APPENDIX 12-A

Baseline Water Quality Report

GOLDCORP

Appendix 12-A

Coffee Gold Project

Baseline Water Quality Report

Project No. A362-2
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LORAX ENVIRONMENTAL

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1. Introduction

1.1 Background

Goldcorp Inc (Goldcorp) is in the process of developing and permitting the Coffee Gold Project (Project), a proposed heap leach operation located in west-central Yukon, approximately 130 km south of Dawson City (Figure 1.1-1). The Coffee Gold Project contains several gold occurrences within an exploration concession covering an area more than 600 km^2.

The Project is located in the Yukon-Tanana Terrane (YTT), an accreted pericratonic rock sequence that covers a large portion of the Omineca Belt in the Yukon and extends into Alaska and British Columbia. The YTT underlies part of the Tintina gold belt and hosts multiple gold deposits, including the Sonora Gulch gold deposit, the Casino copper-gold-molybdenum porphyry, the Boulevard gold prospect, and the Golden Saddle gold deposit.

Under the direction of Kaminak Gold Corporation (Kaminak), the Project underwent a detailed Feasibility Study (Coffee Gold 43-101 FS) in 2015 with project engineering and design progressing with full consideration of environmental conditions within the project area. Prior to, and coincident with, exploration activities and feasibility studies, Kaminak commenced several baseline programs (*e.g.*, meteorology, hydrology, surface water quality, groundwater, soils, air, fish and fish habitat, wildlife) to characterize site conditions. The overarching objective of the baseline programs are to provide detailed characterization of the pre-mine condition to be used to the define environmental benchmarks that potential Project effects may be measured against during operations and closure monitoring.

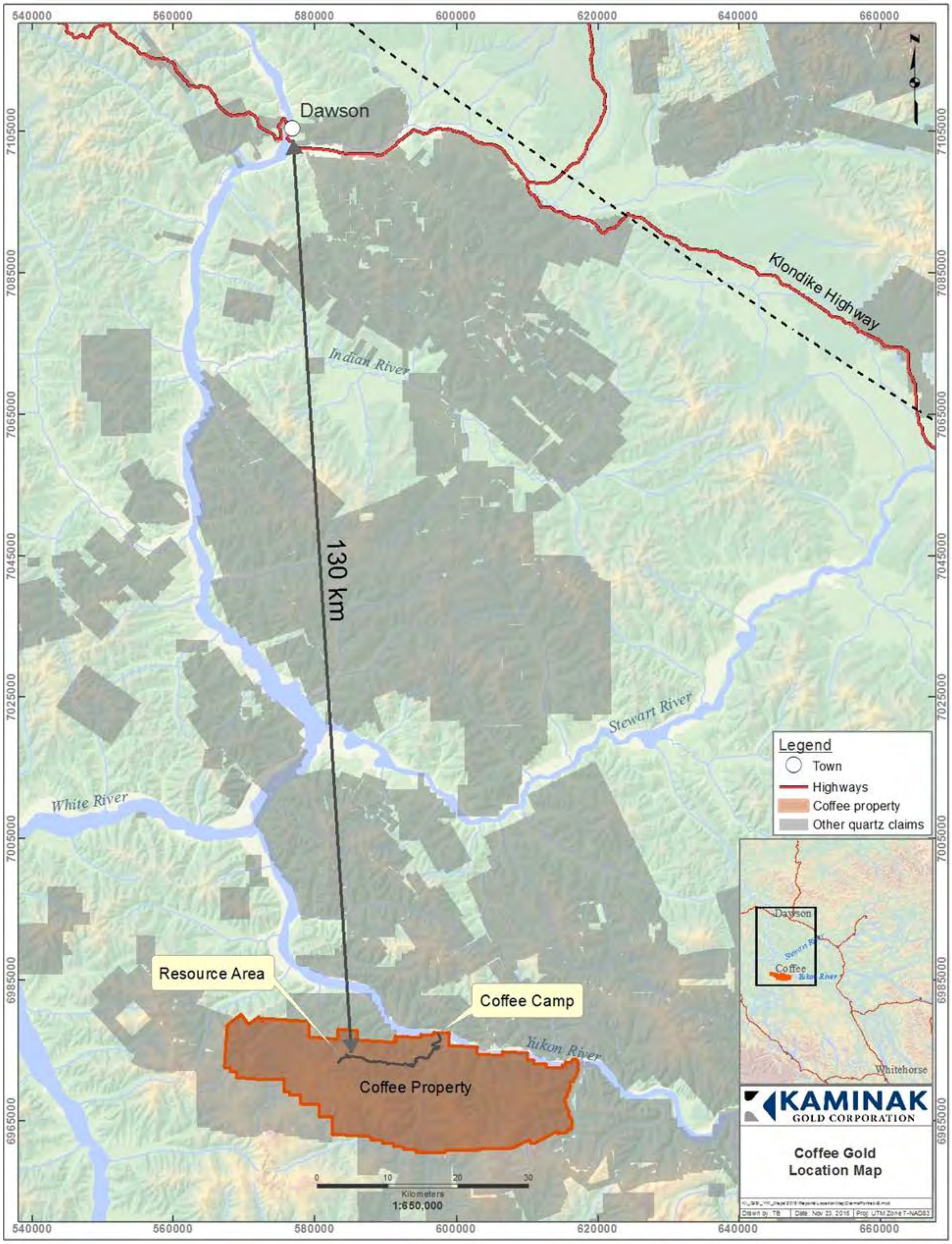


Figure 1.1-1: Coffee Gold Project Location Map

The following report describes the baseline water quality conditions in the receiving environment proximal to the Coffee Gold Project (Project). The Coffee Gold Project is a proposed open pit gold heap leach mine that will have mine components within three catchments (Figure 1.1-2):

- Latte Creek;
- Halfway Creek; and
- YT-24

Major infrastructure related to the proposed mining and processing operations at the site includes: the primary and secondary crushing facilities; a carbon adsorption plant; a gold refinery; the heap leach facilities; waste rock storage areas (WRSA); water drainage structures and storage ponds; haul roads; the accommodations complex; and an all-weather airstrip.

This baseline report characterizes water quality in receiving environment watercourses with the potential to be affected by project development. In addition, baseline water quality in Independence Creek, which is unaffected by project development and therefore serves as a reference stream, is also characterized. The local study area and primary focus of this report is on the following drainages:

- Latte Creek;
- Coffee Creek;
- Halfway Creek;
- YT-24;
- Independence Creek; and
- Yukon River

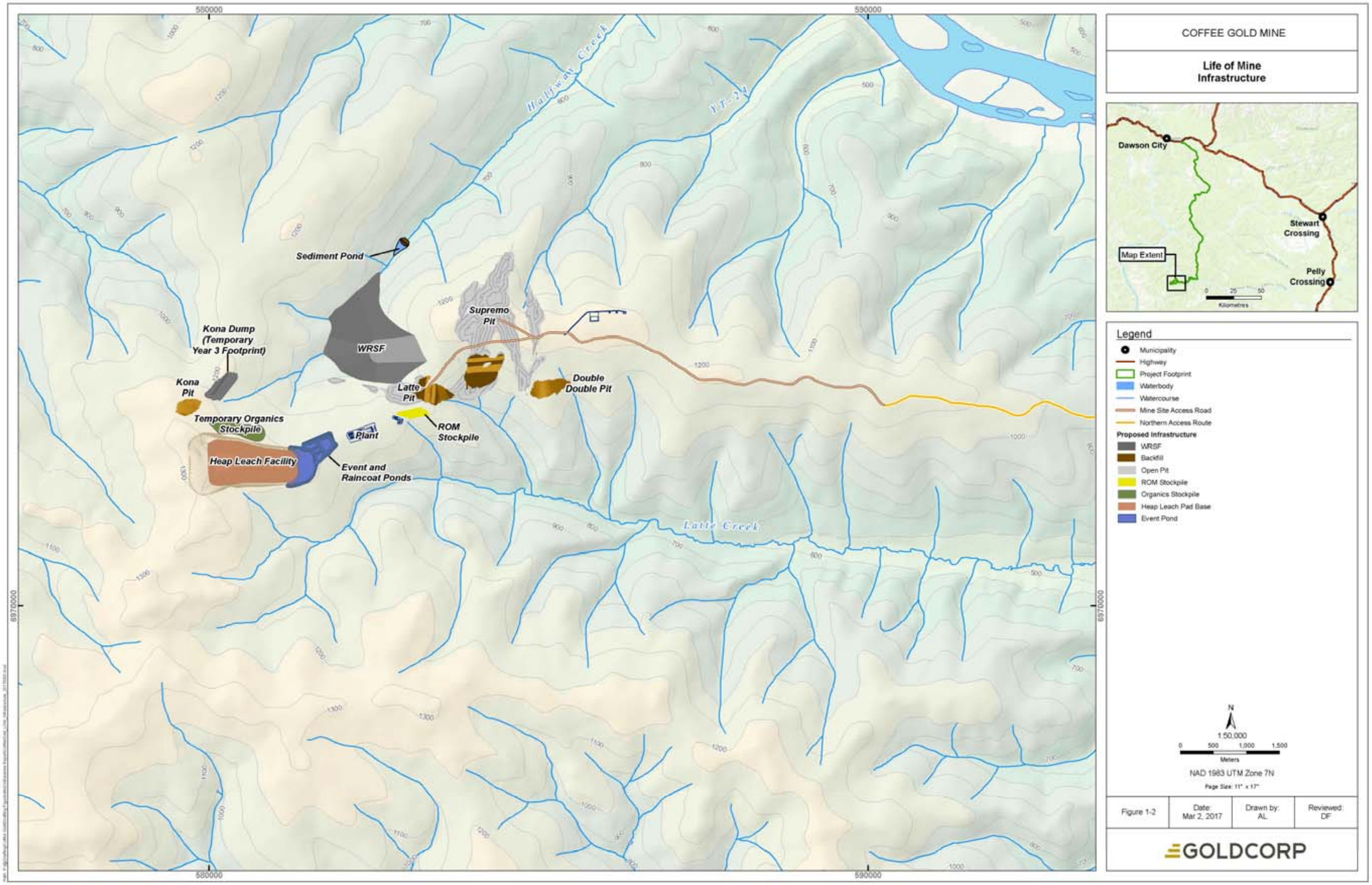


Figure 1.1-2: Life of Mine Coffee Gold Project Infrastructure Layout in Relation to Receiving Environment Catchments

1.2 Report Structure

Section 2 outlines the overarching objectives of the baseline water quality program and provides a description of the sampling stations and locations for each station monitored from 2010 to 2015. In addition, sampling and analytical methods are described along with a brief description of data analysis methods and quality assurance/quality control programs. Section 3 presents the results of the baseline water quality program. The section provides a characterization of the baseline water quality in the key project drainages of Latte Creek, Coffee Creek, Halfway Creek, YT-24, Independence Creek (reference) and Yukon River. Full water quality monitoring data for all stations are provided in Appendix A and Appendix B.

2. Baseline Water Quality Program

2.1 Overview and Objectives

The Coffee Gold Project water quality program has been developed with the following objectives in mind:

- Obtain (pre-mining) baseline data on water quality that can be used to assess potential changes in water quality that could be related to construction, operation, closure, and post-closure stages of the Project;
- Identify parameters that may be present at naturally elevated levels and therefore require special management and or site-specific water quality objectives; and
- Provide baseline receiving environment data to be used in water quality modeling and water quality predictions for key mining phases of the project; and

As previously stated, the report characterizes water quality in receiving environment watercourses that may be affected by project development. Existing water quality in Independence Creek, which will be unaffected by project development and therefore serves as a reference stream, is also characterized. The immediate local study area includes Latte Creek, Halfway Creek and YT-24 – basins that contain project mining components. In addition, the local study area also includes analysis of Coffee Creek immediately upstream and downstream of the confluence with Latte Creek as well as a select reach of the Yukon River from upstream of Coffee Creek confluence and immediately downstream of the Independence Creek confluence (see Figure 2.1-1 and Figure 2.1-2). For the period of 2010 to 2015, a total of 18 monitoring stations have been sampled within the study area (Table 2.1-1).

Water quality monitoring is ongoing at the Project site, and will continue throughout permitting of the Project. Upon issuance of mine licenses, an approved water quality program will continue for mine development, operations and into closure.

Photographic records of each monitoring station location are provided in Plate 2.1-1 through Plate 2.1-5. Specifically, monitoring stations within Independence Creek are presented in Plate 2.1-1; Latte Creek stations are shown in Plate 2.1-2; Halfway Creek and YT-24 stations are illustrated in Plate 2.1-3; Coffee Creek stations are presented in Plate 2.1-4; and Yukon River stations are illustrated in Plate 2.1-5.

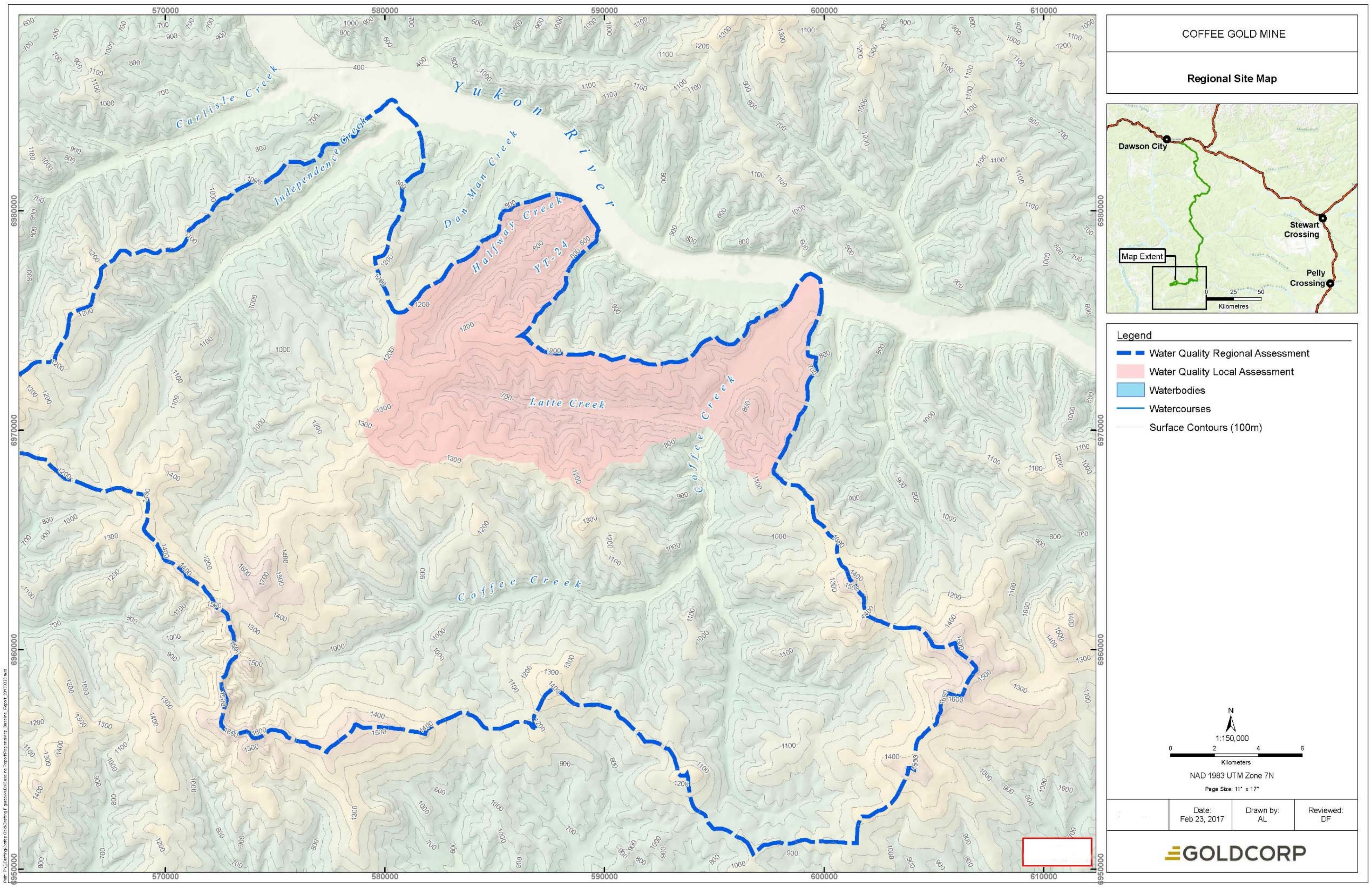


Figure 2.1-1: Baseline Water Quality Local Assessment and Regional Assessment Areas

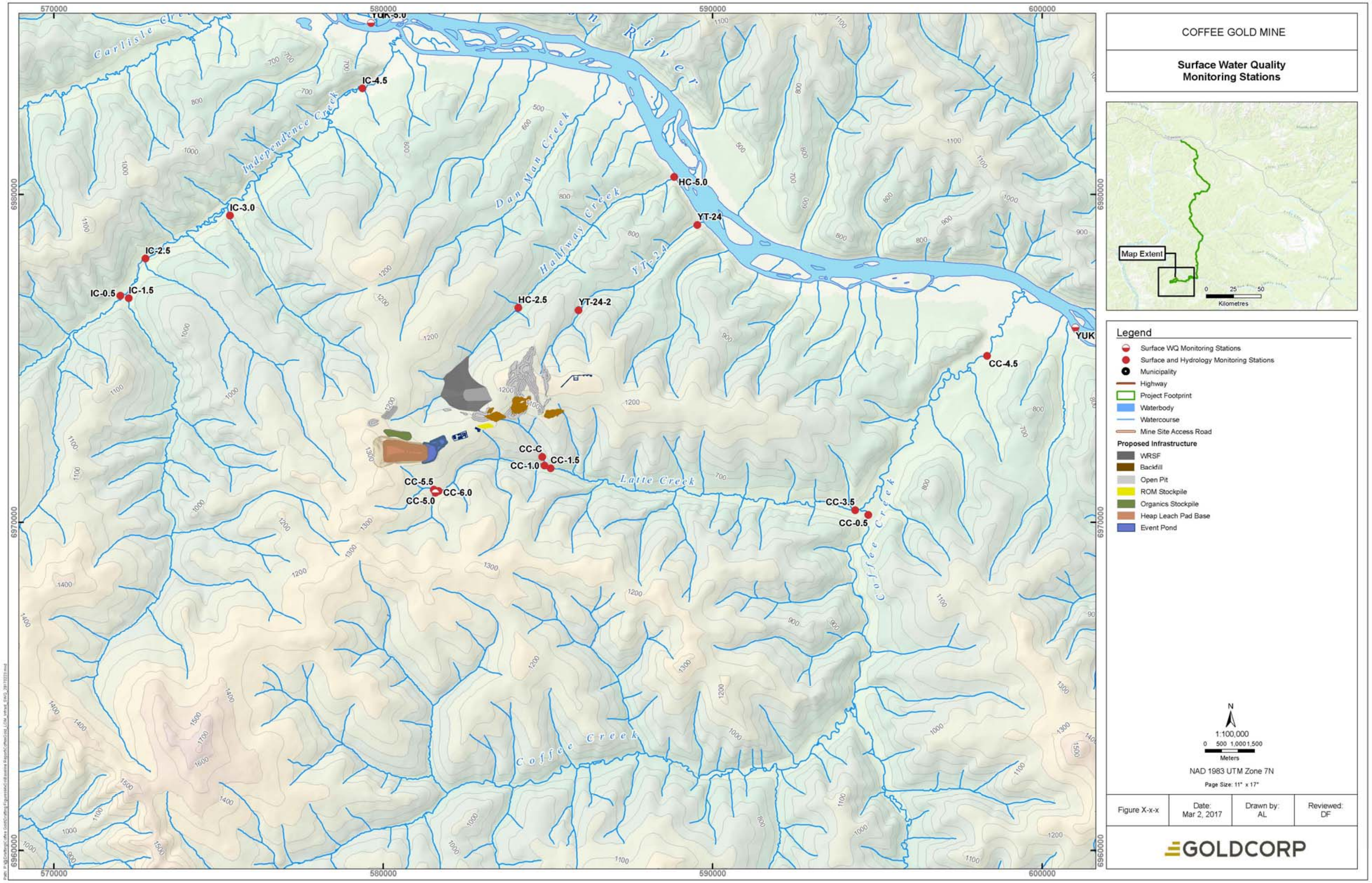


Figure 2.1-2: Locations of Key Project Water Quality Monitoring Sampling Sites (2010 to 2015)

Table 2.1-1:
Water Quality Sampling Stations, Coordinates and Rationale

Site	Drainage	Coordinates		Site	Sampling	Rationale
		North	East	Type	Start Date	
Independence Creek						
IC-0.5	Independence Creek – main stem	6976911	572012	Reference	Oct-2010	Outside Project influence
IC-1.5	Un-named larger tributary to Independence Creek	6976835	572260	Reference	Oct-2010	Outside Project influence
IC-2.5	Small un-named tributary to Independence Creek	6978044	572771	Reference	Oct-2010	Outside Project influence
IC-3.0	Small un-named tributary to Independence Creek	6979357	575334	Reference	Oct-2010	Outside Project influence
IC-4.5	Independence Creek - mouth	6983237	579358	Reference	Oct-2010	Outside Project influence
Latte Creek						
CC-6.0	Upper Latte Creek	6971061	581317	Potential exposure	June-2014	Below Project influence
CC-5.5	Small tributary from northwest to upper Latte Creek	6971100	581061	Potential exposure	June-2014	Below Project influence
CC-5.0	Small tributary from south to upper Latte Creek	6970905	581079	Potential exposure	June-2014	Below Project influence
CC-1.0	Small tributary to Latte Creek draining proposed South WRSF	6971733	584890	Exposure	June-2014	Below Project influence
CC-1.5	Latte Creek downstream of CC-1.0 drainage	6971654	585071	Exposure	Oct-2010	Below Project influence
CC-3.5	Latte Creek immediately upstream of confluence with Coffee Creek	6970375	594319	Exposure	Oct-2010	Below Project influence
Halfway Creek						
HC-2.5	Halfway Creek midway	6976548	584089	Exposure	Oct-2010	Below Project influence
HC-5.0	Halfway Creek mouth	6980536	588823	Exposure	Oct-2010	Below Project influence
YT-24						
ML-1.0	Mouth of YT-24, small tributary to Yukon River and draining North WRSF	6979073	589526	Exposure	June-2014	Below Project influence
Coffee Creek						
CC-0.5	Coffee Creek immediately upstream of confluence with Latte Creek	6970225	594719	Reference	Oct-2010	Above Project influence
CC-4.5	Coffee Creek	6975084	598330	Exposure	Oct-2010	Below Project influence
Yukon River						
YUK-2.0	Yukon River upstream of Coffee Creek confluence	6975946	601011	Reference	Oct-2010	No Project influence
YUK-5.0	Yukon River downstream of Independence Creek confluence	6985228	579624	Exposure	Oct-2010	Below Project influence

Plate 2.1-1: Photos of monitoring stations within Independence Creek (August 2014)

Plate 2.1-2: Photos of monitoring stations within Latte Creek drainage (August 2014)

Plate 2.1-3: Photos of monitoring stations within Halfway Creek (HC-2.5 and HC-5.0) and YT-24 (ML-1.0) (August 2014)

Plate 2.1-4: Photos of monitoring stations within Coffee Creek (August 2014)

Plate 2.1-5: Photos of monitoring stations within Yukon River (August 2014)

2.2 Field and Analytical Methods

2.2.1 Sampling Frequency and Locations

Figure 2.1-2 illustrates water quality sampling sites within the study area sampled during the period of 2010 to present. Table 2.1-1 provides the coordinates for each sampling station location; the type of station (e.g. reference or potential exposure); the date that monthly sampling commenced at each station; and, the rationale for station selection. Sampling at each station is attempted on a monthly basis; some stations are not able to be sampled during the winter months, owing to completely frozen or dry stream bed conditions.

2.2.2 Field Sampling Methods

During the period of October 2010 to May 2014, Access Consulting Group conducted the surface water quality sampling program for the Coffee Project. In June 2014, Lorax Environmental Services Ltd. (Lorax) assumed responsibility for the surface water quality program and commissioned Laberge Environmental Services (Laberge) to perform monthly water quality sampling. Since June 2014, Laberge has collected all the surface water quality samples on a monthly basis.

Maxxam Analytics of Burnaby, British Columbia (Maxxam) has been the analytical lab for the duration of the program and provided all sampling containers and bottles. Maxxam supplied a sample container request form for each sampling event which detailed the label identification, size and type of container, preservative required, analysis and sampling instructions.

During open water periods, samples were collected by wading into the small streams to the thalweg and filling bottles with gloved hands while facing upstream into the current. For larger streams and rivers, the same procedure was followed only closer to the bank and usually in not more than 0.2m depth. During open water periods, field filtering and sample preservation are completed at the sampling location. In winter, the samples are sometimes obtained by drilling or chiseling through the ice and filling the bottles as normal, an additional 1L bottle is filled for processing at the end of the day at room temperature in a clean room.

After samples were collected, a YSI Sonde was placed in the sample waters to log *in-situ* measurements of temperature, pH, specific conductance, Dissolved Oxygen (DO) and oxidation-reduction potential (ORP). Generally speaking, surface water samples were collected in accordance with the *British Columbia Field Sampling Manual* (BCMOE 2013).

2.2.3 Laboratory Methods

Samples collected at each station were analyzed for a suite of parameters listed in Table 2.2-1, which include physical parameters (pH, conductivity, hardness, total suspended solids (TSS), total dissolved solids (TDS), turbidity), major ions, nutrients, total organic carbon (TOC) and dissolved organic carbon (DOC), weak acid dissociable (WAD) cyanide, and total and dissolved metals.

Conventional parameters, major ions and nutrients, and metals were analyzed using procedures described in APHA Standard Methods for the Examination of Water and Wastewater (2005). Cyanide analysis was carried out using procedures adapted from APHA Method 4500-CN "Cyanide". WAD cyanide was determined by sample distillation and analysis using the chloramine-t colourimetric method. The lowest available limit of detection for metals was achieved by using ICP/MS (inductively coupled plasma/mass spectrometry; EPA Method 6020). Mercury analysis in water was carried out by cold vapor atomic fluorescence spectrophotometry (EPA Method 245.7). This procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride.

For the baseline period of 2010 to 2015, laboratory detection limits have been excellent and very low allowing for comparison of monitoring results with applicable water quality guidelines, including Canadian Council of Ministers of the Environment (CCME) and British Columbia (BC) Approved Water Quality Guidelines:

(http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html).

Table 2.2-1:
Analytical Parameter List and Reportable Detection Limits

Analysis		**Reportable Detection Limit**
Physical Parameters		
Conductivity	µS/cm	1.0
Hardness (as $CaCO_3$)	mg/L	0.5
pH	pH	0.01 unit
Total Suspended Solids (TSS)	mg/L	1.0
Total Dissolved Solids (TDS)	mg/L	10.0
Turbidity	NTU	0.1
Major Ions and Nutrients		
$Alkalinity_{Total}$ (as $CaCO_3$)	mg/L	0.5
$Alkalinity_{PP}$ (as $CaCO_3$)	mg/L	0.5
Bicarbonate (HCO_3)	mg/L	0.5
Cabonate (CO_3)	mg/L	0.5
Chloride (Cl)	mg/L	0. 5
Sulphate (SO_4)	mg/L	0.5
Fluoride (F)	mg/L	0.01
Nitrate (as N)	mg/L	0.002
Nitrite (as N)	mg/L	0.002
Total Ammonia (as N)	mg/L	0.005
Nitrate plus Nitrite (as N)	mg/L	0.002
Total Phosphorus as P	µg/L	0.002
Cyanide and Organic Carbon		
Weak acid dissociable cyanide (CN_{WAD})	mg/L	0.0005
Total Organic Carbon (TOC)	mg/L	0.5
Dissolved Organic Carbon (DOC)	mg/L	0.5
Total and Dissolved Metals		
Aluminum (Al)	µg/L	0.5
Antimony (Sb)	µg/L	0.02
Arsenic (As)	µg/L	0.02
Barium (Ba)	µg/L	0.02
Beryllium (Be)	µg/L	0.02
Bismuth (Bi)	µg/L	0.01
Boron (B)	µg/L	10
Cadmium (Cd)	µg/L	0.005
Calcium (Ca)	mg/L	0.05
Chromium (Cr)	µg/L	0.1
Cobalt (Co)	µg/L	0.005
Copper (Cu)	µg/L	0.05
Iron (Fe)	µg/L	1.0
Lead (Pb)	µg/L	0.005
Lithium (Li)	µg/L	0.5
Magnesium (Mg)	mg/L	0.05
Manganese (Mn)	µg/L	0.05
Mercury (Hg)	µg/L	0.002
Molybdenum (Mo)	µg/L	0.5
Nickel (Ni)	µg/L	0.02
Potassium (K)	mg/L	0.05
Selenium (Se)	µg/L	0.04
Silicon (Si)	mg/L	50
Silver (Ag)	µg/L	0.005
Sodium (Na)	mg/L	0.05
Strontium (Sr)	µg/L	0.05
Thallium (Tl)	µg/L	0.002
Tin (Sn)	µg/L	0.2
Titanium (Ti)	µg/L	0.5
Uranium (U)	µg/L	0.002
Vanadium (V)	µg/L	0.2
Zinc (Zn)	µg/L	0.1

2.2.4 Data Analysis

Laboratory results data for all monitoring sites have been compiled into summary data sheets for the period of 2010 to December 2015 (Appendix A). All data are represented and no outliers have been identified or removed. Where applicable, water quality parameters were screened against available CCME guidelines (CCME 2013a) and approved and working BC guidelines (BCMOE 2006) for the protection of aquatic life. Most of the CCME guidelines are defined for long-term exposure, although chloride, nitrate and uranium have both short-term (maximum) and long-term (chronic) guidelines. For this report, monitoring data were compared to the chronic guidelines. Similarly, most BC guidelines include a maximum concentration as well as a 30-day, chronic exposure guideline; data in this report are compared only to the BC chronic exposure concentration.

Parameters that were analyzed and reported as "less than detection" are assumed in the statistical analysis to be present at the detection limit value (e.g. <0.05 µg/L is assumed to be 0.05 µg/L). Following the conversion of less than detection limit values for all parameters (Appendix B), monthly and annual summary statistics were compiled for selected sites within all the project drainage basins. Minimum, maximum, mean, 5th percentile, 25th percentile, 50th percentile, 75th percentile and 95th percentile values were calculated for key stations in each basin (Appendix C).

2.2.5 Quality Assurance/Quality Control

Quality Assurance/Quality Control (QA/QC) protocols were implemented and designed to provide reliable monitoring data by reducing sampling error, preventing contamination due to sample handling, and quantifying any bias in the results. In the field, nitrile gloves were worn while sampling (clean gloves at each site). Chain of custody forms describing sampling location, date, time and analytical requirements were submitted with each sample set.

For each monthly sampling event a field blank was prepared using distilled-deionized water supplied by Maxxam. To assess the potential variability arising from the collection of field samples, duplicate samples were collected at roughly 10% of surface water quality sites. Travel blanks were collected to provide an assessment of potential contamination associated with travel, storage, or the analytical laboratory. Travel blank bottles were filled with distilled deionized water (DDW) at the analytical laboratory and were stored with field-collected samples without being opened. Field blanks were collected to assess potential contamination from sources such as airborne dust, sample preservation, or sample handling. Field blank bottles were filled with DDW in the laboratory and were treated similarly to field-collected samples (i.e., exposed to the air for the same amount of time it took to collect and preserve a sample). All samples and blanks were kept cold from point of collection to relinquishment to Maxxam. Equipment, travel, and field blanks were analyzed by Maxxam for the water quality parameters identified in Table 2.2-1.

3. Water Quality Results

This section presents a characterization of baseline water quality in the drainages of Latte Creek, Coffee Creek, Halfway Creek, Yukon River and the Independence Creek reference drainage. Compiled raw water quality results data for all stations sampled during the period of 2010 to 2015 is provided electronically in Appendix A as an excel spreadsheet.

Baseline water quality characterization is presented and described by catchment:

- Section 3.1 characterizes baseline water quality in Latte Creek utilizing monitoring data primarily from stations CC-6.0 for upper Latte Creek and stations CC-1.5 and CC-3.5 for mid-reach and lower-reach of Latte Creek;
- Section 3.2 provides a summary of water quality in Coffee Creek at locations both upstream and downstream of the project area. Data from station CC-0.5 (upstream of project influences) and CC-4.5 (downstream of confluence with Latte Creek) are utilized to characterize baseline conditions in Coffee Creek;
- Baseline water quality in the Halfway Creek drainage (Section 3.3) is characterized using data from stations HC-2.5 and HC-5.0;
- Section 3.4 provides a brief description of water quality in Yukon River upstream of the project area at YUK-2.0 and downstream of project influence at YUK-5.0; and
- Section 3.5 provides a description of water quality in Independence Creek using data from station IC-4.5.

For each drainage discussion, summary statistics are provided for each parameter for each month to characterize the seasonal variability in water quality. Full statistical analysis for each monitoring station is also provided in Appendix C.

3.1 Latte Creek

Background water chemistry in Latte Creek can be divided between upper Latte Creek and mid to lower Latte Creek. In general, upper Latte Creek water chemistry is dominated by surface runoff whereas mid to lower Latte Creek water chemistry is influenced by both groundwater discharge, as well as surface runoff during the ice-free periods. No measurable flow has been observed in upper Latte Creek during winter sampling campaigns, suggesting little to no groundwater baseflow contributions during these periods. Conversely, mid to lower Latte Creek are routinely successfully sampled during low-flow periods of the winter.

3.1.1 Upper Latte Creek – Station CC-6.0

Upper Latte Creek is characterized by water quality samples taken at Station CC-6.0 (Figure 3.1-1), which includes contributions from two small tributaries (represented by stations CC-5.5 and 5.0) in the headwaters.

Upper Latte Creek sampling locations were not established until later in the baseline surface water quality monitoring program due to adjustments in mine planning. As flow is not observed during winter months, limited samples have been taken at these locations and therefore the results may not capture the entire natural variability of the system. This is not seen as weakness in the dataset, as mid Latte Creek water quality has been well characterised over many sampling periods.

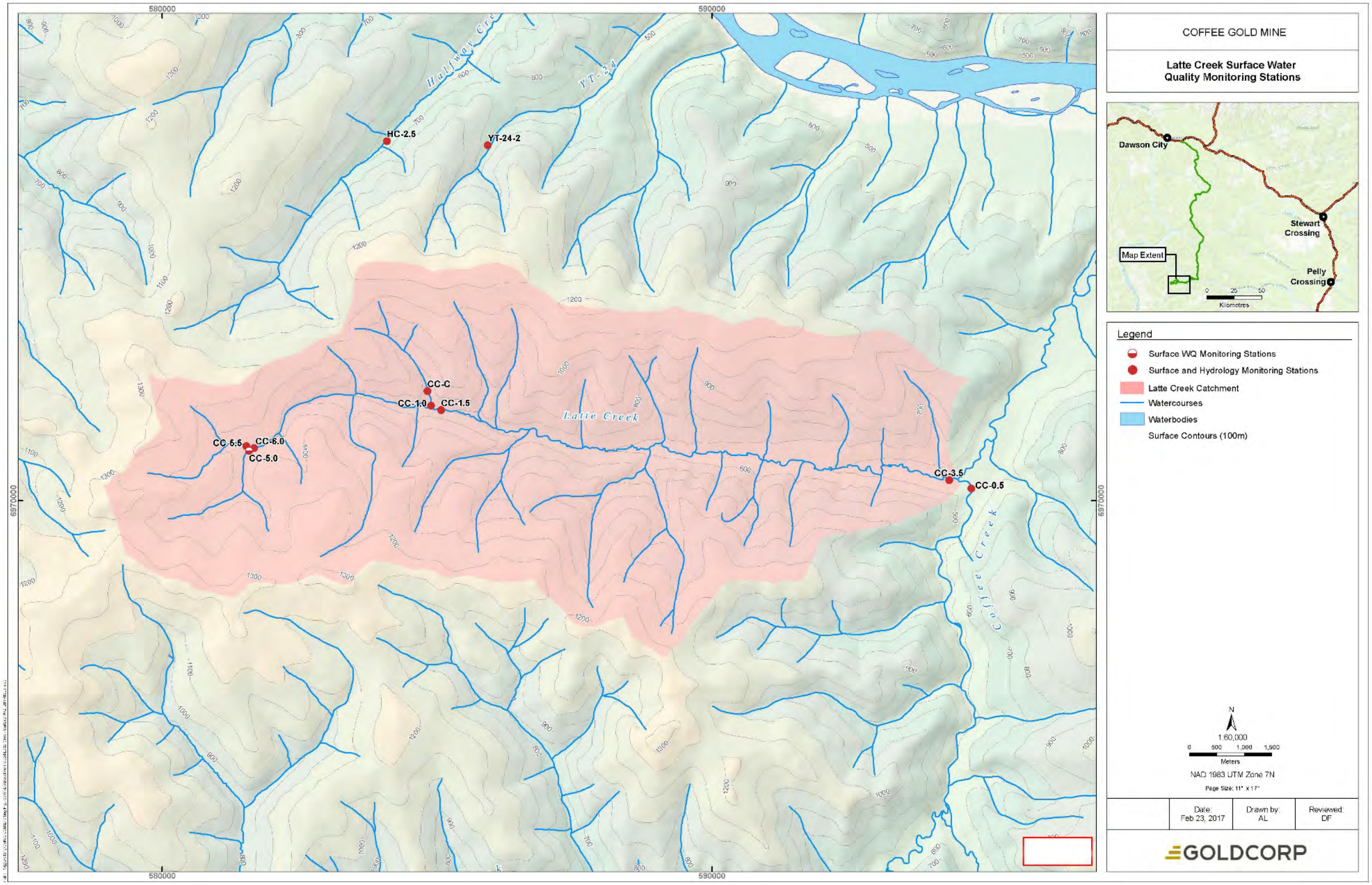


Figure 3.1-1: Detail of Latte Creek drainage illustrating key monitoring station locations

3.1.1.1 Summary Statistics

Table 3.1-1 summarizes the mean monthly values for a suite of the key parameters for station CC-6.0; baseline monitoring at this station commenced in June 2014.

Table 3.1-1:
CC-6.0 Mean Monthly Values

	CC-6.0											
	Jan (n = 0)	Feb (n = 0)	Mar (n = 0)	Apr (n = 1)	May (n = 1)	Jun (n = 2)	Jul (n = 2)	Aug (n = 2)	Sep (n = 2)	Oct (n = 2)	Nov (n = 0)	Dec (n = 0)
Physical Parameters												
pH (s.u.)	-	-	-	7.2	6.2	6.4	6.6	6.8	6.9	7.0	-	-
Cond-L (uS/cm)	-	-	-	58	19	19	19	22	21	26	-	-
TSS (mg/L)	-	-	-	1.0	11	10	4.3	8.6	7.8	2.5	-	-
TDS (mg/L)	-	-	-	52	18	62	52	30	33	32	-	-
T-Alk (mg/L)	-	-	-	21	3.6	3.8	4.7	5.7	6.4	8.7	-	-
T-Hard (mg/L)	-	-	-	26	10	10	11	10	12	13	-	-
Anions												
Sulphate (mg/L)	-	-	-	0.50	0.50	2.8	0.50	0.50	0.50	0.50	-	-
Cl (mg/L)	-	-	-	1.4	0.93	0.91	0.65	0.55	0.53	0.58	-	-
F (mg/L)	-	-	-	0.033	0.019	0.026	0.028	0.024	0.026	0.026	-	-
Nutrients												
T-NH_3 - N (mg/L)	-	-	-	0.014	0.019	0.016	0.017	0.015	0.015	0.017	-	-
NO_2 -N (mg/L)	-	-	-	0.020	0.043	0.002	0.002	0.002	0.002	0.002	-	-
NO_3 - N(mg/L)	-	-	-	0.020	0.020	0.002	0.005	0.011	0.014	0.036	-	-
D-P (mg/L)	-	-	-	0.022	0.0095	0.0075	0.0040	0.0050	0.0042	0.0044	-	-
TOC (mg/L)	-	-	-	22	23	19	15	14	12	9.8	-	-
DOC (mg/L)	-	-	-	17	16	19	15	14	12	10	-	-
WAD-CN (mg/L)	-	-	-	0.00070	0.00095	0.0012	0.0013	0.0011	0.0010	0.00093	-	-
Total Metals												
T-Al (ug/L)	-	-	-	193	361	328	308	326	228	143	-	-
T-Sb (ug/L)	-	-	-	0.064	0.095	0.066	0.078	0.096	0.078	0.075	-	-
T-As (ug/L)	-	-	-	0.54	0.34	0.43	0.47	0.47	0.47	0.47	-	-
T-Cd (ug/L)	-	-	-	0.077	0.019	0.024	0.012	0.015	0.012	0.0075	-	-
T-Ca (mg/L)	-	-	-	6.3	2.9	2.6	2.9	2.8	3.2	3.3	-	-
T-Cr (ug/L)	-	-	-	0.30	0.50	0.63	0.72	0.69	0.60	0.46	-	-
T-Co (ug/L)	-	-	-	0.29	0.22	0.10	0.13	0.13	0.14	0.086	-	-
T-Cu (ug/L)	-	-	-	1.6	2.5	2.1	2.0	1.7	1.7	1.3	-	-
T-Fe (ug/L)	-	-	-	172	315	312	307	303	275	206	-	-
T-Pb (ug/L)	-	-	-	0.0067	0.050	0.070	0.076	0.087	0.041	0.010	-	-
T-Mg (mg/L)	-	-	-	2.6	0.79	0.82	0.87	0.86	0.98	1.0	-	-
T-Mn (ug/L)	-	-	-	259	38	23	30	24	45	33	-	-
T-Hg (ug/L)	-	-	-	0.0093	0.011	0.0081	0.0055	0.0070	0.0050	0.0039	-	-
T-Mo (ug/L)	-	-	-	0.050	0.076	0.050	0.057	0.050	0.050	0.073	-	-
T-Ni (ug/L)	-	-	-	1.2	1.5	1.2	1.0	0.93	0.89	0.75	-	-
T-K (mg/L)	-	-	-	2.0	0.49	0.19	0.15	0.16	0.090	0.093	-	-
T-Se (ug/L)	-	-	-	0.040	0.052	0.054	0.042	0.040	0.043	0.040	-	-
T-Ag (ug/L)	-	-	-	0.0050	0.015	0.0060	0.0074	0.0055	0.0050	0.0050	-	-
T-Na (mg/L)	-	-	-	2.6	0.93	0.67	0.87	0.86	1.1	1.3	-	-
T-Tl (ug/L)	-	-	-	0.0020	0.0030	0.0030	0.0033	0.0040	0.0020	0.0020	-	-
T-U (ug/L)	-	-	-	0.42	0.64	0.46	0.54	0.50	0.48	0.47	-	-
T-Zn (ug/L)	-	-	-	6.2	2.1	2.1	1.3	1.9	1.0	0.81	-	-
Dissolved Metals												
D-Al (ug/L)	-	-	-	199	322	310	228	200	174	136	-	-
D-Sb (ug/L)	-	-	-	0.064	0.046	0.058	0.063	0.070	0.082	0.067	-	-
D-As (ug/L)	-	-	-	0.53	0.18	0.37	0.44	0.39	0.45	0.43	-	-
D-Cd (ug/L)	-	-	-	0.067	0.015	0.019	0.0088	0.0085	0.0090	0.0065	-	-
D-Ca (mg/L)	-	-	-	6.2	2.9	3.1	2.8	2.8	2.9	3.2	-	-
D-Cr (ug/L)	-	-	-	0.30	0.32	0.54	0.52	0.52	0.53	0.43	-	-
D-Co (ug/L)	-	-	-	0.28	0.035	0.044	0.076	0.076	0.099	0.075	-	-
D-Cu (ug/L)	-	-	-	1.6	2.1	2.4	1.7	1.6	1.6	1.3	-	-
D-Fe (ug/L)	-	-	-	164	188	235	151	126	141	139	-	-
D-Pb (ug/L)	-	-	-	0.0050	0.0077	0.0080	0.011	0.0075	0.0085	0.0055	-	-
D-Mg (mg/L)	-	-	-	2.6	0.76	0.82	0.85	0.83	0.87	1.0	-	-
D-Mn (ug/L)	-	-	-	246	1.8	5.7	18	14	32	28	-	-
D-Hg (ug/L)	-	-	-	0.0091	0.011	0.0090	0.0059	0.0068	0.0041	0.0058	-	-
D-Mo (ug/L)	-	-	-	0.050	0.050	0.13	0.050	0.050	0.10	0.050	-	-
D-Ni (ug/L)	-	-	-	1.2	1.6	1.1	0.91	0.82	0.87	0.71	-	-
D-K (mg/L)	-	-	-	2.0	0.41	0.15	0.063	0.064	0.10	0.077	-	-
D-Se (ug/L)	-	-	-	0.040	0.040	0.040	0.041	0.044	0.044	0.044	-	-
D-Ag (ug/L)	-	-	-	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	-	-
D-Na (mg/L)	-	-	-	2.5	0.62	1.2	0.88	0.87	1.1	1.1	-	-
D-Tl (ug/L)	-	-	-	0.0020	0.0024	0.0020	0.0020	0.0020	0.0020	0.0020	-	-
D-U (ug/L)	-	-	-	0.45	0.66	0.47	0.48	0.46	0.45	0.46	-	-
D-Zn (ug/L)	-	-	-	6.2	1.4	1.5	0.79	1.1	0.77	0.71	-	-

3.1.1.2 Major Ions

The major ion chemistry of upper Latte Creek is assessed with respect to conductivity, hardness, alkalinity, sulphate and pH. Upper Latte Creek is characterized by very soft waters, with monthly mean hardness values ranging from only 10 to approximately 25 mg/L at station CC-6.0 (Table 3.1-1; Appendix C). Similarly, conductivity values measured at CC-6.0 are very low (i.e., range of 10 to 50 µS/cm) and reflect a dominantly snow-melt and surface run-off driven system. Indeed, sample collection during the period of November to March has not occurred owing to the absence of flow.

