Blue Pearl Mining

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AQUATICS BASELINE REPORT, DAVIDSON PROJECT, 2006-2008

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DAVIDSON PROJECT
Aquatics Baseline Report, 2006-2008

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Prepared for:

Blue Pearl Mining

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Engineers and Scientists

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Vancouver, British Columbia

Executive Summary

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This report describes aquatics baseline studies conducted in the Davidson study area from 2006 (June) until 2008 (November). The objective of these studies was to characterize water quality, sediment quality and benthic invertebrate communities. Aquatic toxicity samples were also analysed for water collected from two sites on the Bulkley River. Rescan initiated baseline studies for the project in April 2005. Surface water quality results (April 2005 to June 2006) have been previously reported in Rescan 2006. Aquatic biology results from 2005 and 2006 have been previously reported in Rescan 2006a and Rescan 2007, respectively.

Throughout 2006, 2007 and 2008 many physical parameters and total metal concentrations were most elevated within the Adit watershed group. The high concentrations within the Adit watershed group are a reflection of the high mineralization within the existing underground workings. Seasonal trends for nutrients were apparent at several sites with peak concentrations occurring during the spring. Various parameters (i.e., aluminum, antimony, iron cadmium, chromium or molybdenum) exceeded either the Health Canada and BC drinking water guidelines or the BC Maximum or CCME guidelines for the protection of aquatic life. In Lake Kathlyn, most concentrations were relatively low and close to or below available detection limits, although total iron, cadmium and manganese concentrations did exceeded available guidelines.

Moderate toxicity was found in both Bulkley River samples (rainbow trout bioassay). Water from site BR3 also inhibited growth in the duckweed (*Lemna minor*) bioassay. No toxicity was observed with the samples in the remaining two bioassays (*Ceriodaphnia Dubia* and *Pseudokirchneriella Subcapitata*).

The majority of stream sediments were composed of sand, while silt and clay particles composed less than 20% of the substrate at each site. Guidelines for cadmium, chromium, lead, mercury and zinc were not exceeded at any site. Several metals (chromium, mercury, lead, nickel, aluminum, iron and zinc) had highest concentrations within the Bulkley River sites. The Toboggan Creek sites had the highest concentrations of arsenic, cadmium, copper and molybdenum. Sediments in Lake Kathlyn were composed of silt and sand with several nutrients and metals having low concentrations in most samples. However, lake sediments exceeded the available CCME and BC guidelines for arsenic, cadmium, copper, iron and nickel.

The most dominant stream benthic invertebrate taxonomic group was Diptera, primarily at site BR5b and BR6b. The Kathlyn Lake benthos community was primarily composed of oligochaetes and dipterans. Average density of benthos was lowest at the two Toboggan Creek sites and highest at the Lake Kathlyn site. Among the Bulkley River sites, density was greater at the downstream sites. Genus richness was greatest in the Bulkley River sites.

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1. Introduction

1. Introduction

1.1 INTRODUCTION

The Davidson property is located approximately 9 km northwest of the Town of Smithers in central British Columbia (latitude: 54° 49′ 40.4″ N; longitude: 127° 15′ 31.5″ W) (Figure 1.1-1). The Project footprint is within the Bulkley-Nechako Regional District and the traditional territory of the Wet'suwet'en people.

Blue Pearl Mining Ltd. (Blue Pearl) is proposing to develop the Davidson deposit as an underground mine producing an average of 2,000 metric tonnes of ore per day for 10 years. The scope of the Project includes four main project components: Underground Mine, Mine Site and Loadout, Ore Hauling, and Utilities. The Davidson ore will not be milled on site, but rather hauled to the existing Endako Mine for processing.

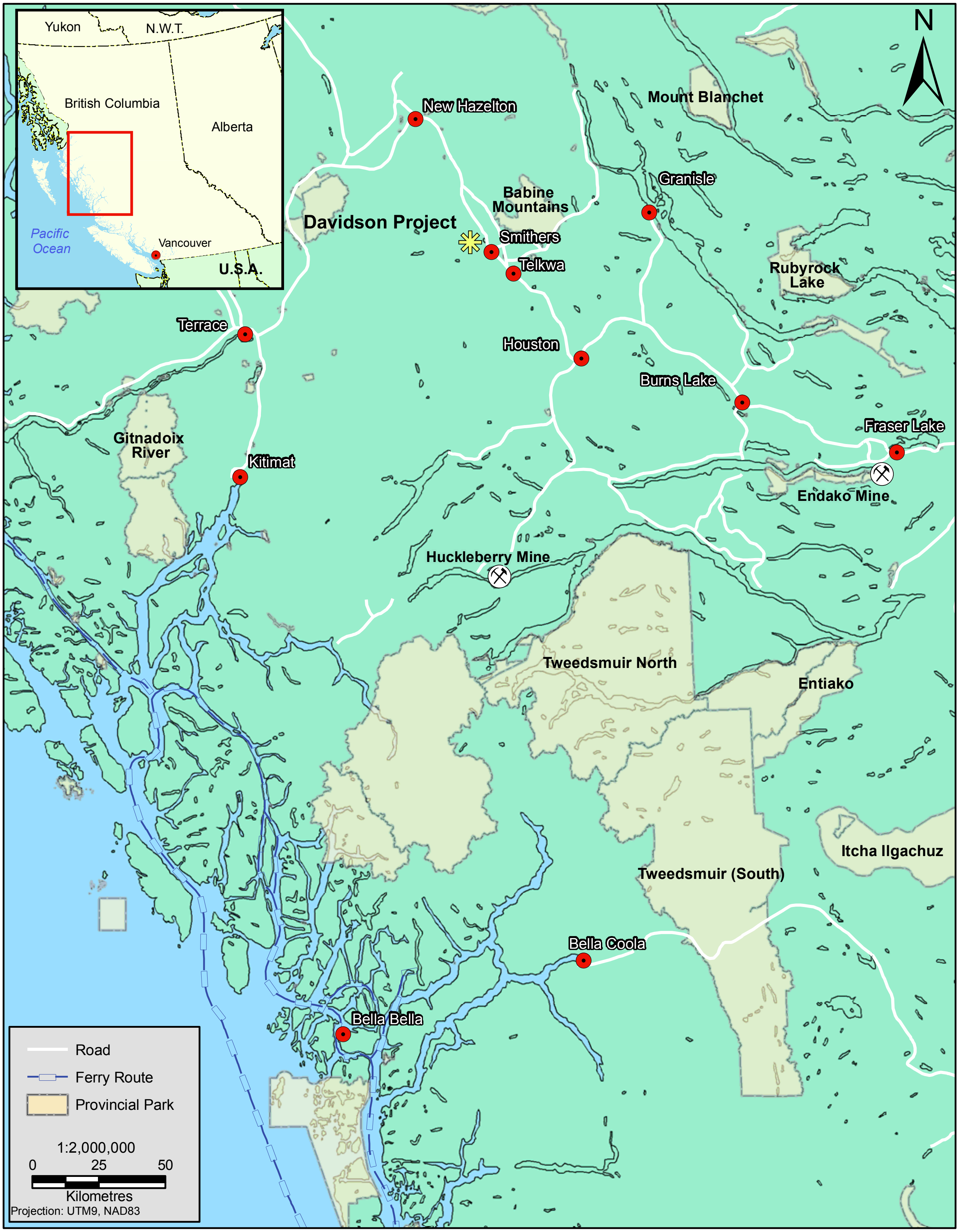
The Davidson Project is unique in terms of mining in British Columbia due to its location relative to the Town of Smithers and to the source of drinking water used by local residents. Seventeen residences and the Smithers Rod and Gun Club are located on Glacier Gulch and Davidson roads, immediately adjacent to the Project area. Many of these residents obtain their drinking water from surface and/or shallow surficial sources within the Kathlyn Creek and Glacier Gulch watersheds. Blue Pearl has made extra effort to ensure minimal impact on water quality.

1.2 STUDY OBJECTIVE

This report describes the surface water quality, sediment quality and benthic invertebrate studies completed in 2008 as well as the water quality studies from 2006 and 2007. These studies are a continuation of the work for monitoring baseline conditions of the receiving environments (Environment Canada 2003). This report describes the following aspects of the aquatic environment:

- ***Water Quality:*** Water samples were analyzed for general physio-chemical variables, anions, nutrients, and total and dissolved metals at 21 stream sites and one lake site. Quality assurance and quality control (QA/QC) steps were taken to minimize contamination of water samples. The water quality data presented in this report include all data available from June 2006 to November 2008. The last summary report of water quality data included data up to June 2006 (Rescan 2006).
- ***Aquatic Toxicity:*** Chronic toxicity tests were conducted for samples from BR3 and BR4 using rainbow trout embryos, spiny waterflea (*Ceriodaphnia dubia*), common duckweed (*Lemna minor*), and a species of green algae (*Pseudokirchneriella Subcapitata*). All toxicity tests were conducted in accordance with procedures described by Environment Canada (1992a, 1992b, 1998, 1999).
- ***Sediment Quality:*** Sediment sampling occurred at seven locations, including four in the Bulkley River, two in Toboggan Creek, and one in Lake Kathlyn. All samples were analysed for moisture, particle size, nutrients, and total metals using the lowest available detection limits. When possible, metals analysis was completed on the size fraction <63 μm when it composed a reasonable proportion of the sample. However, to be consistent with existing data whole sediment samples were analyzed.

- ***Benthic Invertebrate Community:*** Benthic invertebrates were sampled at the same locations as the sediment quality sampling. In addition to Hess sampling, three minute kick net samples were also be collected at the Bulkley River sites. Benthic invertebrate density, genus richness, diversity, and similarity to reference stations (Bray-Curtis Index) were determined.



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Davidson Project General Location

FIGURE 1.1-1

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2. Materials and Methods

2. Materials and Methods

2.1 SAMPLING STATIONS

Figure 2.1-1 shows the location of all sampling sites and sampling components. Water quality was sampled at all sites although the frequency of sampling changed at several sites over time. A previous report on water quality (Rescan 2006) described baseline water quality conditions from 2005 up until June 2006. This report contains available water quality data from July 2006 to November 2008.

Sediment quality and benthic invertebrates (benthos) were sampled at 7 stations (6 streams and 1 lake) within the study area (Table 2.1-1). These studies were conducted in mid-September, 2008. Sampling locations BR5b and BR6b are just downstream and upstream respectively from the corresponding water quality site (BR5 and BR6). The location of these sites was based on suitability for sampling sediment and benthos (i.e., depositional zones with silt/sand substrate and riffle zones) and may change slightly in the future depending on the location suitability as a result of the dynamic nature of the river.

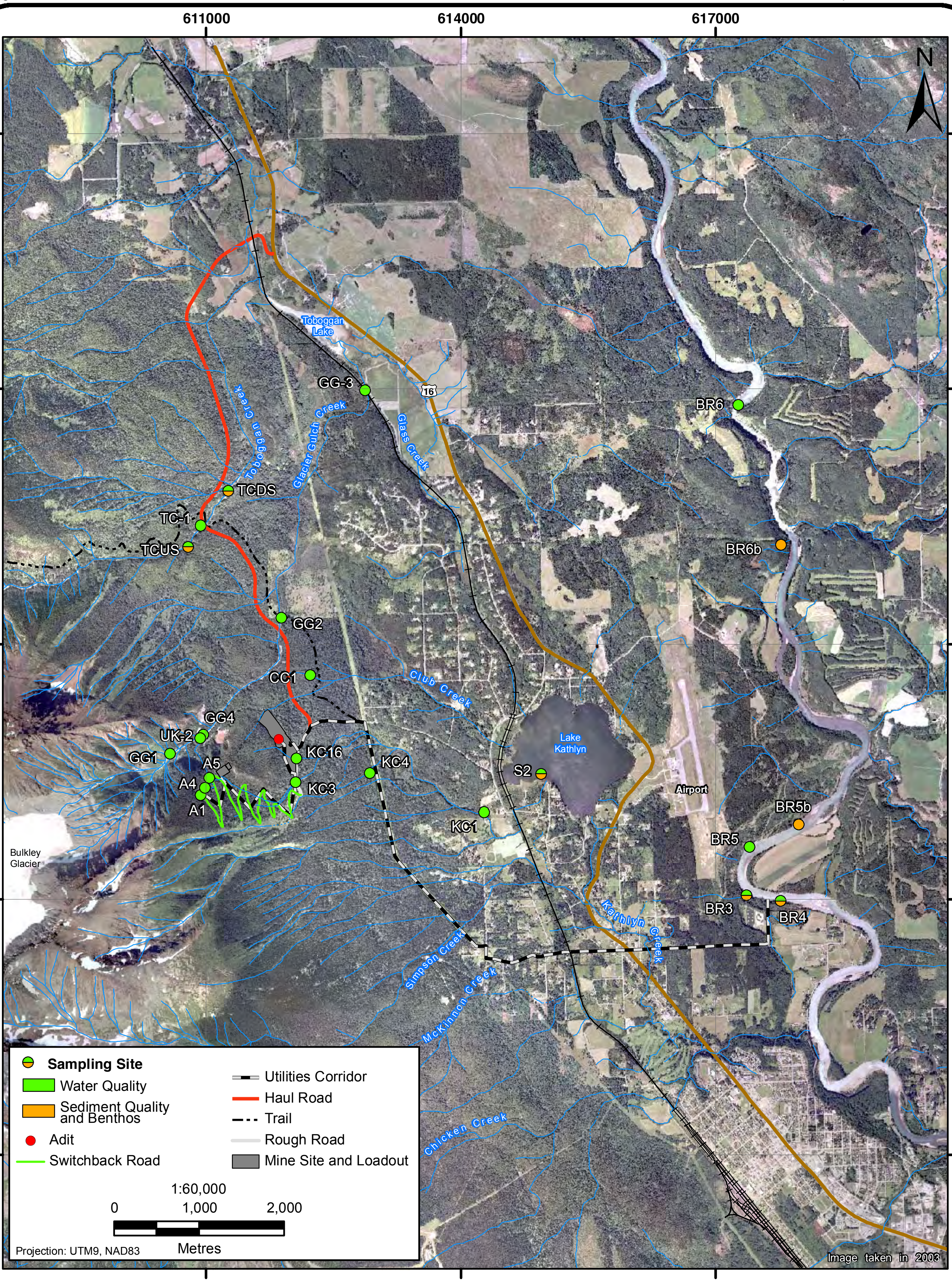
Table 2.1-1. Aquatic Biology and Sediment Sampling Stations in Davidson Study Area, 2008

Station	Location	Easting	Northing
BR3	Bulkley River	617451	6075040
BR4	Bulkley River	617764	6074982
BR5 (water only)	Bulkley River	617401	6075618
BR5b	Bulkley River	617976	6075883
BR6 (water only)	Bulkley River	617401	6075618
BR6b	Bulkley River	617772	6079168
TCUS	Toboggan Creek	610789	6079144
TCDS	Toboggan Creek	611264	6079798
S2	Lake Kathlyn	614944	6076473

2.2 WATER QUALITY

The data presented in this report are from June 2006 to November 2008 sampling of 21 sites. Water was sampled monthly for the majority of the sites. In addition, weekly samples were collected during the fall, freshet, and winter low-flow periods when possible. Water samples were analyzed for general physio-chemical variables, anions, nutrients, and total and dissolved metals.

The report provides baseline water quality data at select sites in five watersheds: Bulkley River, Toboggan Creek, Kathlyn Creek, Glacier Gulch Creek and the Adit watersheds (Figure 2.1-1). Water has been flowing from the 1066 Adit, down the east slope of Hudson Bay Mountain since the 1960's. Glacier Gulch Creek has been identified as the receiving environment for the majority of the water flowing from the 1066 Adit.



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Aquatics Monitoring Locations in the Davidson Project Area

FIGURE 2.1-1

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2.2.1 Sample Collection

One water sample was collected per site per sampling period using standardized methods (RISC 1997). Water samples were analyzed for general physico-chemical variables, anions, nutrients, total organic carbon (TOC), and total and dissolved metals at the lowest feasible detection limit by ALS Laboratory Group of Vancouver.

For each sample, the scientist stood facing upstream and triple-rinsed the bottle and cap prior to filling. Preservatives were added for total metals (ultra-pure nitric acid), and TOC (hydrochloric acid). Precautions were taken to prevent air bubbles in any of the sample bottles.

All field data are presented in appendices (listed in Section 3.1). Variables with guidelines and those that are relevant to potential water quality issues within the Davidson Project area have been presented graphically. The analyzed data were then summarized for each variable by site. Some variables could not be measured reliably below a specified detection limit and are reported by the analytical laboratory as below that detection limit. When required for the purpose of statistical analyses and graphical presentation, these values (called non-detects) were replaced with half of the detection limit.

Data are presented graphically and are plotted with sites grouped as follows:

1. Adit Watershed Group (A1, A4 and A5); Glacier Gulch Creek Watershed Group (GG1, GG2, GG3, GG4, UK2, and CC1)
2. Kathlyn Creek Watershed Group (KC1, KC3, KC4, KC16); Bulkley River and Toboggan Creeks Watershed Group (BR3, BR4, BR5, BR6, TC1, and TCUS, TCDS)

Lake Kathlyn was sampled at S2, the bay where Kathlyn Creek enters the lake. In 2008, this site was sampled twice. The data for S2 are presented in Appendix 3.1-3 and is summarized in the text.

