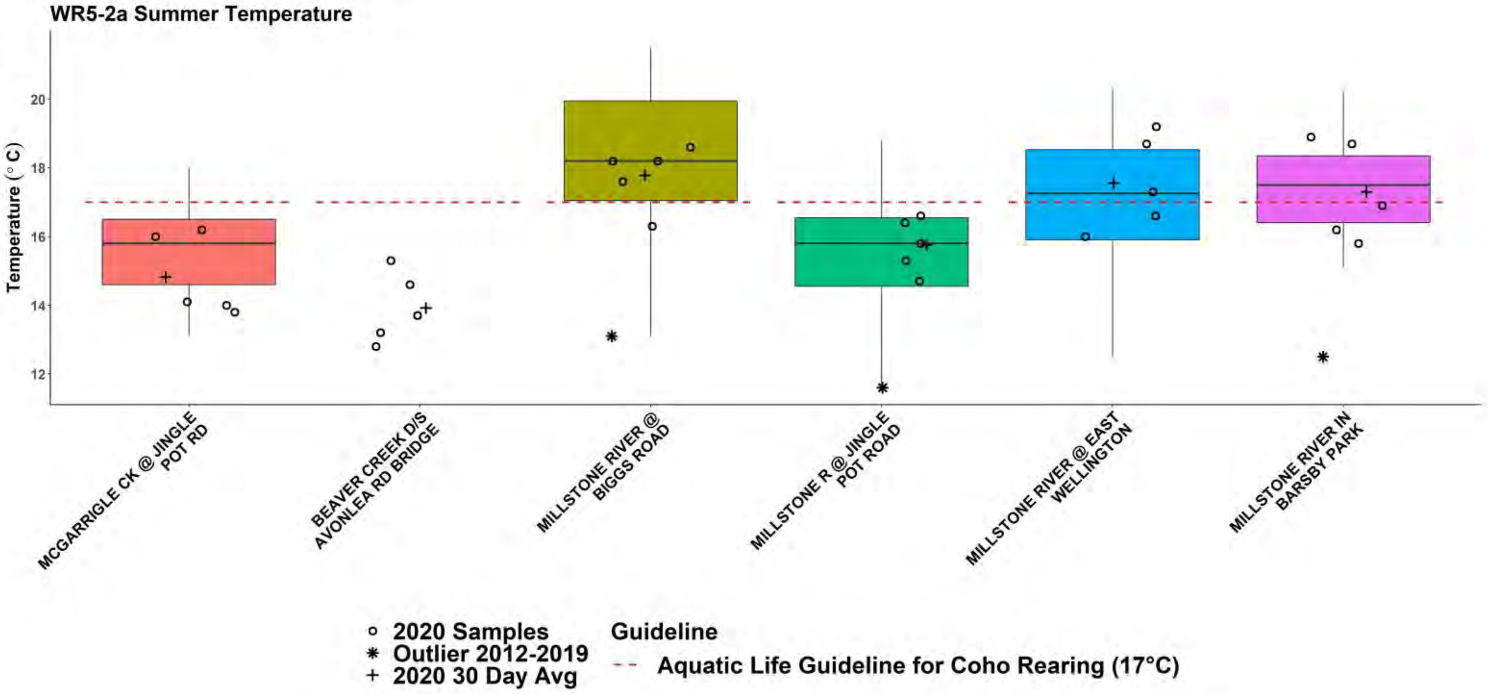

Figure B86: Summer 2012-2020 water temperature of CWMN sites in Water Region 5-2A (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

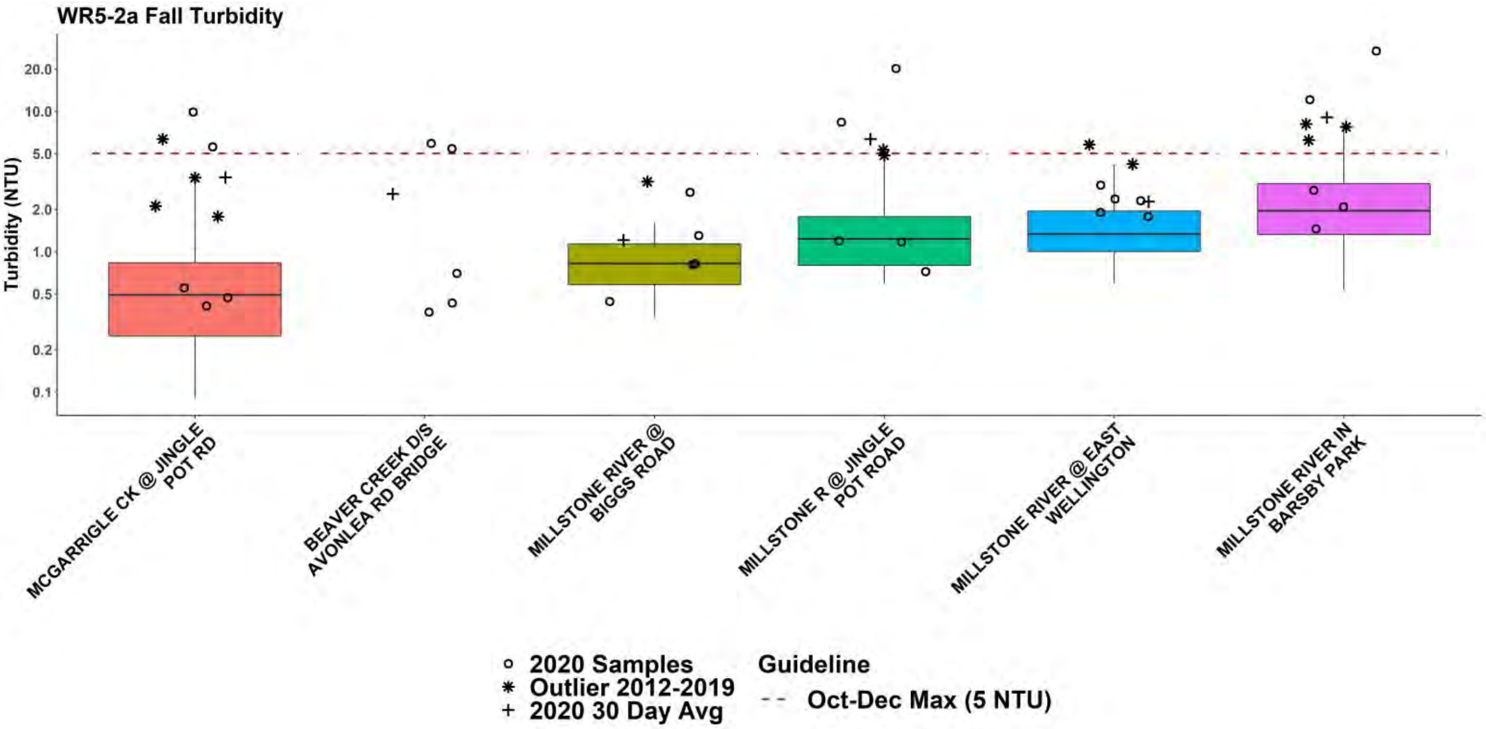

Figure B87: Fall 2012-2020 turbidity of CWMN sites in Water Region 5-2A (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

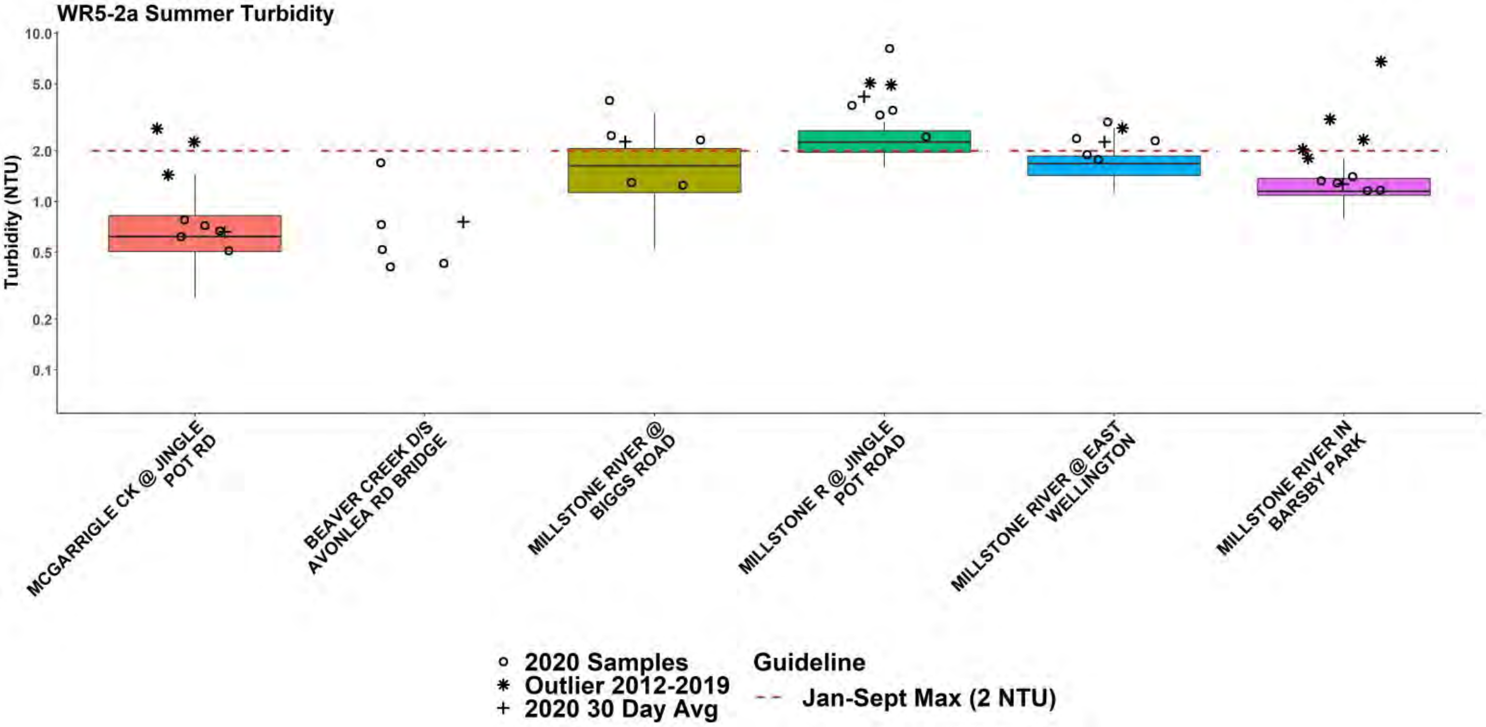

Figure B88: Summer 2012-2020 turbidity of CWMN sites in Water Region 5-2A (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

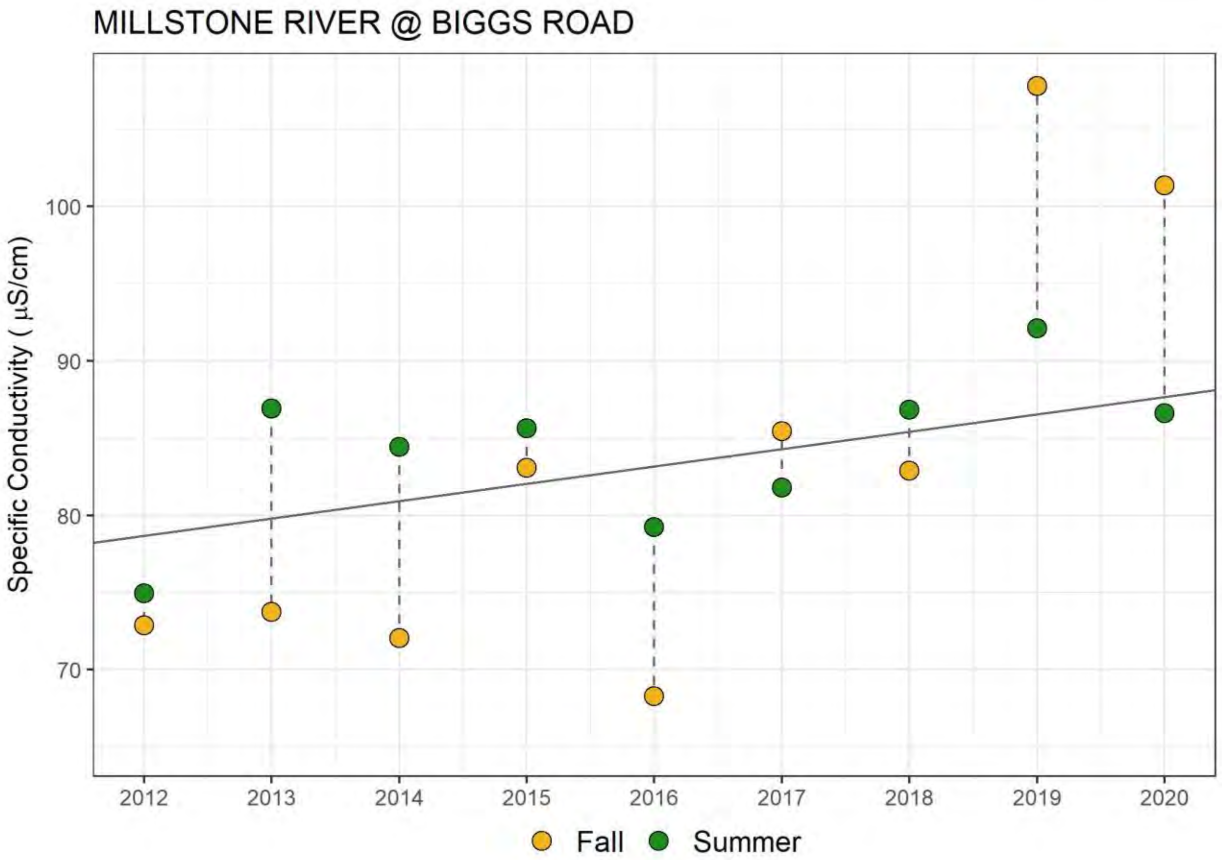

Figure B89: 2012-2020 Seasonal Mann-Kendall analysis plot for specific conductivity at the CMWN site: Millstone River at Biggs Road

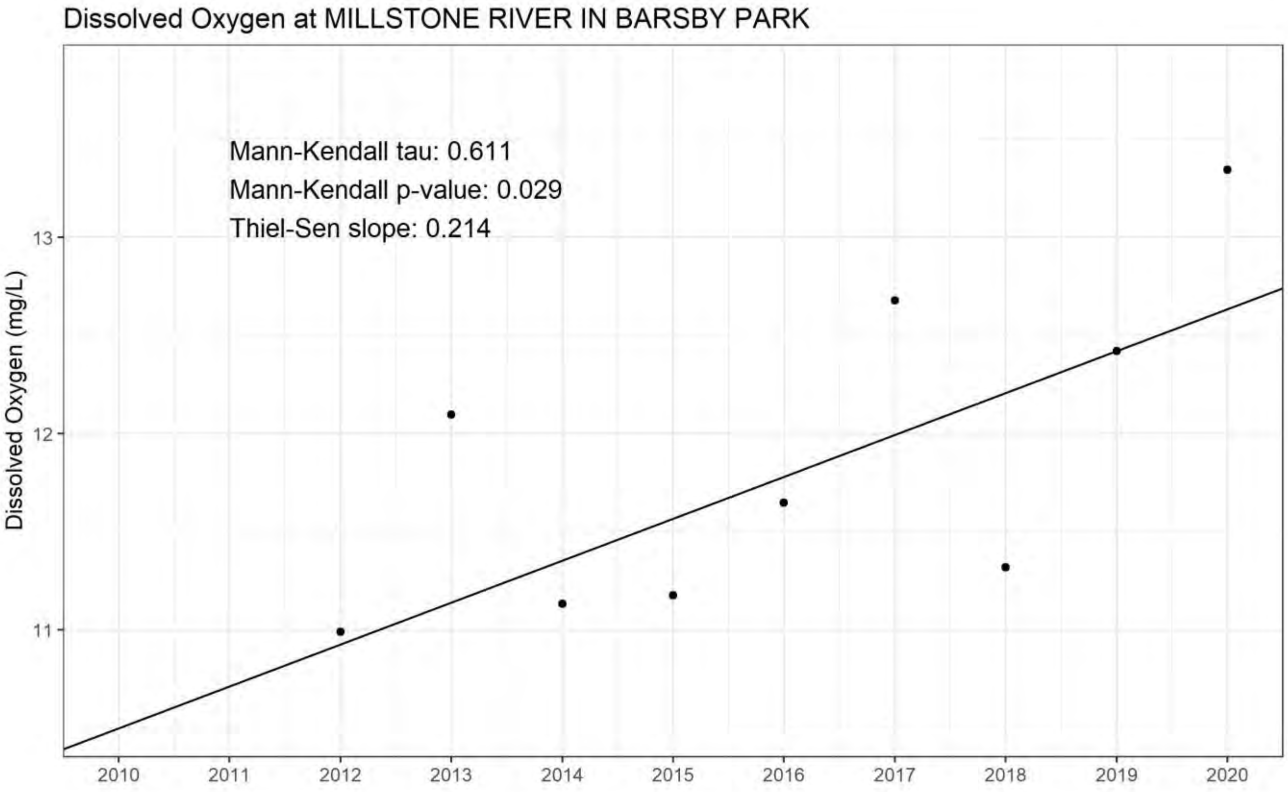

Figure B90: 2012-2020 Mann-Kendall analysis plot for dissolved oxygen in the fall at the CMWN site: Millstone River in Barsby Park

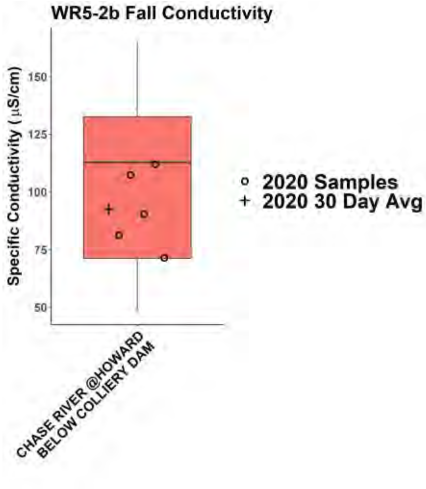

Figure B91: Fall 2012-2020 specific conductivity of CWMN sites in Water Region 5-2B (South Wellington to Nanoose).

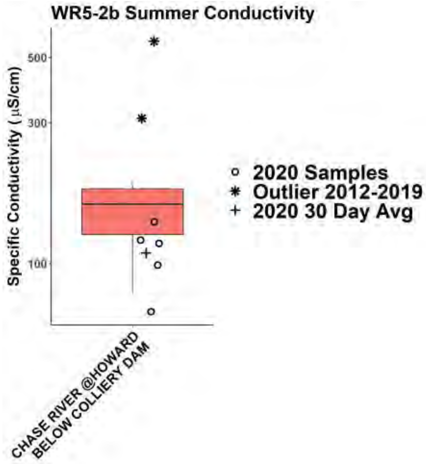

Figure B92: Summer 2012-2020 specific conductivity of CWMN sites in Water Region 5-2B (South Wellington to Nanoose).

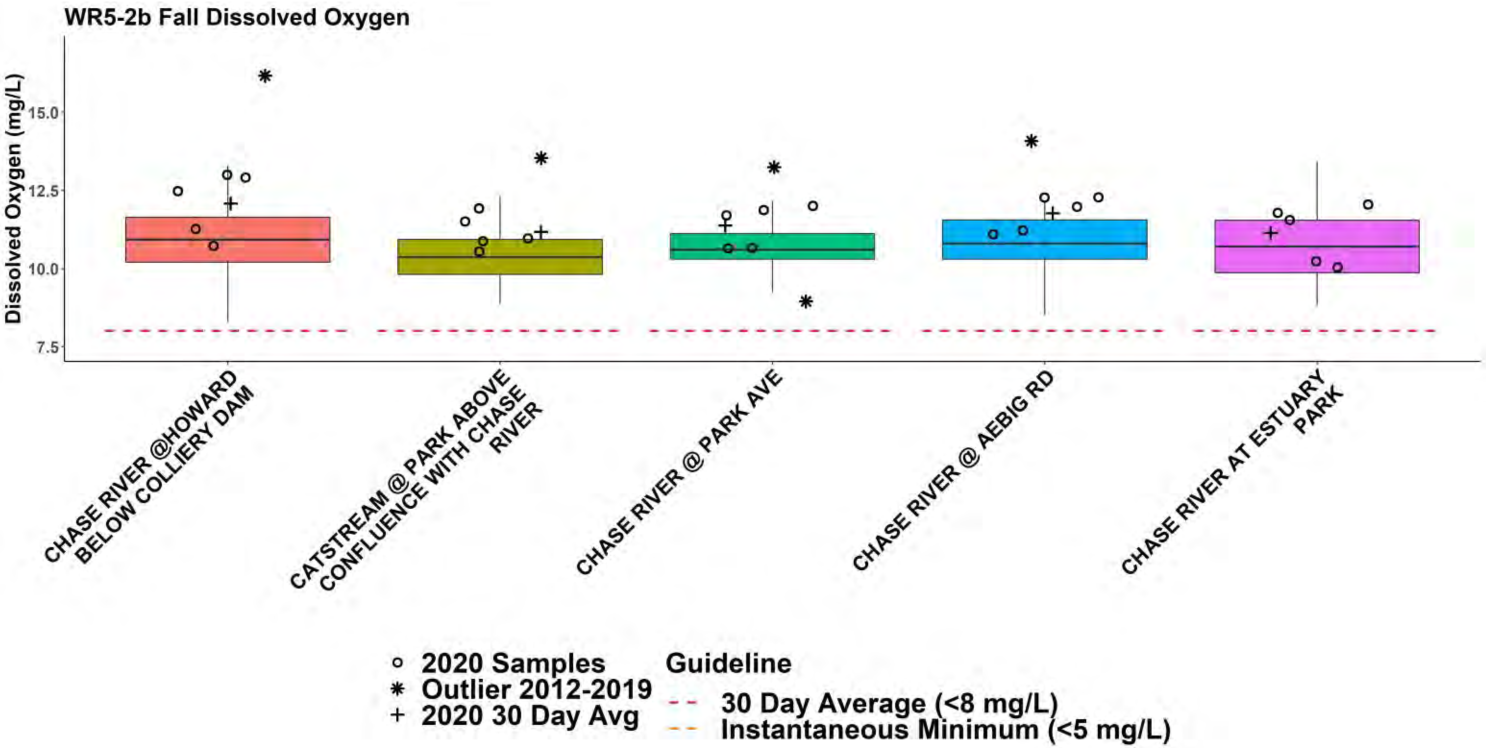

Figure B93: Fall 2012-2020 dissolved oxygen of CWMN sites in Water Region 5-2B (South Wellington to Nanoose) with Englishman River water quality objectives.