The pH in upper Latte Creek is dominantly circumneutral to mildly acidic with values generally ranging between pH 6.2 to 7.2. The mildly acidic values below pH 7.0 are associated with peak snowmelt conditions. Observed pH values reported to date have largely remained within the CCME freshwater guideline range for pH of 6.5 to 9.0, excepting during peak snowmelt periods.

Baseline concentrations for sulphate in upper Latte Creek are very low and generally present at concentrations below the analytical detection limit of 0.5 mg/L (Table 3.1-1). Measured TSS concentrations in upper Latte Creek are generally low with mean values typically less than 10 mg/L (Table 3.1-1).

3.1.1.3 Nutrients

Nutrients quantified in upper Latte Creek include nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_3), and dissolved phosphorus. In overview, nutrient parameters show low values in upper Latte Creek. Ammonia-N concentrations are low with mean monthly values typically between 0.015 and 0.02 mg/L (Table 3.1-1). Similar to ammonia, baseline nitrite-N and nitrate-N concentrations in upper Latte Creek are also low, with mean monthly values ranging from approximately 0.002 to 0.04 mg/L.

Primary productivity in freshwaters is typically limited by available phosphorus. Accordingly, measurements of phosphorus compounds in surface waters can provide an indication of trophic status (i.e., productivity regime). Baseline concentrations for dissolved phosphorus in upper Latte Creek are low, ranging from approximately 0.004 to a maximum of 0.02 mg/L (Table 3.1-1). Mean dissolved phosphorus for all sampling events was 0.0068 mg/L (Appendix C) indicative of oligotrophic conditions in upper Latte Creek waters.

Total organic carbon (TOC) reflects a combination of dissolved organic carbon (DOC) and particulate phases associated with both aquatic and terrestrial organic matter. Highest values of TOC and DOC are typically observed during high flow periods, likely reflecting contributions of particulate carbon associated with terrestrial runoff. Mean monthly TOC and DOC levels in upper Latte Creek are relatively high, ranging between approximately 10 to 25 mg/L, with highest values observed during peak flow periods.

3.1.1.4 Trace Elements

Baseline trace element concentrations in upper Latte Creek were derived from data collected from June 2014 to December 2015 at CC-6.0. In general, mean monthly concentrations of total and dissolved trace elements are low (e.g., As, Sb, Co, Cr, Pb, Hg, Ni, Se, U and Zn). For example, total As and total U concentrations at CC-6.0 are typically well below 1.0 µg/L (Table 3.1-1). Conversely, dissolved Al is consistently observed to be elevated well above BCMOE guideline for the protection of aquatic life of 100 µg/L, with peak concentrations coinciding with higher flow conditions (Figure 3.1-2). However, results of all samples taken in upper Latte Creek were found to have dissolved Al concentrations above the BCMOE guideline of 100 µg/L.

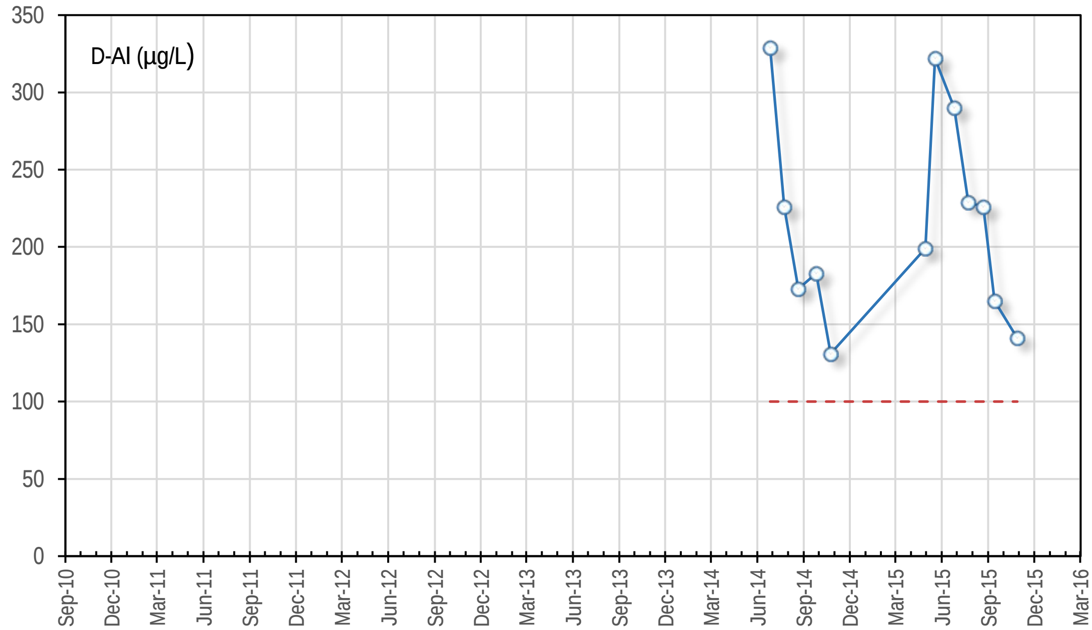


Figure 3.1-2: Dissolved Al concentrations at CC-6.0 in upper Latte Creek for the period June 2014 to December 2015 compared to BCMOE guideline (red dashed line) for protection of aquatic life

Concentrations of total Cu show seasonal maxima associated with peak runoff periods that slightly exceed the CCME hardness-based total Cu guideline for the protection of aquatic life of 2.0 µg/L in these soft waters of upper Latte Creek (Figure 3.1-3).

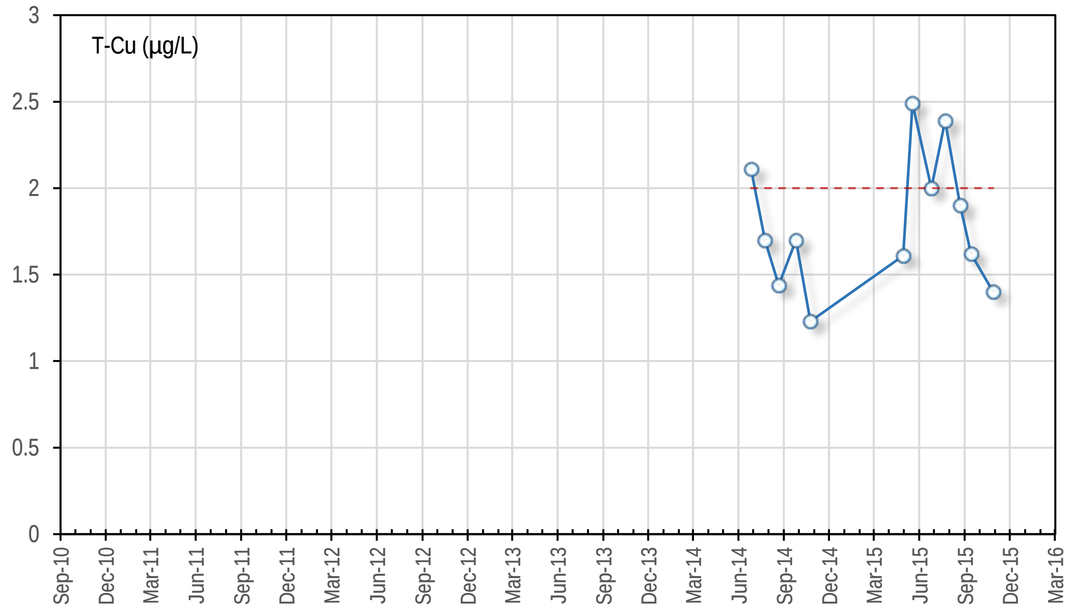


Figure 3.1-3: Total Cu concentrations at CC-6.0 in upper Latte Creek for the period June 2014 to December 2015 compared to CCME hardness based guideline value (red dashed line) for the protection of aquatic life.

Similar to copper, total Cd concentrations slightly exceed the CCME hardness-based chronic guideline for protection of aquatic life for Cd during peak flow periods (Figure 3.1-4). However, observed Cd concentrations do not exceed the CCME short term exposure guidelines for the protection of aquatic life for Cd at station CC-6.0.

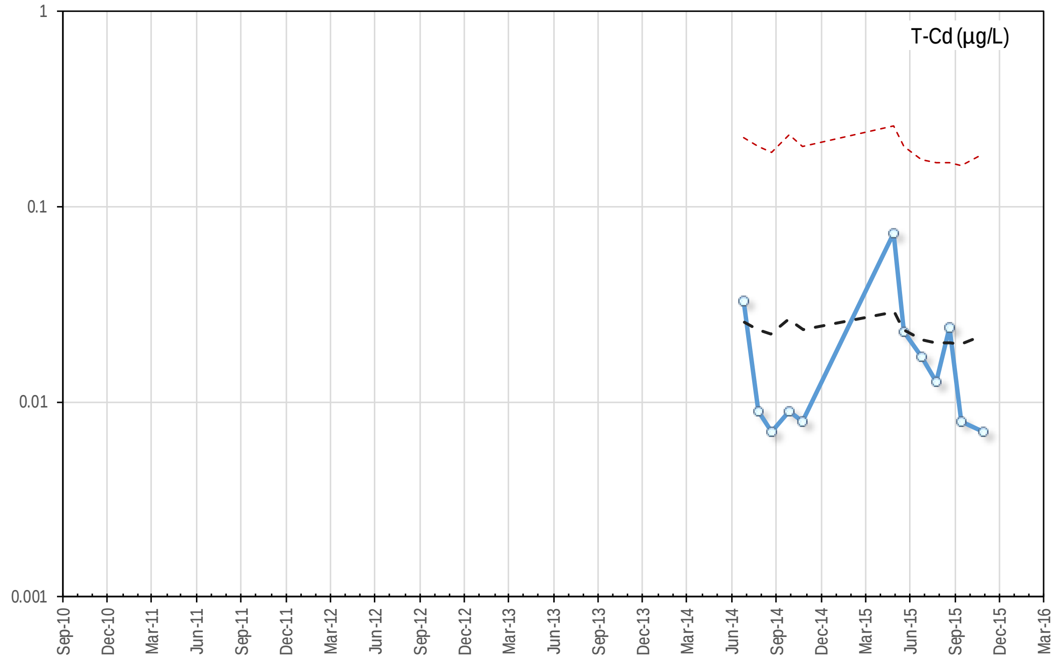


Figure 3.1-4: Total Cd concentrations at CC-6.0 in upper Latte Creek for the period June 2014 to December 2015 compared to CCME chronic (black dashed line) and short-term (red dashed line) hardness based guideline value for the protection of aquatic life.

3.1.2 Mid and Lower Latte Creek – Stations CC-1.5 and CC-3.5

Water quality in mid-reach and lower-reach Latte Creek is distinctly different from the conditions previously described for upper Latte Creek. Groundwater baseflow contributions produce a more pronounced seasonal signature in water chemistry. In addition, with more significant groundwater contributions, periods with little to no surface flow still result in measurable streamflow within Latte Creek. As a result, monitoring of water quality has been possible through all months of the year.

Mid-reach Latte Creek is characterized by water quality data collected at station CC-1.5 for the period of October 2010 to December 2015 (Figure 3.1-1). This station in Latte Creek is located approximately 50 m downstream of the confluence of a small ephemeral tributary that has been monitored at station CC-1.0 since June 2014. Lower Latte Creek is characterized by water quality data collected at station CC-3.5 for the period of October 2010 to December 2015.

3.1.2.1 Summary Statistics

Table 3.1-2 and Table 3.1-3 summarize the mean monthly values for a suite of the key parameters for station CC-1.5 and CC-3.5, respectively.

Table 3.1-2:
CC-1.5 Mean Monthly Values

	CC-1.5											
	Jan (n = 6)	Feb (n = 3)	Mar (n = 2)	Apr (n = 5)	May (n = 5)	Jun (n = 5)	Jul (n = 4)	Aug (n = 6)	Sep (n = 5)	Oct (n = 6)	Nov (n = 6)	Dec (n = 2)
Physical Parameters												
pH (s.u.)	8.0	8.0	8.0	8.0	7.3	7.4	7.7	7.8	7.7	8.0	8.0	8.1
Cond-L (uS/cm)	739	793	803	627	92	111	151	272	215	469	672	706
TSS (mg/L)	1.5	2.2	1.0	17	7.1	13	2.0	27	1.9	2.0	1.5	1.0
TDS (mg/L)	487	537	536	433	85	98	119	187	163	312	451	482
T-Alk (mg/L)	191	205	210	159	24	29	42	68	55	120	171	179
T-Hard (mg/L)	387	410	427	335	47	56	75	131	113	238	349	371
Anions												
Sulphate (mg/L)	189	220	224	176	15	20	32	65	46	121	171	188
Cl (mg/L)	0.73	0.65	0.71	0.95	1.2	1.6	0.76	0.60	0.65	0.56	2.1	0.64
F (mg/L)	0.10	0.11	0.12	0.080	0.036	0.040	0.047	0.058	0.051	0.075	0.081	0.10
Nutrients												
T-NH_3 - N (mg/L)	0.017	0.018	0.012	0.017	0.11	0.014	0.030	0.022	0.050	0.013	0.014	0.0090
NO_2 -N (mg/L)	0.011	0.019	0.004	0.004	0.017	0.013	0.015	0.012	0.012	0.011	0.004	0.002
NO_3 - N(mg/L)	0.256	0.264	0.229	0.128	0.046	0.100	0.154	0.225	0.237	0.332	0.308	0.214
D-P (mg/L)	0.0031	0.0042	0.0046	0.0075	0.0095	0.0073	0.0047	0.0036	0.0043	0.0041	0.0032	0.0020
TOC (mg/L)	4.8	4.9	4.7	8.8	24	18	15	11	11	7.2	5.1	4.5
DOC (mg/L)	4.5	4.8	3.8	8.8	22	17	15	10	11	6.5	4.7	4.4
WAD-CN (mg/L)	0.00050	0.00061	0.00053	0.00061	0.0014	0.0011	0.0012	0.00084	0.00080	0.00074	0.00054	0.00063
Total Metals												
T-Al (ug/L)	16	11	8.2	140	436	462	233	478	148	75	18	13
T-Sb (ug/L)	0.12	0.10	0.10	0.12	0.071	0.093	0.10	0.12	0.11	0.11	0.11	0.10
T-As (ug/L)	1.1	1.3	1.2	1.6	0.84	0.90	0.67	0.96	0.64	0.76	0.80	0.95
T-Cd (ug/L)	0.017	0.013	0.012	0.035	0.043	0.031	0.020	0.018	0.013	0.0083	0.013	0.012
T-Ca (mg/L)	103	108	112	90	13	15	20	35	30	62	92	97
T-Cr (ug/L)	0.27	0.13	0.12	0.32	0.66	0.90	0.55	0.97	0.41	0.26	0.17	0.13
T-Co (ug/L)	0.027	0.025	0.025	0.16	0.30	0.25	0.099	0.25	0.10	0.061	0.025	0.027
T-Cu (ug/L)	1.1	0.99	0.99	1.9	2.6	2.4	2.0	2.0	1.8	1.4	1.2	1.00
T-Fe (ug/L)	17	9.3	5.6	180	409	479	190	592	117	81	13	7.1
T-Pb (ug/L)	0.051	0.019	0.0070	0.20	0.13	0.19	0.078	0.32	0.034	0.068	0.042	0.0070
T-Mg (mg/L)	32	34	36	27	3.9	4.6	6.2	11	9.2	20	29	31
T-Mn (ug/L)	7.2	11	9.5	78	72	32	11	20	8.5	9.4	2.8	4.1
T-Hg (ug/L)	0.0060	0.0047	0.0062	0.0071	0.013	0.0091	0.0078	0.0088	0.0067	0.0067	0.0061	0.0061
T-Mo (ug/L)	0.41	0.38	0.38	0.41	0.073	0.18	0.11	0.19	0.14	0.25	0.38	0.37
T-Ni (ug/L)	0.54	0.44	0.43	0.71	1.7	1.2	0.83	0.95	0.82	0.49	0.49	0.47
T-K (mg/L)	5.5	5.8	6.0	4.9	1.1	0.92	1.1	2.0	1.7	3.5	4.7	4.9
T-Se (ug/L)	0.26	0.26	0.30	0.17	0.057	0.065	0.072	0.092	0.11	0.15	0.21	0.22
T-Ag (ug/L)	0.0056	0.0050	0.0050	0.0052	0.0066	0.0066	0.0058	0.0073	0.0050	0.0052	0.0065	0.0050
T-Na (mg/L)	6.3	6.3	6.3	6.5	0.97	1.7	1.8	2.8	2.6	4.4	5.9	6.2
T-Tl (ug/L)	0.0030	0.0033	0.0035	0.0062	0.0058	0.0050	0.0034	0.0077	0.0028	0.0030	0.0028	0.0024
T-U (ug/L)	29	29	31	19	3.1	3.4	4.3	7.2	5.7	14	23	28
T-Zn (ug/L)	0.85	0.63	0.48	2.3	4.3	3.5	1.4	2.2	1.7	0.86	0.83	0.45
Dissolved Metals												
D-Al (ug/L)	11	7.4	7.8	32	311	285	182	101	123	37	19	13
D-Sb (ug/L)	0.11	0.10	0.10	0.11	0.074	0.084	0.10	0.11	0.11	0.11	0.11	0.11
D-As (ug/L)	1.0	1.3	1.2	1.0	0.64	0.60	0.58	0.60	0.61	0.66	0.82	0.93
D-Cd (ug/L)	0.024	0.020	0.013	0.018	0.037	0.022	0.022	0.0093	0.012	0.012	0.030	0.012
D-Ca (mg/L)	99	103	113	86	13	15	20	34	29	58	91	97
D-Cr (ug/L)	0.12	0.32	0.13	0.18	0.42	0.58	0.47	0.36	0.42	0.17	0.15	0.15
D-Co (ug/L)	0.026	0.024	0.026	0.059	0.19	0.10	0.060	0.065	0.056	0.030	0.028	0.026
D-Cu (ug/L)	1.2	1.2	1.0	1.4	2.2	2.1	1.9	1.6	1.8	1.3	1.3	1.1
D-Fe (ug/L)	6.2	4.6	5.0	36	226	220	117	84	82	18	13	6.5
D-Pb (ug/L)	0.028	0.027	0.011	0.044	0.030	0.035	0.054	0.014	0.049	0.17	0.16	0.010
D-Mg (mg/L)	31	33	35	27	4.2	4.5	6.5	11	8.9	19	29	30
D-Mn (ug/L)	5.9	10	9.4	17	51	8.6	4.8	5.9	6.5	2.3	2.7	3.8
D-Hg (ug/L)	0.0053	0.0049	0.0060	0.0066	0.0082	0.0092	0.0061	0.0075	0.0071	0.0063	0.0052	0.0060
D-Mo (ug/L)	0.42	0.39	0.40	0.25	0.087	0.12	0.12	0.16	0.14	0.25	0.34	0.47
D-Ni (ug/L)	0.46	0.47	0.41	0.64	1.4	1.1	0.84	0.64	0.68	0.48	0.46	0.52
D-K (mg/L)	5.4	5.6	6.0	4.8	1.2	0.90	1.2	2.0	1.6	3.4	4.6	5.1
D-Se (ug/L)	0.25	0.24	0.30	0.16	0.063	0.062	0.087	0.10	0.096	0.15	0.23	0.23
D-Ag (ug/L)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0054	0.0050	0.0050	0.0056	0.0050	0.0050	0.0050
D-Na (mg/L)	6.1	6.2	6.2	5.2	1.5	1.5	1.9	2.9	2.5	4.3	7.2	6.7
D-Tl (ug/L)	0.0027	0.0037	0.0040	0.0039	0.0032	0.0025	0.0026	0.0023	0.0024	0.0025	0.0028	0.0030
D-U (ug/L)	30	28	30	19	3.3	3.1	4.2	7.1	5.8	14	24	28
D-Zn (ug/L)	0.82	1.6	0.74	1.6	3.1	2.8	1.2	0.65	1.1	1.3	2.8	0.87

Table 3.1-3: CC-3.5 Mean Monthly Values

	CC-3.5											
	Jan (n = 5)	Feb (n = 4)	Mar (n = 2)	Apr (n = 3)	May (n = 5)	Jun (n = 5)	Jul (n = 5)	Aug (n = 5)	Sep (n = 5)	Oct (n = 6)	Nov (n = 6)	Dec (n = 3)
Physical Parameters												
pH (s.u.)	7.9	7.8	7.9	8.0	7.5	7.8	7.7	7.8	7.8	8.0	7.9	7.7
Cond-L (uS/cm)	430	439	433	483	148	262	203	277	245	342	385	397
TSS (mg/L)	1.6	8.2	7.3	1.0	8.6	23	1.1	1.7	1.4	1.5	1.5	1.1
TDS (mg/L)	273	271	271	306	122	195	145	194	179	231	246	275
T-Alk (mg/L)	116	121	121	133	37	67	55	72	65	87	98	103
T-Hard (mg/L)	213	213	202	255	74	132	99	129	128	166	189	199
Anions												
Sulphate (mg/L)	103	101	100	118	31	61	44	62	55	83	93	95
Cl (mg/L)	0.82	0.66	0.80	0.96	1.6	0.95	0.74	0.71	0.69	0.61	0.78	0.63
F (mg/L)	0.055	0.053	0.054	0.077	0.043	0.058	0.059	0.060	0.058	0.064	0.059	0.065
Nutrients												
T-NH_3 - N (mg/L)	0.016	0.017	0.024	0.023	0.028	0.014	0.022	0.036	0.019	0.013	0.015	0.0087
NO_2 -N (mg/L)	0.013	0.016	0.004	0.004	0.018	0.029	0.013	0.013	0.012	0.011	0.004	0.019
NO_3 - N(mg/L)	0.444	0.456	0.510	0.227	0.051	0.139	0.193	0.227	0.300	0.411	0.422	0.413
D-P (mg/L)	0.0029	0.0035	0.0024	0.0090	0.0084	0.0033	0.0033	0.0037	0.0029	0.0036	0.0023	0.0020
TOC (mg/L)	5.0	5.0	4.5	9.7	22	12	14	11	11	13	5.8	5.4
DOC (mg/L)	4.9	4.6	4.1	8.9	21	12	14	11	11	8.1	5.9	5.5
WAD-CN (mg/L)	0.00051	0.00062	0.00065	0.00060	0.0013	0.00089	0.0011	0.00086	0.00071	0.00072	0.00064	0.00070
Total Metals												
T-Al (ug/L)	16	39	19	27	353	503	121	92	75	40	20	17
T-Sb (ug/L)	0.063	0.067	0.070	0.066	0.070	0.096	0.11	0.10	0.100	0.093	0.072	0.068
T-As (ug/L)	0.27	0.30	0.28	0.32	0.61	0.70	0.43	0.39	0.39	0.32	0.26	0.26
T-Cd (ug/L)	0.0076	0.013	0.0075	0.026	0.026	0.024	0.014	0.011	0.0074	0.0077	0.0078	0.0087
T-Ca (mg/L)	60	61	56	69	20	36	27	35	35	45	52	55
T-Cr (ug/L)	0.10	0.16	0.11	0.17	0.63	1.7	0.42	0.35	0.34	0.24	0.12	0.10
T-Co (ug/L)	0.027	0.055	0.028	0.059	0.32	0.33	0.068	0.064	0.051	0.040	0.031	0.030
T-Cu (ug/L)	0.86	0.99	4.7	1.0	2.3	2.1	1.8	1.5	1.6	1.4	0.99	0.90
T-Fe (ug/L)	9.6	47	13	24	398	562	99	76	56	26	11	9.1
T-Pb (ug/L)	0.012	0.057	0.093	0.065	0.16	0.29	0.017	0.025	0.011	0.041	0.017	0.0067
T-Mg (mg/L)	15	15	15	20	5.9	10	7.8	10	10	13	14	15
T-Mn (ug/L)	1.0	5.2	1.8	12	61	32	3.1	3.4	2.5	0.95	0.38	0.37
T-Hg (ug/L)	0.0070	0.0083	0.0061	0.0079	0.0089	0.0079	0.0072	0.0076	0.0078	0.0067	0.0065	0.0077
T-Mo (ug/L)	0.28	0.25	0.25	0.75	0.14	0.31	0.22	0.28	0.23	0.31	0.33	0.33
T-Ni (ug/L)	0.47	0.56	0.47	2.2	1.2	1.6	0.69	0.62	0.61	0.99	0.50	0.49
T-K (mg/L)	2.5	2.4	2.4	4.0	1.4	1.9	1.7	2.0	2.1	2.3	2.3	2.4
T-Se (ug/L)	0.091	0.063	0.10	0.10	0.073	0.084	0.086	0.072	0.085	0.093	0.095	0.090
T-Ag (ug/L)	0.0050	0.0050	0.0050	0.0050	0.0066	0.0084	0.0062	0.0052	0.0050	0.0055	0.021	0.0050
T-Na (mg/L)	4.1	4.0	4.0	7.4	1.8	3.3	2.6	3.2	3.2	3.7	4.1	4.1
T-Tl (ug/L)	0.0022	0.0020	0.0020	0.0020	0.0052	0.0084	0.0030	0.0026	0.0026	0.0020	0.0020	0.0020
T-U (ug/L)	12	11	12	30	5.4	9.3	4.2	6.5	5.4	9.6	10	10
T-Zn (ug/L)	0.73	1.3	0.58	4.1	2.5	2.6	0.49	0.99	0.76	2.3	0.62	0.39
Dissolved Metals												
D-Al (ug/L)	16	14	14	24	218	127	112	71	71	33	21	16
D-Sb (ug/L)	0.067	0.061	0.071	0.061	0.063	0.084	0.096	0.097	0.099	0.091	0.074	0.076
D-As (ug/L)	0.26	0.27	0.27	0.32	0.44	0.36	0.41	0.37	0.39	0.31	0.27	0.25
D-Cd (ug/L)	0.0092	0.012	0.0080	0.017	0.025	0.015	0.020	0.0064	0.0064	0.0067	0.011	0.016
D-Ca (mg/L)	59	58	60	69	19	36	27	35	35	43	52	57
D-Cr (ug/L)	0.11	0.10	0.11	0.15	0.39	0.41	0.40	0.32	0.32	0.19	0.14	0.12
D-Co (ug/L)	0.028	0.028	0.020	0.057	0.21	0.080	0.063	0.053	0.047	0.033	0.033	0.027
D-Cu (ug/L)	0.87	0.85	2.9	0.87	2.0	1.6	1.8	1.5	1.5	1.3	1.1	0.98
D-Fe (ug/L)	8.2	6.9	8.0	20	199	111	84	55	48	14	11	7.4
D-Pb (ug/L)	0.022	0.025	0.024	0.043	0.041	0.018	0.055	0.010	0.0096	0.023	0.036	0.017
D-Mg (mg/L)	15	15	15	20	5.6	10	8.0	10	9.7	13	14	15
D-Mn (ug/L)	0.96	0.94	0.73	10	42	5.0	2.2	2.0	2.1	0.47	0.36	0.30
D-Hg (ug/L)	0.0061	0.0078	0.0060	0.0074	0.0076	0.0060	0.0073	0.0079	0.0068	0.0061	0.0056	0.0063
D-Mo (ug/L)	0.30	0.25	0.25	0.60	0.14	0.29	0.22	0.25	0.24	0.33	0.36	0.33
D-Ni (ug/L)	0.47	0.54	0.47	0.62	0.96	0.74	0.68	0.62	0.59	0.50	0.51	0.55
D-K (mg/L)	2.5	2.4	2.4	3.9	1.4	2.0	1.7	2.0	2.0	2.3	2.3	2.4
D-Se (ug/L)	0.100	0.086	0.057	0.091	0.065	0.077	0.077	0.071	0.091	0.089	0.092	0.097
D-Ag (ug/L)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0056	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
D-Na (mg/L)	4.2	4.0	4.0	6.2	1.7	3.5	2.9	3.3	3.0	3.7	4.0	4.1
D-Tl (ug/L)	0.0020	0.0020	0.0020	0.0020	0.0028	0.0029	0.0024	0.0020	0.0026	0.0020	0.0020	0.0020
D-U (ug/L)	12	11	12	29	5.3	8.9	4.2	6.5	5.2	9.5	10	10
D-Zn (ug/L)	0.87	0.80	0.42	2.9	1.8	0.74	0.83	0.82	0.62	1.00	0.76	0.95

3.1.2.2 Major Ions

The major ion chemistry of mid-reach and lower-reach Latte Creek is assessed with respect to conductivity, hardness, alkalinity, sulphate and pH. Station CC-1.5 is characterized by seasonally soft waters (approximately 50 mg/L) during freshet periods and hard to very hard waters (ranging from 110 mg/L to > 400 mg/L) during lower flow periods and winter low flows (Table 3.1-2; Figure 3.1-5).

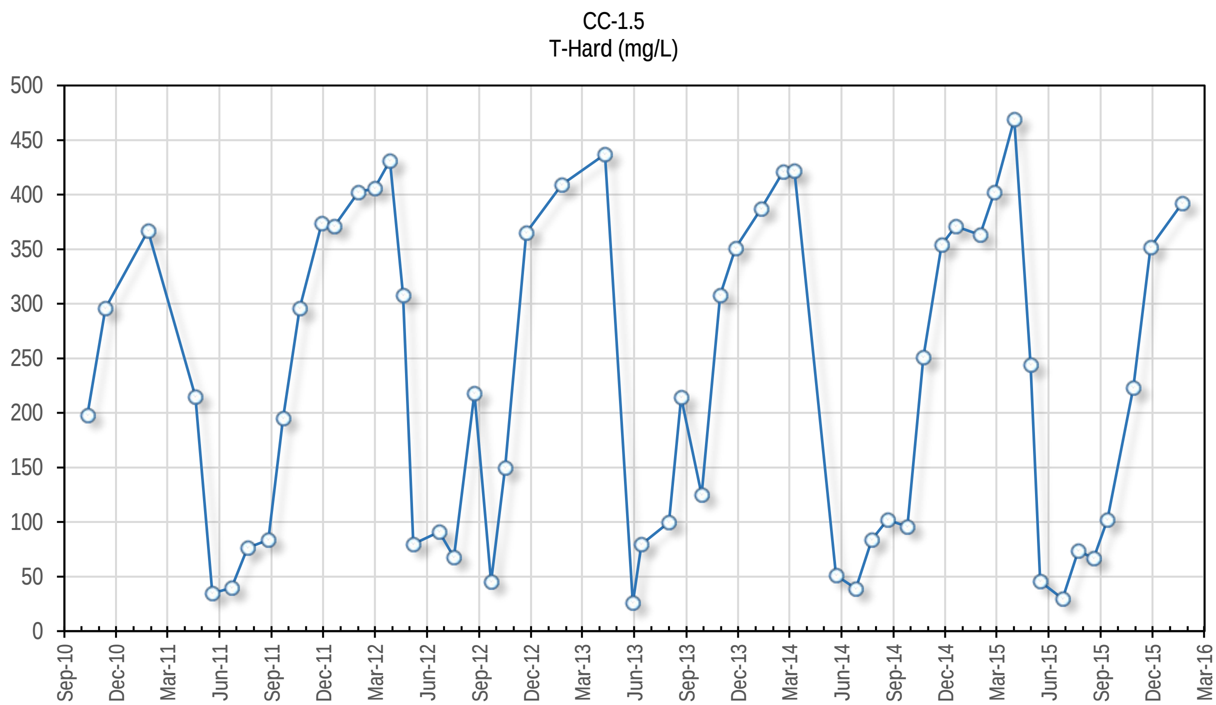


Figure 3.1-5: Total Hardness in mid Latte Creek for the period October 2010 to December 2015

In lower Latte Creek, hardness values show a similar seasonal trend, with minima occurring during freshet or following precipitation runoff events. Hard to very hard waters dominate the fall and winter flow conditions with mean values ranging between approximately 75 mg/L to 210 mg/L (Table 3.1-2 and Table 3.1-3; Figure 3.1-6).

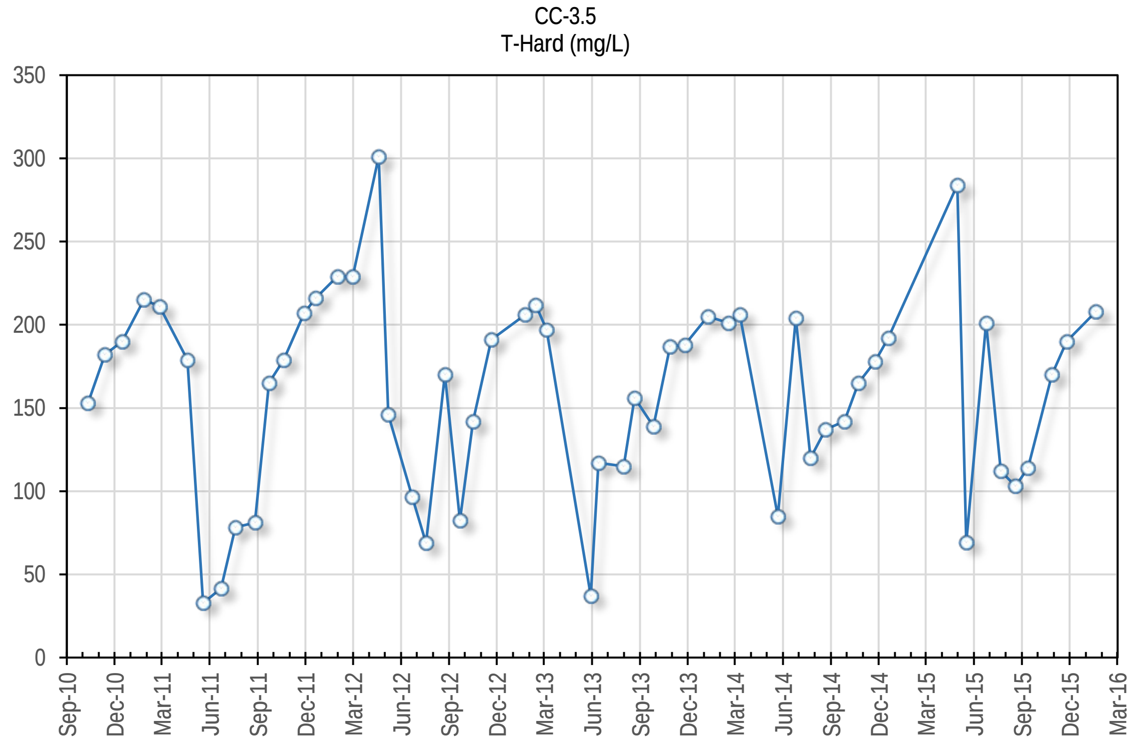


Figure 3.1-6: Total Hardness in lower Latte Creek for the period October 2010 to December 2015

Similar trends for conductivity and alkalinity are also observed with pronounced seasonal fluctuations, with minima coinciding with freshet periods in May and June (Table 3.1-2 and Table 3.1-3). Overall, such trends in stream salinity reflect varying proportions of snow-melt driven surface runoff (lower ionic strength) and groundwater inputs (higher ionic strength) as driven by the seasonal water balance. The stronger seasonal signature observed in mid Latte Creek at CC-1.5 reflects the influence of waters entering Latte Creek from the small tributary monitored at station CC-1.0 (Appendix A).

The pH in mid and lower Latte Creek remains relatively uniform throughout the year with values generally ranging between 7.0 and 8.0. The neutral to slightly basic pH conditions can be linked to bicarbonate alkalinity. All pH values reported to date have remained within the CCME freshwater guideline range for pH of 6.5 to 9.0.

Baseline concentrations for sulphate in mid and lower Latte Creek are notably much higher than in upper Latte Creek. While upper Latte Creek had very low sulphate concentrations (e.g. > 1.0 mg/L), sulphate concentrations in mid to lower Latte Creek range between 15 to 220 mg/L (at CC-1.5) and approximately 30 to 100 mg/L in lower Latte Creek (Table 3.1-2 and Table 3.1-3). Sulphate minima during high flow can be attributed to the influence of low ionic strength melt waters, while higher values during the low-flow periods reflect an increased proportion of groundwater inputs.

Unlike the dissolved ions, higher TSS concentrations in mid and lower Latte Creek generally coincide with the peak snowmelt months or during intense rainfall events (Table 3.1-2 and Table 3.1-3.). At most other flow periods of the year, TSS values in Latte Creek were generally below 3.0 mg/L.

3.1.2.3 Nutrients

Nutrients are found in low concentrations in mid and lower Latte Creek. Ammonia-N concentrations are low with mean monthly values typically between roughly 0.01 to 0.1 mg/L for CC-1.5 and 0.01 to 0.03 mg/L for CC-3.5 (Table 3.1-2 and Table 3.1-3). Nitrate-N and nitrite-N concentrations in mid and lower Latte Creek were comparably higher than upper Latte Creek. Baseline mean nitrate-N concentrations in mid Latte Creek ranged from 0.05 to 0.5 mg/L, with highest monthly means observed during winter low flows. Similarly, monthly mean nitrate-N concentrations in lower Latte Creek ranged from 0.004 to 0.03 mg/L, again with highest monthly means observed during winter low flow conditions. Dissolved phosphorus concentrations at both stations were low (CC-1.5 mean of 0.0047 mg/L and CC-3.5 mean of 0.0035 mg/L) and indicative of oligotrophic to ultra-oligotrophic conditions (Appendix C).

Similar to upper Latte Creek, TOC and DOC exhibit a marked seasonal signature with highest values observed during peak runoff periods. DOC concentrations range from less than 5.0 mg/L during baseflow periods, dominated by groundwater inputs, to upwards of 25 mg/L during higher flow periods reflecting carbon contributions associated with terrestrial runoff (Figure 3.1-7 and Figure 3.1-8).

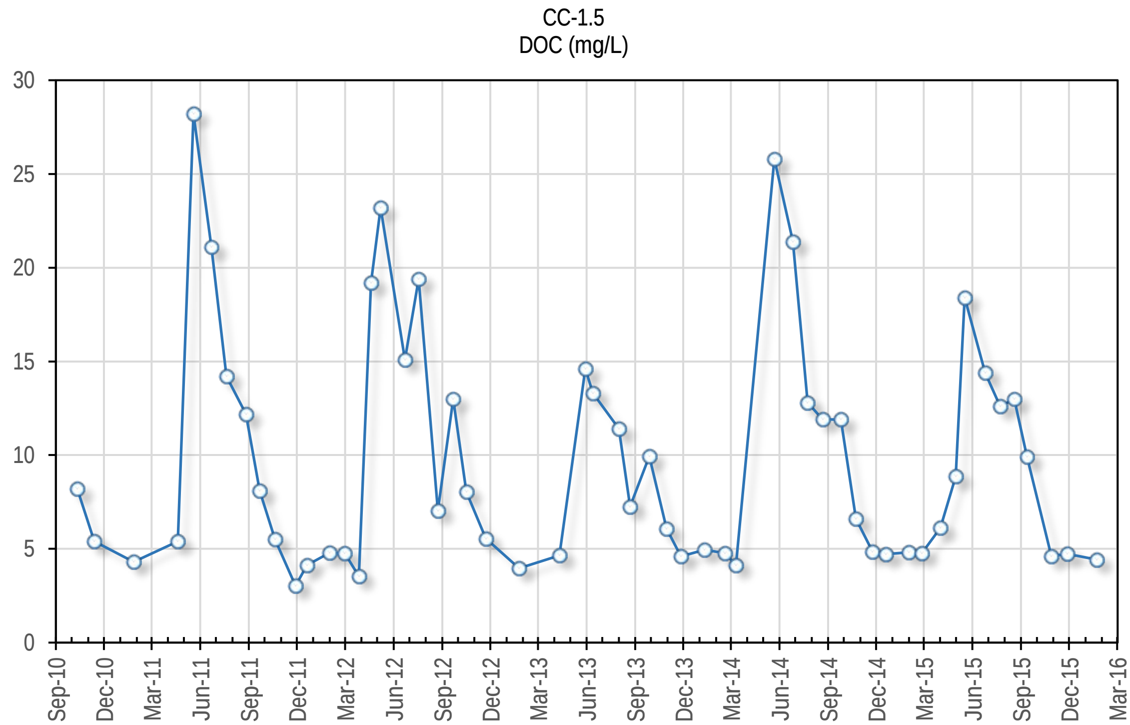


Figure 3.1-7: Dissolved organic carbon in mid Latte Creek for the period October 2010 to December 2015

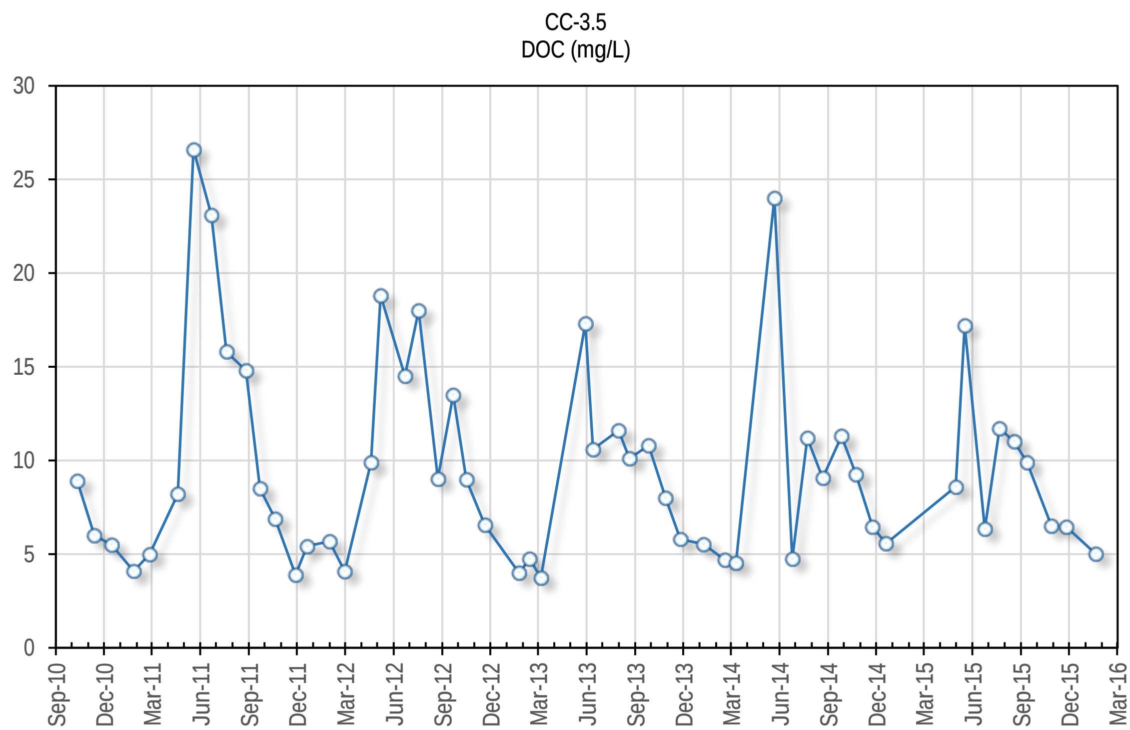


Figure 3.1-8: Dissolved organic carbon in lower Latte Creek for the period October 2010 to December 2015

3.1.2.4 Trace Elements

Baseline trace element concentrations in mid and lower Latte Creek were derived from data collected from October 2010 to December 2015 at CC-1.5 and CC-3.5. For most parameters, mean monthly concentrations of total and dissolved trace elements are considered to be low (e.g., As, Sb, Co, Cr, Pb, Hg, Ni, Se, and Zn). Total As concentrations in mid Latte Creek at CC-1.5 are typically around 1.0 to 1.5 µg/L with maximum concentrations of total As observed coincident with high flow events.