2.2.2 Quality Assurance and Quality Control (QA/QC)

A separate set of bottles for field and travel blanks were included as part of the field QA/QC program. The travel blank bottles were filled with distilled deionised water in the laboratory and remained closed throughout the field trip. This allowed assessment of contamination associated with laboratory procedures. The field blank bottles were also filled with distilled deionised water, but were opened in the field and preserved as required for various analyses. This allowed assessment of contamination associated with field sampling (airborne contamination, contamination of the lid/bottle, etc.) and preservation procedures. All data for field and travel QA/QC are reported in appendices. The frequency of any variable concentration above the method detection limit (MDL) was noted for both travel and field blanks, indicating possible contamination.

For QA/QC purposes, a minimum of 10% of the water samples were randomly collected in duplicate in order to assess the magnitude and potential causes of variability between samples. For each pair of QA/QC field duplicate water samples, the relative percent difference (RPD) was calculated,

where: $$RPD = 100 \,|\, rep1 - rep2 \,|\, / [(rep1 + rep2)/2]$$

The RPD between the duplicates is a measure of the variability inherent in field sampling (environmental heterogeneity, sampler handling leading to contamination). Water quality variables where one or both values were less than five times the MDL were not included in the RPD calculation.

This is because variability near the MDL is too high, according to the BC Field Sampling Manual (BCMOE 2004). Also, RPD values less than 20% were not considered notable. The BC provincial government suggests that any field duplicates with RPD values exceeding 20% should be noted and data should be interpreted accordingly. The results of RPD calculations were examined in order to detect patterns of high variation for multiple variables within sample pairs, indicating possible contamination during field sampling.

Analyses were conducted using the lowest possible detection limit. For some samples, detection limits were greater due to interference from high conductivity, high TSS, or a high metal value. These samples need to be diluted and the result is a higher detection limit.

2.2.3 Water Quality Guidelines

Due to the diversity of water use and resource availability in the Davidson Project area a variety of provincial (BC) and national water quality guidelines and regulations were consulted. Each authority does not have a comprehensive list of all water quality variables and associated guidelines, thus the baseline report includes regulations and guidelines from multiple sources; the Metal Mining Effluent Regulations (MMER) for end-of-pipe discharge levels, Canadian Council of Ministers of the Environment (CCME) Freshwater Quality Guidelines for Protection of Aquatic Life, BC and Health Canada Drinking Water guidelines and the BC Water Quality Guidelines for the Protection of Aquatic Life. It is important to keep in mind that although some samples exceed one, or more, of these water quality guidelines, these results represent the baseline conditions of the receiving environment prior to development of the proposed Davidson Project.

Each figure presented in Section 3.1 contains a list of all applicable water quality guidelines. In some instances hardness-specific guidelines were calculated and reported in the text. The hardness-specific guidelines were most often required for BC and CCME guidelines for the Protection of Aquatic Life.

The CCME water quality guidelines were developed for major water uses and have received international recognition by the United Nations and the World Health Organization. The guidelines are science based and the Aquatic Life water use category represents numerical values which are intended to protect the most vulnerable organisms from potential chronic and/or acute toxic effects (CCME 1999).

The BC water quality guidelines for the Protection of Aquatic Life are often similar to the CCME guidelines, although some province specific guidelines have been developed, notably for molybdenum. The BC maximum guidelines are used since they apply to single grab samples, which was primarily the case for the sampling program.

BC Drinking Water guidelines were also consulted and are divided into two categories. The aesthetic objectives are intended to ensure water users have water that tastes, looks, and smells good. Health based guidelines are often higher than aquatic life guidelines because aquatic life guidelines are designed to protect the most vulnerable aquatic species.

MMER provide numerical values for the allowable levels of total suspended solid (TSS), five metals and cyanide. The regulations are intended for end-of-pipe discharge. The MMER guidelines appear with baseline water quality results to aid in the development of water quality discharge scenarios for the mine. In many cases these are not discussed in detail since they are much higher than the concentrations in natural waters.

2.3 AQUATIC TOXICITY

Aquatic toxicity testing was conducted using water samples from two sites (BR3 and BR4) along the Bulkley River collected on October 27, 2008 (Figure 2.1-1). Four standardized tests were used, including a fish, an invertebrate, an aquatic floating plant, and an alga (Environment Canada 1998; Environment Canada 1992a; Environment Canada 1999; Environment Canada 1992b; Plate 2.3-1). The tests listed as sublethal toxicity effluent monitoring requirements under Metal Mining Effluent Regulations (MMER). These were selected in order to provide a comprehensive assessment of baseline toxicity to the various trophic levels residing in the Bulkley River receiving environment. The use of these tests in baseline studies will serve to better assess water quality because toxicity bioassays link environmental chemistry to biological response.

Green Algae (*Pseudokirchneriella subcapitata*)

Duckweed (*Lemna minor*)

Spiny Waterflea (*Ceriodaphnia dubia*)

Rainbow trout (*Oncorhynchus mykiss)*

Plate 2.3-1. Four toxicity test species used in assessing receiving environment water toxicity, October 2008.

These tests included the:

1. 7-d rainbow trout (*Oncorhynchus mykiss)* embryo viability bioassay;
2. 7-d *Ceriodaphnia dubia* survival and reproduction bioassay;
3. 7-d *Lemna minor* growth inhibition bioassay; and
4. 72-h *Pseudokirchneriella subcapitata* growth inhibition (formerly identified as *Selenastrum capricornutum*).

All water for toxicity testing was collected in clean plastic containers and stored in cool and dark environment for storage and shipping to the Nautilus Environmental laboratory in Burnaby, BC The holding time for these tests is only three days therefore samples were rush delivered to laboratories. All bioassays incorporated several QA/QC measures based on standard test methods. These include controlled test growth within defined limits, controlled feeding (some tests, see below), and use of both negative controls (0% test water concentration) and positive controls (spiked water to measure response, required to be within standardized ranges).

2.3.1 *Oncorhynchus mykiss* Embryo Bioassay

The 7-d rainbow trout embryo viability test required 140 L of test water per site. The test was static with daily water renewal, with four replicates of 30 embryos per test chamber. A total of five test concentrations (plus control) were used including 0, 6.25, 12.5, 25, 50, and 100% test water/control water by volume. The test endpoint was embryo survival, assessed daily, and reported as EC_{25} and EC_{50} values. (EC_{25} is the concentration of test water required to cause an effect in 25% of the fish tested; EC_{50} is the concentration required to cause effects in half the fish tested).

2.3.2 *Ceriodaphnia dubia* Test

The 7-d invertebrate bioassay uses serial dilutions of test waters, with concentrations of 0, 1.6, 3.1, 6.25, 12.5, 25, 50, and 100% test water/control water by volume. The control water consisted of 20% dilute Perrier™ mineral water with filtered de-chlorinated tap water. Tests were static (no flow-through) with renewal at set intervals, following a standard protocol which included standards for test organism health and feeding. The tests used one <24 h old neonate per replicate chamber, with 10 replicates per treatment (Environment Canada 1992a). Test endpoints included both adult survival, expressed as LC_{50} and reproduction (based on numbers of young produced per female). (LC_{50} is the concentration of test water related to lethality in 50% of the test organisms). The reproduction endpoint was reported using the IC_{25} statistic (inhibitory concentration of test water required to cause a 25% reduction in a measurement endpoint – the number of young produced by each female in this case).

2.3.3 *Lemna minor* Bioassay

The 7-d duckweed growth inhibition bioassay used serial dilutions of test waters, with seven concentrations (plus control) including 0, 1.5, 3, 6.1, 12.1, 24.3, 48.5, and 97% test water/control water by volume. Concentrations are slightly lower than concentrations in other bioassays due to the addition of dissolved nutrient solution for all test chambers. Control water was APHA (American Public Health Association) test medium. Standardized test organism health and test validity standards were used throughout the tests. Endpoints to assess growth inhibition included both the number of fronds (new leaves) produced as well as biomass (expressed as plant dry weight), relative to control. Endpoints are expressed as IC_{25} and IC_{50}.

2.3.4 *Pseudokirchneriella subcapitata* Bioassay

This test species was previously named *Selenastrum capricornutum*. The 72-h green algae growth inhibition bioassay uses serial dilutions of test waters, with concentrations of 0, 1.48, 2.95, 5.9, 11.9, 23.8, 47.6, and 95.2% test water/control water by volume. Concentrations are slightly lower than concentrations in other bioassays due to the addition of dissolved nutrient solution for all test chambers. All test and control waters were filtered through a 1 μm glass filter paper prior to test initiation, according to the recommended procedures to reduce possible contamination with algae during testing which would compete for nutrients with test algae. This also removed all particulates greater than 1 μm in diameter, therefore most particulate-bound metals were removed. The control water consisted of distilled water supplemented with nutrients including EDTA. This was a static test, using standards for test organism health, test validity, and positive controls. It used four replicates per treatment, and eight replicates for control group. The test endpoint was algal growth inhibition (based on cell yield) relative to negative control, expressed as IC_{25} and IC_{50}.

2.4 SEDIMENT QUALITY

Stream sediment samples were collected in triplicate from seven stations where each replicate sample was composed of a composite of three sub-samples. Sediment was collected from depositional areas using a stainless steel spoon and bowl. Each sample was manually homogenized for at least one minute. Samples were analyzed for nutrients, total cyanide, total metals, total organic carbon, and particle size using standard methods by ALS Environmental, Vancouver, BC. A full list of the variables analyzed, and their general detection limits are presented in Table 2.4-1.

Table 2.4-1. Sediment Quality Variables and Detection Limits

Variable	Detection Limits (mg/kg Dry Weight)
Physical Tests	
Moisture	0.10%
Grain Size	na
Nutrient/Inorganic/Organic Variables	
Available Phosphorus	1
Total Nitrogen	0.01%
Total Organic Carbon	0.01%
Cyanides	
Total Cyanide	3
Total Metals (mg/kg)	
Aluminum	50
Antimony	20
Arsenic	0.5
Barium	1
Beryllium	0.5
Bismuth	20
Cadmium	0.5
Calcium	50
Chromium	2
Cobalt	2
Copper	1
Iron	50

(continued)

Table 2.4-1. Sediment Quality Variables and Detection Limits (completed)

Variable	Detection Limits (mg/kg Dry Weight)
Total Metals (mg/kg) (continued)	
Lead	2
Lithium	2
Magnesium	50
Manganese	1
Mercury	0.005
Molybdenum	4
Nickel	5
Phosphorus	50
Potassium	200
Selenium	2
Silver	2
Strontium	0.5
Thallium	1
Tin	5
Titanium	1
Vanadium	2
Zinc	1

Total metal concentrations from each sampling station were compared to provincial and federal guidelines (Table 2.4-2). Sediment Quality Guidelines (SQG) include the provincial guidelines lowest effect level (LEL) and severe effect level (SEL) and the federal SQGs, many of which are adapted provincially, interim sediment quality guidelines (ISQG) and the probable effect level (PEL) above which adverse effects are expected to occur frequently (CCME 1999, BCMOE 2006).

2.5 BENTHIC INVERTEBRATES

Stream benthic invertebrate (benthos) samples were collected from six stream stations in the study area (Table 2.1-1). Sampling methods followed BC Provincial standards (RISC 1997). Benthic invertebrate communities were sampled at all stream sites concurrently with water and sediment samples in September, 2008.

Five composite benthic samples were collected using a Hess sampler with a surface area of 0.096 m^2 and a mesh size of 500 µm. For each stream subsample, the Hess sampler was driven at least 10 cm into the sediment of an undisturbed riffle zone, facing upstream with the cod-end trailing downstream. Larger gravel and rocks inside the sampler were carefully cleaned of dirt and debris (washed into the sampler area water) and discarded. The sediment was then stirred, scrubbed, and raised up and dropped inside the Hess sampler for one minute, allowing the stream current to wash benthos into the cod-end. The mesh of the sampler was carefully washed and rinsed into the cod-end to capture all benthos contained in the sampler area. Once the three subsamples were collected, all contents were then carefully transferred to a clean 500 mL, pre-labelled plastic jar which was then filled with 10% buffered formalin. Replicate samples were preserved separately in plastic jars.

Kick net samples were also collected at the four sites on the Bulkley River using the CABIN protocol (Environment Canada 2001). Each timed kick-net sample was placed in a 500 mL jar and preserved with 10% buffered formalin.

Table 2.4-2. Provincial and Federal Sediment Quality Guidelines

	Canadian Sediment Quality Guideline*		BC Provincial Sediment Quality Guideline**	
Parameter	ISQG	PEL	LEL	SEL
Arsenic	5.9	17	n/a	n/a
Cadmium	0.6	3.5	n/a	n/a
Chromium	37	90	n/a	n/a
Copper	36	197	n/a	n/a
Iron	n/a	n/a	21,200	43,766
Lead	35	91	n/a	n/a
Nickel	n/a	n/a	16	75
Zinc	123	315	n/a	n/a

Notes:
all units are mg/kg.
ISQG = interim sediment quality guideline or threshold effects level.
PEL = probable effects level.
LEL = lowest effects level.
SEL = severe effects level.
**CCME, 1999.*
***BCMOE 206.*
n/a: no applicable guideline.

Benthic invertebrate samples were collected in Lake Kathlyn (S2) at a depth of one to two meters where the mouth of Kathlyn Creek empties into the lake. An Ekman grab sampler was used to collect three subsamples per replicate. Sediments were sieved through a 500 µm mesh, transferred to 500 mL jars, and preserved with formalin to a final concentration of 10%.

Taxonomic identification and enumeration was conducted by Biologica Environmental Services (Victoria, BC). Invertebrates were sorted and identified to the lowest possible taxonomic level (usually genus). Density (as organisms/m for Hess samples and total density for kick-net samples), genus richness, evenness, diversity and Bray-Curtis Similarity indices were calculated. Richness of Ephemeroptera/ Plecoptera/Trichoptera (EPT), which are three important taxonomic groups usually associated with pristine stream environments, was also calculated for stream sites. Their constant exposure to substrate and potential contaminants make benthic invertebrates important indicators of aquatic impacts and are therefore an important feature of aquatic environmental effects monitoring programs (Environment Canada 2003).

2.6 DATA ANALYSIS

The number of organisms per sample was converted to density (organisms/m^2 for benthos, organisms/m^3 for zooplankton, and cells/L for phytoplankton) by dividing each sample by the area sampled and calculating the mean of all replicates. All graphically represented data and the calculation of means and standard errors were produced using SigmaPlot software (SYSTAT 2006). Means and standard errors were graphically represented. Genus richness, diversity indices and Bray-Curtis Similarity were calculated using Primer (Clark and Gorley 2006). The results presented from the Bray-Curtis analysis are similarity values, not dissimilarity values, since similarity is interpreted more intuitively. Richness is defined as the number of separate genera present in a sample. In assessing genus richness multiple species of the same genus were pooled together. For sites where the available data only occurred at higher taxonomic levels (e.g., Family or Order), a single genus was considered to be present in the sample.

3. Results and Discussion

3. Results and Discussion

3.1 WATER QUALITY

Watershed groups (WG) were identified to simplify how the water quality data were presented and are based on naturally occurring topographic conditions or relevance to the proposed Davidson Project. As described in Section 2.2.1, these WG include the Adit WG, Glacier Gulch Creek WG, the Kathlyn Creek WG and the Bulkley River and Toboggan Creeks WG. All water quality data are available in Appendices 3.1-1 (2006 data), 3.1-2 (2007 data) and 3.1-3 (2008 data). Summary data of each watershed group including minimum, maximum, mean, and median values are available in Appendix 3.1-4. Data from one site on Simpson's Creek (SC2; see Rescan 2006) is included in Appendix 3.1-4 but not in the discussion or figures below as it was only sampled in June, July and August of 2006. This site was originally chosen as a reference site for assessing stream variation over time.

Results are not presented for a variable below the detection limit in more than 50% of the samples at a particular site. This is most noticeable in the discussion of total metal concentrations where a figure and discussion are often provided for the Adit and Glacier Gulch sites but not the Kathlyn Creek, Bulkley River and Toboggan Creek sites as concentrations were regularly below detection limits.

Where results were available for more than one date per month (from either weekly freshet sampling or some overlap in monthly sampling), the monthly average values were presented in the figures below. The discrete results and the calculated averages are discussed in the text.

