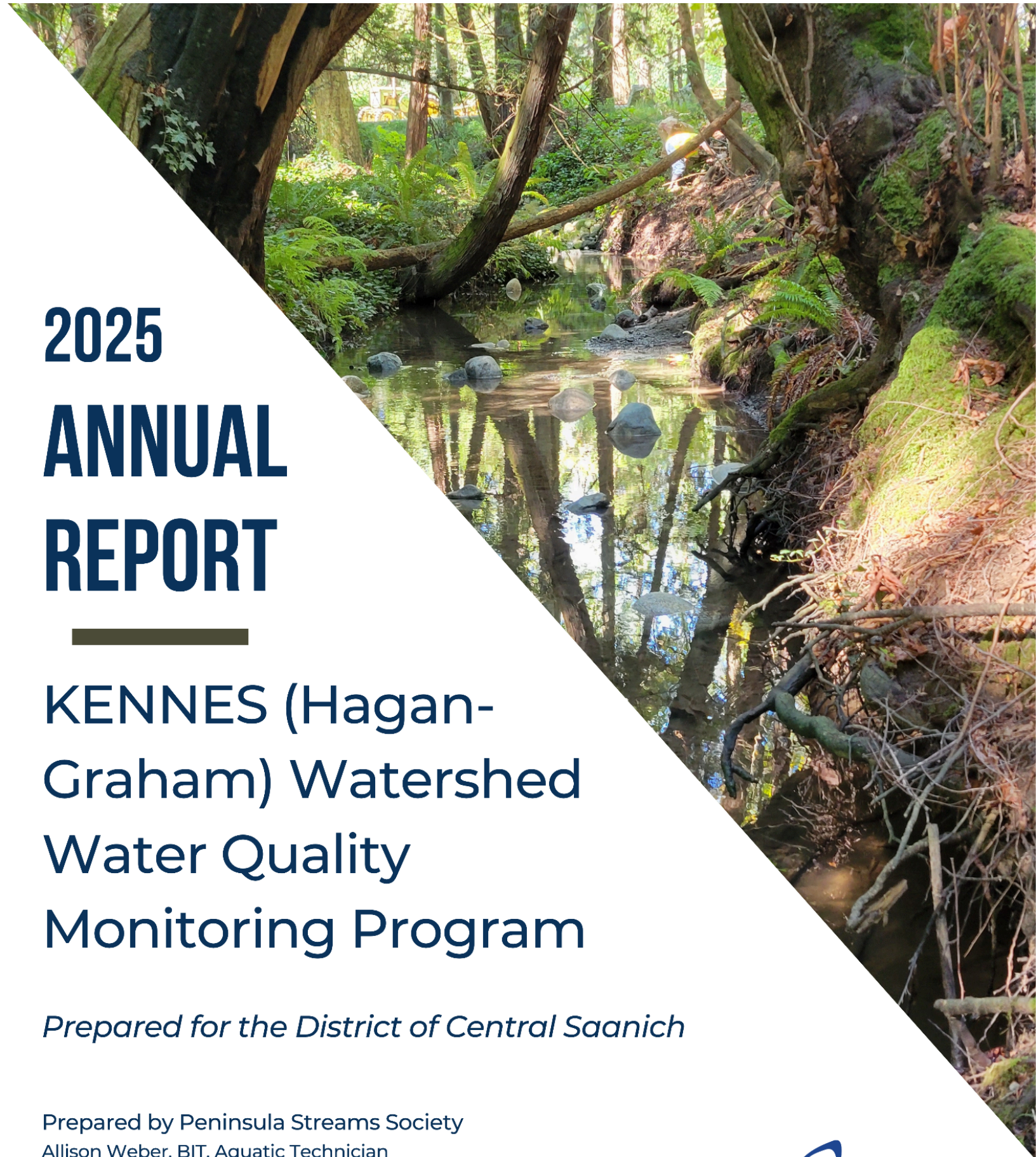


2025 ANNUAL REPORT

KENNES (Hagan-Graham) Watershed Water Quality Monitoring Program

Prepared for the District of Central Saanich

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Peninsula Streams & Shorelines
Since 2002

Abstract

Since 2005, Peninsula Streams & Shorelines (PSS), in partnership with the District of Central Saanich (DCS), has conducted long-term water quality monitoring throughout the Hagan–Graham (ḰENNES) watershed to assess watershed health and track potential impacts associated with urbanization, agriculture, and runoff from the Keating Industrial Area. Monthly monitoring at six sites includes physical water quality parameters, nutrients, fecal coliforms, hydrocarbons, dissolved metals, and sediment-associated metals. This report examines long-term trends in water quality conditions over the 20-year monitoring period of the program. Overall, several parameters showed evidence of long-term improvement, including cadmium, lead, zinc, phosphorus, orthophosphate, nitrite, ammonia, and polycyclic aromatic hydrocarbons (PAHs), while some physical parameters, including turbidity and low dissolved oxygen events at select sites, also improved over time. However, several chronic water quality concerns persisted throughout the watershed. Elevated concentrations and frequent guideline exceedances for copper, iron, phosphorus, hydrocarbons, fecal coliforms, and several sediment-associated metals continued to occur throughout the monitoring record at the Kirkpatrick Crescent outfall, downstream of the Keating Industrial Area. Total extractable hydrocarbons (TEH) and several sediment-associated metals showed little evidence of long-term improvement and remained highly variable between years. Overall, results indicate that while some aspects of water quality within the watershed have improved over the past two decades, ongoing contaminant inputs associated with stormwater runoff, industrial activity, and surrounding land use continue to affect watershed health. Continued long-term monitoring, stormwater management, source control initiatives, habitat restoration, and community stewardship remain important for improving water quality and protecting aquatic habitat within the watershed.

Acknowledgements

We respectfully acknowledge that the study area for this project is located within the traditional territories of the W̱JOŁEŁP (Tsartlip), W̱SIKEM (Tseycum), and SȾÁUTW̱ (Tsawout) Nations. The W̱SÁNEĆ peoples describe this land as an intricate system where land, water, and humans are equal members, with all elements connected through cultural customs

We would also like to acknowledge the immense support from the District of Central Saanich, Pacific Salmon Foundation and BC Gaming Association with whom the collection of this valuable information would not have been possible.

Executive Summary

Since 2005, Peninsula Streams & Shorelines (PSS), in partnership with the District of Central Saanich (DCS), has conducted water quality monitoring throughout the Hagan–Graham (ḰENNES) watershed. The program was established to assess watershed health and evaluate the potential impacts of urbanization, agricultural activity, transportation corridors, and runoff associated with the Keating Industrial Area on aquatic habitat and receiving watercourses. Monitoring currently includes six sampling sites distributed throughout the watershed, with enhanced monitoring conducted at the Kirkpatrick Crescent Outfall (Site 6), including monthly water sampling and quarterly sediment sampling. Parameters assessed throughout the monitoring program include physical water quality properties, nutrients, fecal coliforms, dissolved metals, hydrocarbons, and sediment-associated metals.

This report summarizes water and sediment quality results collected between 2005 and 2025 and evaluates long-term temporal trends throughout the watershed. Overall, several physical water quality conditions remained relatively stable throughout the monitoring period. Water temperature and pH generally remained within ranges supportive of aquatic life, with high temperature exceedances above 19 °C occurring infrequently across the watershed. Dissolved oxygen conditions were poorest at Stelly's Road Culvert (Site 5), which recorded the majority of low oxygen events observed over the monitoring period; however, the frequency of these events declined over time, suggesting some improvement in oxygen conditions at this site. Elevated turbidity events were common throughout the watershed, particularly at Stelly's Road Culvert (Site 5) and Kirkpatrick Crescent Outfall (Site 6), although several sites exhibited significant declines in annual median turbidity or exceedance frequency over time. Conductivity conditions remained broadly stable across most monitoring locations, with relatively few significant temporal trends identified.

Water quality monitoring at Kirkpatrick Crescent Outfall (Site 6) identified several persistent contaminant concerns associated with stormwater runoff downstream of the Keating Industrial Area. Copper, iron, phosphorus, and zinc regularly exceeded applicable water quality guidelines throughout the monitoring period, with copper and phosphorus remaining particularly persistent concerns. Copper concentrations exceeded hardness-adjusted aquatic life guidelines in nearly 90% of samples collected between 2005 and 2025, while phosphorus exceeded guideline thresholds in 224 samples over the monitoring record. Iron and zinc also remained elevated, with 214 and 188 exceedances recorded respectively. Despite the persistence of several contaminants, some metals exhibited clear long-term improvement trends. Cadmium, lead, zinc, phosphorus, and copper concentrations all declined significantly over time, with cadmium, lead, and zinc exceedance frequencies likewise decreasing substantially throughout the monitoring period. Polycyclic aromatic hydrocarbon (PAH) detections also declined significantly over time, indicating reduced occurrence of these compounds in recent years. In contrast, total extractable hydrocarbons (TEH) showed no evidence of long-term improvement and remained highly variable between years, including unusually elevated concentrations observed in 2024.

Fecal coliform concentrations at Site 6 remained highly variable throughout the monitoring period, with no statistically significant long-term increasing or decreasing trend identified. Elevated concentrations and repeated exceedances of the recreational guideline threshold of 200 CFU/100 mL indicate the continued presence of fecal contamination within stormwater runoff entering the watershed. However,

measured concentrations declined substantially following the transition from MB Laboratories to Bureau Veritas in 2025, suggesting that analytical methodology may influence reported concentrations and should be considered when interpreting recent data.

Nutrient monitoring at Malcolm Road (Site 3) and Cultra Road CRD Water Station (Site 4) identified several ongoing nutrient-related concerns within the watershed. Nitrate-N concentrations were consistently higher at Site 4 and frequently exceeded the CCME chronic guideline threshold; however, exceedance frequency remained relatively stable over time at both sites. Nitrite-N exceedances declined significantly at Site 3 and showed a weaker declining tendency at Site 4. Orthophosphate exceedance frequency declined significantly at both nutrient monitoring sites, while ammonia-N exceedances became rare in recent years and were no longer observed after 2014. Collectively, these results suggest that several nutrient-related conditions within the watershed may be improving over time, particularly for ammonia, nitrite, and orthophosphate.

Sediment quality monitoring at Site 6 indicated that several sediment-associated metals remain persistently elevated. Copper, nickel, chromium, and zinc frequently exceeded sediment quality guidelines throughout the monitoring period, with chromium, nickel, and zinc continuing to exceed guidelines in most samples collected in 2025. Despite these elevated concentrations, most sediment-associated metals did not exhibit statistically significant long-term increasing or decreasing trends, suggesting relatively stable but chronically elevated sediment contamination conditions over time. Some improvement was observed for sediment cadmium concentrations, which declined significantly over the monitoring record, while sediment lead exceedances have not been observed since 2021.

Overall, results from the KENNES watershed long-term monitoring program indicate that while several aspects of watershed condition have improved over the past two decades, including reductions in several dissolved metals, nutrients, and PAHs, persistent pollutant inputs associated with stormwater runoff, surrounding land use, and industrial activity continue to affect water and sediment quality throughout the watershed. Continued long-term monitoring, source control initiatives, stormwater treatment, green infrastructure implementation, habitat restoration, and community stewardship remain important for improving health and protecting aquatic habitat within the watershed.

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1.0 Introduction

Peninsula Streams & Shorelines (PSS) has been working to restore and protect aquatic ecosystems throughout Greater Victoria since its formation in 2002. Through research, habitat restoration, environmental monitoring, education, and community stewardship, PSS works to support healthy freshwater and marine environments capable of sustaining native species populations over the long term. A key component of this work is the collection and interpretation of long-term environmental data, particularly water quality information, which provides critical insight into watershed health and informs restoration and management priorities.

The KENNES watershed is the largest watershed in the District of Central Saanich and supports several creeks and tributaries that provide important habitat for aquatic species, including coastal cutthroat trout (CCT). Both Hagan and Graham Creeks support CCT populations, including a potentially genetically distinct resident population in Hagan Creek that is isolated from marine access by a barrier at the creek mouth. As a blue-listed species in British Columbia, coastal cutthroat trout are considered vulnerable, making the protection and monitoring of habitat conditions within this watershed especially important. At the same time, the watershed is influenced by a range of anthropogenic pressures, including agricultural land use, urban development, roadways, and industrial runoff associated with the Keating Industrial Area, all of which have the potential to affect water quality and aquatic habitat function.

Monitoring within the KENNES watershed was one of the foundational projects undertaken by PSS when the organization was first established, building on earlier restoration work completed through the KENNES Hagan Graham Creek Watershed Project (KHGWP). This effort was formalized into a long-term monthly water quality monitoring program in 2005 through support from the District of Central Saanich, with a particular focus on tracking water quality conditions near outfalls draining the Keating Industrial Area. Since then, PSS has conducted regular sampling across multiple sites throughout the watershed, measuring physical parameters, nutrients, metals, fecal coliforms, hydrocarbons, and sediment quality indicators. With over 20 years of continuous data collection, this program now represents one of the most temporally extensive watershed water quality datasets on Vancouver Island.

This report provides a comprehensive review of the water quality data collected over the more than 20 years that the KENNES water quality monitoring program has been in operation, highlighting long-term trends, areas of concern, and the ongoing importance of sustained watershed monitoring in informing stewardship, restoration, and stormwater management efforts.

2.0 Methods

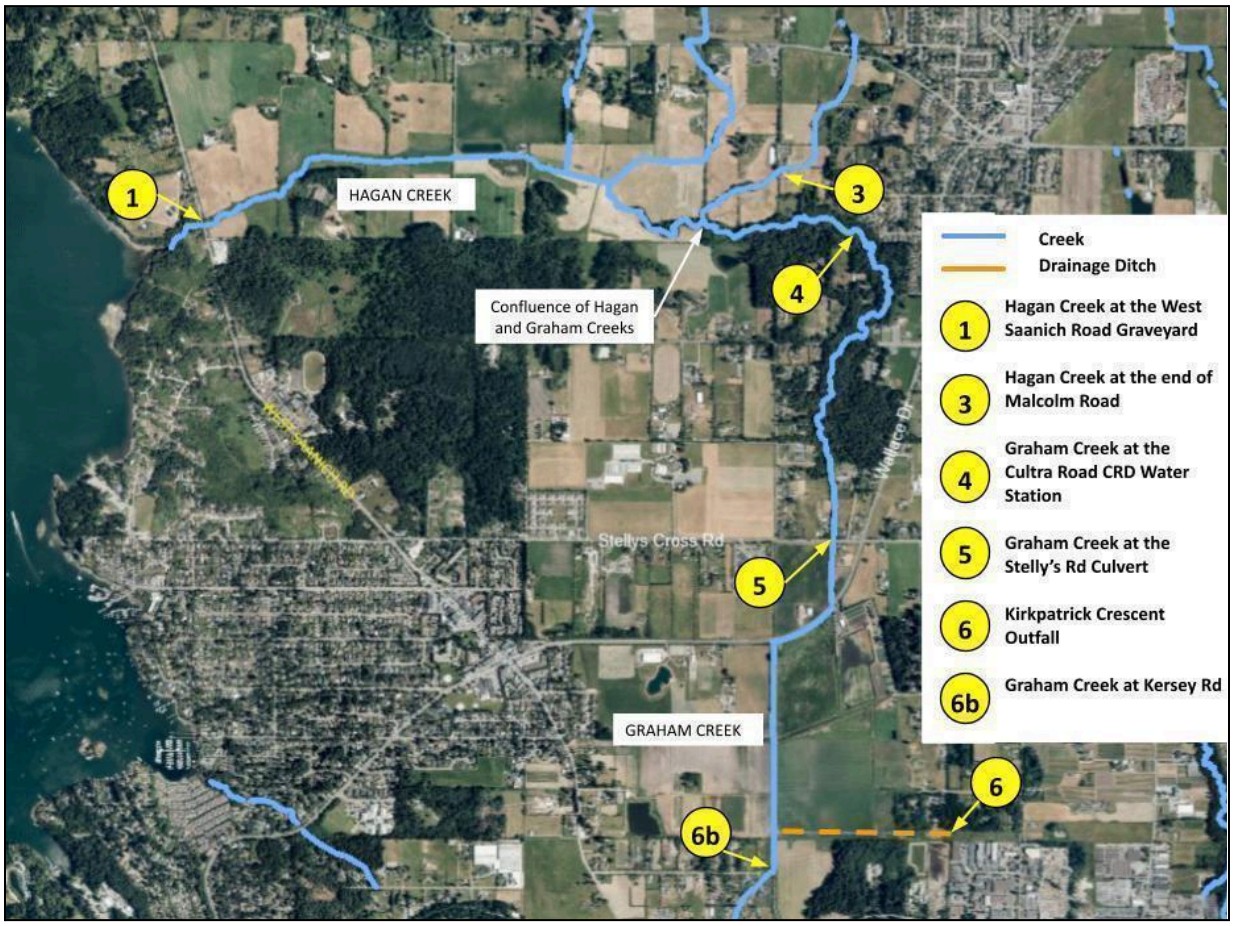


Figure 1. Map of KENNES (Hagan-Graham) watershed sampling sites.