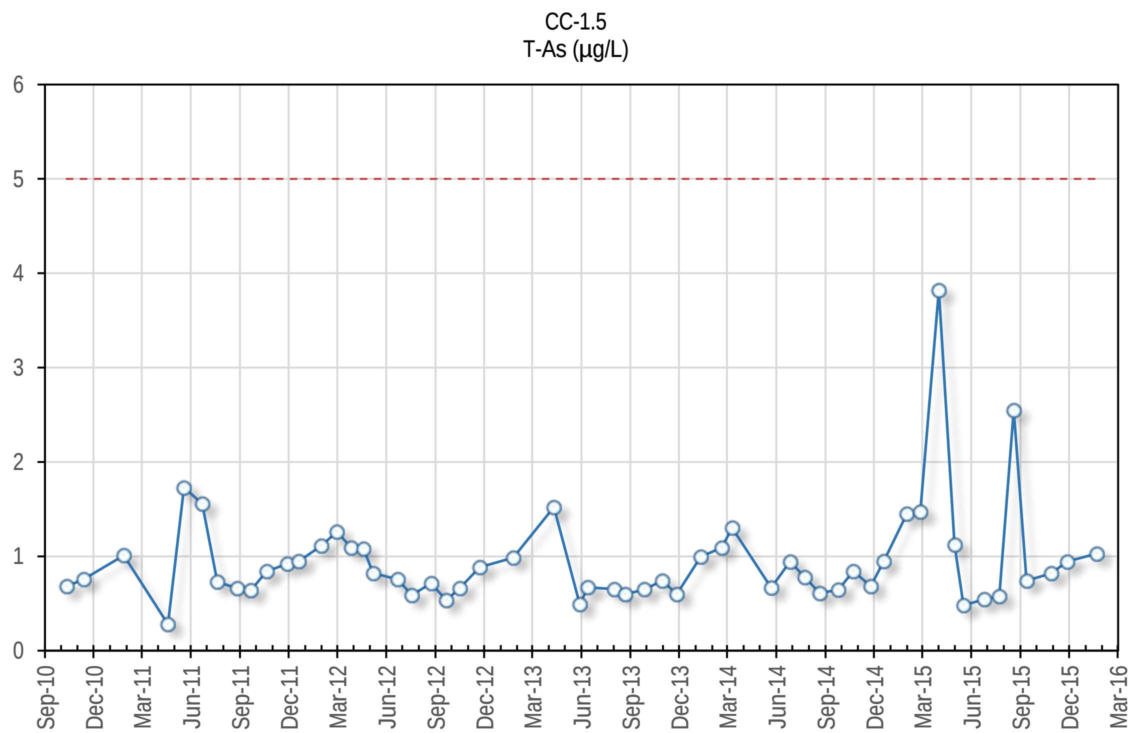


Figure 3.1-9: Total As in mid Latte Creek for the period October 2010 to December 2015 compared to CCME guideline (red dashed line) for protection of aquatic life

In lower Latte Creek at station CC-3.5, total As concentrations are lower and consistently below 0.5 µg/L (Table 3.1-3 and Figure 3.1-10) and well below the CCME guideline of 5.0 µg/L for the protection of aquatic life.

Total Se concentrations in mid and lower Latte Creek are typically less than 0.2 µg/L and 0.1 µg/L, respectively (Table 3.1-2 and Table 3.1-3).

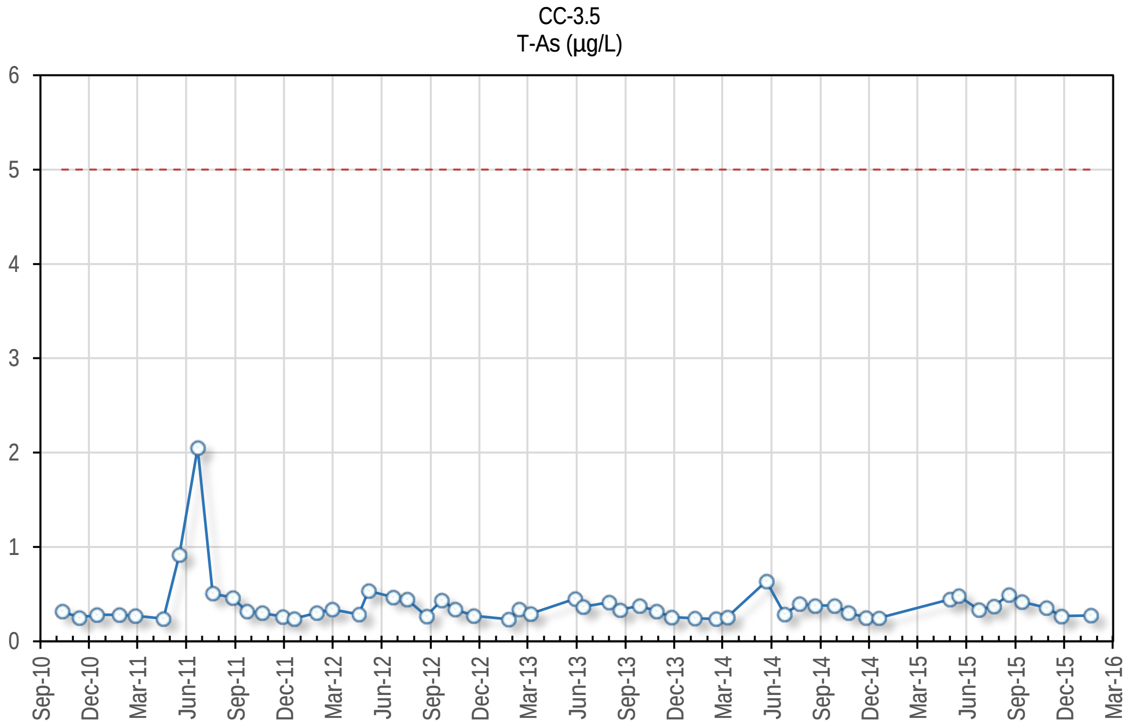


Figure 3.1-10: Total As in lower Latte Creek for the period October 2010 to December 2015 compared to CCME guideline (red dashed line) for protection of aquatic life

Similar to upper Latte Creek, dissolved Al is consistently observed to be elevated well above BCMOE guideline for the protection of aquatic life of 100 µg/L throughout Latte Creek, with peak concentrations coinciding with higher flow conditions (Figure 3.1-11 and Figure 3.1-12). During baseflow periods, dissolved Al concentrations throughout Latte Creek are generally below 10 µg/L (Figure 3.1-11 and Figure 3.1-12).

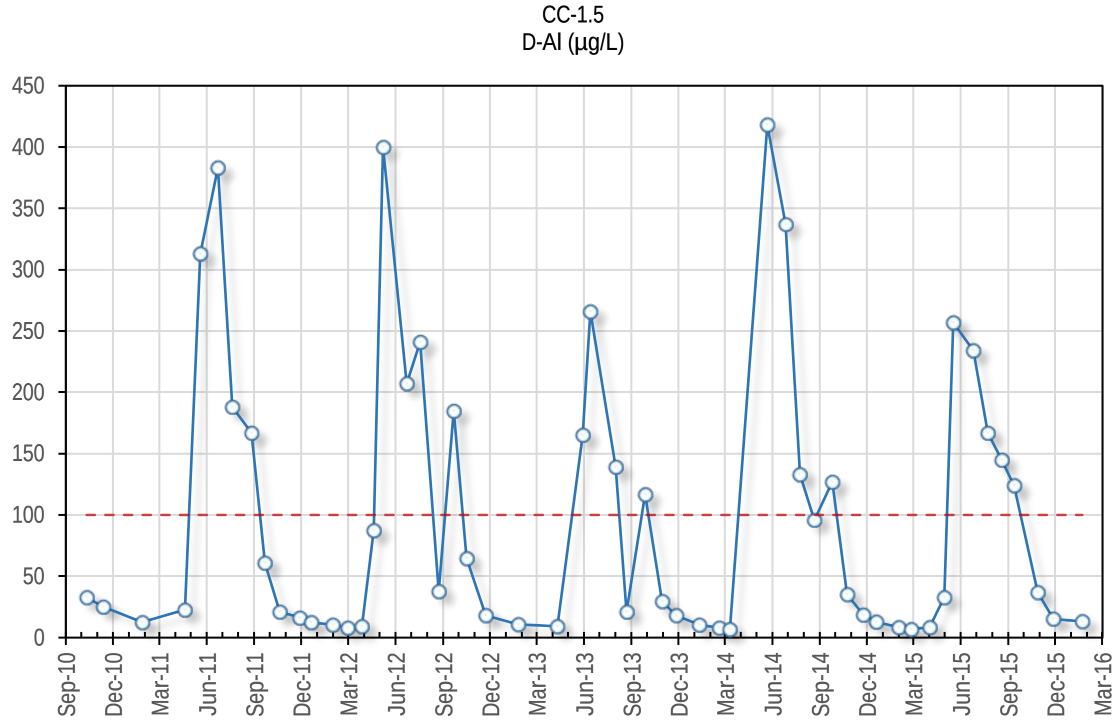


Figure 3.1-11: Dissolved Al in mid Latte Creek for the period October 2010 to December 2015 compared to BCMOE guideline (red dashed line) for protection of aquatic life

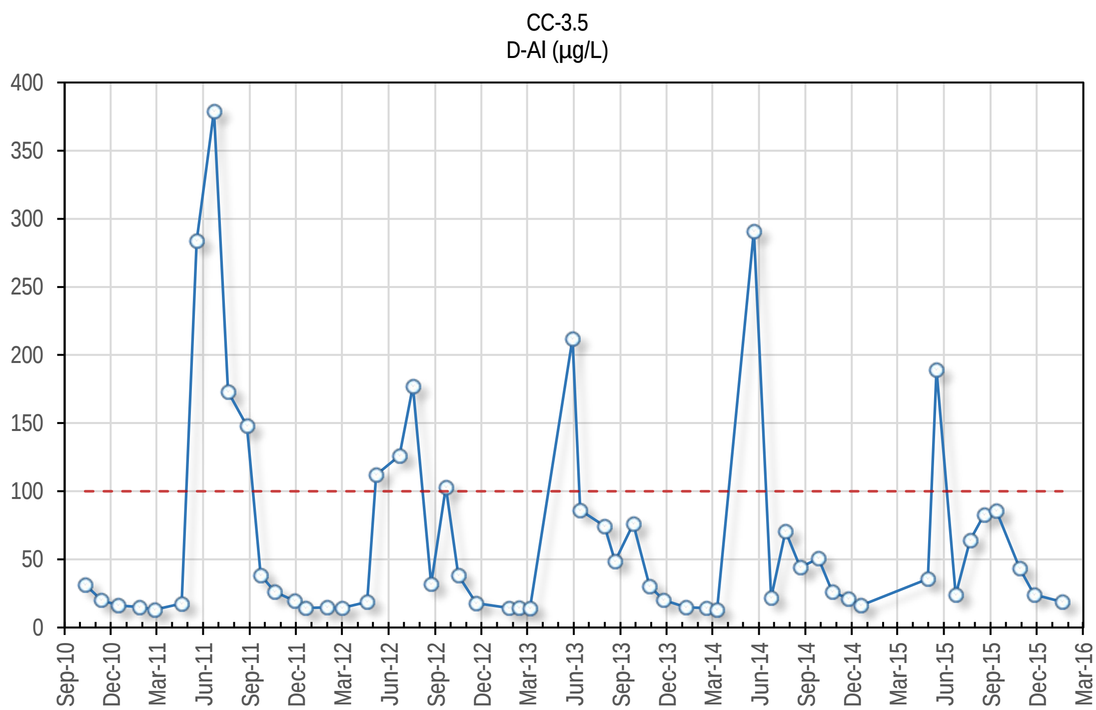


Figure 3.1-12: Dissolved Al in lower Latte Creek for the period October 2010 to December 2015 compared to BCMOE guideline (red dashed line) for protection of aquatic life

Concentrations of total Cu in mid and lower Latte Creek show seasonal maxima associated with peak runoff periods that can episodically exceed the CCME hardness-based Cu guideline for the protection of aquatic life (Figure 3.1-13 and Figure 3.1-14).

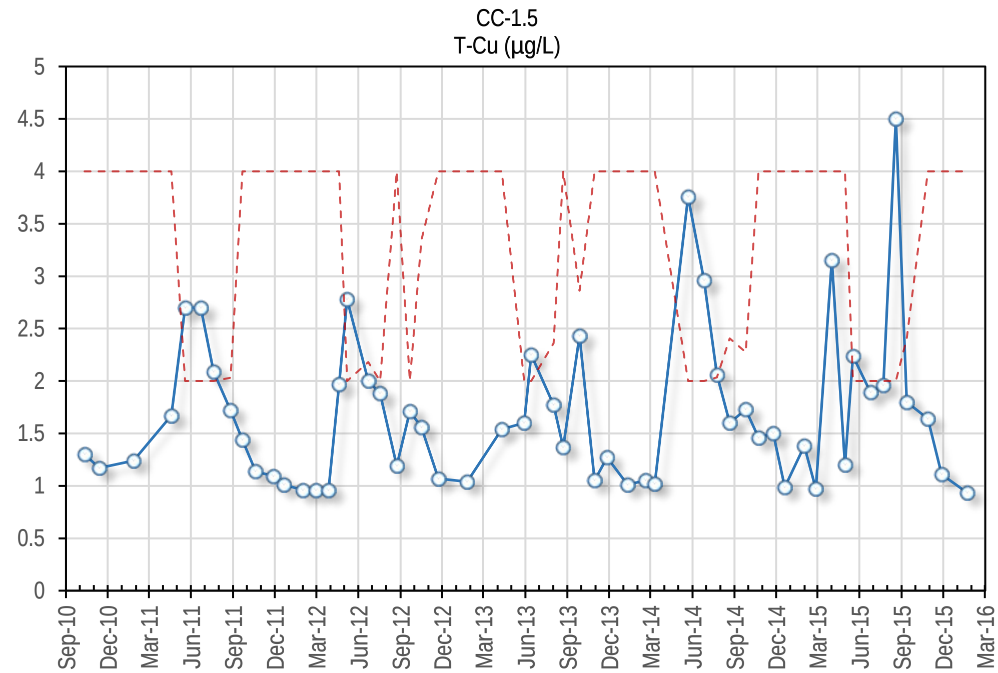


Figure 3.1-13: Total Cu in mid Latte Creek for the period October 2010 to December 2015 compared to CCME hardness based guideline value (red dashed line) for the protection of aquatic life.

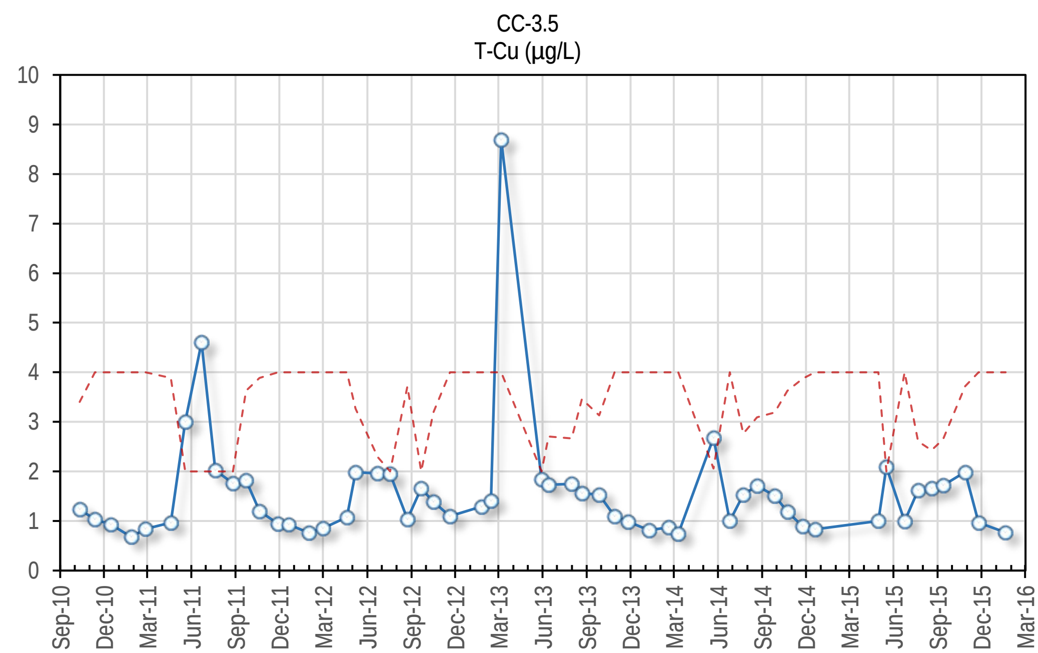


Figure 3.1-14: Total Cu in lower Latte Creek for the period October 2010 to December 2015 compared to CCME hardness based guideline value (red dashed line) for the protection of aquatic life.

In mid and lower Latte Creek, total Cd concentrations do not exceed the chronic or short-term CCME hardness-based guidelines for protection of aquatic life for Cd (Figure 3.1-15 and Figure 3.1-16).

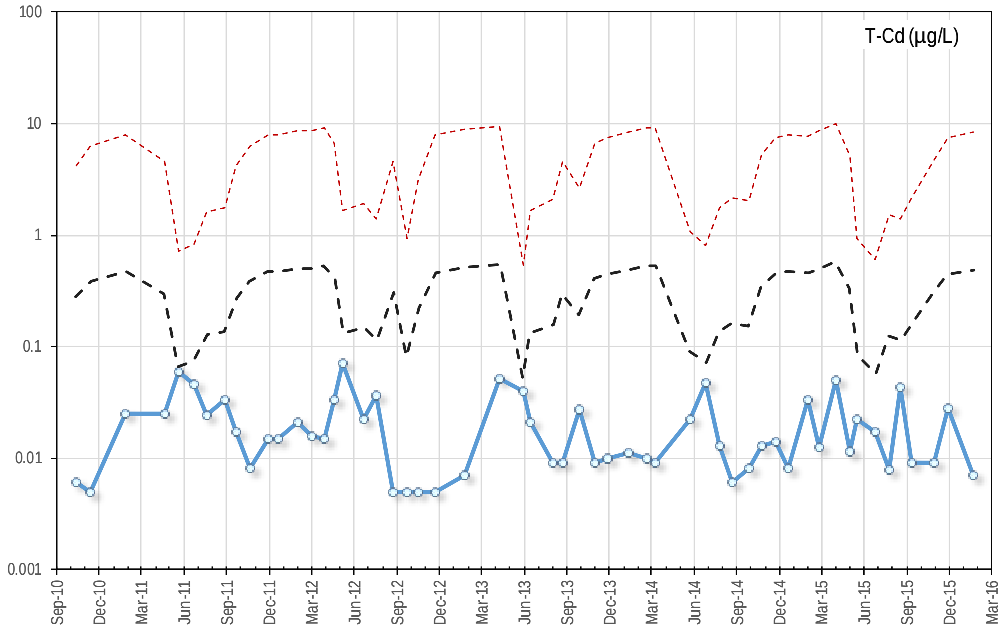


Figure 3.1-15: Total Cd concentrations in mid Latte Creek for the period October 2010 to December 2015 compared to CCME chronic (black dashed line) and short-term (red dashed line) hardness based guideline value for the protection of aquatic life.

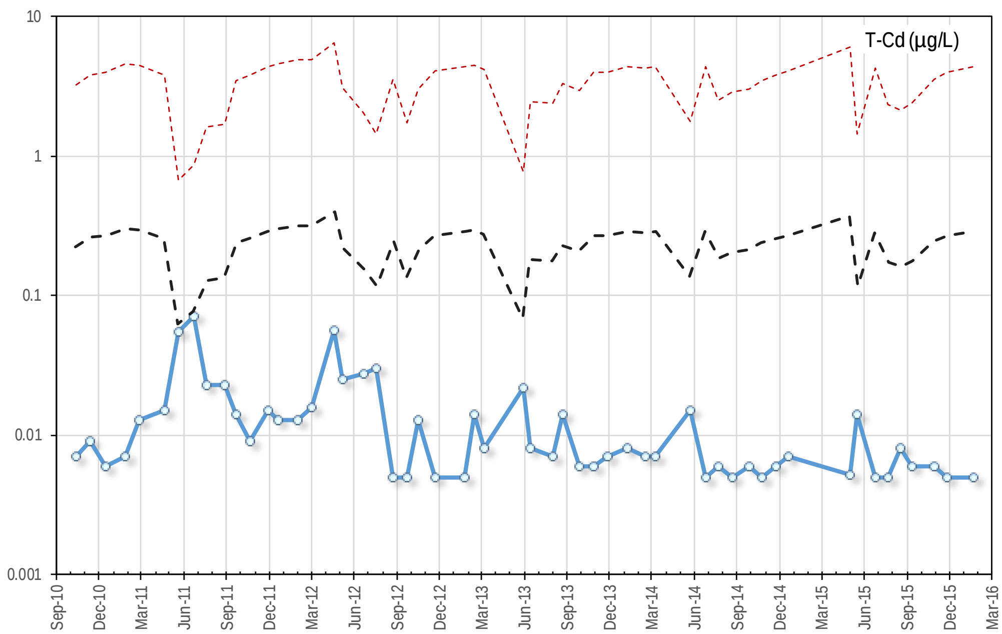


Figure 3.1-16: Total Cd concentrations in lower Latte Creek for the period October 2010 to December 2015 compared to CCME chronic (black dashed line) and short-term (red dashed line) hardness based guideline value for the protection of aquatic life.

The most notable parameter of interest in mid and lower Latte Creek is uranium. Total U concentrations in mid Latte Creek at station CC-1.5 show a distinct seasonal signature with maxima observed during winter low flow periods, and coinciding with baseflow conditions. Concentrations during low flow periods can exceed 30 µg/L and are often over 20 µg/L and well above the CCME guideline of 15 µg/L for the protection of aquatic life (Figure 3.1-17). The strong inverse relationship ($R^2 = 0.93$) between total U and flow in mid Latte Creek at station CC-1.5 is illustrated in Figure 3.1-18.

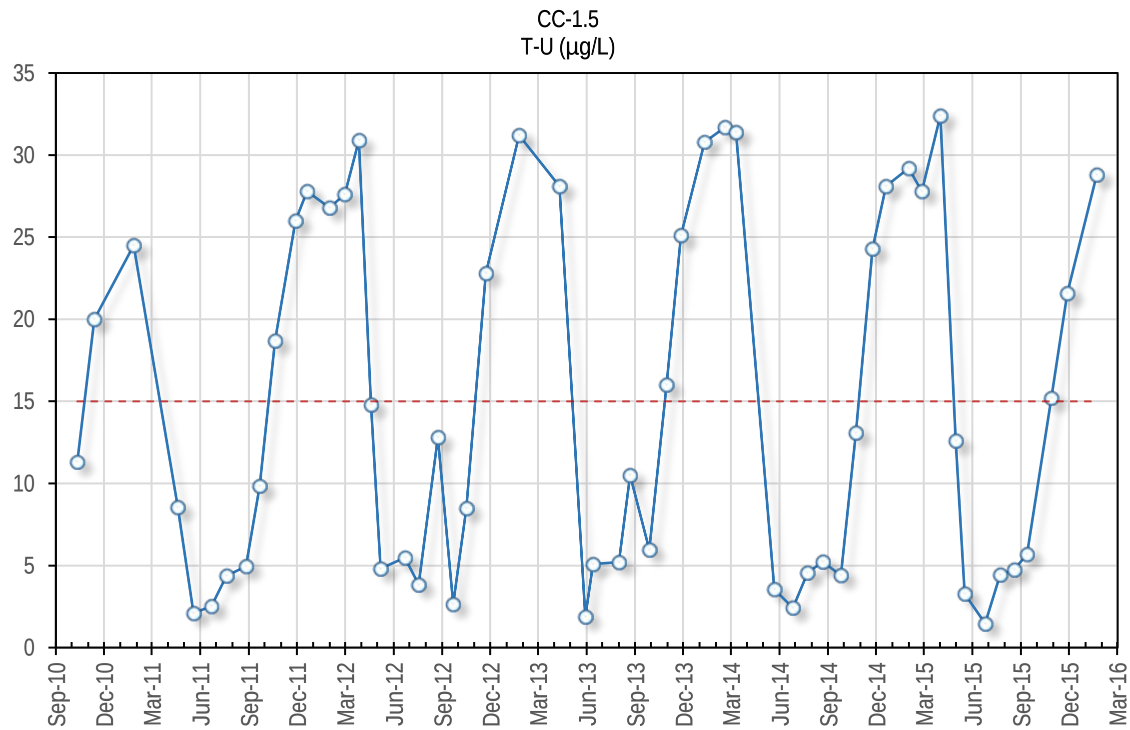


Figure 3.1-17: Total U in mid Latte Creek for the period October 2010 to December 2015 compared to CCME guideline value (red dashed line) for the protection of aquatic life.

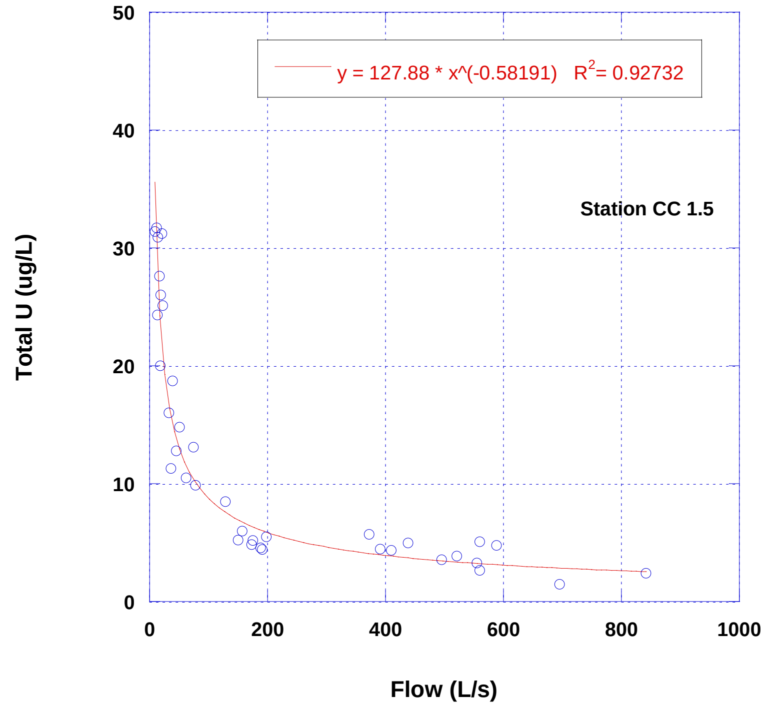


Figure 3.1-18: Relationship between total U and flow in mid Latte Creek for the period October 2010 to December 2015

Graphical representation of monthly mean total U data at CC-1.5 illustrates that concentrations in excess of the CCME guideline of 15 µg/L for U typically occurs from November to April (Figure 3.1-19).

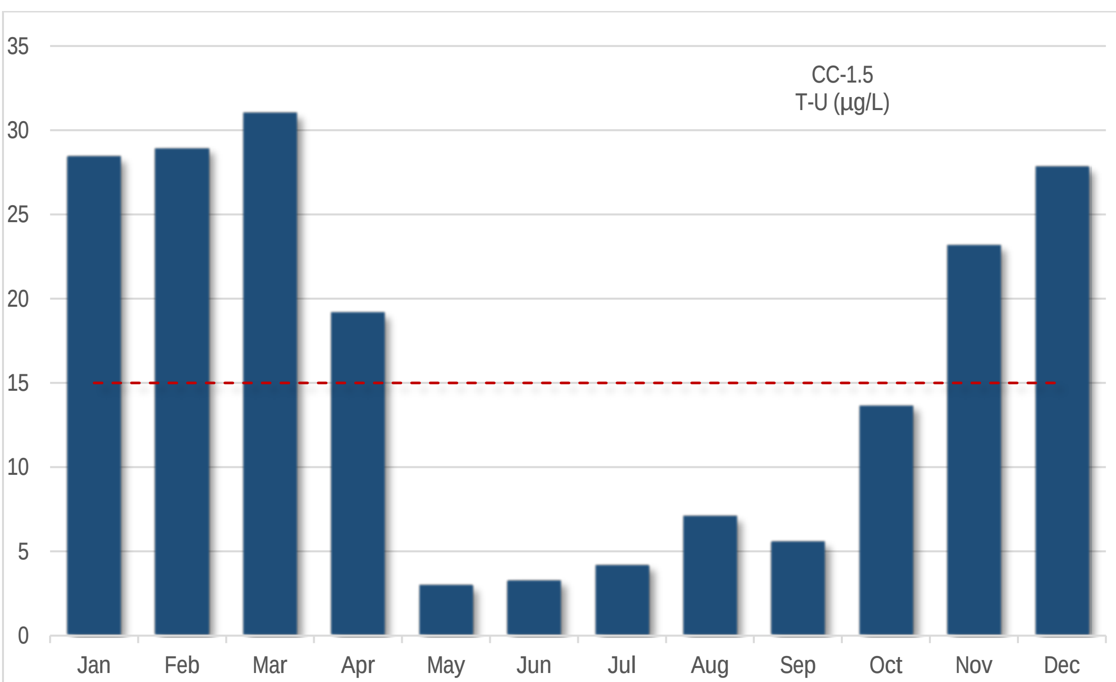


Figure 3.1-19: Mean monthly total U concentrations at CC-1.5 in mid Latte Creek for the period October 2010 to December 2015 and compared to CCME guideline (dashed red line) for protection of aquatic life.

A similar, yet less pronounced seasonal trend of total U concentrations is observed in lower Latte Creek at station CC-3.5. Peak concentrations on the order of 30 µg/L to 35 µg/L occur in late winter low flow periods; observed concentrations in most other months are less than the CCME guideline of 15 µg/L for the protection of aquatic life (Figure 3.1-20 and Figure 3.1-21).

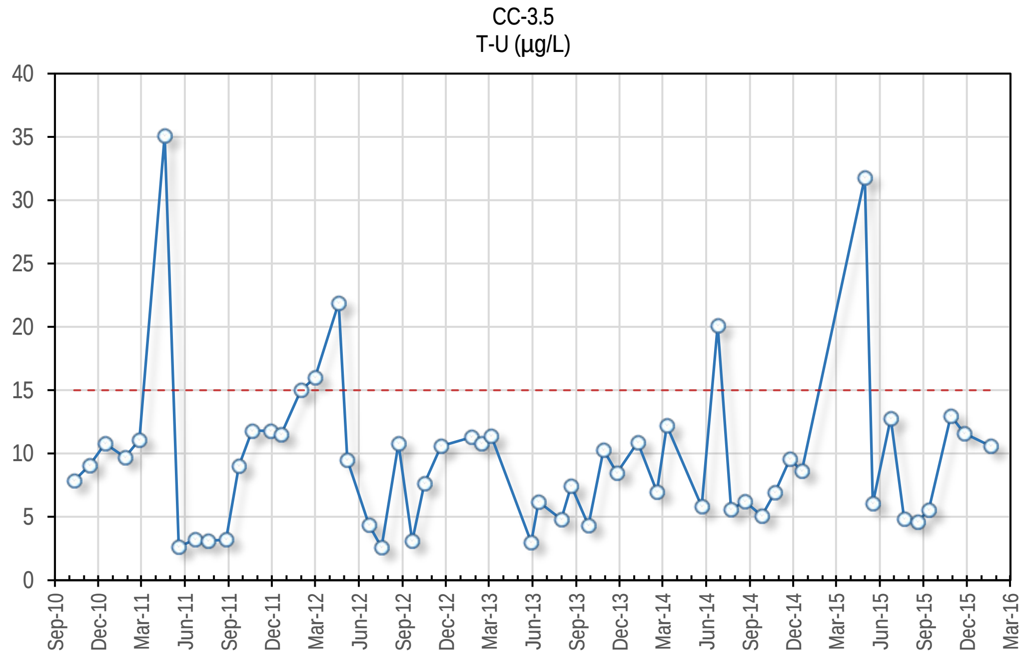


Figure 3.1-20: Total U in lower Latte Creek for the period October 2010 to December 2015 compared to CCME guideline value (red dashed line) for the protection of aquatic life.

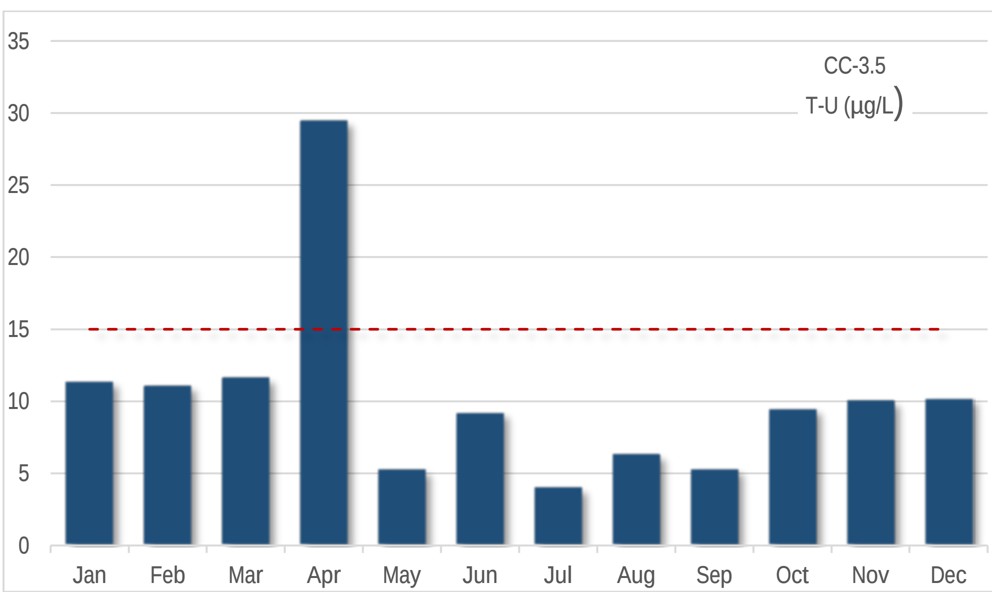


Figure 3.1-21: Mean monthly total U concentrations at CC-3.5 in lower Latte Creek for the period October 2010 to December 2015 and compared to CCME guideline (dashed red line) for protection of aquatic life.

3.2 Coffee Creek

Background water chemistry in Coffee Creek can be divided between upper Coffee Creek (e.g. above the confluence with Latte Creek) and lower Coffee Creek (Figure 3.2-1). Upper Coffee Creek is represented by data collected from CC-0.5 and lower Coffee Creek is represented by data collected at station CC-4.5. Monthly water quality monitoring at both stations commenced in October 2010 and continue to present.

3.2.1 Upper Coffee Creek – Station CC-0.5

Upper Coffee Creek is characterized by water quality measured at Station CC-0.5 (Figure 3.2-1) which reflects contributions from a large watershed of approximately 385 km^2. This compares to the Latte Creek watershed area at CC-3.5 of approximately 70 km^2 described in section 3.1.

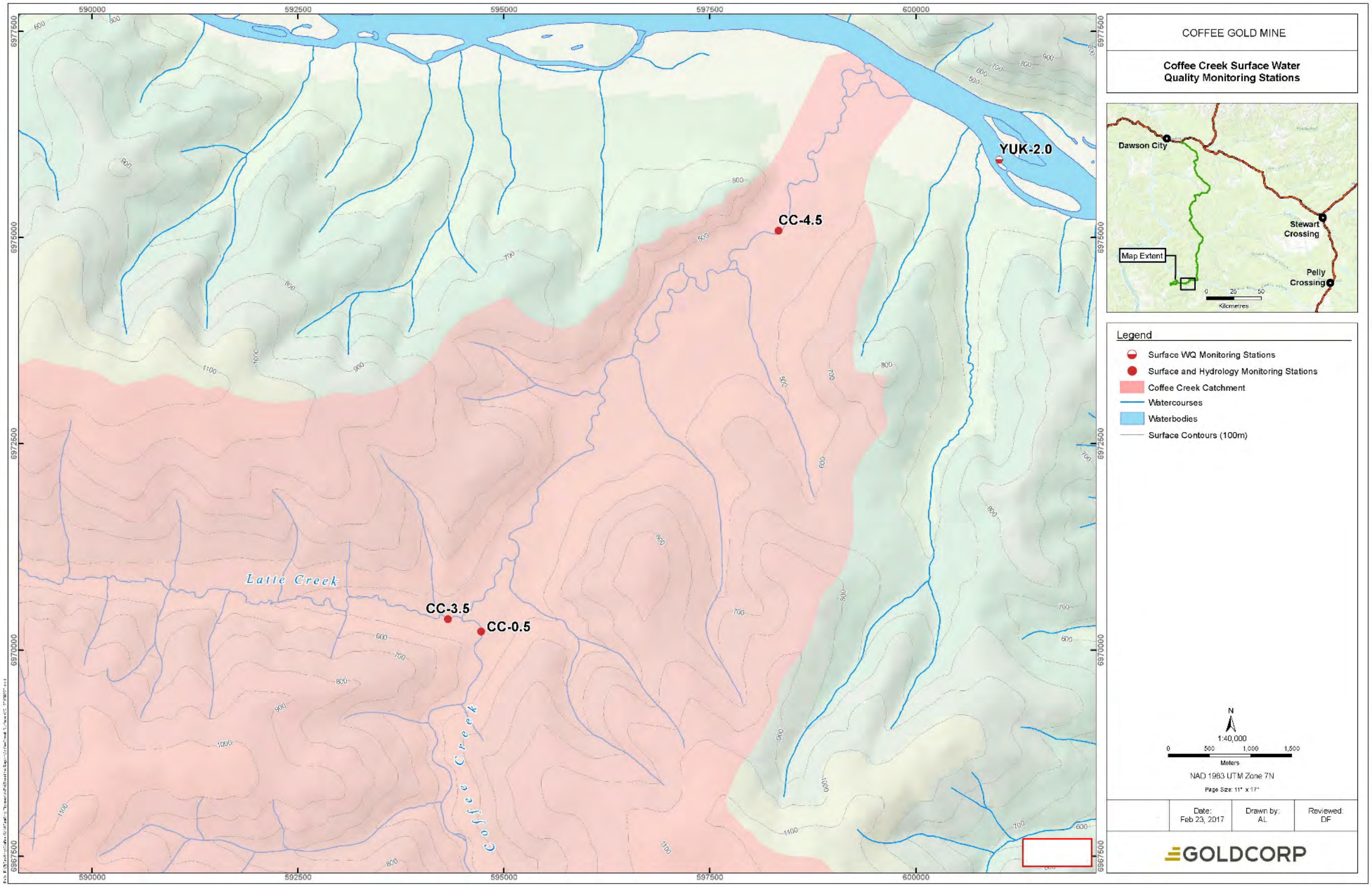


Figure 3.2-1: Detail of Coffee Creek drainage illustrating key monitoring station locations upstream and downstream of Latte Creek confluence

3.2.1.1 Summary Statistics

Table 3.2-1 summarizes the mean monthly values for a suite of the key parameters for station CC-0.5 in Coffee Creek.

3.2.1.2 Major Ions

The major ion chemistry of upper Coffee Creek is assessed with respect to conductivity, hardness, alkalinity, sulphate and pH. Station CC-0.5 is characterized by seasonally comparatively soft to moderately soft waters (between 35 mg/L and 65 mg/L) during open water periods of May to September) and hard to very hard waters (ranging from approximately 100 mg/L to 200 mg/L) during lower flow periods and winter low flows (Table 3.2-1; Figure 3.2-2).

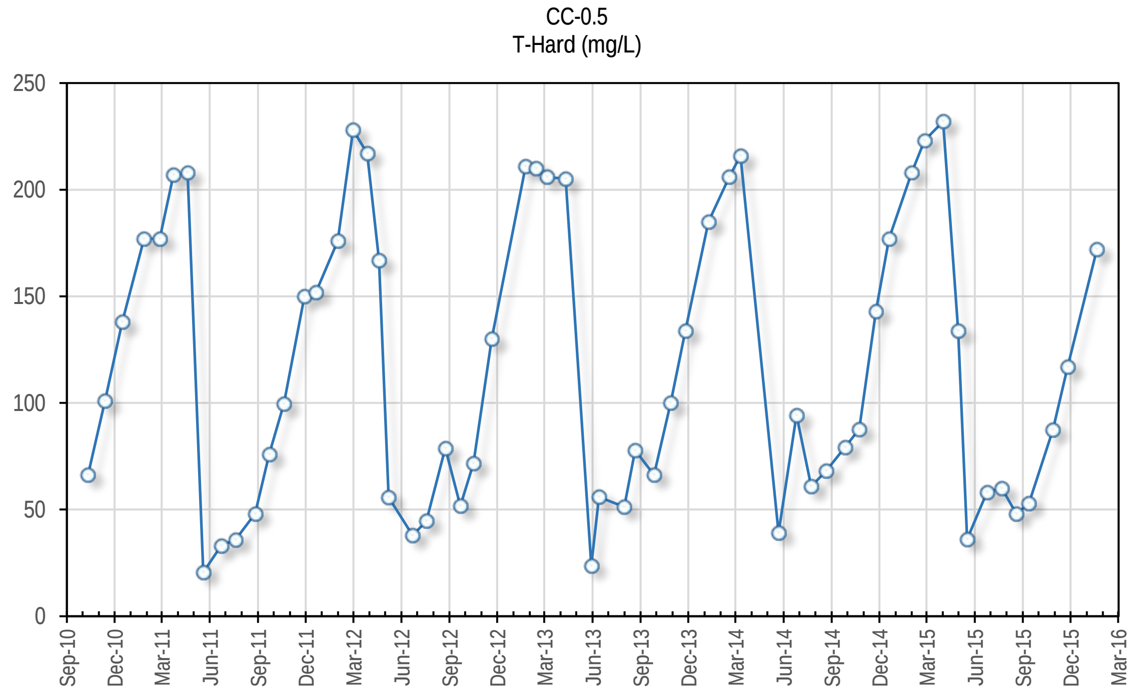


Figure 3.2-2: Total Hardness in upper Coffee Creek for the period October 2010 to December 2015

Table 3.2-1:
Station CC-0.5 Monthly Mean Values

	CC-0.5											
	Jan (n = 6)	Feb (n = 5)	Mar (n = 4)	Apr (n = 5)	May (n = 5)	Jun (n = 5)	Jul (n = 5)	Aug (n = 5)	Sep (n = 5)	Oct (n = 6)	Nov (n = 6)	Dec (n = 3)
Physical Parameters												
pH (s.u.)	7.8	7.8	7.8	7.8	7.0	7.4	7.4	7.7	7.6	7.7	7.7	7.6
Cond-L (uS/cm)	396	431	439	400	65	118	109	142	130	192	291	326
TSS (mg/L)	1.7	1.0	1.0	1.0	31	30	18	8.9	1.4	1.5	1.5	1.2
TDS (mg/L)	261	277	271	262	78	117	88	102	104	139	179	225
T-Alk (mg/L)	98	116	128	92	14	28	28	38	34	43	61	71
T-Hard (mg/L)	188	209	212	189	35	56	51	64	65	86	129	156
Anions												
Sulphate (mg/L)	99	100	100	110	7.8	23	20	27	25	43	76	84
Cl (mg/L)	1.1	1.0	1.1	1.3	1.3	1.8	0.90	0.72	0.72	0.88	0.99	1.1
F (mg/L)	0.078	0.073	0.073	0.066	0.044	0.064	0.062	0.068	0.061	0.072	0.083	0.092
Nutrients												
T-NH_3 - N (mg/L)	0.019	0.020	0.022	0.022	0.049	0.012	0.030	0.021	0.026	0.015	0.021	0.046
NO_2 -N (mg/L)	0.011	0.013	0.004	0.004	0.011	0.013	0.013	0.013	0.012	0.011	0.004	0.019
NO_3 - N(mg/L)	0.251	0.164	0.097	0.030	0.066	0.096	0.172	0.189	0.283	0.339	0.386	0.313
D-P (mg/L)	0.0034	0.0026	0.0025	0.0076	0.010	0.0061	0.0040	0.0037	0.0039	0.0028	0.0027	0.0020
TOC (mg/L)	5.1	5.1	4.2	9.8	23	17	17	12	12	9.9	6.8	6.1
DOC (mg/L)	5.0	4.8	3.8	9.1	23	16	16	12	12	9.0	6.5	5.8
WAD-CN (mg/L)	0.00077	0.00064	0.00057	0.00059	0.0012	0.0012	0.0012	0.00081	0.00075	0.00086	0.00075	0.00073
Total Metals												
T-Al (ug/L)	23	15	15	37	921	499	522	221	146	71	32	29
T-Sb (ug/L)	0.33	0.059	0.052	0.16	0.12	0.12	0.13	0.12	0.12	0.12	0.11	0.092
T-As (ug/L)	0.35	0.34	0.32	0.47	1.0	0.77	0.72	0.55	0.49	0.40	0.34	0.31
T-Cd (ug/L)	0.022	0.010	0.0080	0.026	0.049	0.031	0.028	0.029	0.017	0.012	0.011	0.014
T-Ca (mg/L)	52	61	62	52	9.0	14	13	17	17	21	33	40
T-Cr (ug/L)	0.24	0.19	0.10	0.24	1.4	1.1	1.2	0.54	0.47	0.30	0.20	0.32
T-Co (ug/L)	0.063	0.088	0.087	0.11	0.70	0.38	0.32	0.15	0.11	0.065	0.049	0.048
T-Cu (ug/L)	1.1	0.87	0.85	1.1	3.9	3.7	5.4	2.6	2.7	2.1	1.5	1.3
T-Fe (ug/L)	69	103	90	124	1181	630	639	281	159	67	41	40
T-Pb (ug/L)	0.081	0.020	0.011	0.033	0.37	0.23	0.21	0.079	0.042	0.050	0.032	0.020
T-Mg (mg/L)	14	14	14	14	3.1	5.0	4.4	5.6	5.5	7.8	11	14
T-Mn (ug/L)	31	49	61	54	62	25	18	13	12	10	18	22
T-Hg (ug/L)	0.0060	0.0069	0.0080	0.0072	0.0095	0.0062	0.0074	0.0076	0.0064	0.0068	0.0066	0.0076
T-Mo (ug/L)	0.54	0.33	0.30	0.53	0.47	0.64	0.62	0.69	0.72	0.71	0.61	0.55
T-Ni (ug/L)	0.69	0.64	0.60	0.88	2.2	1.8	1.6	1.2	1.2	0.92	0.76	0.75
T-K (mg/L)	1.8	1.9	2.0	2.4	1.1	0.98	0.92	1.1	1.2	1.2	1.4	1.5
T-Se (ug/L)	0.13	0.070	0.069	0.12	0.072	0.093	0.10	0.092	0.098	0.10	0.13	0.14
T-Ag (ug/L)	0.0072	0.0050	0.0050	0.0050	0.012	0.0077	0.0092	0.0054	0.0050	0.0072	0.0050	0.0050
T-Na (mg/L)	6.6	5.5	5.2	6.2	1.6	2.9	2.4	3.1	3.1	3.8	5.4	5.9
T-Tl (ug/L)	0.0024	0.0026	0.0023	0.0023	0.016	0.0090	0.011	0.0062	0.0046	0.0040	0.0027	0.0024
T-U (ug/L)	21	12	9.6	7.8	2.4	3.8	2.6	3.4	3.2	6.3	15	17
T-Zn (ug/L)	1.5	1.4	0.40	3.1	5.2	3.1	3.1	1.8	2.7	1.3	1.5	0.81
Dissolved Metals												
D-Al (ug/L)	17	12	13	31	291	208	170	102	113	58	31	24
D-Sb (ug/L)	0.080	0.056	0.055	0.071	0.061	0.10	0.13	0.12	0.11	0.11	0.11	0.094
D-As (ug/L)	0.32	0.31	0.28	0.41	0.47	0.50	0.50	0.47	0.46	0.39	0.33	0.27
D-Cd (ug/L)	0.015	0.0096	0.015	0.024	0.029	0.017	0.019	0.011	0.010	0.0085	0.012	0.016
D-Ca (mg/L)	50	58	66	52	8.3	14	13	16	16	21	33	40
D-Cr (ug/L)	0.14	0.10	0.10	0.17	0.44	0.48	0.50	0.40	0.40	0.26	0.20	0.13
D-Co (ug/L)	0.055	0.091	0.093	0.10	0.22	0.12	0.12	0.083	0.078	0.056	0.050	0.044
D-Cu (ug/L)	1.1	0.76	1.0	1.1	3.0	2.8	2.8	2.4	2.4	1.9	1.4	1.2
D-Fe (ug/L)	39	62	66	59	258	182	152	99	102	48	36	28
D-Pb (ug/L)	0.038	0.0092	0.0098	0.019	0.050	0.017	0.083	0.012	0.0098	0.026	0.026	0.012
D-Mg (mg/L)	15	14	14	14	2.8	4.9	4.3	5.6	5.4	7.6	12	13
D-Mn (ug/L)	31	49	62	52	25	7.6	7.0	6.8	8.3	9.7	18	20
D-Hg (ug/L)	0.0052	0.0062	0.0073	0.0065	0.0083	0.0079	0.0075	0.0072	0.0069	0.0059	0.0053	0.0062
D-Mo (ug/L)	0.55	0.36	0.31	0.51	0.33	0.53	0.57	0.65	0.76	0.75	0.64	0.55
D-Ni (ug/L)	0.65	0.60	0.66	0.88	1.4	1.3	1.3	1.1	1.1	0.89	0.85	0.73
D-K (mg/L)	1.8	1.8	2.0	2.3	0.99	0.98	0.90	1.1	1.0	1.2	1.4	1.5
D-Se (ug/L)	0.12	0.070	0.071	0.12	0.054	0.082	0.098	0.088	0.10	0.10	0.12	0.14
D-Ag (ug/L)	0.0050	0.0050	0.0050	0.0050	0.0052	0.0056	0.0050	0.0056	0.0050	0.0050	0.0050	0.0050
D-Na (mg/L)	6.4	5.3	5.3	6.0	1.3	2.6	2.5	3.0	2.9	3.7	5.7	5.6
D-Tl (ug/L)	0.0020	0.0020	0.0023	0.0023	0.0047	0.0043	0.0051	0.0038	0.0044	0.0032	0.0027	0.0020
D-U (ug/L)	22	12	8.9	7.8	2.0	3.6	2.4	3.2	3.2	6.2	16	17
D-Zn (ug/L)	1.5	1.6	0.71	2.8	2.7	0.98	3.2	0.99	0.83	0.70	1.3	1.2

The pH in upper Coffee Creek remains relatively uniform throughout the year with values generally ranging between 7.0 and 7.8. All pH values reported to date have remained within the CCME freshwater guideline range for pH of 6.5 to 9.0.