3.1.1 Streams

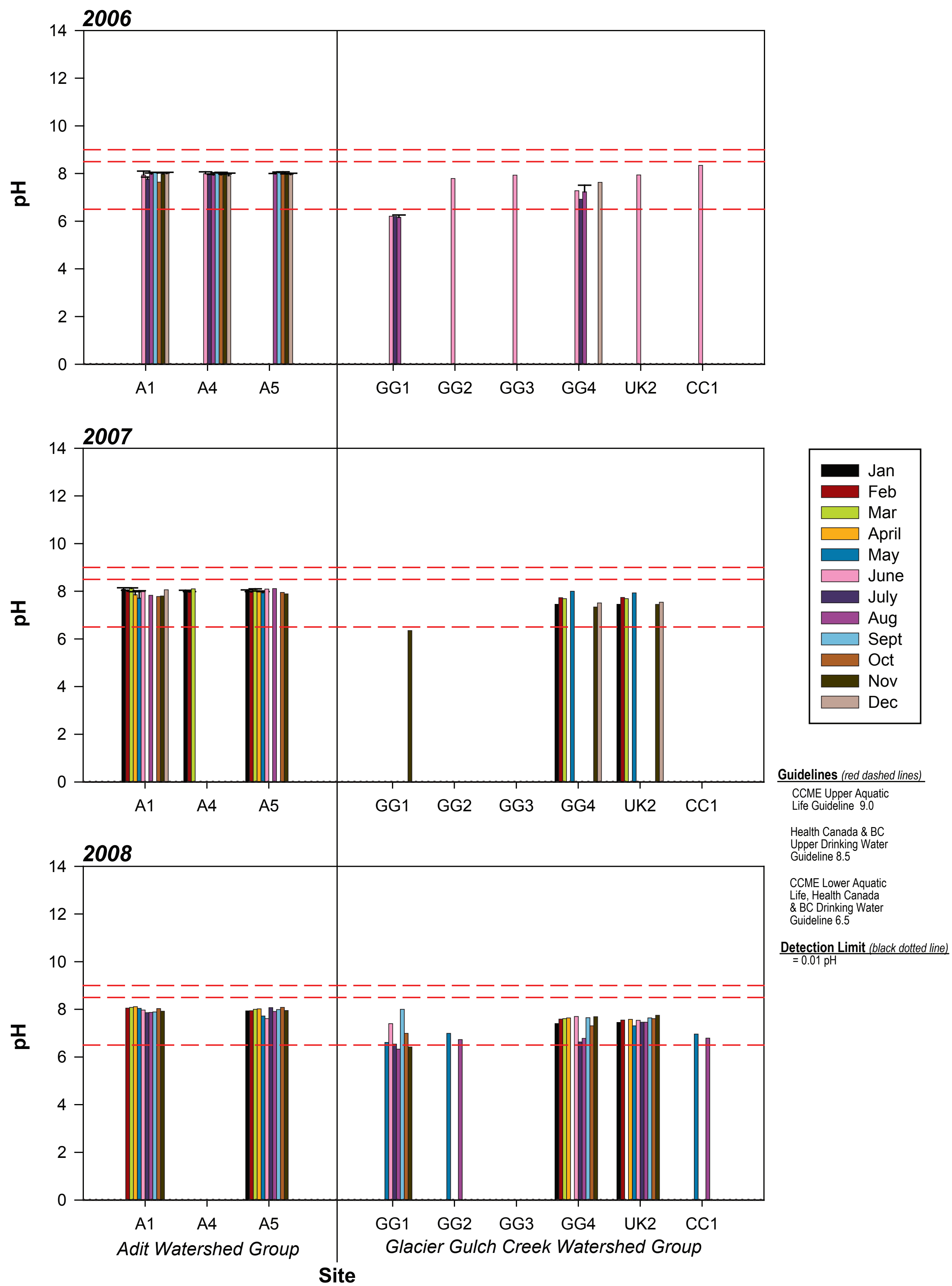
Many physical parameters and total metals had their highest concentrations within the Adit WG. These concentrations are a result of the mineralized water flowing out the historic adit (A1). Water then flows through the historic waste rock dump, along a ditch at the base of the dump past stations A4 and A5, then down a slope into the Glacier Gulch WG to UK2 and GG4. This contribution from the Adit WG elevates levels observed at UK2 and GG4 compared with both upstream (GG1) and downstream (GG2 and GG3) stations on Glacier Gulch Creek. No data are available for the Kathlyn Creek or the Toboggan Creek sites during 2007.

3.1.1.1 Physical Variables and Nutrients

Generally, study area streams were similar and near neutral to slightly alkaline in pH, with all but one site (GG1), consistently falling within CCME Aquatic Life guidelines of 6.5 to 9 (Figures 3.1-1 and 3.1-2). Site GG1 had pH values frequently below 6.5, ranging from 6.07 (on Aug 21, 2006) to 8.00 (September, 2008).

Total suspended solids (TSS) were variable over time with many samples close to or below the detection limit of 3 mg/L (Figures 3.1-3 and 3.1-4). The highest concentrations occurred during spring at A1 and the Bulkley River sites (between 150 and 200 mg/L).

Turbidity, a measure of water cloudiness, showed high variability between sampling dates, sites, and years (Figures 3.1-5 and 3.1-6). Turbidity samples were greatest at GG1 (69.5 NTU) in 2006, A1 (283 NTU) in 2007 and BR6 (75.9 NTU) in 2008. In 2006 and 2008 each watershed group (WG) possessed at least one site with a turbidity sample > 10 NTU, but in 2007 turbidity was >10 NTU at A1 and A5 (one



Note: Error bars represent standard error of the mean.

FIGURE 3.1-1

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pH in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

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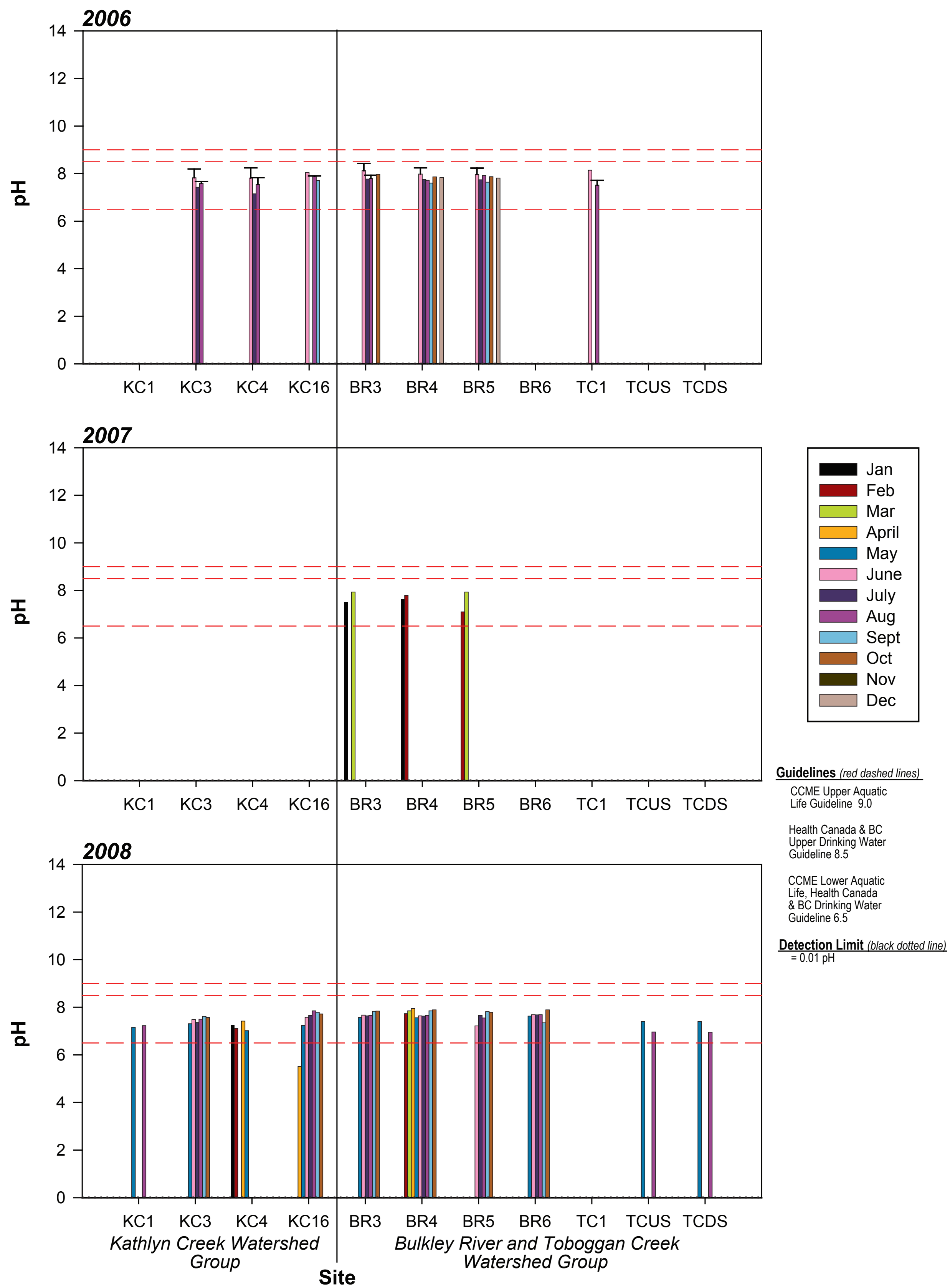


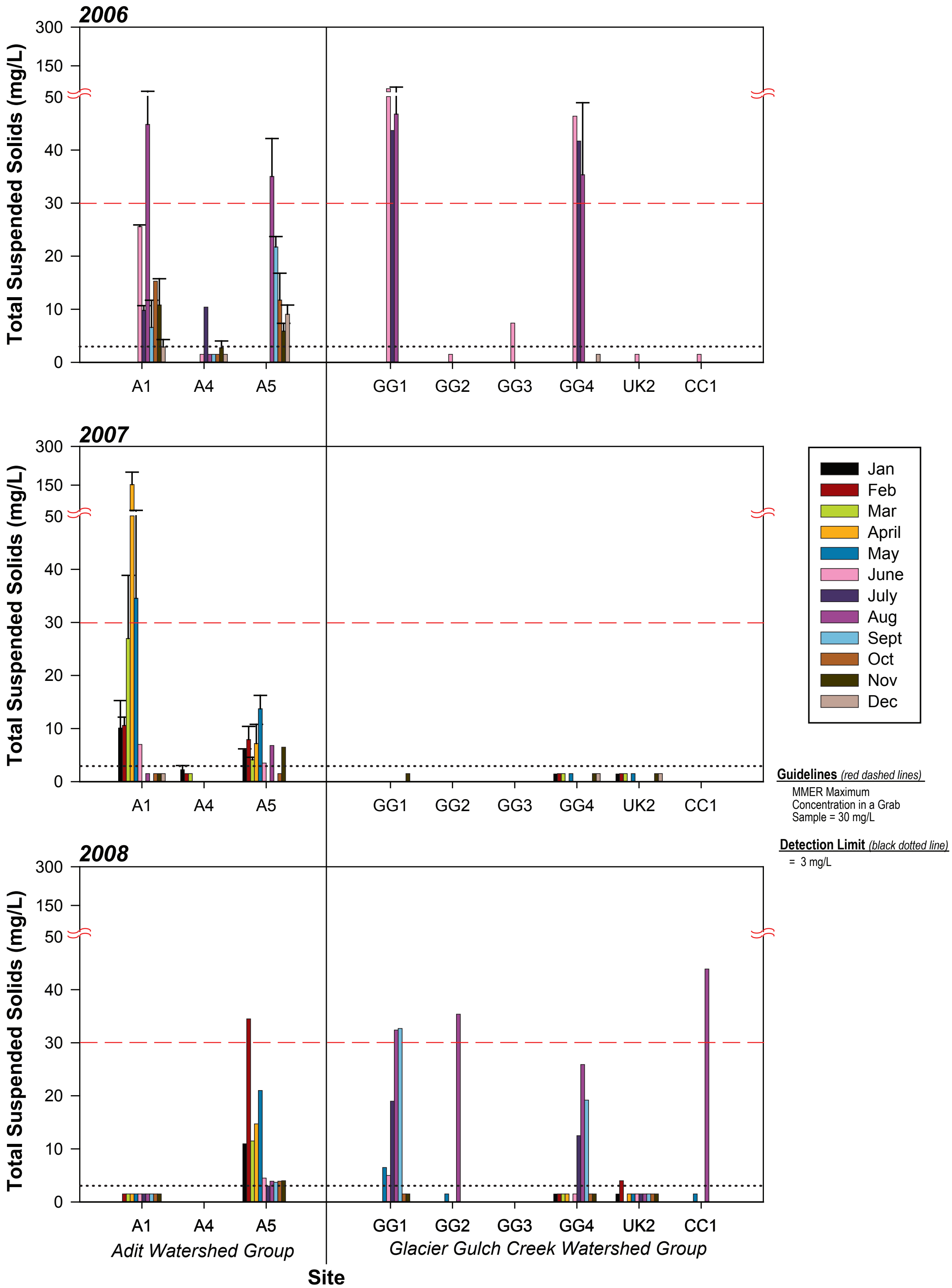
Note: Error bars represent standard error of the mean.

BLUE PEARL MINING

FIGURE 3.1-2

pH in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

Rescan™



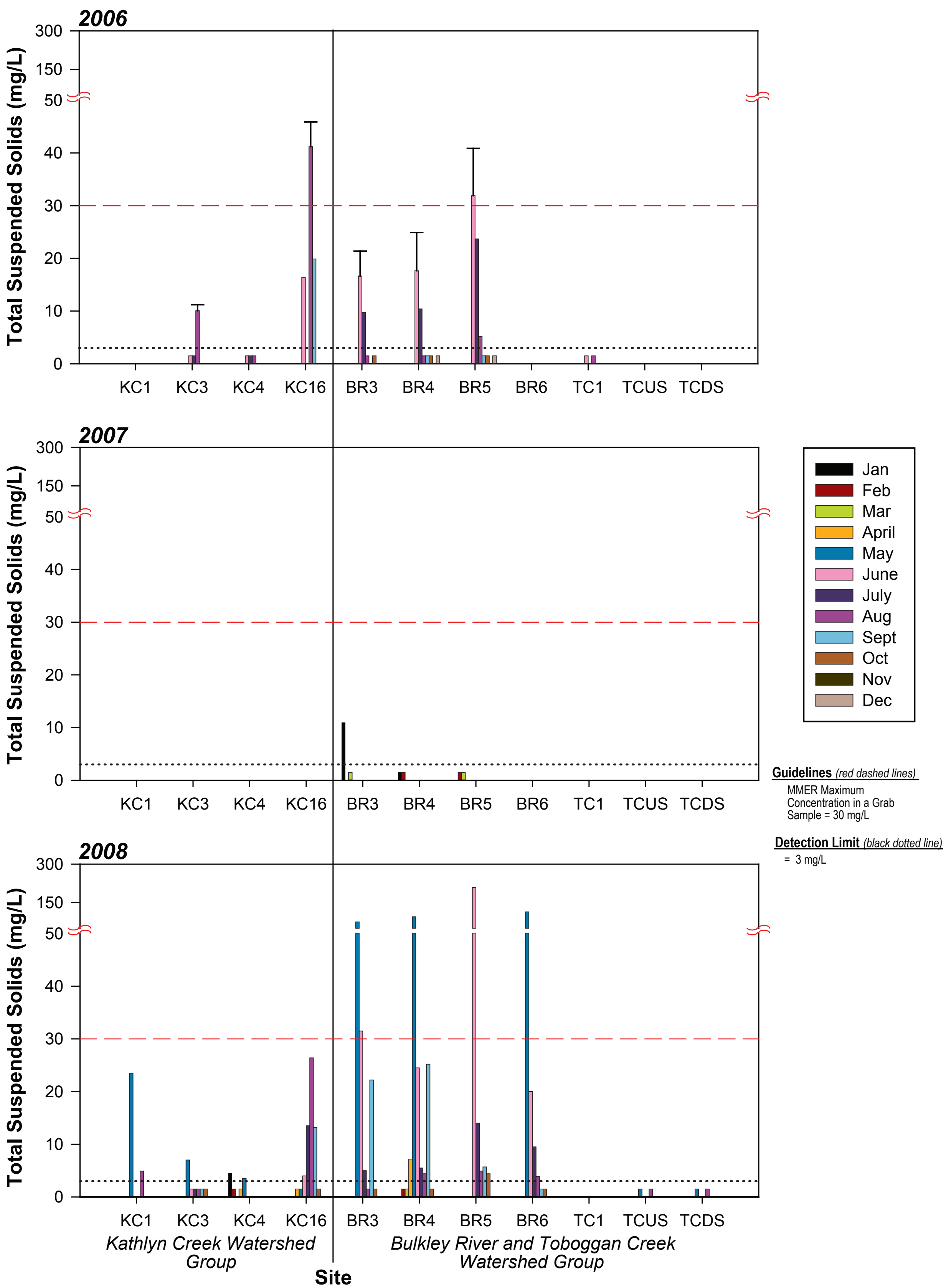
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