2.1 Sampling Sites and Parameters Measured

Water quality monitoring is conducted monthly at six sites distributed throughout the KENNES watershed (Figure 1):

Site 1: Hagan Creek at West Saanich Rd graveyard
Site 3: Hagan Creek at the end of Malcolm Road
Site 4: Graham Creek at the Cultra Road CRD water station
Site 5: Graham Creek at the Stelly's Road culvert
Site 6: Kirkpatrick Crescent outfall (Keating Outfall West)
Site 6B: Graham Creek at Kersey Road

All six sites are monitored for physical water quality parameters, including dissolved oxygen (% saturation), temperature (°C), electrical conductivity (µS/cm), pH, and turbidity (NTU).

Table 1: Description of the analytes included within each water quality parameter class.

Parameter Class	Analytes Included
Physical	Dissolved oxygen (%), temperature (°C), electrical conductivity, pH, turbidity
Nutrients	Nitrite (as N, as NO_2), nitrate (as N, as NO_3), ammonia (as N, as NH_3), total nitrogen, orthophosphate (as PO_4)
Metals	Arsenic, cadmium, copper, iron, lead, manganese, mercury, elemental phosphorus, zinc
Hydrocarbons	Total extractable hydrocarbons (TEH), polycyclic aromatic hydrocarbons (PAHs)
Fecal Coliforms	Fecal coliform bacteria

In addition to physical parameters, nutrient analyses are conducted monthly at two sites:

Site 3: Hagan Creek at Malcolm Road
Site 4: Graham Creek at Cultra Road

Nutrient parameters include nitrite (as N, as NO_2), nitrate (as N, as NO_3), ammonia (as N, as NH_3), total nitrogen, and orthophosphate (as PO_4).

Table 2: Parameters measured, by site.

Site	Physical	Metals	Nutrients	Fecal	Hydrocarbons	Sediment Metals
Site 1 Graveyard	**X**					
Site 3 Malcolm Rd	**X**		**X**			
Site 4 Cultra Rd	**X**		**X**			
Site 5 Stelly's Rd	**X**					
Site 6 Kirkpatrick Cres.	**X**	**X**		**X**	**X**	**X**
Site 6B Kersey Rd	**X**					

Enhanced monitoring is conducted at Site 6 (Kirkpatrick Crescent outfall/Keating Outfall West) due to its location downstream of the Keating Industrial Area. In addition to physical parameters, monthly grab samples are collected at this site for laboratory analysis of metals, hydrocarbons, and fecal coliforms. Sediment samples are also collected at Site 6 on a quarterly basis (every third month) and submitted for laboratory analysis of sediment-associated metals.

2.2 Field Sampling Methods and Laboratory Analyses

Given the long-term nature of this monitoring program, a number of field methods, analytical instruments, and laboratory service providers have been used over time.

From 2005 to July 2025, laboratory analyses for fecal coliforms, metals, hydrocarbons, and sediment chemistry were conducted by MB Laboratories Ltd. in Sidney, British Columbia. Beginning in August 2025, these analyses transitioned to Bureau Veritas (BV). Nutrient analysis methods have also evolved over the duration of the program. From 2005 to 2017, nutrient concentrations were measured by PSS staff and volunteers using field testing kits. From 2017 to August 2025, nutrient analyses were conducted by MB Laboratories. Since August 2025, nutrient testing has been conducted by Bureau Veritas. Currently, PSS staff and trained volunteers collect monthly grab samples at designated sites and record physical water quality properties in the field. Samples are then transported to Bureau Veritas for laboratory analysis.

Physical parameters have been measured using several instruments over the course of the program. Historically, dissolved oxygen was measured using an OxyGuard Handy Polaris, while pH and conductivity were measured using HANNA handheld probes. The current field protocol uses a YSI DSS Pro

for measurement of water temperature (°C), conductivity (µS/cm), pH, and dissolved oxygen (% saturation). Turbidity is measured in the field using a LaMotte 2020t Portable Turbidity Meter, which uses a radiometric method to report turbidity in Nephelometric Turbidity Units (NTU). All samples are collected using sterile sampling containers and standard field protocols consistent with Environment and Climate Change Canada procedures.

2.3 Data Interpretation, Quality Standards, and Trend Analysis

To support interpretation of long-term water quality trends, analytical results were compared against applicable provincial, national, and international water and sediment quality guidelines (Table A27).

Guideline values were derived from multiple sources, including:

- Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines
- BC Ministry of Environment Approved Water Quality Guidelines (BCAWQG)
- United States Environmental Protection Agency (USEPA)

Priority was given to guidelines developed for British Columbia and Canada, particularly those intended for the protection of freshwater aquatic life. For several metals, including cadmium, copper, lead, manganese, and zinc, guideline values are hardness-dependent. For these parameters, site-specific water hardness values were used to calculate applicable thresholds. For fecal coliforms, a threshold of 200 CFU/100 mL was used, consistent with the recreational freshwater safe swimming guideline. Although no specific aquatic life guideline exists for creek systems, this threshold is used operationally within the monitoring program to identify potential contamination events and inform follow-up communication with partner agencies where necessary. Site-specific turbidity baselines were developed using historical background conditions observed at each monitoring location across the full sampling record beginning in 2005 (Table A28).

Because continuous flow data are not available for all sites, 48-hour precipitation totals (the day of sampling and preceding day) were compiled from Environment and Climate Change Canada records and paired with sampling results. Precipitation is used as a proxy for runoff and dilution conditions, providing important context for interpreting variability in contaminant concentrations and identifying potential storm-driven loading events.

All field and laboratory data undergo quality control and quality assurance (QA/QC) review by PSS staff prior to analysis and reporting. This includes review of field sheets, instrument readings, laboratory certificates of analysis, detection limits, metadata completeness, and data entry accuracy. Following QA/QC review, validated data are uploaded to Pacific DataStream, an open-access online environmental data platform, where the full KENNES watershed dataset is made publicly available to support transparency, long-term stewardship, and broader watershed management initiatives.

For this 20-year synthesis, long-term trends were assessed by examining temporal patterns in parameter concentrations, frequency of guideline exceedances, seasonal variability, and site-specific changes over time. Where appropriate, annual and seasonal summary statistics, including means,

medians, ranges, and exceedance frequencies, were used to evaluate changes in watershed condition and identify persistent or emerging water quality concern

3.0 Results

3.1 Physical Results, all sites

3.1.1 Temperature

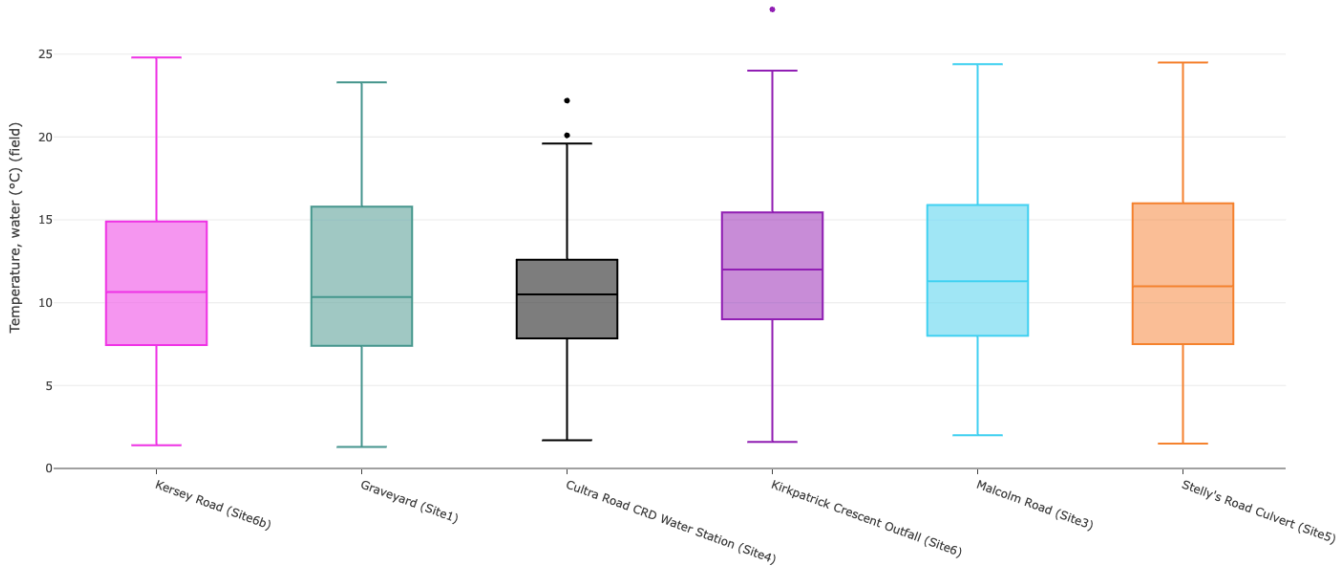


Figure 2. Boxplot comparison of water temperature (°C) across all sites over the 20 year monitoring period. Figure taken from Pacific Datastream.

Over the 20-year monitoring period, median water temperatures were broadly similar across sites, ranging from 10.35 °C at Graveyard (Site 1) to 12.0 °C at Kirkpatrick Crescent Outfall (Site 6), indicating that Site 6 exhibited the highest overall median temperature across the watershed. Median temperatures at the remaining sites were 10.50 °C at Cultra Road CRD Water Station (Site 4), 10.65 °C at Kersey Road (Site 6B), 11.0 °C at Stelly's Road Culvert (Site 5), and 11.3 °C at Malcolm Road (Site 3; Figure 2). Despite Site 6 having the highest overall median temperature, Site 5 exhibited the greatest number of temperature exceedances above 19 °C over the monitoring record, with 15 exceedances over the 20-year period, followed by Site 3 with 12 exceedances. Trend analysis indicated slight increasing temperature trends at Site 4, Site 6B, and Site 5; however, these trends were weak and suggest only minor long-term warming over the monitoring period. In 2025 alone, no sites recorded temperatures exceeding 19 °C.

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3.1.2 Oxygen Saturation

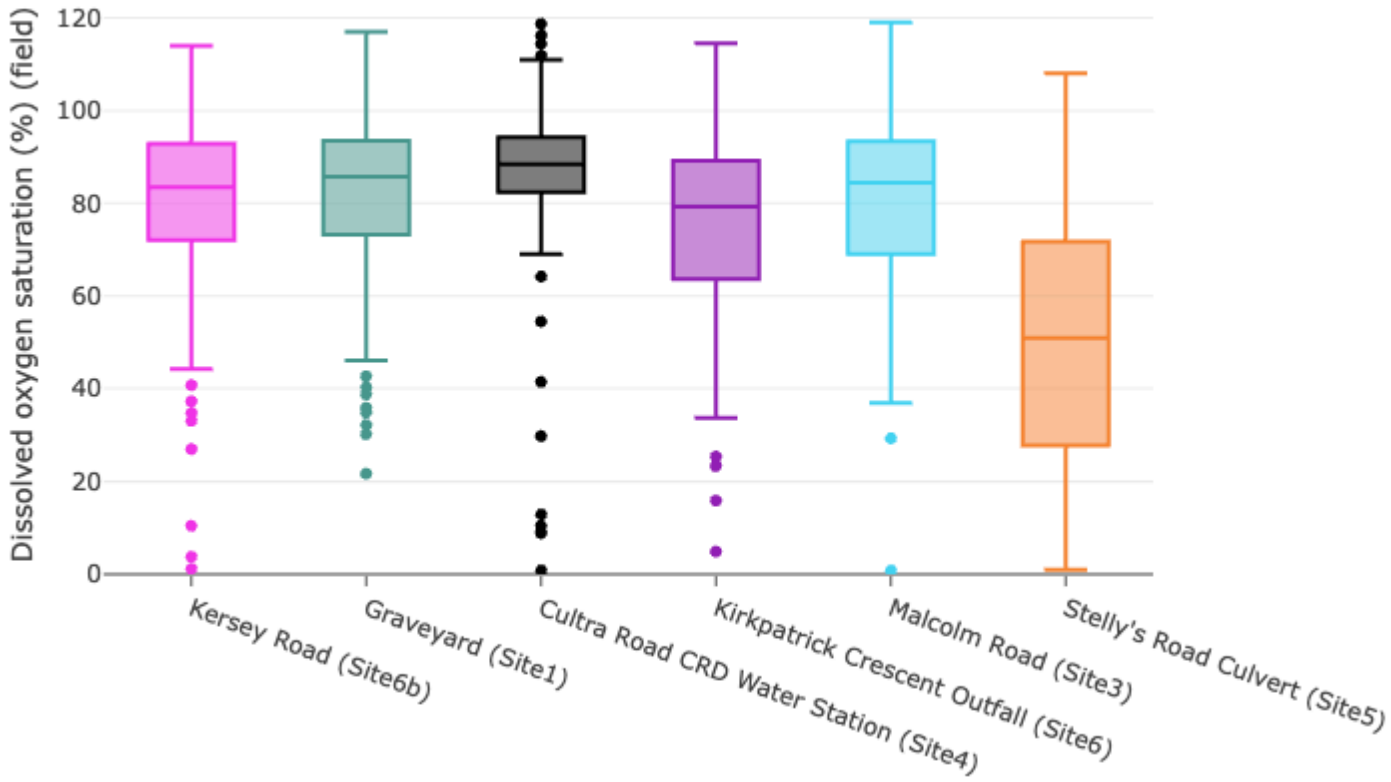


Figure 3. Boxplot comparison of % oxygen saturation across all sites over the 20 year monitoring period. Figure taken from Pacific Datastream.

Median dissolved oxygen saturation varied more substantially across sites than temperature, ranging from 51.0% at Stelly's Road (Site 5) to 88.4% at Cultra Road (Site 4), indicating that Site 5 consistently exhibited the lowest overall oxygen conditions across the watershed. Median oxygen saturation at the remaining sites was 85.7% at Graveyard (Site 1), 84.4% at Malcolm Road (Site 3), 79.3% at Kirkpatrick Crescent Outfall (Site 6), and 83.5% at Kersey Road (Site 6b; Figure 3). Consistent with this pattern, Site 5 exhibited by far the greatest number of dissolved oxygen saturation measurements below 50% over the monitoring record, with 96 occurrences, while the second highest frequency occurred at Site 6, which recorded 26 low-oxygen events since 2005. Although Site 5 had the highest cumulative number of low oxygen events over the 20-year monitoring period, the annual frequency of oxygen saturation measurements below 50% has declined in recent years. A linear trend analysis indicated a negative slope, suggesting a moderate decreasing trend in low oxygen events over time and potential improvement in seasonal oxygen conditions at this site. In contrast, all other monitoring sites showed weak or no clear temporal trend in the annual frequency of low oxygen exceedances over the same period. In 2025, only two low oxygen events (<50%) were recorded, both occurring at Site 5, while no low oxygen events were observed at the remaining sites.