Baseline concentrations for sulphate in upper Coffee Creek also exhibit a strong seasonal signature with lowest concentrations occurring during peak runoff conditions. During low flow periods, mean sulphate concentrations at CC-0.5 range from 75 mg/L to 110 mg/L (Table 3.2-1). As described previously, sulphate minima during high flow can be attributed to the influence of low ionic strength melt waters, while higher values during the low-flow periods reflect an increased proportion of groundwater inputs.

Unlike the dissolved ions, higher TSS concentrations in upper Coffee Creek generally coincide with the peak snowmelt months or during intense rainfall events (Table 3.2-1). At most other flow periods of the year, TSS values in upper Coffee Creek at CC-0.5 were generally below 2.0 mg/L.

3.2.1.3 Nutrients

Nutrient parameters have been observed at low concentrations in Coffee Creek at station CC-0.5. Ammonia-N concentrations are low with mean monthly values typically between roughly 0.01 to 0.046 mg/L (Table 3.2-1). Nitrate-N monthly mean concentrations in upper Coffee Creek ranged from 0.03 mg/L to 0.38 mg/L with higher nitrate-N associated with winter low flows. Monthly mean dissolved phosphorus concentrations at CC-0.5 range between 0.002 mg/L to 0.01 mg/L and are indicative of oligotrophic to ultra-oligotrophic conditions.

TOC and DOC exhibit a marked seasonal signature with highest values observed during peak runoff periods in Coffee Creek at station CC-0.5. DOC concentrations range from less than 5.0 mg/L during baseflow periods when groundwater inputs dominate the flow regime. During the open water period, DOC values typically range between 10 mg/L and 20 mg/L during higher flow periods reflecting carbon inputs from terrestrial runoff (Figure 3.2-3).

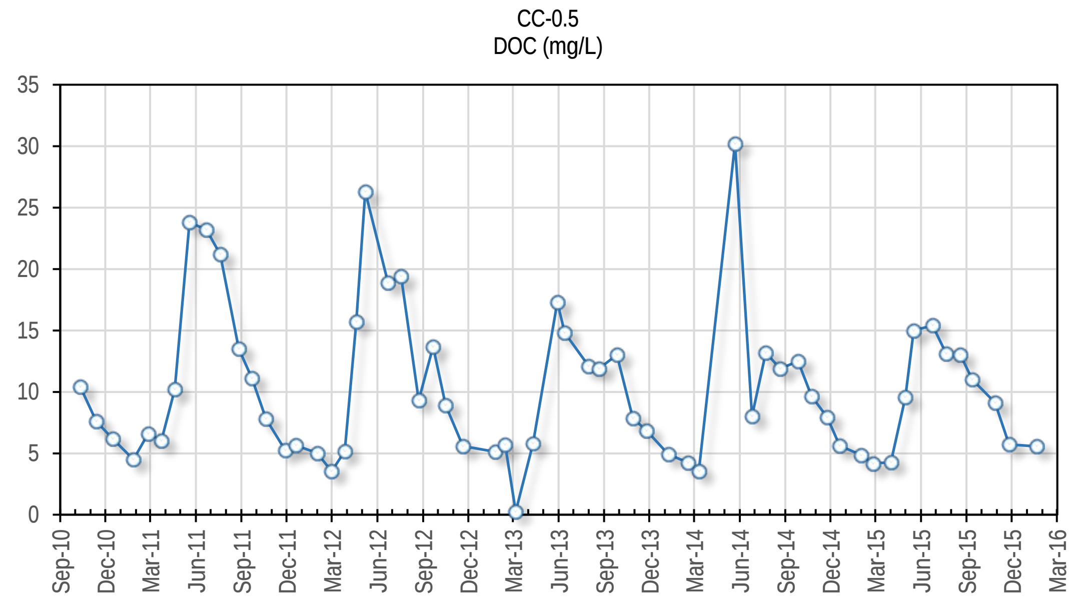


Figure 3.2-3: Dissolved organic carbon in upper Coffee Creek for the period October 2010 to December 2015

3.2.1.4 Trace Elements

Baseline trace element concentrations in upper Coffee Creek were derived from data collected from October 2010 to December 2015 at CC-0.5. For most parameters, mean monthly concentrations of total and dissolved trace elements are low (e.g., As, Sb, Co, Cr, Pb, Hg, Ni, Se, and Zn). Mean monthly total As concentrations in upper Coffee Creek at CC-0.5 are generally below 1.0 µg/L (Figure 3.2-4).

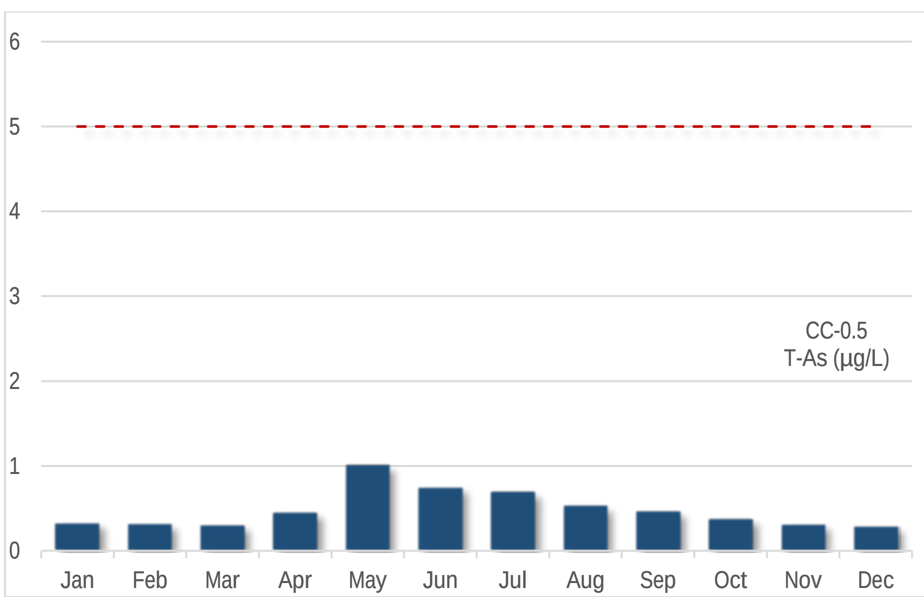


Figure 3.2-4: Mean monthly total As in upper Coffee Creek for the period October 2010 to December 2015 compared to CCME guideline (red dashed line) for protection of aquatic life

Mean monthly total Se concentrations in upper Coffee Creek are typically less than 0.15 µg/L (Table 3.2-1).

Dissolved Al is seasonally elevated in upper Coffee Creek and consistently observed to be elevated well above BCMOE guideline for the protection of aquatic life of 100 µg/L during peak runoff periods (Figure 3.2-5).

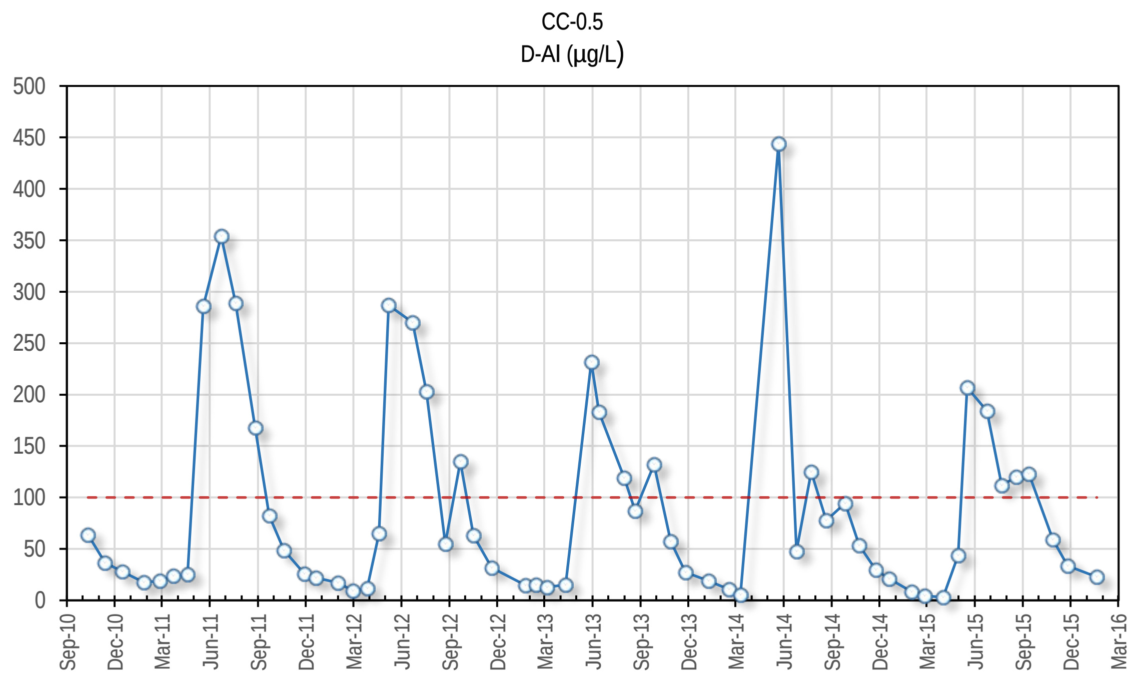


Figure 3.2-5: Dissolved Al in upper Coffee Creek for the period October 2010 to December 2015 compared to BCMOE guideline (red dashed line) for protection of aquatic life

During baseflow periods, dissolved Al concentrations in upper Coffee Creek are typically between 15 and 20 µg/L (Table 3.2-1).

Concentrations of total Cu in upper Coffee Creek exhibit a strong seasonal signature with maxima associated with peak runoff periods that exceed the CCME hardness-based Cu guideline for the protection of aquatic life (Figure 3.2-6 and Figure 3.2-8). During most months of the open water period (e.g., May to September), mean monthly total Cu concentrations are naturally elevated above the CCME guideline for Cu (Figure 3.2-7).

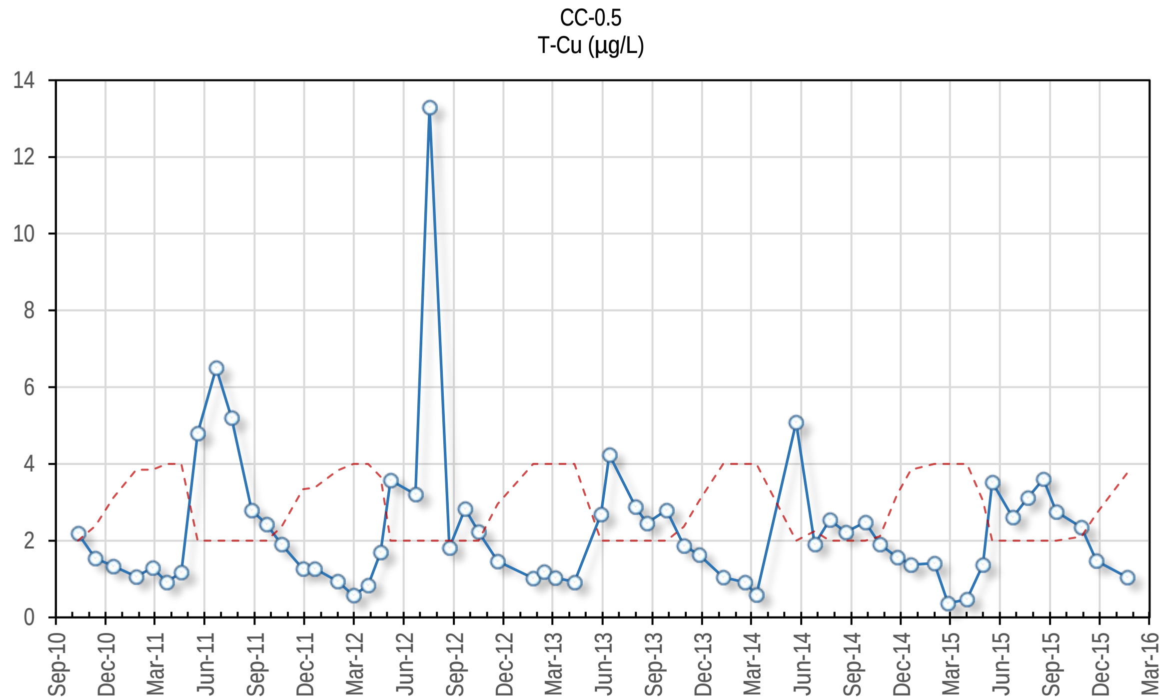


Figure 3.2-6: **Total Cu in upper Coffee Creek for the period October 2010 to December 2015 compared to CCME hardness based guideline value (red dashed line) for the protection of aquatic life.**

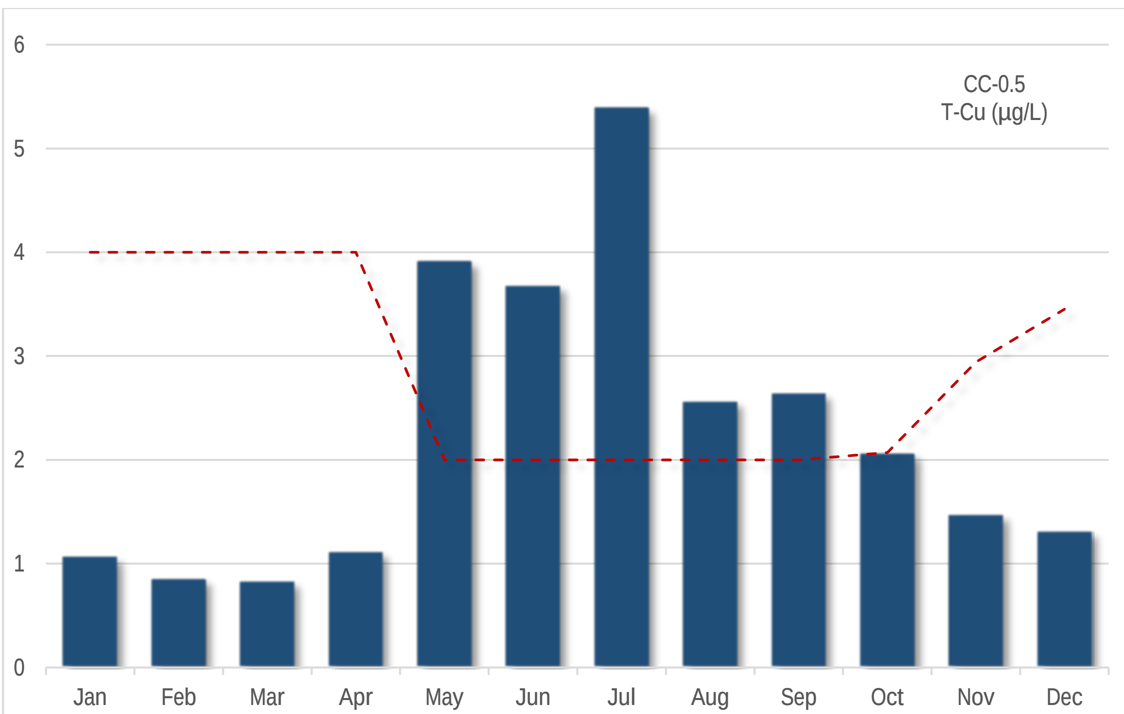


Figure 3.2-7: **Monthly mean total Cu in upper Coffee Creek for the period October 2010 to December 2015 compared to CCME hardness based guideline value (red dashed line) for the protection of aquatic life.**

In upper Coffee Creek, total Cd concentrations generally do not exceed the chronic or short-term CCME hardness-based guidelines for protection of aquatic life for Cd (Figure 3.2-8).

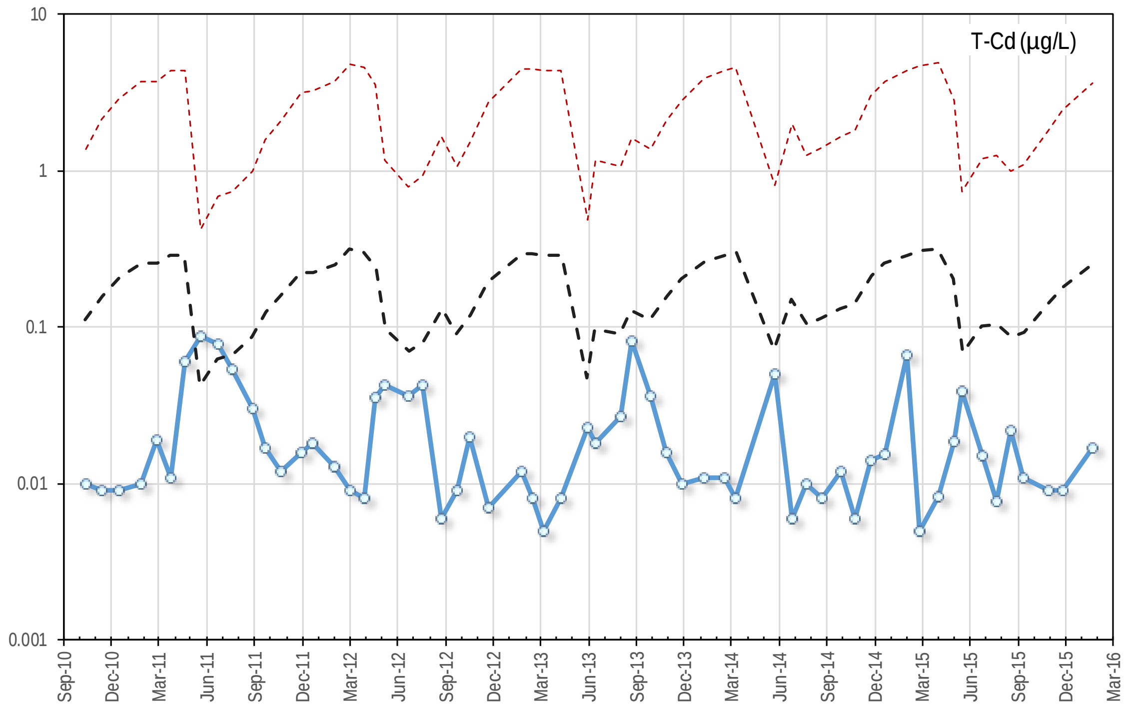


Figure 3.2-8: Total Cd concentrations in upper Coffee Creek for the period October 2010 to December 2015 compared to CCME chronic (black dashed line) and short-term (red dashed line) hardness based guideline value for the protection of aquatic life.

Similar to the monitoring observations in Latte Creek, total U concentrations in upper Coffee Creek at CC-0.5 show a distinct seasonal signature with maxima observed during winter low flow periods, and coinciding with baseflow conditions. Concentrations during low flow periods often exceed 20 µg/L with peak concentrations of 45 µg/L observed in January 2013 and are above the CCME guideline of 15 µg/L for the protection of aquatic life (Figure 3.2-9).

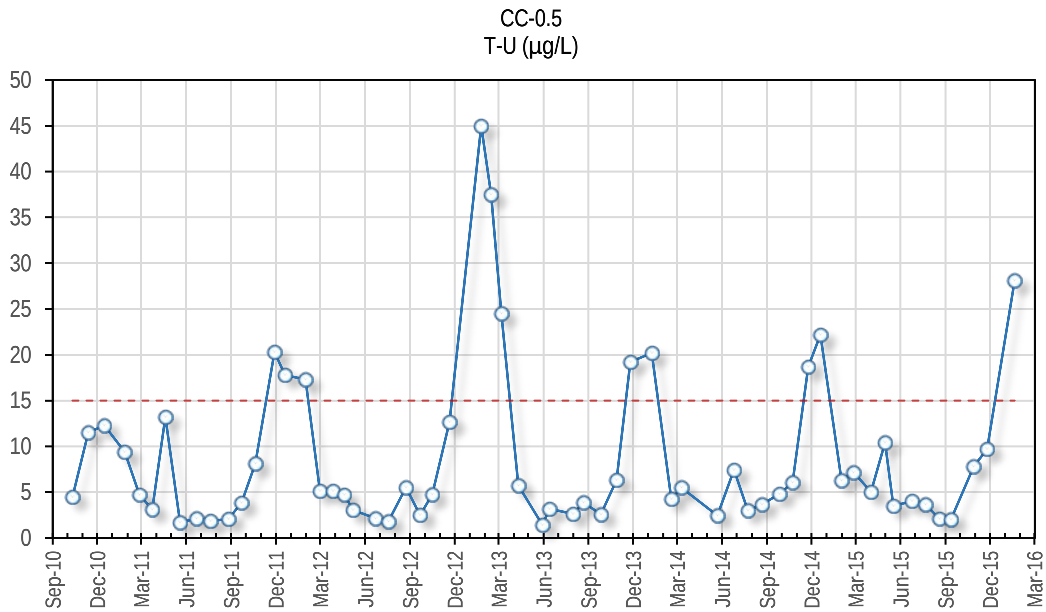


Figure 3.2-9: Total U in upper Coffee Creek for the period October 2010 to December 2015 compared to CCME guideline value (red dashed line) for the protection of aquatic life.

Graphical representation of monthly mean total U data at CC-0.5 illustrates that concentrations in excess of the CCME guideline of 15 µg/L for U typically occurs from November to January (Figure 3.2-10) although specific sampling events have measured elevated concentrations in February and March (Figure 3.2-9).

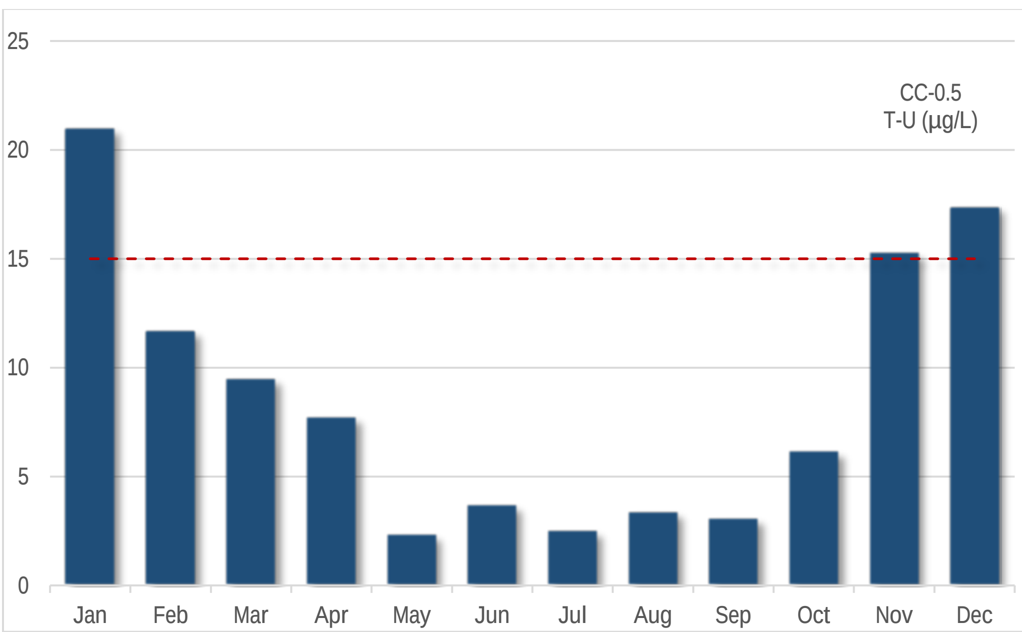


Figure 3.2-10: Mean monthly total U concentrations at CC-0.5 in upper Coffee Creek for the period October 2010 to December 2015 and compared to CCME guideline (dashed red line) for protection of aquatic life.

3.2.2 Lower Coffee Creek – Station CC-4.5

Lower Coffee Creek is characterized by water quality measured at Station CC-4.5 (Figure 3.2-1) which reflects contributions from Latte Creek that enters Coffee Creek immediately downstream of previously described station CC-0.5 on upper Coffee Creek.

3.2.2.1 Summary Statistics

Table 3.2-2 summarizes the mean monthly values for a suite of the key parameters for station CC-4.5 in Coffee Creek.

3.2.2.2 Major Ions

The major ion chemistry of lower Coffee Creek is assessed with respect to hardness, sulphate and pH. Station CC-4.5 is characterized by seasonally comparatively soft waters (between 45 mg/L and 75 mg/L) during open water periods of May to September) and hard waters (ranging from approximately 90 mg/L to 140 mg/L) during lower flow periods and winter low flows (Table 3.2-2; Figure 3.2-11).

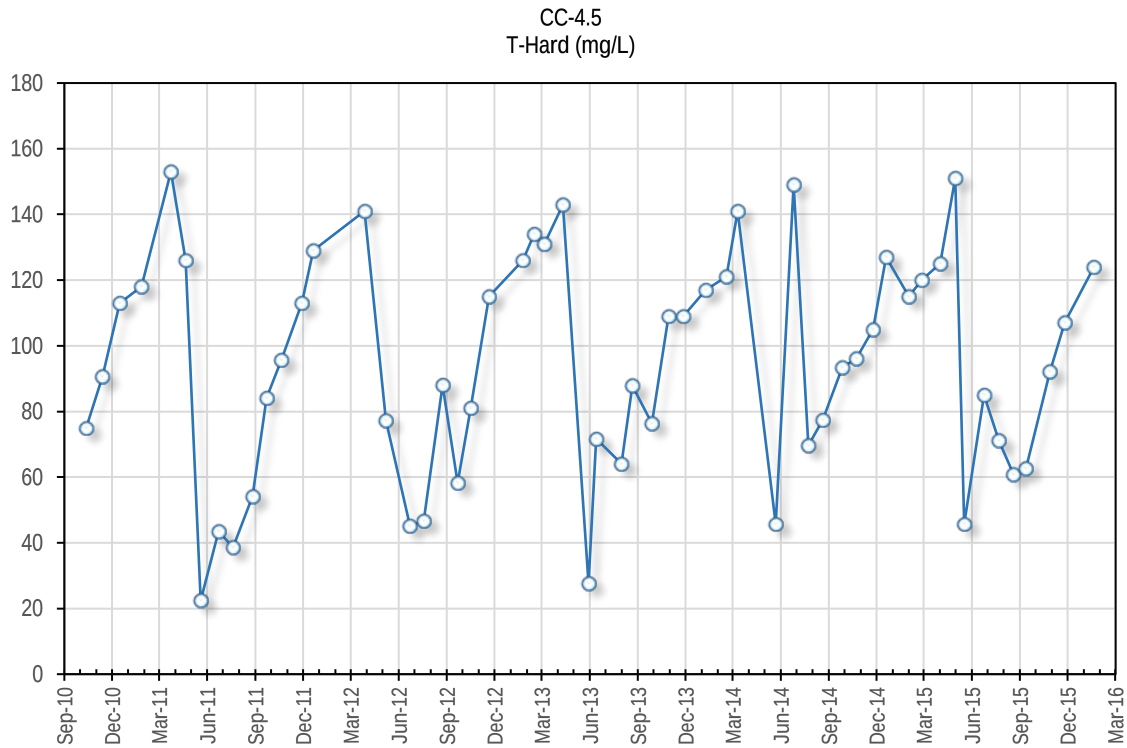


Figure 3.2-11: Total Hardness in lower Coffee Creek for the period October 2010 to December 2015

Table 3.2-2:
Station CC-4.5 Monthly Mean Values

	CC-4.5											
	Jan (n = 5)	Feb (n = 3)	Mar (n = 4)	Apr (n = 4)	May (n = 5)	Jun (n = 5)	Jul (n = 5)	Aug (n = 5)	Sep (n = 5)	Oct (n = 6)	Nov (n = 6)	Dec (n = 3)
Physical Parameters												
pH (s.u.)	7.6	7.6	7.5	7.8	7.1	7.5	7.5	7.7	7.6	7.6	7.7	6.6
Cond-L (uS/cm)	263	274	310	297	86	143	124	162	148	200	238	269
TSS (mg/L)	1.6	1.0	1.0	1.0	28	43	11	3.0	1.2	1.6	1.5	1.0
TDS (mg/L)	171	179	193	191	90	116	100	121	126	139	154	188
T-Alk (mg/L)	56	59	69	66	20	34	35	43	40	48	54	58
T-Hard (mg/L)	120	125	142	136	44	79	58	74	75	91	107	123
Anions												
Sulphate (mg/L)	67	73	80	79	13	29	24	32	28	38	56	65
Cl (mg/L)	0.95	0.92	1.2	1.6	1.1	1.6	0.94	0.66	0.72	0.68	0.78	0.82
F (mg/L)	0.055	0.056	0.057	0.053	0.040	0.059	0.061	0.066	0.059	0.065	0.061	0.066
Nutrients												
T-NH_3 - N (mg/L)	0.015	0.010	0.021	0.025	0.034	0.014	0.030	0.016	0.019	0.010	0.020	0.069
NO_2 -N (mg/L)	0.003	0.003	0.004	0.004	0.017	0.013	0.013	0.013	0.012	0.011	0.004	0.019
NO_3 - N(mg/L)	0.478	0.537	0.668	0.513	0.069	0.101	0.190	0.173	0.260	0.312	0.362	0.380
D-P (mg/L)	0.0039	0.0035	0.0023	0.0045	0.0092	0.0042	0.0032	0.0031	0.0032	0.0035	0.0024	0.0023
TOC (mg/L)	6.4	6.8	5.6	6.5	24	15	15	11	12	9.0	7.3	6.7
DOC (mg/L)	6.0	6.2	5.1	5.9	23	15	15	11	12	9.1	7.0	6.5
WAD-CN (mg/L)	0.00051	0.00069	0.00066	0.00059	0.0013	0.00097	0.0011	0.00088	0.00072	0.00072	0.00072	0.00073
Total Metals												
T-Al (ug/L)	38	30	30	35	667	971	386	130	117	60	37	30
T-Sb (ug/L)	0.12	0.082	0.085	0.082	0.18	0.13	0.12	0.12	0.11	0.11	0.094	0.092
T-As (ug/L)	0.27	0.25	0.28	0.28	0.87	0.97	0.61	0.47	0.45	0.36	0.29	0.25
T-Cd (ug/L)	0.023	0.012	0.025	0.025	0.041	0.059	0.022	0.013	0.012	0.013	0.011	0.017
T-Ca (mg/L)	31	33	36	35	11	21	15	19	19	23	27	32
T-Cr (ug/L)	0.28	0.20	0.17	0.28	1.1	2.1	0.84	0.40	0.44	0.26	0.22	0.16
T-Co (ug/L)	0.037	0.026	0.028	0.045	0.54	0.61	0.23	0.10	0.083	0.055	0.035	0.033
T-Cu (ug/L)	1.9	1.3	1.5	1.2	3.7	3.7	2.9	2.5	2.5	2.0	1.6	1.5
T-Fe (ug/L)	27	14	11	30	872	1139	442	146	118	48	23	17
T-Pb (ug/L)	0.076	0.019	0.018	0.062	0.29	0.42	0.13	0.037	0.027	0.037	0.093	0.024
T-Mg (mg/L)	10	11	12	12	3.7	6.3	5.0	6.4	6.4	8.0	9.3	11
T-Mn (ug/L)	2.4	0.81	1.0	6.4	48	39	13	9.8	8.3	6.0	3.2	1.7
T-Hg (ug/L)	0.0052	0.0050	0.0081	0.0062	0.011	0.0095	0.0065	0.0079	0.0082	0.0086	0.0060	0.0073
T-Mo (ug/L)	0.54	0.68	0.47	0.53	0.53	0.86	0.53	0.62	0.66	0.61	0.52	0.57
T-Ni (ug/L)	0.72	0.73	0.68	0.83	1.8	2.5	1.3	1.0	1.1	0.89	0.75	0.79
T-K (mg/L)	1.5	1.6	1.6	1.7	1.2	1.3	1.0	1.2	1.2	1.3	1.3	1.4
T-Se (ug/L)	0.063	0.058	0.091	0.070	0.082	0.091	0.096	0.083	0.10	0.093	0.074	0.073
T-Ag (ug/L)	0.0051	0.0050	0.0050	0.0050	0.010	0.011	0.0076	0.0050	0.0050	0.0050	0.0050	0.0050
T-Na (mg/L)	4.4	5.0	4.5	4.5	2.1	3.9	2.5	3.2	3.2	3.5	3.9	4.2
T-Tl (ug/L)	0.0021	0.0020	0.0020	0.0020	0.011	0.017	0.0075	0.0040	0.0036	0.0027	0.0022	0.0020
T-U (ug/L)	1.3	1.0	1.3	3.4	2.5	3.0	2.2	2.8	2.6	3.8	2.6	2.8
T-Zn (ug/L)	3.1	2.1	1.1	1.7	4.0	6.0	1.6	4.0	1.1	1.6	0.65	1.8
Dissolved Metals												
D-Al (ug/L)	31	26	29	27	261	174	146	88	95	50	36	28
D-Sb (ug/L)	0.087	0.075	0.089	0.074	0.12	0.10	0.12	0.12	0.11	0.10	0.087	0.090
D-As (ug/L)	0.25	0.26	0.27	0.28	0.45	0.46	0.47	0.43	0.43	0.34	0.28	0.27
D-Cd (ug/L)	0.015	0.012	0.036	0.016	0.027	0.020	0.018	0.0086	0.012	0.0092	0.011	0.017
D-Ca (mg/L)	31	32	40	36	11	18	16	19	19	23	27	33
D-Cr (ug/L)	0.18	0.15	0.16	0.17	0.45	0.44	0.43	0.40	0.36	0.27	0.19	0.12
D-Co (ug/L)	0.028	0.027	0.031	0.036	0.19	0.11	0.097	0.070	0.068	0.046	0.037	0.032
D-Cu (ug/L)	1.4	1.7	2.2	1.6	2.7	2.6	2.5	2.2	2.4	1.9	1.6	1.4
D-Fe (ug/L)	13	9.0	12	20	246	156	132	81	81	34	19	13
D-Pb (ug/L)	0.029	0.014	0.031	0.028	0.037	0.025	0.25	0.012	0.012	0.016	0.012	0.013
D-Mg (mg/L)	10	11	12	12	3.5	5.9	5.2	6.4	6.1	7.8	9.5	11
D-Mn (ug/L)	1.5	0.63	1.2	5.3	19	6.3	5.8	6.2	6.9	5.4	3.1	1.5
D-Hg (ug/L)	0.0040	0.0051	0.0073	0.0050	0.0061	0.0064	0.0074	0.0076	0.0066	0.0059	0.0054	0.0063
D-Mo (ug/L)	0.54	0.50	0.47	0.57	0.39	0.51	0.53	0.62	0.66	0.62	0.55	0.57
D-Ni (ug/L)	0.72	0.71	0.75	0.67	1.3	1.2	1.2	0.98	1.0	0.83	0.75	0.65
D-K (mg/L)	1.4	1.5	1.7	1.7	1.1	1.1	1.1	1.2	1.2	1.3	1.4	1.4
D-Se (ug/L)	0.067	0.088	0.079	0.062	0.072	0.074	0.095	0.093	0.11	0.094	0.073	0.076
D-Ag (ug/L)	0.0052	0.0050	0.0050	0.0050	0.0050	0.0050	0.0058	0.0050	0.0050	0.0050	0.0072	0.0050
D-Na (mg/L)	4.1	4.1	4.6	4.6	1.7	2.8	2.5	3.1	3.0	3.5	4.0	4.2
D-Tl (ug/L)	0.0020	0.0020	0.0020	0.0020	0.0049	0.0038	0.0037	0.0034	0.0034	0.0027	0.0020	0.0020
D-U (ug/L)	1.2	1.0	1.3	3.4	2.2	2.6	2.2	2.7	2.6	3.9	2.6	2.8
D-Zn (ug/L)	0.89	1.6	2.0	1.3	2.3	1.3	1.0	0.61	0.91	0.85	0.82	1.1

The pH in lower Coffee Creek remains relatively uniform throughout the year with values generally ranging between 7.5 and 7.8 (Table 3.2-2). All pH values reported to date have remained within the CCME freshwater guideline range for pH of 6.5 to 9.0.

Baseline concentrations for sulphate in lower Coffee Creek also exhibit a strong seasonal signature with lowest concentrations occurring during peak runoff conditions. During low flow periods, mean sulphate concentrations at CC-4.5 range from 55 mg/L to 80 mg/L (Table 3.2-2). Sulphate concentrations during freshet and the open water period range from roughly 15 mg/L to 30 mg/L.

As with the other stations monitored, total suspended solids (TSS) concentrations in lower Coffee Creek exhibit maxima coincident with the peak snowmelt months (Table 3.2-2). At most other flow periods of the year, TSS values in lower Coffee Creek at CC-4.5 were generally below 2.0 mg/L.

3.2.2.3 Nutrients

As with upper Coffee Creek, nutrient parameters are found in low concentrations in lower Coffee Creek at station CC-4.5. Ammonia-N concentrations are low with mean monthly values typically less than 0.03 mg/L (Table 3.2-2). Mean monthly nitrate-N concentrations in lower Coffee Creek are higher than observed in upper Coffee Creek. Mean monthly nitrate-N at CC-4.5 ranged approximately an order of magnitude, with peak flow minima of 0.069 mg/L and winter low flow maxima of 0.67 mg/L. Lower Coffee Creek waters are oligotrophic to ultra-oligotrophic with monthly mean dissolved phosphorus concentrations at CC-4.5 ranging between 0.0023 mg/L to 0.009 mg/L (Table 3.2-2).

As with upper Coffee Creek, TOC and DOC exhibit a marked seasonal signature with highest values observed during peak runoff periods at station CC-4.5. DOC accounts for virtually all of the TOC. Mean monthly DOC concentrations range from approximately 5.0 mg/L during baseflow periods to concentrations in excess of 20 mg/L during higher flow periods (Figure 3.2-12).

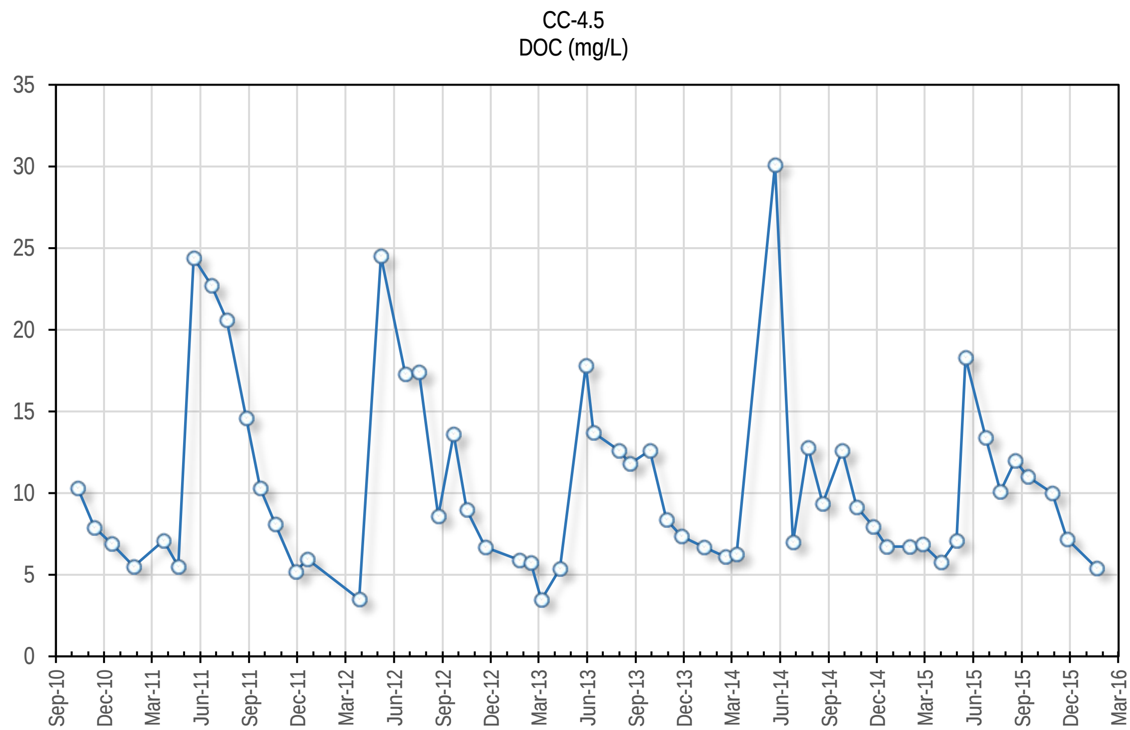


Figure 3.2-12: Dissolved organic carbon (DOC) in lower Coffee Creek for the period October 2010 to December 2015

3.2.2.4 Trace Elements

Baseline trace element concentrations in lower Coffee Creek were derived from data collected from October 2010 to December 2015 at CC-4.5 (Figure 3.2-1). For most parameters monitored, mean monthly concentrations of total and dissolved trace elements are low; the sole exceptions to this observation are for dissolved Al and total Cu. Of particular note is the absence of elevated total U in lower Coffee Creek and this result marks a departure of the trend observed at the other stations monitored in the immediate project area (Table 3.2-2).