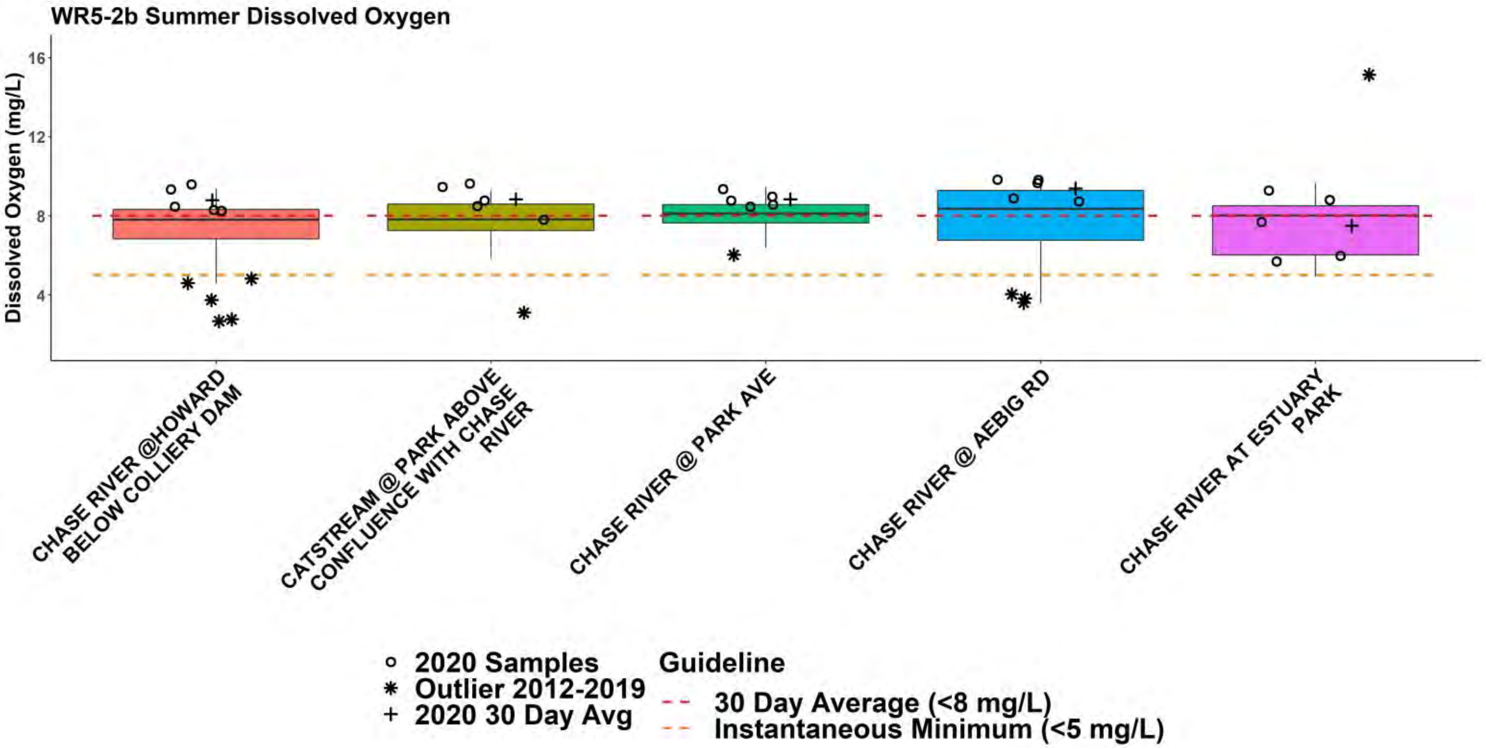

Figure B94: Summer 2012-2020 dissolved oxygen of CWMN sites in Water Region 5-2B (South Wellington to Nanoose) with Englishman River water quality objectives.

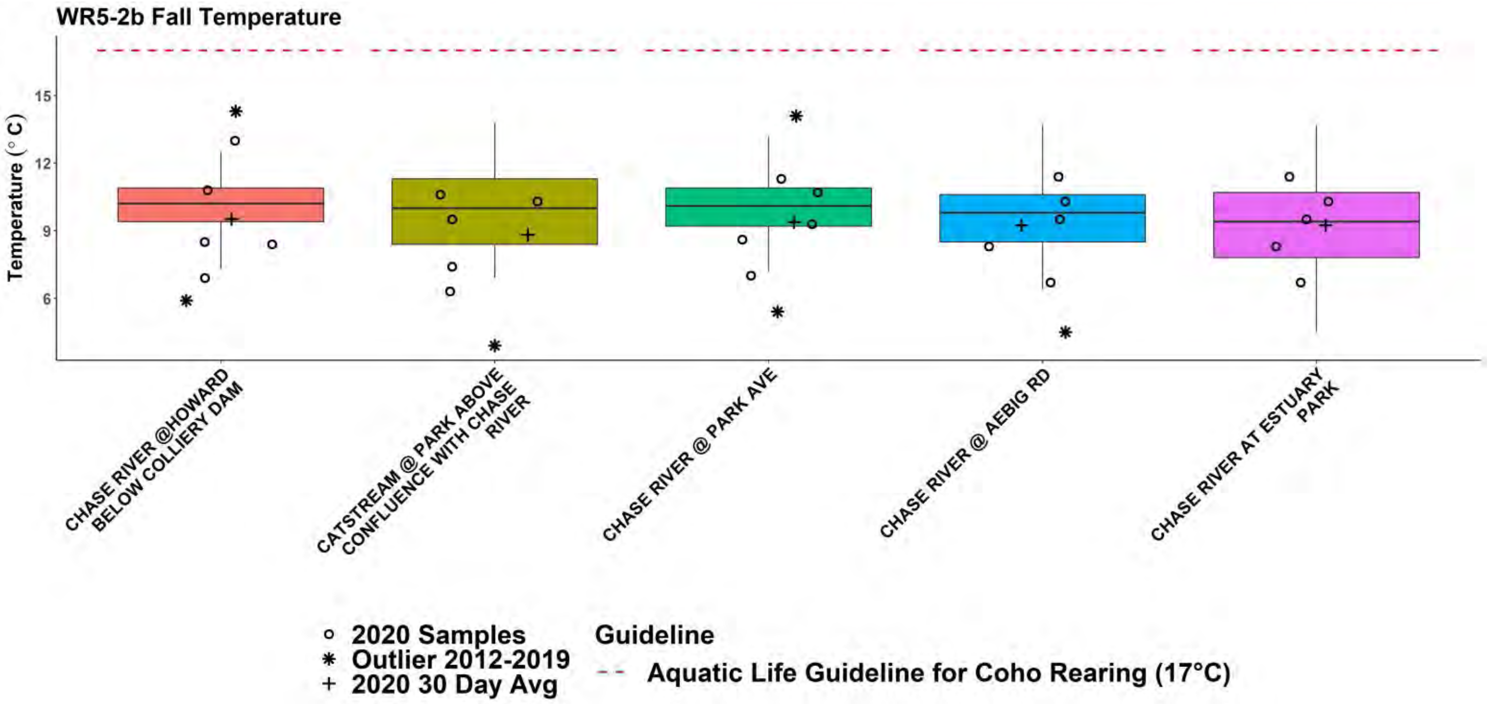

Figure B95: Fall 2012-2020 water temperature of CWMN sites in Water Region 5-2B (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

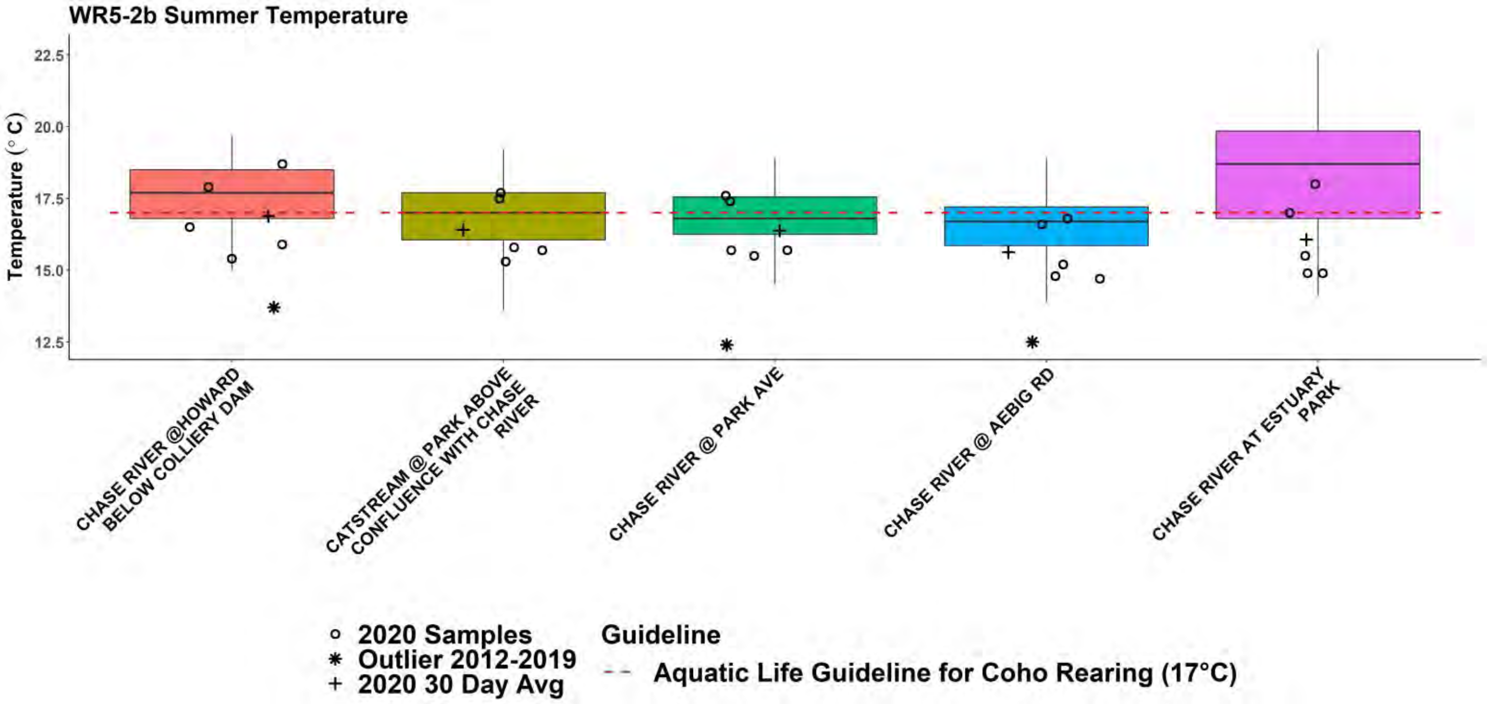

Figure B96: Summer 2012-2020 water temperature of CWMN sites in Water Region 5-2B (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

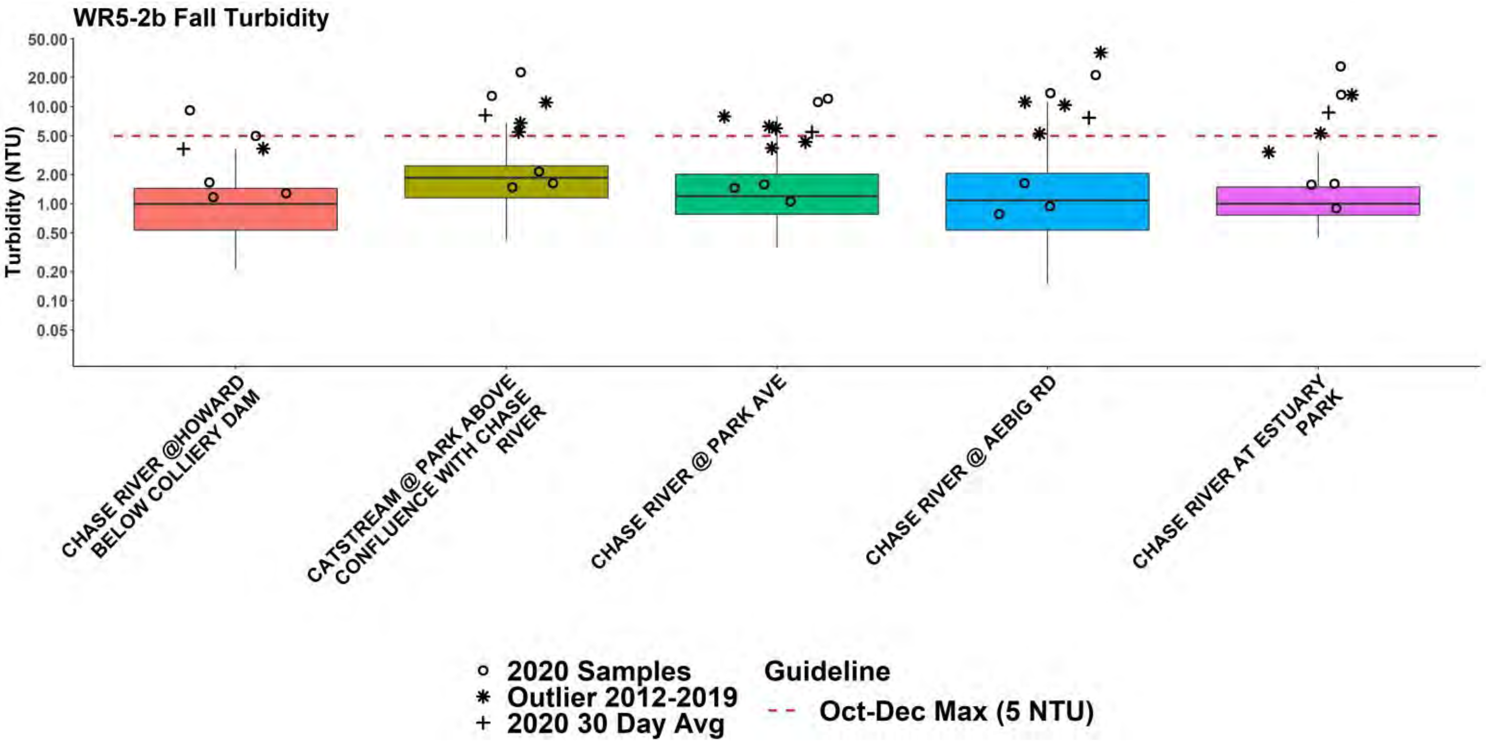

Figure B97: Fall 2012-2020 turbidity of CWMN sites in Water Region 5-2B (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

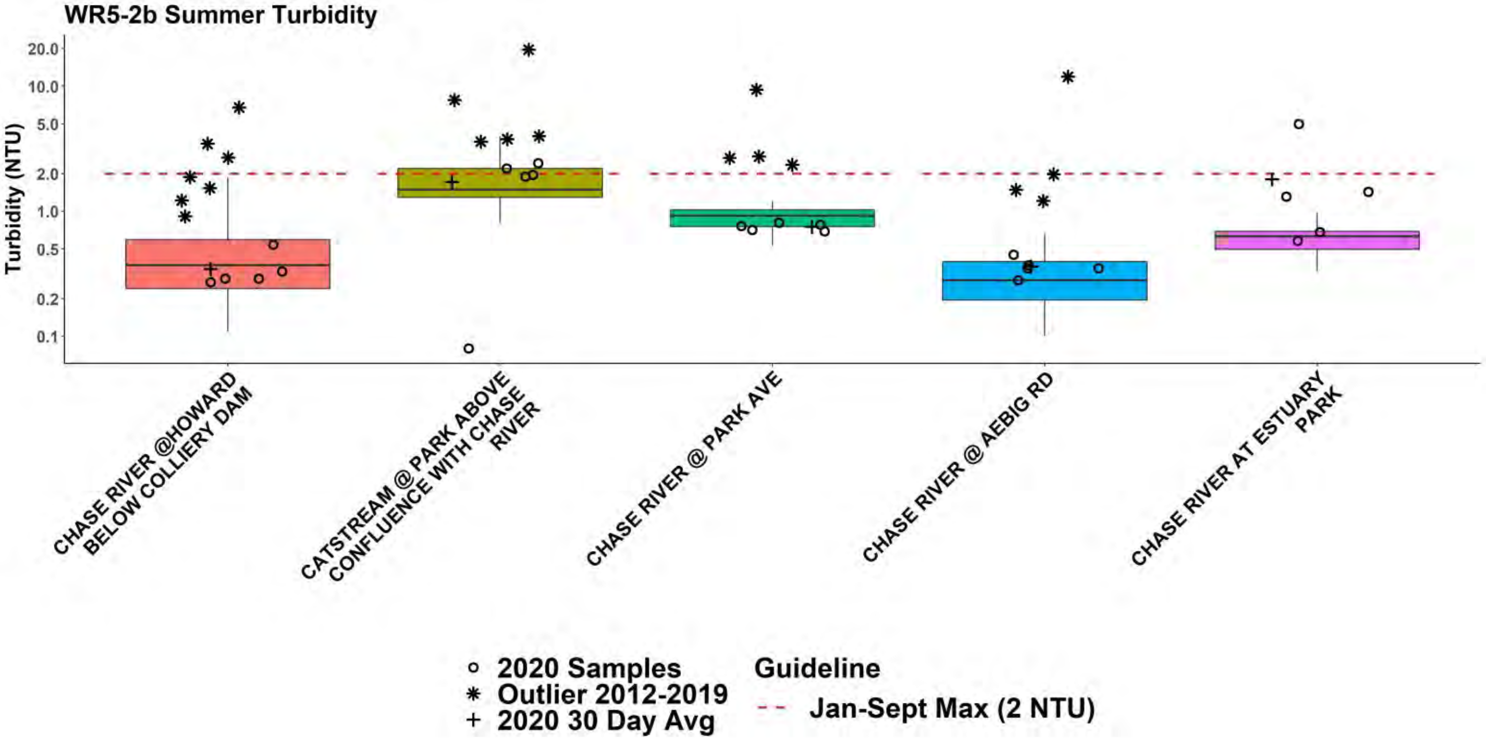

Figure B98: Summer 2012-2020 turbidity of CWMN sites in Water Region 5-2B (South Wellington to Nanoose) with BC Water Quality guidelines for Aquatic Life.

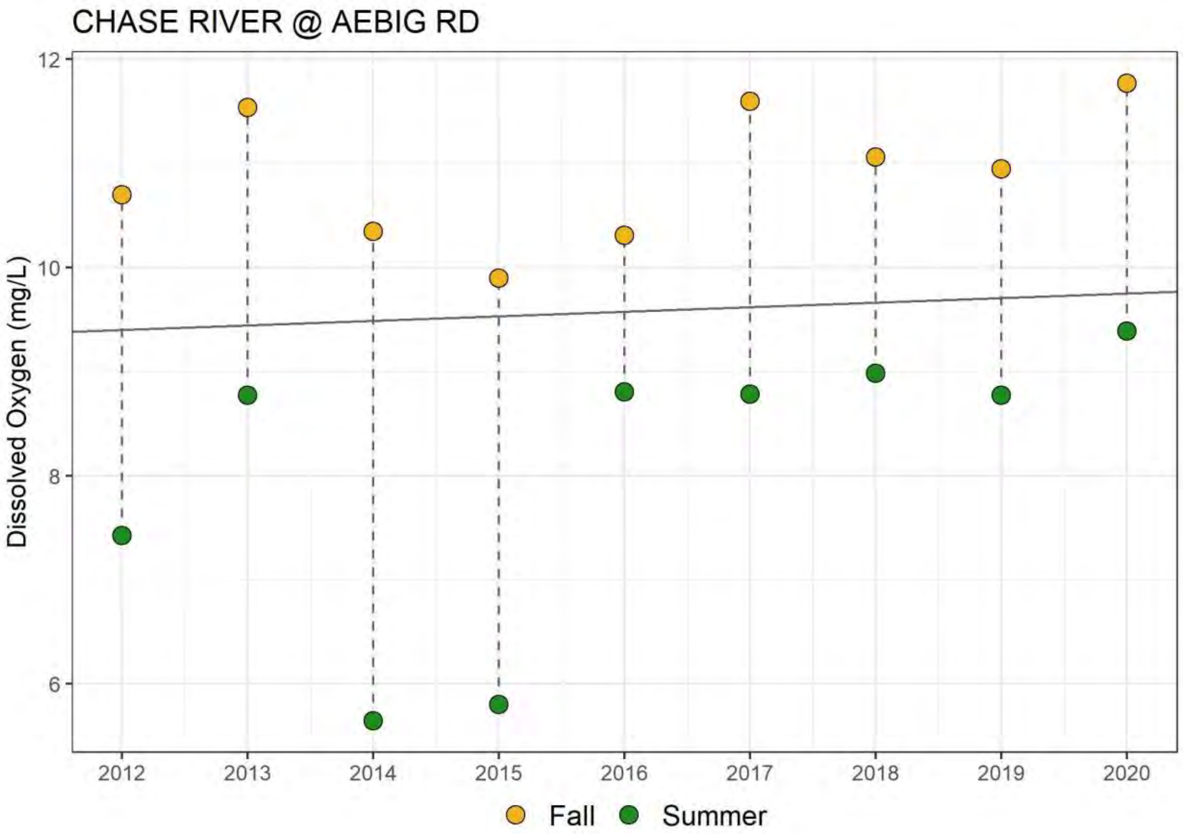

Figure B99: 2012-2020 Seasonal Mann-Kendall analysis plot for dissolved oxygen at the CMWN site: Chase River at Aebig

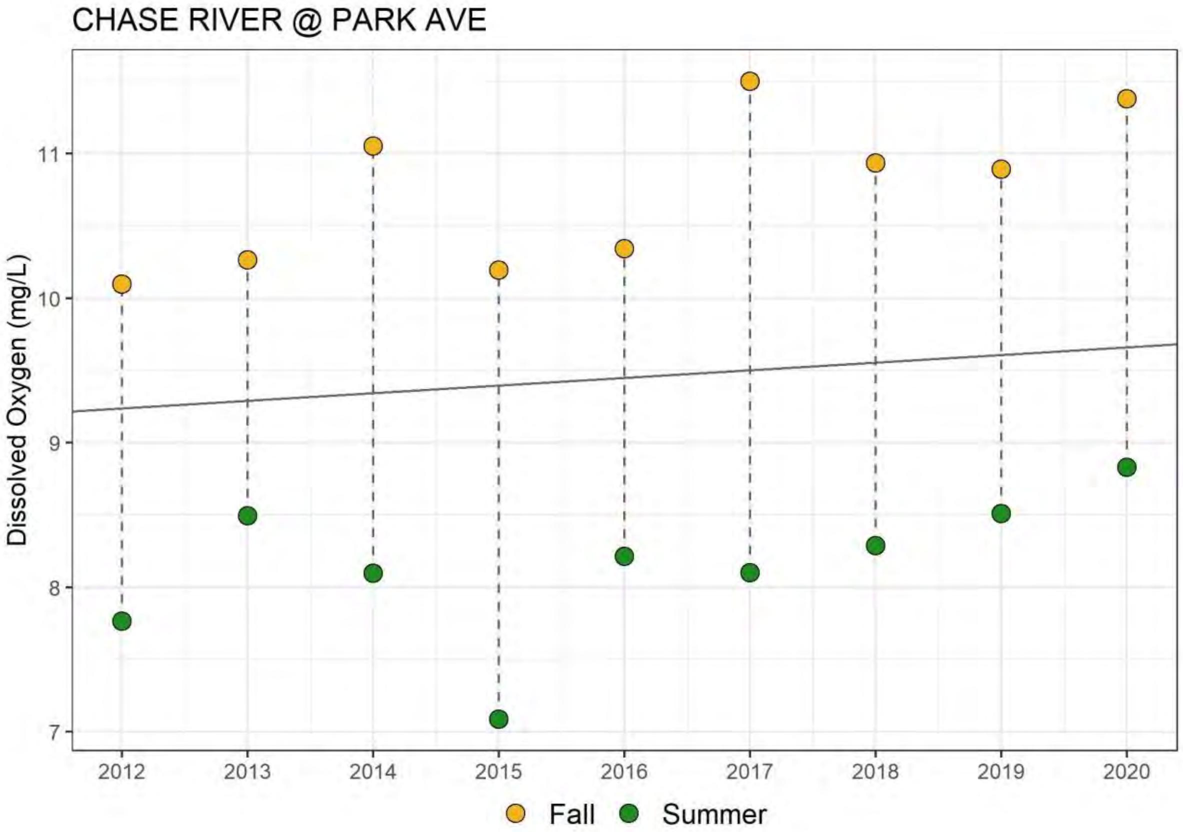

Figure B100: 2012-2020 Seasonal Mann-Kendall analysis plot for dissolved oxygen at the CMWN site: Chase River at Park Ave