3.1.3 Turbidity

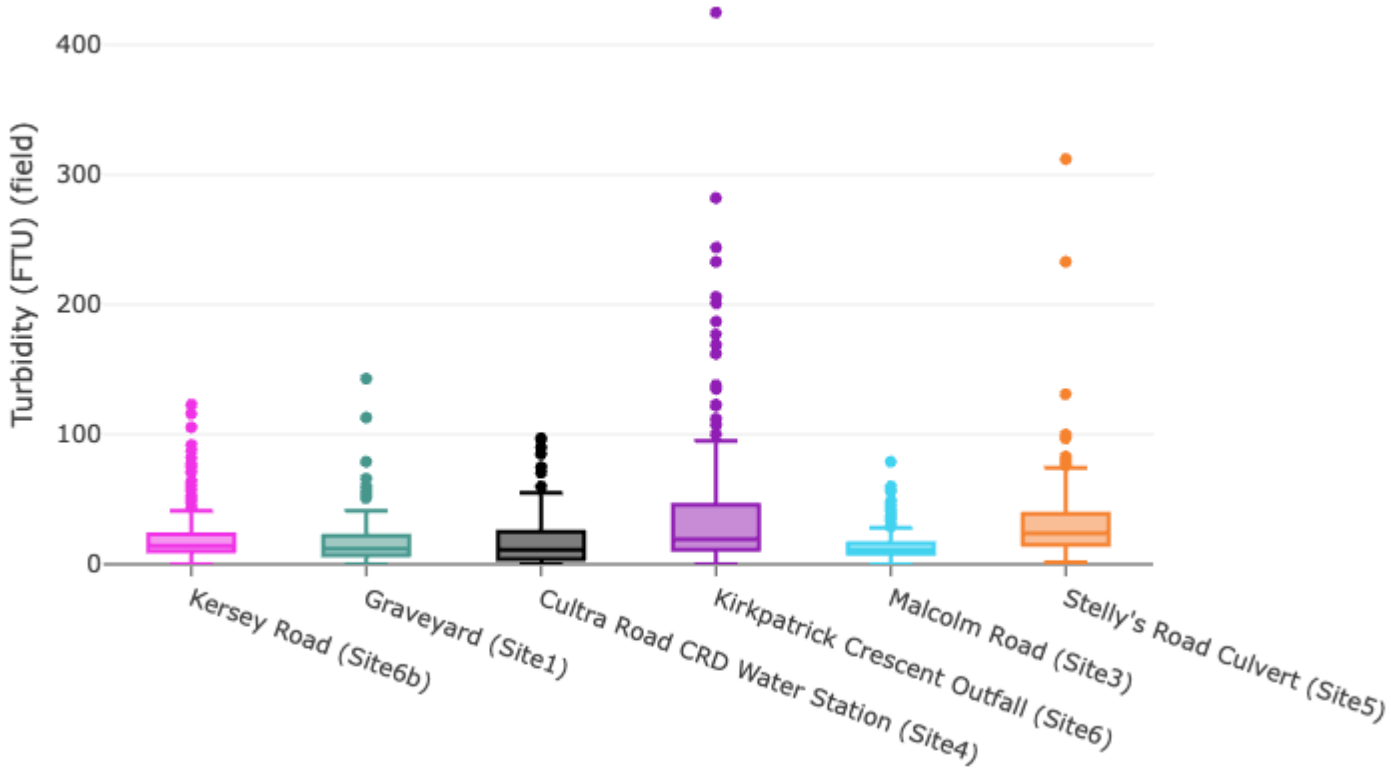


Figure 4. Boxplot comparison of turbidity across all sites over the 20 year monitoring period. Figure taken from Pacific Datastream.

Turbidity varied across sites, ranging from a median of 11 NTU at Malcolm Road (Site 3) and Cultra Road (Site 4) to 24 NTU at Stelly's Road (Site 5), indicating that Site 5 exhibited the highest overall median turbidity across the watershed. Median turbidity at the remaining sites was 12 NTU at Graveyard (Site 1), 19.2 NTU at Kirkpatrick Crescent Outfall (Site 6), and 14.25 NTU at Kersey Road (Site 6b; Figure 4). Using annual median turbidity values, statistically significant decreasing trends were observed at Graveyard (Site 1; m = −0.49 NTU year^{-1}, p = 0.007; Kendall's τ = −0.362, p = 0.019) and Kersey Road (Site 6b; m = −0.45 NTU year^{-1}, p = 0.0055; Kendall's τ = −0.403, p = 0.0093), suggesting gradual improvement in baseline turbidity conditions at these sites over time. In contrast, no statistically significant temporal trends in annual median turbidity were observed at Malcolm Road (Site 3), Cultra Road (Site 4), Stelly's Road Culvert (Site 5), or Kirkpatrick Crescent Outfall (Site 6). A threshold of 25 NTU was selected as an indicator of elevated turbidity conditions to identify and compare extreme turbidity events across sites over the monitoring period. Although site-specific baseline thresholds were also calculated using each site's running mean turbidity ± standard error (Appendix Table A28), these thresholds were not used for the primary exceedance analysis

presented here. This approach was chosen because sites with chronically elevated turbidity conditions would inherently have higher calculated baseline thresholds, potentially masking persistently poor water quality conditions and reducing comparability among sites. Instead, the fixed 25 NTU threshold was used to provide a consistent watershed-wide benchmark for identifying and comparing elevated turbidity events across all monitoring locations. Based on this threshold, Site 5 recorded the greatest number of exceedance events (103), followed by Site 6 (85), Site 4 (60), Site 6b (46), Site 1 (41), and Site 3 (27). Trend analysis of annual exceedance frequency indicated no evidence that elevated turbidity events are becoming more frequent at any monitoring site. Rather, only Site 6 exhibited a statistically significant decline in the annual number of turbidity exceedances over time (m = −0.134 exceedances year^{-1}, p = 0.036; Kendall's τ = −0.316, p = 0.050), suggesting that high turbidity events at this site have become less frequent over the monitoring period. In 2025, a total of 16 turbidity exceedance events (>25 NTU) were recorded across the watershed, including four events each at Site 5 and Site 6b, three at Site 4, two each at Site 1 and Site 3, and one at Site 6.

3.1.4 pH

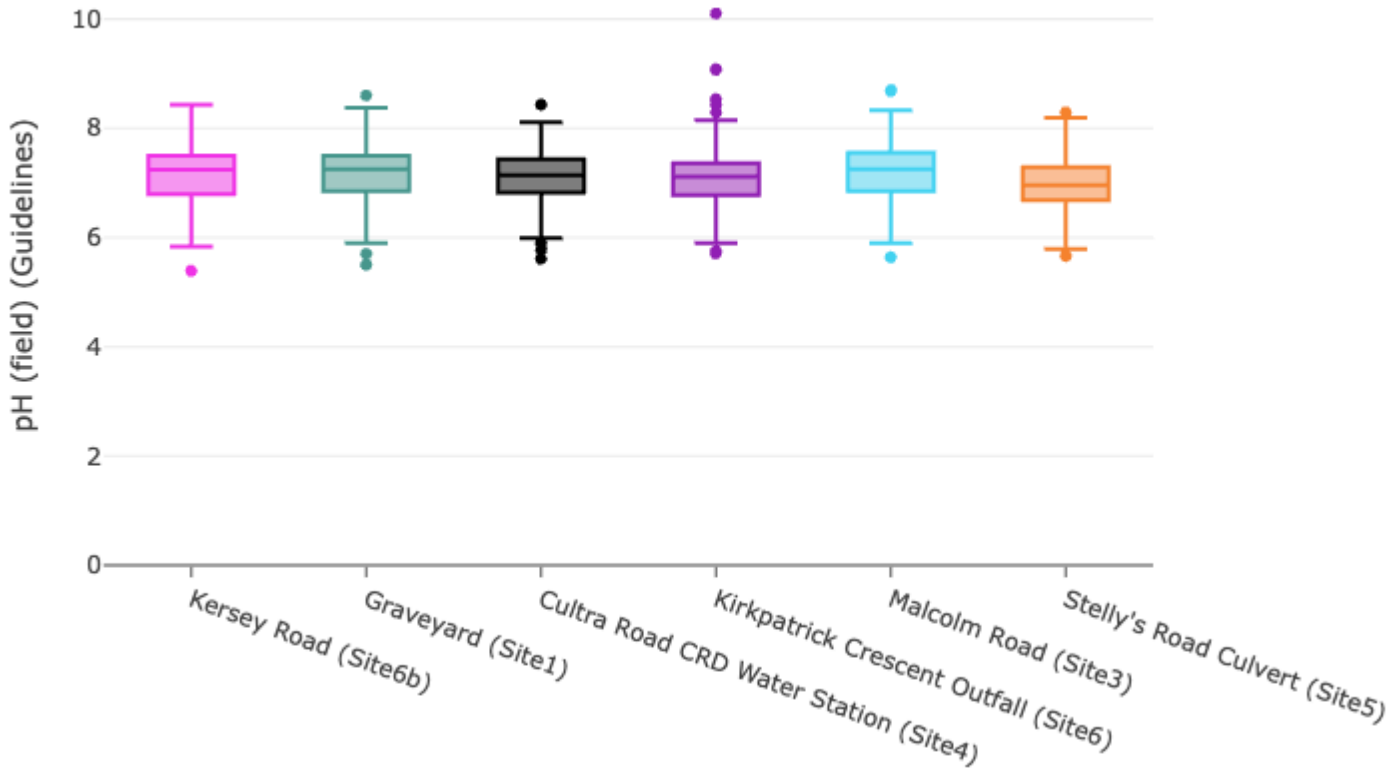


Figure 5. Boxplot comparison of pH across all sites over the 20 year monitoring period. Figure taken from Pacific Datastream.

Median pH remained relatively consistent across all monitoring sites, ranging from 6.96 at Stelly's Road (Site 5) to 7.25 at Graveyard (Site 1) and Malcolm Road (Site 3), indicating that pH conditions were generally stable and remained within a near-neutral range across the watershed. Median pH at the remaining sites was 7.14 at Cultra Road (Site 4), 7.11 at Kirkpatrick Crescent Outfall (Site 6), and 7.24 at Kersey Road (Site 6b; Figure 5). Consistent with this pattern, annual median pH values remained stable over time at all sites, with no clear long-term increasing or decreasing trends observed over the monitoring record. Over the full dataset, only three high pH exceedance events (>9) were recorded, all of which occurred at Kirkpatrick Crescent Outfall (Site 6). Low pH exceedances (<6) were infrequent and sporadic across the watershed, with the greatest number occurring at Cultra Road (Site 4) and Graveyard (Site 1), which each recorded five events over the monitoring period. Kirkpatrick Crescent Outfall (Site 6) recorded four low pH events, while Kersey Road (Site 6b) and Malcolm Road (Site 3) each recorded three, and Stelly's Road Culvert (Site 5) recorded two. Trends in low pH event frequency were weak and inconsistent across sites, with no clear evidence of increasing or decreasing frequency over time, likely reflecting the low and sporadic occurrence of pH exceedances from year to year. In 2025, no high or low pH exceedance events were recorded at any monitoring site. Overall, the pH dataset indicates that watershed conditions have remained consistently well-buffered and generally stable over time.

3.1.5 Conductivity

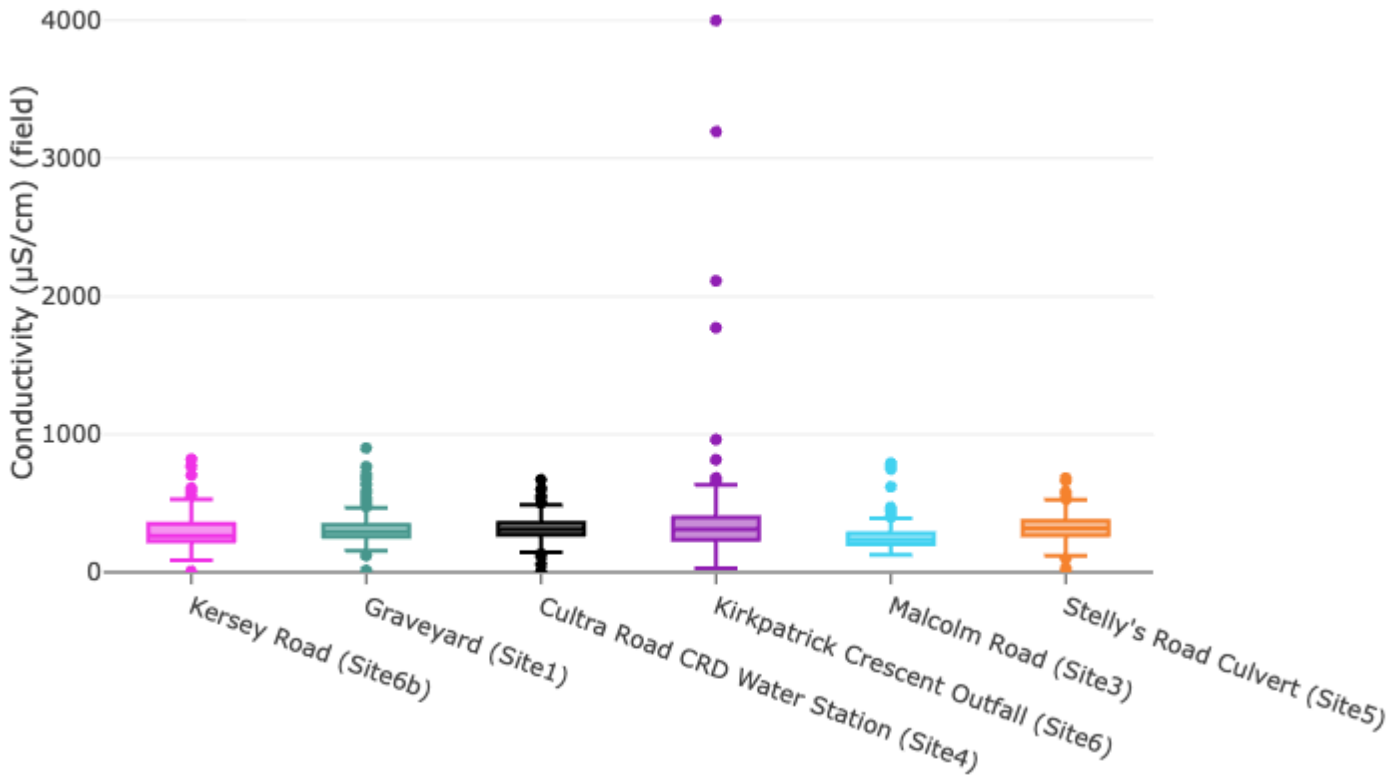


Figure 6. Boxplot comparison of conductivity (µS/cm) across all sites over the 20 year monitoring period. Figure taken from Pacific Datastream.

Median conductivity was broadly similar across monitoring sites, ranging from 235.5 µS/cm at Malcolm Road (Site 3) to 320 µS/cm at Stelly's Road Culvert (Site 5), indicating relatively consistent baseline conductivity conditions across the watershed. Median conductivity at the remaining sites was 292 µS/cm at Graveyard (Site 1), 310 µS/cm at Cultra Road CRD Water Station (Site 4), 311.5 µS/cm at Kirkpatrick Crescent Outfall (Site 6), and 263.7 µS/cm at Kersey Road (Site 6b; Figure 6). Thresholds of >500 µS/cm and <150 µS/cm were selected as indicators of elevated and reduced conductivity conditions to identify and compare extreme conductivity events across sites over the monitoring period. Elevated conductivity exceedances (>500 µS/cm) were observed at all sites over the monitoring record, with the greatest number occurring at Kirkpatrick Crescent Outfall (Site 6; 22 events), followed by Graveyard (Site 1; 19), Stelly's Road Culvert (Site 5; 14), Kersey Road (Site 6b; 12), and Cultra Road and Malcolm Road (Sites 4 and 3; 4 each). Low conductivity events (<150 µS/cm) were also recorded across all sites, with the highest frequency occurring at Kirkpatrick Crescent Outfall (Site 6; 23 events), followed by Kersey Road (Site 6b; 10), Cultra Road and Malcolm Road (Sites 4 and 3; 8 each), Stelly's Road Culvert (Site 5; 7), and Graveyard (Site 1; 5). Trend analysis indicated that only two exceedance patterns were statistically

significant over time. At Kersey Road (Site 6b), the annual frequency of low conductivity events increased significantly (m = 0.0553 events year^{-1}; R^2 = 0.2015; p = 0.036), suggesting a slight increase in the occurrence of low conductivity conditions over the monitoring period. In contrast, Kirkpatrick Crescent Outfall (Site 6) showed a significant decline in low conductivity events over time (m = −0.1508 events year^{-1}; R^2 = 0.4477; p = 0.0007), indicating that low conductivity conditions have become less frequent at this site. No statistically significant temporal trends were observed for high conductivity exceedances at any site. In 2025, one high conductivity exceedance event (>500 µS/cm) was recorded at Kirkpatrick Crescent Outfall (Site 6). Low conductivity events (<150 µS/cm) recorded in 2025 included three at Kersey Road (Site 6b), two each at Cultra Road (Site 4) and Malcolm Road (Site 3), one each at Graveyard (Site 1) and Stelly's Road Culvert (Site 5), and none at Kirkpatrick Crescent Outfall (Site 6).