FIGURE 3.1-3

Total Suspended Solid in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

Rescan™



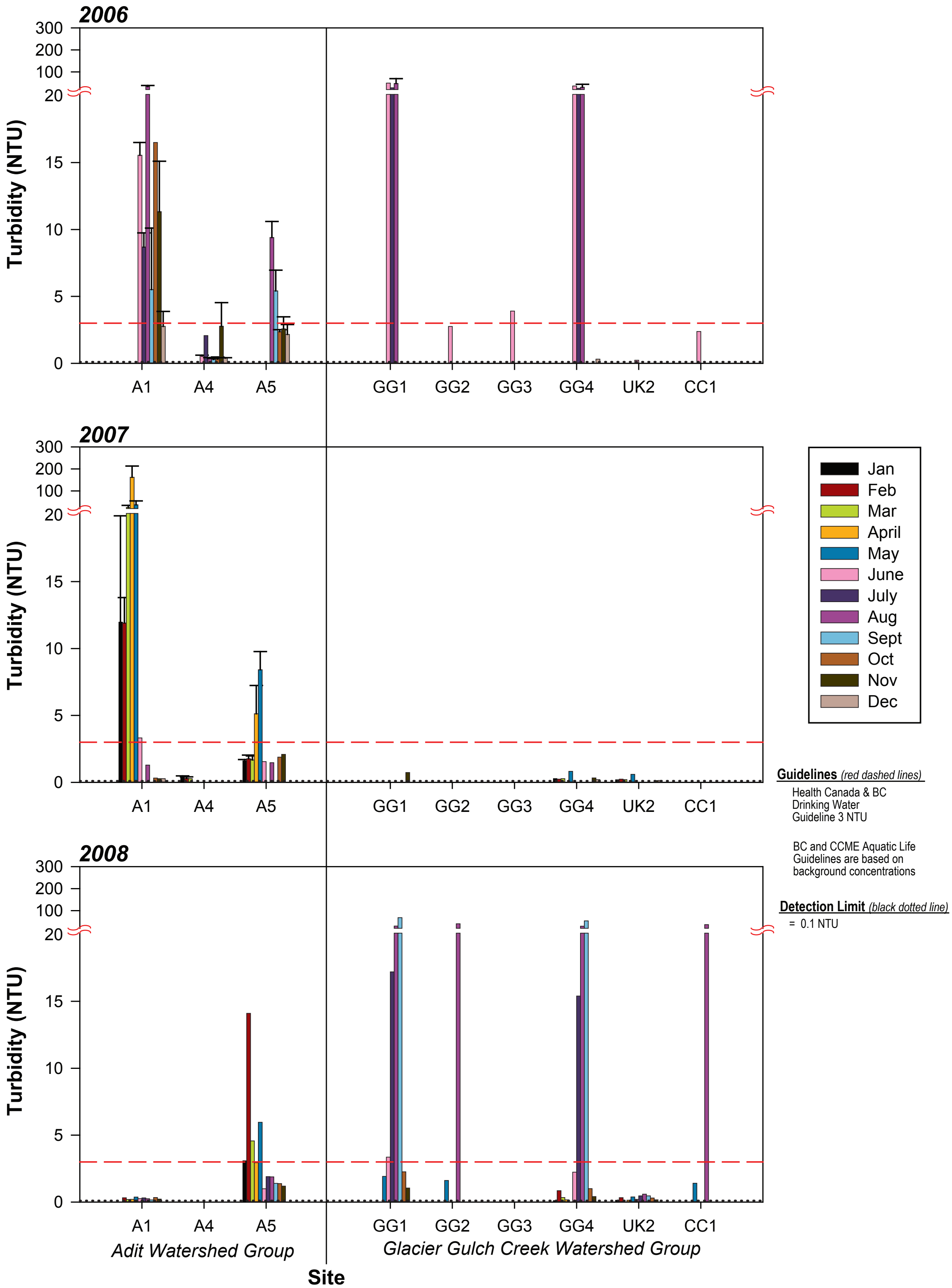
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

Total Suspended Solids in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

FIGURE 3.1-4

Rescan™



Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

FIGURE 3.1-5

Turbidity in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

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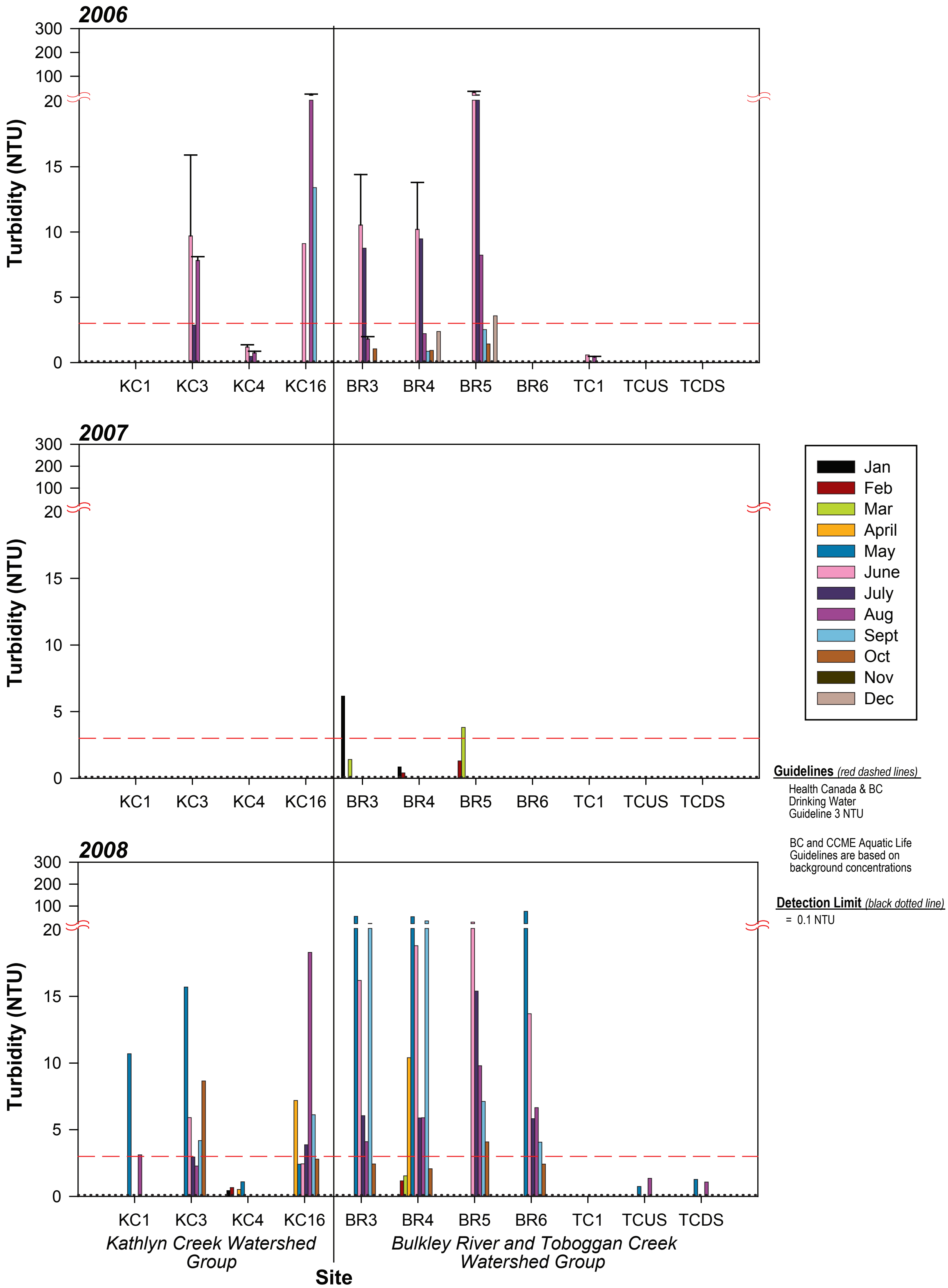

Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

FIGURE 3.1-6

BLUE PEARL MINING

Turbidity in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

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sample) within the Adit WG and remained <5 NTU at other sites. Turbidity frequently exceeded Health Canada and BC drinking water guidelines of 3 NTU at most sites at some point over the three years examined. BC and CCME aquatic life turbidity guidelines are based on deviations from background (baseline) levels.

In all years, total dissolved solid (TDS) concentrations were notably highest within the Adit WG (Figures 3.1-7 and 3.1-8). Adit annual watershed averages ranged from 310 mg/L in 2006, to 234 mg/L in 2007, to 291 mg/L in 2008 and TDS concentrations were relatively consistent over time. Neighbouring sites GG4 and UK2 possessed the highest TDS values (most notably occurring in 2007 and 2008) observed outside of the Adit WG. No TDS concentrations exceeded the Health Canada and BC drinking water guideline of 500 mg/L.

Hardness fluctuated in a similar manner to that seen for TDS (Figures 3.1-9 and 3.1-10). Hardness was consistently four to five times higher in the Adit WG (generally ranging between 200 and 250 mg/L as $CaCO_3$) than most sites. Other sites, except GG4 and UK2, generally had concentrations below 50 mg/L as $CaCO_3$. No BC or CCME guidelines for aquatic life exist for hardness.

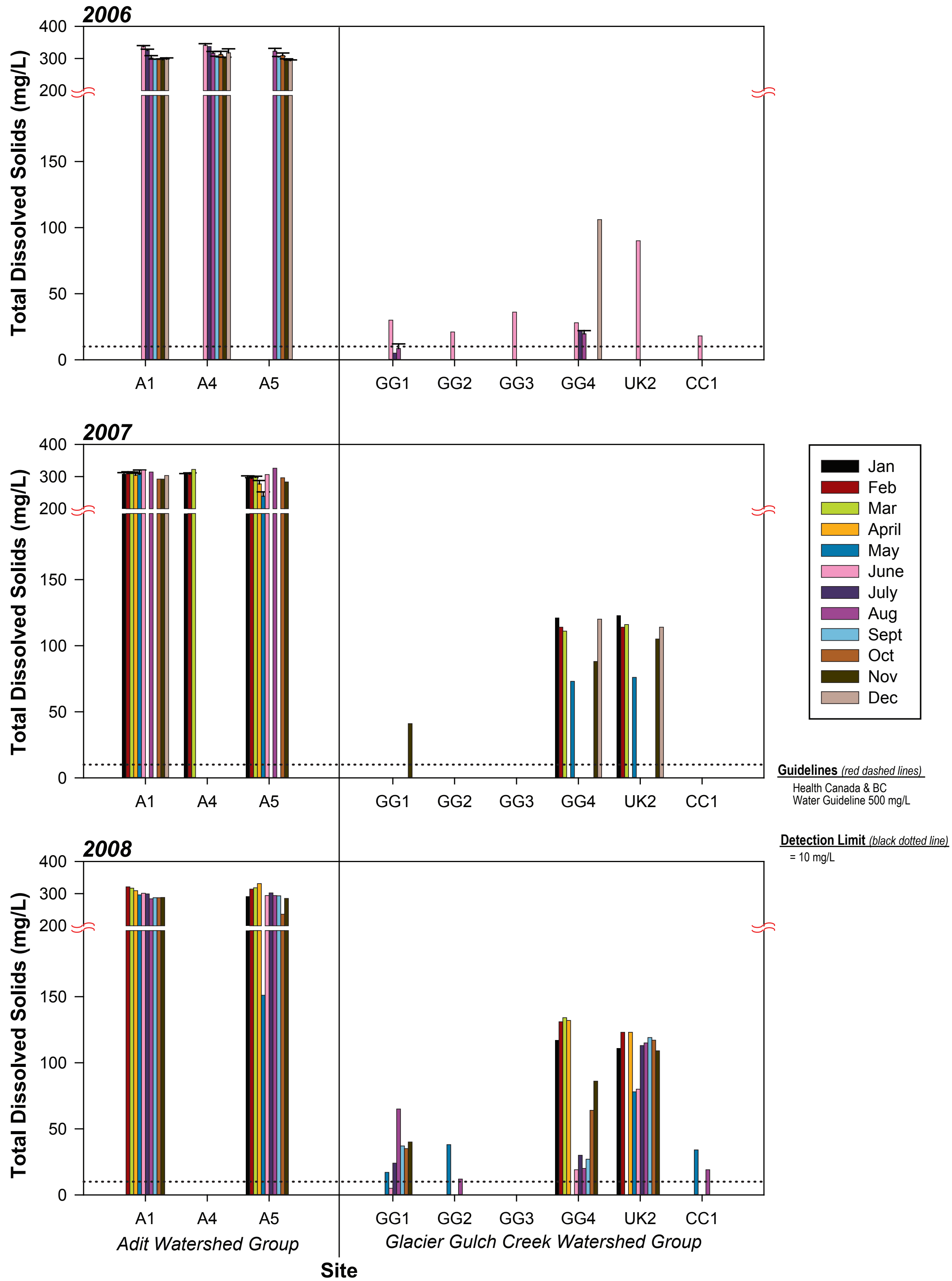
With the exception of the Adit WG, chloride concentrations were generally below, or near the detection limit of 0.5 mg/L (Figures 3.1-11 and 3.1-12). In the Adit WG, chloride concentrations were highest in 2006 (4.35 mg/L at A1, November), with average values generally ranging between 2 and 4 mg/L over the three sample years. Chloride concentrations were not considerably different between years at all sites, although slight seasonal peaks (spring and fall high flow periods) were observed. Chloride concentrations remained < 5 mg/L at all sites, well below the Health Canada and BC drinking water guidelines (250 mg/L).

Patterns of fluoride concentration fluctuations were similar to those observed for TDS, although at much lower values (Figures 3.1-13 and 3.1-14). Fluoride concentrations were consistently highest within the Adit WG (between 1.0 and 1.5 mg/L). All other sites had concentrations <0.02 mg/L over the three sample years. Some samples from the Adit WG came very close but never exceeded Health Canada and BC drinking water guideline of 1.5 mg/L. Fluoride concentrations regularly exceeded the calculated BC Maximum guideline for the protection of aquatic life.

Sulphate concentrations were consistently below 20 mg/L at the Kathlyn Creek, Bulkley River and Toboggan Creek WGs (Figures 3.1-15 and 3.1-16). In each sample year, the Adit WG had the highest sulphate concentrations with most average values between 120 and 160 mg/L. Samples from GG4 and UK2 also had relatively high concentrations during low flow periods (November to March). Sites from the Adit WG regularly exceeded the BC Maximum guideline of 100 mg/L. All samples were well below the Health Canada and BC drinking water guideline of 500 mg/L.

Total phosphate (TP) concentrations were highly variable among sites and over time (Figures 3.1-17 and 3.1-18) with no clear trends. Although most samples ranged between the detection limit (0.002 mg/L) and 0.04 mg/L each year, several sites had samples with TP concentrations greater than 0.06 mg/L (A1, A5, KC16, BR3, BR4 and BR6). The timing of these higher concentrations at the Adit and Bulkley River sites correspond to spring freshet (April and May).

Although some sites showed higher nitrate concentrations in 2008 than previous years (primarily in the Bulkley River WG) concentrations were variable among watershed groups and years (Figures 3.1-19 and 3.1-20). The greatest average nitrate concentration was seen at A5 (2.4 mg/L) in 2006. All sites had average concentrations below the CCME aquatic life guideline (2.9 mg/L), and the Health Canada and BC drinking water guidelines (45 mg/L and 10 mg/L, respectively).



Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

FIGURE 3.1-7

BLUE PEARL MINING

Total Dissolved Solids in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

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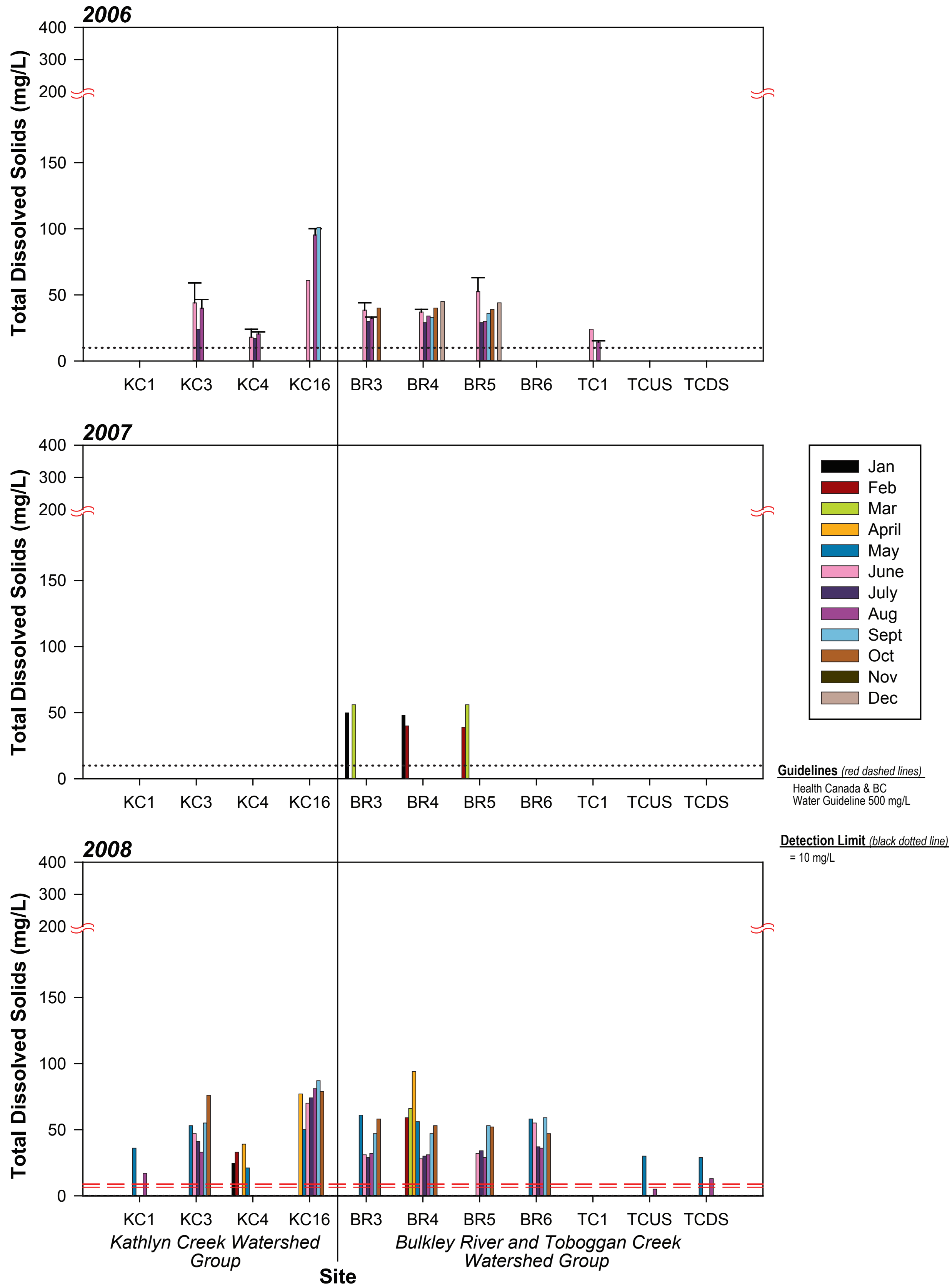