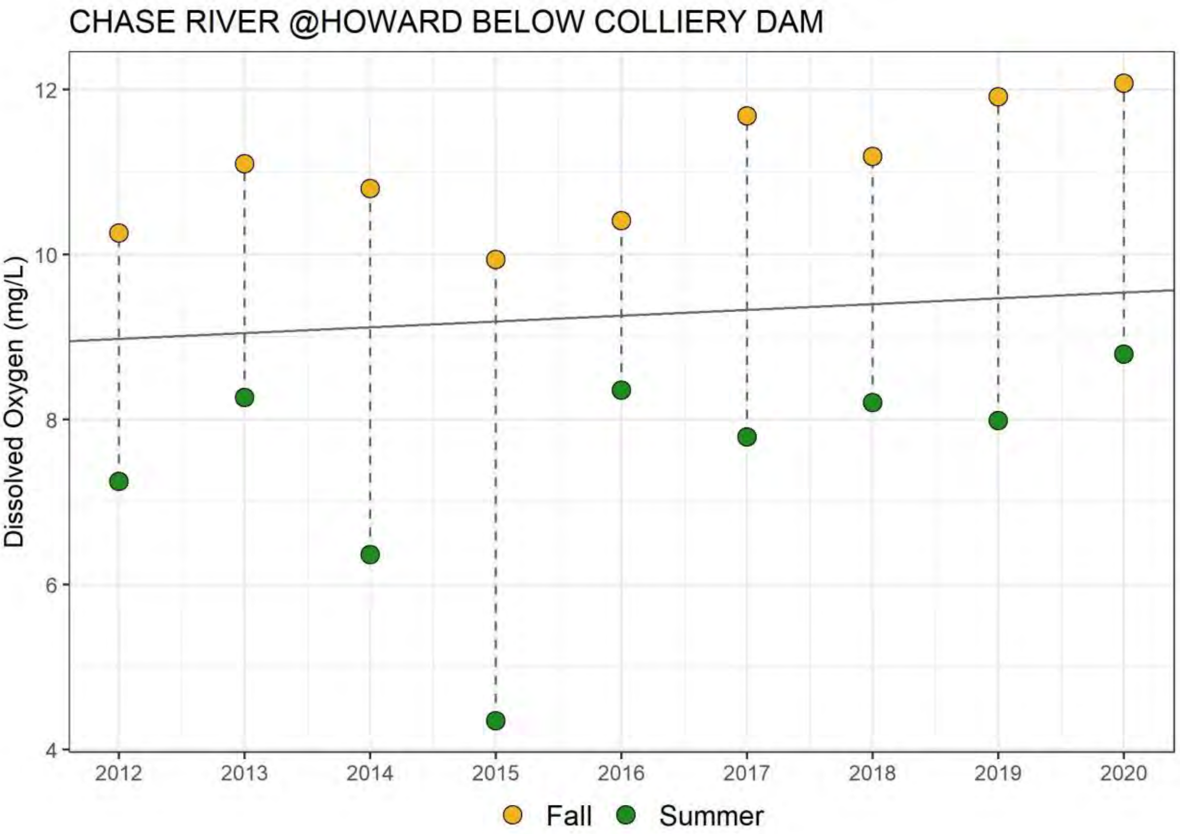

Figure B101: 2012-2020 Seasonal Mann-Kendall analysis plot for dissolved oxygen at the CMWN site: Chase River at Howard

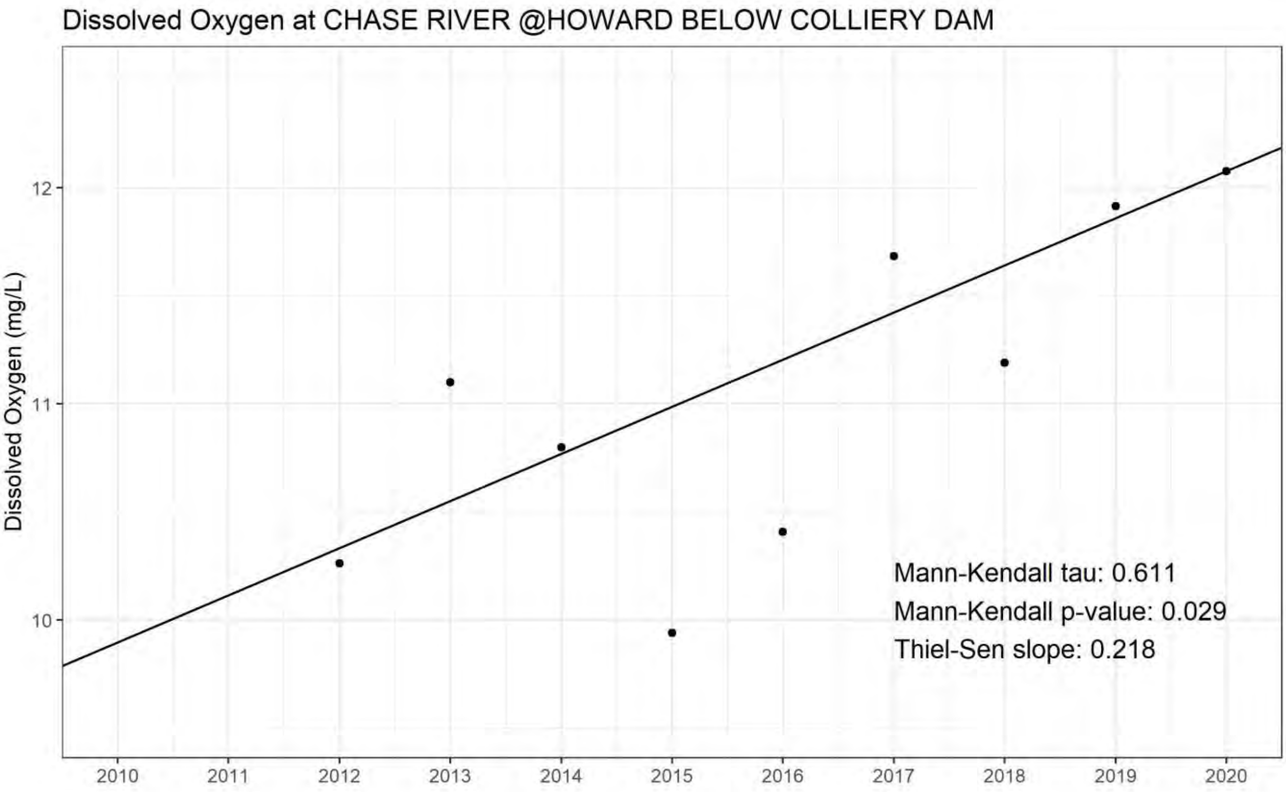

Figure B102: 2012-2020 Mann-Kendall analysis plot for dissolved oxygen in the fall at the CMWN site: Chase River at Howard

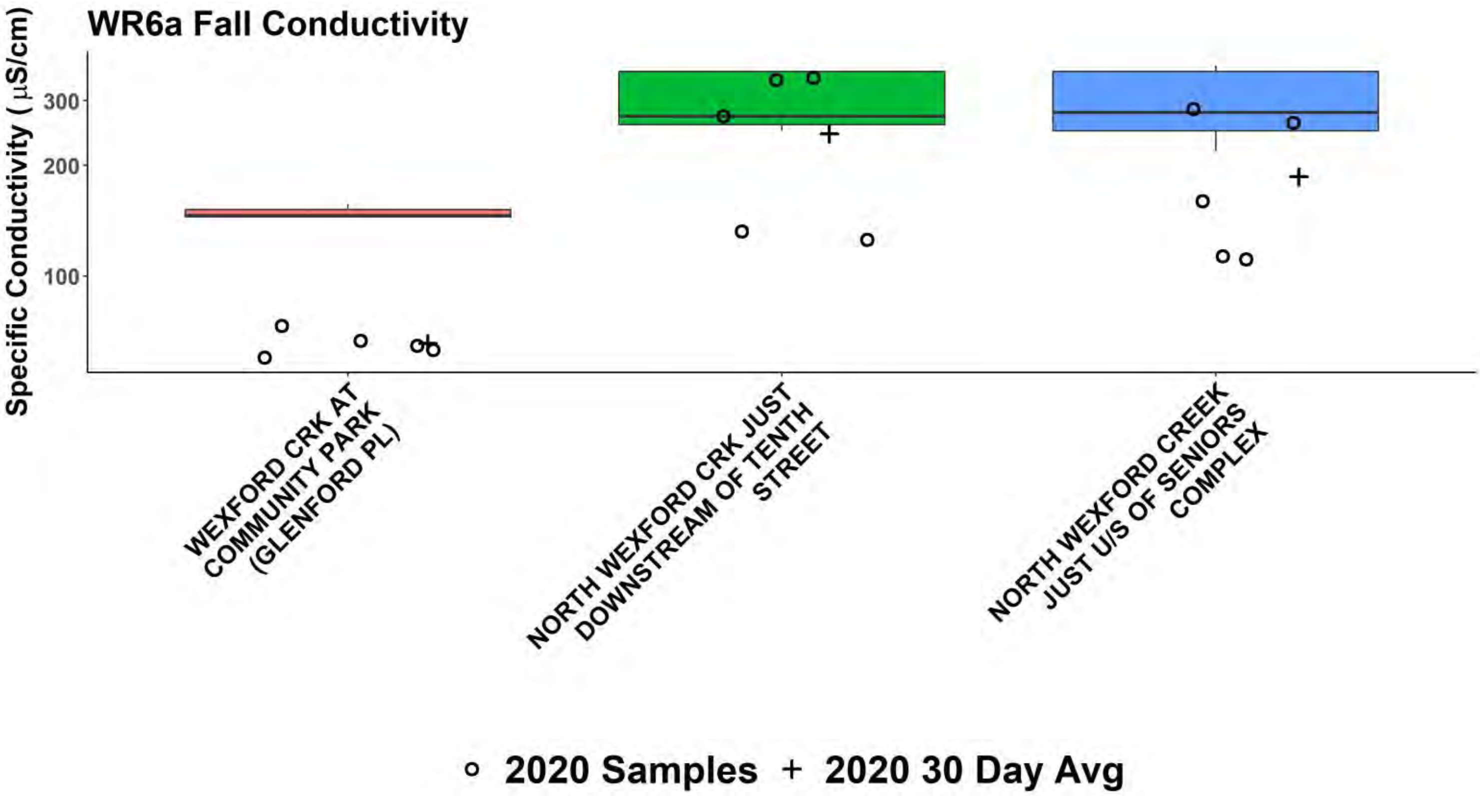

Figure B103: Fall 2019-2020 specific conductivity of CWMN sites in Water Region 6a (Nanaimo River).

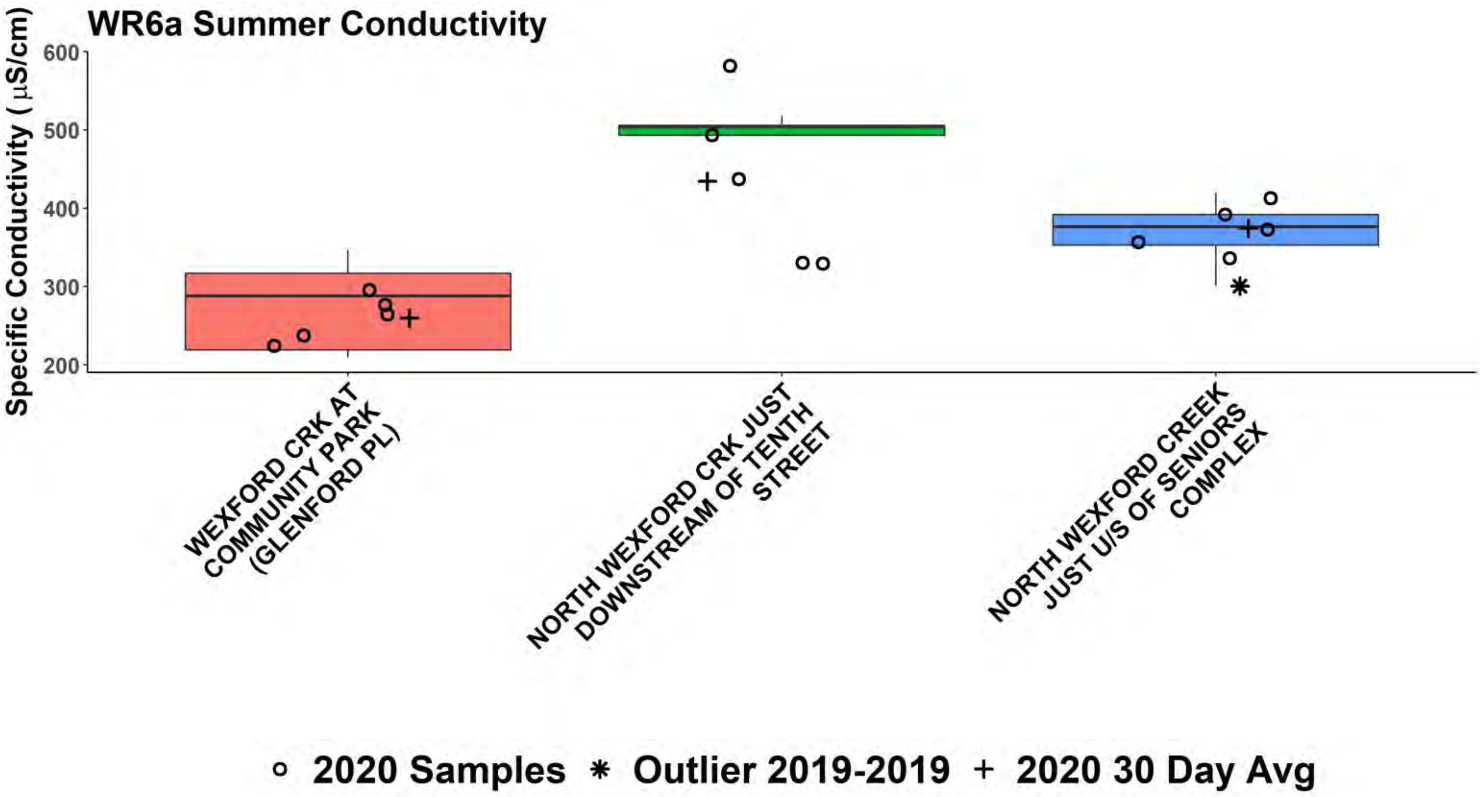

Figure B104: Summer 2019-2020 specific conductivity of CWMN sites in Water Region 6a (Nanaimo River).

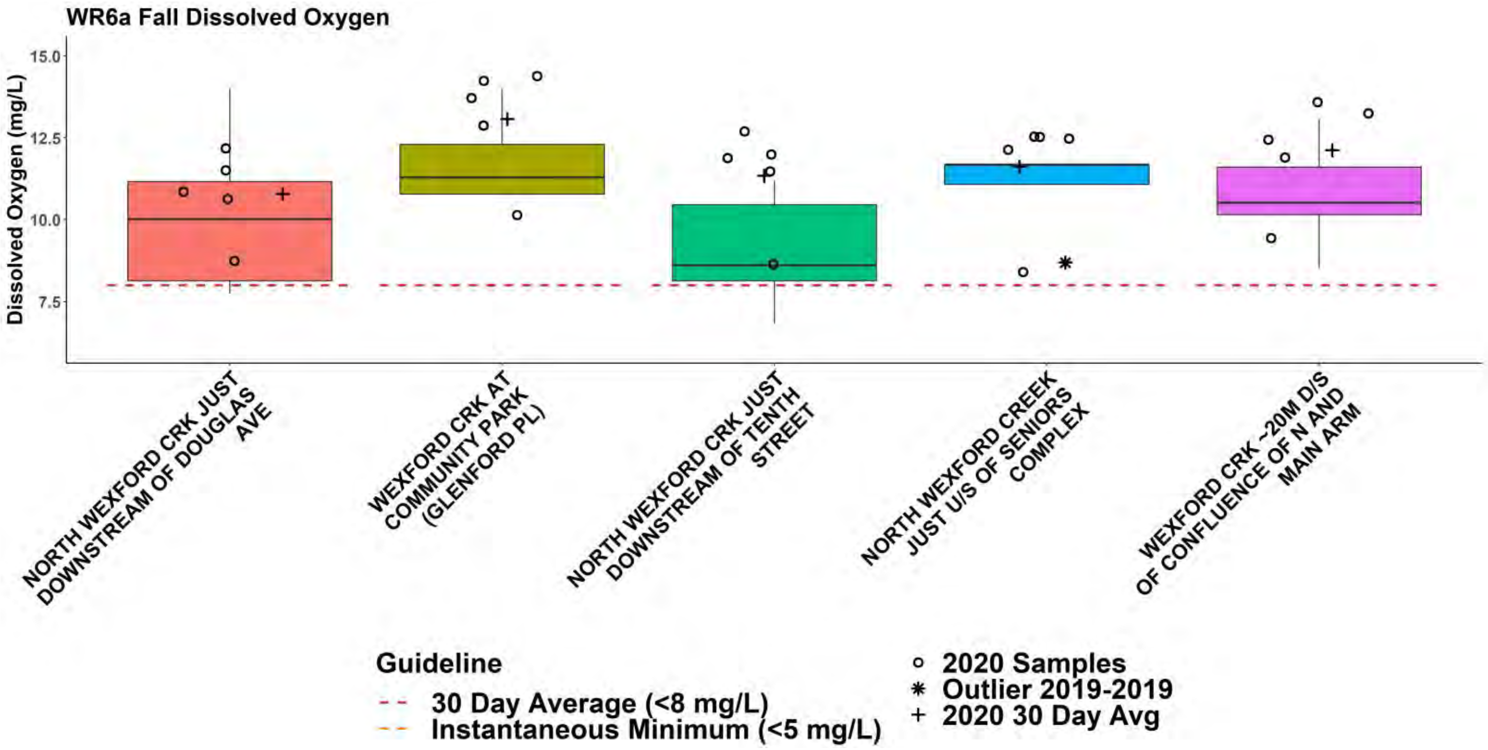

Figure B105: Fall 2019-2020 dissolved oxygen of CWMN sites in Water Region 6a (Nanaimo River) with Englishman River water quality objectives.

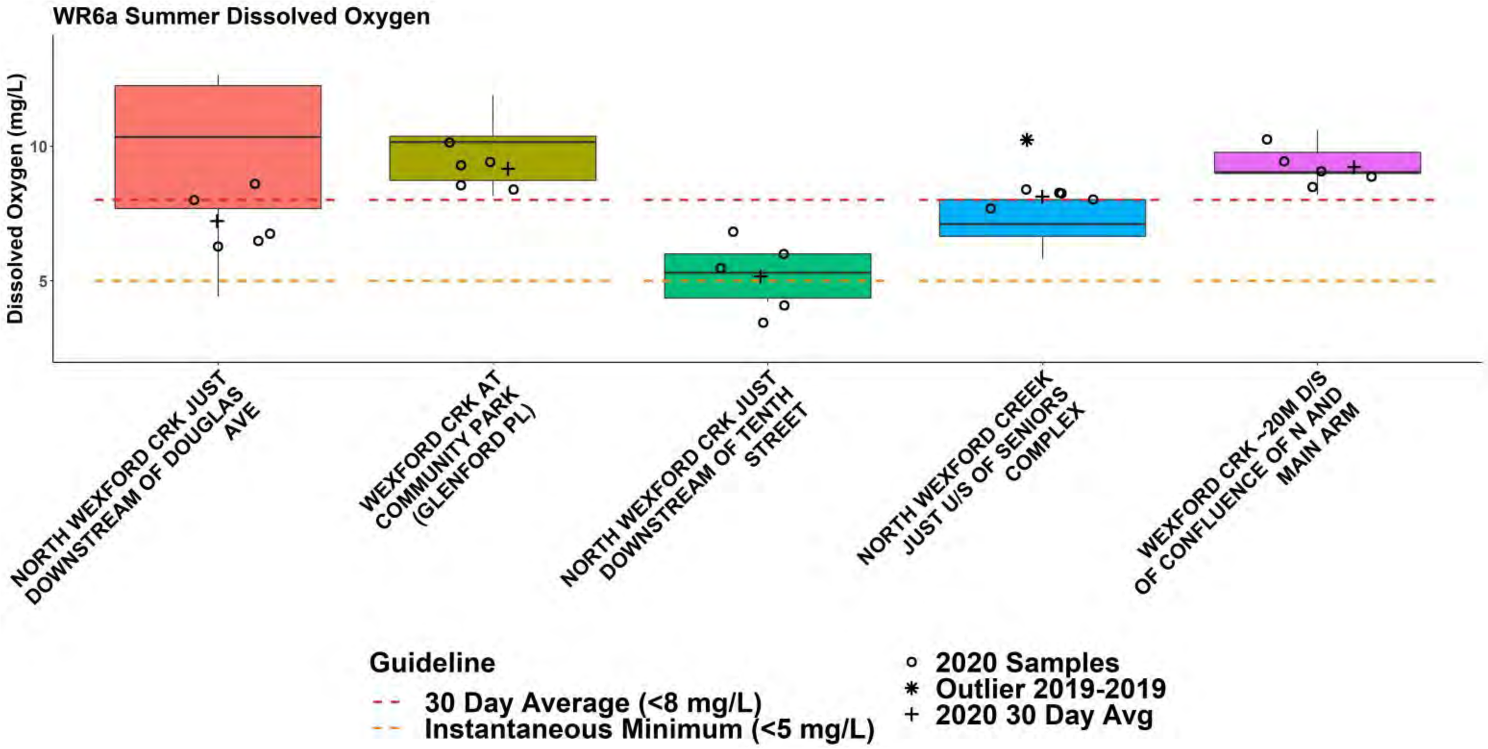

Figure B106: Summer 2019-2020 dissolved oxygen of CWMN sites in Water Region 6a (Nanaimo River) with Englishman River water quality objectives.