3.2 Fecal Coliforms

Annual median fecal coliform concentrations did not exhibit a clear long-term temporal trend. A non-parametric Kendall trend test indicated no statistically significant monotonic change over time (Kendall's τ = 0.177, p = 0.263). Similarly, annual exceedance counts remained relatively stable from 2005 to 2025, with year-to-year fluctuations but no clear evidence of a long-term increasing or decreasing trend in exceedance frequency. In 2025, nine exceedances of the safe swimming water quality guideline (200 CFU/100 mL) were recorded. However, laboratory methods changed in August 2025 as we switched from MB labs to Bureau Veritas, after which fecal coliform concentrations decreased substantially. Because only 5 of 12 months in 2025 were analyzed using the new laboratory, this shift was not fully captured by the annual median trend analysis or exceedance trend analysis. Although concentrations often continued to exceed safe swimming guidelines, the magnitude of exceedance was substantially lower. The annual median concentration in 2025 was 660, while the median of samples collected to date in 2026 has declined further to 160, suggesting a substantial recent reduction in measured fecal coliform concentrations following the laboratory transition (see Table 3).

Table 3. Annual fecal coliform medians from 2020 onward.

Year	Annual Median Fecal Coliform Concentration (CFU/100mL)
2020	2700
2021	6800
2022	6200
2023	7900
2024	8300
2025	660
2026	160

3.3 Heavy Metals

Figures for heavy metal data are not included within this report. However, exceedance occurrence tables for each parameter can be found in the appendix, and all data, with figures and statistics, can be found publicly available on Pacific Datastream: Peninsula Streams Society Central Saanich Water Quality Monitoring - KENNES.

3.3.1 Arsenic

Annual median arsenic concentrations did not exhibit a clear increasing or decreasing trend over time. Rather, the data are better interpreted as showing substantial year-to-year variability, with no strong long-term directional trend in background arsenic concentrations at the site. Similarly, guideline exceedances were infrequent, with only nine occurrences recorded over the full monitoring period, and no clear temporal trend in exceedance frequency was observed, indicating that exceedances have neither increased nor decreased consistently over time. In 2025, one minor exceedance of the applicable guideline was recorded, exceeding the threshold by 0.27 µg/L.

3.3.2 Cadmium

Over the 20-year monitoring period, annual median cadmium concentrations at Kirkpatrick Crescent Outfall (Site 6) exhibited a significant decreasing trend over time. A linear trend analysis estimated a slope of $m = -0.034$ µg/L year^{-1} ($p = 0.0021$; $R^2 = 0.384$), indicating that median cadmium concentrations declined

by approximately 0.034 µg/L per year on average over the monitoring period. A non-parametric Kendall trend test produced consistent results (Kendall's $\tau = -0.528$, $p = 0.0020$), further supporting a significant long-term decline in cadmium concentrations at this site. Consistent with this pattern, annual cadmium guideline exceedance counts also showed a significant decline over time. Linear trend analysis estimated a slope of $m = -0.35$ exceedances year^{-1} ($p = 0.0000098$; $R^2 = 0.65$), indicating that Site 6 experienced approximately one-third fewer exceedance events with each passing year. This strong negative trend was further supported by the Kendall trend test (Kendall's $\tau = -0.67$, $p = 0.000041$), suggesting that cadmium exceedances have become substantially less frequent over the monitoring record. In 2025, no cadmium guideline exceedances were observed.

3.3.3 Copper

Annual median copper concentrations exhibited a significant decreasing trend over time. A linear trend analysis estimated a slope of $m = -1.77$ µg/L year^{-1} ($p = 0.0016$), indicating that annual median copper concentrations declined by approximately 1.8 µg/L per year on average between 2005 and 2025. A rank-based Spearman trend test produced consistent results (Spearman's $\rho = -0.63$, $p = 0.0021$), further supporting a statistically significant long-term reduction in median copper concentrations at the site. While year-to-year concentrations remained variable, the overall pattern was clearly downward, with annual median concentrations declining from approximately 45–83 µg/L in the early years of monitoring to 13.0 µg/L in 2024 and 10.47 µg/L in 2025. However, copper guideline exceedances remained persistently high throughout the monitoring record. Over the 20-year period, copper concentrations exceeded the hardness-adjusted CCME guideline in 215 of 242 samples (89%). Exceedances were recorded every year from 2005 through 2025, with annual counts ranging from 8 to 12 exceedances per year and no evidence of a meaningful decline over time. Several years, including 2007, 2019, 2021, and 2022, exceeded guideline thresholds in every sample collected, while even years with comparatively lower counts, such as 2017 and 2018, still recorded eight exceedances each. Overall, this pattern indicates that copper exceedances have remained chronically elevated across the full monitoring period despite the decline in annual median concentrations. In 2025, nine copper guideline exceedances were recorded.

3.3.4 Iron

Iron concentrations exhibited an overall decreasing trend, although the decline was not statistically significant due to substantial year-to-year variability. A linear trend analysis on annual iron medians indicated a general downward direction in annual median iron concentrations from 2005 to 2025. A non-parametric Kendall trend test produced similar results, also suggesting a weak decreasing pattern but no significant long-term monotonic trend. While iron concentrations were generally higher in the early years of monitoring and lower in many recent years, notable spikes in concentrations, particularly in 2006 and 2022, weakened the formal trend signal. Similarly, annual exceedance counts above the 300 µg/L guideline threshold showed a weak downward trend over time; however, this trend was also not statistically significant. Linear trend analysis estimated a negative slope; the non-parametric trend test likewise indicated a weak negative association, although neither were significant. Overall, these results suggest that while iron concentrations and exceedance frequencies may have declined slightly over the monitoring

period, the evidence does not support a clear statistically significant long-term decrease. In 2025, nine iron exceedances above 300 µg/L were recorded.

3.3.5 Lead

Annual median lead concentrations at Kirkpatrick Crescent Outfall (Site 6) exhibited a clear decreasing trend over time. A linear trend analysis estimated that annual median lead concentrations declined on average by approximately 0.18 µg/L per year. A non-parametric Kendall trend test showed a similar downward pattern, further supporting an overall decline despite some year-to-year variability. From a practical standpoint, this decrease was substantial, with the average annual median concentration declining from approximately 3.61 µg/L during 2005–2010 to 1.13 µg/L during 2020–2025. Consistent with this pattern, annual lead guideline exceedance counts also showed a significant decline over time. A linear trend analysis estimated a slope of $m = -0.26$ exceedances year^{-1} ($p = 0.000057$), indicating that the site experienced approximately one-quarter fewer exceedances per year over the monitoring record. This strong negative trend was further supported by the Kendall trend test ($p = 0.000162$). Exceedance frequency declined markedly from an average of 5.33 exceedances per year during 2005–2010 to 1.67 exceedances per year during 2020–2025, indicating substantial long-term improvement in lead conditions at the site. In 2025, one lead guideline exceedance was recorded.

3.3.6 Manganese

Over the 20-year monitoring period, manganese concentrations remained consistently low and stable, with no evidence of a statistically significant increasing or decreasing trend in annual median concentrations between 2005 and 2025. Consistent with this stable pattern, no guideline exceedances were recorded over the entire monitoring record, indicating that manganese concentrations have remained well below threshold levels throughout the study period.

3.3.7 Mercury

Yearly median mercury concentrations remained stable, with no clear long-term increasing or decreasing trend observed between 2005 and 2025. Guideline exceedances were generally infrequent, with most years recording no exceedances and only a small number of years showing one or two events. The highest annual frequency occurred in 2013, when three exceedances were recorded. Trend analysis of annual exceedance counts did not indicate a statistically significant temporal trend; while the pattern suggests a slight downward tendency, year-to-year variability was too high to support a clear long-term decline. In 2025, no mercury guideline exceedances were observed.

3.3.8 Phosphorus

Median phosphorus concentrations exhibited an overall decreasing trend, although the pattern was irregular and characterized by substantial year-to-year variability, including a pronounced spike in 2022 (median = 1079 µg/L). Because of this variability, a non-parametric trend approach was used to better

assess long-term change. A Mann–Kendall trend test indicated a statistically significant downward trend in annual median phosphorus concentrations from 2005 to 2025 (Kendall's $\tau = -0.348$, $p = 0.0296$), and Sen's slope estimated a typical long-term decrease of 7.12 µg/L year^{-1}. These results suggest that phosphorus concentrations have declined significantly over the monitoring period despite the irregular year-to-year pattern. In contrast, annual exceedance counts above the 10 µg/L threshold remained relatively stable over time, with no clear increasing or decreasing trend observed across the monitoring record. Although yearly exceedance counts fluctuated, they did not indicate a consistent long-term directional change. In 2025, a total of 11 phosphorus exceedance events (>10 µg/L) were recorded.

3.3.9 Zinc

Over the entire monitoring period, annual median zinc concentrations at Kirkpatrick Crescent Outfall (Site 6) exhibited a clear and statistically significant decreasing trend over time. A linear trend analysis estimated a slope of $m = -4.99$ µg/L year^{-1} ($p = 0.00085$; $R^2 = 0.45$). A non-parametric Kendall trend test supported this result (Kendall's $\tau = -0.53$, $p = 0.00080$), confirming a significant long-term decline. From a practical standpoint, this decrease was substantial, with annual median concentrations declining from 203.5 µg/L in 2005 to 27.35 µg/L in 2025, despite some year-to-year variability. Consistent with this improvement, annual zinc guideline exceedance counts exhibited a statistically significant downward trend over the monitoring period. Linear regression estimated a significantly negative slope. This pattern was supported by multiple nonparametric and correlation-based tests, all of which indicated a significant negative trend. In practical terms, exceedance frequency decreased from an average of 10.5 events per year during 2005–2010 to 6.0 events per year during 2020–2025, representing an approximate 43% reduction. Despite this overall improvement, five zinc guideline exceedances were recorded in 2025.

3.4 Nutrients

3.4.1 Ammonia as NH3-N

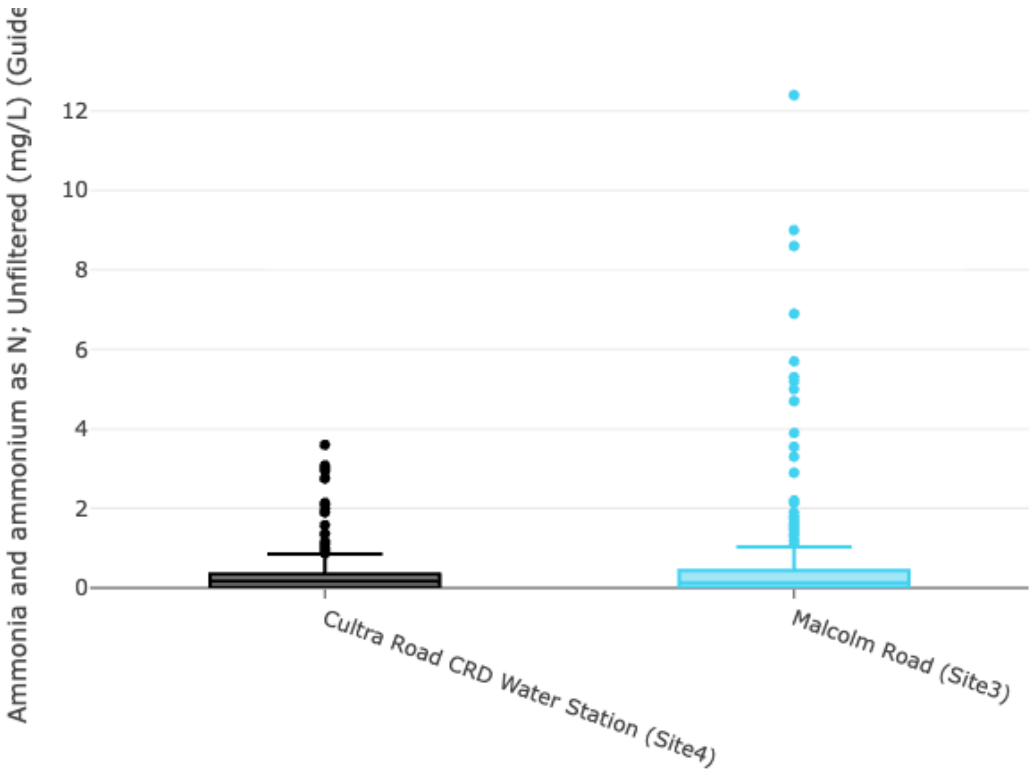


Figure 7. Boxplot comparison of ammonia-N across sites 3 and 4 over the 20 year monitoring period. Figure taken from Pacific Datastream.

Median ammonia-N (NH_3-N) concentrations were 0.12 mg/L at Malcolm Road (Site 3) and 0.165 mg/L at Cultra Road CRD Water Station (Site 4), indicating slightly higher baseline concentrations at Site 4 (Figure 7). Guideline exceedances were assessed using threshold values that were calculated specifically for each sampling day based on the corresponding temperature and pH conditions. Using these site- and date-specific guideline limits, Site 3 recorded a total of nine exceedances over the monitoring period, while no exceedances were observed at Site 4. Non-parametric trend analysis indicated a significant decline in exceedance frequency at Site 3 over time, indicating that exceedances were more common in the early years of monitoring and became largely absent in recent years. A linear regression analysis supported the same conclusion (m = −0.0805 exceedances year^{-1}; p = 0.0116). Overall, these results indicate a significant

long-term improvement in ammonia-N conditions at Site 3. In 2025, no ammonia-N guideline exceedances were recorded at either site.

3.4.2 Nitrite as N

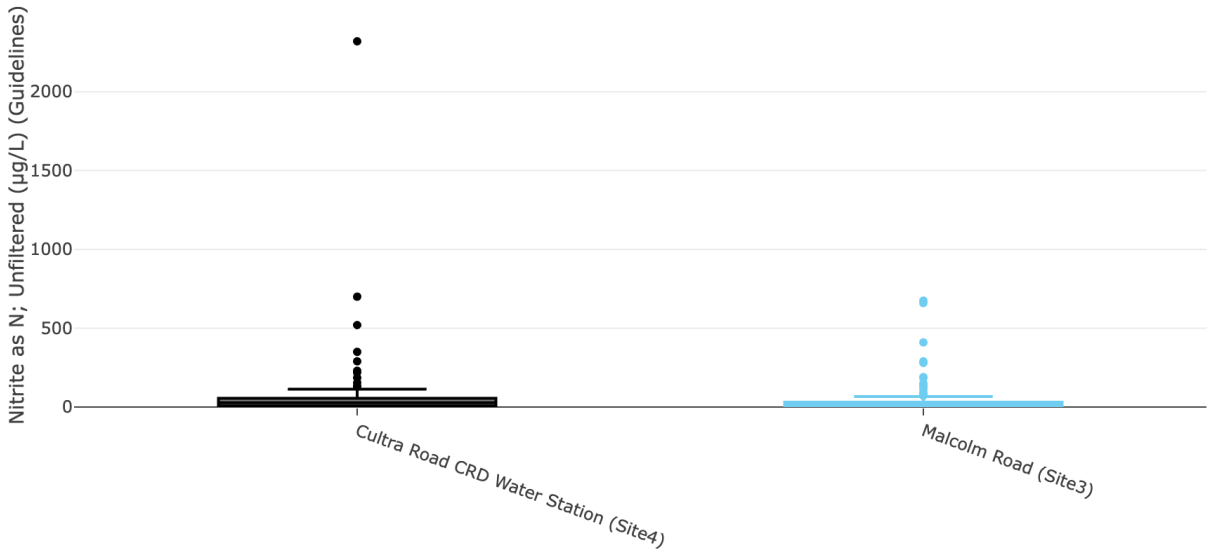


Figure 8. Boxplot comparison of nitrite-N across sites 3 and 4 over the 20 year monitoring period. Figure taken from Pacific Datastream.

Median nitrite concentrations differed between the two nutrient monitoring sites, with a median of 15.9 µg/L at Malcolm Road (Site 3) and 28 µg/L at Cultra Road CRD Water Station (Site 4; Figure 8), indicating consistently higher nitrite concentrations at Site 4. Consistent with this pattern, Site 4 also recorded a greater number of exceedances above the 60 µg/L threshold over the monitoring record, with 48 exceedances compared with 28 at Site 3. Trend analysis of annual exceedance counts indicated a clear and statistically significant downward trend at Site 3 (p = 0.000426), suggesting that nitrite exceedances have declined substantially over time at this site. Site 4 also showed a negative slope, indicating a general downward direction; however, this trend was weaker and not statistically significant (p = 0.0949), and is therefore better interpreted as no clear long-term significant trend in exceedance frequency. Overall, these results suggest that nitrite exceedances have decreased significantly at Site 3, while conditions at Site 4 may be improving but remain more variable over time. In 2025, no nitrite exceedances were recorded at Site 3, while one exceedance was recorded at Site 4.