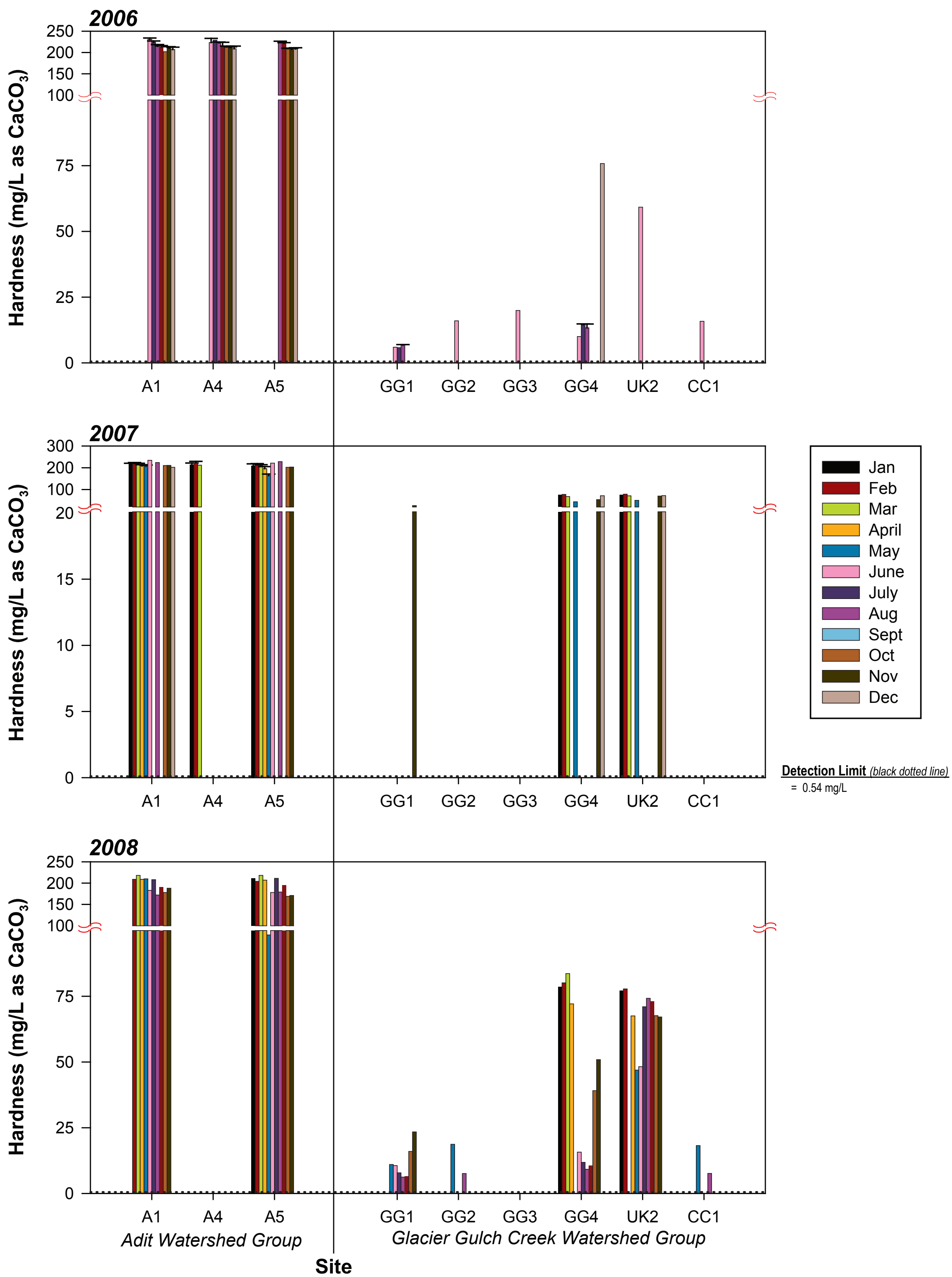
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

Total Dissolved Solids in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

FIGURE 3.1-8

Rescan™



Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

FIGURE 3.1-9

Hardness in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

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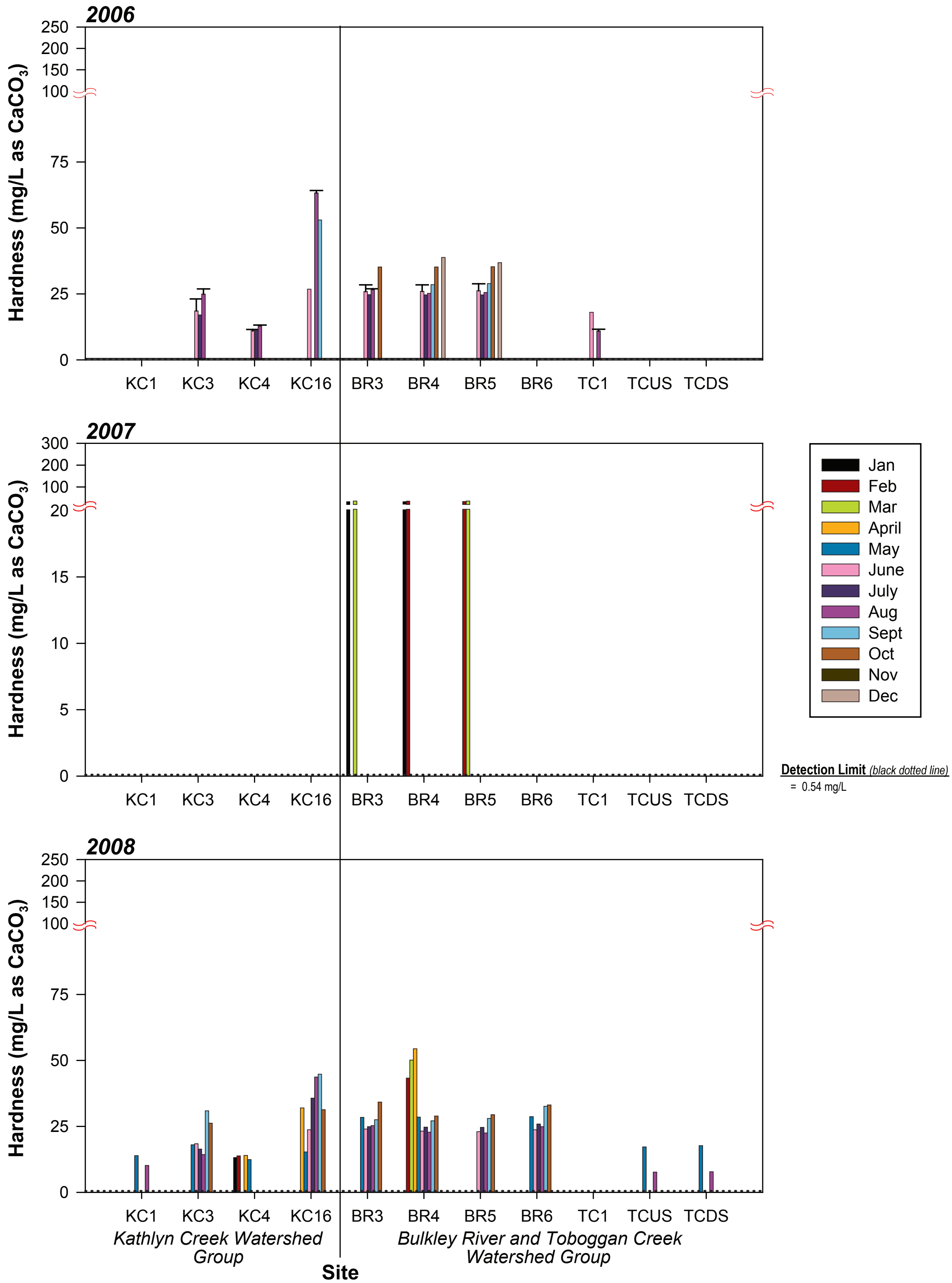

Note: Error bars represent standard error of the mean.
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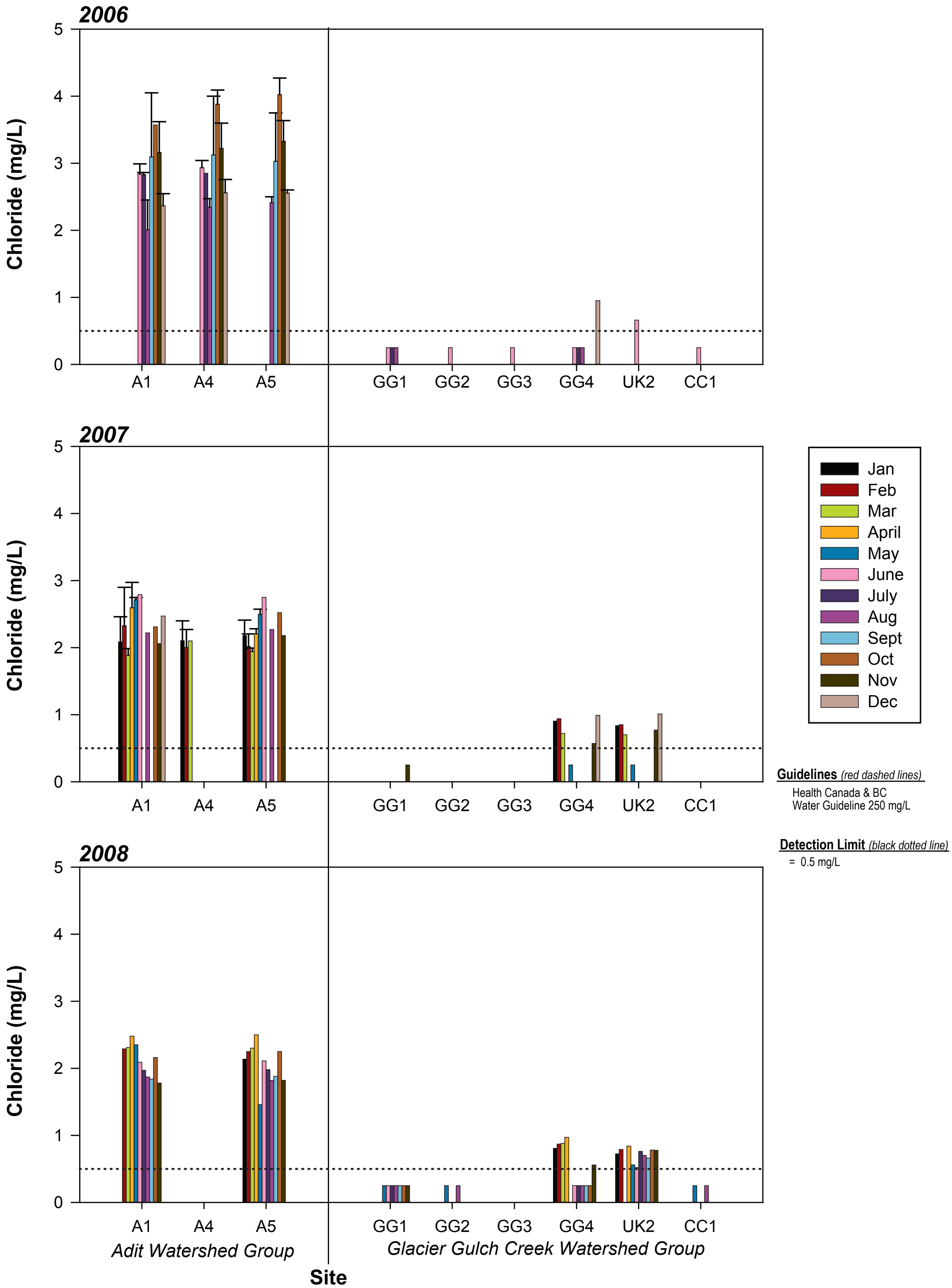
BLUE PEARL MINING

FIGURE 3.1-10

Hardness in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

Rescan™



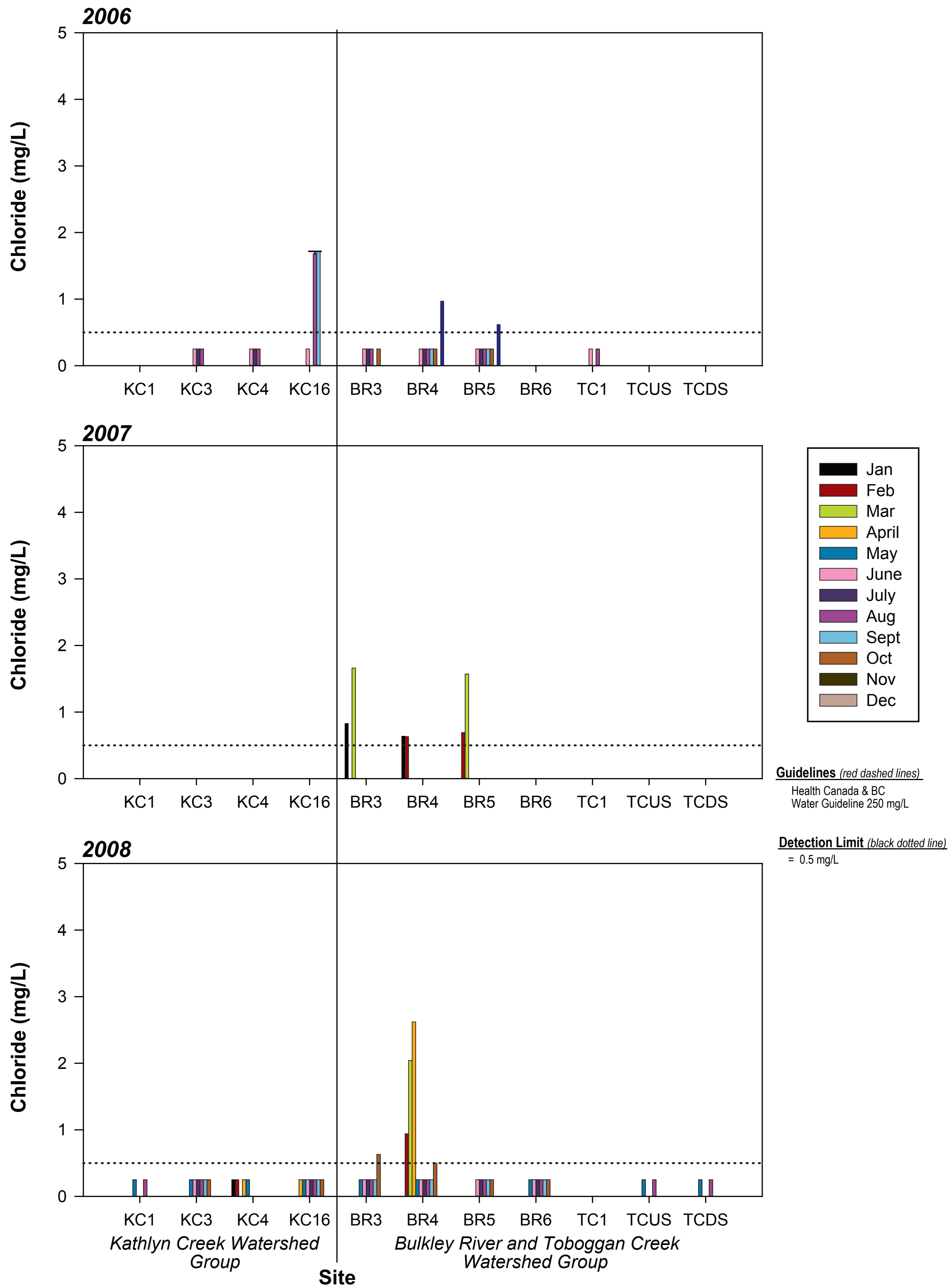
Note: Error bars represent standard error of the mean.

BLUE PEARL MINING

FIGURE 3.1-11

Chloride in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

Rescan™



Note: Error bars represent standard error of the mean.