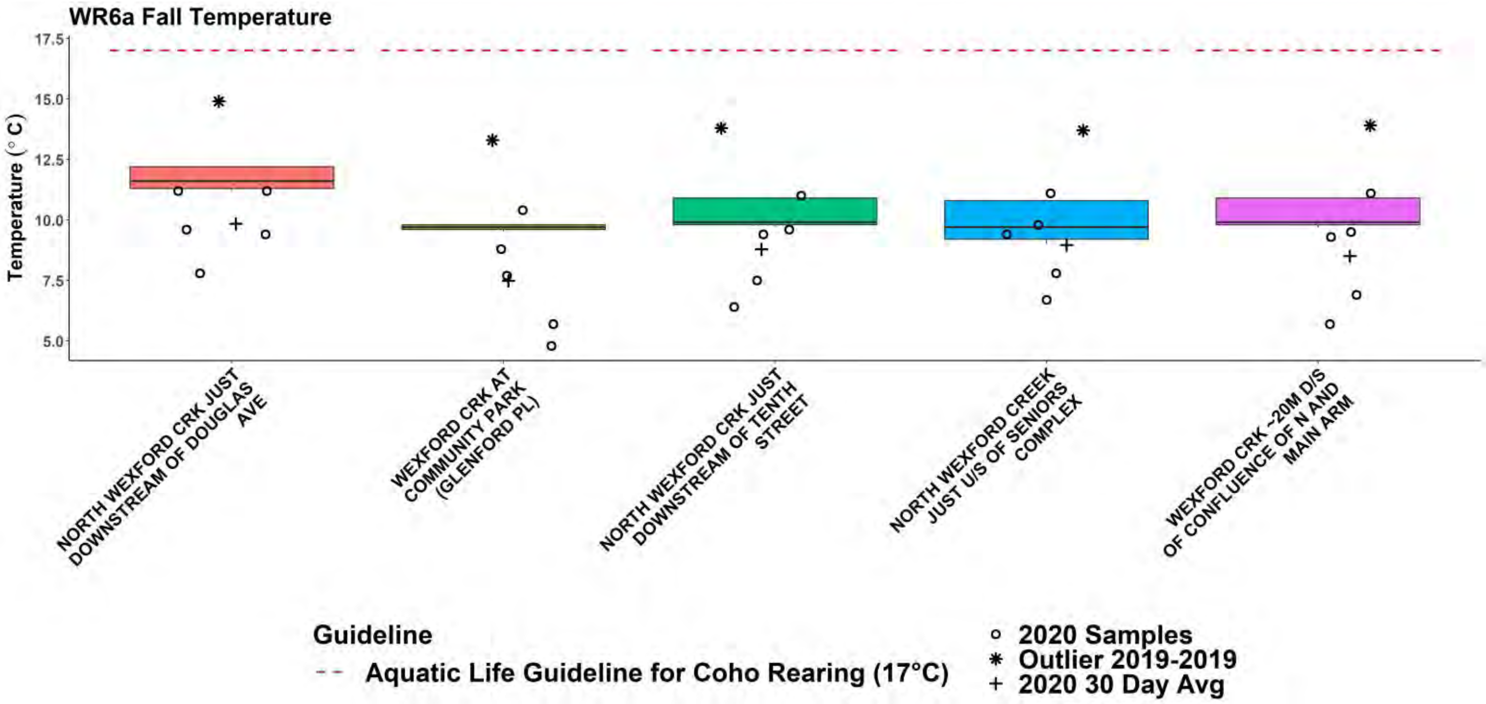

Figure B107: Fall 2019-2020 water temperature of CWMN sites in Water Region 6a (Nanaimo River) with BC Water Quality guidelines for Aquatic Life.

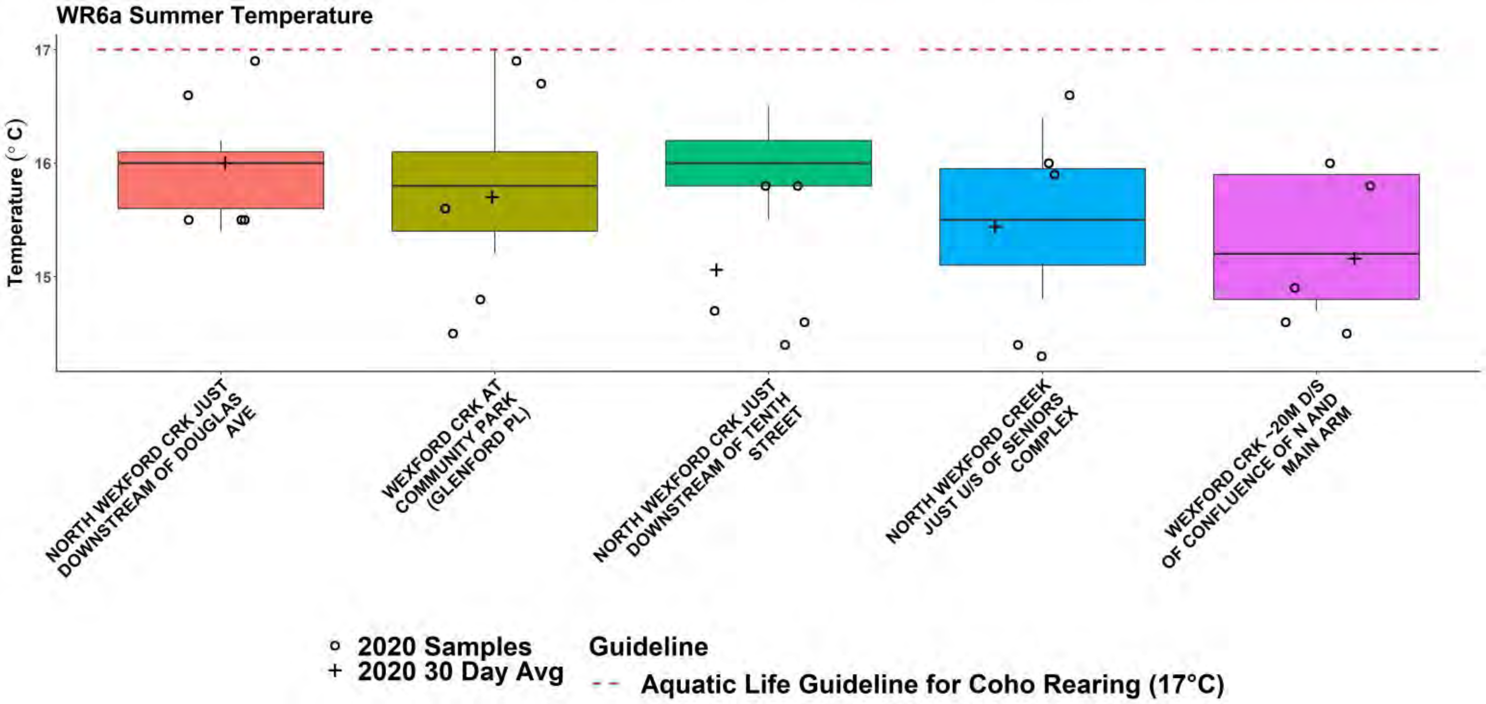

Figure B108: Summer 2019-2020 water temperature of CWMN sites in Water Region 6a (Nanaimo River) with BC Water Quality guidelines for Aquatic Life.

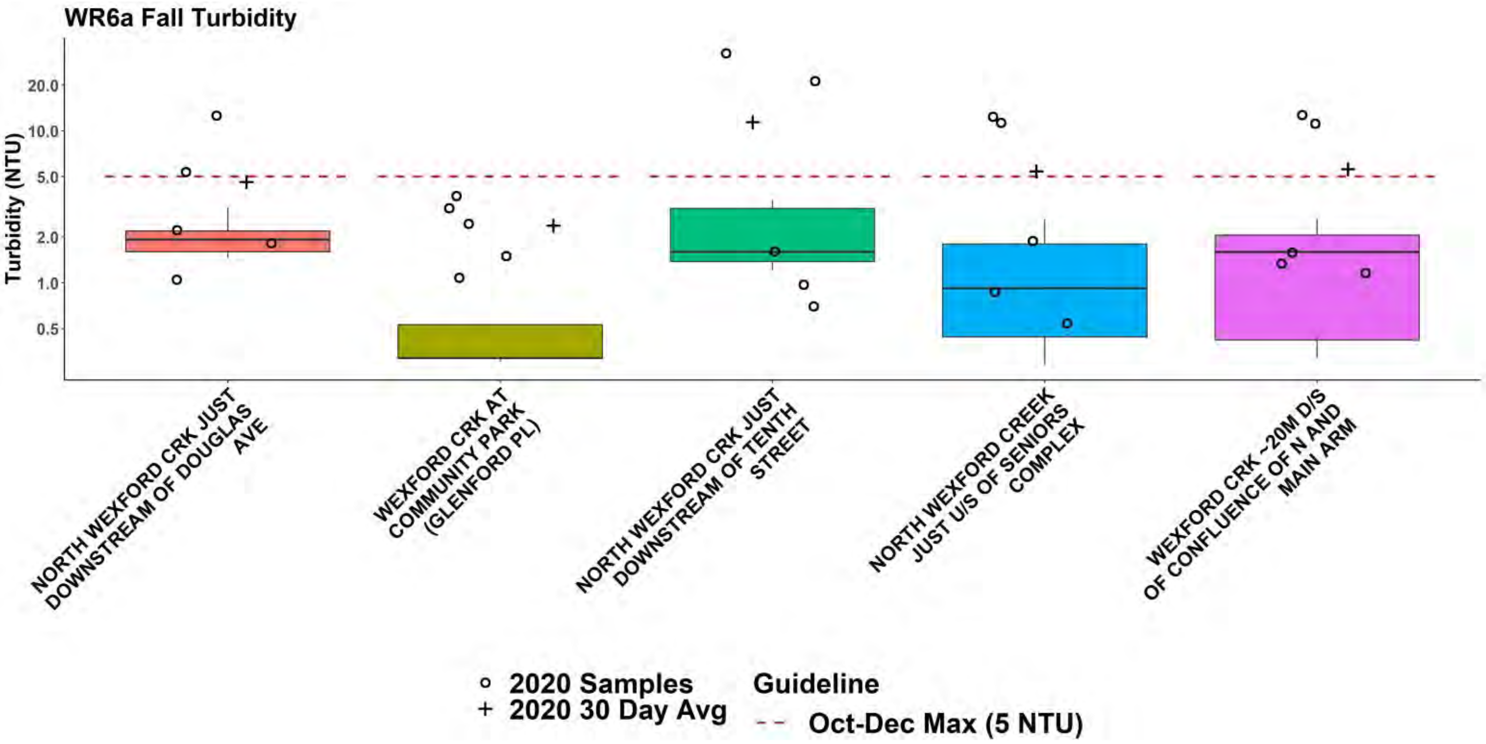

Figure B109: Fall 2019-2020 turbidity of CWMN sites in Water Region 6a (Nanaimo River) with BC Water Quality guidelines for Aquatic Life.

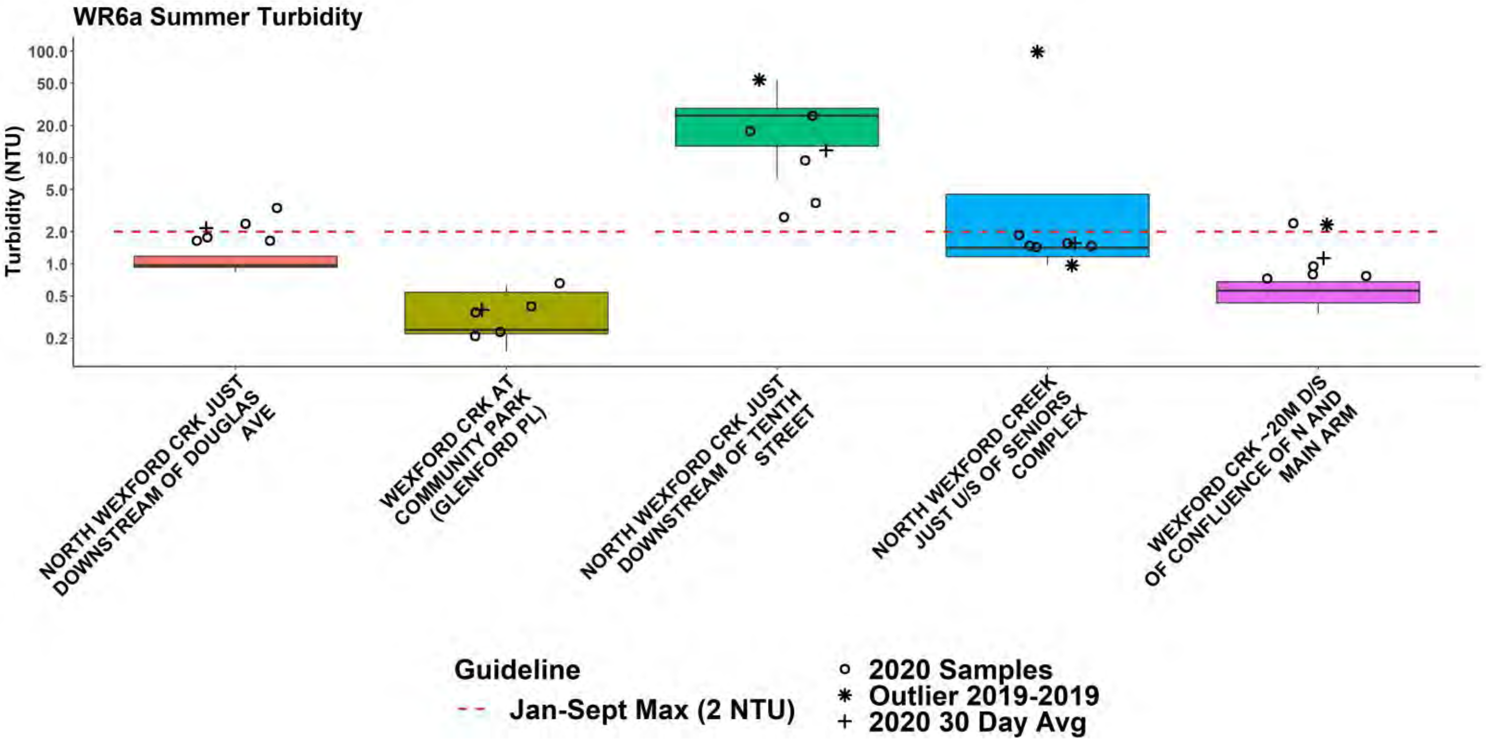

Figure B110: Summer 2019-2020 turbidity of CWMN sites in Water Region 6a (Nanaimo River) with BC Water Quality guidelines for Aquatic Life.

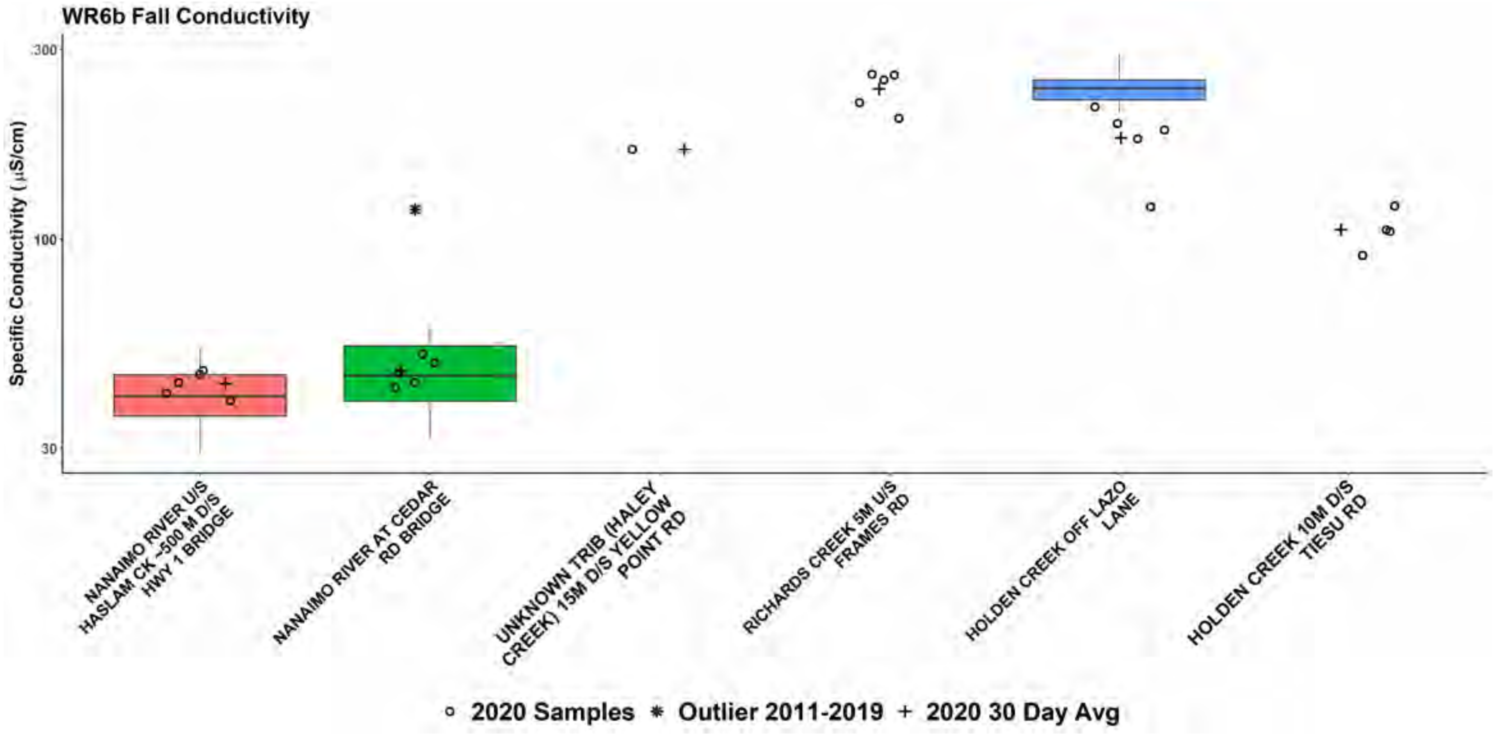

Figure B111: Fall 2011-2020 specific conductivity of CWMN sites in Water Region 6b (Nanaimo River).

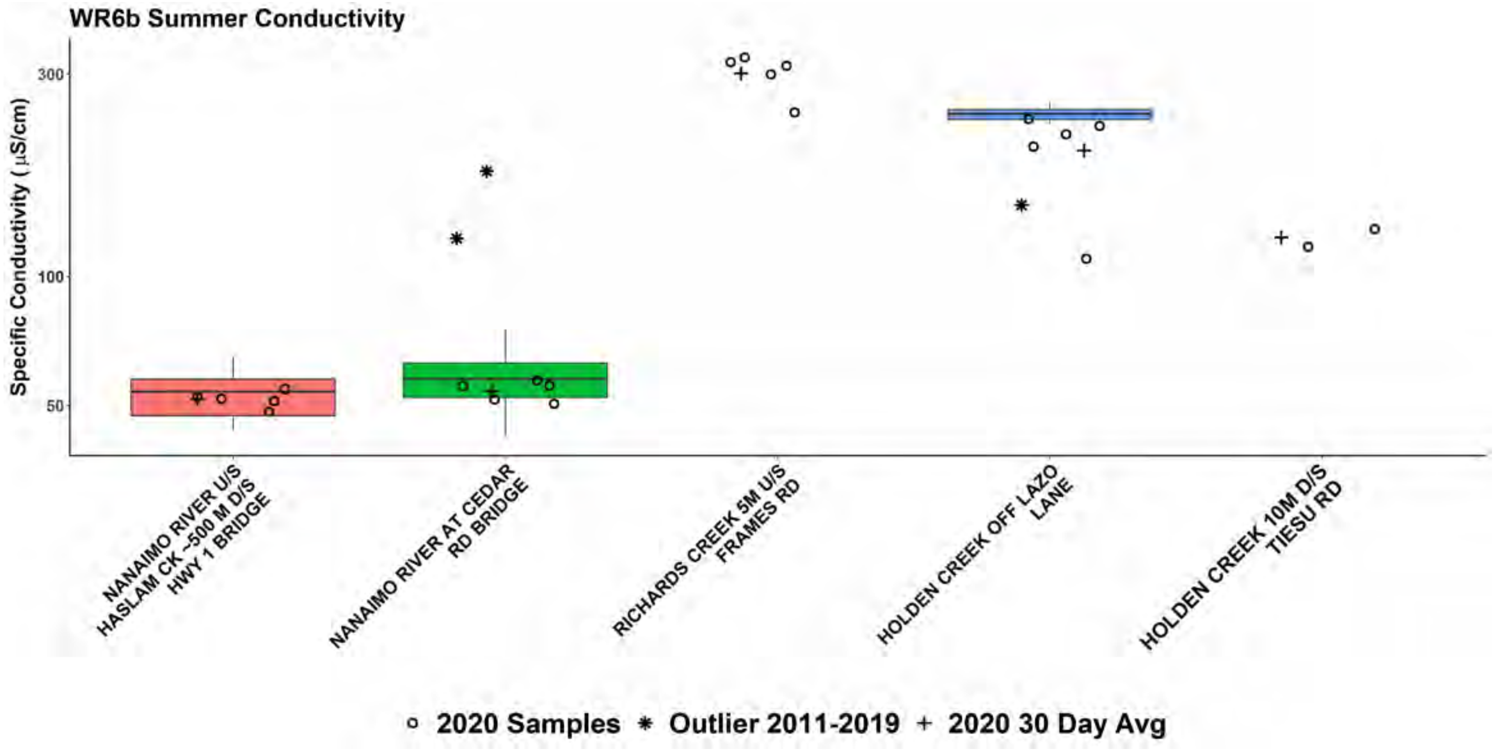

Figure B112: Summer 2011-2020 specific conductivity of CWMN sites in Water Region 6b (Nanaimo River).

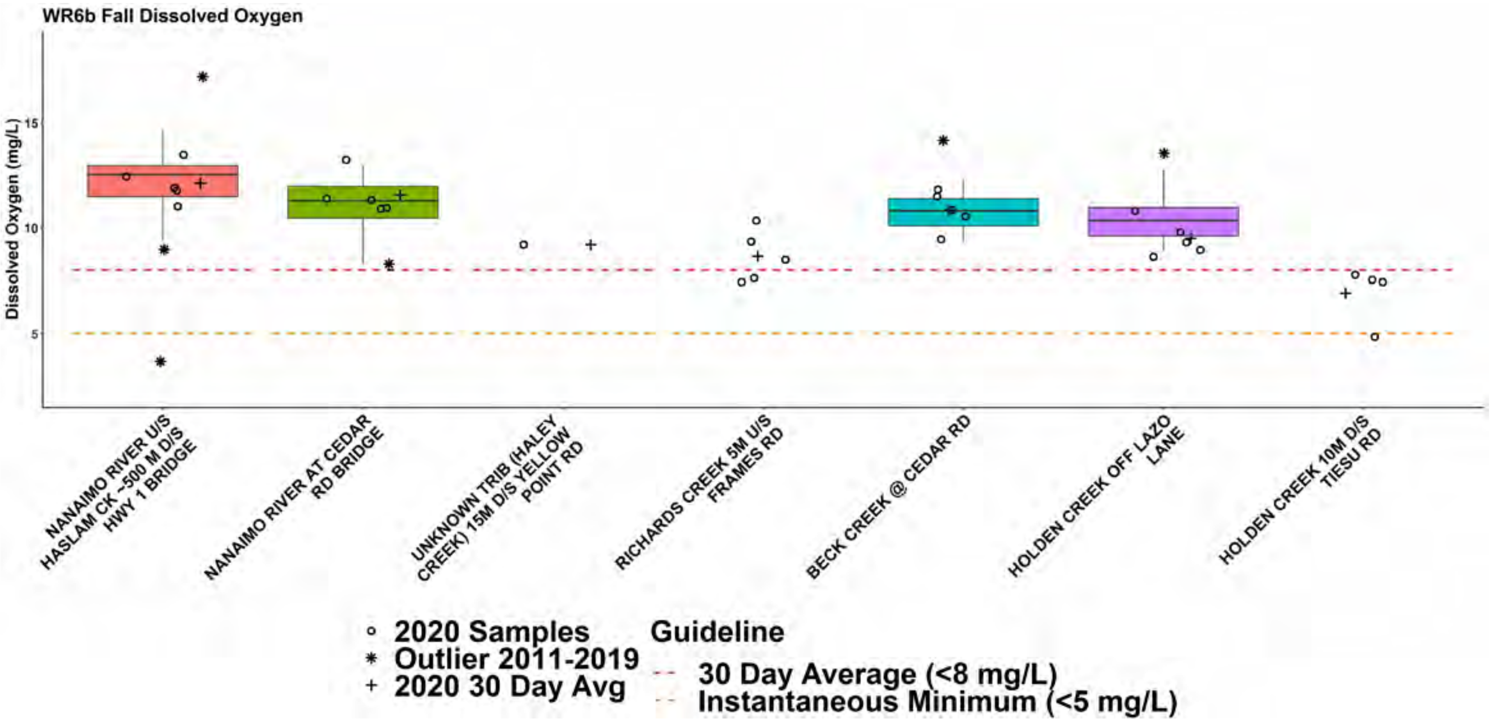

Figure B113: Fall 2011-2020 dissolved oxygen of CWMN sites in Water Region 6b (Nanaimo River) with Englishman River water quality objectives.