3.4.3 Nitrate as N

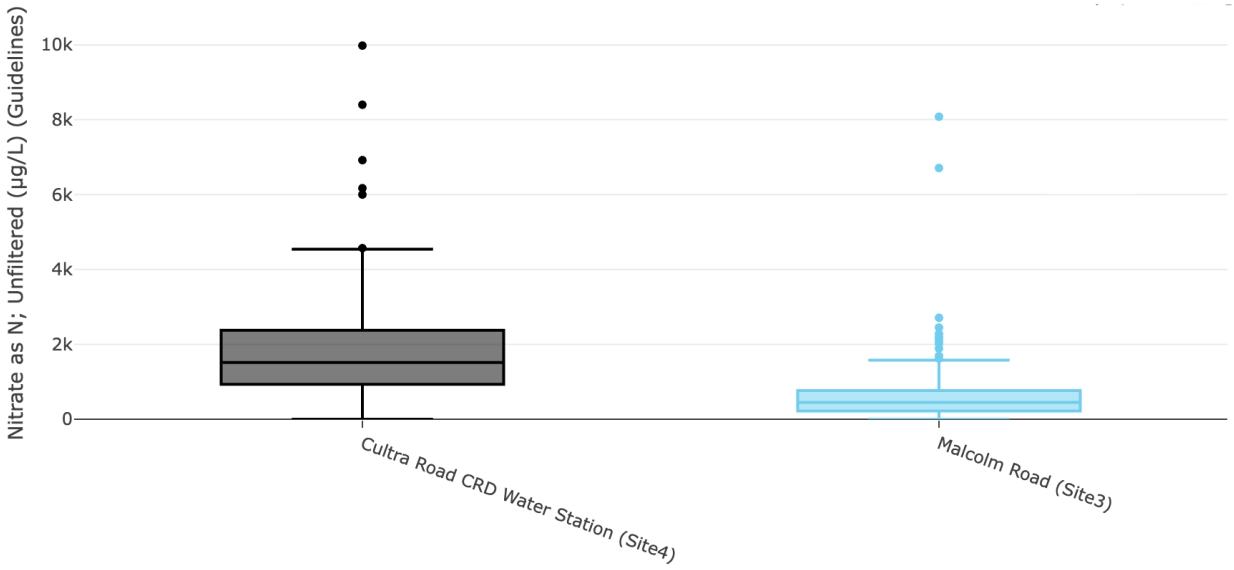


Figure 9. Boxplot comparison of nitrate-N across sites 3 and 4 over the 20 year monitoring period. Figure taken from Pacific Datastream.

Median nitrate-N concentrations differed substantially between the two nutrient monitoring sites, with a median of 450 µg/L at Malcolm Road (Site 3) and 1,515 µg/L at Cultra Road CRD Water Station (Site 4), indicating consistently higher nitrate concentrations at Site 4 (Figure 9). The applicable CCME chronic guideline threshold for nitrate-N is 3 mg/L (3,000 µg/L). Consistent with this threshold, Site 4 recorded a much greater number of chronic guideline exceedances over the monitoring record, with 27 exceedances compared with only 2 at Site 3. Trend analysis of annual exceedance counts, did not identify a statistically significant temporal trend at either site. At Site 3, the regression slope was slightly positive, suggesting a weak upward tendency; however, this relationship was not statistically significant (p = 0.0525). A non-parametric Kendall trend test produced a similar result (Kendall's τ = 0.358, p = 0.055), indicating only a marginal suggestion of increasing exceedance frequency. At Site 4, the exceedance trend was likewise effectively stable over time, with a slight positive slope but no statistical support for a directional trend (p = 0.582; R^2 = 0.016). This interpretation was further supported by the non-parametric analysis, indicating no meaningful monotonic trend. Overall, nitrate-N exceedance frequency at both sites is best described as remaining relatively stable over the monitoring period. In 2025, one chronic guideline exceedance above the 3 mg/L CCME threshold was recorded at each site.

3.4.4 Orthophosphate

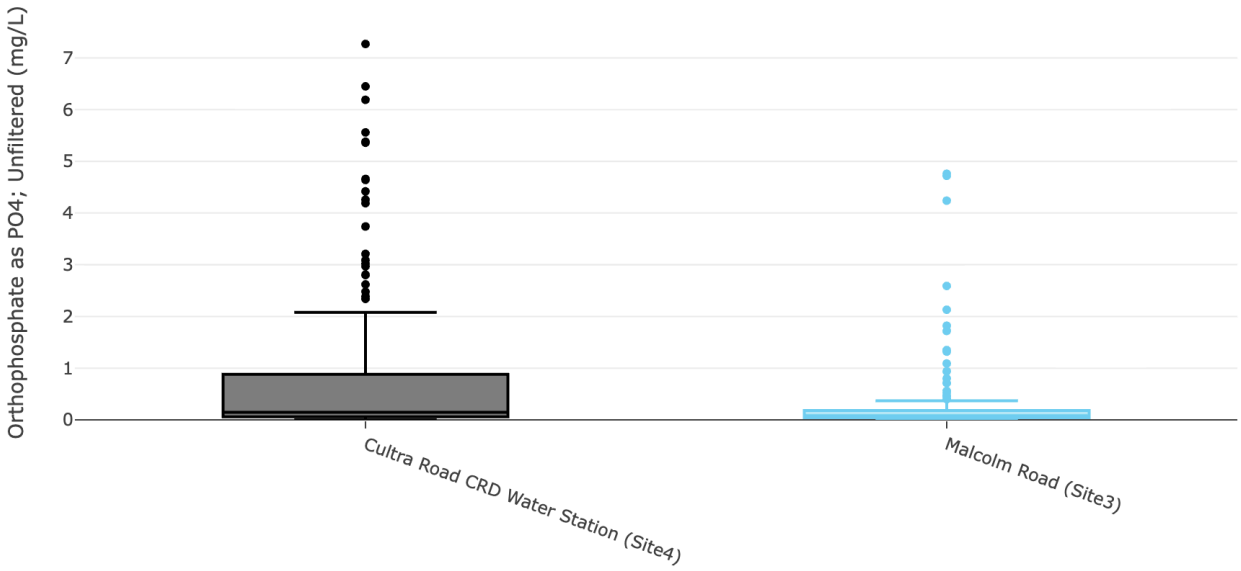


Figure 10. Boxplot comparison of orthophosphate across sites 3 and 4 over the 20 year monitoring period. Figure taken from Pacific Datastream.

Median orthophosphate concentrations were 0.08 mg/L at Malcolm Road (Site 3) and 0.145 mg/L at Cultra Road CRD Water Station (Site 4), indicating consistently higher concentrations at Site 4 (Figure 10). No officially recognized CCME water quality guideline exists for orthophosphate specifically; however, for the purposes of this analysis, a threshold of 100 µg/L was used as a benchmark for elevated concentrations, consistent with thresholds commonly referenced in freshwater nutrient assessments. Using this 100 µg/L threshold, total exceedance counts over the monitoring record were 101 at Site 3 and 141 at Site 4. Focusing on the non-parametric trend analyses, both sites exhibited statistically significant downward trends in annual exceedance frequency over time. At Site 3, tests indicated that annual exceedance counts have declined by approximately 0.5 events per year on average. Site 4 showed an even stronger and more consistent decline, with the Mann–Kendall test likewise indicating a highly significant downward trend (Kendall's $\tau = -0.633$, $p = 0.000055$). Overall, these results indicate that elevated orthophosphate concentrations have declined significantly over time at both sites, with the strongest improvement observed at Site 4. In 2025, no orthophosphate exceedances were recorded at Site 3, while one exceedance was recorded at Site 4.

3.5 Hydrocarbons

Figures for hydrocarbon data are not included within this report. However, exceedance occurrence tables for each parameter can be found in the appendix, and all data, with figures and statistics, can be found publicly available on Pacific Datastream: Peninsula Streams Society Central Saanich Water Quality Monitoring - KENNES.

3.5.1 Total Extractable Hydrocarbons

Total extractable hydrocarbons (TEH) concentrations did not exhibit a clear long-term directional trend. Annual median TEH concentrations showed no evidence of a statistically significant decrease over time. Linear trend analysis estimated a slight positive slope, while the non-parametric Kendall trend test likewise indicated no significant monotonic trend (Kendall's $\tau = -0.131$, $p = 0.464$). Rather than a steady decline or increase, the data were characterized by many years with annual median concentrations of zero, interrupted by several years with elevated medians, including notable spikes in 2005 (2.235 mg/L), 2006 (2.430 mg/L), 2015 (2.000 mg/L), 2016 (0.460 mg/L), and especially 2024 (12.550 mg/L). Consistent with this pattern, TEH exceedance frequency also showed no significant temporal trend over the monitoring period. A total of 70 exceedances were recorded over the 20-year record, with annual exceedance counts fluctuating from year to year but showing no evidence of a sustained decline. Overall, the TEH dataset is best interpreted as showing substantial interannual variability rather than a clear long-term improvement trend. In 2025, four TEH exceedances were recorded. Notably, TEH concentrations were unusually elevated in 2024, suggesting the need for continued monitoring and further investigation of potential episodic hydrocarbon inputs at the site.

3.5.2 Polycyclic Aromatic Hydrocarbons

Over the 2007–2025 monitoring period, polycyclic aromatic hydrocarbon (PAH) detections exhibited a statistically significant decreasing trend over time. Linear trend analysis estimated a slope of $m = -0.2386$ detections year^{-1} ($p = 0.000315$), indicating that the annual number of PAH detections declined by approximately 0.24 detections per year on average. This downward pattern was strongly supported by a non-parametric Kendall trend test (Kendall's $\tau = -0.5946$, $p = 0.000878$), confirming a significant long-term reduction in PAH detections over the monitoring period. Overall, these results indicate a clear and statistically robust decline in PAH occurrence at the site from 2007 to 2025. In 2025, two PAH detections were recorded, both primarily driven by 2-methylnaphthalene, a compound commonly associated with petroleum-based fuel products.

3.6 Sediment Metals

Figures for sediment data are not included within this report. However, exceedance occurrence tables for each parameter can be found in the appendix, and all data, with figures and statistics, can be found publicly available on Pacific Datastream: Peninsula Streams Society Central Saanich Water Quality Monitoring - KENNES.

3.6.1 Arsenic

Annual median sediment arsenic concentrations did not exhibit a clear long-term increasing or decreasing trend. While the data suggest a slight positive directional signal, the trend was weak and not statistically significant, and is therefore best interpreted as broad interannual variability rather than a consistent long-term change. Guideline exceedances were rare throughout the monitoring record, with only five exceedance events recorded over the full 20-year period. The most recent exceedance occurred in

2022, and no exceedances have been observed since then, suggesting that sediment arsenic concentrations have remained below guideline thresholds in recent years.

3.6.2 Cadmium

Annual median sediment cadmium concentrations exhibited a statistically significant decreasing trend over time. A non-parametric trend analysis indicated a negative long-term trend (Kendall's $\tau = -0.3462$, $p = 0.0293$), confirming a significant decline in median cadmium concentrations from 2005 to 2025. In contrast, annual exceedance counts showed only a weak downward tendency and did not exhibit a statistically significant long-term trend, and are therefore best interpreted as broadly stable over time. A total of 15 exceedance events were recorded over the 20-year monitoring period. Notably, no exceedances were observed in 2025, and no cadmium sediment exceedances have been recorded since 2022, suggesting improved recent conditions.

3.6.3 Chromium

Over the 2008–2025 monitoring period, sediment chromium concentrations did not exhibit a clear long-term temporal trend. Annual median concentrations showed only a very slight positive directional signal, but this trend was effectively flat and not statistically significant. Linear trend analysis estimated a slope of $m = 0.0012$ µg/g year^{-1}, indicating that year explained virtually none of the variation in annual median chromium concentrations. A non-parametric Kendall trend test supported this interpretation (Kendall's $\tau = 0.1503$, $p = 0.4101$), suggesting only a weak and non-significant upward tendency. Similarly, annual exceedance counts showed a slight positive direction but no statistically significant trend over time. Overall, chromium sediment conditions are best interpreted as broadly stable over time, with no clear evidence of long-term improvement or deterioration. In 2025, chromium concentrations exceeded the applicable guideline threshold in 3 of 4 samples collected, suggesting concentrations are frequently elevated.

3.6.4 Copper

Sediment copper concentrations did not exhibit a clear long-term temporal trend. Annual median copper concentrations showed a weak downward tendency over time, with a negative Sen's slope estimate of approximately −1.055 µg/g year^{-1}; however, this trend was not statistically significant, and is therefore best interpreted as broad interannual variability rather than a consistent decline. Similarly, annual exceedance counts showed no statistically significant long-term trend from 2005 to 2025. The Mann–Kendall analysis indicated a very weak positive association, suggesting that exceedance frequency has fluctuated from year to year without a clear increasing or decreasing pattern over time. Overall, sediment copper conditions are best described as broadly stable but elevated across the monitoring period. In 2025, copper concentrations exceeded the applicable guideline threshold in 75% of samples collected.

3.6.5 Lead

Sediment lead concentrations exhibited an overall weak downward tendency, although no statistically significant long-term trend was detected in annual median concentrations.. Similarly, annual exceedance counts showed a weak-to-moderate downward trend over time, with negative Mann–Kendall statistics (Kendall's $\tau = -0.340$; $Z = -1.919$; $p = 0.051$), suggesting that exceedances have generally become less frequent. However, this result was just above the conventional 0.05 significance threshold and is therefore best described as a borderline non-significant downward trend. Notably, no sediment lead exceedances have been recorded since 2021, suggesting improved recent conditions despite the lack of a formally significant long-term trend.

3.6.6 Nickel

Sediment nickel concentrations did not exhibit a clear long-term temporal trend. Annual median nickel concentrations showed a very slight downward directional signal, but this trend was effectively negligible and not statistically significant ($p = 0.976$), and is therefore best interpreted as stable conditions with year-to-year variability rather than a meaningful long-term change. Similarly, annual exceedance counts showed no statistically significant trend over time. While the Mann–Kendall analysis suggested a weak positive directional tendency (Kendall's $\tau = 0.200$), this relationship was not statistically significant, indicating that exceedance frequency has remained effectively stable over the monitoring period. Overall, sediment nickel conditions are best described as broadly unchanged from 2005 to 2025, with no clear evidence of improvement or deterioration over time. In 2025, nickel concentrations exceeded the applicable guideline threshold in 3 of 4 samples collected, suggesting these concentrations are frequently elevated.

3.6.7 Zinc

Sediment zinc concentrations did not exhibit a clear long-term temporal trend. Annual median zinc concentrations showed a slight downward directional tendency over time, with negative Mann–Kendall statistics; however, this trend was not statistically significant ($p = 0.4874$) and is therefore best interpreted as stable conditions with year-to-year variability rather than a consistent long-term decline. Similarly, annual exceedance counts showed no meaningful temporal trend. Overall, sediment zinc conditions are best described as broadly stable over the monitoring period, with no statistically significant long-term increase or decrease in either concentrations or exceedance frequency. In 2025, zinc concentrations exceeded the applicable guideline threshold in 3 of 4 samples collected, suggesting that zinc is frequently elevated in sediment samples.

4.0 Discussion

Overall, results from the 2005–2025 Hagan–Graham (KENNES) watershed monitoring program indicate that while several aspects of water quality have improved over the course of the monitoring period, a number of contaminants and water quality concerns continue to persist throughout the watershed. The long-term dataset suggests that several dissolved metals, nutrient parameters, and some physical water

quality indicators have shown measurable improvement over time, while other parameters have remained chronically elevated or highly variable. These findings highlight both the value of sustained long-term monitoring and the continued influence of anthropogenic activities within the watershed.

Physical water quality conditions throughout much of the watershed remained generally consistent with conditions capable of supporting aquatic life. Water temperatures remained relatively stable across all sites, and exceedances above 19 °C were infrequent and sporadic throughout the monitoring period, with no evidence of widespread or severe long-term warming trends. Similarly, pH conditions remained consistently near-neutral and well-buffered across all monitoring locations, suggesting relatively stable conditions within the watershed. Dissolved oxygen conditions also remained relatively stable overall; however, Stelly's Road Culvert (Site 5) experienced recurring low oxygen events throughout the monitoring period and consistently exhibited the lowest median dissolved oxygen saturation values across all sites. These low oxygen conditions may reflect localized organic enrichment, reduced summer flow conditions, stagnant water conditions (all of these have been observed at the Stelly's Rd culvert), or the accumulation and decomposition of organic material within the reach of the watershed. Despite the persistence of low oxygen events at Site 5, exceedance frequency declined over time, suggesting that oxygen conditions at this site may be gradually improving.