BLUE PEARL MINING

Chloride in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

FIGURE 3.1-12

Rescan™

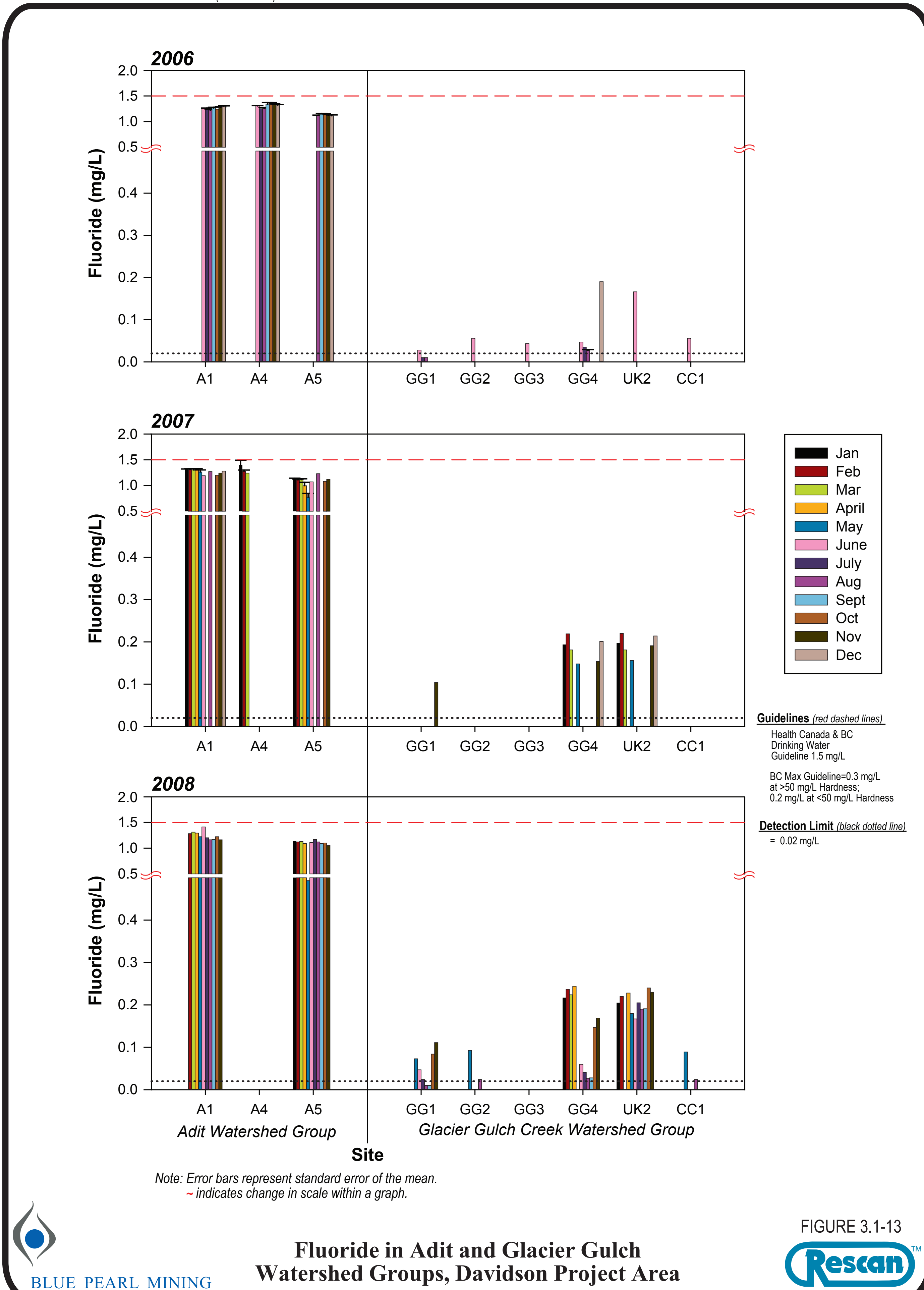
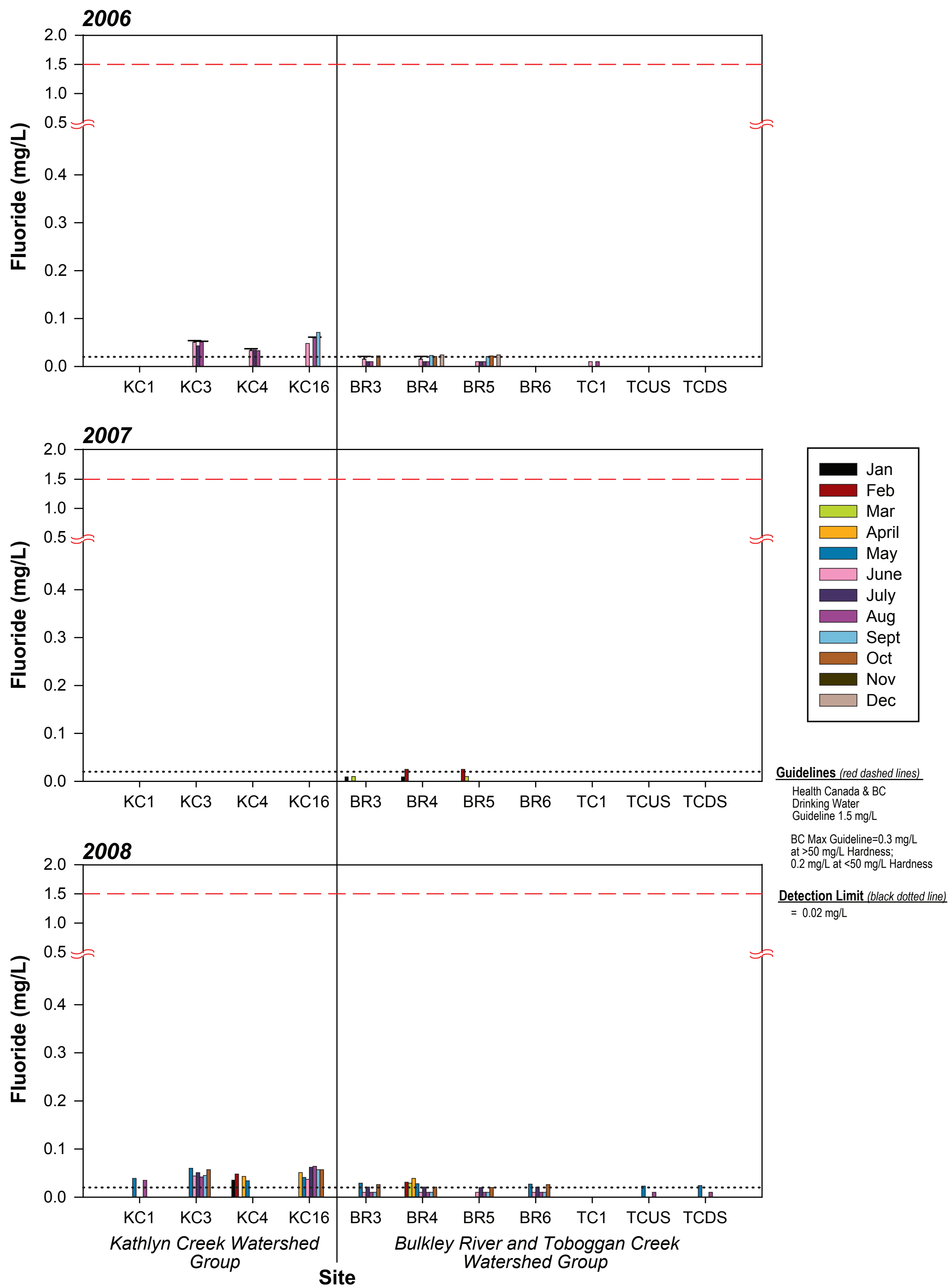


FIGURE 3.1-13

Fluoride in Adit and Glacier Gulch Watershed Groups, Davidson Project Area



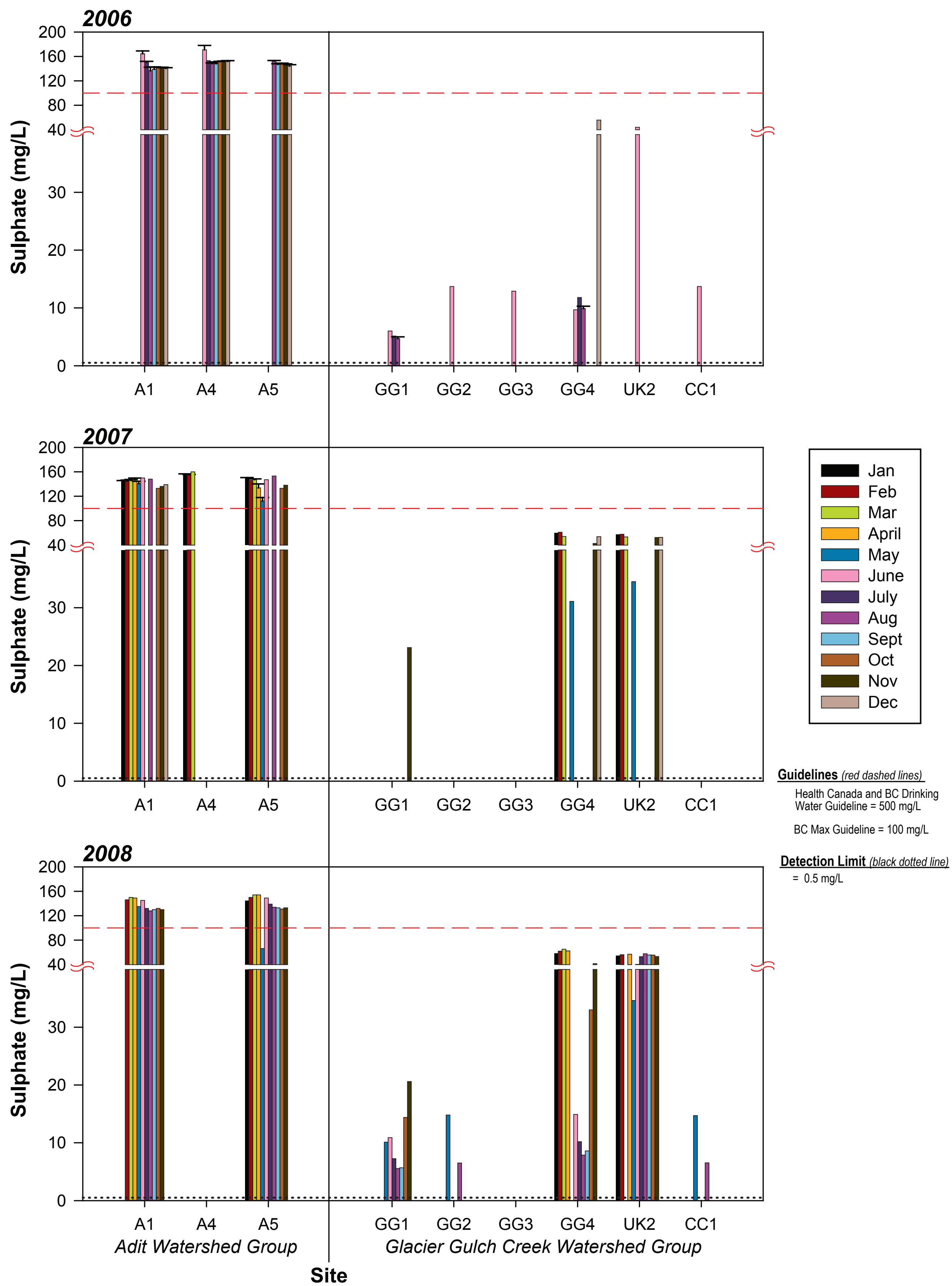
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

Fluoride in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

FIGURE 3.1-14

Rescan™



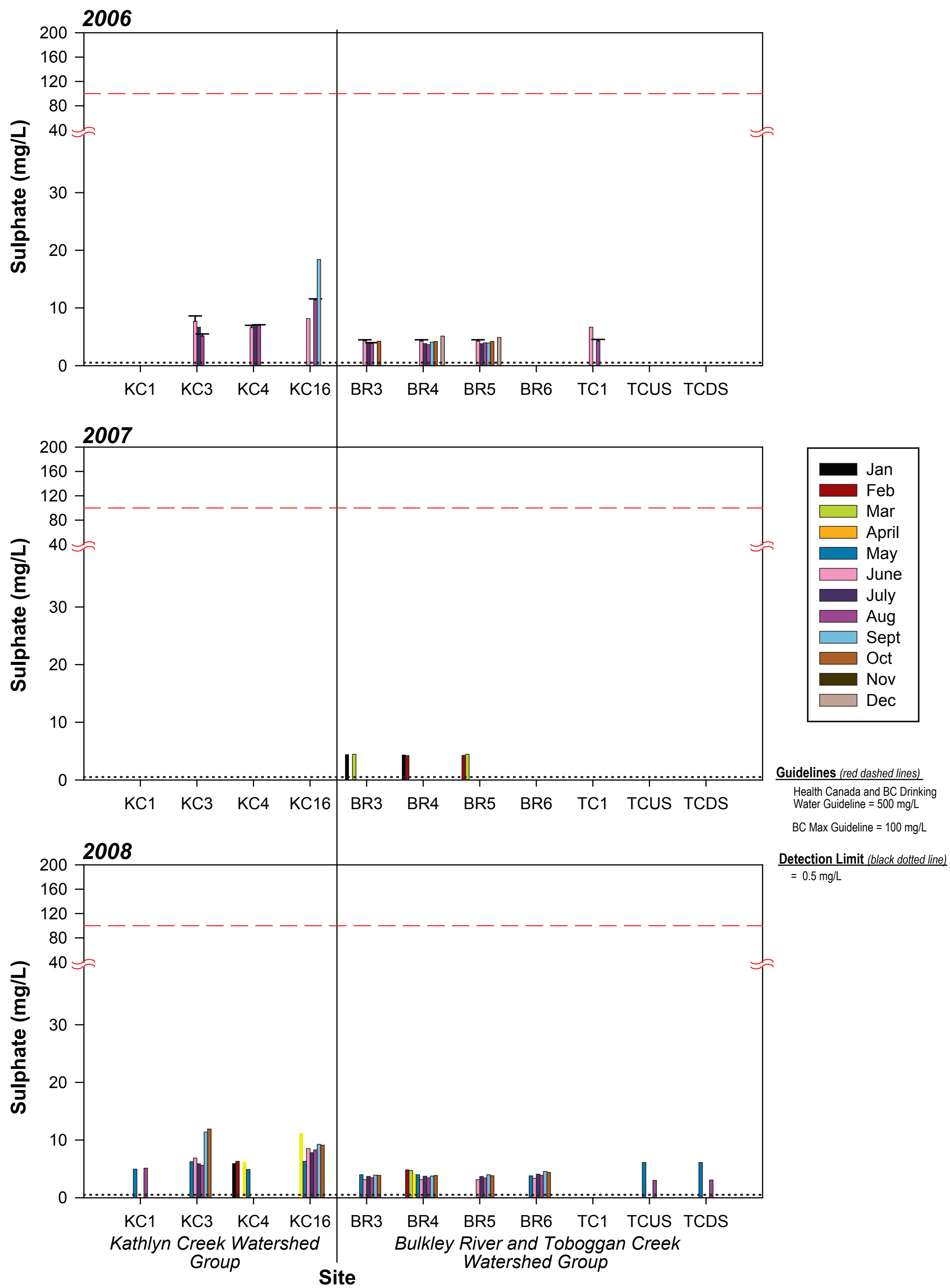
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

FIGURE 3.1-15

Sulphate in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

Rescan™



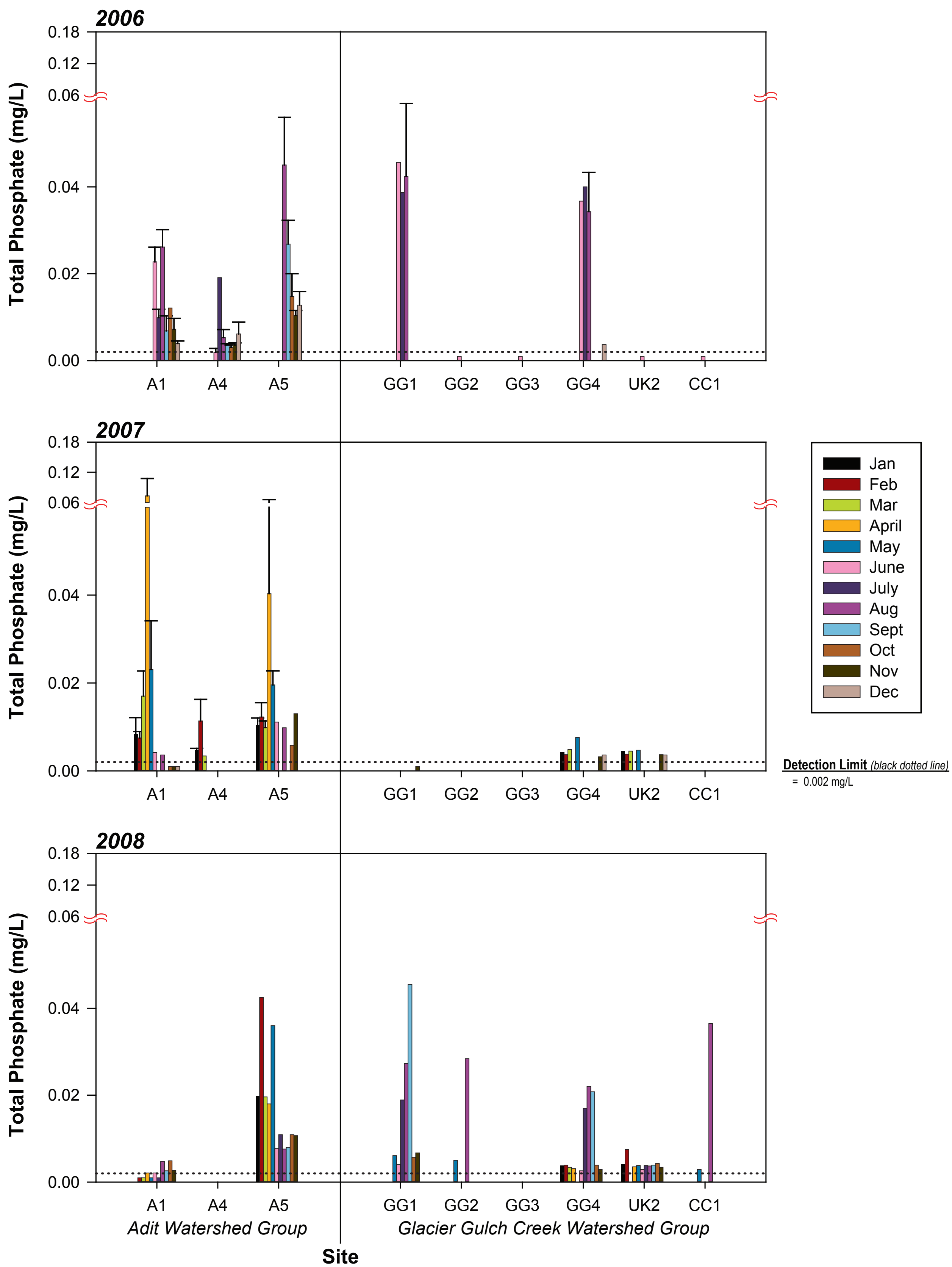
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