Dissolved Al at CC-4.5 is seasonally elevated in lower Coffee Creek and consistently observed to be elevated well above BCMOE guideline for the protection of aquatic life of 100 µg/L during peak runoff periods (Figure 3.2-13).

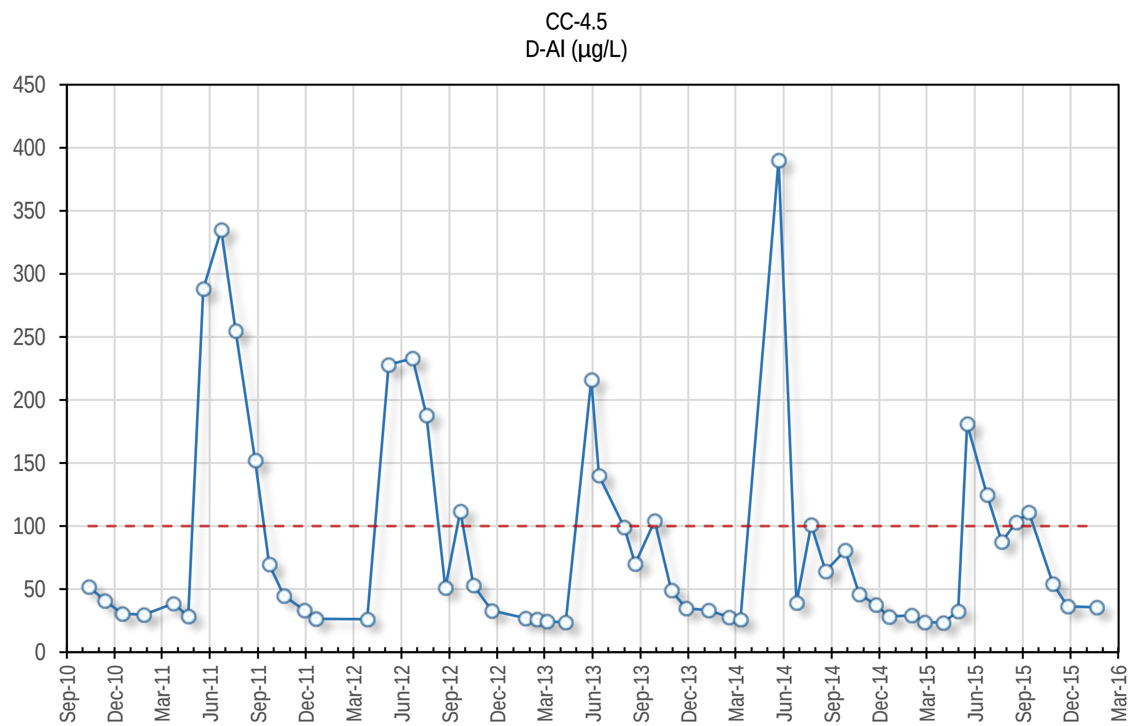


Figure 3.2-13: Dissolved Al in lower Coffee Creek for the period October 2010 to December 2015 compared to BCMOE guideline (red dashed line) for protection of aquatic life

During baseflow periods, dissolved Al concentrations in lower Coffee Creek are typically between 25 and 40 µg/L (Table 3.2-2).

Concentrations of total Cu in lower Coffee Creek exhibit the same strong seasonal signature observed at CC-0.5, with maxima associated with peak runoff periods that exceed the CCME hardness-based Cu guideline for the protection of aquatic life (Figure 3.2-14 and Figure 3.2-15). During most months of the open water period including May to September, mean monthly total Cu concentrations are naturally elevated above the CCME guideline for copper (Figure 3.2-15).

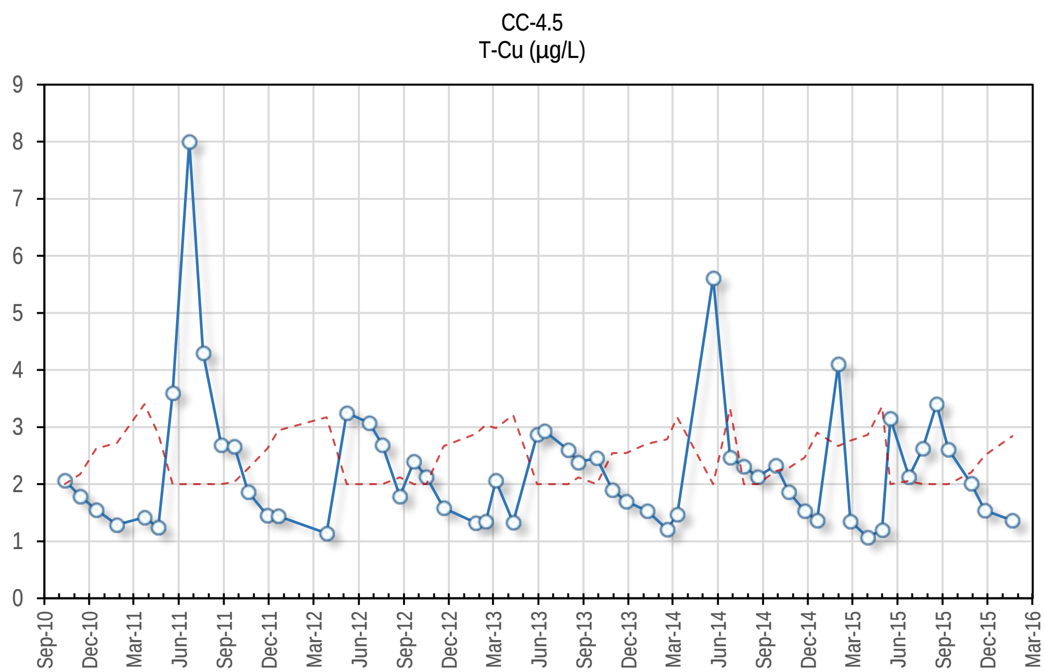


Figure 3.2-14: Total Cu in lower Coffee Creek for the period October 2010 to December 2015 compared to CCME hardness based guideline value (red dashed line) for the protection of aquatic life.

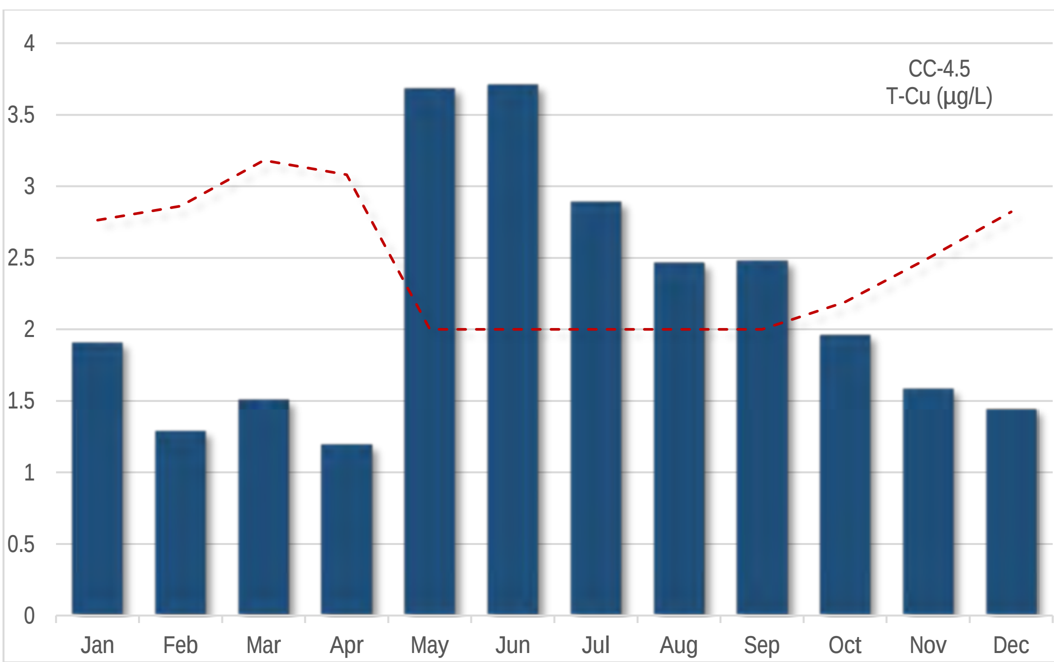


Figure 3.2-15: Monthly mean total Cu in lower Coffee Creek for the period October 2010 to December 2015 compared to CCME hardness based guideline value (red dashed line) for the protection of aquatic life.

Similar to that observed in upper Coffee Creek, total Cd concentrations in lower Coffee Creek at CC-4.5 generally do not exceed the chronic or short-term CCME hardness-based guidelines for protection of aquatic life for Cd (Figure 3.2-16).

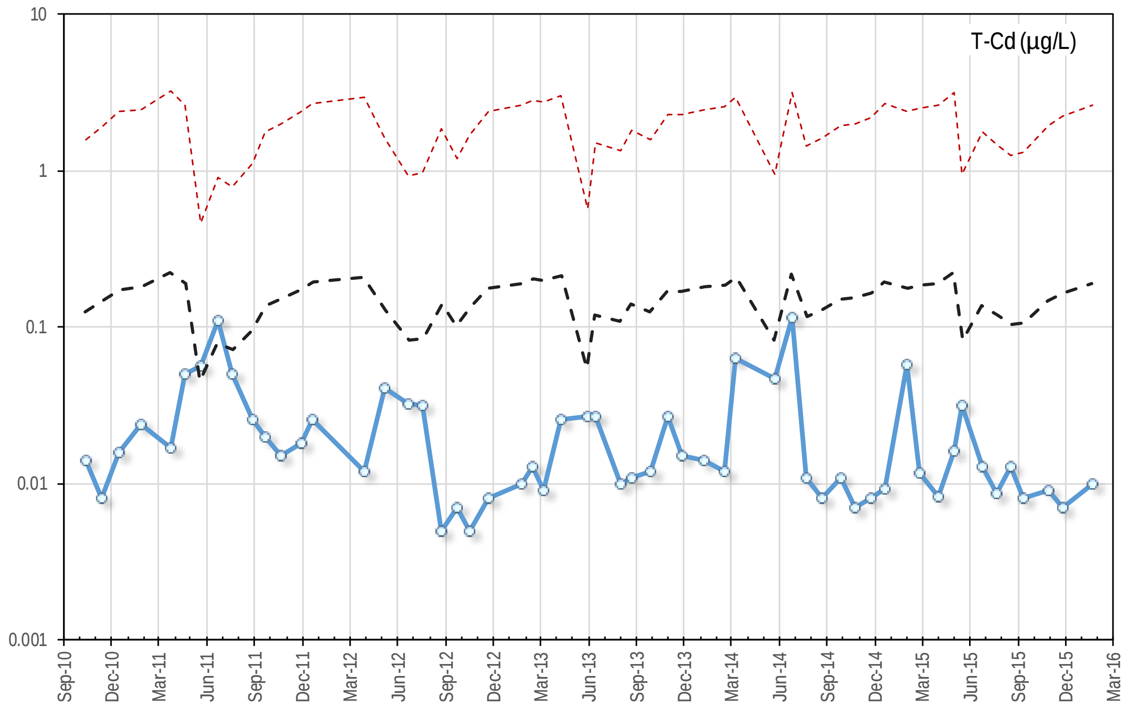


Figure 3.2-16: Total Cd concentrations in lower Coffee Creek for the period October 2010 to December 2015 compared to CCME chronic (black dashed line) and short-term (red dashed line) hardness based guideline value for the protection of aquatic life.

As previously introduced, total U concentrations in lower Coffee Creek do not exhibit the same pronounced seasonal signature observed in upper Coffee Creek or Latte Creek. Total U concentrations at CC-4.5 have never exceeded the CCME guideline of 15 µg/L for the protection of aquatic life since the inception of monitoring in October 2010 (Figure 3.2-17). Interestingly, the lowest mean monthly total U concentrations at CC-4.5 occur during winter low flows, a notable departure from observations in upper Coffee Creek and may indicate a different groundwater source or input into lower Coffee Creek that is comparatively deplete in uranium. Mean monthly total U concentrations at CC-4.5 typically are on the order of only 1 to 3 µg/L (Figure 3.2-18).

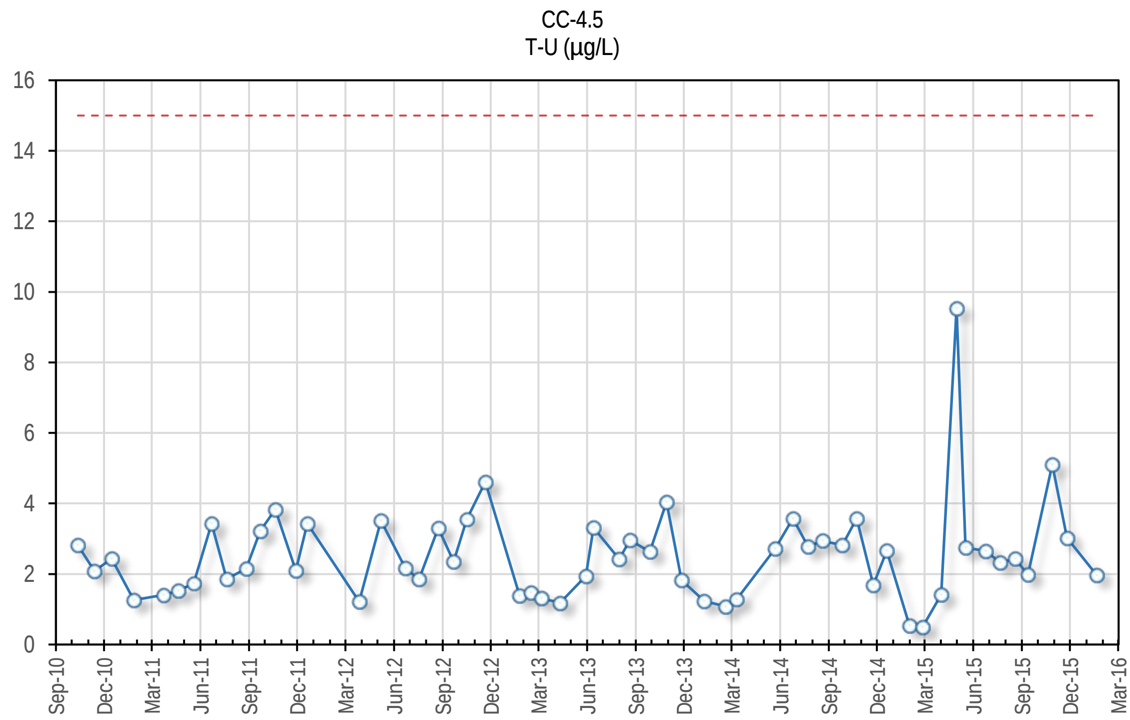


Figure 3.2-17: Total U in lower Coffee Creek for the period October 2010 to December 2015 compared to CCME guideline value (red dashed line) for the protection of aquatic life.

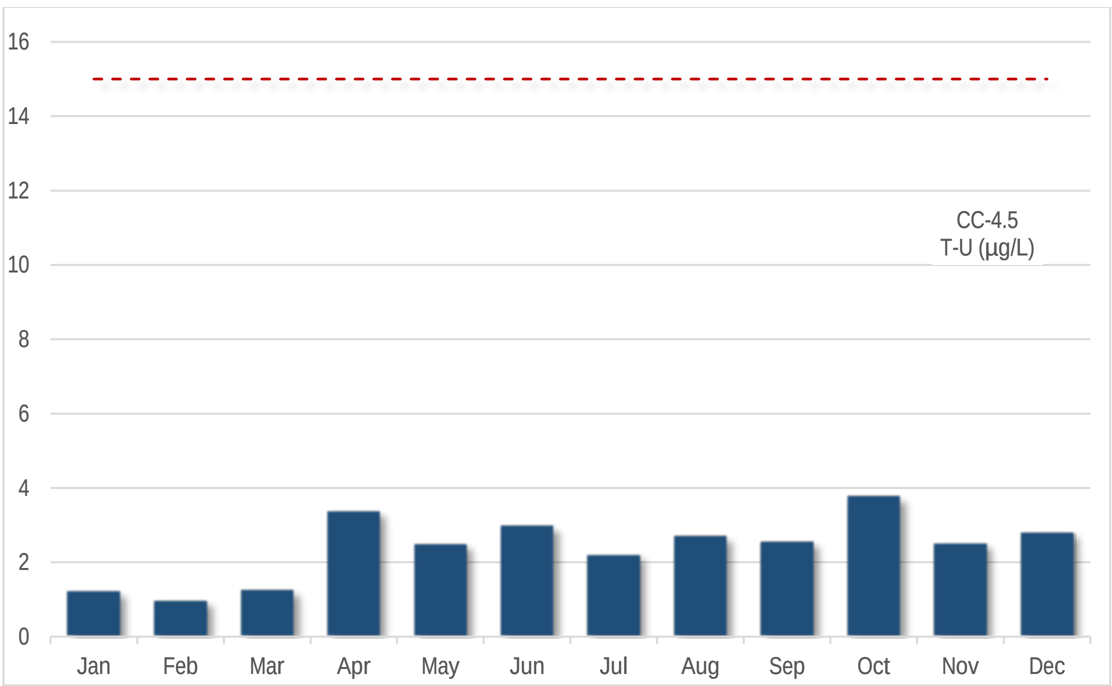


Figure 3.2-18: Mean monthly total U concentrations at CC-4.5 in lower Coffee Creek for the period October 2010 to December 2015 and compared to CCME guideline (dashed red line) for protection of aquatic life.

3.3 Halfway Creek and YT-24

The following section describes baseline water quality results for Halfway Creek and the small, ephemeral creek named YT-24.

Halfway Creek contains two water quality monitoring stations at HC-2.5, approximately mid-way down the watershed, and at station HC-5.0, at the mouth of Halfway Creek prior to entering the Yukon River (Figure 3.3-1).

Water quality in YT-24 is characterized by data collected at ML-1.0 at the mouth of the creek prior to entering the Yukon River (Figure 3.3-1).

3.3.1 Halfway Creek – Stations HC-2.5 and HC-5.0

3.3.1.1 Summary Statistics

Water quality at stations HC-2.5 and HC-5.0 has been collected since October 2010 and continues to present. Data for HC-2.5 represents a nearly continuous monthly record for the period of October 2010 to December 2015. For station HC-5.0, monthly sampling in the winter period has proved sporadic as a result of freezing conditions and during the low-low flow periods, the lower reaches of Halfway Creek do not contain flow.

Table 3.3-1 and Table 3.3-2 summarize monthly mean concentrations for a suite of key parameters at station HC-2.5 and HC-5.0, respectively.

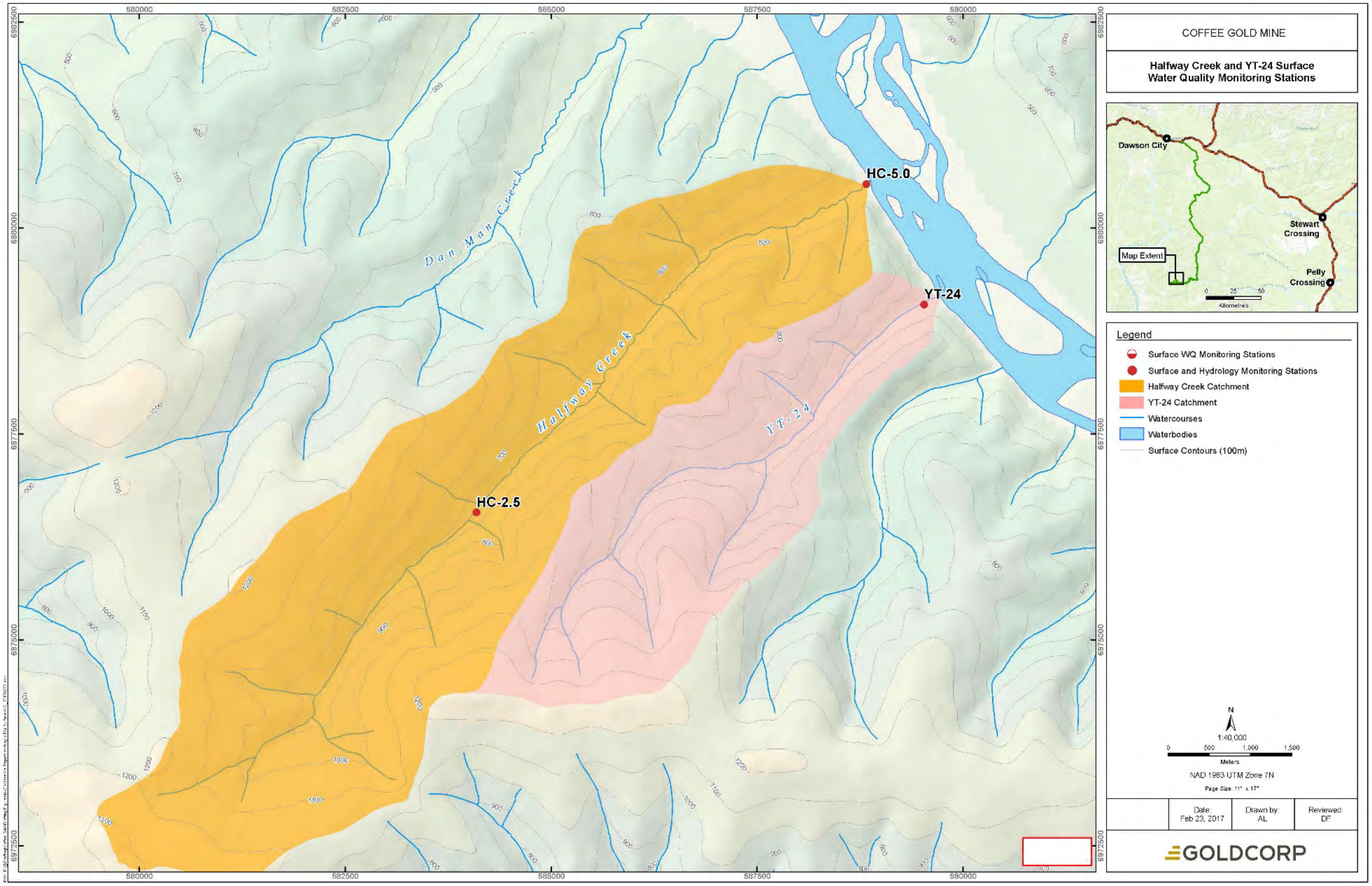


Figure 3.3-1: Detail of Halfway Creek and YT-24 drainages illustrating key monitoring station locations

Table 3.3-1: Station HC-2.5 Monthly Mean Values

	HC-2.5											
	Jan (n = 5)	Feb (n = 4)	Mar (n = 4)	Apr (n = 6)	May (n = 5)	Jun (n = 5)	Jul (n = 5)	Aug (n = 5)	Sep (n = 5)	Oct (n = 6)	Nov (n = 6)	Dec (n = 3)
Physical Parameters												
pH (s.u.)	7.9	7.9	7.9	8.0	7.1	7.3	7.6	7.7	7.7	7.9	7.9	8.0
Cond-L (uS/cm)	380	399	407	366	67	104	113	170	148	246	330	345
TSS (mg/L)	1.7	1.0	1.4	1.4	9.4	22	5.0	23	1.3	1.5	1.6	1.0
TDS (mg/L)	227	235	243	224	79	96	91	114	120	159	202	231
T-Alk (mg/L)	125	129	136	109	19	33	39	56	51	84	108	118
T-Hard (mg/L)	187	186	197	184	36	53	56	83	78	119	160	175
Anions												
Sulphate (mg/L)	70	75	78	72	4.6	16	15	24	19	38	56	62
Cl (mg/L)	0.68	0.60	0.55	0.74	1.3	1.7	0.61	0.61	0.72	0.53	4.5	0.50
F (mg/L)	0.069	0.076	0.074	0.073	0.037	0.046	0.048	0.056	0.052	0.067	0.064	0.077
Nutrients												
T-NH_3 - N (mg/L)	0.018	0.014	0.013	0.011	0.025	0.013	0.031	0.023	0.020	0.014	0.025	0.048
NO_2 -N (mg/L)	0.013	0.016	0.004	0.007	0.014	0.013	0.013	0.013	0.012	0.011	0.004	0.019
NO_3 - N(mg/L)	0.435	0.426	0.358	0.246	0.087	0.186	0.326	0.347	0.483	0.505	0.483	0.374
D-P (mg/L)	0.0029	0.0039	0.0024	0.0086	0.0093	0.0062	0.0037	0.0042	0.0043	0.0031	0.0028	0.0020
TOC (mg/L)	4.0	3.8	3.7	11	27	19	16	12	12	8.2	5.2	3.8
DOC (mg/L)	3.6	3.8	3.0	9.4	24	18	15	12	12	7.3	4.7	3.9
WAD-CN (mg/L)	0.00058	0.00056	0.00052	0.00061	0.0016	0.0012	0.0011	0.00088	0.00083	0.00069	0.00070	0.00065
Total Metals												
T-Al (ug/L)	15	11	11	71	521	503	259	537	177	62	30	16
T-Sb (ug/L)	0.62	0.52	0.52	0.70	0.18	0.31	0.39	0.56	0.47	0.70	0.75	0.69
T-As (ug/L)	0.75	0.62	0.63	1.1	1.4	1.9	1.4	1.9	1.2	1.1	0.94	0.81
T-Cd (ug/L)	0.012	0.0085	0.012	0.017	0.034	0.029	0.021	0.019	0.0094	0.0075	0.0063	0.012
T-Ca (mg/L)	45	45	47	46	9.6	13	14	21	20	29	39	42
T-Cr (ug/L)	0.27	0.13	0.10	0.25	0.94	1.2	0.69	1.4	0.57	0.29	0.20	0.12
T-Co (ug/L)	0.025	0.025	0.023	0.064	0.47	0.40	0.16	0.36	0.10	0.046	0.034	0.020
T-Cu (ug/L)	0.76	0.72	0.67	1.2	2.5	2.4	1.9	2.1	1.8	1.3	0.87	0.78
T-Fe (ug/L)	14	7.3	7.6	71	542	559	247	648	147	45	27	10
T-Pb (ug/L)	0.040	0.013	0.016	0.036	0.17	0.20	0.060	0.39	0.042	0.038	0.029	0.025
T-Mg (mg/L)	18	18	19	17	2.9	4.8	4.8	7.3	6.8	11	15	17
T-Mn (ug/L)	6.3	9.9	12	9.3	61	32	10	25	5.2	1.9	3.4	2.8
T-Hg (ug/L)	0.0068	0.0081	0.0080	0.0079	0.012	0.0079	0.0072	0.0082	0.0079	0.0067	0.0077	0.0073
T-Mo (ug/L)	1.9	1.8	1.8	2.1	0.35	0.62	0.75	1.1	1.0	1.7	1.9	2.0
T-Ni (ug/L)	0.34	0.38	0.38	0.66	5.1	1.4	1.00	1.4	0.81	0.54	0.39	0.38
T-K (mg/L)	2.7	2.7	2.8	3.0	1.1	1.1	1.2	1.6	1.6	2.2	2.5	2.5
T-Se (ug/L)	0.12	0.12	0.11	0.13	0.061	0.064	0.073	0.065	0.091	0.100	0.11	0.11
T-Ag (ug/L)	0.0050	0.0050	0.0050	0.0052	0.0064	0.0060	0.0052	0.0092	0.0050	0.0050	0.0055	0.0050
T-Na (mg/L)	4.4	4.1	4.4	4.9	1.1	1.7	1.6	2.3	2.3	3.1	3.8	4.0
T-Tl (ug/L)	0.0020	0.0020	0.0020	0.0026	0.0068	0.0068	0.0033	0.0092	0.0034	0.0022	0.0020	0.0020
T-U (ug/L)	66	78	85	71	9.2	14	12	21	18	37	53	61
T-Zn (ug/L)	0.71	0.50	0.45	1.8	4.2	2.6	0.91	3.0	0.97	1.1	0.52	1.8
Dissolved Metals												
D-Al (ug/L)	11	9.5	8.5	54	369	329	199	133	126	47	18	13
D-Sb (ug/L)	0.59	0.51	0.53	0.66	0.16	0.31	0.38	0.51	0.47	0.68	0.76	0.70
D-As (ug/L)	0.75	0.64	0.62	1.1	1.0	1.2	1.2	1.2	1.2	1.1	0.91	0.80
D-Cd (ug/L)	0.014	0.0078	0.0073	0.013	0.026	0.019	0.017	0.0096	0.011	0.0058	0.014	0.0080
D-Ca (mg/L)	43	47	49	43	9.1	14	15	20	20	28	40	42
D-Cr (ug/L)	0.11	0.10	0.10	0.22	0.59	0.68	0.61	0.48	0.49	0.26	0.19	0.11
D-Co (ug/L)	0.023	0.020	0.020	0.057	0.34	0.23	0.13	0.11	0.089	0.042	0.026	0.022
D-Cu (ug/L)	0.93	0.71	0.83	1.00	2.1	1.9	1.8	1.5	2.4	1.2	0.96	0.80
D-Fe (ug/L)	5.9	5.0	5.5	51	304	306	173	118	106	28	12	6.5
D-Pb (ug/L)	0.044	0.0078	0.011	0.017	0.036	0.029	0.021	0.016	0.047	0.013	0.040	0.0067
D-Mg (mg/L)	18	18	19	17	2.8	4.7	5.0	7.3	6.6	11	15	16
D-Mn (ug/L)	5.7	9.2	12	8.0	49	15	6.9	9.1	4.6	1.4	2.7	2.4
D-Hg (ug/L)	0.0060	0.0076	0.0073	0.0077	0.013	0.0079	0.0084	0.0084	0.0076	0.0059	0.0052	0.0060
D-Mo (ug/L)	1.9	1.8	1.9	1.9	0.35	0.60	0.76	1.1	1.0	1.7	2.0	2.1
D-Ni (ug/L)	0.35	0.40	0.37	0.46	1.3	1.1	0.91	0.76	0.85	0.51	0.40	0.35
D-K (mg/L)	2.7	2.6	2.8	2.9	1.1	1.1	1.2	1.6	1.6	2.1	2.5	2.5
D-Se (ug/L)	0.11	0.13	0.11	0.13	0.068	0.058	0.069	0.063	0.079	0.098	0.11	0.11
D-Ag (ug/L)	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0051	0.0050
D-Na (mg/L)	4.1	4.1	4.4	4.2	1.0	1.6	1.7	2.3	2.2	3.1	4.1	3.9
D-Tl (ug/L)	0.0020	0.0020	0.0020	0.0023	0.0038	0.0027	0.0031	0.0024	0.0030	0.0020	0.0020	0.0020
D-U (ug/L)	68	78	89	70	8.9	14	11	21	18	37	54	61
D-Zn (ug/L)	1.0	0.89	0.51	1.2	4.7	1.1	0.80	0.89	0.87	0.88	0.83	0.64

Table 3.3-2:
Station HC-5.0 Monthly Mean Values

	HC-5.0											
	Jan (n = 1)	Feb (n = 0)	Mar (n = 0)	Apr (n = 4)	May (n = 5)	Jun (n = 3)	Jul (n = 3)	Aug (n = 5)	Sep (n = 5)	Oct (n = 6)	Nov (n = 2)	Dec (n = 1)
Physical Parameters												
pH (s.u.)	8.0	-	-	7.9	7.4	7.6	7.9	7.8	7.9	7.9	8.0	7.5
Cond-L (uS/cm)	337	-	-	308	97	167	176	176	169	215	249	276
TSS (mg/L)	17	-	-	1.0	17	26	2.3	68	1.4	1.5	1.0	1.0
TDS (mg/L)	224	-	-	210	93	134	129	121	122	144	173	180
T-Alk (mg/L)	104	-	-	98	29	52	58	59	58	71	80	86
T-Hard (mg/L)	134	-	-	155	48	89	89	88	89	102	118	136
Anions												
Sulphate (mg/L)	64	-	-	65	11	29	28	24	23	33	41	47
Cl (mg/L)	1.1	-	-	0.88	1.3	2.2	0.61	0.64	0.85	0.65	1.3	0.50
F (mg/L)	0.070	-	-	0.082	0.043	0.066	0.069	0.067	0.065	0.073	0.064	0.070
Nutrients												
T-NH_3 - N (mg/L)	0.045	-	-	0.013	0.026	0.010	0.022	0.026	0.026	0.018	0.015	0.10
NO_2 -N (mg/L)	0.002	-	-	0.004	0.026	0.003	0.003	0.013	0.012	0.011	0.005	0.005
NO_3 - N(mg/L)	0.437	-	-	0.027	0.083	0.143	0.207	0.227	0.375	0.447	0.463	0.340
D-P (mg/L)	0.0036	-	-	0.0071	0.0087	0.0029	0.0026	0.0038	0.0033	0.0033	0.0044	-
TOC (mg/L)	9.4	-	-	10.0	23	16	12	14	13	11	9.6	9.0
DOC (mg/L)	10	-	-	9.0	22	14	13	13	12	11	10.0	9.2
WAD-CN (mg/L)	0.00050	-	-	0.00071	0.0018	0.0011	0.0012	0.0011	0.00083	0.00073	0.00075	0.00090
Total Metals												
T-Al (ug/L)	36	-	-	20	399	542	77	1349	71	38	28	34
T-Sb (ug/L)	0.23	-	-	0.19	0.17	0.23	0.27	0.29	0.28	0.25	0.21	0.20
T-As (ug/L)	0.43	-	-	0.56	1.2	1.5	0.77	2.2	0.74	0.59	0.52	0.51
T-Cd (ug/L)	0.065	-	-	0.014	0.017	0.020	0.0053	0.029	0.0068	0.014	0.0050	0.072
T-Ca (mg/L)	36	-	-	42	13	24	23	23	24	27	32	37
T-Cr (ug/L)	0.50	-	-	0.15	0.87	3.7	0.40	3.4	0.39	0.29	0.21	0.30
T-Co (ug/L)	0.050	-	-	0.039	0.34	0.45	0.091	1.0	0.067	0.052	0.048	0.047
T-Cu (ug/L)	2.7	-	-	0.99	2.5	2.7	2.1	4.1	2.0	1.9	1.8	3.4
T-Fe (ug/L)	42	-	-	24	477	624	87	1792	68	31	19	29
T-Pb (ug/L)	0.10	-	-	0.019	0.18	0.29	0.024	0.78	0.018	0.086	0.016	0.42
T-Mg (mg/L)	11	-	-	12	4.0	7.2	7.5	7.2	7.2	8.5	9.5	11
T-Mn (ug/L)	4.5	-	-	4.1	37	28	2.6	49	1.7	0.60	0.25	1.3
T-Hg (ug/L)	0.0020	-	-	0.0061	0.0099	0.0063	0.0057	0.0077	0.0075	0.0068	0.010	0.010
T-Mo (ug/L)	0.52	-	-	0.75	0.33	0.77	0.59	0.54	0.61	0.60	0.57	0.67
T-Ni (ug/L)	0.95	-	-	0.63	1.5	2.8	0.87	3.0	0.91	0.96	1.0	1.1
T-K (mg/L)	2.5	-	-	2.8	1.3	2.0	2.0	2.0	1.9	2.2	2.2	2.3
T-Se (ug/L)	0.087	-	-	0.15	0.057	0.066	0.079	0.078	0.062	0.082	0.070	0.060
T-Ag (ug/L)	0.0050	-	-	0.0050	0.0064	0.0070	0.011	0.012	0.0050	0.0050	0.0050	0.0050
T-Na (mg/L)	3.8	-	-	4.3	1.4	4.5	2.9	2.6	2.8	3.1	3.3	4.8
T-Tl (ug/L)	0.0020	-	-	0.0020	0.0054	0.0090	0.0044	0.019	0.0024	0.0027	0.0020	0.0020
T-U (ug/L)	17	-	-	13	7.4	10	6.9	7.9	7.6	9.6	10.0	14
T-Zn (ug/L)	8.7	-	-	2.1	1.8	2.5	0.71	5.8	0.65	1.7	0.43	20
Dissolved Metals												
D-Al (ug/L)	18	-	-	17	227	151	55	72	58	35	27	23
D-Sb (ug/L)	0.25	-	-	0.18	0.18	0.22	0.27	0.24	0.28	0.24	0.22	0.18
D-As (ug/L)	0.46	-	-	0.51	0.94	0.90	0.74	0.77	0.75	0.58	0.45	0.48
D-Cd (ug/L)	0.065	-	-	0.011	0.017	0.012	0.0050	0.0072	0.0076	0.0068	0.0070	0.010
D-Ca (mg/L)	43	-	-	42	13	23	24	23	23	26	31	36
D-Cr (ug/L)	0.29	-	-	0.17	0.51	0.46	0.32	0.40	0.35	0.27	0.20	0.20
D-Co (ug/L)	0.039	-	-	0.042	0.19	0.100	0.061	0.071	0.059	0.049	0.043	0.039
D-Cu (ug/L)	2.6	-	-	0.93	2.0	1.9	1.9	2.0	2.0	1.8	1.6	1.5
D-Fe (ug/L)	16	-	-	19	228	141	51	82	51	24	15	14
D-Pb (ug/L)	0.025	-	-	0.0086	0.037	0.017	0.0057	0.012	0.013	0.018	0.0085	0.011
D-Mg (mg/L)	13	-	-	12	4.0	6.9	7.5	6.8	6.9	8.3	9.6	9.9
D-Mn (ug/L)	1.1	-	-	3.1	23	3.3	0.76	1.4	1.3	0.31	0.11	0.21
D-Hg (ug/L)	0.0020	-	-	0.0049	0.0100	0.0034	0.0063	0.0083	0.0070	0.0043	0.010	-
D-Mo (ug/L)	0.62	-	-	0.72	0.47	0.52	0.61	0.54	0.65	0.60	0.55	0.57
D-Ni (ug/L)	1.0	-	-	0.66	1.0	0.95	0.81	0.87	0.87	0.81	0.85	0.92
D-K (mg/L)	2.8	-	-	2.7	1.3	1.8	2.0	1.9	1.9	2.1	2.2	2.2
D-Se (ug/L)	0.084	-	-	0.13	0.053	0.059	0.071	0.069	0.069	0.081	0.055	0.070
D-Ag (ug/L)	0.0050	-	-	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
D-Na (mg/L)	4.6	-	-	4.1	1.7	2.7	2.9	2.7	2.7	3.0	3.7	3.3
D-Tl (ug/L)	0.0020	-	-	0.0020	0.0032	0.0031	0.0025	0.0026	0.0028	0.0022	0.0025	0.0020
D-U (ug/L)	20	-	-	14	6.8	9.6	6.7	6.2	7.8	10	10.0	14
D-Zn (ug/L)	8.8	-	-	1.3	1.4	0.50	0.24	0.36	0.58	0.55	0.72	0.80

3.3.1.1 Major Ions

The major ion chemistry of mid-reach and lower-reach Halfway Creek is assessed with respect to hardness, sulphate and pH. Station HC-2.5 is characterized by seasonally soft waters (approximately 35 mg/L) during freshet periods and moderately hard to hard waters (ranging from 80 mg/L to ~200 mg/L) during lower flow periods and winter low flows (Table 3.3-1; Figure 3.3-2).

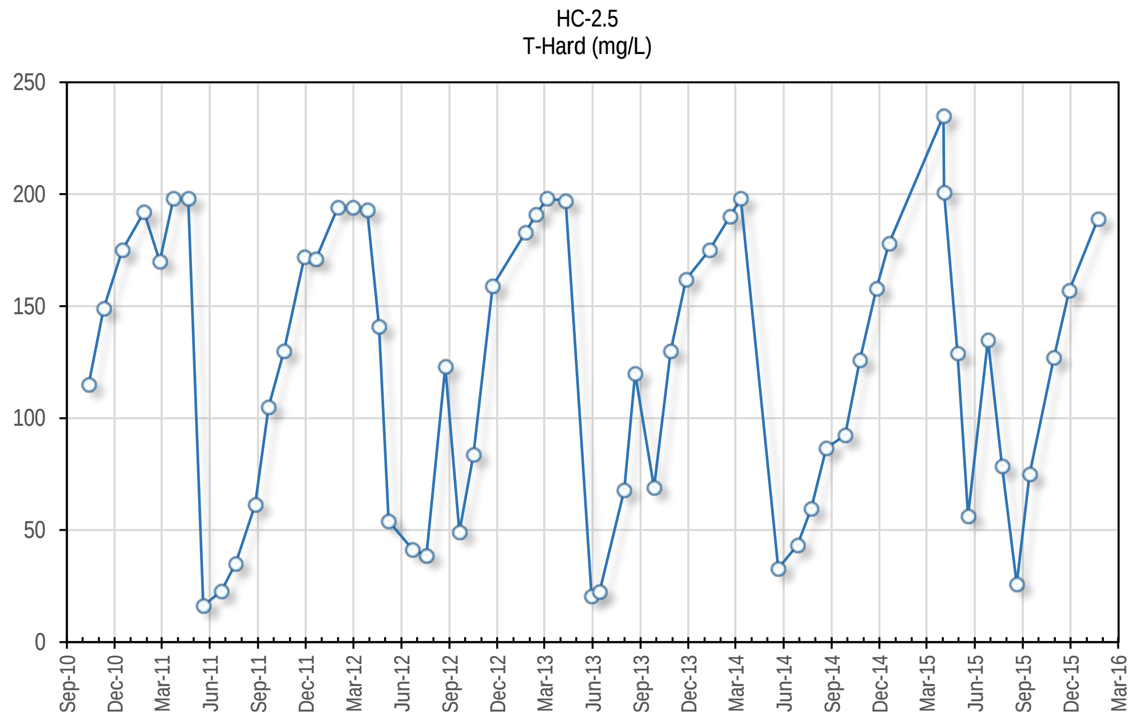


Figure 3.3-2: Total Hardness in mid Halfway Creek for the period October 2010 to December 2015

In lower Halfway Creek, hardness values range typically between roughly 50 mg/L to 150 mg/L (Table 3.3-2; Figure 3.3-3).

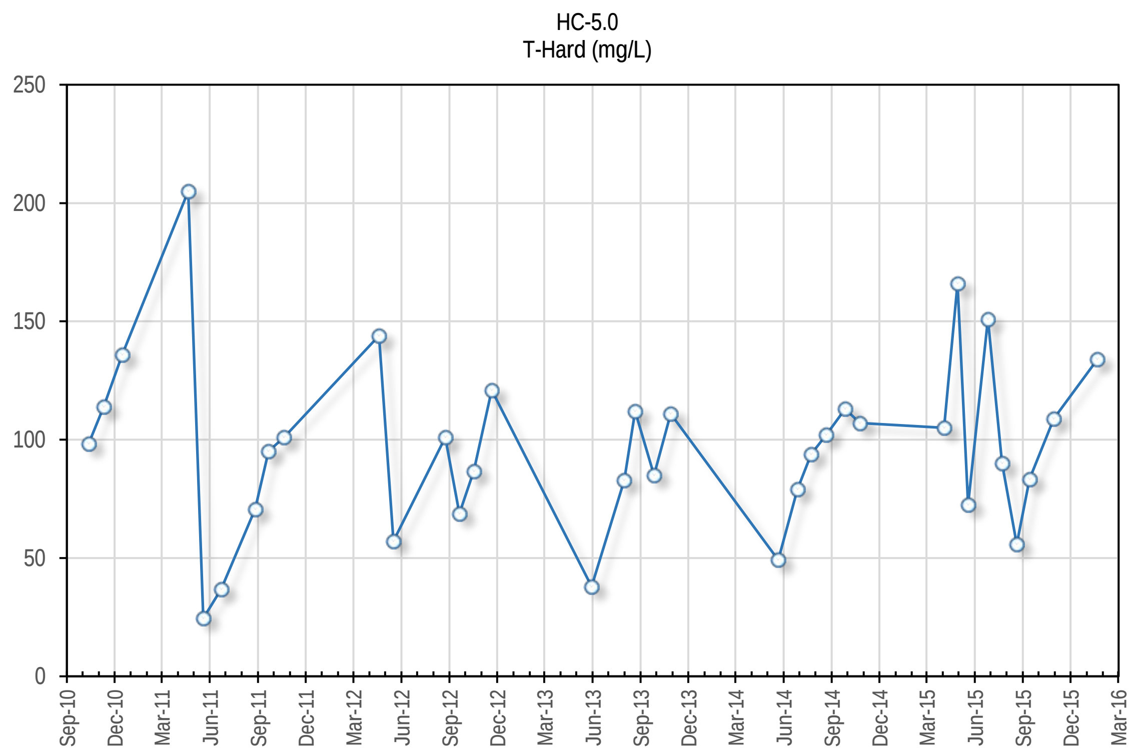


Figure 3.3-3: Total Hardness in lower Halfway Creek for the period October 2010 to December 2015

Similar trends for conductivity and alkalinity are also observed at stations HC-2.5 and HC-5.0 with pronounced seasonal fluctuations, with minima coinciding with freshet periods in May and June (Table 3.3-1 and Table 3.3-2). As observed in the other drainages at the project site, these trends in stream salinity reflect varying proportions of low ionic strength snow-melt driven surface runoff and groundwater inputs (higher ionic strength). The stronger seasonal signature observed in mid Halfway Creek at HC-2.5 reflects a more pronounced groundwater influence in the winter low flow periods as compared to HC-5.0.