Turbidity remained one of the most consistently elevated physical water quality parameters throughout the watershed. Elevated turbidity events were recorded at all sites over the monitoring period, with the greatest number occurring at Stelly's Road Culvert (Site 5) and Kirkpatrick Crescent Outfall (Site 6). These elevated turbidity conditions likely reflect a combination of urban runoff, bank erosion, storm-driven sediment transport, low summer flows, agricultural influences, and fine sediment inputs associated with surrounding land use activities. Elevated turbidity is ecologically important because suspended sediments can damage fish gills, reduce feeding efficiency, smother spawning gravels, impair egg survival, and transport attached contaminants such as metals and hydrocarbons (Kemp et al., 2011). Despite the continued occurrence of elevated turbidity events throughout the watershed, several sites, including Graveyard (Site 1), Kersey Road (Site 6b), and Kirkpatrick Crescent Outfall (Site 6), exhibited statistically significant declines in median turbidity or exceedance frequency over time, suggesting gradual improvement in turbidity conditions at these locations.

Conductivity conditions were similarly stable overall, although both elevated and reduced conductivity events occurred periodically throughout the watershed. Kirkpatrick Crescent Outfall (Site 6) experienced the highest number of both high and low conductivity events, reflecting the highly variable nature of runoff conditions associated with stormwater discharge and changing hydrologic conditions at this site. While most conductivity exceedance trends remained stable over time, Kersey Road (Site 6b) exhibited a statistically significant increase in low conductivity events, while Site 6 showed a significant decline in low conductivity events over the monitoring period. These trends may reflect alterations in stormwater inputs over time.

Enhanced monitoring at Kirkpatrick Crescent Outfall (Site 6) continues to indicate that runoff downstream of the Keating Industrial Area remains a significant source of contamination within the watershed. Copper, iron, phosphorus, and zinc consistently exceeded applicable water quality guidelines throughout the monitoring period and remain among the primary dissolved contaminant concerns at this site. Copper was particularly persistent, exceeding hardness-adjusted aquatic life guidelines in nearly 90%

of all samples collected between 2005 and 2025, despite annual median concentrations declining significantly over time. Similarly, phosphorus and iron exceedances remained chronically elevated throughout the monitoring record, indicating that these contaminants continue to enter the watershed on a regular basis. Elevated concentrations of these contaminants are ecologically important because many dissolved metals are known to negatively affect aquatic organisms, particularly salmonids and other sensitive fish species. Copper can impair olfactory function, predator avoidance behaviour, osmoregulation, and respiration in juvenile salmonids (Hecht et al., 2007; Price, 2013), while elevated zinc and iron concentrations may contribute to physiological stress, gill damage, and reduced survival (Price, 2013). Elevated phosphorus concentrations may also contribute to nutrient enrichment, excessive algal growth, and reduced oxygen conditions under low-flow summer conditions.

Despite the persistence of several contaminants, multiple dissolved metals exhibited clear evidence of long-term improvement over the monitoring period. Cadmium, lead, zinc, phosphorus, and copper concentrations all declined significantly between 2005 and 2025, while cadmium, lead, and zinc exceedance frequencies likewise decreased substantially over time. In particular, cadmium exceedances, which were common during the early years of monitoring, became rare in recent years, with no exceedances recorded after 2023. Similarly, lead exceedances declined markedly over time, while zinc exceedance frequency decreased by approximately 43% relative to early monitoring years. Polycyclic aromatic hydrocarbon (PAH) detections also declined significantly over time, suggesting reduced occurrence of these compounds within stormwater runoff entering the watershed. These improvements may reflect changes in industrial practices, improved spill prevention measures, source control initiatives, infrastructure upgrades, or broader improvements in stormwater management throughout the watershed and surrounding industrial areas.

In contrast, total extractable hydrocarbons (TEH) showed little evidence of long-term improvement and remained highly variable between years. Several years, particularly 2005, 2006, 2015, and 2024, exhibited notably elevated TEH concentrations, suggesting the continued occurrence of episodic hydrocarbon contamination events associated with industrial runoff, vehicle-related pollutants, spills, or stormwater transport. The unusually elevated TEH concentrations observed in 2024 highlight the importance of continued monitoring and suggest that hydrocarbon contamination remains an ongoing concern within the watershed. Hydrocarbon contamination is ecologically important because petroleum-based compounds may exert direct toxic effects on aquatic organisms, reduce water quality, impair benthic habitat quality, and contribute to long-term sediment contamination.

Fecal coliform concentrations at Site 6 also remained highly variable throughout the monitoring period, with repeated exceedances of the recreational water quality guideline threshold of 200 CFU/100 mL. Elevated concentrations indicate the continued presence of fecal contamination within stormwater runoff entering the watershed, potentially originating from wildlife, agricultural activity, failing infrastructure, pet waste, or cross-connections between sanitary and stormwater systems. However, a substantial decline in measured fecal coliform concentrations was observed following the transition from MB Laboratories to Bureau Veritas in August 2025. Following this laboratory transition, annual median concentrations declined sharply relative to previous years, with preliminary 2026 concentrations declining further still. It is possible that differences in analytical methods, laboratory procedures, detection techniques, or reporting practices between laboratories contributed to the observed shift in measured concentrations. As such, caution should be exercised when interpreting recent fecal coliform trends across the laboratory transition period, and

additional years of monitoring will be necessary to determine whether the apparent reduction reflects a true environmental improvement.

Nutrient monitoring at Malcolm Road (Site 3) and Cultra Road CRD Water Station (Site 4) identified several ongoing nutrient-related concerns throughout the watershed. Nitrate-N concentrations were consistently higher at Site 4 and frequently exceeded chronic guideline thresholds, although exceedance frequency remained relatively stable over time at both monitoring sites. In contrast, several other nutrient parameters showed evidence of improvement. Nitrite exceedances declined significantly at Site 3 and exhibited a weaker declining tendency at Site 4, while orthophosphate exceedance frequency declined significantly at both nutrient monitoring sites. Ammonia-N exceedances also declined substantially over time and became absent in recent years. Elevated nutrient concentrations throughout the watershed are likely associated with a combination of agricultural runoff, fertilizers, organic waste inputs, or urban stormwater runoff. These nutrient inputs may contribute to eutrophication, excessive aquatic vegetation growth, and oxygen depletion under low-flow summer conditions.

Sediment quality monitoring at Site 6 indicated that several sediment-associated metals remain chronically elevated within the watershed. Copper, chromium, nickel, and zinc repeatedly exceeded sediment quality guidelines throughout the monitoring period, with chromium, nickel, and zinc continuing to exceed guidelines in most samples collected during 2025. Despite these elevated concentrations, most sediment-associated metals did not exhibit statistically significant increasing or decreasing trends over time, suggesting relatively stable but chronically contaminated sediment conditions near the outfall. Sediment contamination is ecologically important because contaminants may accumulate over time, remain biologically available to benthic organisms, and act as long-term contaminant reservoirs within aquatic systems. Some improvements were observed for sediment cadmium concentrations, which declined significantly over the monitoring period, while sediment lead exceedances have not been observed since 2021, suggesting that some aspects of sediment quality may also be gradually improving.

Overall, the long-term KENNES watershed monitoring program demonstrates that while several aspects of watershed condition appear stable or have improved over the past two decades, several indicators of urban and industrial stormwater contamination remain persistent throughout the watershed. The continued occurrence of elevated metals, hydrocarbons, nutrients, fecal contamination, turbidity, and sediment-associated contaminants suggests that ongoing pollutant inputs continue to affect aquatic habitat quality. At the same time, observed improvements in parameters such as cadmium, lead, zinc, ammonia, orthophosphate, and PAHs demonstrate that positive long-term changes are possible and may reflect the benefits of source control initiatives, stormwater management improvements, infrastructure upgrades, and ongoing stewardship efforts. Continued long-term monitoring will remain critical for identifying emerging trends, evaluating management effectiveness, informing restoration priorities, and supporting the long-term protection of aquatic habitat within the watershed.

To better contextualize the elevated contaminant concentrations observed within the watershed, several of the parameters that were most frequently elevated throughout the monitoring program were compared against other available Vancouver Island and CRD-area stream datasets. The goal of this comparison was to assess whether the concentrations observed within KENNES were broadly consistent with conditions commonly observed elsewhere across the region, or whether they appeared unusually elevated relative to other local stream systems.

Comparison of the watershed to other streams suggests that KENNES may experience substantially greater contamination for several key water quality parameters commonly associated with urban and industrial stormwater runoff. Copper and zinc, in particular, were consistently elevated relative to regional comparison streams. Median copper concentrations within KENNES were approximately 13 times higher than the regional median, while median zinc concentrations were approximately 11 times higher than regional comparison values. Iron and phosphorus concentrations were also elevated relative to regional streams, although less dramatically, as these parameters appear to be comparatively high in several other streams across the Saanich Peninsula as well. Hydrocarbon comparisons were more limited because most regional datasets contained PAH measurements rather than total extractable hydrocarbons (TEH), making direct comparisons difficult. However, KENNES exhibited evidence of recurring episodic petroleum hydrocarbon contamination, including frequent elevated TEH events and occasional very large hydrocarbon spikes. In contrast, PAH concentrations appeared broadly comparable to regional datasets, suggesting that hydrocarbon contamination within the watershed may be driven more strongly by non-PAH petroleum compounds than by PAHs specifically. Fecal coliform concentrations also appeared substantially elevated relative to regional comparison streams. However, concentrations measured following the transition from MB Laboratories to Bureau Veritas declined considerably and fell much closer to regional ranges, suggesting that previously elevated concentrations may have been influenced, at least in part, by differences in analytical methodology between laboratories.

Collectively, these results suggest that KENNES exhibits a particularly strong urban and industrial contamination signal relative to many comparable regional streams. Copper, zinc, and likely TEH associated with petroleum products appear to be consistently elevated beyond what may be considered regionally typical conditions. Copper and zinc commonly co-occur in urban runoff because both are strongly associated with roads, vehicles and general industrial activities. Copper is frequently linked to brake pad wear, while zinc can originate from tire wear, galvanized materials, brake components, and general vehicle corrosion. Additional potential sources for both metals include metal fabrication and machinery maintenance. The co-occurrence of elevated copper, zinc, and petroleum hydrocarbons within KENNES therefore suggests that runoff associated with transportation, vehicle wear, and industrial land use likely represents an important source of contamination within the watershed.

It is important to note, however, that these regional comparisons should be interpreted cautiously. The comparison datasets were collected using different sampling designs, analytical methodologies, detection limits, monitoring objectives, temporal coverage, and sampling frequencies, all of which can influence reported concentrations and comparability among datasets. Additionally, many of the regional comparison sites represent stream mainstem monitoring locations, whereas the primary KENNES monitoring site is located directly downstream of industrial stormwater outfalls draining the Keating Industrial Area. Consequently, these comparisons are best interpreted as providing broad regional context rather than precise one-to-one assessments of watershed condition.

5.0 Conclusion

The KENNES Watershed Water Quality Monitoring Program has provided more than 20 years of continuous environmental monitoring data, representing one of the longest-running watershed-scale water quality datasets on Vancouver Island. Since monitoring began in 2005, the program has generated

important baseline information on physical water quality conditions, nutrients, fecal contamination, dissolved metals, hydrocarbons, and sediment-associated contaminants throughout the watershed, while also helping identify long-term trends and persistent areas of concern.

Overall, results from the 2005–2025 monitoring period indicate that many physical water quality parameters within the watershed have remained relatively stable over time. Water temperature, pH, dissolved oxygen, and conductivity conditions generally remained within ranges capable of supporting aquatic life, with relatively few strong long-term changes observed across most sites. However, elevated turbidity remained a persistent issue throughout portions of the watershed, particularly at Stelly's Road Culvert (Site 5) and Kirkpatrick Crescent Outfall (Site 6), where repeated elevated turbidity events were observed throughout the monitoring period. Low dissolved oxygen conditions also remained a recurring concern at Site 5, although the frequency of these events declined over time, suggesting gradual improvement in oxygen conditions at this location.

Despite the relative stability of many physical parameters, the monitoring program identified several ongoing contaminant concerns associated with stormwater runoff downstream of the Keating Industrial Area at Kirkpatrick Crescent Outfall (Site 6). Dissolved copper, iron, phosphorus, zinc, hydrocarbons, fecal coliforms, and several sediment-associated metals repeatedly exceeded applicable guidelines throughout the monitoring period, indicating that chronic pollutant inputs continue to affect watershed conditions. Sediment quality results further demonstrated the persistence of elevated chromium, nickel, copper, and zinc concentrations within depositional sediments near the outfall, with little evidence of substantial long-term improvement for many of these parameters.

At the same time, the long-term dataset identified several encouraging trends. Cadmium, lead, zinc, phosphorus, ammonia, nitrite, orthophosphate, and PAH detections all declined significantly over time, suggesting that some aspects of watershed condition may be improving. Several physical water quality indicators, including turbidity at some sites and low dissolved oxygen events at Site 5, also exhibited evidence of gradual improvement. These improvements may reflect the cumulative benefits of source control initiatives, infrastructure upgrades, improved industrial practices, stormwater management measures, and ongoing stewardship efforts occurring throughout the watershed over the past two decades. In contrast, total extractable hydrocarbons (TEH) remained highly variable and showed little evidence of long-term improvement, indicating that hydrocarbon contamination associated with stormwater runoff and industrial activity remains an ongoing concern within the watershed.

Interpretation of recent fecal coliform trends should be approached cautiously due to the transition from MB Laboratories to Bureau Veritas in 2025, which coincided with a substantial reduction in reported concentrations. Additional years of monitoring will be necessary to determine whether these lower concentrations reflect true environmental improvement or methodological differences between laboratories.

Results from both the KENNES and Tetayut watershed monitoring programs indicate that the two watersheds experience many similar water quality challenges associated with urbanization, stormwater runoff, industrial activity, and surrounding land use. Both watersheds exhibited generally stable physical water quality conditions over time, while also experiencing persistent turbidity, fecal coliform exceedances, nutrient enrichment, dissolved metal contamination, hydrocarbon contamination, and elevated sediment-associated metals near outfalls draining the Keating Industrial Area. Copper, iron, phosphorus,

zinc, hydrocarbons, and sediment-associated chromium, copper, nickel, and zinc emerged as consistent concerns in both systems. At the same time, both watersheds showed evidence of improvement for several parameters over time, including cadmium exceedances, ammonia, and PAH detections, suggesting that some aspects of watershed condition may be gradually improving. Despite these similarities, several notable differences were observed between the watersheds. The KENNES watershed generally exhibited more severe dissolved metal contamination at the primary industrial outfall site, particularly for copper, phosphorus, and zinc, while Tetayut exhibited stronger nutrient-related concerns, especially increasing nitrate exceedances at Kennel Creek (Site 4). Tetayut also showed a statistically significant increase in total extractable hydrocarbon (TEH) exceedances over time, whereas the KENNES watershed exhibited persistently elevated but more variable TEH conditions. In contrast, the KENNES watershed experienced poorer dissolved oxygen conditions at Stelly's Road Culvert (Site 5), while Tetayut generally exhibited higher conductivity conditions at several downstream urban-influenced sites. Collectively, these results suggest that although both watersheds are affected by similar anthropogenic pressures, the severity and type of water quality impacts vary depending on watershed characteristics, hydrology, and surrounding land use.

Comparison of the KENNES watershed to other Vancouver Island and CRD-area stream datasets further suggests that several contaminants within KENNES, particularly copper, zinc, fecal coliforms, and likely petroleum hydrocarbons, occur at concentrations substantially elevated relative to many comparable regional streams. In particular, copper and zinc concentrations appeared consistently higher than regional medians, indicating a strong urban and industrial stormwater contamination signal associated with runoff draining the Keating Industrial Area. While these regional comparisons should be interpreted cautiously due to differences in monitoring design and analytical methodologies among datasets, the results nevertheless suggest that contaminant concentrations within portions of the KENNES watershed may be elevated beyond what is typically observed in many other streams across the region.

This long-term monitoring program demonstrates the importance of sustained watershed-scale environmental monitoring in identifying chronic pollution sources, evaluating temporal trends, and informing management priorities. The results indicate that while portions of the KENNES watershed remain in relatively good physical condition and several parameters have improved over time, persistent contaminant inputs associated with urbanization, stormwater runoff, agriculture, and industrial activity continue to affect water and sediment quality throughout the watershed. Continued long-term monitoring, source control initiatives, stormwater treatment and green infrastructure implementation, habitat restoration, and community stewardship, including collaboration with local First Nations, will remain important for improving watershed health and protecting aquatic habitat within watersheds into the future.

The data collected here would not have been possible without the support of our volunteers. Together, water quality sampling for the Hagan-Graham and Tetayut watersheds amassed a total of 163 volunteer hours in 2025, and over 3,500 hours over the course of the entire PSS Central Saanich Water Quality Program.