Sulphate in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

FIGURE 3.1-16

Rescan™



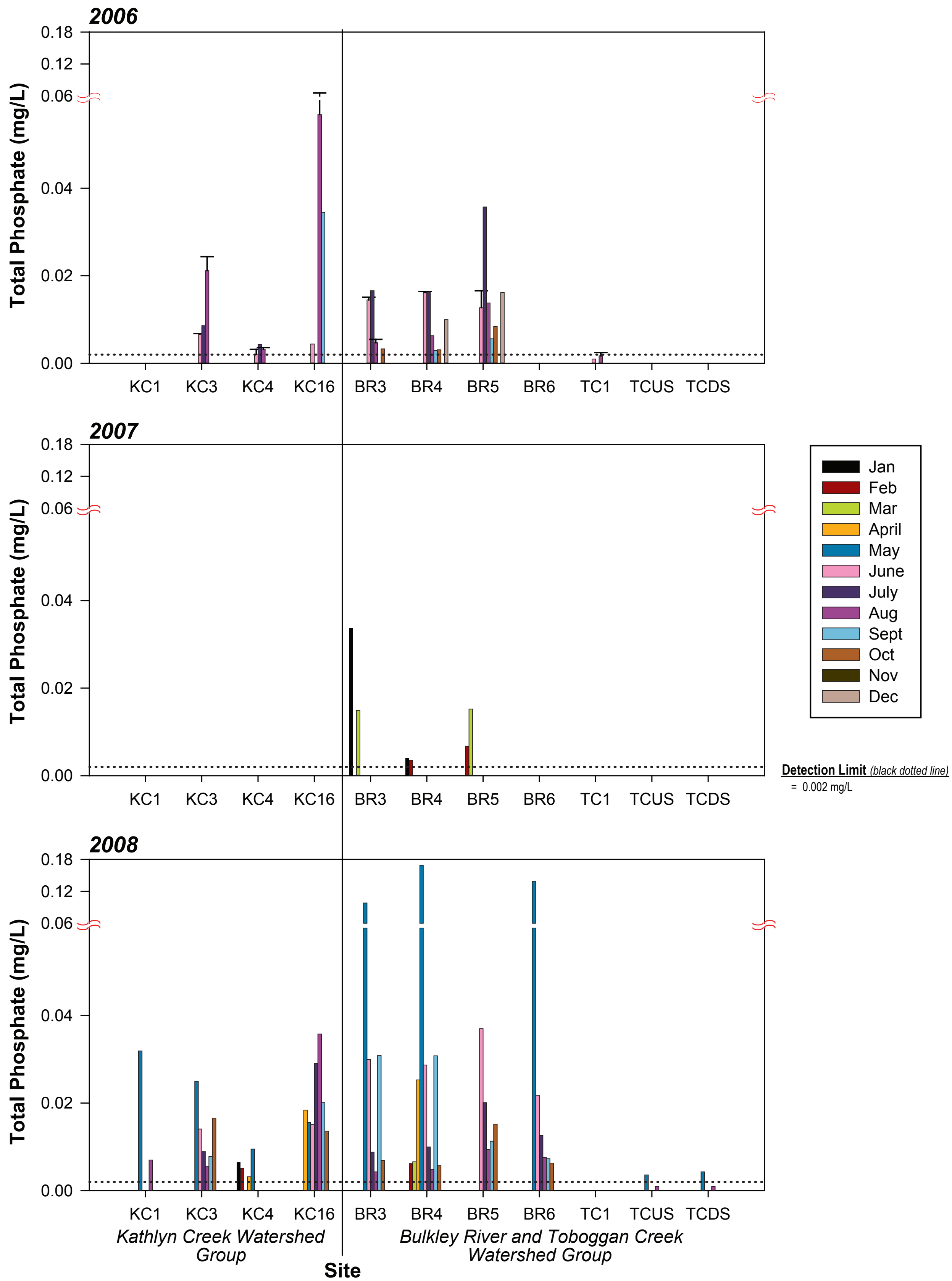
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

FIGURE 3.1-17

Total Phosphate in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

Rescan™



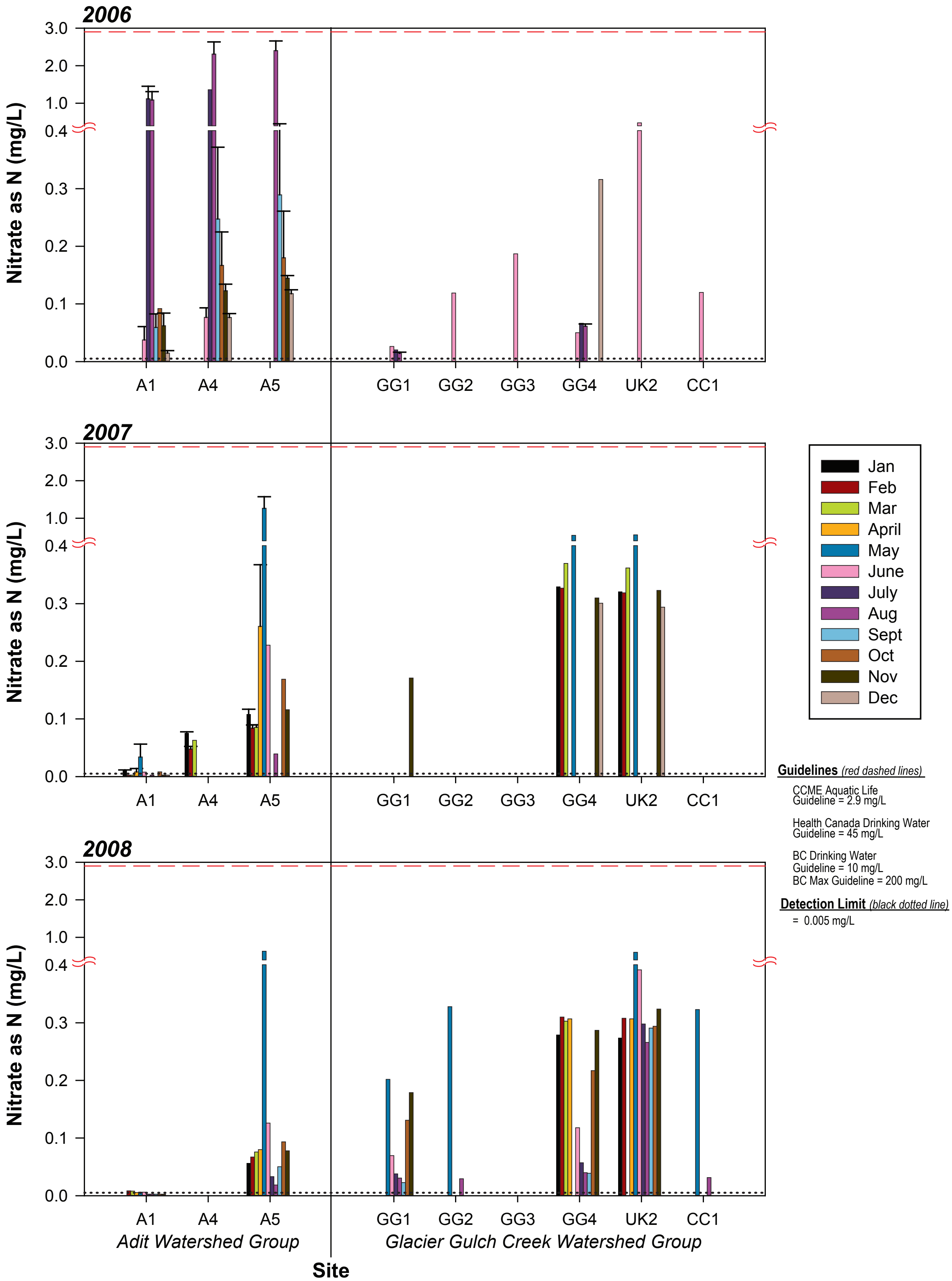
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

FIGURE 3.1-18

Total Phosphate in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

Rescan™



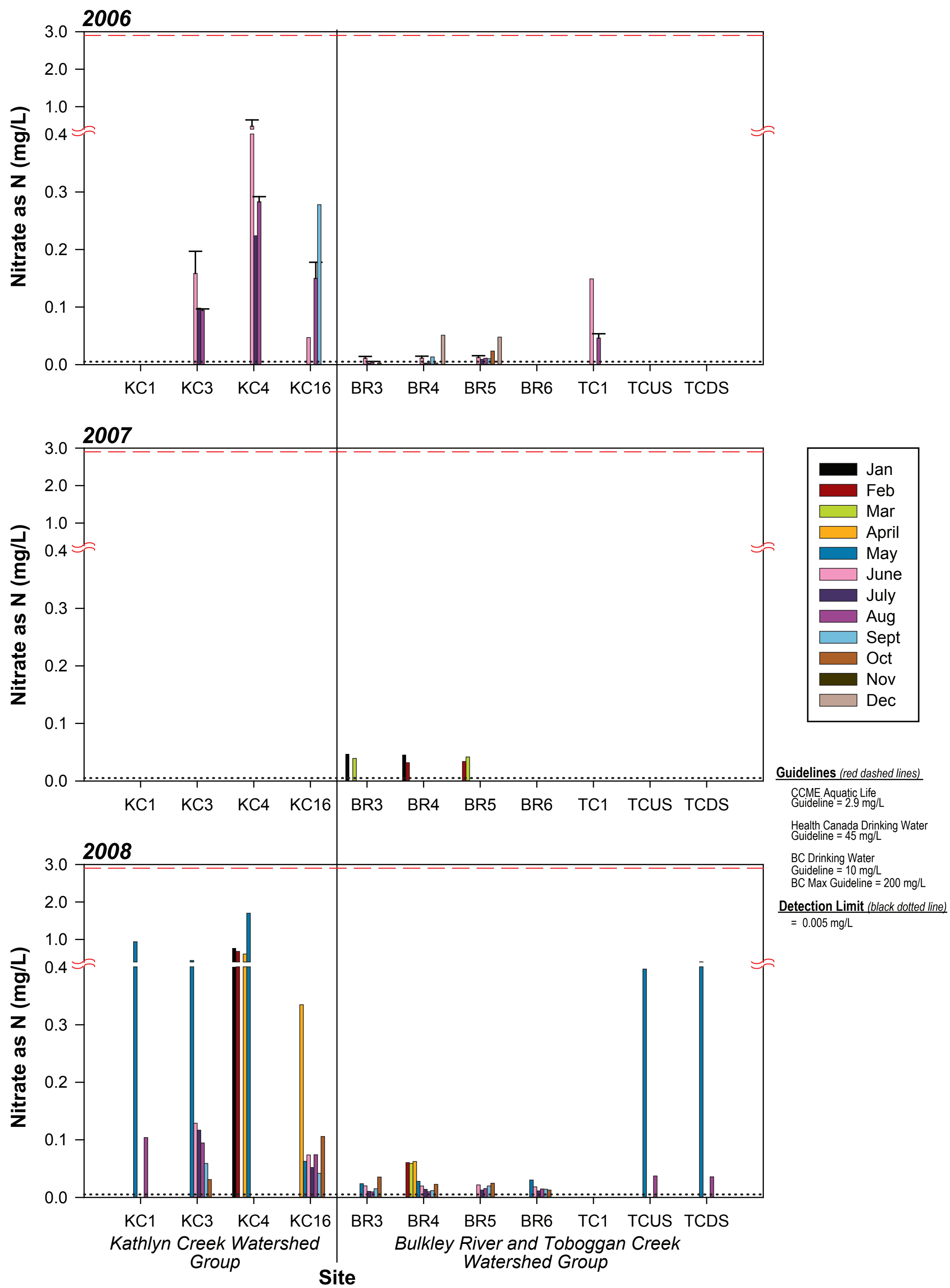
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

FIGURE 3.1-19

Nitrate as N in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

BLUE PEARL MINING

Rescan™



Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

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Nitrate as N in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

FIGURE 3.1-20

Rescan™

Total organic carbon (TOC) concentrations were low (<4 mg/L) in the Adit and Glacier Gulch sites compared to the Kathly Creek and Bulkley River sites, especially in 2008 (Figures 3.1-21 and 3.1-22). These higher concentrations primarily occurred during the April or May sampling periods. This is what would be expected since the sites from higher order streams (i.e., Bulkley River) would receive more organic input from the watershed during spring freshet than sites from lower order streams. The highest TOC concentration (10.1 mg/L) was at BR6 in 2008.

3.1.1.2 Total Metals

Total metal concentrations were most often highest within the Adit and Glacier Gulch Creek WG. In several cases (i.e., antimony, arsenic, cadmium, molybdenum and uranium) the data for the remaining watershed groups were not discussed since the sample did not exist (i.e. Kathlyn Creek and Toboggan Creek sites in 2007) or most of the data (at least 50%) were at or below detection limits.

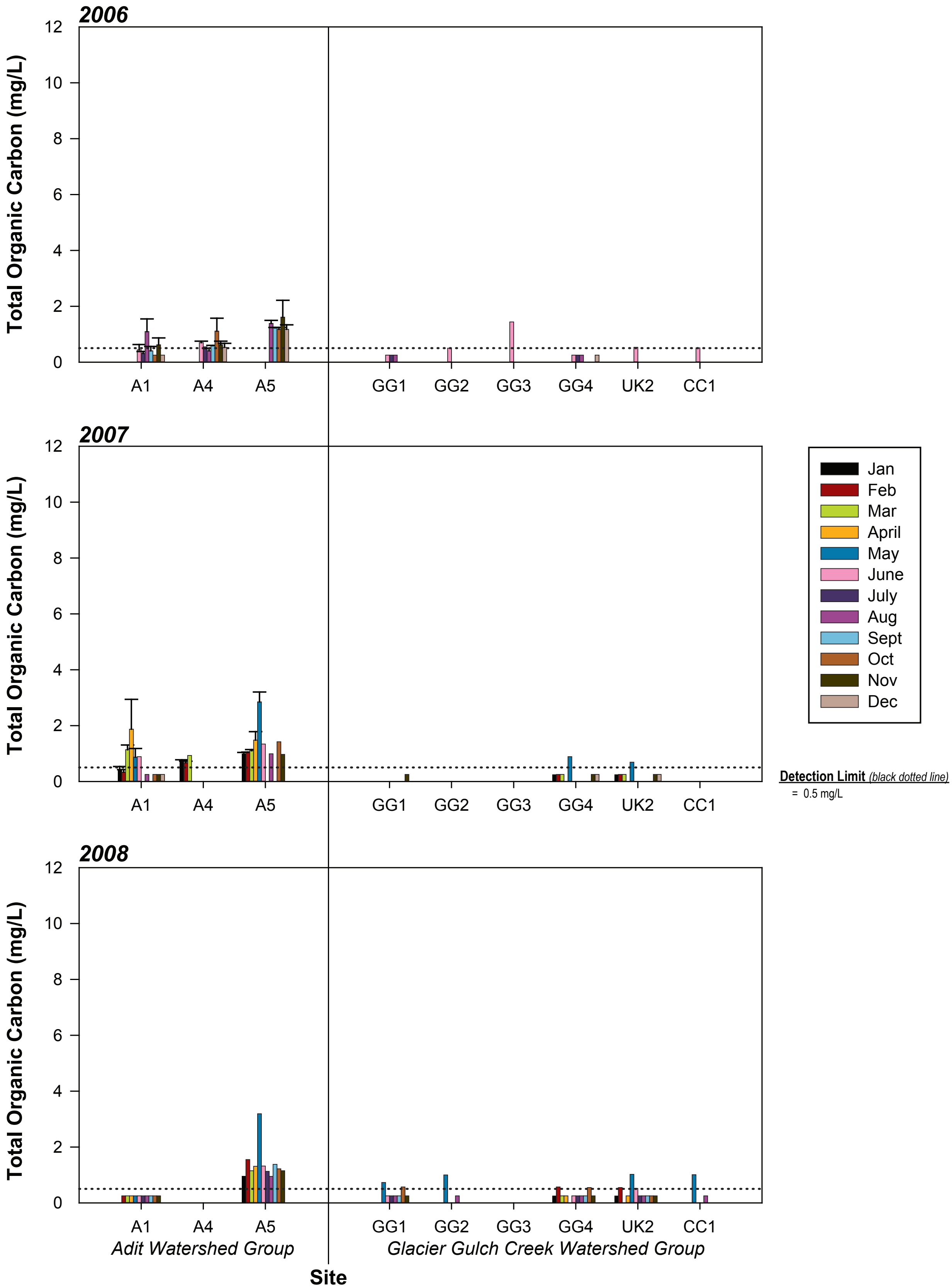
Total aluminum concentrations were variable at each site over time. Peak concentrations occurred during spring freshet at some sites (A1-2006 and all Bulkley River sites-2008) and during June or September at others (GG1 and GG4-2006; GG1 and GG4-2008, respectively) (Figures 3.1-23 and 3.1-24). Most samples had concentrations below 0.4 mg/L. With the exception of the Toboggan Creek WG, each WG had several samples over multiple years that exceeded the Health Canada and BC drinking water guideline (0.1 mg/L) for total aluminum. Since GG1 frequently had samples with a pH below 6.5, this site also exceeded the CCME aquatic life guideline.