The pH in mid and lower Halfway Creek remains relatively uniform throughout the year with values generally ranging between 7.0 and 8.0 with the lower pH occurring during peak snow-melt periods. All pH values reported to date have remained within the CCME freshwater guideline range for pH of 6.5 to 9.0.

Baseline concentrations for sulphate in mid and lower Halfway Creek exhibit similar trends and concentrations with lower values (e.g., 5.0 to 10 mg/L) occurring in peak freshet periods 40 to 70 mg/L during lower flow conditions (Table 3.3-1 and Table 3.3-2).

Unlike the dissolved ions, higher TSS concentrations in mid and lower Halfway Creek coincide with the peak snowmelt months or during intense summer rainfall events (Table

3.3-1 and Table 3.3-2). At most other flow periods of the year, TSS values in Halfway Creek were generally below 2.0 mg/L.

3.3.1.2 Nutrients

As with other Project catchments, nutrient parameters are found in low concentrations in mid and lower Halfway Creek. Ammonia-N concentrations are low with mean monthly values typically between roughly 0.01 to 0.05 mg/L for HC-2.5 and 0.01 to 0.1 mg/L for HC-5.0 (Table 3.3-1 and Table 3.3-2). Baseline mean nitrate-N concentrations in mid Halfway Creek ranged from 0.08 to 0.5 mg/L, with highest monthly means observed during late fall-early winter low flows. Similarly, mean nitrate-N concentrations in lower Halfway Creek ranged from 0.03 to 0.46 mg/L, again with highest monthly means observed during late fall-early winter low flow conditions. Dissolved phosphorus concentrations at both stations were low with mean (all data) dissolved phosphorus for both stations of approximately 0.0044 mg/L and indicative of oligotrophic to ultra-oligotrophic conditions (Appendix C).

As with other streams monitored for the project, TOC and DOC exhibit a marked seasonal signature with highest values observed during peak runoff periods. DOC concentrations range from less than 5.0 mg/L during baseflow periods, dominated by groundwater inputs, to upwards of 25 to 30 mg/L during higher flow periods reflecting carbon contributions associated with terrestrial runoff (Figure 3.3-4 and Figure 3.3-5).

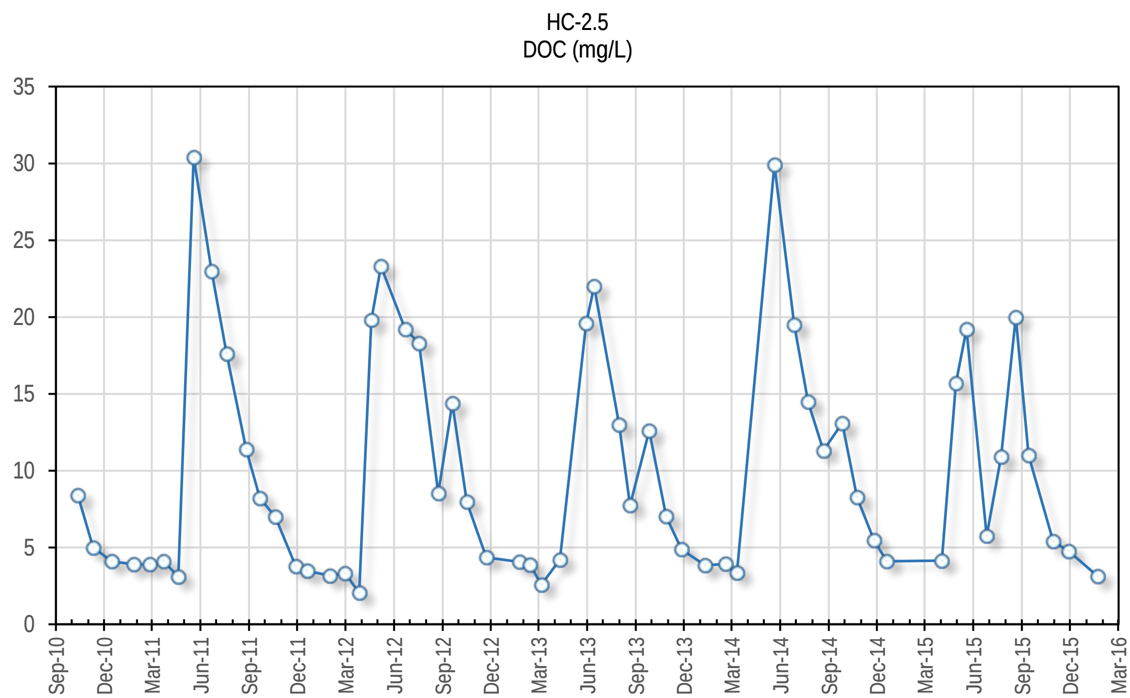


Figure 3.3-4: Dissolved organic carbon in mid Halfway Creek for the period October 2010 to December 2015

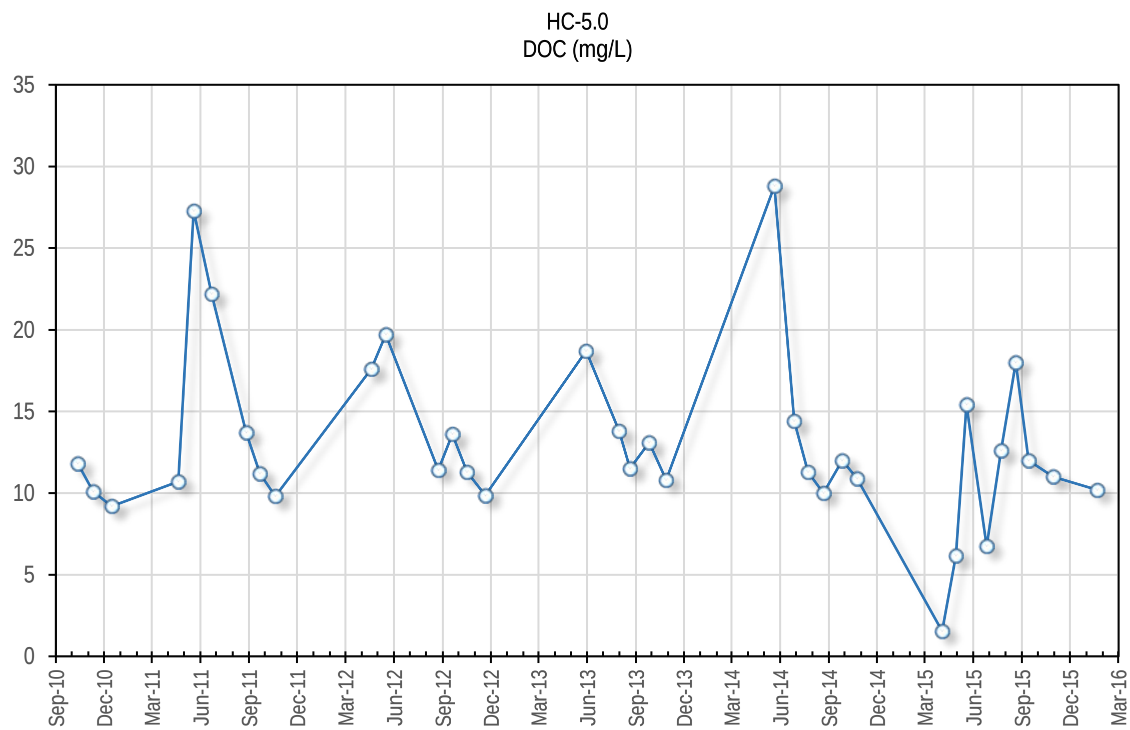


Figure 3.3-5: Dissolved organic carbon in lower Halfway Creek for the period October 2010 to December 2015

3.3.1.3 Trace Elements

Characterization of baseline trace element concentrations in mid and lower Halfway Creek was developed from data collected from October 2010 to December 2015 at HC-2.5 and HC-5.0. For most parameters, mean monthly concentrations of total and dissolved trace elements are low (e.g., As, Sb, Co, Cr, Pb, Hg, Ni, Se, and Zn). Total As concentrations in mid Halfway Creek at HC-2.5 are typically between 0.5 to 1.5 µg/L with maximum concentrations of total As observed coincident with high flow events and elevated TSS (Figure 3.3-6 and Appendix A).

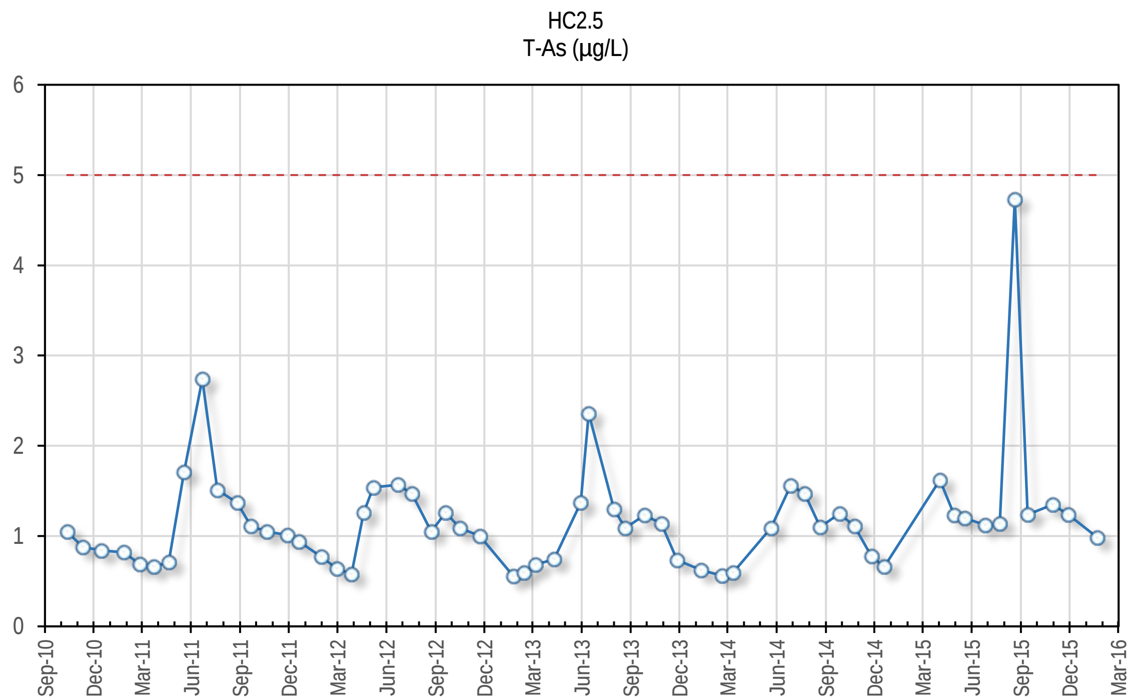


Figure 3.3-6: Total As in mid Halfway Creek for the period October 2010 to December 2015 compared to CCME guideline (red dashed line) for protection of aquatic life

In lower Halfway Creek at station HC-5.0, total As concentrations are slightly lower and consistently below 1.0 µg/L (Figure 3.3-7) and well below the CCME guideline of 5.0 µg/L for the protection of aquatic life. However, precipitation events that produce elevated TSS also produce elevated total As concentrations (e.g., August 2015 event; TSS = 333 mg/L; total As = 8.4 µg/L; see Appendix A).

Total Se concentrations in mid and lower Halfway Creek are very low and typically less than 0.15 µg/L (Table 3.3-1 and Table 3.3-2).

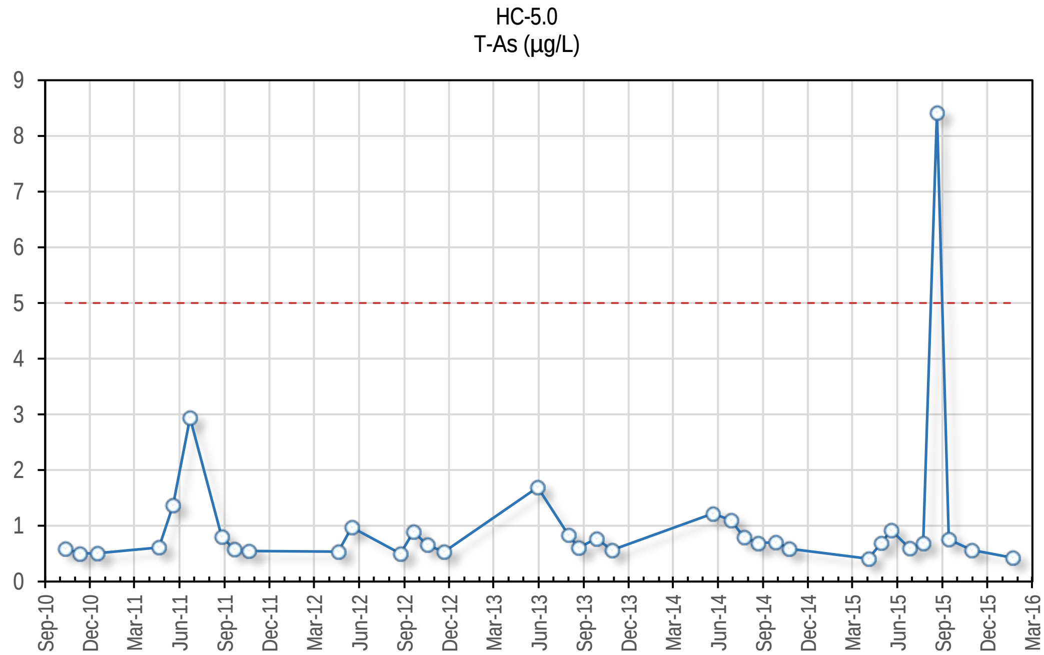


Figure 3.3-7: Total As in lower Halfway Creek for the period October 2010 to December 2015 compared to CCME guideline (red dashed line) for protection of aquatic life

Dissolved Al is consistently observed to be elevated well above BCMOE guideline for the protection of aquatic life of 100 µg/L throughout Halfway Creek, with peak concentrations coinciding with higher flow conditions (Figure 3.3-8 and Figure 3.3-9). The highest dissolved Al values are observed at HC-2.5 with peak concentrations on the order of 500 µg/L (Figure 3.3-8). During baseflow periods, dissolved Al concentrations throughout Halfway Creek are generally below 10 µg/L (Figure 3.3-8 and Figure 3.3-9).

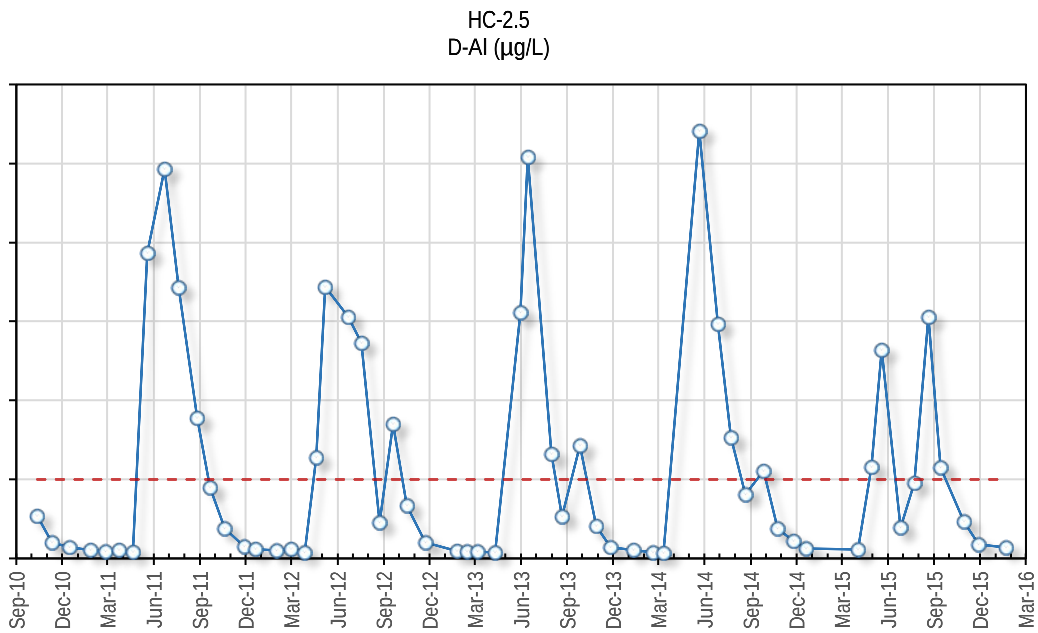


Figure 3.3-8: Dissolved Al in mid Halfway Creek for the period October 2010 to December 2015 compared to BCMOE guideline (red dashed line) for protection of aquatic life

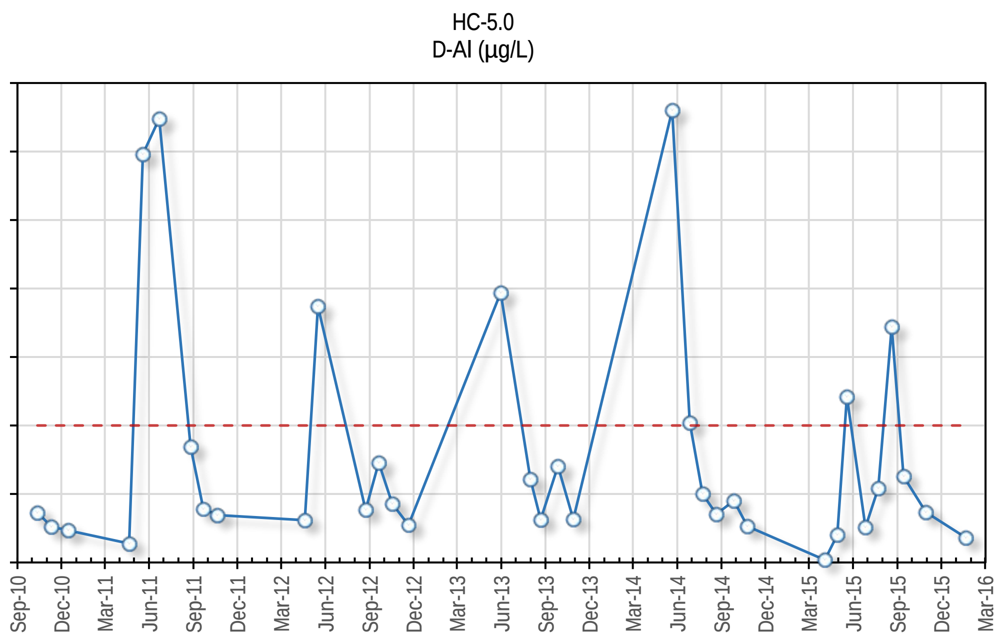


Figure 3.3-9: Dissolved Al in lower Halfway Creek for the period October 2010 to December 2015 compared to BCMOE guideline (red dashed line) for protection of aquatic life

Concentrations of total Cu in mid and lower Halfway Creek show seasonal maxima associated with peak runoff periods that can slightly exceed the CCME hardness-based Cu guideline for the protection of aquatic life (Figure 3.3-10 and Figure 3.3-11).

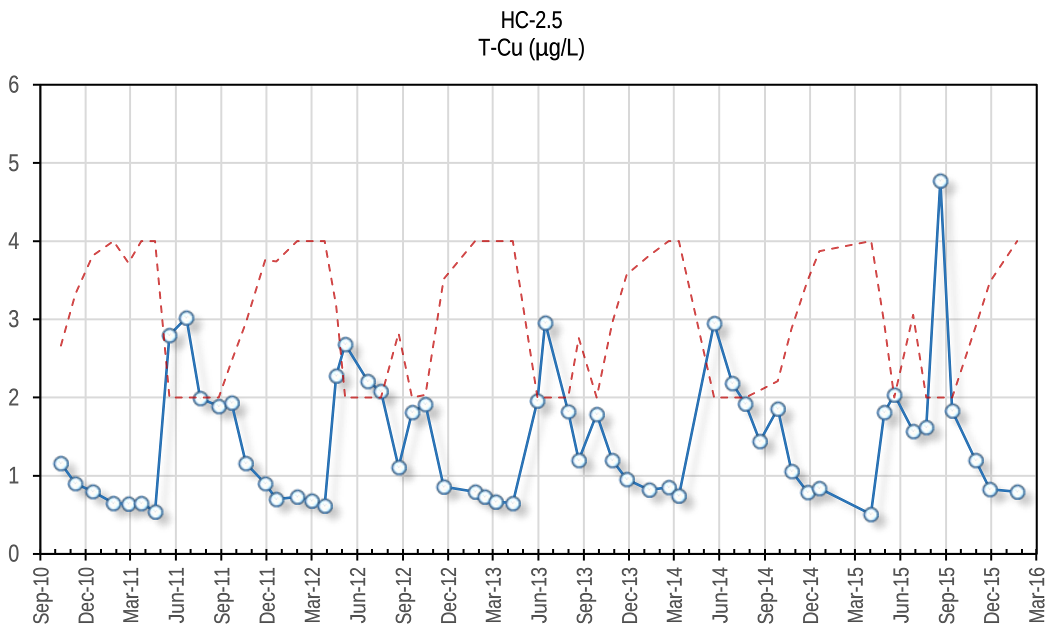


Figure 3.3-10: Total Cu in mid Halfway Creek for the period October 2010 to December 2015 compared to CCME hardness based guideline value (red dashed line) for the protection of aquatic life.

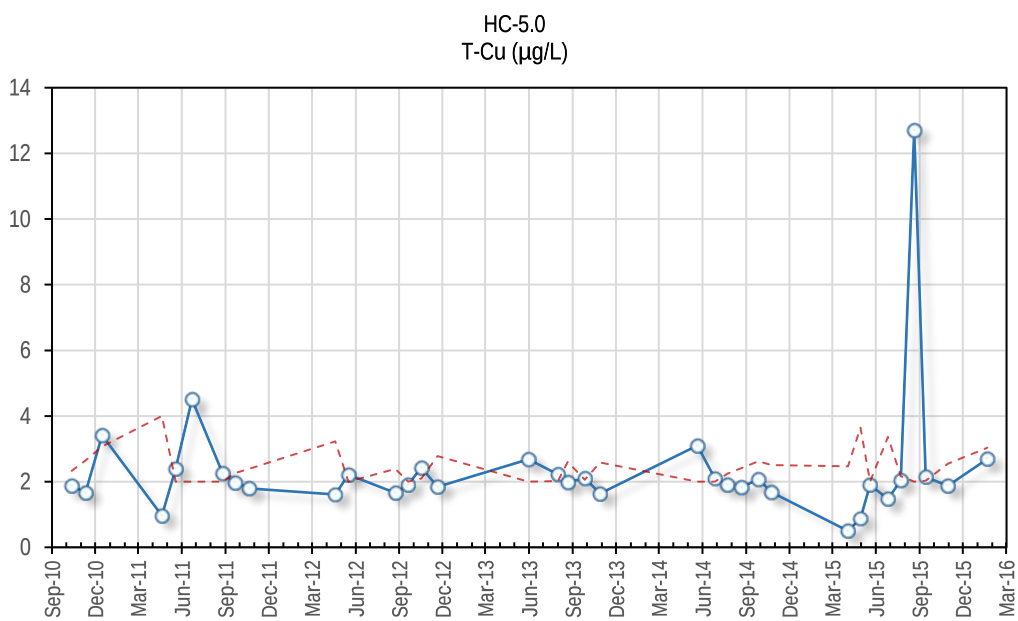


Figure 3.3-11: Total Cu in lower Halfway Creek for the period October 2010 to December 2015 compared to CCME hardness based guideline value (red dashed line) for the protection of aquatic life.

In mid and lower Halfway Creek, total Cd concentrations do not exceed the chronic or short-term CCME hardness-based guidelines for protection of aquatic life for Cd (Figure 3.3-12 and Figure 3.3-13).

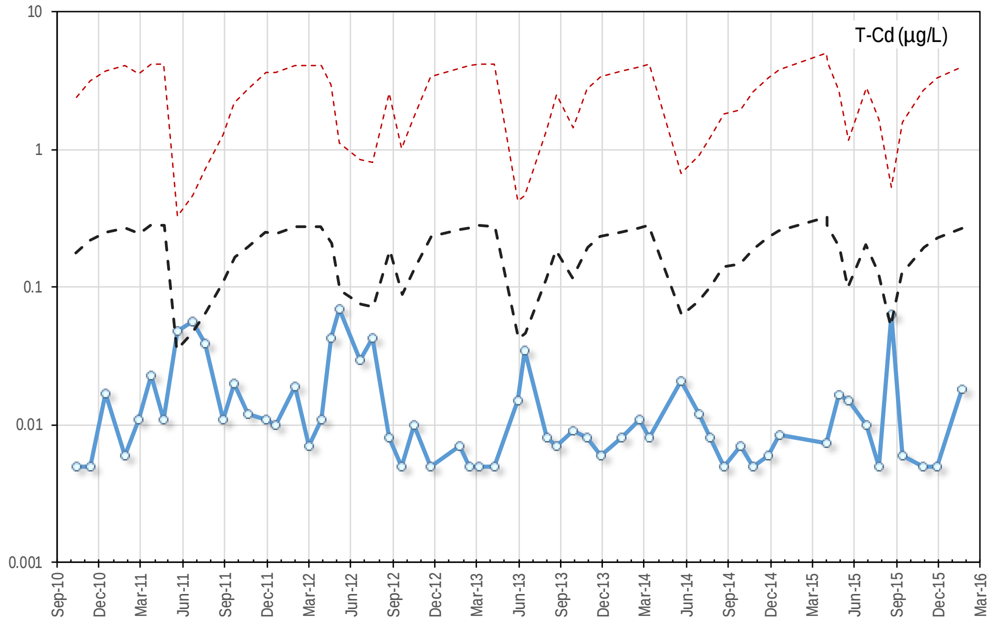


Figure 3.3-12: Total Cd concentrations in mid Halfway Creek for the period October 2010 to December 2015 compared to CCME chronic (black dashed line) and short-term (red dashed line) hardness based guideline value for the protection of aquatic life.

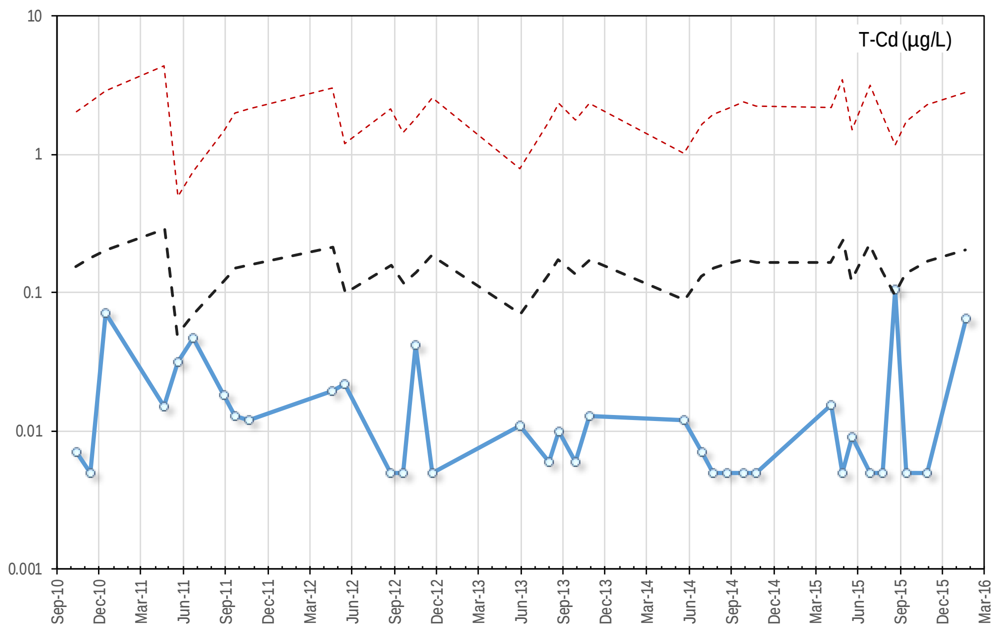


Figure 3.3-13: Total Cd concentrations in lower Halfway Creek for the period October 2010 to December 2015 compared to CCME chronic (black dashed line) and short-term (red dashed line) hardness based guideline value for the protection of aquatic life.

Like Latte Creek and upper Coffee Creek, total U concentrations in Halfway Creek exhibit a distinct seasonality at station HC-2.5. Total U concentrations in mid Halfway Creek at station HC-2.5 exceed 90 µg/L during winter low flow periods and are often over 40 µg/L in late fall, well above the CCME guideline of 15 µg/L for the protection of aquatic life (Figure 3.3-14). The high magnitude of the winter values can be attributed to the input of U-enriched groundwater which sustains baseflow conditions during the ice-up period. During the freshet and summer periods, the introduction of surface runoff dilutes the groundwater signature, resulting in considerably lower U concentrations (to values less than 10 µg/L). The strong inverse relationship ($R^2 = 0.85$) between total U and flow in mid Halfway Creek at station HC-2.5 is illustrated in Figure 3.3-15.

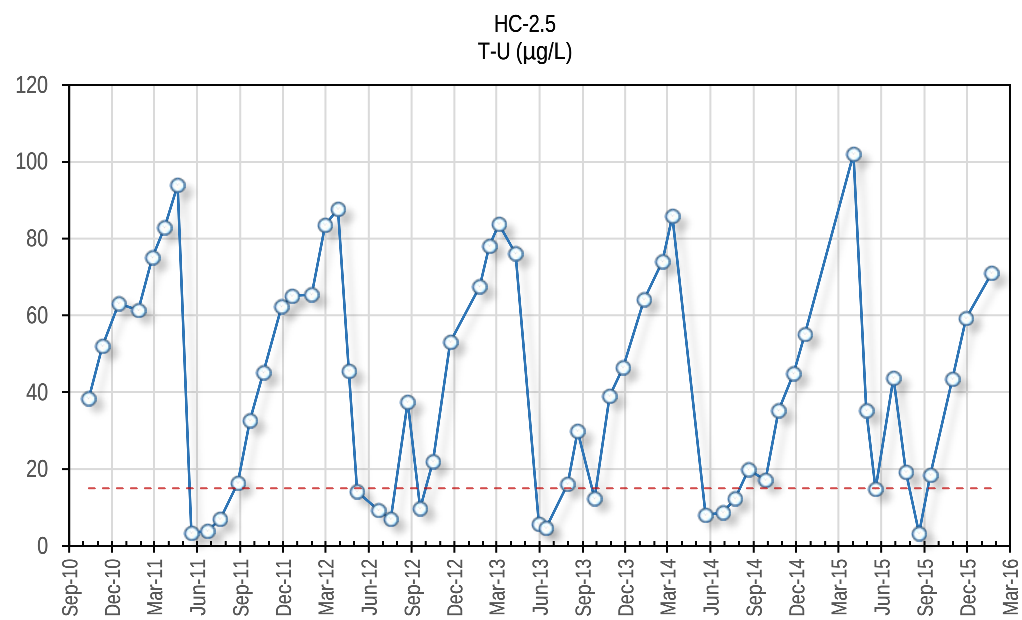


Figure 3.3-14: Total U in mid Halfway Creek for the period October 2010 to December 2015 compared to CCME guideline value (red dashed line) for the protection of aquatic life.

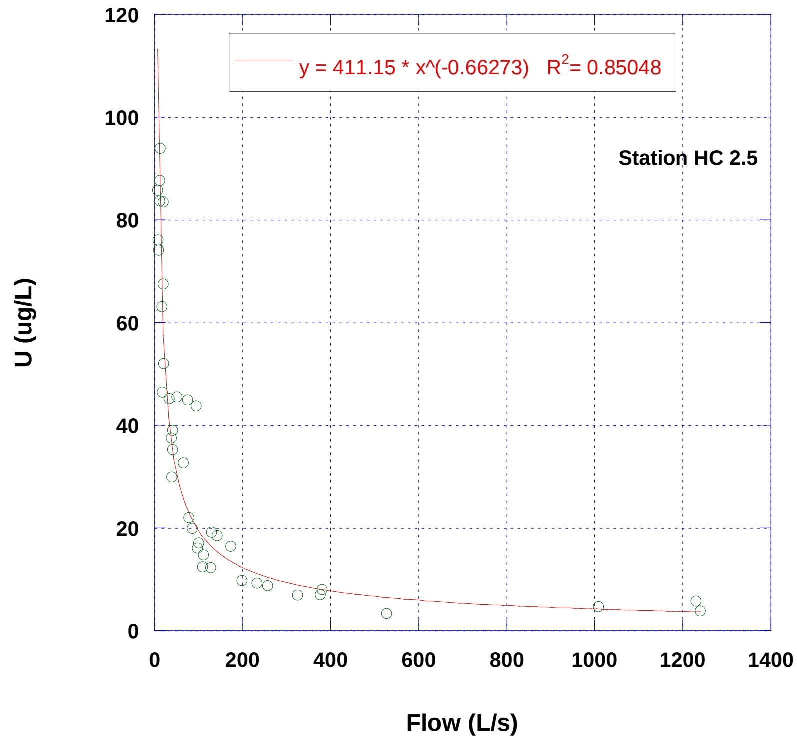


Figure 3.3-15: Relationship between total U and flow in mid Halfway Creek for the period October 2010 to December 2015

Graphical representation of monthly mean total U data at HC-2.5 illustrates that monthly mean concentrations in excess of the CCME guideline of 15 µg/L for U occurs in most months of the year from August to April (Figure 3.3-16).

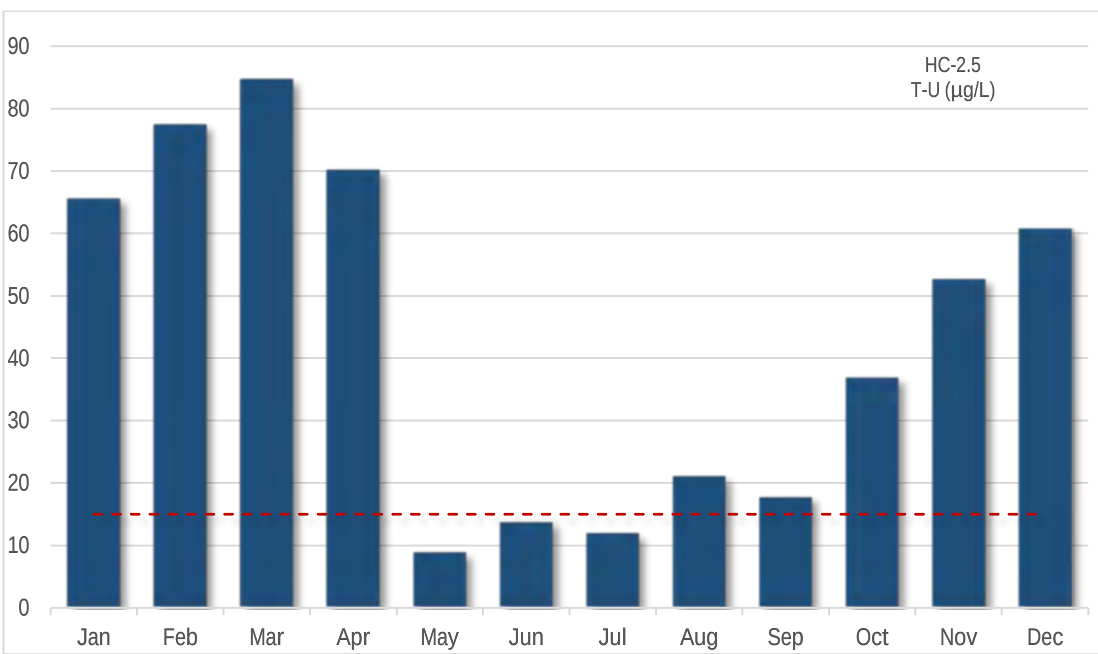


Figure 3.3-16: Mean monthly total U concentrations at HC-2.5 in mid Halfway Creek for the period October 2010 to December 2015 and compared to CCME guideline (dashed red line) for protection of aquatic life.

In lower Halfway Creek this same seasonal trend for total U is less prominent and may be an artifact of the dataset being biased to the open water period (i.e., minimal baseflow representation due to absence of flow in lower Halfway Creek). However, low flow conditions were observed in Halfway Creek in June 2015 that coincided with peak total U concentrations on the order of 30 µg/L at station HC-5.0. Measured concentrations in most other months are less than the CCME guideline of 15 µg/L for the protection of aquatic life (Figure 3.3-17 and Figure 3.3-18).

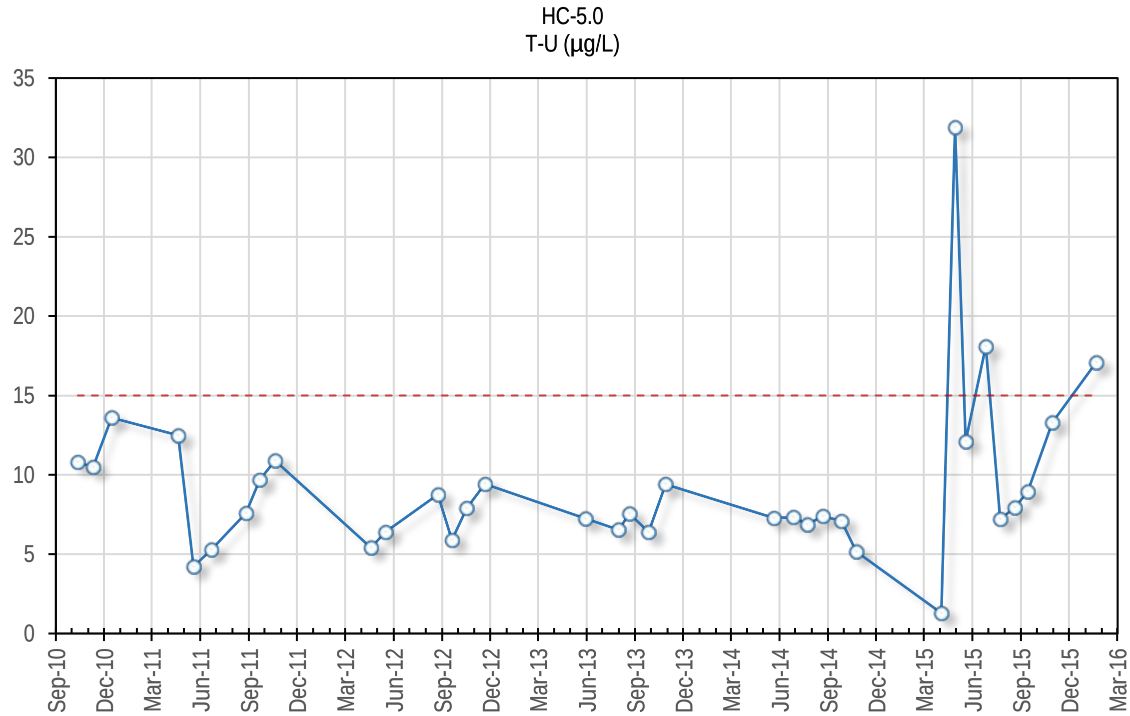


Figure 3.3-17: Total U in lower Halfway Creek for the period October 2010 to December 2015 compared to CCME guideline value (red dashed line) for the protection of aquatic life.

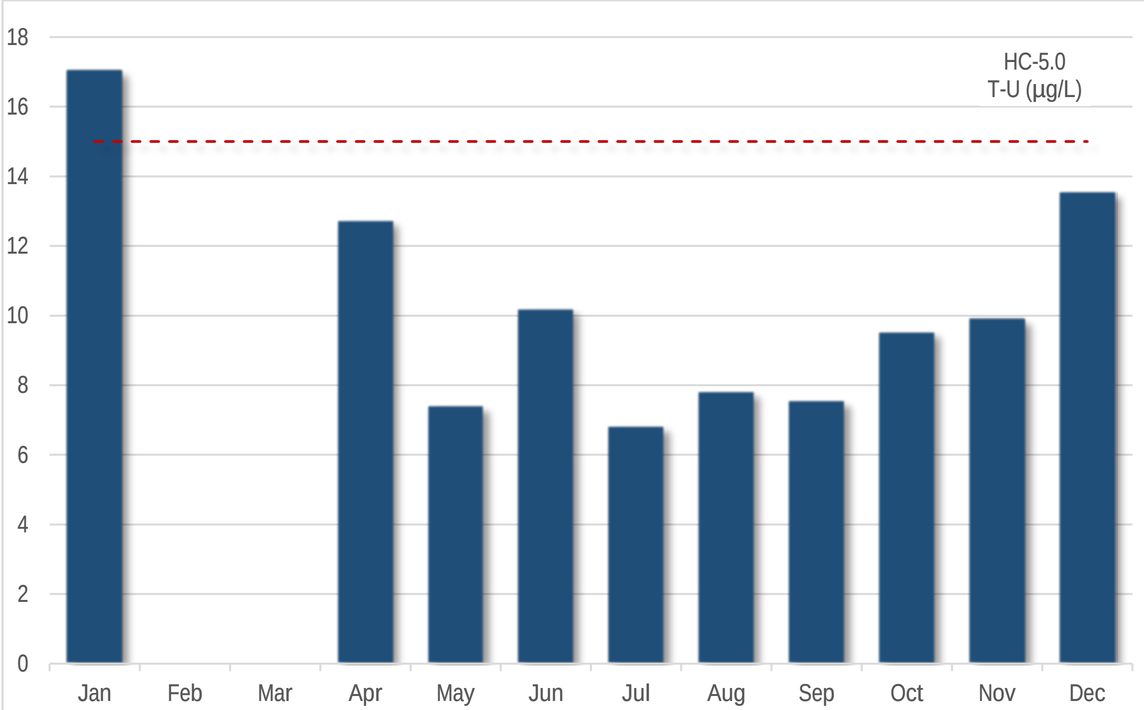


Figure 3.3-18: Mean monthly total U concentrations at HC-5.0 in lower Halfway Creek for the period October 2010 to December 2015 and compared to CCME guideline (dashed red line) for protection of aquatic life.

3.3.2 YT-24 Station ML-1.0

A relatively small, ephemeral drainage named YT-24, drains the northern slopes of the Coffee Project area and enters the Yukon River. Monitoring of this drainage occurs near the mouth at station ML-1.0 (Figure 3.3-1).

3.3.2.1 Summary Statistics

Table 3.3-3 summarizes the mean monthly values for a suite of the key parameters for station ML-1.0; baseline monitoring at this station commenced in June 2014. Data is not available for the period of November to March owing to an absence of flow.