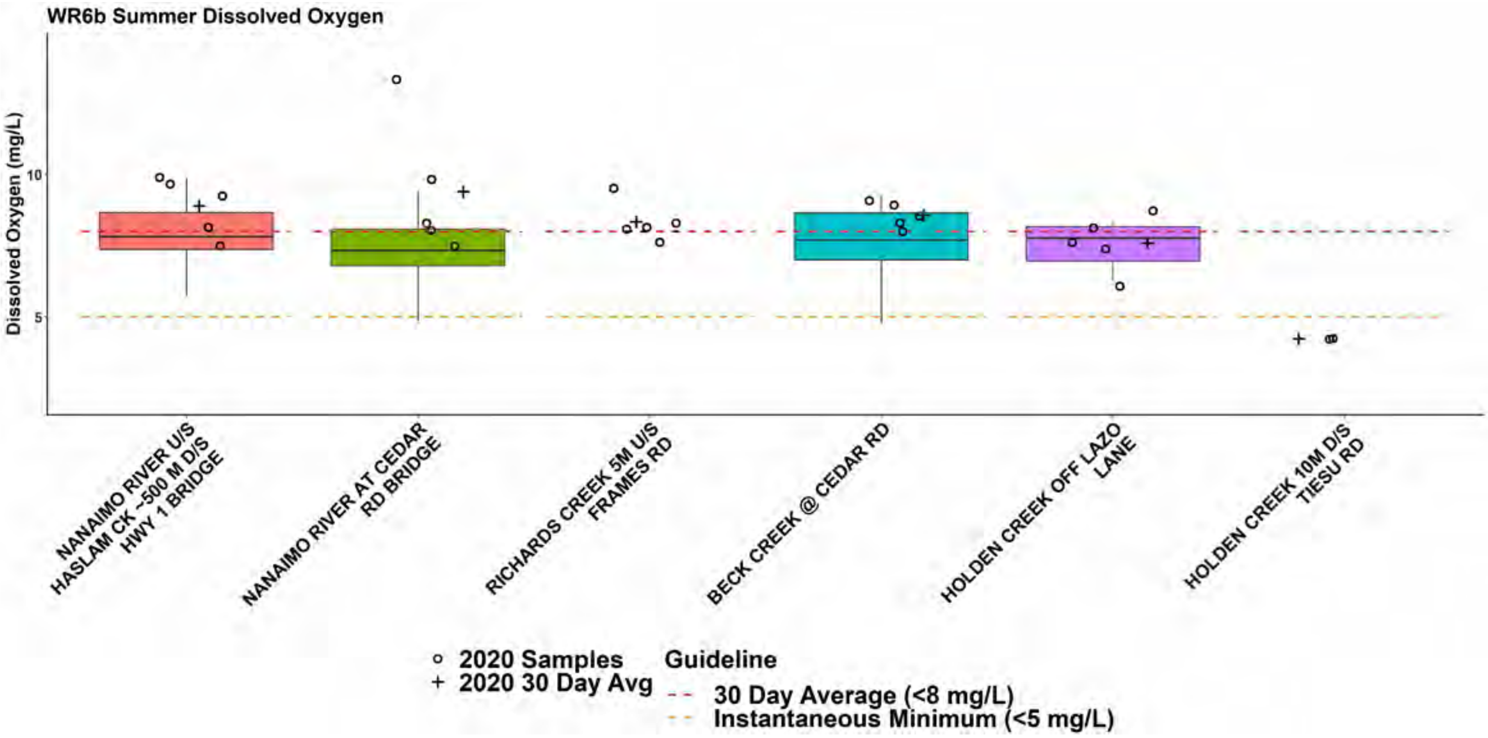

Figure B114: Summer 2011-2020 dissolved oxygen of CWMN sites in Water Region 6b (Nanaimo River) with Englishman River water quality objectives.

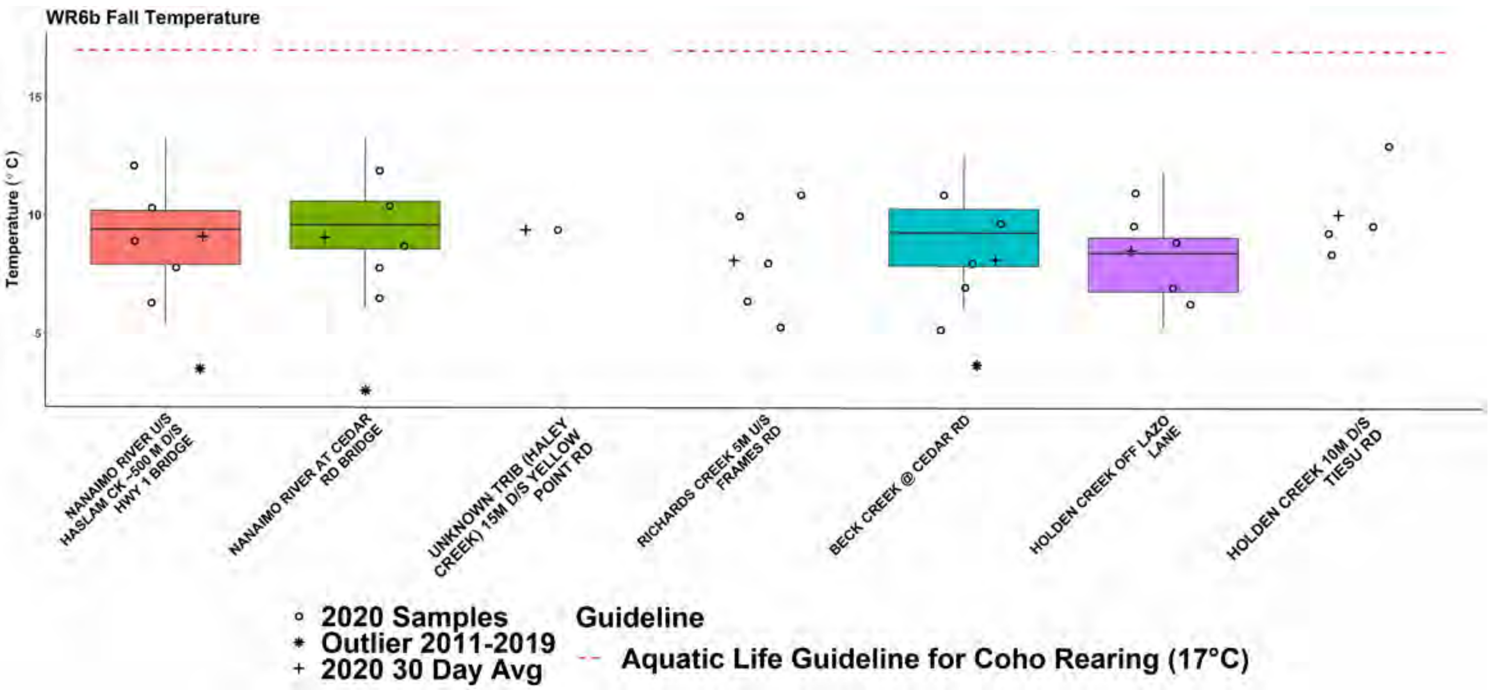

Figure B115: Fall 2011-2020 water temperature of CWMN sites in Water Region 6b (Nanaimo River) with BC Water Quality guidelines for Aquatic Life.

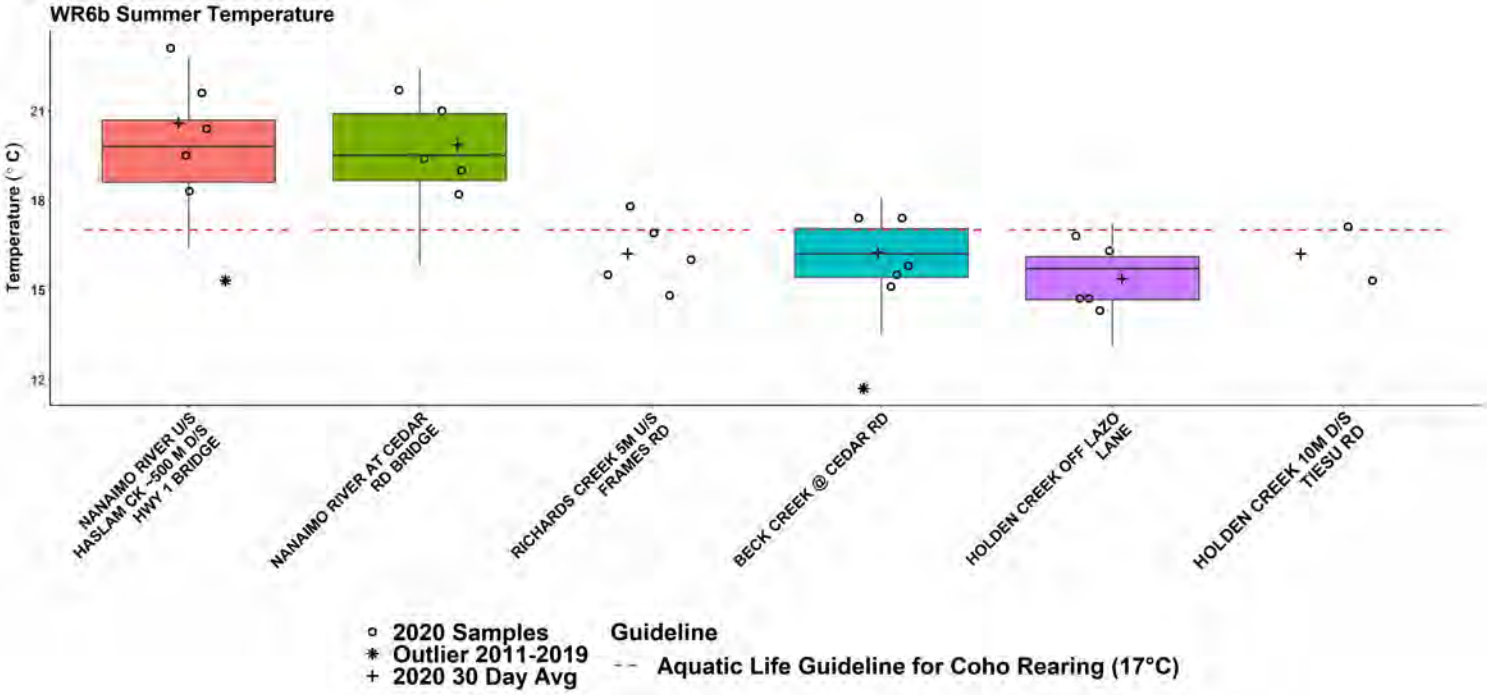

Figure B116: Summer 2011-2020 water temperature of CWMN sites in Water Region 6b (Nanaimo River) with BC Water Quality guidelines for Aquatic Life.

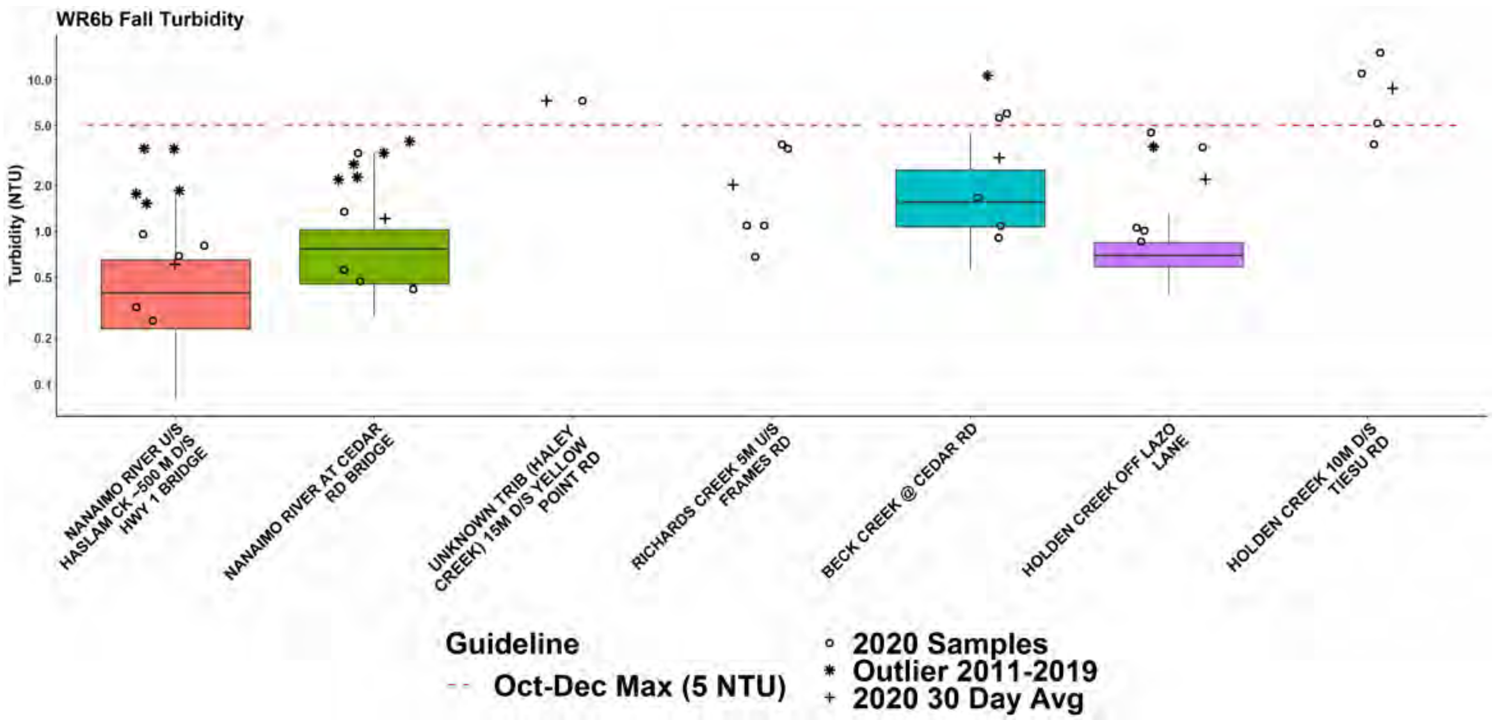

Figure B117: Fall 2011-2020 turbidity of CWMN sites in Water Region 6b (Nanaimo River) with BC Water Quality guidelines for Aquatic Life.

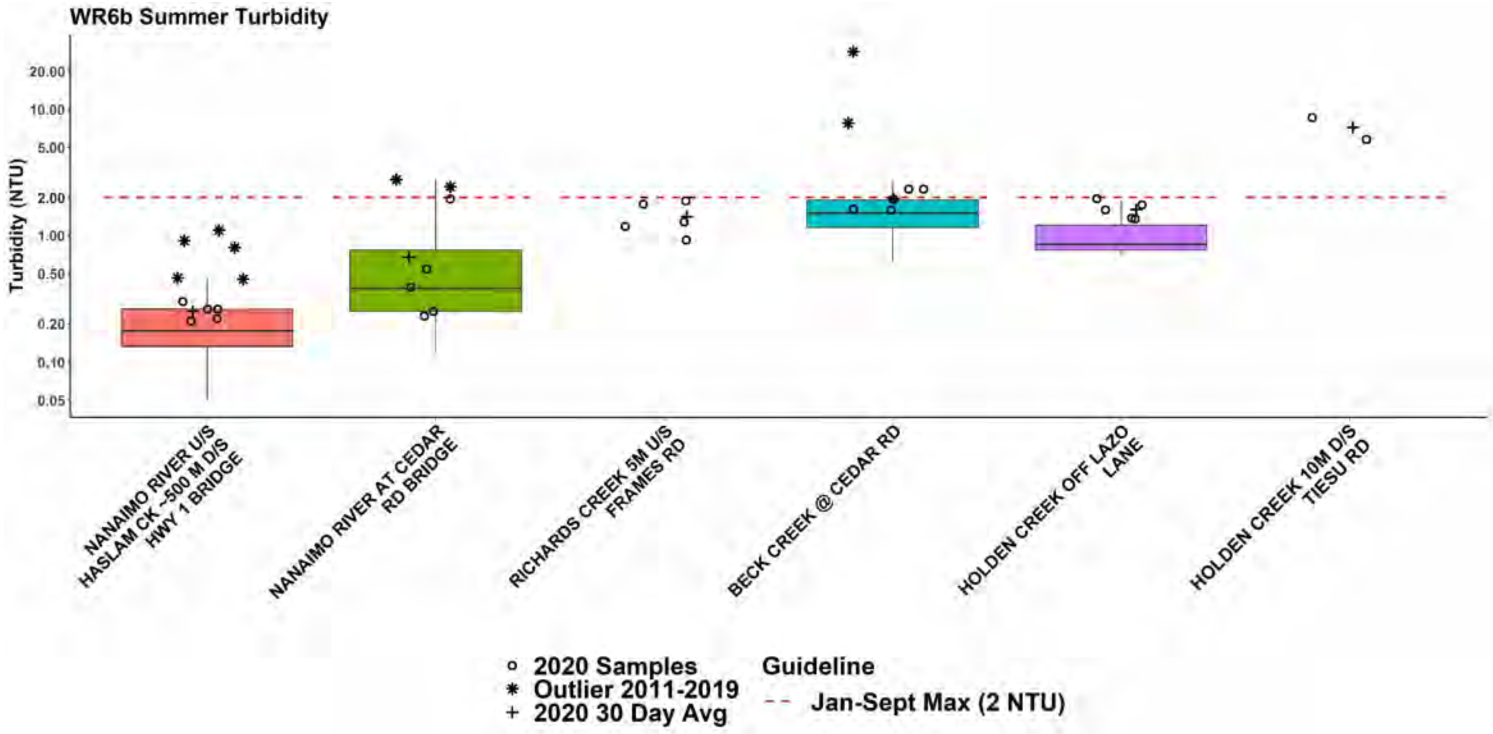

Figure B118: Summer 2011-2020 turbidity of CWMN sites in Water Region 6b (Nanaimo River) with BC Water Quality guidelines for Aquatic Life.

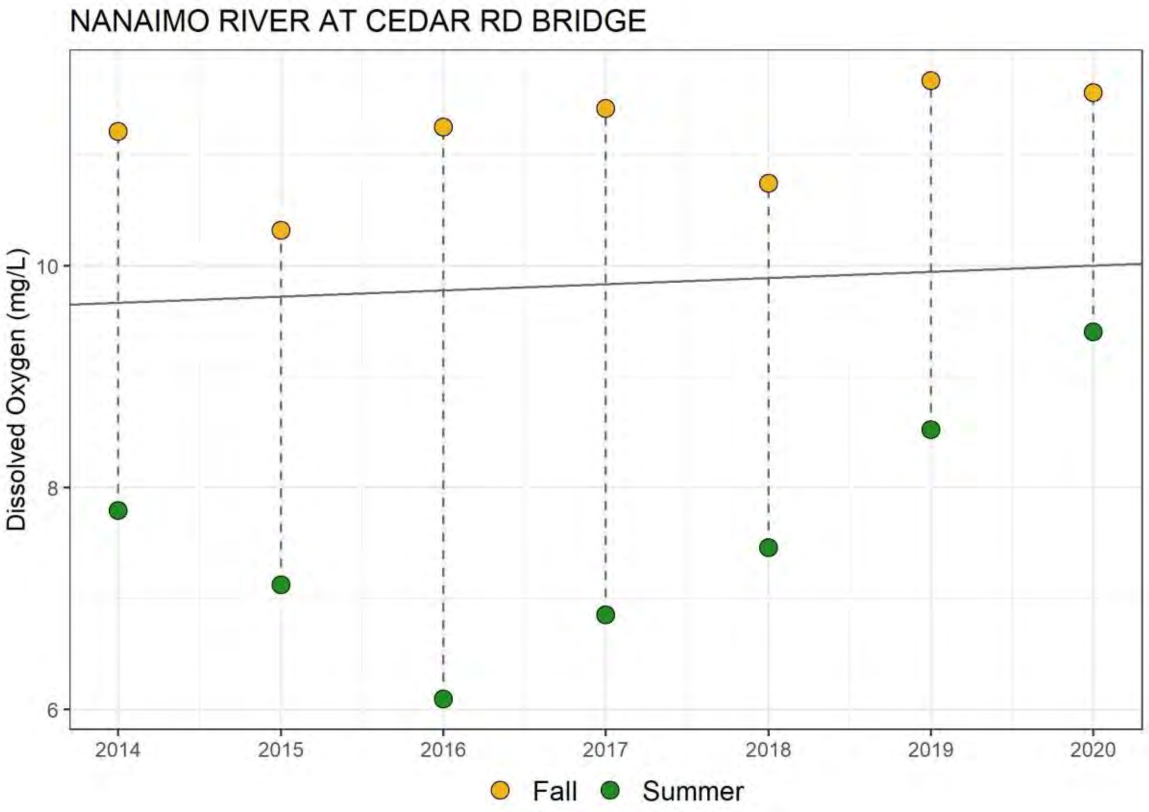

Figure B119: 2014-2020 Seasonal Mann-Kendall analysis plot for dissolved oxygen at the CMWN site: Nanaimo River at Cedar Road bridge

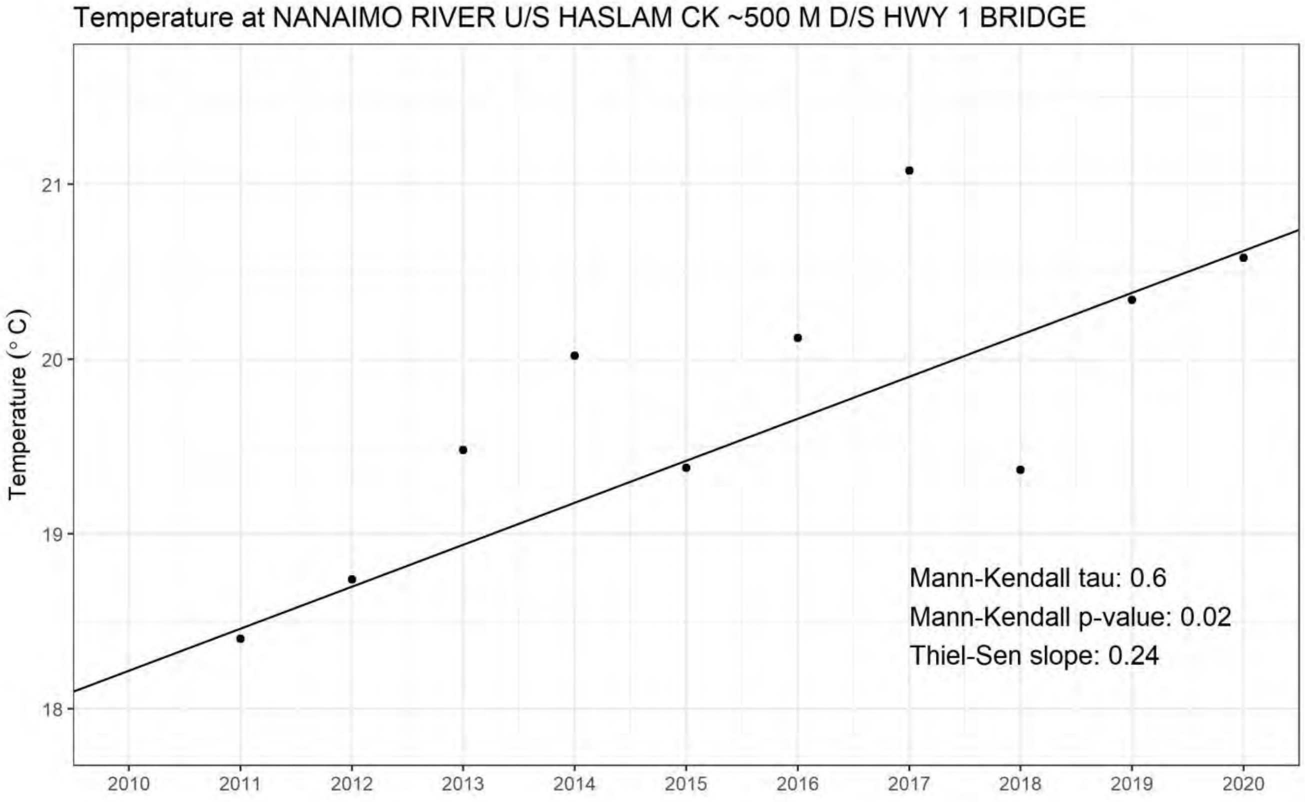

Figure B120: 2011-2020 Mann-Kendall analysis plot for water temperature in the summer at the CMWN site: Nanaimo River u/s Haslam Ck

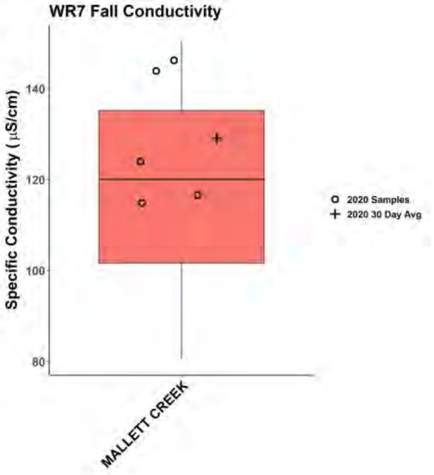

Figure B121: Fall 2015-2020 specific conductivity of CWMN sites in Water Region 7 (Gabriola Island).