Volunteers, PSS staff, and Tsawout fisheries team testing water quality.

6.0 Appendix

6.1 Physical Parameters Exceedance Tables

Table A1: Number of low oxygen events (below 50% saturation) per year, by site.

Year	Site 1	Site 3	Site 4	Site 5	Site 6	Site 6B
2005	1	0	0	9	1	0
2006	0	1	1	5	0	0
2007	0	1	0	5	3	0
2008	0	0	2	6	0	0
2009	1	2	1	6	4	4

2010	0	0	0	5	2	2
2011	0	0	0	6	0	0
2012	0	0	0	5	1	1
2013	1	0	1	3	0	1
2014	3	2	0	9	1	1
2015	0	1	0	7	2	1
2016	0	0	0	7	1	0
2017	0	1	0	2	1	0
2018	0	1	0	3	3	0
2019	3	1	0	4	3	0
2020	1	1	0	3	3	0
2021	1	0	2	3	1	0
2022	0	0	0	1	0	0
2023	0	3	0	3	0	0
2024	0	0	0	2	0	0
2025	0	0	0	2	0	0
Total	**11**	**14**	**7**	**96**	**26**	**10**

Table A2: Number of high temperature events (greater than 19 °C) per year, by site.

Year	Site 1	Site 3	Site 4	Site 5	Site 6	Site 6B
2005	3	2	0	2	2	0
2006	0	0	0	0	0	0
2007	0	2	0	0	1	0
2008	1	0	0	0	0	0
2009	0	0	0	0	0	0
2010	1	0	0	0	0	0
2011	0	1	0	0	0	0
2012	0	0	0	0	0	0
2013	0	0	0	0	0	0
2014	0	0	0	0	0	0
2015	1	1	0	1	0	0
2016	1	0	0	0	0	0
2017	0	0	0	0	0	0

2018	0	0	0	2	0	0
2019	0	0	0	0	0	0
2020	0	0	0	2	0	1
2021	1	1	0	2	1	1
2022	3	3	2	4	2	2
2023	0	2	1	2	1	2
2024	0	0	0	0	0	0
2025	0	0	0	0	0	0
Total	**11**	**12**	**3**	**15**	**7**	**6**

Table A3: Number of high turbidity events (greater than 25 NTU) per year, by site.

Year	Site 1	Site 3	Site 4	Site 5	Site 6	Site 6B
2005	1	0	1	3	4	1
2006	0	2	1	1	6	3
2007	2	0	3	3	6	3
2008	2	1	7	7	7	2
2009	4	2	2	9	3	4
2010	3	2	5	5	4	5
2011	3	1	5	7	6	0
2012	5	1	4	7	1	2
2013	0	1	2	3	5	0
2014	2	1	3	9	2	0
2015	4	1	3	4	3	2
2016	1	2	3	7	2	2
2017	1	1	2	5	4	1

2018	1	2	4	5	6	2
2019	2	1	2	5	5	3
2020	5	6	5	6	4	5
2021	0	0	2	5	6	2
2022	0	0	1	2	4	0
2023	1	0	0	2	4	1
2024	2	1	2	4	2	4
2025	2	2	3	4	1	4
Total	41	27	60	103	85	46

Table A4: Number of low conductivity events (less than 150 uS/cm) per year, by site.

Year	Site 1	Site 3	Site 4	Site 5	Site 6	Site 6B
2005	0	0	0	0	4	0
2006	0	0	0	1	6	0
2007	0	0	0	0	1	0
2008	0	0	0	0	2	0
2009	1	1	0	0	1	0
2010	1	1	1	1	2	0
2011	1	1	1	2	1	1
2012	0	0	0	0	1	0
2013	0	0	0	0	0	0
2014	0	0	1	0	0	0
2015	0	0	0	0	1	0
2016	0	0	0	0	1	1

2017	0	0	1	0	1	1
2018	0	0	0	0	0	0
2019	0	0	0	1	0	0
2020	0	1	2	1	1	2
2021	0	0	0	0	0	0
2022	0	0	0	0	0	1
2023	1	1	0	0	0	1
2024	0	1	0	0	1	0
2025	1	2	2	1	0	3
Total	5	8	8	7	23	10

Table A5: Number of high conductivity events (greater than 500 uS/cm) per year, by site.

Year	Site 1	Site 3	Site 4	Site 5	Site 6	Site 6B
2005	0	0	0	0	1	0
2006	0	0	0	0	0	0
2007	0	0	0	0	2	1
2008	0	0	0	0	0	0
2009	2	0	0	0	1	1
2010	0	0	0	0	0	0
2011	4	0	1	2	1	2
2012	8	0	1	3	2	3
2013	5	3	1	5	1	3
2014	0	1	0	1	1	0
2015	0	0	0	1	0	0

2016	0	0	1	1	1	1
2017	0	0	0	0	0	0
2018	0	0	0	0	1	0
2019	0	0	0	0	3	1
2020	0	0	0	0	1	0
2021	0	0	0	0	1	0
2022	0	0	0	0	4	0
2023	0	0	0	0	0	0
2024	0	0	0	0	1	0
2025	0	0	0	0	1	0
Total	**19**	**4**	**4**	**14**	**22**	**12**

6.2 Heavy Metals Exceedance Tables

Table A6: Number of Arsenic guideline (5 ug/L) exceedances at Site 6, by year.

Year	Site 6
2005	0
2006	0
2007	2
2008	0
2009	0
2010	0
2011	0
2012	2
2013	0
2014	0
2015	0
2016	1
2017	0
2018	0
2019	0
2020	0
2021	2

2022	1
2023	0
2024	0
2025	1
Total	9

Table A7: Number of cadmium guideline (hardness dependent) exceedances at Site 6, by year.

Year	Site 6
2005	6
2006	8
2007	9
2008	7
2009	7
2010	2
2011	5
2012	5
2013	7
2014	4
2015	2
2016	2
2017	3
2018	1
2019	1
2020	2
2021	5
2022	0
2023	2
2024	0
2025	0
Total	**78**

Table A8: Number of copper guideline (hardness dependent) exceedances at Site 6, by year.

Year	Site 6
2005	8
2006	10
2007	12
2008	11
2009	11
2010	11
2011	9
2012	9
2013	11
2014	11
2015	10
2016	10
2017	8
2018	8
2019	12
2020	11
2021	12
2022	12
2023	10
2024	9
2025	9
Total	**214**

Table A9: Number of iron guideline (300 ug/L) exceedances at Site 6, by year.

Year	Site 6
2005	8
2006	10
2007	12
2008	11
2009	11
2010	11
2011	9

2012	9
2013	11
2014	11
2015	10
2016	10
2017	8
2018	8
2019	12
2020	11
2021	12
2022	12
2023	10
2024	9
2025	9
Total	**214**

Table A10: Number of lead guideline (hardness dependent) exceedances at Site 6, by year.

Year	Site 6
2005	7
2006	6
2007	4
2008	6
2009	4
2010	5
2011	3
2012	3
2013	7
2014	2
2015	1
2016	3
2017	2
2018	1

2019	0
2020	2
2021	3
2022	0
2023	2
2024	2
2025	1
Total	64

Table A11: Number of manganese guideline (hardness dependent) exceedances at Site 6, by year.

Year	Site 6
2005	0
2006	0
2007	0
2008	0
2009	0
2010	0
2011	0
2012	0
2013	0
2014	0
2015	0
2016	0
2017	0
2018	0
2019	0
2020	0
2021	0
2022	0
2023	0
2024	0
2025	0

Total	0

Table A12: Number of mercury guideline (0.026 ug/L) exceedances at Site 6, by year.

Year	Site 6
2005	0
2006	1
2007	2
2008	0
2009	1
2010	2
2011	2
2012	1
2013	3
2014	0
2015	0
2016	0
2017	0
2018	1
2019	0
2020	0
2021	1
2022	0
2023	0
2024	1
2025	0
Total	**15**

Table A13: Number of phosphorus guideline (10 ug/L) exceedances at Site 6, by year.

Year	Site 6
2005	8
2006	11

2007	12
2008	11
2009	12
2010	10
2011	12
2012	10
2013	11
2014	12
2015	11
2016	9
2017	11
2018	9
2019	9
2020	11
2021	11
2022	11
2023	10
2024	12
2025	11
Total	**224**

Table A14: Number of zinc guideline (hardness dependent) exceedances at Site 6, by year.

Year	Site 6
2005	8
2006	11
2007	11
2008	11
2009	12
2010	10
2011	10
2012	11
2013	11
2014	10

2015	12
2016	9
2017	11
2018	6
2019	9
2020	7
2021	7
2022	2
2023	7
2024	8
2025	5
Total	188

6.3 Nutrient Exceedance Tables

Table A15: Number of ammonia-N guideline (temperature and pH dependent) exceedances at Sites 3 and 4.

Year	Site 3	Site 4
2005	1	0
2006	1	0
2007	1	0
2008	4	0
2009	1	0
2010	0	0
2011	0	0
2012	0	0
2013	0	0
2014	1	0
2015	0	0
2016	0	0
2017	0	0
2018	0	0
2019	0	0

2020	0	0
2021	0	0
2022	0	0
2023	0	0
2024	0	0
2025	0	0
Total	9	0

Table A16: Number of Nitrite-N guideline (0.06 mg/L) exceedances at Sites 3 and 4.

Year	Site 3	Site 4
2005	1	2
2006	2	3
2007	2	1
2008	3	7
2009	3	3
2010	5	6
2011	4	5
2012	3	2
2013	1	1
2014	3	1
2015	1	2
2016	0	1
2017	0	1
2018	0	0
2019	0	1
2020	0	2
2021	0	4
2022	0	0
2023	0	2
2024	0	3
2025	0	1
Total	**28**	**48**

Table A17: Number of Nitrate-N guideline (13 mg/L) exceedances at Sites 3 and 4.

Year	Site 3	Site 4
2005	0	0
2006	0	0
2007	0	0
2008	0	3
2009	0	0
2010	0	2
2011	0	1
2012	0	0
2013	0	0
2014	0	4
2015	0	5
2016	0	2
2017	0	1
2018	0	2
2019	0	0
2020	0	0
2021	1	3
2022	0	1
2023	0	1
2024	0	1
2025	1	1
Total	**2**	**27**

6.4 Hydrocarbon Exceedance Tables

Table A18: Number of total extractable hydrocarbon guideline (0.5 mg/L) exceedances at Sites 3 and 4.

Year	Site 6
2005	6

2006	10
2007	2
2008	3
2009	0
2010	1
2011	1
2012	0
2013	3
2014	4
2015	7
2016	5
2017	2
2018	0
2019	2
2020	4
2021	5
2022	2
2023	2
2024	7
2025	4
Total	**70**

Table A19: Number of polycyclic aromatic hydrocarbon detections at Sites 3 and 4.

Year	Site 6
2007	5
2008	5
2009	3
2010	4
2011	2
2012	1
2013	5
2014	1
2015	2

2016	0
2017	1
2018	1
2019	0
2020	0
2021	0
2022	1
2023	0
2024	0
2025	2
Total	33

6.5 Sediment Metals Exceedance Tables

Table A20: Number of sediment arsenic guideline (5.9 µg/g) exceedances per year. Note that only four sediment samples are collected per year.

Year	# of Exceedances	% Exceedances
2005	0	0
2006	0	0
2007	0	0
2008	1	25%
2009	0	0
2010	0	0
2011	0	0
2012	0	0
2013	1	25%
2014	0	0
2015	1	25%
2016	0	0
2017	0	0
2018	0	0
2019	0	0
2020	0	0

2021	1	25%
2022	1	25%
2023	0	0
2024	0	0
2025	0	0
Total	**5**	

Table A21: Number of sediment cadmium guideline (0.6 µg/g) exceedances per year. Note that only four sediment samples are collected per year.

Year	# of Exceedances	% Exceedances
2005	0	0
2006	1	25%
2007	2	50%
2008	1	25%
2009	1	25%
2010	0	0
2011	1	25%
2012	0	0
2013	1	25%
2014	1	25%
2015	2	50%
2016	1	25%
2017	1	25%
2018	0	0
2019	1	25%
2020	0	0
2021	1	25%
2022	1	25%
2023	0	0
2024	0	0
2025	0	0
Total	**15**	

Table A22: Number of sediment chromium guideline (37.3 µg/g) exceedances per year. Note that only four sediment samples are collected per year.

Year	# of Exceedances	% Exceedances
2008	0	0%
2009	1	20%
2010	0	0%
2011	0	0%
2012	2	50%
2013	3	50%
2014	1	25%
2015	3	75%
2016	3	75%
2017	0	0%
2018	1	25%
2019	2	50%
2020	0	0%
2021	2	50%
2022	1	25%
2023	2	50%
2024	1	25%
2025	3	75%
Total	**25**	

Table A23: Number of sediment copper guideline (35.7 µg/g) exceedances per year. Note that only four sediment samples are collected per year.

Year	# of Exceedances	% Exceedances
2005	2	100%
2006	3	100%
2007	3	100%
2008	3	60%
2009	2	40%

2010	2	50%
2011	1	20%
2012	4	100%
2013	6	100%
2014	3	75%
2015	4	100%
2016	4	100%
2017	4	100%
2018	3	75%
2019	4	100%
2020	3	75%
2021	2	50%
2022	1	25%
2023	4	100%
2024	3	75%
2025	3	75%
Total	**64**	

Table A24: Number of sediment lead guideline (35.7 µg/g) exceedances per year. Note that only four sediment samples are collected per year.

Year	# of Exceedances	% Exceedances
2005	2	
2006	3	
2007	3	
2008	3	
2009	2	
2010	2	
2011	1	
2012	4	
2013	6	
2014	3	
2015	4	

2016	4	
2017	4	
2018	3	
2019	4	
2020	3	
2021	2	
2022	1	
2023	4	
2024	3	
2025	3	
Total	**64**	

Table A25: Number of sediment nickel guideline (16 µg/g) exceedances per year. Note that only four sediment samples are collected per year.

Year	# of Exceedances	% Exceedances
2005	1	50.00%
2006	2	66.70%
2007	1	33.30%
2008	2	40.00%
2009	0	0.00%
2010	1	25.00%
2011	1	20.00%
2012	3	75.00%
2013	3	50.00%
2014	2	50.00%
2015	3	75.00%
2016	4	100.00%
2017	3	75.00%
2018	2	50.00%
2019	3	75.00%
2020	0	0.00%
2021	2	50.00%
2022	1	25.00%

2023	3	75.00%
2024	1	25.00%
2025	3	75.00%
Total	**41**	

Table A26: Number of sediment zinc guideline (123 µg/g) exceedances per year. Note that only four sediment samples are collected per year.

Year	# of Exceedances	% Exceedances
2005	2	100.00%
2006	2	66.70%
2007	1	33.30%
2008	1	20.00%
2009	0	0.00%
2010	1	25.00%
2011	0	0.00%
2012	0	0.00%
2013	3	50.00%
2014	1	25.00%
2015	2	50.00%
2016	2	50.00%
2017	1	25.00%
2018	1	25.00%
2019	1	25.00%
2020	0	0.00%
2021	1	25.00%
2022	1	25.00%
2023	1	25.00%
2024	1	25.00%
2025	2	50.00%
Total	24	

6.6 Sampling Sites within the KENNES Watershed

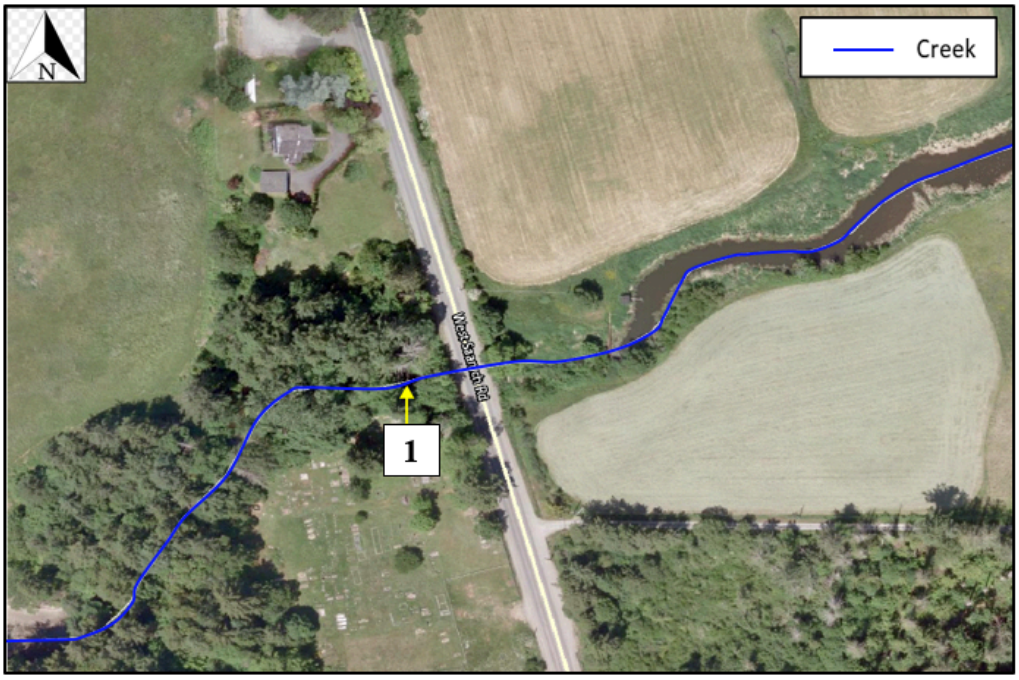


Figure A1. Hagan Creek at the West Saanich Road Graveyard (Site 1).