Table 3.3-3:
Station ML-1.0 Monthly Mean Values

	ML-1.0											
	Jan (n = 0)	Feb (n = 0)	Mar (n = 0)	Apr (n = 1)	May (n = 1)	Jun (n = 2)	Jul (n = 2)	Aug (n = 2)	Sep (n = 2)	Oct (n = 2)	Nov (n = 0)	Dec (n = 0)
Physical Parameters												
pH (s.u.)	-	-	-	8.0	7.5	7.6	7.7	7.5	7.7	7.8	-	-
Cond-L (uS/cm)	-	-	-	235	92	144	130	97	113	160	-	-
TSS (mg/L)	-	-	-	1.0	1.8	25	2.4	28	1.0	7.6	-	-
TDS (mg/L)	-	-	-	164	84	120	98	74	86	107	-	-
T-Alk (mg/L)	-	-	-	70	26	42	43	32	37	49	-	-
T-Hard (mg/L)	-	-	-	111	46	68	66	47	67	75	-	-
Anions												
Sulphate (mg/L)	-	-	-	41	12	24	17	9.5	12	24	-	-
Cl (mg/L)	-	-	-	1.5	0.96	0.71	0.61	0.70	0.73	0.75	-	-
F (mg/L)	-	-	-	0.085	0.054	0.074	0.081	0.062	0.069	0.080	-	-
Nutrients												
T-NH_3 - N (mg/L)	-	-	-	0.020	0.018	0.015	0.018	0.023	0.019	0.014	-	-
NO_2-N (mg/L)	-	-	-	0.020	0.049	0.002	0.002	0.002	0.002	0.002	-	-
NO_3-N (mg/L)	-	-	-	0.028	0.309	0.439	0.460	0.453	0.524	0.671	-	-
D-P (mg/L)	-	-	-	0.015	0.0084	0.0024	0.0031	0.0050	0.0043	0.0034	-	-
TOC (mg/L)	-	-	-	17	18	13	13	17	13	12	-	-
DOC (mg/L)	-	-	-	14	19	12	13	15	13	11	-	-
WAD-CN (mg/L)	-	-	-	0.00074	0.0014	0.00087	0.00100	0.0014	0.0010	0.00085	-	-
Total Metals												
T-Al (ug/L)	-	-	-	61	192	104	86	506	73	50	-	-
T-Sb (ug/L)	-	-	-	0.095	0.16	0.17	0.19	0.27	0.21	0.19	-	-
T-As (ug/L)	-	-	-	0.57	0.68	0.53	0.50	0.97	0.51	0.42	-	-
T-Cd (ug/L)	-	-	-	0.027	0.0090	0.0059	0.0071	0.022	0.0050	0.0080	-	-
T-Ca (mg/L)	-	-	-	30	14	20	19	13	20	22	-	-
T-Cr (ug/L)	-	-	-	0.27	0.49	0.47	0.40	1.2	0.42	0.28	-	-
T-Co (ug/L)	-	-	-	0.23	0.11	0.082	0.093	0.42	0.076	0.068	-	-
T-Cu (ug/L)	-	-	-	2.2	2.7	1.9	2.4	3.0	2.4	2.0	-	-
T-Fe (ug/L)	-	-	-	82	159	70	76	677	58	28	-	-
T-Pb (ug/L)	-	-	-	0.011	0.024	0.024	0.031	0.35	0.014	0.0090	-	-
T-Mg (mg/L)	-	-	-	8.8	3.0	4.7	4.5	3.2	4.4	5.0	-	-
T-Mn (ug/L)	-	-	-	37	2.3	1.8	1.3	22	1.9	0.29	-	-
T-Hg (ug/L)	-	-	-	0.0046	0.0084	0.0051	0.0050	0.0042	0.0046	0.0031	-	-
T-Mo (ug/L)	-	-	-	0.47	0.29	0.42	0.50	0.39	0.51	0.46	-	-
T-Ni (ug/L)	-	-	-	1.1	1.0	0.80	0.82	1.4	0.87	0.76	-	-
T-K (mg/L)	-	-	-	3.5	1.4	1.6	1.6	1.1	1.6	1.7	-	-
T-Se (ug/L)	-	-	-	0.11	0.075	0.067	0.067	0.064	0.090	0.087	-	-
T-Ag (ug/L)	-	-	-	0.0050	0.0050	0.0064	0.0070	0.012	0.0050	0.0050	-	-
T-Na (mg/L)	-	-	-	4.0	1.7	2.6	2.4	1.9	2.4	2.5	-	-
T-Tl (ug/L)	-	-	-	0.0020	0.0050	0.0028	0.0030	0.0070	0.0025	0.0030	-	-
T-U (ug/L)	-	-	-	2.8	0.98	0.85	0.91	0.74	0.65	0.83	-	-
T-Zn (ug/L)	-	-	-	0.80	0.42	1.1	0.71	4.1	0.34	0.41	-	-
Dissolve Metals												
D-Al (ug/L)	-	-	-	63	176	80	66	146	66	49	-	-
D-Sb (ug/L)	-	-	-	0.11	0.17	0.17	0.18	0.20	0.20	0.19	-	-
D-As (ug/L)	-	-	-	0.56	0.59	0.52	0.49	0.64	0.51	0.40	-	-
D-Cd (ug/L)	-	-	-	0.020	0.0085	0.0055	0.0055	0.0090	0.0055	0.012	-	-
D-Ca (mg/L)	-	-	-	33	12	20	19	14	17	22	-	-
D-Cr (ug/L)	-	-	-	0.30	0.51	0.35	0.33	0.56	0.35	0.34	-	-
D-Co (ug/L)	-	-	-	0.23	0.10	0.068	0.073	0.14	0.072	0.071	-	-
D-Cu (ug/L)	-	-	-	2.3	4.3	1.9	2.2	2.2	2.2	2.3	-	-
D-Fe (ug/L)	-	-	-	84	124	55	42	142	42	25	-	-
D-Pb (ug/L)	-	-	-	0.0081	0.082	0.0060	0.0070	0.019	0.0050	0.015	-	-
D-Mg (mg/L)	-	-	-	8.9	3.0	4.7	4.4	2.9	3.8	5.2	-	-
D-Mn (ug/L)	-	-	-	36	0.81	0.73	0.16	5.0	1.5	0.24	-	-
D-Hg (ug/L)	-	-	-	0.0057	0.0086	0.0063	0.0063	0.0059	0.0042	0.0038	-	-
D-Mo (ug/L)	-	-	-	0.71	0.40	0.38	0.49	0.37	0.50	0.52	-	-
D-Ni (ug/L)	-	-	-	1.2	1.5	0.72	0.77	0.95	0.80	0.79	-	-
D-K (mg/L)	-	-	-	3.7	1.3	1.6	1.6	1.1	1.4	1.8	-	-
D-Se (ug/L)	-	-	-	0.092	0.057	0.076	0.071	0.062	0.070	0.091	-	-
D-Ag (ug/L)	-	-	-	0.0050	0.0052	0.0050	0.0050	0.0050	0.0050	0.0050	-	-
D-Na (mg/L)	-	-	-	5.1	2.2	2.6	2.5	1.8	2.0	2.7	-	-
D-Tl (ug/L)	-	-	-	0.0020	0.0037	0.0021	0.0025	0.0030	0.0020	0.0025	-	-
D-U (ug/L)	-	-	-	3.0	1.1	0.83	0.78	0.61	0.76	0.83	-	-
D-Zn (ug/L)	-	-	-	1.2	1.6	0.25	0.42	0.78	0.30	0.33	-	-

3.3.2.2 Major Ions

The major ion chemistry for YT-24 is assessed with respect to conductivity, hardness, alkalinity, sulphate and pH. YT-24 is characterized by predominantly moderately soft waters, with monthly mean hardness values ranging from approximately 45 mg/L to approximately 75 mg/L for the open water period of May to October (Table 3.3-3; Appendix C). Conductivity values measured at YT-24 range from approximately 100 to 200 µS/cm.

The pH in YT-24 is consistently circumneutral values consistently between pH 7.5 to 8.0. Observed pH values have remained within the CCME freshwater guideline range for pH of 6.5 to 9.0.

Baseline concentrations for sulphate in YT-24 are low and range between approximately 10 mg/L and 40 mg/L (Table 3.3-3). Measured TSS concentrations in YT-24 are generally low, however peak flow events are associated with elevated TSS over 20 mg/L (Table 3.3-3).

3.3.2.3 Nutrients

Nutrient concentrations quantified in YT-24 include those for nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_3), and dissolved phosphorus. Like all the other project drainages, nutrients are present at low concentrations in YT-24. Ammonia-N concentrations are low with mean monthly values typically between 0.015 and 0.02 mg/L (Table 3.3-3). Mean monthly nitrate-N values ranged from peak flow minima of 0.02 mg/L to late fall low flow values of approximately 0.67 mg/L (Table 3.3-3).

Baseline concentrations for dissolved phosphorus in YT-24 are low, ranging from approximately 0.002 to a maximum of 0.015 mg/L (Table 3.3-3). Mean dissolved phosphorus for all sampling events was 0.009 mg/L (Appendix C) indicative of oligotrophic conditions in YT-24 waters.

TOC and DOC values were relatively consistent throughout the open water period. Mean monthly TOC and DOC levels in YT-24 are relatively high, ranging between approximately 12 to 19 mg/L, with highest values observed during peak flow periods (Table 3.3-3).

3.3.2.4 Trace Elements

Baseline trace element concentrations in YT-24 were derived from data collected from June 2014 to December 2015 at ML-1.0. In general, mean monthly concentrations of total and dissolved trace elements are low (e.g., As, Sb, Co, Cr, Pb, Hg, Ni, Se, U and Zn). For example, total As concentrations at ML-1.0 are typically well below 1.0 µg/L (Table 3.3-3).

Unlike nearby Halfway Creek, total U concentrations in YT-24 are much lower and are below 1.0 µg/L for most of the open water period.

Dissolved Al is episodically observed to be elevated above BCMOE guideline for the protection of aquatic life of 100 µg/L and appears to coincide with peak flow periods and elevated TSS (Figure 3.3-19; see Appendix A ML-1.0 August 2015).

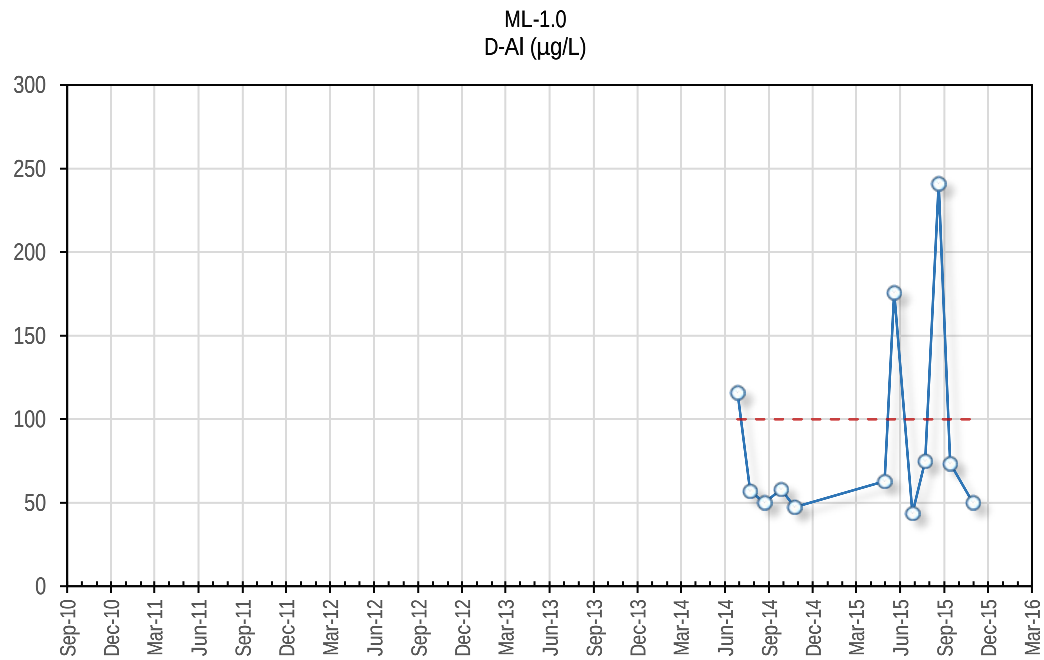


Figure 3.3-19: Dissolved Al concentrations at ML-1.0 in YT-24 for the period June 2014 to December 2015 compared to BCMOE guideline (red dashed line) for protection of aquatic life

Concentrations of total Cu routinely exceed the CCME hardness-based Cu guideline for the protection of aquatic life in these moderately soft waters of YT-24 throughout much of the open water period (Figure 3.3-20).

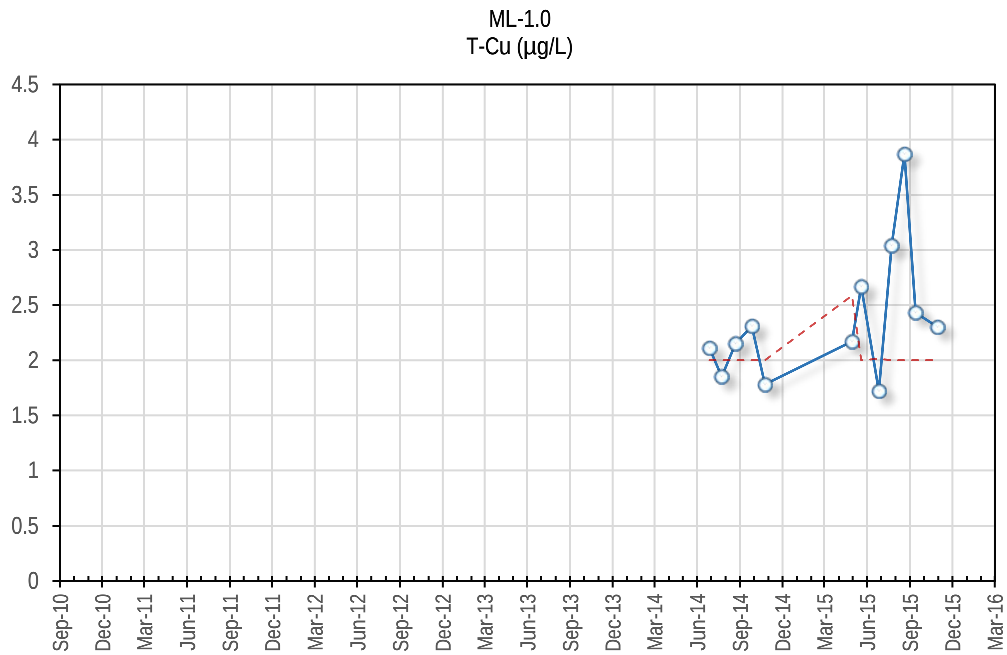


Figure 3.3-20: Total Cu concentrations at ML-1.0 in YT-24 for the period June 2014 to December 2015 compared to CCME hardness based guideline value (red dashed line) for the protection of aquatic life.

Total Cd concentrations do not exceed either of the CCME hardness-based chronic or short-term guideline for protection of aquatic life for Cd (Figure 3.3-21).

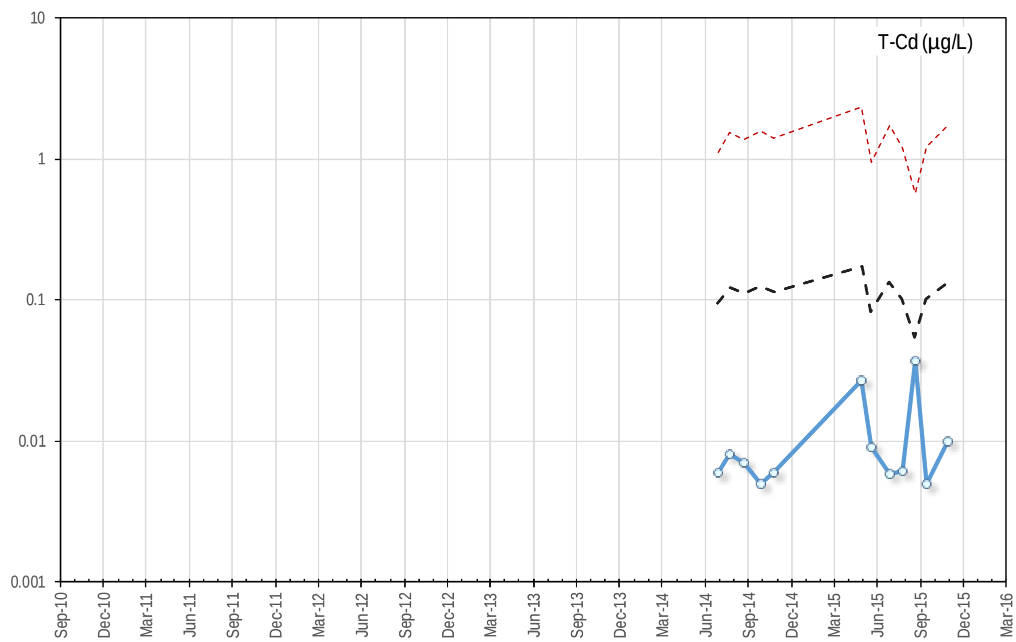


Figure 3.3-21: Total Cd concentrations at ML-1.0 in YT-24 for the period June 2014 to December 2015 compared to CCME chronic (black dashed line) and short-term (red dashed line) hardness based guideline value for the protection of aquatic life.

3.4 Yukon River – YUK-2.0 and YUK-5.0

The following section describes baseline water quality results for the Yukon River in the immediate vicinity of the proposed project. Specifically, data are summarized for stations YUK-2.0 and YUK-5.0 (see Figure 2.1-2) that are located immediately upstream of Coffee Creek and downstream of Independence Creek, respectively.

3.4.1 Summary Statistics

Table 3.4-1 and Table 3.4-2 summarize the mean monthly values for a suite of the key parameters for station YUK-2.0 and YUK-5.0, respectively.

3.4.2 Major Ions

Yukon River major ion chemistry at stations YUK-2.0 and YUK-5.0 is assessed with respect to hardness, sulphate and pH. The Yukon River is characterized as dominantly hard waters with mean monthly hardness values for both stations ranging primarily between approximately 85 mg/L and 120 mg/L (Figure 3.4-1; Table 3.4-1, Table 3.4-2)

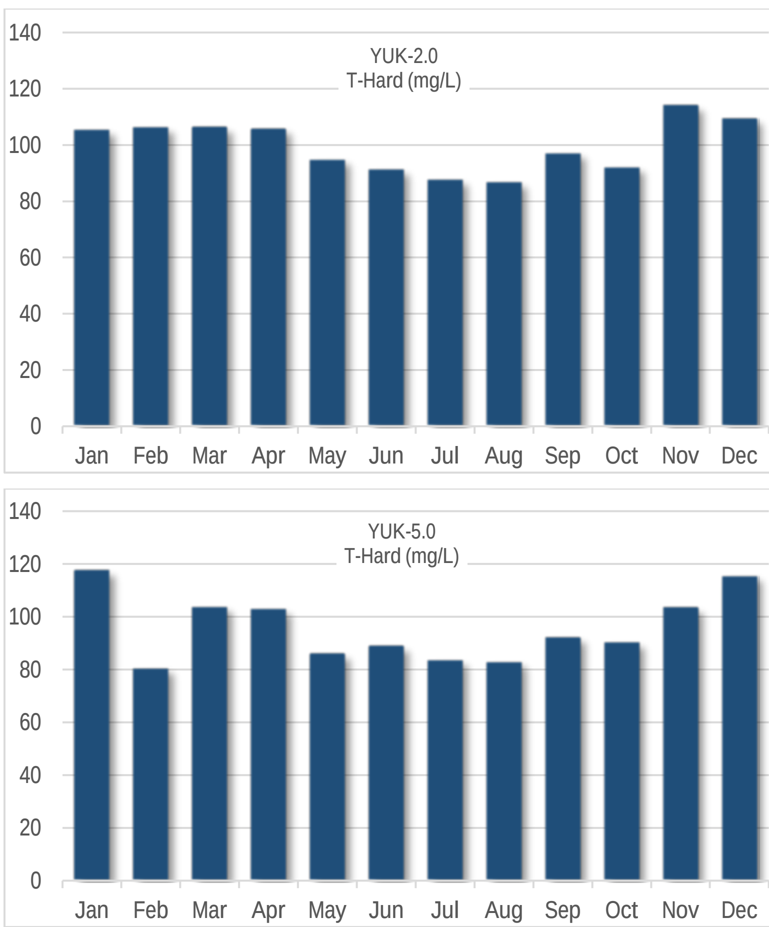


Figure 3.4-1: Mean monthly total hardness in the Yukon River at YUK-2.0 and YUK-5.0 for the period October 2010 to December 2015.

Table 3.4-1: Station YUK-2.0 Monthly Mean Values

	YUK-2.0											
	Jan (n = 3)	Feb (n = 3)	Mar (n = 2)	Apr (n = 3)	May (n = 5)	Jun (n = 5)	Jul (n = 4)	Aug (n = 6)	Sep (n = 5)	Oct (n = 5)	Nov (n = 4)	Dec (n = 1)
Physical Parameters												
pH (s.u.)	8.0	8.0	8.0	8.0	7.8	7.9	7.9	7.9	8.0	8.0	8.0	7.9
Cond-L (uS/cm)	212	221	221	218	178	180	176	182	184	197	235	213
TSS (mg/L)	3.0	1.1	3.0	19	193	48	28	16	13	6.7	2.7	1.0
TDS (mg/L)	121	127	127	132	130	112	111	110	117	118	143	118
T-Alk (mg/L)	83	87	90	87	67	68	66	70	71	77	91	81
T-Hard (mg/L)	106	107	107	106	95	92	88	87	98	93	115	110
Anions												
Sulphate (mg/L)	23	25	23	24	21	23	23	21	23	22	27	23
Cl (mg/L)	0.54	0.54	0.58	0.73	1.1	0.63	0.57	0.56	0.59	0.58	3.0	0.65
F (mg/L)	0.11	0.11	0.11	0.099	0.092	0.10	0.11	0.12	0.11	0.11	0.12	0.11
Nutrients												
T-NH_3 - N (mg/L)	0.017	0.011	0.022	0.014	0.026	0.010	0.026	0.013	0.016	0.014	0.016	0.0059
NO_2 -N (mg/L)	0.002	0.003	0.004	0.003	0.021	0.013	0.015	0.012	0.013	0.012	0.004	0.002
NO_3 - N(mg/L)	0.073	0.090	0.099	0.067	0.058	0.055	0.075	0.045	0.049	0.061	0.051	0.074
D-P (mg/L)	0.0022	0.0022	0.0020	0.0021	0.0052	0.0034	0.0025	0.0023	0.0020	0.0021	0.0026	0.0020
TOC (mg/L)	2.3	1.8	2.7	1.9	11	4.0	3.8	3.1	3.3	2.9	2.9	2.1
DOC (mg/L)	2.3	1.3	0.94	2.0	9.7	3.4	3.5	3.1	2.9	2.7	2.5	2.5
WAD-CN (mg/L)	0.00050	0.00062	0.00059	0.00051	0.00090	0.00072	0.00060	0.00052	0.00054	0.00059	0.00066	0.00058
Total Metals												
T-Al (ug/L)	24	11	9.9	75	1524	309	347	146	134	74	33	20
T-Sb (ug/L)	0.11	0.12	0.092	1.9	0.26	0.15	0.15	0.11	0.11	0.090	0.12	0.15
T-As (ug/L)	0.40	0.33	0.32	0.44	2.5	0.91	0.82	0.61	0.54	0.44	0.46	0.41
T-Cd (ug/L)	0.042	0.033	0.024	0.050	0.52	0.14	0.083	0.057	0.050	0.092	0.038	0.046
T-Ca (mg/L)	29	30	30	30	25	25	24	24	27	25	32	30
T-Cr (ug/L)	0.17	0.20	0.10	0.27	2.8	0.61	0.77	0.34	0.25	0.24	0.15	0.47
T-Co (ug/L)	0.029	0.018	0.027	0.12	1.9	0.48	0.35	0.15	0.11	0.066	0.039	0.025
T-Cu (ug/L)	0.93	0.64	0.45	1.00	8.1	2.5	2.0	1.3	1.2	1.0	1.1	0.96
T-Fe (ug/L)	49	24	31	180	3224	635	560	238	179	111	69	39
T-Pb (ug/L)	0.060	0.11	0.062	0.15	2.4	0.71	0.41	0.20	0.17	0.10	0.15	0.064
T-Mg (mg/L)	7.9	7.9	8.0	7.9	7.8	7.2	6.9	6.6	7.6	7.2	8.7	8.3
T-Mn (ug/L)	3.0	6.6	12	22	181	47	29	15	12	7.6	4.4	3.3
T-Hg (ug/L)	0.0020	0.0047	0.0060	0.0047	0.0073	0.0068	0.0061	0.0073	0.0068	0.0053	0.0060	0.0020
T-Mo (ug/L)	1.3	1.3	1.1	1.0	0.95	0.86	1.1	1.2	1.1	1.1	1.3	1.4
T-Ni (ug/L)	1.1	0.67	0.55	1.0	10.0	3.1	2.3	1.3	1.5	1.4	1.5	1.1
T-K (mg/L)	0.92	0.98	0.97	0.97	1.2	0.81	0.81	0.78	0.84	0.83	0.98	0.97
T-Se (ug/L)	0.35	0.40	0.45	0.37	0.42	0.50	0.38	0.34	0.41	0.35	0.40	0.30
T-Ag (ug/L)	0.0050	0.0050	0.0050	0.0050	0.041	0.013	0.010	0.0062	0.0054	0.0050	0.0088	0.0050
T-Na (mg/L)	2.3	2.6	2.2	2.2	2.0	1.7	1.7	1.8	2.0	2.0	2.6	2.8
T-Tl (ug/L)	0.0022	0.0020	0.0020	0.0020	0.032	0.0088	0.0080	0.0042	0.0036	0.0022	0.0020	0.0020
T-U (ug/L)	1.1	1.1	1.1	1.1	1.1	0.90	0.91	0.94	0.95	0.98	1.2	1.2
T-Zn (ug/L)	3.1	2.5	1.9	4.6	38	9.9	6.5	3.8	4.0	7.0	2.9	3.7
Dissolved Metals												
D-Al (ug/L)	5.2	1.7	1.6	3.5	46	28	21	25	25	15	14	4.4
D-Sb (ug/L)	0.096	0.092	0.089	0.12	0.13	0.13	0.12	0.11	0.11	0.088	0.11	0.11
D-As (ug/L)	0.38	0.29	0.29	0.30	0.52	0.50	0.49	0.48	0.43	0.38	0.44	0.38
D-Cd (ug/L)	0.040	0.024	0.020	0.026	0.071	0.031	0.026	0.017	0.030	0.027	0.030	0.047
D-Ca (mg/L)	30	29	31	29	24	25	25	24	27	26	32	29
D-Cr (ug/L)	0.10	0.10	0.10	0.11	0.13	0.12	0.10	0.11	0.10	0.10	0.15	0.21
D-Co (ug/L)	0.0093	0.016	0.014	0.021	0.053	0.023	0.016	0.014	0.019	0.014	0.021	0.011
D-Cu (ug/L)	0.69	0.49	0.38	0.44	2.5	1.1	0.88	0.76	0.87	0.70	0.77	0.73
D-Fe (ug/L)	7.2	5.6	5.4	6.9	100	29	16	13	17	13	30	4.4
D-Pb (ug/L)	0.011	0.014	0.0075	0.011	0.070	0.041	0.031	0.014	0.021	0.012	0.060	0.0069
D-Mg (mg/L)	8.1	7.8	7.8	7.9	6.7	6.9	6.8	6.5	7.3	7.3	8.9	8.4
D-Mn (ug/L)	1.6	6.7	11	11	7.7	2.6	2.4	0.95	1.6	1.8	3.1	1.7
D-Hg (ug/L)	0.0020	0.0047	0.0060	0.0047	0.0069	0.0060	0.0047	0.0070	0.0060	0.0042	0.0055	0.0024
D-Mo (ug/L)	1.3	1.2	1.1	1.1	0.89	1.00	1.1	1.2	1.2	1.1	1.4	1.3
D-Ni (ug/L)	0.99	0.71	0.55	0.66	2.8	1.3	0.96	0.80	1.2	1.2	1.2	1.3
D-K (mg/L)	0.93	0.92	0.92	0.97	1.0	0.78	0.77	0.78	0.79	0.80	0.98	0.94
D-Se (ug/L)	0.35	0.41	0.45	0.37	0.37	0.50	0.41	0.34	0.39	0.34	0.43	0.32
D-Ag (ug/L)	0.0073	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
D-Na (mg/L)	2.4	2.4	2.1	2.2	1.8	1.7	1.8	1.8	2.0	2.0	2.8	2.5
D-Tl (ug/L)	0.0020	0.0020	0.0020	0.0020	0.0034	0.0029	0.0028	0.0020	0.0020	0.0020	0.0020	0.0020
D-U (ug/L)	1.2	1.1	1.1	1.1	0.80	0.89	0.88	0.94	0.97	1.0	1.3	1.2
D-Zn (ug/L)	3.2	2.7	1.4	2.0	3.8	1.9	0.89	1.3	1.1	1.3	1.4	3.2

Table 3.4-2:
Station YUK-5.0 Monthly Mean Values

	YUK-5.0											
	Jan (n = 3)	Feb (n = 3)	Mar (n = 3)	Apr (n = 4)	May (n = 4)	Jun (n = 5)	Jul (n = 4)	Aug (n = 6)	Sep (n = 5)	Oct (n = 4)	Nov (n = 3)	Dec (n = 1)
Physical Parameters												
pH (s.u.)	8.0	7.9	8.0	8.0	7.8	7.9	7.9	7.9	8.0	8.0	8.0	7.9
Cond-L (uS/cm)	235	228	215	213	171	173	166	169	174	186	217	223
TSS (mg/L)	8.2	14.8	1.1	1	94	60	36	29	10	2.7	7.6	1.0
TDS (mg/L)	123	129	117	122	115	104	102	106	110	107	129	142
T-Alk (mg/L)	93	92	89	85	64	66	65	65	68	75	87	85
T-Hard (mg/L)	118	81	104	104	87	90	84	83	93	91	104	116
Anions												
Sulphate (mg/L)	24	24	22	23	20	20	20	20	20	20	23	25
Cl (mg/L)	0.64	0.60	0.50	0.63	1.2	0.68	0.58	0.55	0.62	0.54	1.1	0.99
F (mg/L)	0.12	0.10	0.11	0.090	0.088	0.10	0.11	0.11	0.11	0.11	0.10	0.11
Nutrients												
T-NH_3 - N (mg/L)	0.012	0.018	0.013	0.011	0.020	0.012	0.023	0.018	0.014	0.016	0.019	0.0150
NO_2 -N (mg/L)	0.003	0.004	0.004	0.004	0.015	0.013	0.015	0.012	0.012	0.015	0.004	0.002
NO_3 - N(mg/L)	0.095	0.096	0.111	0.077	0.069	0.057	0.061	0.066	0.055	0.070	0.058	0.075
D-P (mg/L)	0.0023	0.0027	0.0024	0.0028	0.0052	0.0041	0.0021	0.0028	0.0022	0.0077	0.0020	0.0023
TOC (mg/L)	2.4	1.8	0.9	1.8	11	4.0	4.3	4.6	3.5	2.9	1.9	2.3
DOC (mg/L)	2.2	1.6	0.94	2.0	10.7	2.9	4.1	4.1	3.5	2.5	2.7	2.5
WAD-CN (mg/L)	0.00050	0.00067	0.00053	0.00050	0.00105	0.00064	0.00059	0.00065	0.00055	0.00055	0.00053	0.00069
Total Metals												
T-Al (ug/L)	16	69	9.5	22	1306	315	398	356	123	46	32	14
T-Sb (ug/L)	0.11	0.08	0.090	0.6	0.26	0.14	0.22	0.12	0.11	0.092	0.10	0.10
T-As (ug/L)	0.39	0.26	0.21	0.31	2.0	0.87	0.88	0.76	0.51	0.43	0.38	0.38
T-Cd (ug/L)	0.043	0.035	0.020	0.027	0.32	0.12	0.096	0.057	0.038	0.079	0.026	0.023
T-Ca (mg/L)	33	23	29	29	23	25	23	23	26	25	28	32
T-Cr (ug/L)	0.14	0.23	0.10	0.12	2.6	0.66	0.77	0.80	0.27	0.64	0.11	0.10
T-Co (ug/L)	0.020	0.110	0.018	0.04	1.4	0.46	0.41	0.37	0.10	0.038	0.044	0.017
T-Cu (ug/L)	0.85	0.58	0.44	0.54	6.5	2.5	2.1	1.9	1.2	1.0	0.7	0.53
T-Fe (ug/L)	31	157	21	54	2599	633	678	578	171	62	61	25
T-Pb (ug/L)	0.059	0.35	0.039	0.04	1.6	0.66	0.52	0.33	0.12	0.11	0.05	0.013
T-Mg (mg/L)	9.0	6.0	7.9	7.5	7.2	6.9	6.5	6.3	7.0	7.0	8.1	8.9
T-Mn (ug/L)	3.1	12.3	1	15	119	45	44	27	11	5.1	10.0	3.8
T-Hg (ug/L)	0.0047	0.0047	0.0084	0.0060	0.0090	0.0069	0.0060	0.0075	0.0068	0.0070	0.0073	0.0020
T-Mo (ug/L)	1.5	0.7	1.1	0.9	0.99	0.93	1.1	1.1	1.1	1.1	1.1	1.2
T-Ni (ug/L)	0.9	0.66	0.34	0.6	7.8	2.8	2.3	1.8	1.3	1.1	1.0	1.0
T-K (mg/L)	1.15	0.65	0.87	0.93	1.2	0.83	0.85	0.82	0.83	0.86	0.86	0.93
T-Se (ug/L)	0.38	0.41	0.48	0.41	0.41	0.43	0.31	0.36	0.32	0.33	0.31	0.38
T-Ag (ug/L)	0.0050	0.0060	0.0050	0.0050	0.036	0.009	0.013	0.0083	0.0058	0.0050	0.0050	0.0050
T-Na (mg/L)	3.5	1.4	2.1	2.1	2.0	1.8	1.8	1.8	2.1	2.1	3.1	2.3
T-Tl (ug/L)	0.0025	0.0027	0.0020	0.0021	0.027	0.0081	0.0091	0.0073	0.0034	0.0020	0.0023	0.0020
T-U (ug/L)	1.4	0.9	1.3	1.2	1.2	0.95	0.94	0.96	1.01	0.91	1.3	1.2
T-Zn (ug/L)	2.5	4.9	1.1	1.6	28	9.5	7.0	4.6	3.0	3.2	1.4	1.6
Dissolved Metals												
D-Al (ug/L)	2.1	2.7	1.4	3.2	61	28	22	36	22	16	8	2.5
D-Sb (ug/L)	0.101	0.091	0.088	0.09	0.16	0.12	0.11	0.10	0.09	0.092	0.12	0.10
D-As (ug/L)	0.40	0.21	0.20	0.28	0.54	0.50	0.49	0.48	0.44	0.38	0.35	0.36
D-Cd (ug/L)	0.024	0.029	0.017	0.025	0.072	0.030	0.025	0.016	0.021	0.046	0.046	0.022
D-Ca (mg/L)	32	31	29	30	22	24	23	23	25	25	30	31
D-Cr (ug/L)	0.11	0.11	0.10	0.10	0.14	0.13	0.10	0.15	0.11	0.10	0.10	0.10
D-Co (ug/L)	0.0088	0.012	0.006	0.019	0.065	0.025	0.016	0.024	0.021	0.016	0.014	0.008
D-Cu (ug/L)	0.63	0.50	0.40	0.50	2.3	1.1	0.93	0.98	0.88	0.70	0.82	0.46
D-Fe (ug/L)	7.3	7.4	2.1	10.0	104	30	18	33	19	18	17	2.8
D-Pb (ug/L)	0.020	0.017	0.0083	0.014	0.060	0.041	0.016	0.014	0.016	0.026	0.044	0.0050
D-Mg (mg/L)	9.1	8.2	7.7	7.7	6.3	6.7	6.3	6.1	6.9	6.9	8.1	8.5
D-Mn (ug/L)	2.4	2.7	0	12	8.8	2.6	4.9	1.22	2.3	2.8	6.6	2.5
D-Hg (ug/L)	0.0047	0.0047	0.0073	0.0060	0.0051	0.0064	0.0047	0.0072	0.0060	0.0047	0.0063	0.0020
D-Mo (ug/L)	1.5	0.9	1.1	1.0	0.89	0.98	1.1	1.1	1.2	1.1	1.2	1.2
D-Ni (ug/L)	0.88	0.51	0.33	0.54	2.5	1.2	0.83	0.90	1.0	1.1	1.1	1.2
D-K (mg/L)	1.05	0.89	0.85	0.95	1.0	0.80	0.78	0.80	0.81	0.83	0.91	0.92
D-Se (ug/L)	0.42	0.50	0.47	0.39	0.32	0.41	0.30	0.28	0.32	0.31	0.34	0.35
D-Ag (ug/L)	0.0067	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
D-Na (mg/L)	2.6	2.1	2.1	2.3	2.2	1.7	1.8	1.8	2.1	2.0	2.6	2.2
D-Tl (ug/L)	0.0020	0.0020	0.0020	0.0020	0.0040	0.0027	0.0024	0.0023	0.0020	0.0020	0.0020	0.0020
D-U (ug/L)	1.4	1.0	1.3	1.2	0.96	0.92	0.91	0.88	1.01	1.0	1.3	1.2
D-Zn (ug/L)	2.0	3.0	1.1	1.3	2.7	1.4	0.74	0.8	1.1	2.9	2.1	1.5

Baseline concentrations of sulphate in the Yukon River are consistent throughout the year and don't exhibit a pronounced seasonal signature. Mean monthly sulphate values for both stations narrowly range between 20 and 25 mg/L (Table 3.4-1 and Table 3.4-2).

The pH remains relatively uniform throughout the year at stations YUK-2.0 and YUK-5.0, with values generally 7.8 and 8.0. The neutral to slightly basic pH conditions can be linked to bicarbonate alkalinity. All pH values reported to date have remained within the CCME freshwater guideline range for pH of 6.5 to 9.0.

TSS concentrations in the Yukon River show maxima coinciding with the peak snowmelt months (e.g., May and June). Elevated TSS also occurs during summer flow periods and generally decrease to values less than 5.0 mg/L during the late fall and winter low flow conditions (Table 3.4-1and Table 3.4-2).

3.4.3 Nutrients

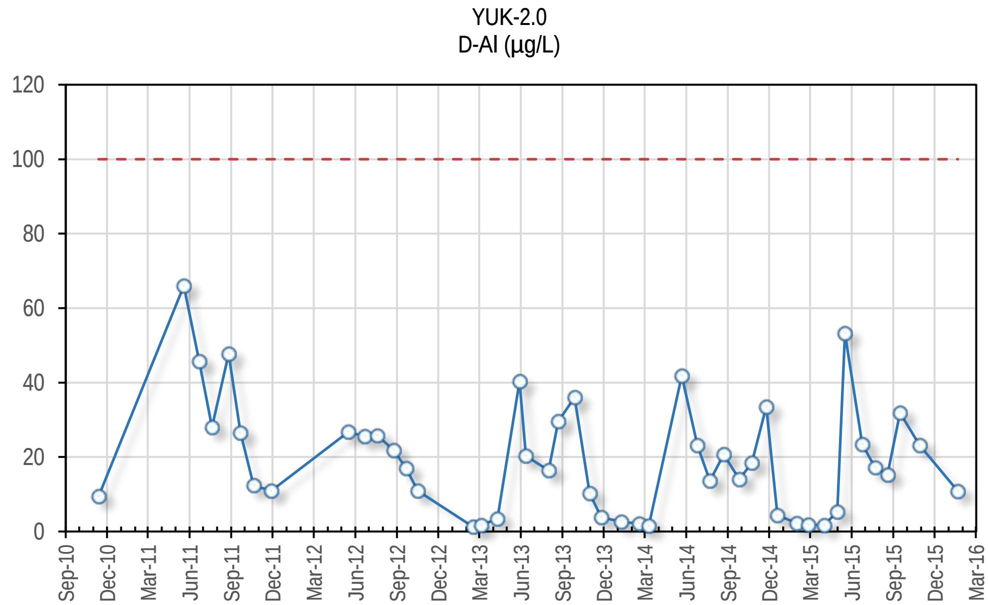
Nutrient parameters are found in low concentrations in the Yukon River at stations YUK-2.0 and YUK-5.0. Ammonia-N concentrations are low with mean monthly values typically between roughly 0.01 to 0.03 mg/L. Mean monthly nitrate-N concentrations at both Yukon River stations were low and ranged between 0.05 mg/L and 0.1 mg/L. Dissolved phosphorus concentrations at both stations were low with mean monthly values narrowly ranging between 0.002 mg/L and 0.005 mg/L and indicative of oligotrophic to ultra-oligotrophic conditions (Appendix C).

Unlike the other project streams, TOC and DOC are present in lower concentrations in the Yukon River. Mean monthly DOC concentrations ranged from less than 1.0 mg/L during baseflow periods, to roughly 11 mg/L (Table 3.4-1 and Table 3.4-2).

3.4.4 Trace Elements

Baseline trace element concentrations in the Yukon River were derived from data collected from October 2010 to December 2015 at YUK-2.0 and YUK-5.0. In general, mean monthly concentrations of total and dissolved trace elements are low (e.g., Al, As, Sb, Co, Cr, Pb, Hg, Ni, Se, U and Zn). Mean monthly total As concentrations in the Yukon River are typically well below 1.0 µg/L for most flow periods of the year with maximum values coincident with elevated TSS (Table 3.4-1 and Table 3.4-2). Similarly, total U concentrations in the Yukon River are also low and mean monthly values range typically between approximately 0.9 µg/L and 1.2 µg/L (Table 3.4-1 and Table 3.4-2).

In contrast to all the other monitoring locations in the vicinity of the project site, dissolved Al in the Yukon River never exceed the BCMOE guideline for the protection of aquatic life of 100 µg/L.



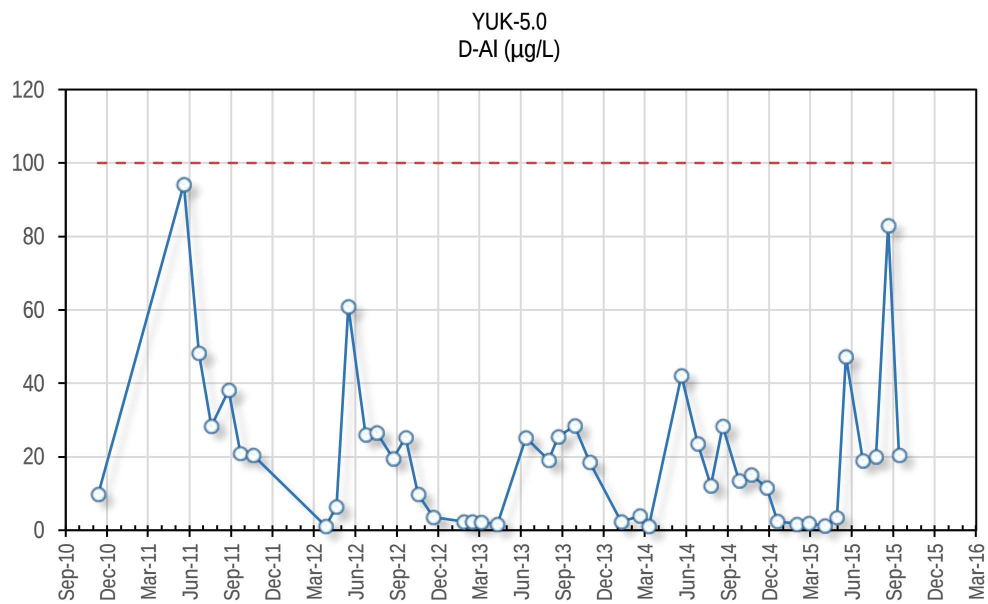
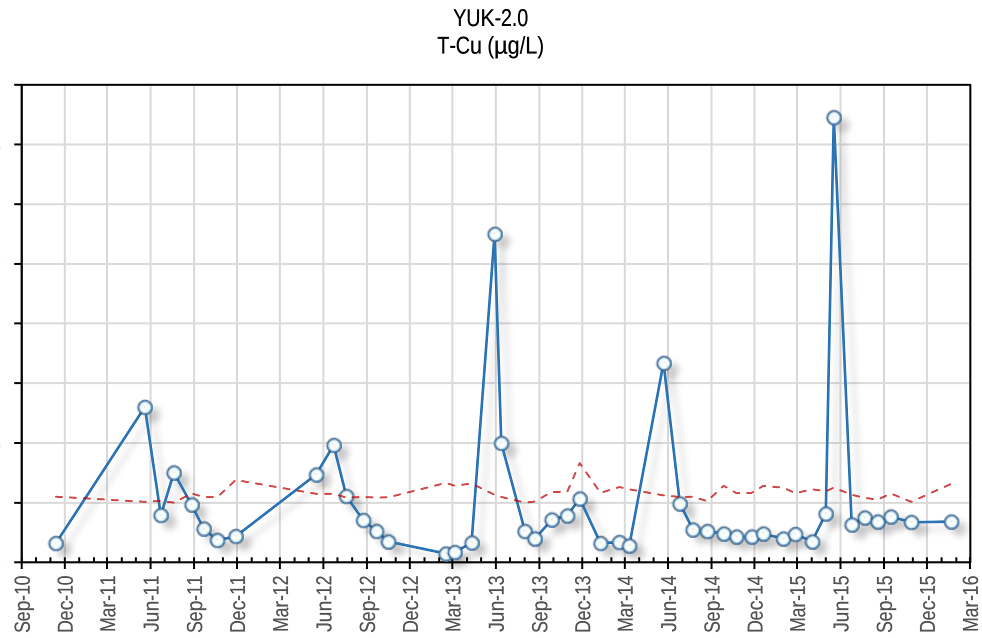


Figure 3.4-2: Dissolved Al concentrations at YUK-2.0 and YUK-5.0 in the Yukon River for the period October 2010 to December 2015 compared to BCMOE guideline (red dashed line) for protection of aquatic life

Interestingly, concentrations of total Cu in the Yukon River at station YUK-2.0 and YUK-5.0 routinely exceeded the CCME hardness-based Cu guideline for the protection of aquatic life even in these moderately hard to hard waters (Figure 3.4-3). Mean monthly total Cu concentrations at both Yukon River stations indicate that elevated total Cu concentrations are associated with the peak flow months of May and June (Figure 3.4-4).