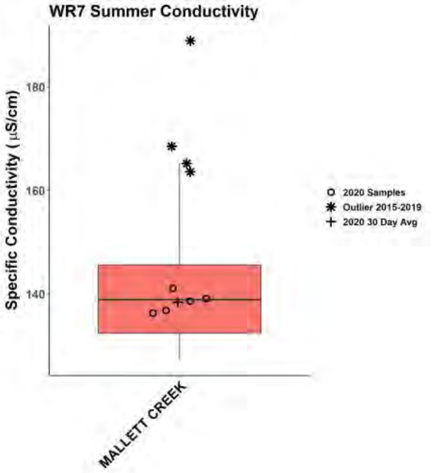

Figure B122: Summer 2015-2020 specific conductivity of CWMN sites in Water Region 7 (Gabriola Island).

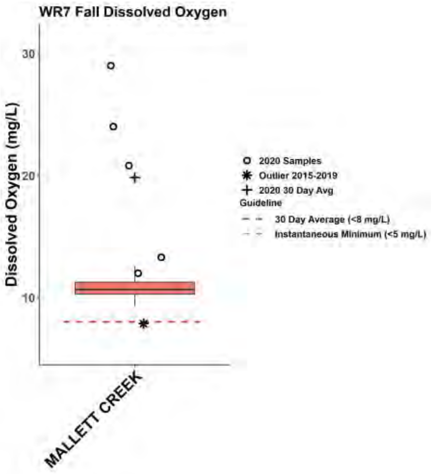

Figure B123: Fall 2015-2020 dissolved oxygen of CWMN sites in Water Region 7 (Gabriola Island) with Englishman River water quality objectives.

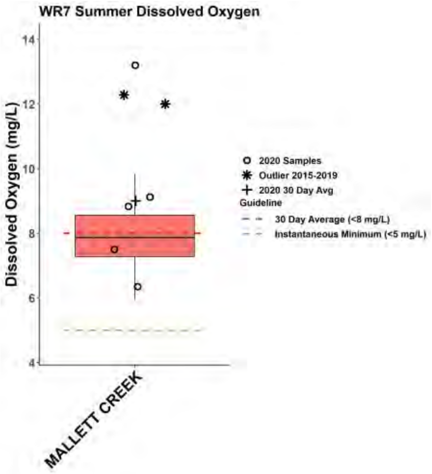

Figure B124: Summer 2015-2020 dissolved oxygen of CWMN sites in Water Region 7 (Gabriola Island) with Englishman River water quality objectives.

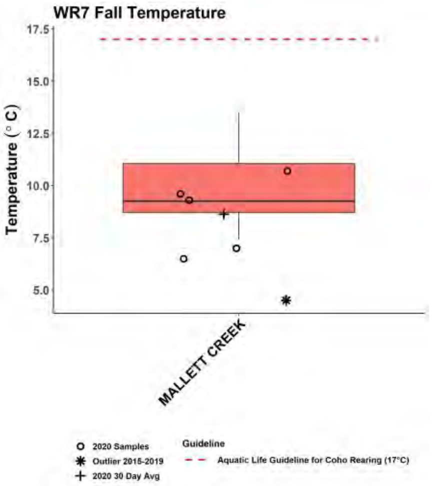

Figure B125: Fall 2015-2020 water temperature of CWMN sites in Water Region 7 (Gabriola Island) with BC Water Quality guidelines for Aquatic Life.

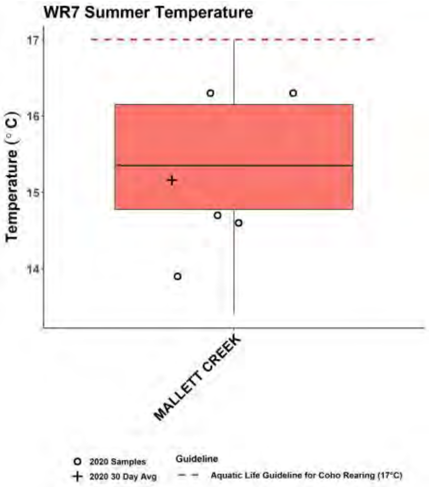

Figure B126: Summer 2015-2020 water temperature of CWMN sites in Water Region 7 (Gabriola Island) with BC Water Quality guidelines for Aquatic Life.

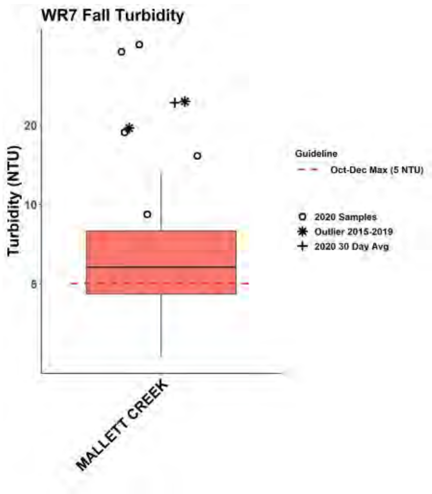

Figure B127: Fall 2015-2020 turbidity of CWMN sites in Water Region 7 (Gabriola Island) with BC Water Quality guidelines for Aquatic Life.

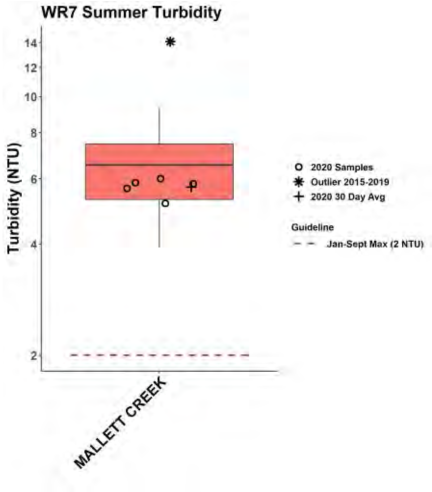

Figure B128: Summer 2015-2020 turbidity of CWMN sites in Water Region 7 (Gabriola Island) with BC Water Quality guidelines for Aquatic Life.

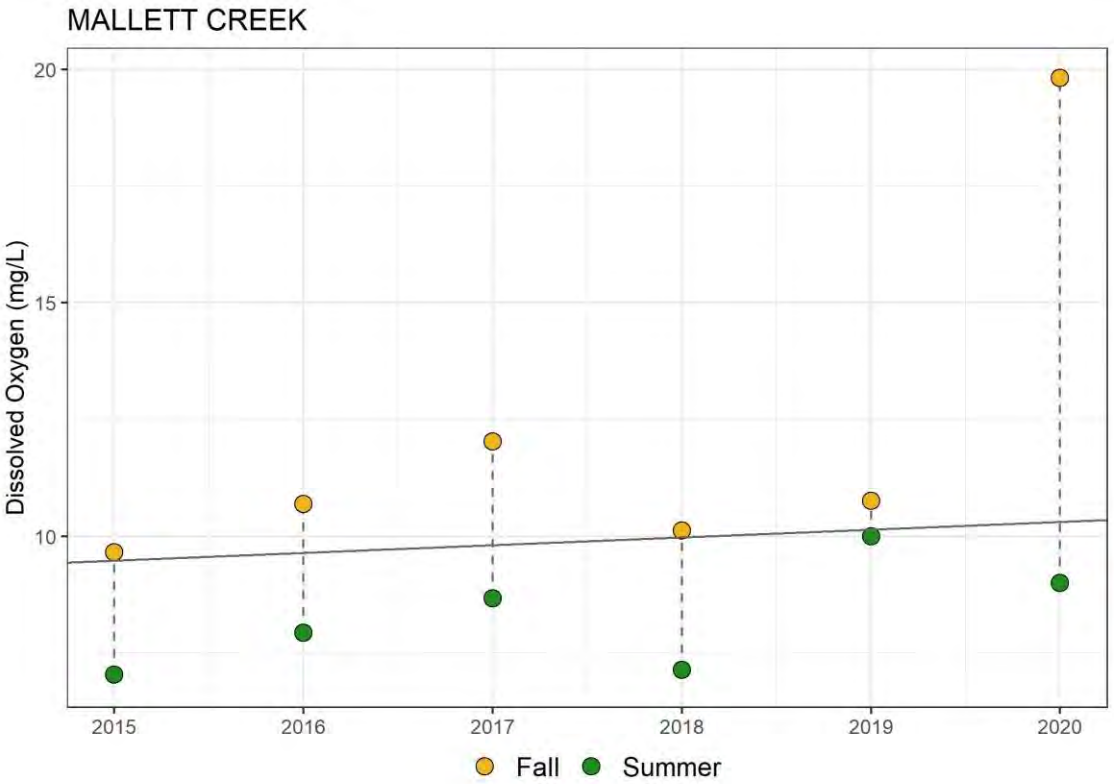

Figure B129: 2015-2020 Seasonal Mann-Kendall analysis plot for dissolved oxygen at the CMWN site: Mallett Creek

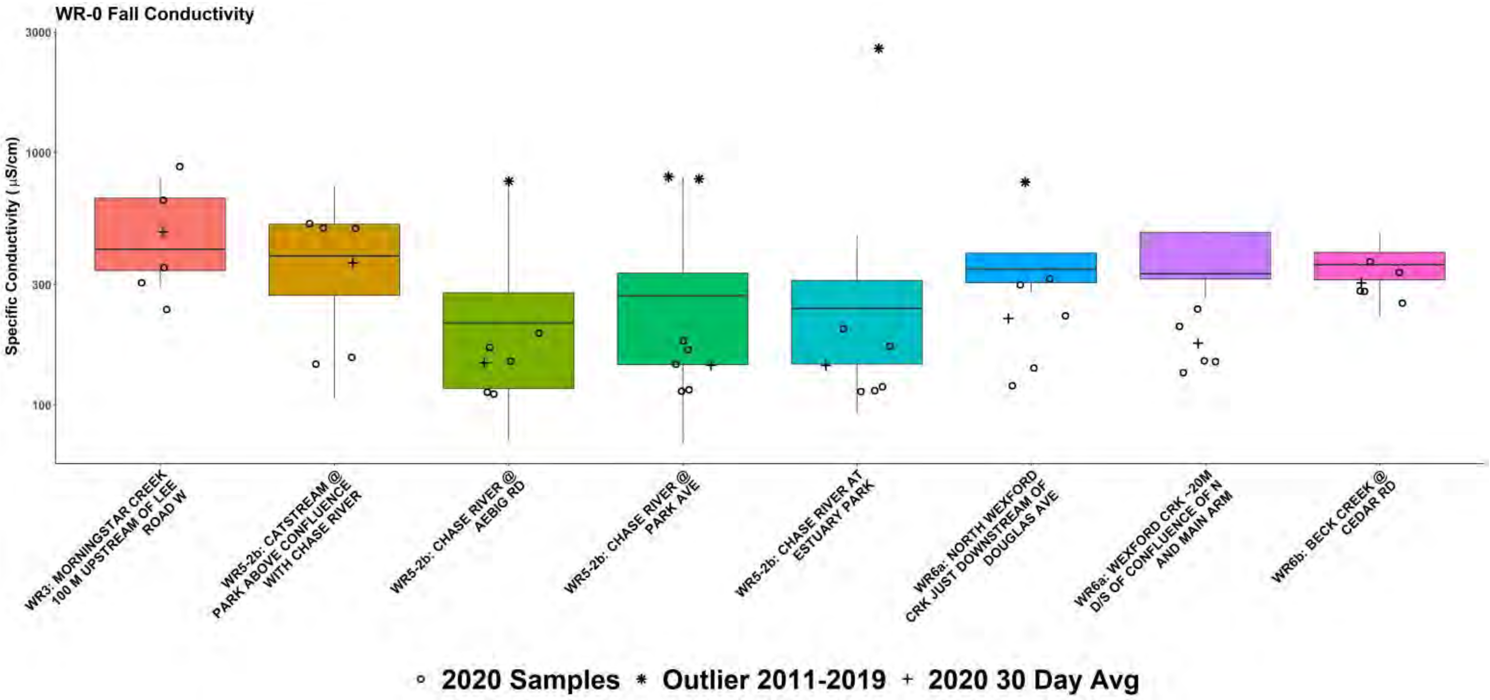

Figure B130: Fall 2011-2020 specific conductivity at CMWN sites with high specific conductivity.

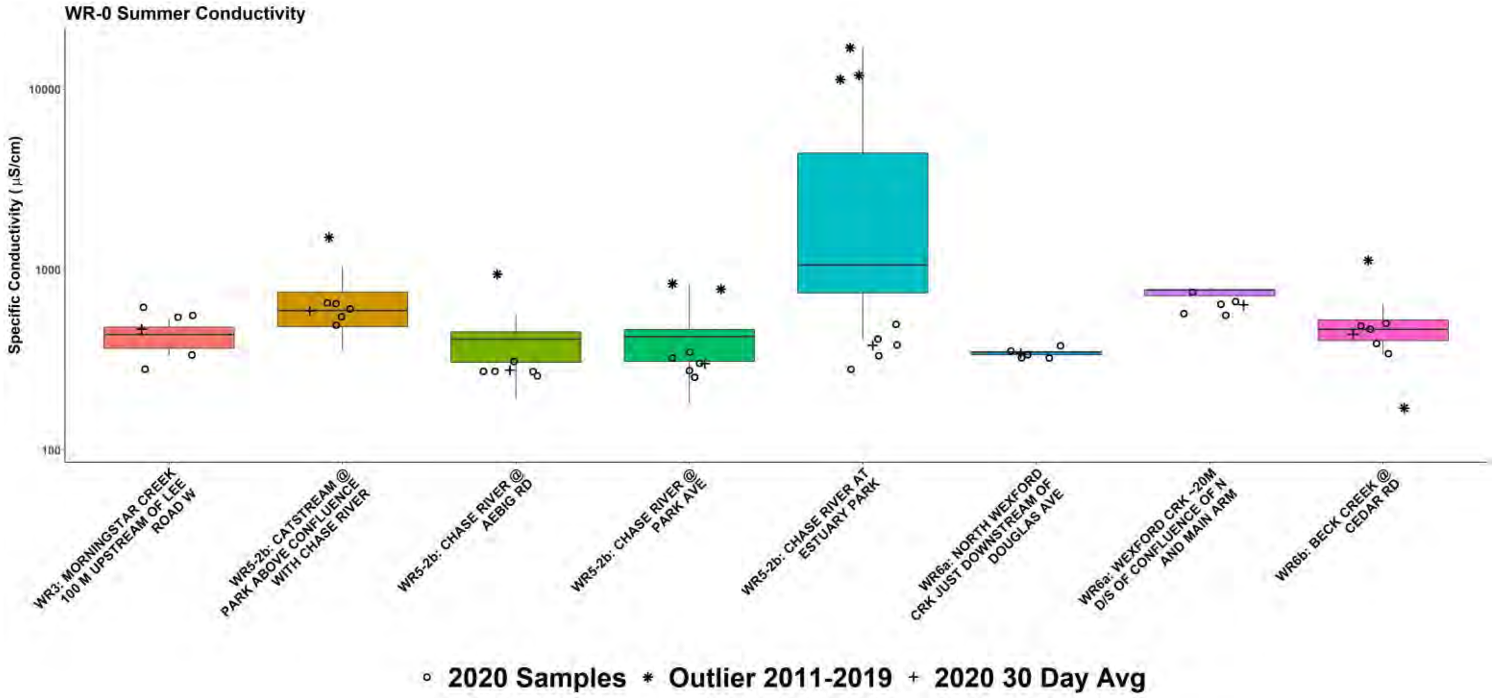

Figure B131: Summer 2011-2020 specific conductivity at CMWN sites with high specific conductivity.

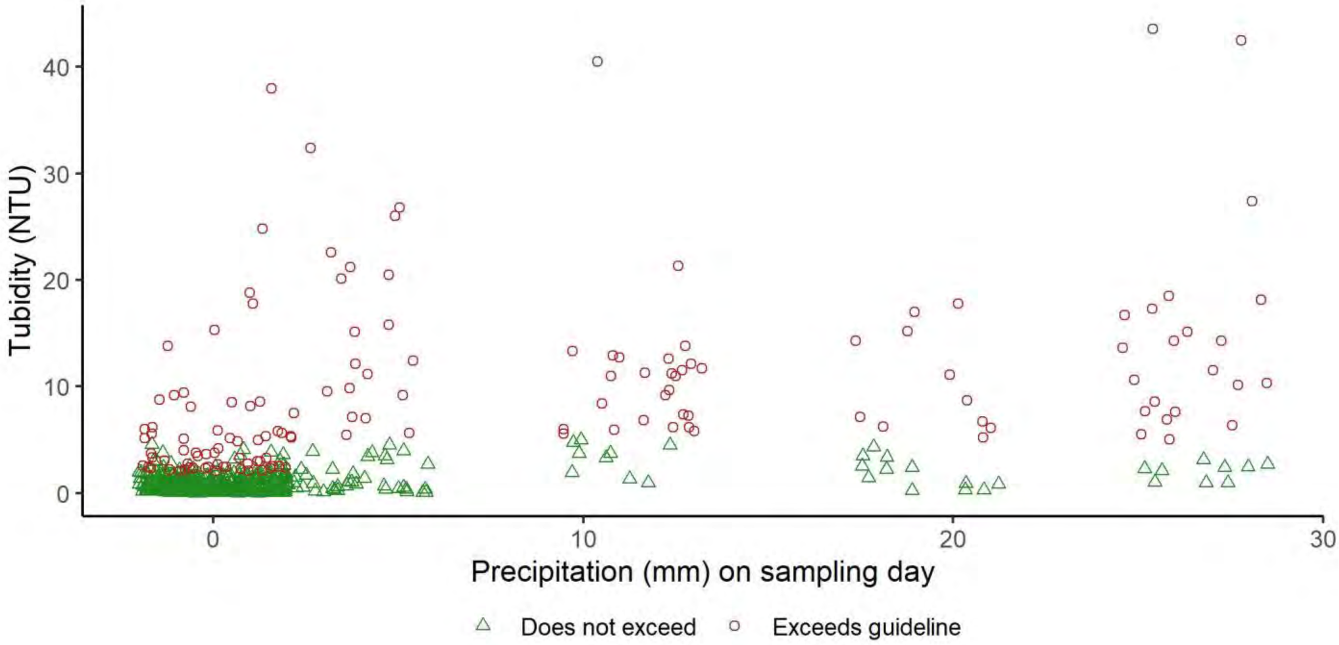

Figure B132: 2011-2020 plot of turbidity vs total precipitation recorded at the nearest Environment Canada weather monitoring station (Qualicum Beach or Nanaimo Airport) on the turbidity sampling date.

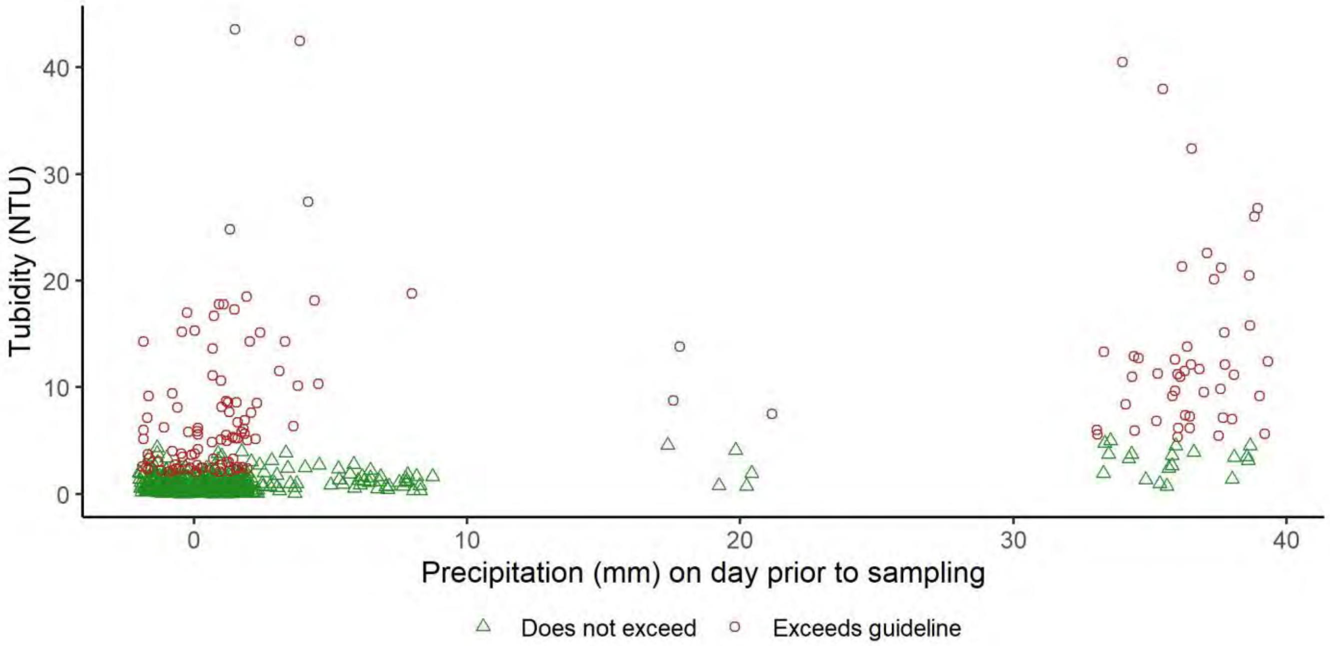

Figure B133: 2011-2020 plot of turbidity vs total precipitation recorded at the nearest Environment Canada weather monitoring station (Qualicum Beach or Nanaimo Airport) on the day preceding turbidity sampling.