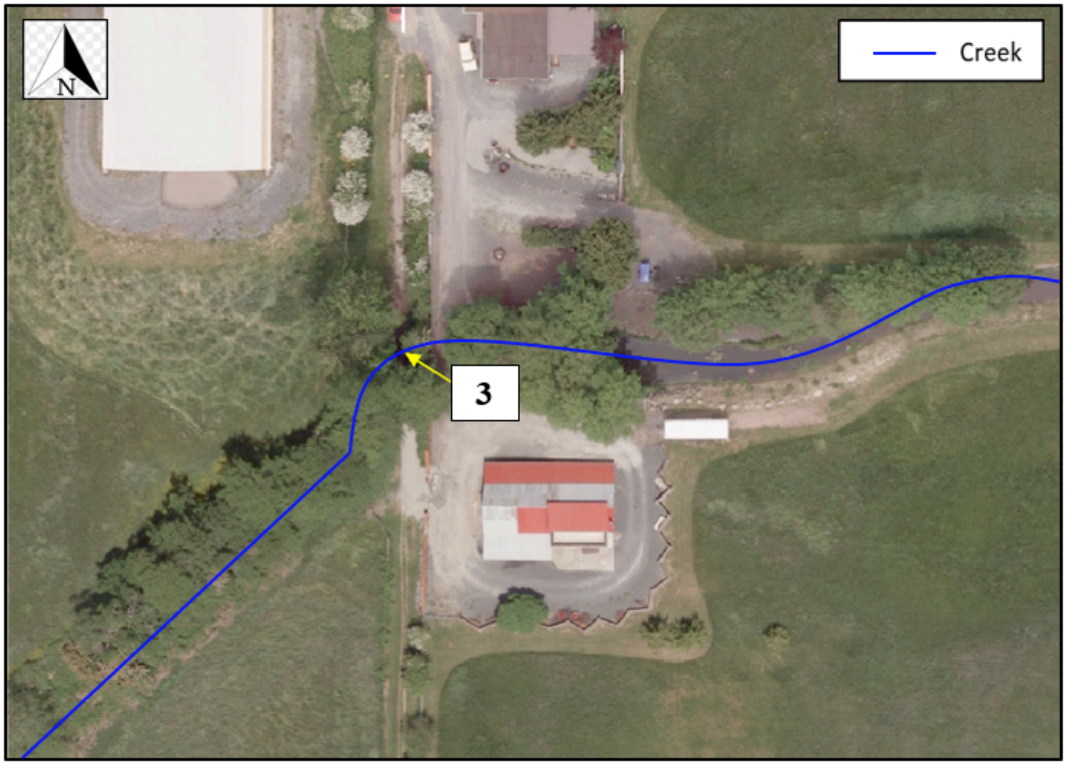


Figure A2. Hagan Creek at the end of Malcolm Road (Site 3).



Figure A3. Graham Creek at the Cultra Road CRD water station (Site 4).

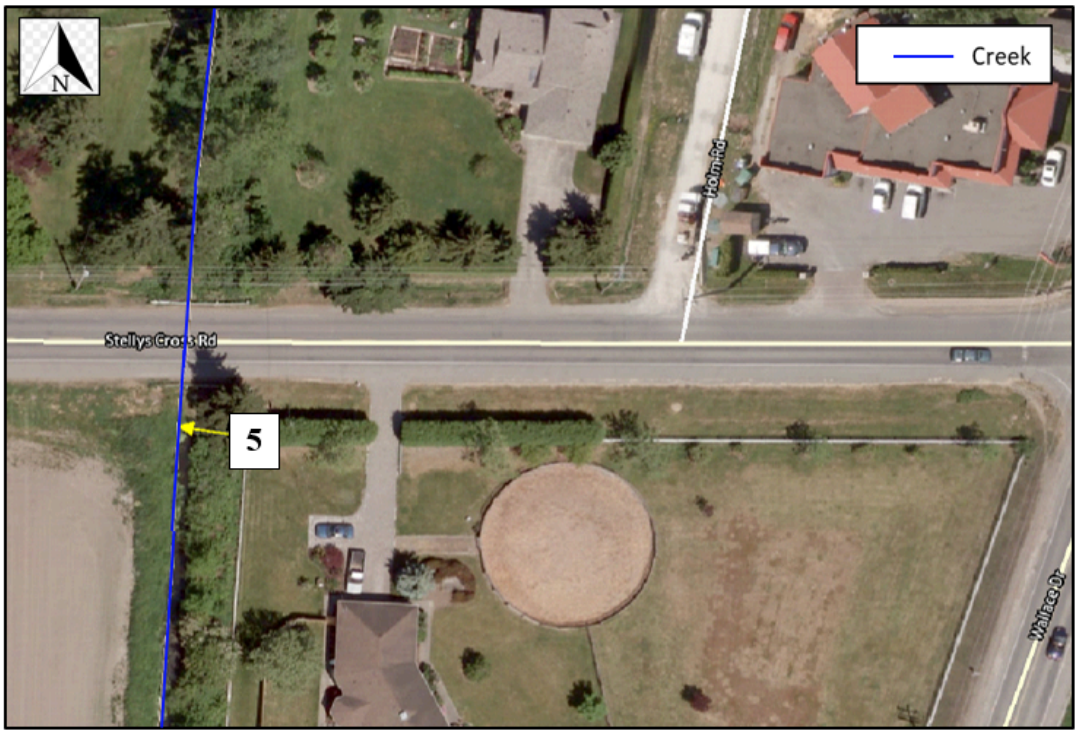


Figure A4. Graham Creek at the Stelly's Road culvert (Site 5).

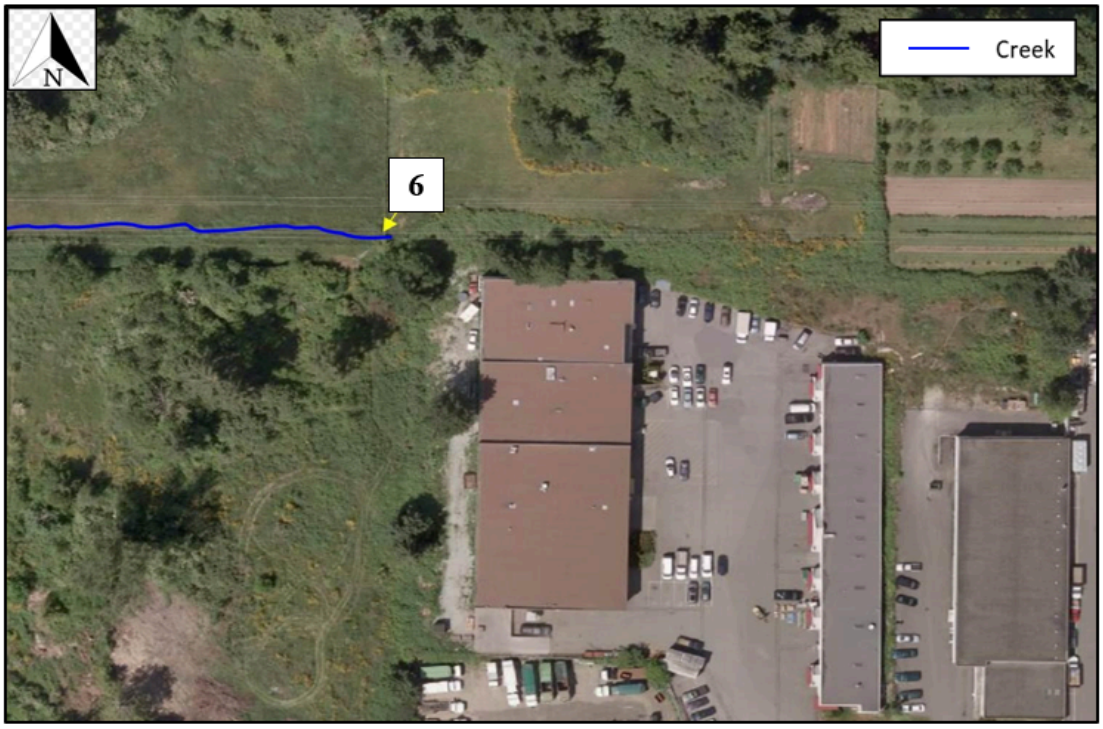


Figure A5. Kirkpatrick Crescent Outfall (Site 6).

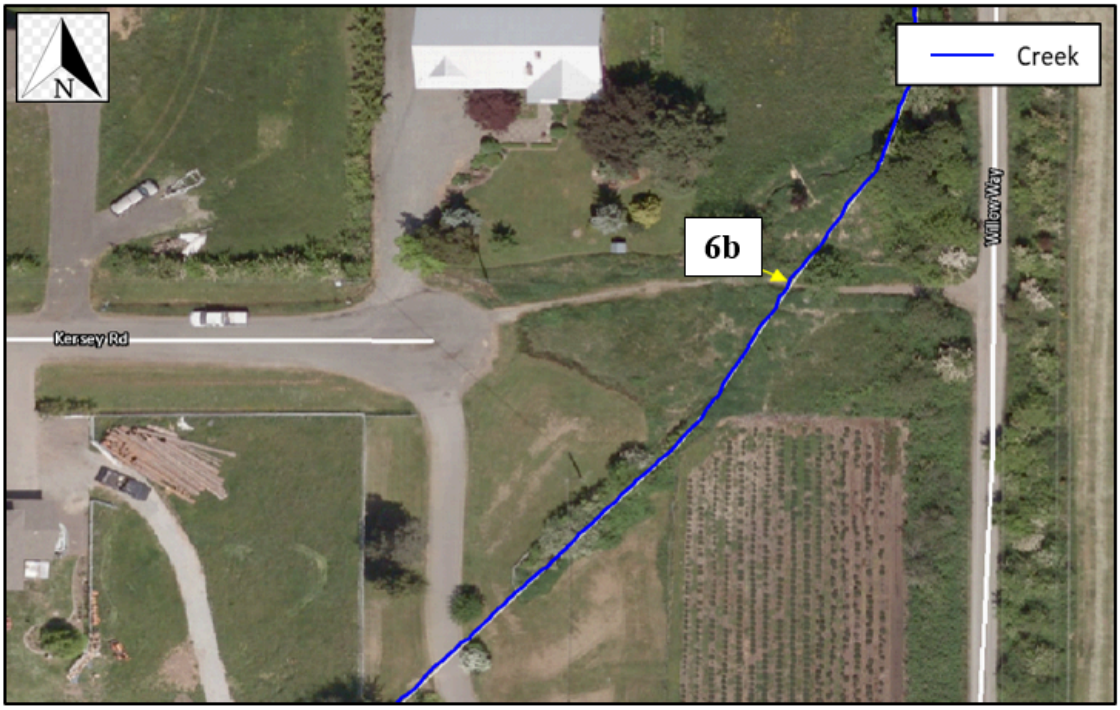


Figure A6. Graham Creek at Kersey Road (Site 6b).

6.7 Water Quality Guidelines

Table A27. Parameters and Water Quality Guidelines and Sources

Type	Parameter	Guideline	Source
Water	Fecal Coliforms	200 CFU/100mL	Guideline for Canadian Recreational Water Quality
Heavy Metals			
Water	Arsenic	5 µg/L	CCME Freshwater Chronic
	Cadmium	When the water hardness is > 0 to < 17 mg/L, the CWQG is 0.04 µg/L At hardness ≥ 17 to ≤ 280 mg/L, the CWQG is calculated using this equation: CWQG (µg/L) = 10^{0.83(log[hardness]) – 2.46 } At hardness > 280 mg/L, the CWQG is 0.37 µg/L	CCME Freshwater Chronic
	Copper	When water hardness is 0 to <82 mg/L, the CWQG is 2 µg/L. At hardness ≥82 to ≤180 mg/L the CWQG is calculated using this equation: CWQG (µg/L) = 0.2 * e^{0.8545[ln(hardness)]-1.465} At hardness >180 mg/L, the CWQG is 4 µg/L	CCME Freshwater Chronic
	Iron	300 µg/L	CCME Freshwater Chronic
	Lead	When the hardness is 0 to ≤ 60 mg/L, the CWQG is 1 µg/L At hardness >60 to ≤ 180 mg/L the CWQG is calculated using this equation: CWQG (µg/L)= e{1.273[ln(hardness)]-4.705} At hardness >180 mg/L, the CWQG is 7 µg/L	CCME
	Mercury	0.026 µg/L	CCME Freshwater Chronic
	Phosphorus	0.01 mg/L	BC Govt - Phosphorus Management in Vancouver Island Streams
	Zinc	If water hardness is </= 90, CWQG is 7.5 ug/L, if hardness if > 90, use this equation: =0.75*(hardness - 60)	1997 BC Water Quality Guidelines Chronic*
Hydrocarbon Parameters			

	TEH	0.5 mg/L	Screening value, not an actual guideline limit, used for detection of general hydrocarbon contamination.
	PAH	Guidelines are specific to the type of PAH.	
Physical Parameters			
	Water Temperature	19°C, daily maximum	BC Approved Water Quality Guidelines
	Conductivity	No specific CCME guidelines exist for conductivity in freshwater; generally, <150 or >500 µS/cm is considered harmful to aquatic organisms.	
	pH	6.5-9	CCME Freshwater Chronic
	Turbidity	Site Specific, see calculated guidelines in table A28.	
	Oxygen Saturation	Below 50% saturation is generally considered harmful to aquatic life. CCME guidelines are specific to baseline habitat water temperature and organism life stage.	
Nutrient Parameters			
	Un-ionized Ammonia	19 µg/L	CCME Freshwater Chronic
	Total Ammonia Nitrogen	pH and temperature dependent: =0.0156256*(10^((0.0901821+(2729.92/(temperature in C+273.15)))-pH)+1)	BC Approved Water Quality Guidelines
	Nitrate for NO3-N	3.0 mg/L	CCME Freshwater Chronic
	Nitrite, as NO2-N	0.06 mg/L	CCME Freshwater Chronic
	Phosphate	No official guideline exists for orthophosphate (PO4) specifically.	
Sediment Heavy Metals			
	Arsenic	5.9 µg/g	CCME Freshwater Threshold Effect Level
	Cadmium	0.6 µg/g	CCME Freshwater Threshold Effect Level
	Chromium	37.3 µg/g	CCME Freshwater Threshold Effect Level
	Copper	35.7 µg/g	CCME Freshwater Threshold Effect Level

	Lead	35 µg/g	CCME Freshwater Threshold Effect Level
	Nickel	15.9 µg/g	CCME Interim Sediment Quality Guideline - out dated**
	Zinc	123 µg/g	CCME Freshwater Threshold Effect Level

*For total zinc in water we are using the 1997 BC Freshwater Guidelines Chronic as the updated CCME and BC Approved Water Quality Guidelines are based on Dissolved Organic Carbon, which we do not measure.

** In the past, CCME used a long term guideline of 15.9 µg/g. Currently, no CCME freshwater sediment quality guidelines (ISQG/PEL) are currently published for nickel in the CCME summary tables. For the sake of this report, we have used the previous, older guideline limits.

Table A28. Calculated baselines for each site. Baselines are based on running averages plus or minus standard error. The site specific baseline is the upper limit of the average with standard error.

Site	**Calculated Site Specific Baseline**
Site 1 Graveyard	18.69
Site 3 Malcolm Rd	14.67
Site 4 Cultra Rd	18.87
Site 5 Stelly’s Rd	33.56
Site 6 Kirkpatrick Cres.	45.28
Site 6B Kersey Rd	21.76

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