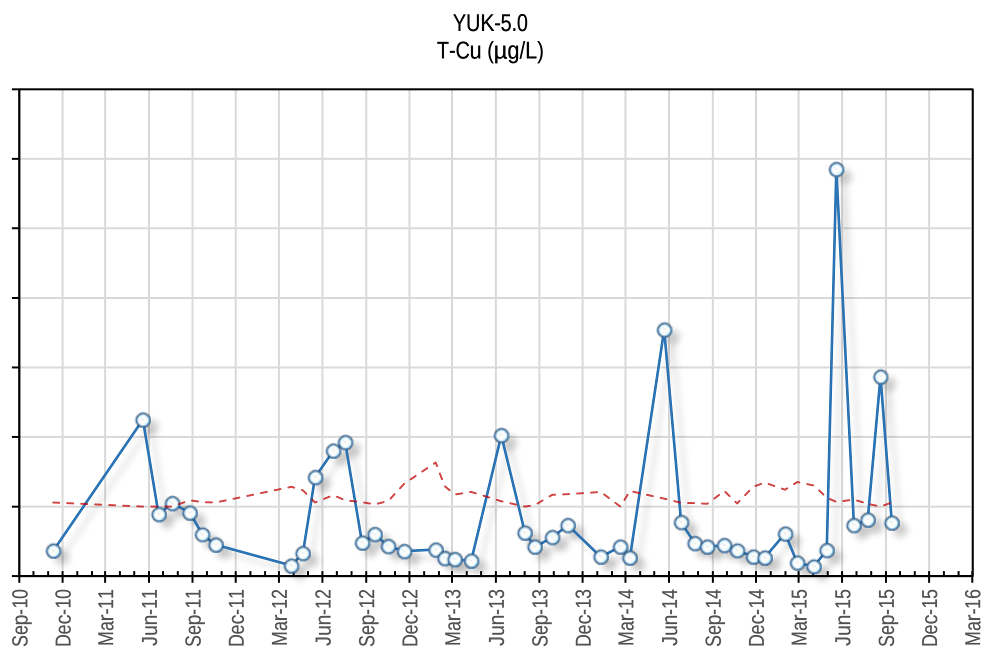
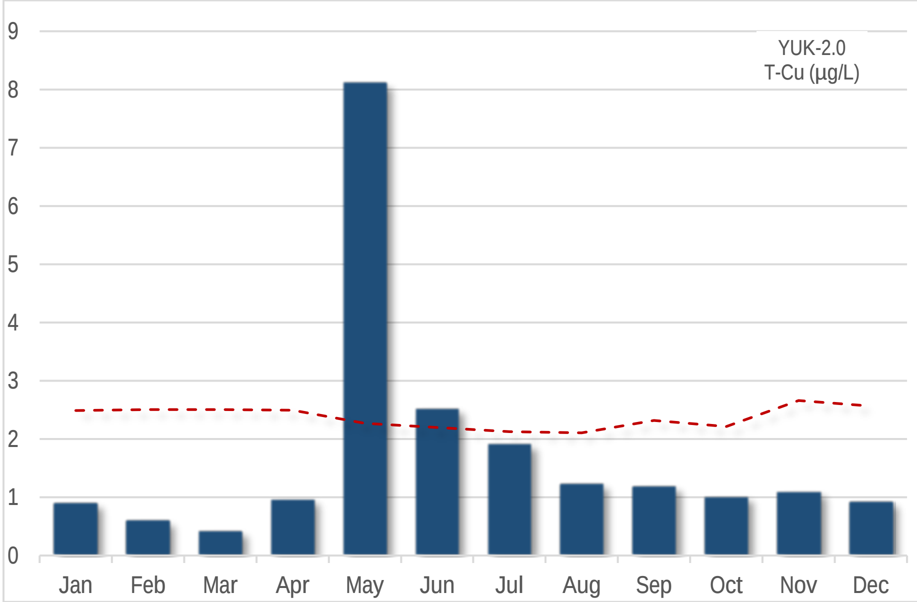


Figure 3.4-3: Total Cu concentrations at YUK-2.0 and YUK-5.0 in the Yukon River for the period October 2010 to December 2015 compared to CCME hardness based guideline value (red dashed line) for the protection of aquatic life



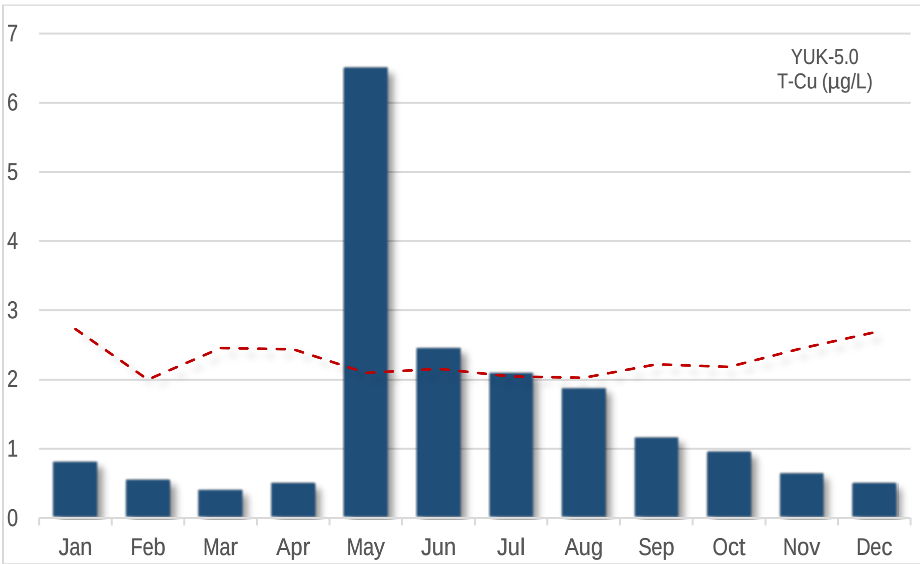


Figure 3.4-4: Monthly mean total Cu in the Yukon River at station YUK-2.0 and YUK-5.0 for the period October 2010 to December 2015 compared to CCME hardness based guideline value (red dashed line) for the protection of aquatic life.

Similar to Cu, total Cd concentrations slightly exceeded the CCME hardness-based chronic guideline for protection of aquatic life for Cd during peak flow periods (Figure 3.4-5). However, observed Cd concentrations do not exceed the CCME short term exposure guidelines for the protection of aquatic life for Cd at stations YUK-2.0 and YUK-5.0.

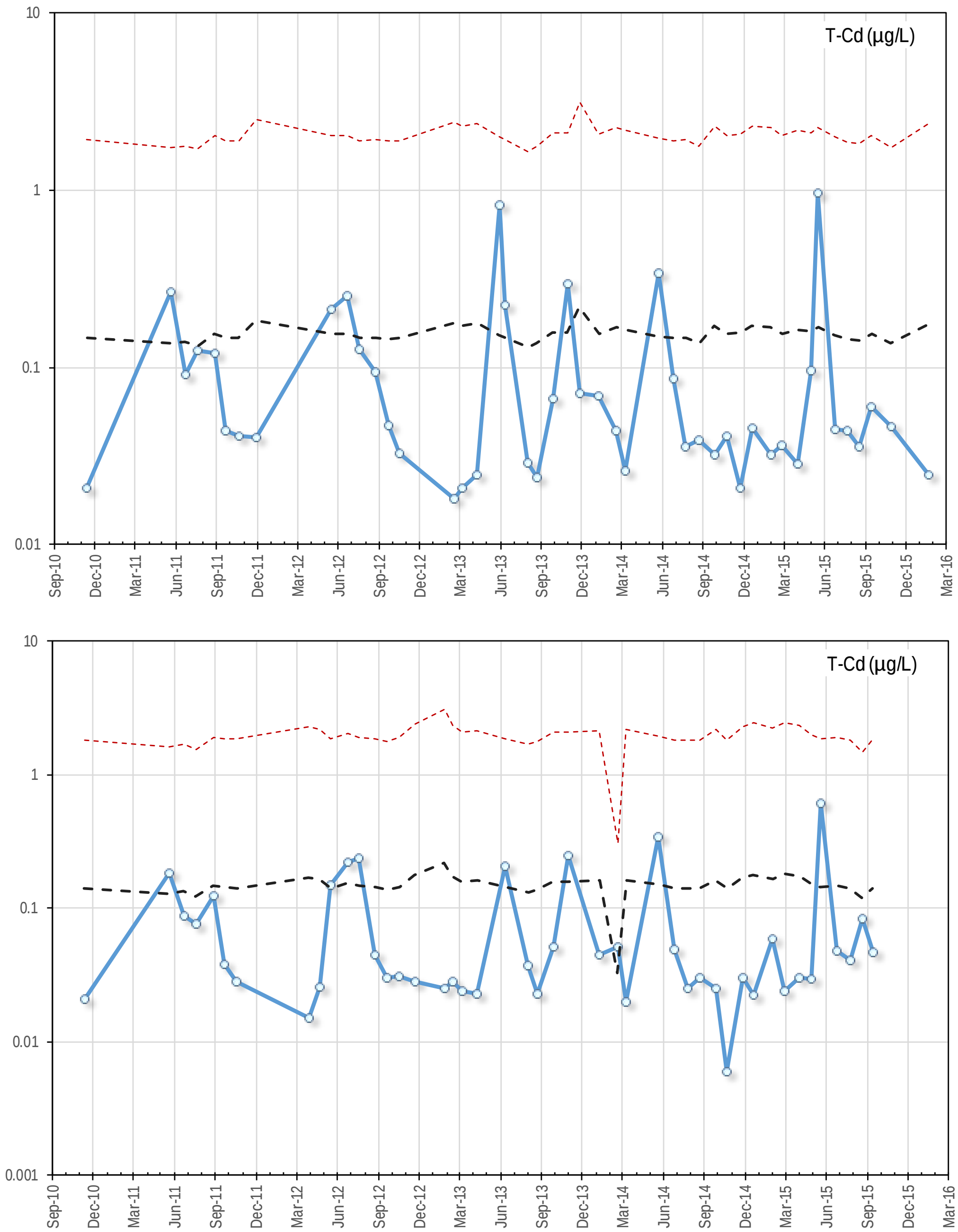


Figure 3.4-5: Total Cd concentrations at YUK-2.0 and YUK-5.0 in the Yukon River for the period October 2010 to December 2015 compared to CCME chronic (black dashed line) and short-term (red dashed line) hardness based guideline value for the protection of aquatic life

3.5 Independence Creek

This section describes baseline water quality results for Independence Creek. Independence Creek is not affected by proposed mining operations and therefore serves as a reference monitoring watershed. (Figure 3.5-1).

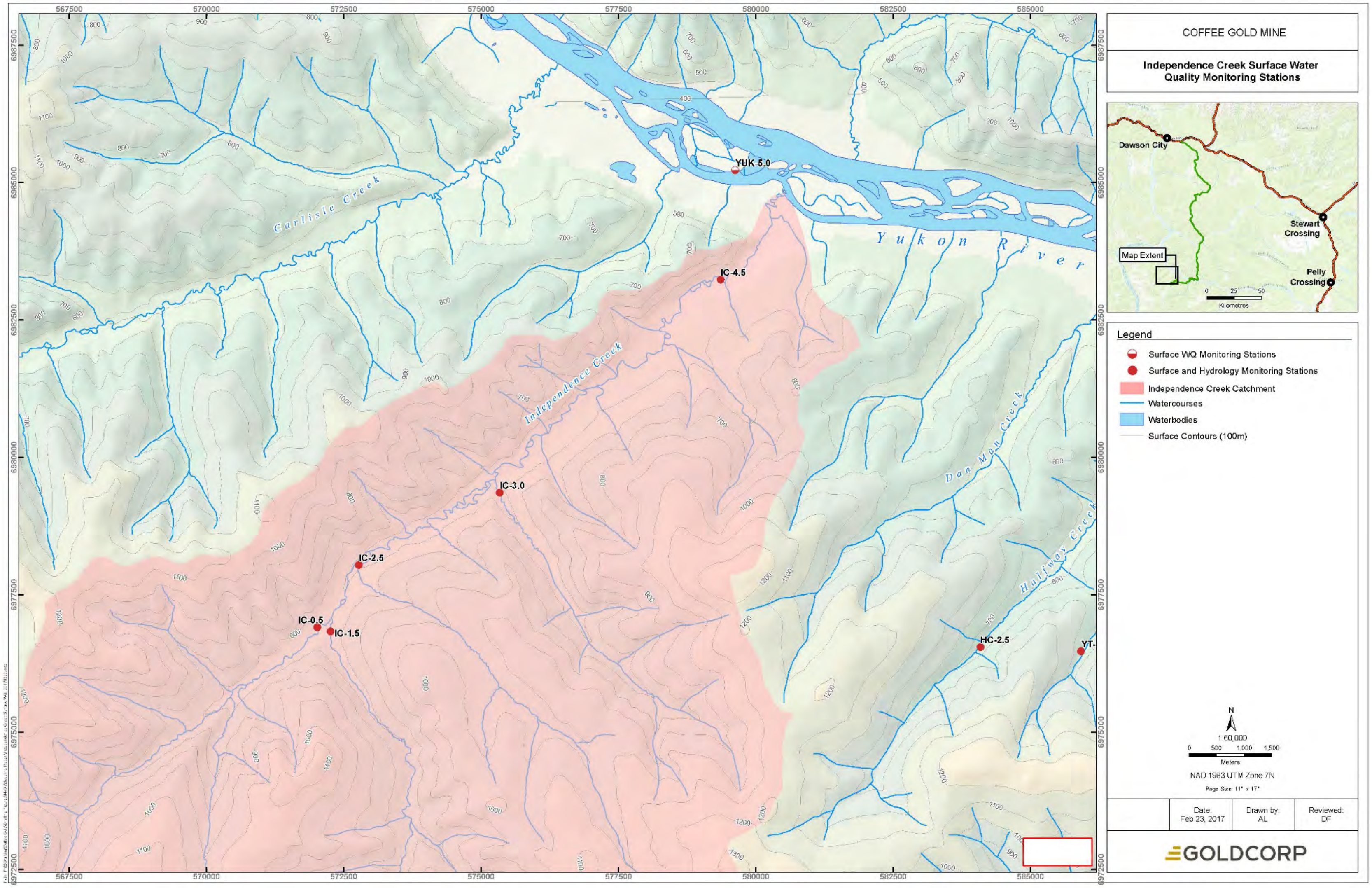


Figure 3.5-1: Detail of Independence Creek drainage illustrating key monitoring station locations

3.5.1 Summary Statistics

Independence Creek is characterized by water quality measured at Station IC-4.5 (Figure 3.5-1) which reflects water quality conditions in lower Independence Creek and downstream of contributions from three small un-named catchments that drain the east slope of the drainage divide between upper Latte Creek and Independence Creek (IC-1.5 and IC-2.5) and the eastern slope of the drainage divide of Halfway Creek and Independence Creek (IC-3.0) (see Figure 2.1-2 and Figure 3.5-1).

3.5.1.1 Summary Statistics

Table 3.5-1 summarizes the mean monthly values for a suite of the key parameters for station IC-4.5 in Independence Creek.

3.5.2 Major Ions

The major ion chemistry of Independence Creek is assessed with respect to hardness, sulphate and pH. Station CC-4.5 is characterized by seasonally very soft to moderately soft waters (between 20 mg/L and 75 mg/L) during open water periods of May to September) and moderately hard to hard waters (ranging from approximately 90 mg/L to 140 mg/L) during lower flow periods and winter low flows (Table 3.5-1; Figure 3.5-2).

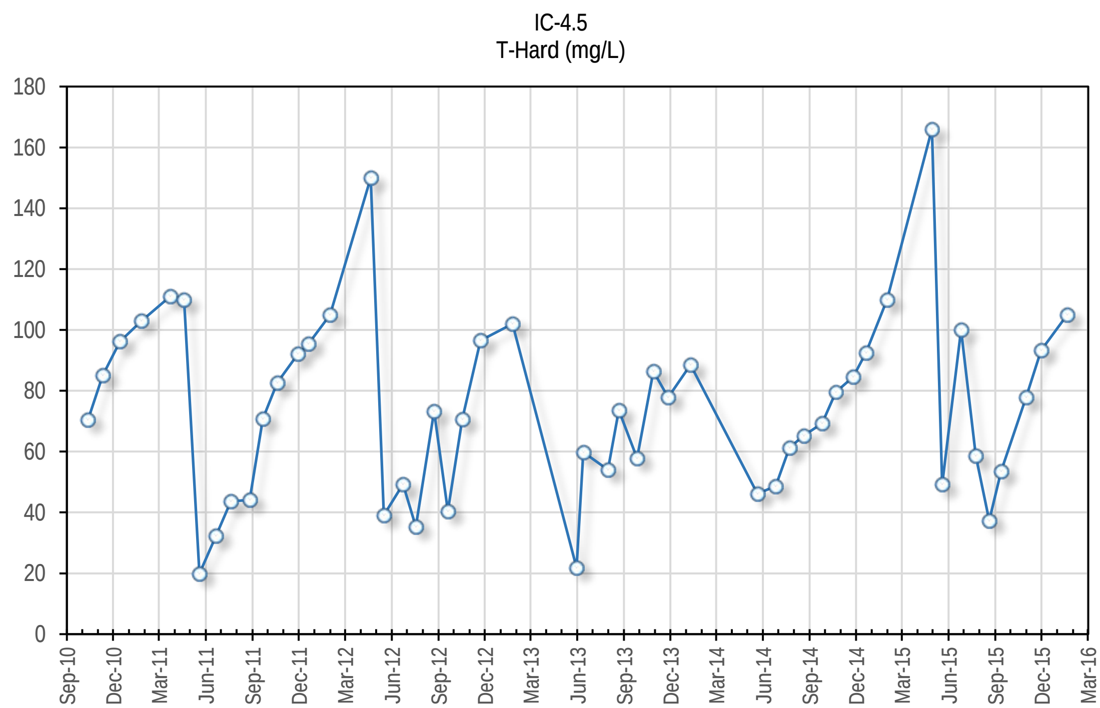


Figure 3.5-2: Total Hardness in Independence Creek for the period October 2010 to December 2015

Table 3.5-1: Station IC-4.5 Monthly Mean Values

	IC-4.5											
	Jan (n = 6)	Feb (n = 0)	Mar (n = 1)	Apr (n = 3)	May (n = 5)	Jun (n = 5)	Jul (n = 5)	Aug (n = 5)	Sep (n = 5)	Oct (n = 6)	Nov (n = 6)	Dec (n = 3)
Physical Parameters												
pH (s.u.)	7.5	-	7.0	7.6	7.1	7.5	7.5	7.6	7.6	7.6	7.6	7.4
Cond-L (uS/cm)	224	-	250	303	70	116	104	121	132	171	197	211
TSS (mg/L)	7.7	-	1.0	4.1	16	29	2.7	47	1.6	1.5	1.9	1.0
TDS (mg/L)	148	-	170	197	74	100	92	97	99	116	126	155
T-Alk (mg/L)	49	-	55	65	18	31	34	35	41	45	47	47
T-Hard (mg/L)	102	-	111	142	35	58	51	59	58	78	88	95
Anions												
Sulphate (mg/L)	54	-	64	89	8.0	23	16	18	17	32	45	46
Cl (mg/L)	0.90	-	1.1	0.96	1.5	1.7	0.87	0.87	0.61	0.77	0.66	0.62
F (mg/L)	0.054	-	0.050	0.073	0.043	0.063	0.067	0.067	0.064	0.067	0.055	0.063
Nutrients												
T-NH_3 - N (mg/L)	0.041	-	0.021	0.015	0.025	0.016	0.031	0.026	0.029	0.014	0.021	0.020
NO_2 -N (mg/L)	0.011	-	0.005	0.004	0.025	0.013	0.013	0.013	0.012	0.011	0.004	0.019
NO_3 - N(mg/L)	0.511	-	0.600	0.094	0.069	0.114	0.154	0.214	0.290	0.382	0.415	0.411
D-P (mg/L)	0.0033	-	-	0.012	0.0083	0.0041	0.0038	0.0048	0.0042	0.0048	0.0025	0.0020
TOC (mg/L)	8.0	-	7.8	11	23	16	16	15	13	11	9.1	7.6
DOC (mg/L)	7.2	-	8.0	11	23	15	16	14	14	10	8.6	7.7
WAD-CN (mg/L)	0.00055	-	0.00050	0.00070	0.0015	0.00088	0.0012	0.0011	0.00073	0.00073	0.00071	0.00057
Total Metals												
T-Al (ug/L)	130	-	49	64	586	476	174	1082	156	66	53	46
T-Sb (ug/L)	0.13	-	0.14	0.081	0.071	0.098	0.12	0.16	0.12	0.11	0.094	0.091
T-As (ug/L)	0.41	-	0.26	0.46	0.77	0.83	0.58	1.3	0.54	0.42	0.33	0.29
T-Cd (ug/L)	0.053	-	0.054	0.044	0.049	0.034	0.027	0.044	0.017	0.011	0.022	0.018
T-Ca (mg/L)	27	-	29	38	9.3	16	14	16	16	21	24	25
T-Cr (ug/L)	0.50	-	0.30	0.22	1.1	1.3	0.53	2.3	0.53	0.31	0.28	0.19
T-Co (ug/L)	0.13	-	0.032	0.10	0.53	0.39	0.10	0.76	0.100	0.060	0.043	0.035
T-Cu (ug/L)	2.2	-	1.7	1.4	3.1	3.1	2.6	3.8	2.5	1.9	1.8	1.5
T-Fe (ug/L)	169	-	25	76	755	620	177	1489	170	61	31	19
T-Pb (ug/L)	0.24	-	0.094	0.050	0.34	0.32	0.068	0.84	0.046	0.017	0.075	0.011
T-Mg (mg/L)	8.2	-	9.5	12	2.9	4.7	3.9	4.7	4.6	6.2	7.1	7.6
T-Mn (ug/L)	22	-	3.0	21	51	30	7.4	46	8.7	6.0	7.5	4.1
T-Hg (ug/L)	0.0061	-	0.010	0.0074	0.012	0.0076	0.0079	0.0075	0.0063	0.0069	0.0062	0.0077
T-Mo (ug/L)	0.25	-	0.17	0.24	0.14	0.22	0.23	0.29	0.25	0.27	0.21	0.21
T-Ni (ug/L)	1.2	-	1.1	1.3	2.0	1.9	1.3	2.5	1.3	1.2	1.1	0.97
T-K (mg/L)	1.5	-	1.5	2.1	0.95	1.0	0.92	1.0	0.95	1.2	1.2	1.2
T-Se (ug/L)	0.093	-	0.080	0.16	0.072	0.081	0.091	0.099	0.093	0.091	0.074	0.069
T-Ag (ug/L)	0.0087	-	0.0050	0.0053	0.0088	0.0056	0.0054	0.013	0.0050	0.0055	0.0050	0.0050
T-Na (mg/L)	4.2	-	4.4	5.1	1.3	2.5	2.3	2.5	2.5	3.2	3.6	3.6
T-Tl (ug/L)	0.0033	-	0.0020	0.0026	0.0097	0.0071	0.0040	0.018	0.0030	0.0025	0.0022	0.0025
T-U (ug/L)	0.52	-	0.38	3.0	1.4	1.5	1.3	1.4	1.3	1.3	0.68	0.53
T-Zn (ug/L)	4.1	-	4.1	2.5	4.3	3.2	2.5	5.1	1.1	0.68	1.5	0.61
Dissolved Metals												
D-Al (ug/L)	44	-	55	46	256	163	141	130	127	66	52	45
D-Sb (ug/L)	0.10	-	0.15	0.072	0.055	0.094	0.12	0.12	0.12	0.12	0.100	0.097
D-As (ug/L)	0.28	-	0.27	0.41	0.44	0.48	0.52	0.54	0.53	0.42	0.32	0.31
D-Cd (ug/L)	0.036	-	0.051	0.036	0.029	0.019	0.022	0.015	0.013	0.030	0.022	0.019
D-Ca (mg/L)	26	-	38	38	9.2	16	14	15	16	20	24	26
D-Cr (ug/L)	0.23	-	0.20	0.21	0.42	0.59	0.46	0.50	0.48	0.37	0.27	0.21
D-Co (ug/L)	0.035	-	0.027	0.080	0.21	0.086	0.080	0.083	0.077	0.058	0.042	0.032
D-Cu (ug/L)	2.2	-	1.8	1.3	2.4	2.4	3.2	2.4	2.4	2.1	1.8	1.5
D-Fe (ug/L)	21	-	27	53	256	155	123	134	123	55	27	18
D-Pb (ug/L)	0.064	-	0.043	0.015	0.038	0.034	0.050	0.021	0.015	0.13	0.028	0.020
D-Mg (mg/L)	8.3	-	11	12	2.7	4.4	4.1	4.4	4.4	6.1	7.1	7.7
D-Mn (ug/L)	3.4	-	2.7	18	24	4.7	4.8	5.1	6.9	6.1	7.3	3.9
D-Hg (ug/L)	0.0059	-	-	0.0064	0.0088	0.0071	0.0073	0.0082	0.0071	0.0083	0.0055	0.0063
D-Mo (ug/L)	0.20	-	0.18	0.30	0.13	0.21	0.24	0.24	0.24	0.29	0.24	0.22
D-Ni (ug/L)	1.0	-	1.3	1.2	1.5	1.4	1.2	1.3	1.3	1.1	1.1	1.0
D-K (mg/L)	1.4	-	1.6	2.1	0.92	0.97	0.92	0.97	0.93	1.1	1.3	1.2
D-Se (ug/L)	0.088	-	0.090	0.16	0.064	0.080	0.088	0.081	0.092	0.099	0.072	0.073
D-Ag (ug/L)	0.0072	-	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
D-Na (mg/L)	3.8	-	4.9	5.2	1.3	2.4	2.2	2.5	2.4	3.3	3.5	3.6
D-Tl (ug/L)	0.0021	-	0.0020	0.0024	0.0040	0.0027	0.0033	0.0032	0.0030	0.0025	0.0025	0.0021
D-U (ug/L)	0.41	-	0.46	3.1	1.2	1.2	1.2	1.0	1.3	1.3	0.68	0.56
D-Zn (ug/L)	2.3	-	4.3	2.4	2.2	1.4	1.3	0.87	1.3	3.0	1.4	0.97

The pH in Independence Creek remains relatively uniform throughout the year with values generally ranging between 7.0 and 7.6 (Table 3.5-1). All pH values reported to date have remained within the CCME freshwater guideline range for pH of 6.5 to 9.0.

Baseline concentrations for sulphate in Independence Creek also exhibit a strong seasonal signature with lowest concentrations occurring during peak runoff conditions. During peak flow periods, mean sulphate concentrations at IC-4.5 range from less than 10 mg/L to approximately 20 mg/L (Table 3.5-1). Mean monthly sulphate concentrations during late fall and winter low flows range from roughly 40 mg/L to 90 mg/L.

As with the other stations monitored, total suspended solids (TSS) concentrations in Independence Creek exhibit maxima coincident with the peak snowmelt months (Table 3.5-1). At most other flow periods of the year, TSS values in Independence Creek at IC-4.5 are generally below 2.0 mg/L.

3.5.3 Nutrients

As with all other stations monitored, nutrient parameters are found in low concentrations in Independence Creek at station IC-4.5. Ammonia-N concentrations are low with mean monthly values typically less than 0.02 mg/L (Table 3.5-1). Mean monthly nitrate-N concentrations in Independence Creek are ranged almost an order of magnitude, with peak flow minima of 0.07 mg/L and winter low flow maxima of 0.6 mg/L. Independence Creek waters are oligotrophic to ultra-oligotrophic with monthly mean dissolved phosphorus concentrations at IC-4.5 ranging between 0.002 mg/L to 0.012 mg/L (Table 3.5-1).

Total organic carbon and DOC exhibit a similar marked seasonal signature as observed in other catchments within the project area. The highest DOC values are observed during peak runoff periods at station IC-4.5. DOC accounts for virtually all of the TOC. DOC concentrations range from approximately 6.0 mg/L during baseflow periods to concentrations in excess of 20 mg/L during higher flow periods (Figure 3.5-3).

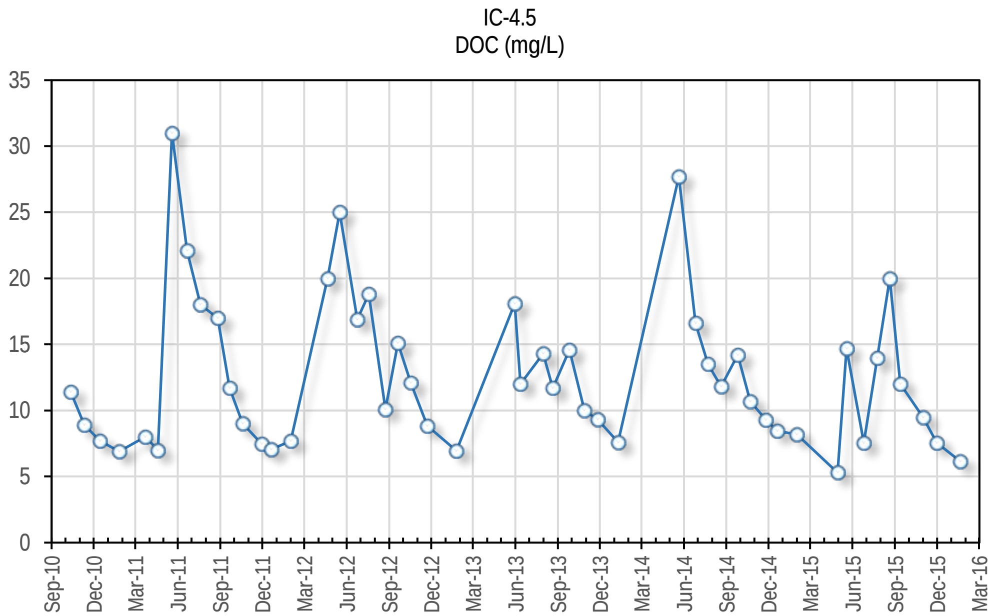


Figure 3.5-3: Dissolved organic carbon in Independence Creek for the period October 2010 to December 2015

3.5.4 Trace Elements

Baseline trace element concentrations in Independence Creek were derived from data collected from October 2010 to December 2015 at IC-4.5 (Figure 3.5-1). For most parameters monitored, mean monthly concentrations of total and dissolved trace elements are low; the sole exceptions to this observation are for dissolved Al and total Cu. Of note is the absence of elevated total U in Independence Creek (Table 3.5-1;Figure 3.5-4).

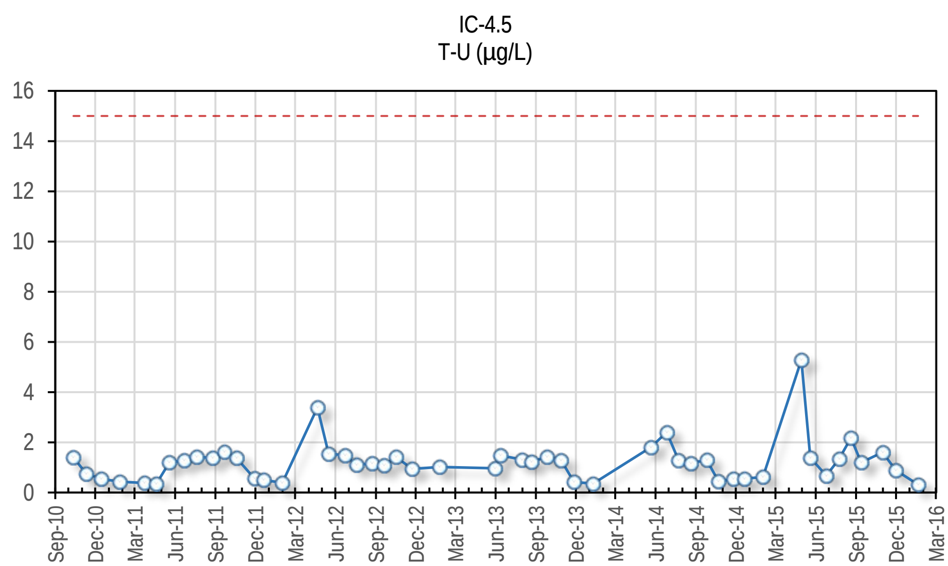


Figure 3.5-4: Total U in Independence Creek for the period October 2010 to December 2015

Dissolved Al at IC-4.5 is seasonally elevated in Independence Creek and consistently observed to be elevated well above BCMOE guideline for the protection of aquatic life of 100 µg/L during peak runoff periods (Figure 3.5-5).

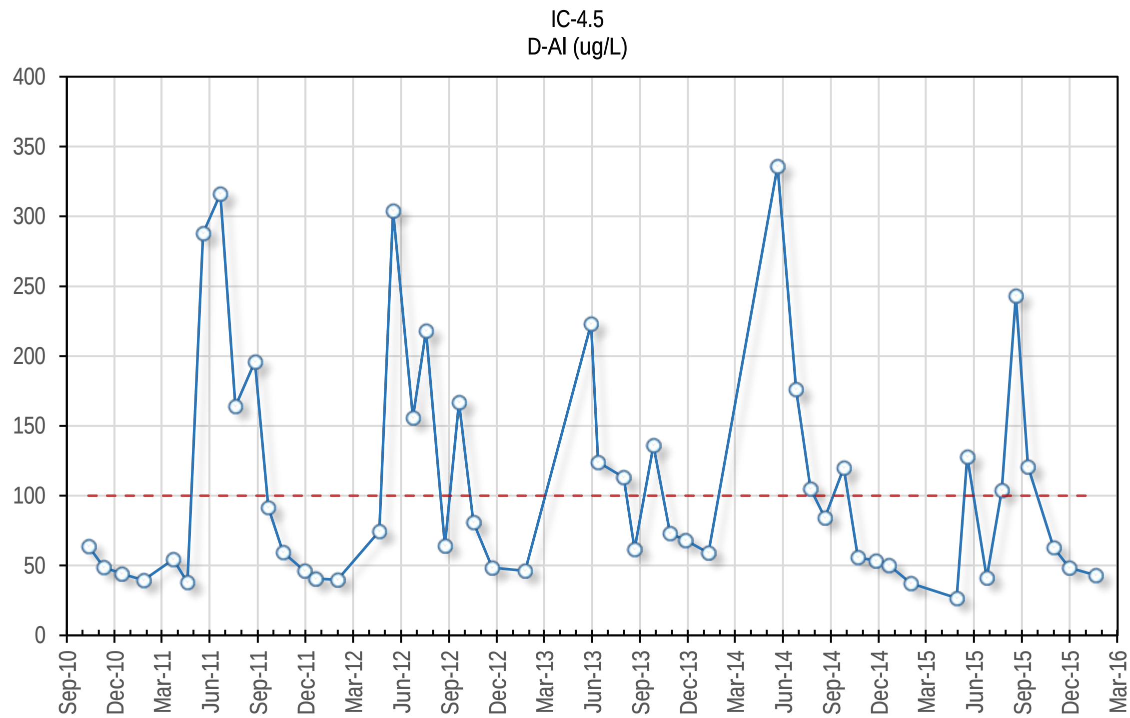


Figure 3.5-5: Dissolved Al in Independence Creek for the period October 2010 to December 2015

During baseflow periods, dissolved Al concentrations in Independence Creek are typically between 45 and 55 µg/L (Table 3.5-1 and Figure 3.5-5).

Concentrations of total Cu in Independence Creek exhibit a strong seasonal signature with maxima associated with peak runoff periods that exceed the CCME hardness-based Cu guideline for the protection of aquatic life (Figure 3.5-6). During most months of the open water period including May to September, mean monthly total Cu concentrations are naturally elevated above the CCME guideline for Cu (Figure 3.5-7).

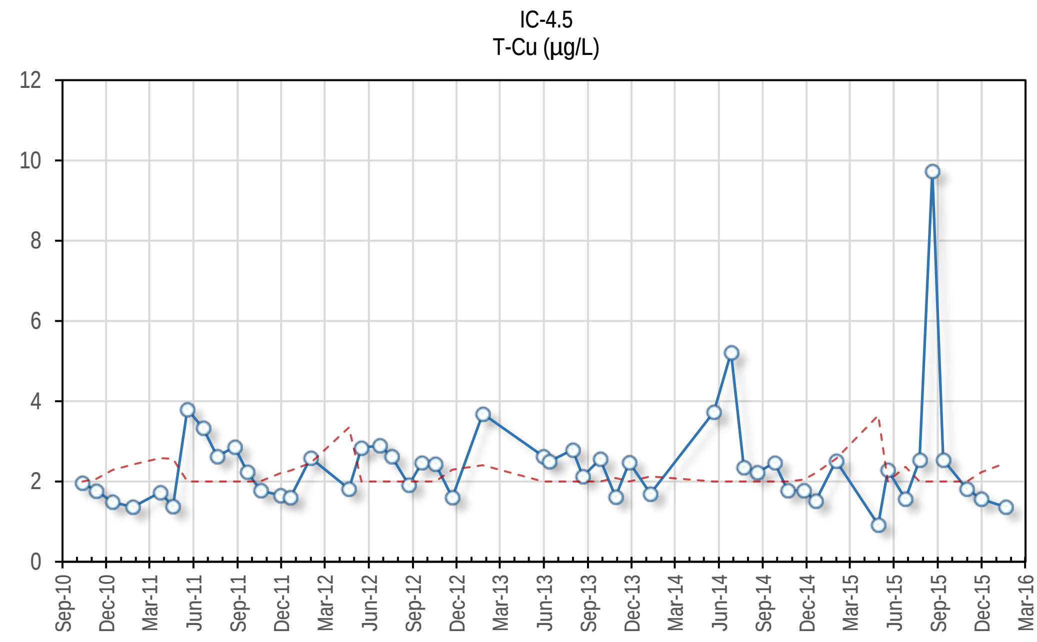


Figure 3.5-6: Total Cu in Independence Creek for the period October 2010 to December 2015

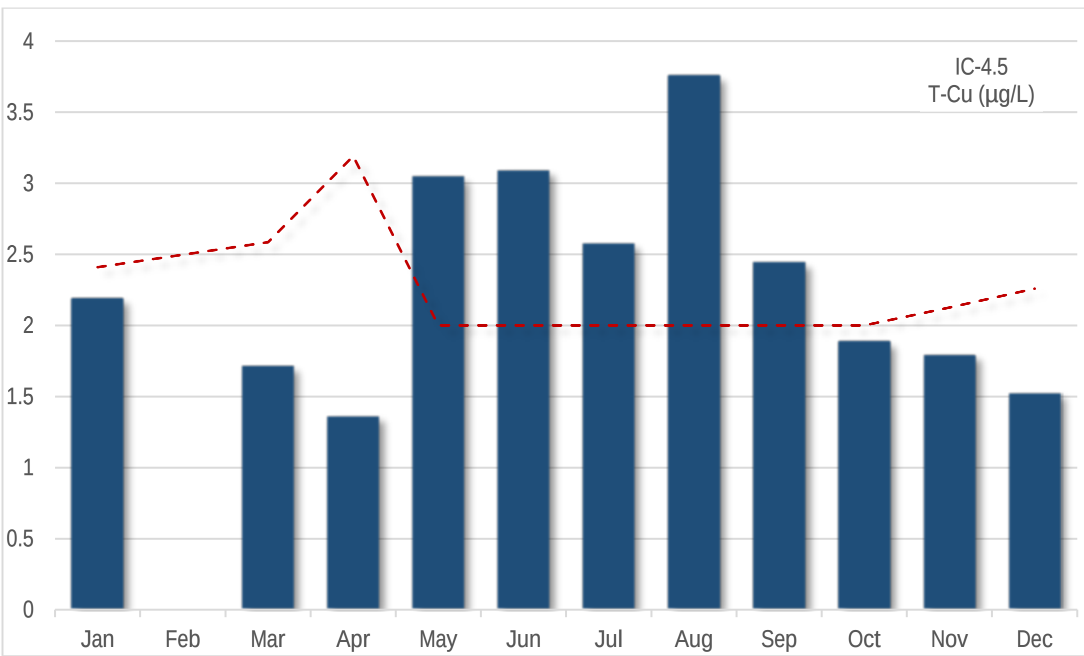


Figure 3.5-7: Mean monthly total Cu in Independence Creek for the period October 2010 to December 2015

Total Cd concentrations in Independence Creek at IC-4.5 generally do not exceed the chronic or short-term CCME hardness-based guidelines for protection of aquatic life for Cd (Figure 3.5-8).

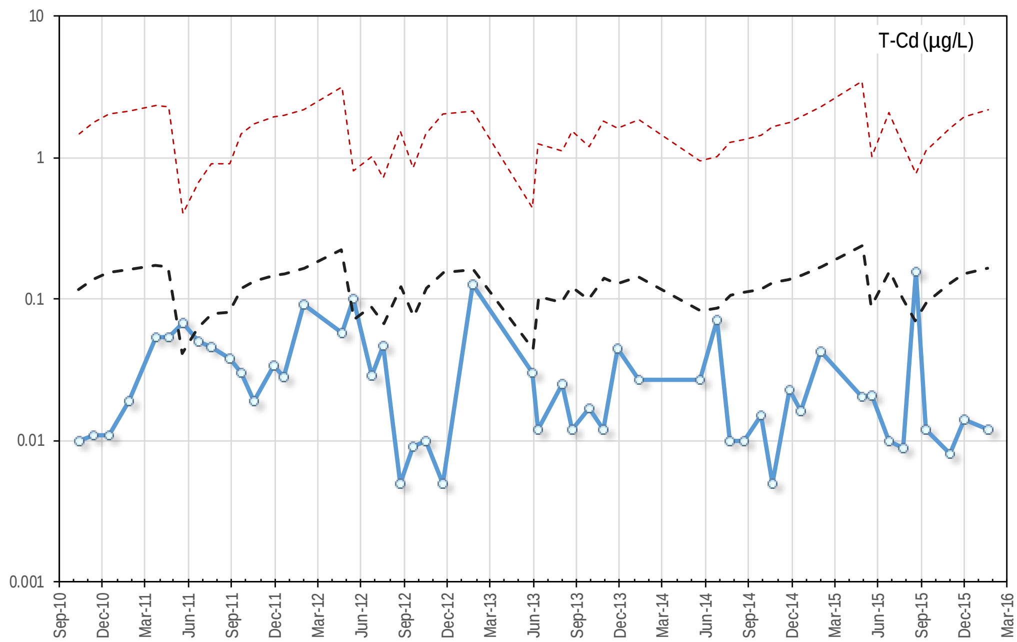


Figure 3.5-8: Total Cd in Independence Creek for the period October 2010 to December 2015

BC MOE. 2013. *British Columbia Field Sampling Manual — For continuous monitoring and the collection of air, air-emission, water, wastewater, soil, sediment and biological samples.* Queens Printer, Victoria, BC.

BC MOE. 2009. *British Columbia Environmental Laboratory Manual*. 2009 Edition. Water & Air Monitoring and Reporting Section, Environmental Quality Branch. Ministry of Environment. Province of British Columbia.

Canadian Council of Ministers of the Environment (CCME). 2007. Canadian environmental quality guidelines. Chapter 4 Canadian Water Quality Guidelines for the Protection of Aquatic Life. Canadian Council of Ministers of the Environment, Winnipeg, Manitoba.

Ministry of Environment (MOE). 2006. British Columbia Approved Water Quality Guidelines, 2006 Edition. Science and Information Branch. http://www.env.gov.bc.ca/wat/wq/BCguidelines/approv_wq_guide/approved.html

Appendix A
Unprocessed Data

An electronic copy of this file has been provided with the digital version of the Project Proposal. The digital file is an Excel spreadsheet and is named:

Appendix A_Raw Data_Coffee Gold Baseline Water Quality Report.xlsx with Tab "RAWDATA"

This document is available in digital version only.

Appendix B
Detection Limit Corrected Data

An electronic copy of this file has been provided with the digital version of the Project Proposal. The digital file is an Excel spreadsheet and is named:

Appendix B_ DLRemoved_Coffee Gold Baseline Water Quality Report.xlsx with Tab "AppB_NoDetection Limit"

This document is available in digital version only.

Appendix C
Statistical Summary by Station

An electronic copy of this file has been provided with the digital version of the Project Proposal. The digital file is an Excel spreadsheet and is named:

Appendix C_StatsSummaries_Coffee Gold Baseline Water Quality Report.xlsx

with Tabs "Latte"; "Coffee"; "Halfway"; "YT24"; "Independence"; "YUKON"

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