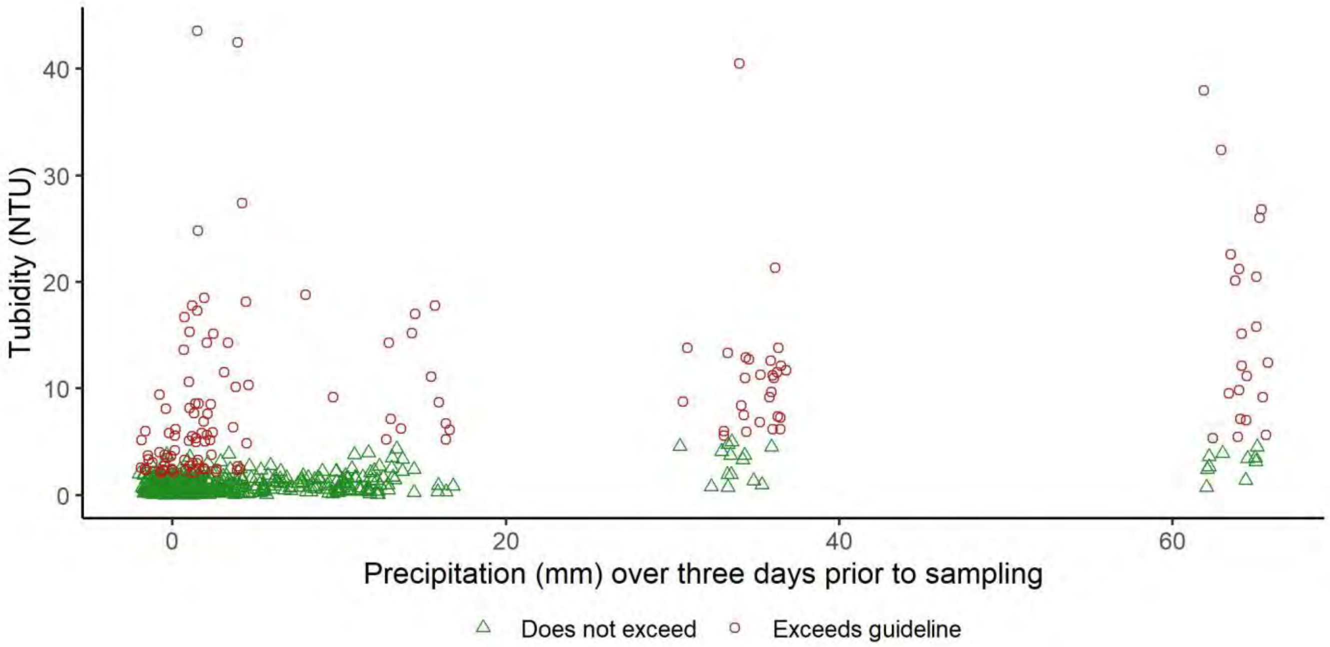

Figure B134: 2011-2020 plot of turbidity vs total precipitation recorded at the nearest Environment Canada weather monitoring station (Qualicum Beach or Nanaimo Airport) over the three days preceding turbidity sampling.

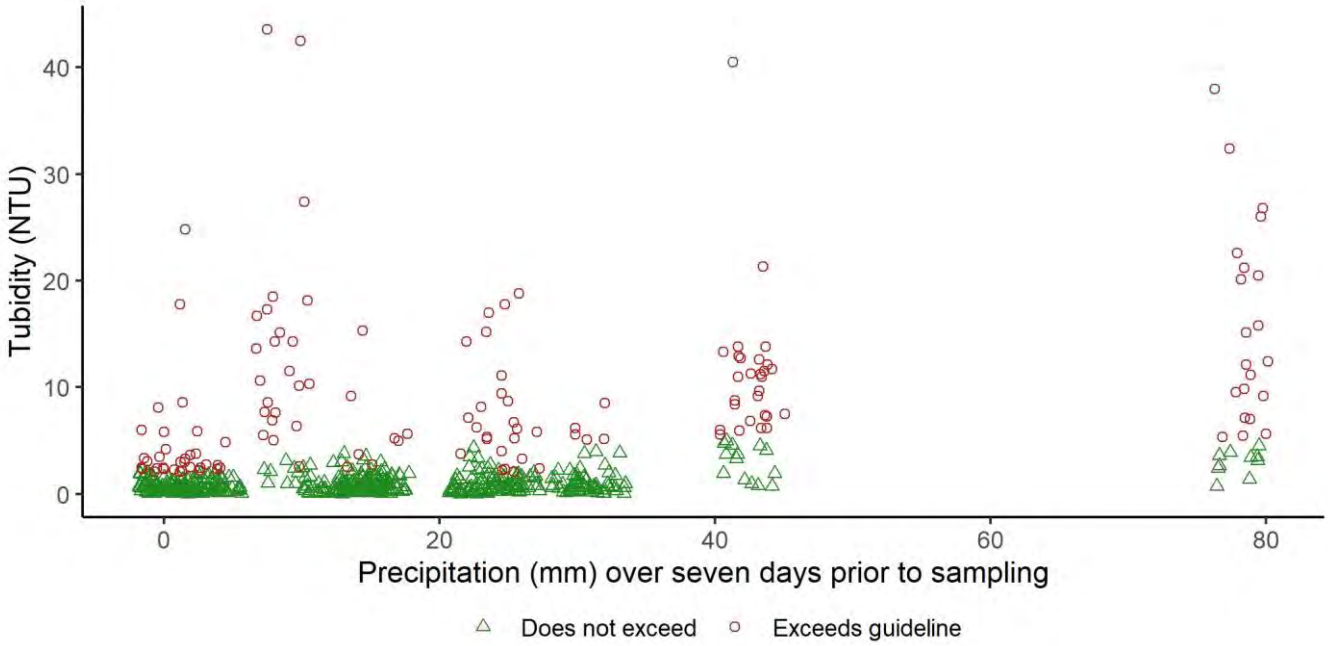

Figure B135: 2011-2020 plot of turbidity vs total precipitation recorded at the nearest Environment Canada weather monitoring station (Qualicum Beach or Nanaimo Airport) over the seven days preceding turbidity sampling.

Appendix C

Water Quality Summaries (Tables)

Table C6-1: Summary of Spearman's rank correlation test for correlation between rainfall and turbidity in summer and fall seasons at listed CWMN sites for four different time windows preceding sampling events. For an EMS ID : site label key, see Table C6-4.

WR	**EMS ID**	**Season**	**n**	**Precipitation on same day**		**Precipitation on previous day**		**Precipitation on previous three days**		**Precipitation on previous seven days**	
				r_S	***p*-value**	r_S	***p*-value**	r_S	***p*-value**	r_S	***p*-value**
WR1	E240141	Summer	5	-	-	0.71	0.182	0.783	0.118	-0.700	0.233
		Fall	5	0.67	0.219	0.30	0.683	0.200	0.783	-0.500	0.450
	E286549	Summer	5	-	-	0.00	1.000	0.335	0.581	0.700	0.233
		Fall	5	0.67	0.219	0.30	0.683	0.200	0.783	-0.500	0.450
	E286553	Summer	5	-	-	0.00	1.000	0.671	0.215	0.500	0.450
		Fall	5	0.67	0.219	0.30	0.683	0.200	0.783	-0.500	0.450
	E298597	Summer	5	-	-	-0.35	0.559	0.112	0.858	-0.500	0.450
		Fall	5	0.41	0.493	0.60	0.350	-0.100	0.950	-0.300	0.683
	E298598	Summer	5	-	-	-0.71	0.182	0.224	0.718	0.300	0.683
		Fall	5	0.34	0.573	0.46	0.434	-0.359	0.553	-0.821	0.089
	E306374	Summer	5	-	-	-0.72	0.165	-0.287	0.640	-0.359	0.553
		Fall	5	0.67	0.219	0.30	0.683	0.200	0.783	-0.500	0.450
	E306375	Summer	5	-	-	-0.35	0.559	0.112	0.858	-0.700	0.233
		Fall	5	0.67	0.219	0.30	0.683	0.200	0.783	-0.500	0.450
	E309086	Summer	5	-	-	0.00	1.000	-0.335	0.581	-0.400	0.517
		Fall	5	0.67	0.219	0.30	0.683	0.200	0.783	-0.500	0.450
WR2	E220635	Summer	5	-	-	-0.54	0.343	0.344	0.571	-0.359	0.553
		Fall	5	0.97	0.005	0.30	0.683	0.700	0.233	-0.400	0.517
	E256394	Summer	5	-	-	-0.35	0.559	0.447	0.450	-0.500	0.450
		Fall	5	0.67	0.219	0.30	0.683	0.200	0.783	-0.500	0.450
	E268993	Summer	5	-	-	0.35	0.559	0.224	0.718	-1.000	0.017
		Fall	5	0.56	0.322	0.70	0.233	0.200	0.783	-0.100	0.950
	E285669	Summer	5	-	-	0.18	0.770	0.803	0.102	-0.667	0.219
	E287697		5	-	-	0.00	1.000	0.671	0.215	0.300	0.683
		Fall	5	0.82	0.089	0.00	1.000	0.300	0.683	-0.900	0.083
	E318150	Summer	5	-	-	0.35	0.559	-0.112	0.858	0.100	0.950
		Fall	5	0.82	0.089	0.40	0.517	0.500	0.450	-0.300	0.683
WR3	E243021	Summer	5	-	-	0.35	0.559	-0.447	0.450	-0.700	0.233
		Fall	5	0.82	0.089	0.40	0.517	0.500	0.450	-0.300	0.683
	E243022	Summer	5	-	-	0.71	0.182	0.783	0.118	-0.600	0.350
		Fall	5	0.82	0.089	0.40	0.517	0.500	0.450	-0.300	0.683

WR	**EMS ID**	**Season**	**n**	**Precipitation on same day**		**Precipitation on previous day**		**Precipitation on previous three days**		**Precipitation on previous seven days**	
				r_S	***p*-value**	r_S	***p*-value**	r_S	***p*-value**	r_S	***p*-value**
	E243024	Summer	5	-	-	0.00	1.000	0.344	0.571	0.564	0.322
		Fall	5	0.82	0.089	0.40	0.517	0.500	0.450	-0.300	0.683
	E288090	Summer	5	-	-	-0.36	0.548	-0.057	0.927	-0.667	0.219
		Fall	5	0.82	0.089	0.40	0.517	0.500	0.450	-0.300	0.683
	E288091	Summer	5	-	-	0.00	1.000	0.671	0.215	0.300	0.683
		Fall	5	0.67	0.219	0.30	0.683	0.200	0.783	-0.500	0.450
	E288092	Summer	5	-	-	0.35	0.559	0.894	0.041	-0.100	0.950
		Fall	5	0.97	0.005	0.30	0.683	0.700	0.233	-0.400	0.517
	E288093	Summer	5	-	-	-0.35	0.559	0.112	0.858	0.300	0.683
		Fall	5	0.82	0.089	0.00	1.000	0.300	0.683	-0.900	0.083
	E318151	Summer	5	-	-	-0.71	0.182	0.224	0.718	0.100	0.950
		Fall	5	0.82	0.089	0.40	0.517	0.500	0.450	-0.300	0.683
WR4	0121580	Summer	5	-	-	0.00	1.000	-0.671	0.215	-0.500	0.450
		Fall	5	0.41	0.493	1.00	0.017	0.700	0.233	0.400	0.517
	E248834	Summer	5	-	-	0.00	1.000	0.335	0.581	-0.800	0.133
		Fall	5	0.62	0.269	0.90	0.083	0.500	0.450	0.000	1.000
	E248835	Summer	5	-	-	0.35	0.559	0.894	0.041	-0.500	0.450
		Fall	5	0.36	0.553	0.80	0.133	0.200	0.783	-0.100	0.950
	E248836	Summer	5	-	-	-0.56	0.327	0.177	0.776	-0.316	0.604
		Fall	5	0.62	0.269	0.90	0.083	0.500	0.450	0.000	1.000
	E282969	Summer	5	-	-	0.00	1.000	0.688	0.199	-0.667	0.219
	E287131		5	-	-	0.00	1.000	0.671	0.215	-0.700	0.233
		Fall	5	0.34	0.573	0.67	0.219	0.051	0.935	-0.154	0.805
	E290452	Summer	5	-	-	0.71	0.182	0.447	0.450	-0.300	0.683
		Fall	5	0.62	0.269	0.90	0.083	0.500	0.450	0.000	1.000
	E299852	Summer	5	-	-	0.35	0.559	-0.112	0.858	-0.900	0.083
		Fall	5	-0.15	0.805	-0.10	0.950	-0.500	0.450	-0.500	0.450
	E308186	Summer	5	-	-	-0.35	0.559	0.112	0.858	0.300	0.683
		Fall	5	0.62	0.269	0.90	0.083	0.500	0.450	0.000	1.000
WR5-1	E290469	Summer	5	-	-	-	-	-0.154	0.805	-0.500	0.450
		Fall	5	0.97	0.005	0.72	0.172	0.900	0.083	0.800	0.133
	E290470	Summer	5	-	-	-	-	0.821	0.089	-0.600	0.350
		Fall	5	0.92	0.026	0.82	0.092	0.872	0.054	0.872	0.054
	E290471	Summer	5	-	-	-	-	-0.237	0.701	0.872	0.054

WR	EMS ID	Season	n	Precipitation on same day		Precipitation on previous day		Precipitation on previous three days		Precipitation on previous seven days	
				r_S	*p*-value	r_S	*p*-value	r_S	*p*-value	r_S	*p*-value
		Fall	5	0.72	0.172	0.97	0.005	0.900	0.083	1.000	0.017
	E290472	Summer	5	-	-	-	-	0.205	0.741	-0.600	0.350
		Fall	5	0.56	0.322	0.82	0.089	0.600	0.350	0.700	0.233
	E290473	Summer	5	-	-	-	-	-0.308	0.614	-0.600	0.350
		Fall	5	0.87	0.054	0.82	0.089	1.000	0.017	0.900	0.083
	E290475	Summer	5	-	-	-	-	-0.051	0.935	-0.900	0.083
	E294010		5	-	-	-0.35	0.559	-0.894	0.041	0.100	0.950
		Fall	5	0.72	0.172	0.00	1.000	0.700	0.233	-0.100	0.950
	E294013	Summer	5	-	-	0.35	0.559	0.224	0.718	-1.000	0.017
		Fall	5	0.87	0.054	-0.10	0.950	0.900	0.083	-0.200	0.783
	E294017		-	-	-	-	-	-	-	-	-
	E294019		-	-	-	-	-	-	-	-	-
	E294020		-	-	-	-	-	-	-	-	-
	E306256	Summer	5	-	-	-	-	-0.872	0.054	-0.300	0.683
		Fall	5	0.82	0.089	0.87	0.054	0.800	0.133	0.900	0.083
	E306257	Summer	5	-	-	-	-	0.605	0.279	0.051	0.935
		Fall	5	0.82	0.089	0.87	0.054	0.800	0.133	0.900	0.083
	E306434	Summer	5	-	-	-	-	-0.359	0.553	0.300	0.683
		Fall	5	0.72	0.172	0.97	0.005	0.900	0.083	1.000	0.017
	E309186	Summer	5	-	-	-	-	-0.462	0.434	-0.700	0.233
WR5-2	E290478		5	-	-	-	-	-0.821	0.089	0.000	1.000
		Fall	5	0.72	0.172	0.97	0.005	0.900	0.083	1.000	0.017
	E290479	Summer	5	-	-	-	-	0.718	0.172	0.400	0.517
		Fall	5	0.72	0.172	0.97	0.005	0.900	0.083	1.000	0.017
	E290480	Summer	5	-	-	-	-	-0.462	0.434	-0.500	0.450
		Fall	5	0.72	0.172	0.97	0.005	0.900	0.083	1.000	0.017
	E290481	Summer	5	-	-	-	-	-0.205	0.741	0.400	0.517
		Fall	5	0.72	0.172	0.97	0.005	0.900	0.083	1.000	0.017
	E290483	Summer	5	-	-	-	-	0.921	0.026	-0.462	0.434
		Fall	5	0.87	0.054	0.67	0.219	0.900	0.083	0.700	0.233
	E290484	Summer	5	-	-	-	-	0.289	0.637	-0.154	0.805
		Fall	5	0.87	0.054	0.67	0.219	0.900	0.083	0.700	0.233
	E290485	Summer	5	-	-	-	-	0.205	0.741	0.600	0.350
		Fall	5	0.87	0.054	0.82	0.089	1.000	0.017	0.900	0.083

WR	**EMS ID**	**Season**	**n**	**Precipitation on same day**		**Precipitation on previous day**		**Precipitation on previous three days**		**Precipitation on previous seven days**	
				r_S	***p*-value**	r_S	***p*-value**	r_S	***p*-value**	r_S	***p*-value**
	E290486	Summer	5	-	-	-	-	-0.564	0.322	-0.300	0.683
		Fall	5	0.87	0.054	0.82	0.089	1.000	0.017	0.900	0.083
	E306294	Summer	5	-	-	-	-	-0.051	0.935	-0.300	0.683
		Fall	5	0.87	0.054	0.82	0.089	1.000	0.017	0.900	0.083
	E309280	Summer	5	-	-	-	-	0.051	0.935	0.900	0.083
		Fall	5	0.72	0.172	0.97	0.005	0.900	0.083	1.000	0.017
	E321394	Summer	5	-	-	-	-	-0.359	0.553	0.900	0.083
		Fall	5	0.82	0.089	0.87	0.054	0.800	0.133	0.900	0.083
WR6	E215789	Summer	5	-	-	-	-	0.205	0.741	-0.800	0.133
		Fall	5	0.97	0.005	0.56	0.322	0.800	0.133	0.600	0.350
	E287699	Summer	5	-	-	-	-	0.105	0.866	-0.103	0.870
		Fall	5	0.56	0.322	0.67	0.219	0.500	0.450	0.700	0.233
	E290487	Summer	5	-	-	-	-	0.154	0.805	-0.300	0.683
		Fall	5	0.97	0.005	0.56	0.322	0.800	0.133	0.600	0.350
	E310147	Summer	5	-	-	-	-	-0.462	0.434	-0.500	0.450
		Fall	5	0.67	0.219	0.87	0.054	0.600	0.350	0.800	0.133
	E318152	Summer	5	-	-	-	-	-0.263	0.669	0.308	0.614
		Fall	5	0.67	0.219	0.87	0.054	0.600	0.350	0.800	0.133
	E318153	Summer	5	-	-	-	-	-0.308	0.614	-0.600	0.350
		Fall	5	0.72	0.172	0.97	0.005	0.900	0.083	1.000	0.017
	E318154	Summer	5	-	-	-	-	-0.154	0.805	-0.500	0.450
		Fall	5	0.97	0.005	0.72	0.172	0.900	0.083	0.800	0.133
	E318155	Summer	5	-	-	-	-	-0.051	0.935	0.900	0.083
		Fall	5	0.97	0.005	0.72	0.172	0.900	0.083	0.800	0.133
	E318172	Summer	5	-	-	-	-	-0.616	0.269	-0.600	0.350
		Fall	5	0.72	0.172	0.97	0.005	0.900	0.083	1.000	0.017
	E321392		-	-	-	-	-	-	-	-	-
	E321393		-	-	-	-	-	-	-	-	-
	E321395	Summer	5	-	-	-	-	-0.667	0.219	0.700	0.233
		Fall	5	0.82	0.089	0.56	0.322	0.600	0.350	0.500	0.450
WR7	E304070	Summer	5	0.00	1.000	0.00	1.000	0.564	0.322	-0.900	0.083
		Fall	5	0.67	0.219	0.87	0.054	0.600	0.350	0.800	0.133

Table C6-2: Summary of exceedance classes for 87 CMWN sites in the Regional District of Nanaimo. Classes shown are: low exceedance frequency (1 or 2 exceedances); moderate exceedance frequency (3 or 4 exceedances); and high exceedance frequency (≥5 exceedances). Dashes indicate no recorded exceedances.

WR	Site label	Dissolved oxygen		Temperature		Turbidity	
		Summer	Fall	Summer	Fall	Summer	Fall
WR1	Annie Creek	-	-	Low	-	Moderate	High
WR1	Thames Creek u/s Old Island Hwy	-	-	-	-	-	Low
WR1	Thames Creek u/s Inland Island Hwy	-	-	-	-	-	-
WR1	Upper Nile Creek at Cochrane Main	-	-	-	-	-	-
WR1	Nile Creek 25m u/s hatchery	-	-	-	-	-	-
WR1	Nile Creek 50m u/s Old Island Hwy	-	-	-	-	-	Low
WR1	Big Qualicum u/s hwy 19A bridge	-	-	-	-	Low	-
WR1	Big Qualicum River d/s hatchery	-	-	-	-	Low	-
WR1	Rosewall Creek @ Rosewall Park	-	-	-	-	-	Low
WR1	Deep Bay Creek	-	-	-	-	Moderate	Low
WR1	Cook Creek @ Connector	-	-	-	-	-	-
WR2	Cameron River (near the highway)	-	-	-	-	-	Low
WR2	Little Qualicum River at Intake	-	-	High	-	-	Low
WR2	Little Qualicum River d/s Cameron	-	-	High	-	-	-
WR2	Upper Cameron River	-	-	-	-	-	-
WR2	Whiskey Creek on Hwy 4 @ Save On	-	-	-	-	-	Moderate
WR2	Little Qualicum River u/s hwy 19A	-	-	Low	-	Low	-
WR2	Harris Creek d/s of HWY 4	-	-	-	-	Low	Low
WR3	French Creek at new highway	-	-	-	-	-	Low
WR3	French Creek at Barclay Bridge	-	-	Moderate	-	Low	Low
WR3	French Creek at Grafton Road	High	-	Low	-	-	Low
WR3	Grandon Creek at West Crescent	-	-	Moderate	-	High	Moderate
WR3	Grandon Creek at Laburnum Road	High	-	-	-	High	Moderate
WR3	Beach Creek near Chester Road	-	-	-	-	High	Low
WR3	Beach Creek near Memorial Golf	-	-	-	-	High	Moderate
WR3	Morningstar Creek u/s Lee Rd W	Low	-	-	-	-	Low
WR4	Englishman River at Highway 19A	-	-	High	-	Low	Moderate
WR4	Englishman River U/S from Morison Creek	-	-	Low	-	Low	Low
WR4	Morison Creek	Low	-	Moderate	-	Low	High
WR4	South Englishman River U/S from Englishman R.	Low	-	High	-	-	Low
WR4	Englishman River U/S Allsbrook	-	-	-	-	-	-
WR4	Upper Englishman River u/s Centre	Low	-	-	-	-	-
WR4	Shelly Creek @ Hamilton Road	Low	-	Moderate	-	Moderate	High
WR4	Shelly Creek @ end of Blower Rd	Low	-	Moderate	-	Low	High
WR4	Centre Creek	Low	-	Moderate	-	-	Low
WR4	Swayne Creek d/s of Errington Road	High	Moderate	Low	-	High	Moderate
WR5-1	Departure Ck @ Neyland Rd	-	-	-	-	Moderate	Moderate
WR5-1	Joseph's Creek (trib to Dep. Ck) off Newton St	-	-	Low	-	High	-

WR	Site label	Dissolved oxygen		Temperature		Turbidity	
		Summer	Fall	Summer	Fall	Summer	Fall
WR5-1	Departure Ck at Woodstream Park	-	-	-	-	Low	Low
WR5-1	Departure Ck @ outlet	-	-	-	-	High	Moderate
WR5-1	Cottle Creek @ Nottingham	High	-	High	-	Moderate	Moderate
WR5-1	North Cottle Creek d/s Burma Rd.	-	-	-	-	-	-
WR5-1	Cottle Creek @ Stephenson Pt Rd	Low	-	High	-	Low	Low
WR5-1	Cottle Creek @ Landalt Rd	-	-	Low	-	Low	-
WR5-1	Bloods Creek just u/s Dickenson Rd	-	-	-	-	-	Moderate
WR5-1	Knarston Ck @ Hydro Bridge		-		-		-
WR5-1	Knarston Ck just u/s Lantzville Rd	-	-	Low	-	-	Moderate
WR5-1	Craig Creek u/s Northwest Bay Rd	Low	Low	-	-	Low	Low
WR5-1	Nanoose Creek @ Campground	Low	Low	-	-	-	Low
WR5-1	Nanoose Creek @ Matthew Crossing	High	Low	Low	-	-	Low
WR5-1	Knarston Ck @ Superior Rd	-	-	-	-	-	-
WR5-1	Walley Ck d/s Hammond Bay	-	-	Moderate	-	High	Moderate
WR5-1	Walley Ck @ Morningside Dr	Low	-	-	-	Low	Moderate
WR5-1	Walley Creek 20m u/s beach	Low	Low	Moderate	-	Low	Moderate
WR5-1	Cottle Creek d/s Hammond Bay Rd	-	-	Moderate	-	Moderate	Low
WR5-1	Walley Creek 100m d/s McGuffie Rd	-	-	-	-	-	-
WR5-2	Benson Creek @ Biggs Road	Moderate	-	-	-	-	-
WR5-2	Millstone River @ Biggs Road	High	-	High	-	High	-
WR5-2	McGarrigle Ck @ Jingle Pot Rd	-	-	Low	-	Low	Low
WR5-2	Millstone River @ East Wellington	High	-	High	-	High	Moderate
WR5-2	Millstone River in Barsby Park	-	-	High	-	Moderate	High
WR5-2	Northfield Creek @ outlet	-	-	Moderate	-	Moderate	Moderate
WR5-2	Chase River @ Aebig	Moderate	-	High	-	Low	Moderate
WR5-2	Chase River @ Howard	Low	-	High	-	Low	Low
WR5-2	Chase River @ Park Ave	-	-	High	-	Moderate	Moderate
WR5-2	Cat Stream	Low	-	High	-	High	Moderate
WR5-2	Slogar Brook	-	-	-	-	-	-
WR5-2	Upper McGarrigle Ck	-	-	-	-	-	-
WR5-2	Millstone River @ Jingle Pot Road	-	-	Moderate	-	High	Low
WR5-2	McClure Creek at Montessori School	-	-	-	-	Moderate	-
WR5-2	Chase River @ Estuary Park	Low	-	Moderate	-	Low	Low
WR5-2	Beaver Creek d/s Avonlea Rd bridge	-	-	-	-	-	Low
WR6	Nanaimo River at Cedar Rd bridge	Moderate	-	High	-	High	High
WR6	Nanaimo River u/s Haslam Ck	-	Low	High	-	-	-
WR6	Haslam Ck u/s Nanaimo River	-	-	Moderate	-	-	-
WR6	Beck Creek @ Cedar Rd	Moderate	-	High	-	High	Moderate
WR6	Lower Holden Creek u/s Duke Pt Hwy	High	-	High	-	High	High
WR6	Holden Creek off Lazo Lane	-	-	Low	-	-	-

WR	Site label	Dissolved oxygen		Temperature		Turbidity	
		Summer	Fall	Summer	Fall	Summer	Fall
WR6	North Wexford Creek d/s Douglas	Low	-	-	-	Moderate	Moderate
WR6	North Wexford Creek d/s Tenth St	Moderate	-	-	-	High	-
WR6	Wexford Creek 20m d/s Confluence	-	-	-	-	High	-
WR6	Wexford Creek @ Community Park	-	-	Low	-	-	-
WR6	North Wexford Creek u/s Senior's	-	-	-	-	High	-
WR6	Holden Creek 10m d/s Tiesu Rd	Moderate	Low	Low	-	Low	Low
WR6	Unknown trib (Haley Creek)		-		-		Low
WR6	Richards Creek 5m u/s Frames Rd	-	-	Low	-	-	-
WR7	Mallett Creek.	-	-	Low	-	High	High

Table C6-3: Differences between field-measured and lab-measured turbidity in 2019 for eight sites. Lab samples were assayed by ALS Global. Percentage difference is calculated as the difference between the field and lab values divided by the mean of the field and lab values.

EMS Number	Label	Date	Field sample (NTU)	Lab sample (NTU)	Absolute difference (NTU)	Percentage difference (%)
E290469	Departure Ck @ Neyland Rd	2019-08-06	0.31	0.41	0.10	27.778
E290469	Departure Ck @ Neyland Rd	2019-08-20	0.30	0.31	0.01	3.279
E290469	Departure Ck @ Neyland Rd	2019-08-27	0.32	0.14	0.18	78.261
E290469	Departure Ck @ Neyland Rd	2019-09-03	0.24	0.16	0.08	40.000
E290470	Joseph's Ck (Dep. Ck trib) off Newton St	2019-10-08	1.86	1.99	0.13	6.753
E290470	Joseph's Ck (Dep. Ck trib) off Newton St	2019-10-15	0.49	0.74	0.25	40.650
E290470	Joseph's Ck (Dep. Ck trib) off Newton St	2019-10-22	1.13	0.98	0.15	14.218
E290470	Joseph's Ck (Dep. Ck trib) off Newton St	2019-10-29	0.48	0.65	0.17	30.088
E290470	Joseph's Ck (Dep. Ck trib) off Newton St	2019-11-05	0.39	0.13	0.26	100.000
E290471	Departure Ck at Woodstream Park	2019-08-06	0.50	0.80	0.30	46.154
E290471	Departure Ck at Woodstream Park	2019-08-20	0.38	0.34	0.04	11.111
E290471	Departure Ck at Woodstream Park	2019-08-27	0.38	0.37	0.01	2.667
E290471	Departure Ck at Woodstream Park	2019-09-03	0.36	0.28	0.08	25.000
E290471	Departure Ck at Woodstream Park	2019-10-08	3.75	3.57	0.18	4.918
E290471	Departure Ck at Woodstream Park	2019-10-15	0.35	0.30	0.05	15.385
E290471	Departure Ck at Woodstream Park	2019-10-22	0.86	0.97	0.11	12.022
E290471	Departure Ck at Woodstream Park	2019-10-29	0.23	0.19	0.04	19.048
E290471	Departure Ck at Woodstream Park	2019-11-05	0.23	0.13	0.10	55.556
E290472	Departure Ck @ outlet	2019-08-06	0.48	0.73	0.25	41.322
E290472	Departure Ck @ outlet	2019-08-20	0.51	0.92	0.41	57.343
E290472	Departure Ck @ outlet	2019-08-27	0.90	0.42	0.48	72.727
E290472	Departure Ck @ outlet	2019-09-03	0.68	0.48	0.20	34.483
E290472	Departure Ck @ outlet	2019-10-08	6.35	5.34	1.01	17.280
E290472	Departure Ck @ outlet	2019-10-15	0.53	0.74	0.21	33.071
E290472	Departure Ck @ outlet	2019-10-22	1.14	1.29	0.15	12.346

EMS Number	Label	Date	Field sample (NTU)	Lab sample (NTU)	Absolute difference (NTU)	Percentage difference (%)
E290472	Departure Ck @ outlet	2019-10-29	0.62	0.35	0.27	55.670
E290472	Departure Ck @ outlet	2019-11-05	0.25	0.34	0.09	30.508
E290475	Cottle Creek @ Stephenson Pt Rd	2019-08-06	0.85	0.84	0.01	1.183
E290475	Cottle Creek @ Stephenson Pt Rd	2019-08-20	0.91	0.90	0.01	1.105
E290475	Cottle Creek @ Stephenson Pt Rd	2019-08-27	0.85	0.97	0.12	13.187
E290475	Cottle Creek @ Stephenson Pt Rd	2019-09-03	0.77	0.72	0.05	6.711
E290475	Cottle Creek @ Stephenson Pt Rd	2019-10-08	1.89	1.46	0.43	25.672
E290475	Cottle Creek @ Stephenson Pt Rd	2019-10-15	0.54	0.68	0.14	22.951
E290475	Cottle Creek @ Stephenson Pt Rd	2019-10-22	2.62	2.45	0.17	6.706
E290475	Cottle Creek @ Stephenson Pt Rd	2019-10-29	0.99	1.21	0.22	20.000
E290475	Cottle Creek @ Stephenson Pt Rd	2019-11-05	0.41	0.54	0.13	27.368
E306256	Walley Ck d/s Hammond Bay	2019-08-06	2.12	2.27	0.15	6.834
E306256	Walley Ck d/s Hammond Bay	2019-08-13	1.41	1.91	0.50	30.120
E306256	Walley Ck d/s Hammond Bay	2019-08-20	1.42	1.74	0.32	20.253
E306256	Walley Ck d/s Hammond Bay	2019-08-27	1.82	1.51	0.31	18.619
E306256	Walley Ck d/s Hammond Bay	2019-09-03	2.14	2.28	0.14	6.335
E306256	Walley Ck d/s Hammond Bay	2019-09-10	2.73	2.22	0.51	20.606
E306256	Walley Ck d/s Hammond Bay	2019-10-08	11.90	1.83	10.07	146.686
E306256	Walley Ck d/s Hammond Bay	2019-10-15	1.42	1.36	0.06	4.317
E306256	Walley Ck d/s Hammond Bay	2019-10-22	1.82	1.70	0.12	6.818
E306256	Walley Ck d/s Hammond Bay	2019-10-29	0.96	0.98	0.02	2.062
E306256	Walley Ck d/s Hammond Bay	2019-11-05	0.77	0.85	0.08	9.877
E306257	Walley Ck @ Morningside Dr	2019-08-13	0.16	0.26	0.10	47.619
E309186	Cottle Creek d/s Hammond Bay Rd	2019-08-20	1.62	1.68	0.06	3.636
E309186	Cottle Creek d/s Hammond Bay Rd	2019-08-27	1.89	1.89	0.00	0.000
E309186	Cottle Creek d/s Hammond Bay Rd	2019-09-03	1.80	1.81	0.01	0.554
E309186	Cottle Creek d/s Hammond Bay Rd	2019-10-08	1.33	1.34	0.01	0.749
E309186	Cottle Creek d/s Hammond Bay Rd	2019-10-15	0.66	0.85	0.19	25.166
E309186	Cottle Creek d/s Hammond Bay Rd	2019-10-22	2.25	2.01	0.24	11.268
E309186	Cottle Creek d/s Hammond Bay Rd	2019-10-29	0.98	0.86	0.12	13.043
E309186	Cottle Creek d/s Hammond Bay Rd	2019-11-05	0.51	0.58	0.07	12.844

Table C6-4: EMS ID, Water region, and site label dictionary

WR	EMS ID	Site label
WR1	E240141	Annie Creek
WR1	E298598	Big Qualicum River d/s hatchery
WR1	E298597	Big Qualicum u/s Hwy 19A bridge
WR1	E309086	Cook Creek @ Connector
WR1	E306375	Deep Bay Creek

WR	EMS ID	Site label
WR1	E286552	Nile Creek 25m u/s hatchery
WR1	E286553	Nile Creek 50m u/s Old Island Hwy
WR1	E306374	Rosewall Creek @ Rosewall Park
WR1	E286550	Thames Creek u/s Inland Island Hwy
WR1	E286549	Thames Creek u/s Old Island Hwy
WR1	E286551	Upper Nile Creek at Cochrane Main
WR2	E220635	Cameron River (near the highway)
WR2	E318150	Harris Creek d/s of HWY 4
WR2	E256394	Little Qualicum River at Intake
WR2	E268993	Little Qualicum River d/s Cameron
WR2	E299853	Little Qualicum River u/s hwy 19A
WR2	E285669	Upper Cameron River
WR2	E287697	Whiskey Creek on Hwy 4 @ Save On
WR3	E288092	Beach Creek near Chester Road
WR3	E288093	Beach Creek near Memorial Golf
WR3	E243022	French Creek at Barclay Bridge
WR3	E243024	French Creek at Grafton Road
WR3	E243021	French Creek at new highway
WR3	E288091	Grandon Creek at Laburnum Road
WR3	E288090	Grandon Creek at West Crescent
WR3	E318151	Morningstar Creek u/s Lee Rd W
WR4	E299852	Centre Creek
WR4	E248834	Englishman River U/S from Morison Creek
WR4	0121580	Englishman River at Highway 19A
WR4	E252010	Englishman River U/S Allsbrook
WR4	E248835	Morison Creek
WR4	E290452	Shelly Creek @ end of Blower Rd
WR4	E287131	Shelly Creek @ Hamilton Road
WR4	E248836	South Englishman River U/S from Englishman River
WR4	E308186	Swayne Creek d/s of Errington Road
WR4	E282969	Upper Englishman River u/s Centre
WR5-1	E294010	Bloods Creek just u/s Dickenson Rd
WR5-1	E290476	Cottle Creek @ Landalt Rd
WR5-1	E290473	Cottle Creek @ Nottingham
WR5-1	E290475	Cottle Creek @ Stephenson Pt Rd
WR5-1	E309186	Cottle Creek d/s Hammond Bay Rd

WR	EMS ID	Site label
WR5-1	E294017	Craig Creek u/s Northwest Bay Rd
WR5-1	E294012	Knarston Ck @ Hydro Bridge
WR5-1	E306255	Knarston Ck @ Superior Rd
WR5-1	E294013	Knarston Ck just u/s Lantzville Rd
WR5-1	E294019	Nanoose Creek @ Campground
WR5-1	E294020	Nanoose Creek @ Matthew Crossing
WR5-1	E290474	North Cottle Creek d/s Burma Rd.
WR5-1	E318233	Walley Creek 100m d/s McGuffie Rd
WR5-1	E290469	Departure Ck @ Neyland Rd
WR5-1	E290472	Departure Ck @ outlet
WR5-1	E290471	Departure Ck at Woodstream Park
WR5-1	E290470	Joseph's Creek (trib to Departure Ck) off Newton St
WR5-1	E306257	Walley Ck @ Morningside Dr
WR5-1	E306256	Walley Ck d/s Hammond Bay
WR5-1	E306434	Walley Creek 20m u/s beach
WR5-2	E321394	Beaver Creek d/s Avonlea Rd bridge
WR5-2	E290477	Benson Creek @ Biggs Road
WR5-2	E309187	McClure Creek at Montessori School
WR5-2	E290479	McGarrigle Ck @ Jingle Pot Rd
WR5-2	E290478	Millstone River @ Biggs Road
WR5-2	E290480	Millstone River @ East Wellington
WR5-2	E306294	Millstone River @ Jingle Pot Road
WR5-2	E290481	Millstone River in Barsby Park
WR5-2	E290482	Northfield Creek @ outlet
WR5-2	E294011	Slogar Brook
WR5-2	E306254	Upper McGarrigle Ck
WR5-2	E290486	Cat Stream
WR5-2	E290483	Chase River @ Aebig
WR5-2	E309280	Chase River @ Estuary Park
WR5-2	E290484	Chase River @ Howard
WR5-2	E290485	Chase River @ Park Ave
WR6	E318152	North Wexford Creek d/s Douglas
WR6	E318153	North Wexford Creek d/s Tenth St
WR6	E318172	North Wexford Creek u/s Senior's
WR6	E318155	Wexford Creek @ Community Park
WR6	E318154	Wexford Creek 20m d/s Confluence

WR	EMS ID	Site label
WR6	E290487	Beck Creek @ Cedar Rd
WR6	E321393	Haley Creek 15m d/s Yellow Point
WR6	E287700	Haslam Ck u/s Nanaimo River
WR6	E321392	Holden Creek 10m d/s Tiesu Rd
WR6	E309281	Lower Holden Creek at Maughan Rd
WR6	E215789	Nanaimo River at Cedar Rd bridge
WR6	E287699	Nanaimo River u/s Haslam Ck
WR6	E321395	Richards Creek 5m u/s Frames Rd
WR6	E310147	Upper Holden Creek at Lazo Lane
WR7	E304070	Mallett Creek.

Table C6-5: Summary of exceedance counts across sampled years at each site. Classification breaks are based on the mean and standard deviation of the exceedance counts: counts lower than one half standard deviation below the mean were considered Very Low (counts of 1-2); counts within one half standard deviation of the mean were considered Low (counts of 3-11); counts lower than 1.5 standard deviations above the mean were considered moderate (counts of 12-19); counts lower than 2.5 standard deviations above the mean were considered High (counts of 20-28); and counts of 29 or greater were considered Very High.

WR	EMS ID	Site label	Dissolved oxygen		Temperature	Turbidity	
			Summer	Fall	Summer	Summer	Fall
WR1	E240141	Annie Creek	-	-	Very Low	Moderate	Moderate
WR1	E306375	Deep Bay Creek	-	-	-	Moderate	Low
WR1	E286553	Nile Creek 50m u/s Old Island Hwy	-	-	-	-	Very Low
WR1	E306374	Rosewall Creek @ Rosewall Creek Park	-	-	-	-	Very Low
WR1	E286549	Thames Creek 200m u/s Old Island Hwy	-	-	-	-	Low
WR1	E298598	Big Qualicum River about 700m d/s hatchery	-	-	-	Very Low	-
WR1	E298597	Big Qualicum u/s site	-	-	-	Very Low	-
WR2	E220635	Cameron River (near the highway)	-	-	-	-	Very Low
WR2	E318150	Harris Creek d/s of HWY 4	-	-	-	Low	Low
WR2	E256394	Little Qualicum River at Intake	-	-	High	-	Very Low
WR2	E287697	Whiskey Creek on Hwy 4, TB Ave Save on Gas	-	-	-	-	Low
WR2	E268993	Little Qualicum River 1.2 km d/s Cameron Lake	-	-	Very High	-	-
WR2	E299853	Little Qualicum River 20m u/s hwy 19A	-	-	Low	Very Low	-
WR3	E288092	Beach Creek near Chester Road at Hemsworth Road	-	-	-	Low	Low
WR3	E288093	Beach Creek near Memorial Golf Course Pond	-	-	-	High	Low
WR3	E243022	French Creek at Barclay Bridge	-	-	Low	Very Low	Low
WR3	E243024	French Creek at Grafton Road	Low	-	Very Low	-	Very Low
WR3	E243021	French Creek at new highway	-	-	-	-	Low
WR3	E288091	Grandon Creek at Laburnum Road	Very High	-	-	High	Low
WR3	E288090	Grandon Creek at West Crescent (Caissons)	-	-	Low	Low	Low

WR	EMS ID	Site label	Dissolved oxygen		Temperature	Turbidity	
			Summer	Fall	Summer	Summer	Fall
WR3	E318151	Morningstar Creek 100m u/s Lee Rd W	Very Low	-	-	-	Low
WR4	E308186	Swane Creek d/s of Errington Road	Moderate	Low	Very Low	Moderate	Low
WR4	E299852	Centre Creek	Very Low	-	Low	-	Very Low
WR4	E248834	E. River U/S from Morison Creek	-	-	Very Low	Very Low	Low
WR4	0121580	Englishman River at Highway 19A	-	-	Moderate	Very Low	Low
WR4	E248835	Morison Creek	Very Low	-	Low	Very Low	Low
WR4	E290452	Shelly Creek @ end of Blower Rd	Low	-	Low	Low	Moderate
WR4	E287131	Shelly Creek @ Hamilton Road	Low	-	Low	Low	Low
WR4	E248836	South E. River U/S from E. River	Very Low	-	Moderate	-	Very Low
WR4	E282969	Upper Englishman River u/s Centre Fork Creek	Very Low	-	-	-	-
WR5-1	E294017	Craig Creek just u/s Northwest Bay Rd	Very Low	Very Low	-	Very Low	Very Low
WR5-1	E294020	Nanoose Creek @ Matthew Crossing	Moderate	Very Low	Very Low	-	Very Low
WR5-1	E294019	Nanoose Creek @ Nanoose Campground	Low	Low	-	-	Very Low
WR5-1	E306434	Walley Creek 20m u/s beach	Very Low	Very Low	Low	Very Low	Low
WR5-1	E294010	Bloods Creek just u/s Dickenson Rd	-	-	-	-	Low
WR5-1	E290473	Cottle Creek @ Nottingham	High	-	Moderate	Low	Low
WR5-1	E290475	Cottle Creek @ Stephenson Pt Rd	Low	-	Moderate	Very Low	Low
WR5-1	E309186	Cottle Creek downstream of Hammond Bay Rd	-	-	Low	Low	Very Low
WR5-1	E290469	Departure Ck @ Neyland Rd	-	-	-	Low	Low
WR5-1	E290472	Departure Ck @ outlet	-	-	-	Low	Low
WR5-1	E290471	Departure Ck at lower end of Woodstream Park	-	-	-	Very Low	Low
WR5-1	E294013	Knarston Ck just u/s Lantzville Rd	-	-	Very Low	-	Low
WR5-1	E306257	Walley Ck @ Morningside Dr	Very Low	-	-	Very Low	Low
WR5-1	E306256	Walley Ck d/s Hammond Bay	-	-	Low	Moderate	Low
WR5-1	E290476	Cottle Creek @ Landalt Rd	-	-	Very Low	Low	-
WR5-1	E290470	Departure Ck off Newton St	-	-	Very Low	Low	-
WR5-2	E321394	Beaver Ck d/s Avonlea Rd	-	-	-	-	Very Low
WR5-2	E290486	Cat Stream	Very Low	-	High	Moderate	Low
WR5-2	E290483	Chase River @ Aebig	Low	-	Moderate	Very Low	Low
WR5-2	E290484	Chase River @ Howard	Low	-	Very High	Low	Very Low
WR5-2	E290485	Chase River @ Park Ave	-	-	High	Low	Low
WR5-2	E309280	Chase River at Estuary Park	Very Low	-	Moderate	Very Low	Low
WR5-2	E290479	McGarrigle Ck @ Jingle Pot Rd	-	-	Low	Very Low	Low
WR5-2	E290480	Millstone River @ East Wellington	Low	-	High	Low	Low
WR5-2	E306294	Millstone River @ Jingle Pot Road	-	-	Low	High	Low
WR5-2	E290481	Millstone River in Barsby Park	-	-	High	Low	Low
WR5-2	E290482	Northfield Creek @ outlet	-	-	Low	Low	Low
WR5-2	E290477	Benson Creek @ Biggs Road	Moderate	-	-	-	-
WR5-2	E290478	Millstone River @ Biggs Road	Low	-	Very High	Moderate	-
WR5-2	E309187	McClure Creek at Montessori School	-	-	-	Moderate	-

WR	EMS ID	Site label	Dissolved oxygen		Temperature	Turbidity	
			Summer	Fall	Summer	Summer	Fall
WR6	E309281	Lower Holden Creek at Maughan Rd	Low	Very Low	Low	Low	Low
WR6	E287699	Nanaimo River u/s Haslam Ck	-	Very Low	Very High	-	-
WR6	E321392	Unknown Trib (Haley Creek)	Very Low	Very Low	Very Low	Very Low	Low
WR6	E290487	Beck Creek @ Cedar Rd	Very Low	-	Moderate	Low	Low
WR6	E321393	Holden Creek 10m d/s Tiesu Rd	-	-	-	-	Very Low
WR6	E318152	North Wexford Creek d/s Douglas Ave	Very Low	-	-	Low	Very Low
WR6	E318153	North Wexford Creek d/s Tenth St	Low	-	-	Low	Very Low
WR6	E318172	North Wexford Creek u/s Senior's Complex	-	-	-	Very Low	Very Low
WR6	E318154	Wexford Creek 20m d/s Confluence	-	-	-	Very Low	Low
WR6	E215789	Nanaimo River at Cedar Rd bridge	Very Low	-	Very High	Very Low	-
WR6	E287700	Haslam Ck u/s Nanaimo River	-	-	Low	-	-
WR6	E310147	Holden Creek off Lazo Lane	-	-	Very Low	-	-
WR6	E321395	Richards Creek 5m u/s Frames Rd	-	-	Very Low	-	-
WR6	E318155	Wexford Creek @ Community Park	-	-	Very Low	-	-
WR7	E304070	Mallett Creek.	-	-	Very Low	Very High	Moderate