Concentrations of total antimony were consistently highest in the Adit WG (Figure 3.1-25). Samples from all other sites fell below 0.001 mg/L. Each of the four Adit sites had several samples that exceeded the Health Canada and BC drinking water guideline of 0.006 mg/L. A1 (August and September of 2006) was the only site that exceeded the BC working aquatic life guideline of 0.02 mg/L.

Similarly, concentrations of total arsenic were considerably higher in the Adit WG than all other sites (Figure 3.1-26). Most other sites were close to or below the detection limit (0.0001 mg/L) with no concentration above 0.003 mg/L. All Adit WG sites exceeded Health Canada (0.01 mg/L), BC (0.025 mg/L) drinking water guideline and the CCME aquatic life guideline (0.005 mg/L) in one or multiple years.

Total barium concentrations were most often below 0.03 mg/L at each site over time (Figures 3.1-27 and 3.1-28). Concentrations were highest in April 2007(0.088 mg/L) and relatively high concentrations in the Bulkley River sites generally occurred in May (2008) or June (2006). All samples were well below the Health Canada and BC drinking water guideline (1 mg/L) and the BC Maximum aquatic life guideline (5 mg/L).

Total cadmium concentrations were highest with the Adit WG in all sample years (Figure 3.1-29). Most other samples were close to or below the detection limit (0.00005 mg/L) with the exception of GG4 and UK2, at which the majority of samples had concentrations between 0.002 and 0.004 mg/L. All samples were well below the Health Canada and BC drinking water guideline (0.005 mg/L). More than 90% of the samples within the Adit and Glacier Gulch Creek WG exceeded the hardness dependent CCME and BC aquatic life guidelines between 2006 and 2008. Several samples from the Kathlyn Creek and Toboggan Creek WGs also exceeded these in 2006 and 2008.



Note: Error bars represent standard error of the mean.

BLUE PEARL MINING

FIGURE 3.1-21

Total Organic Carbon in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

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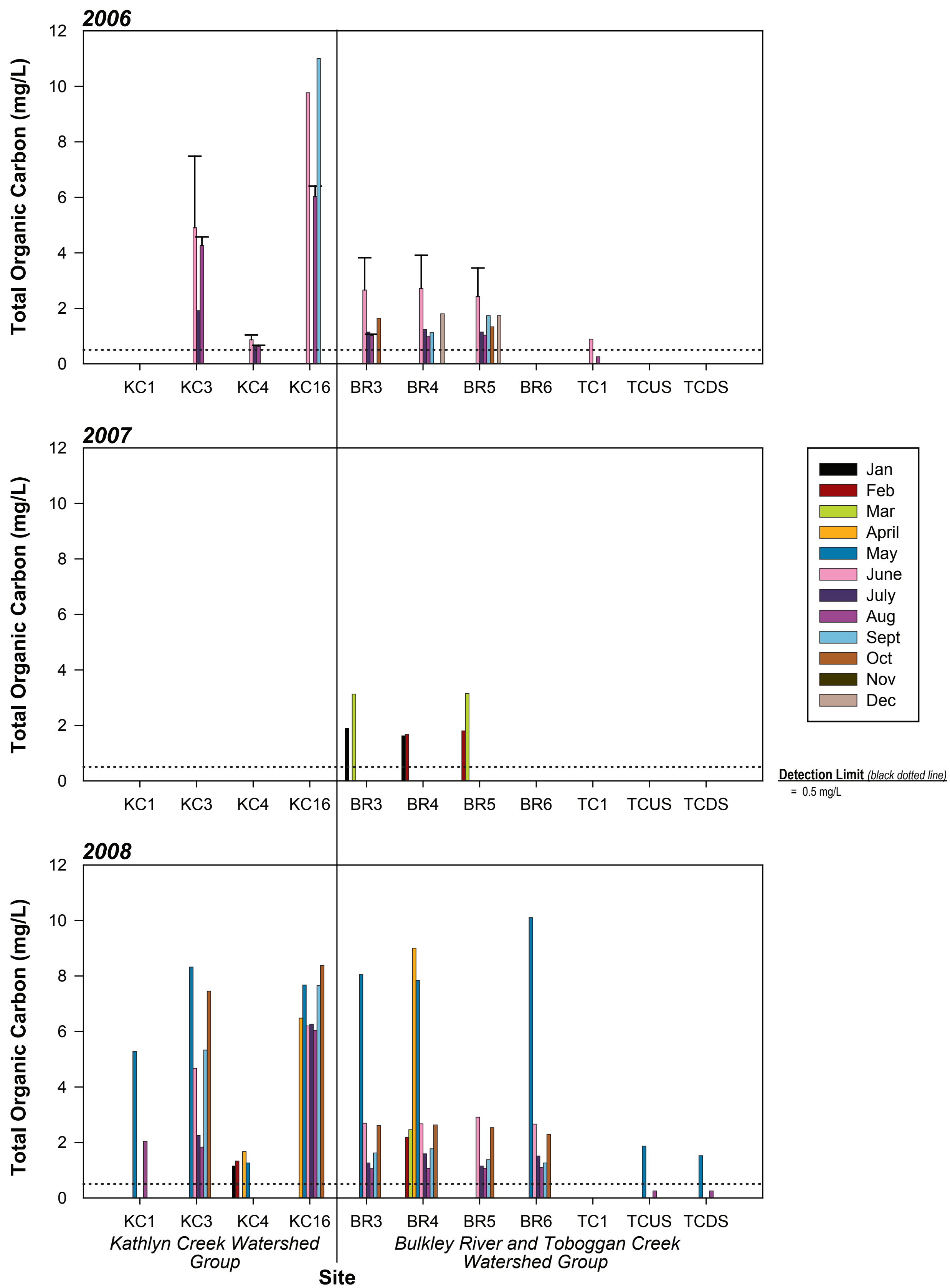


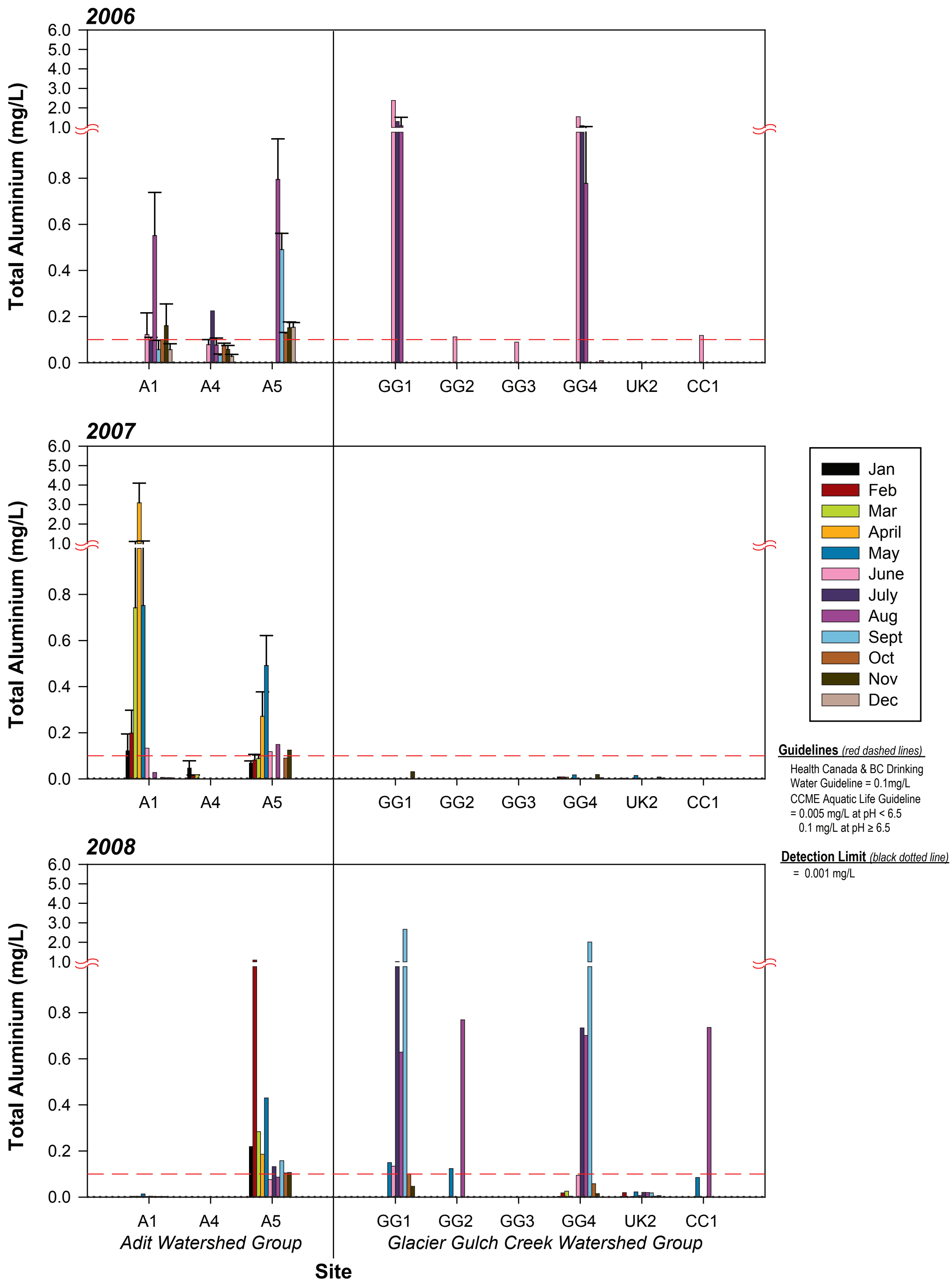
Note: Error bars represent standard error of the mean.

BLUE PEARL MINING

Total Organic Carbon in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

FIGURE 3.1-22

Rescan™



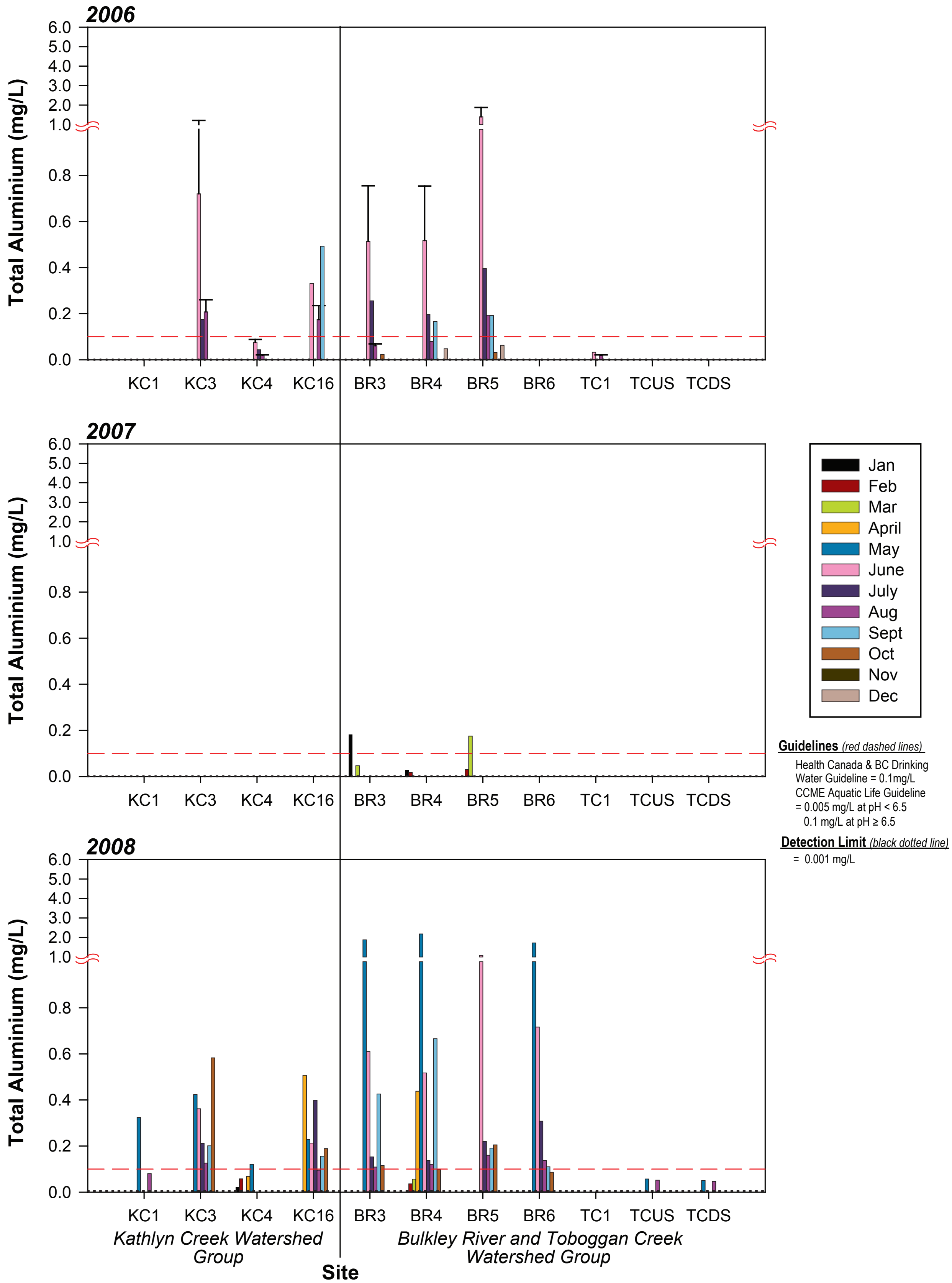
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

FIGURE 3.1-23

Total Aluminium in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

Rescan™



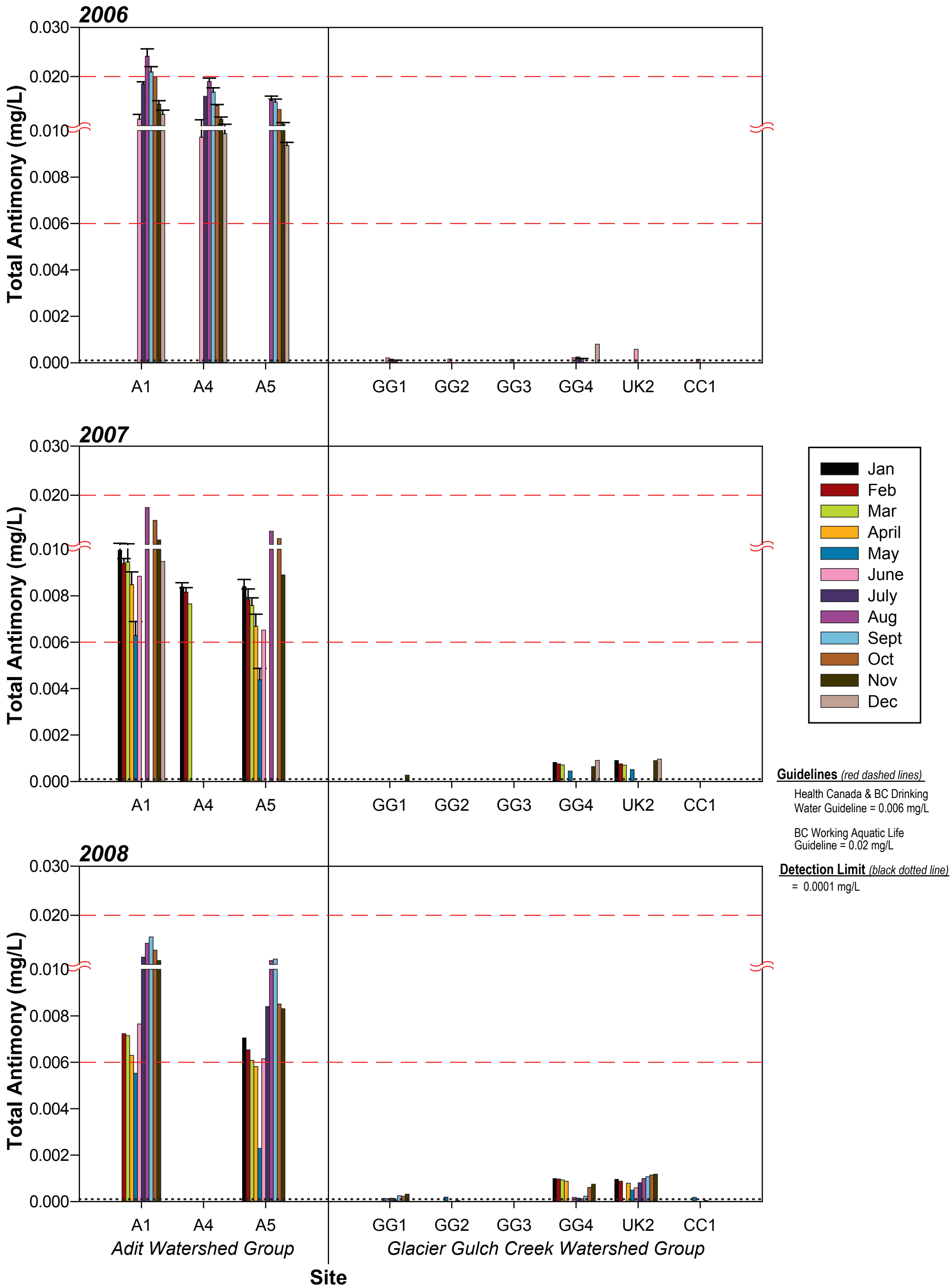
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

Total Aluminium in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

FIGURE 3.1-24

Rescan™



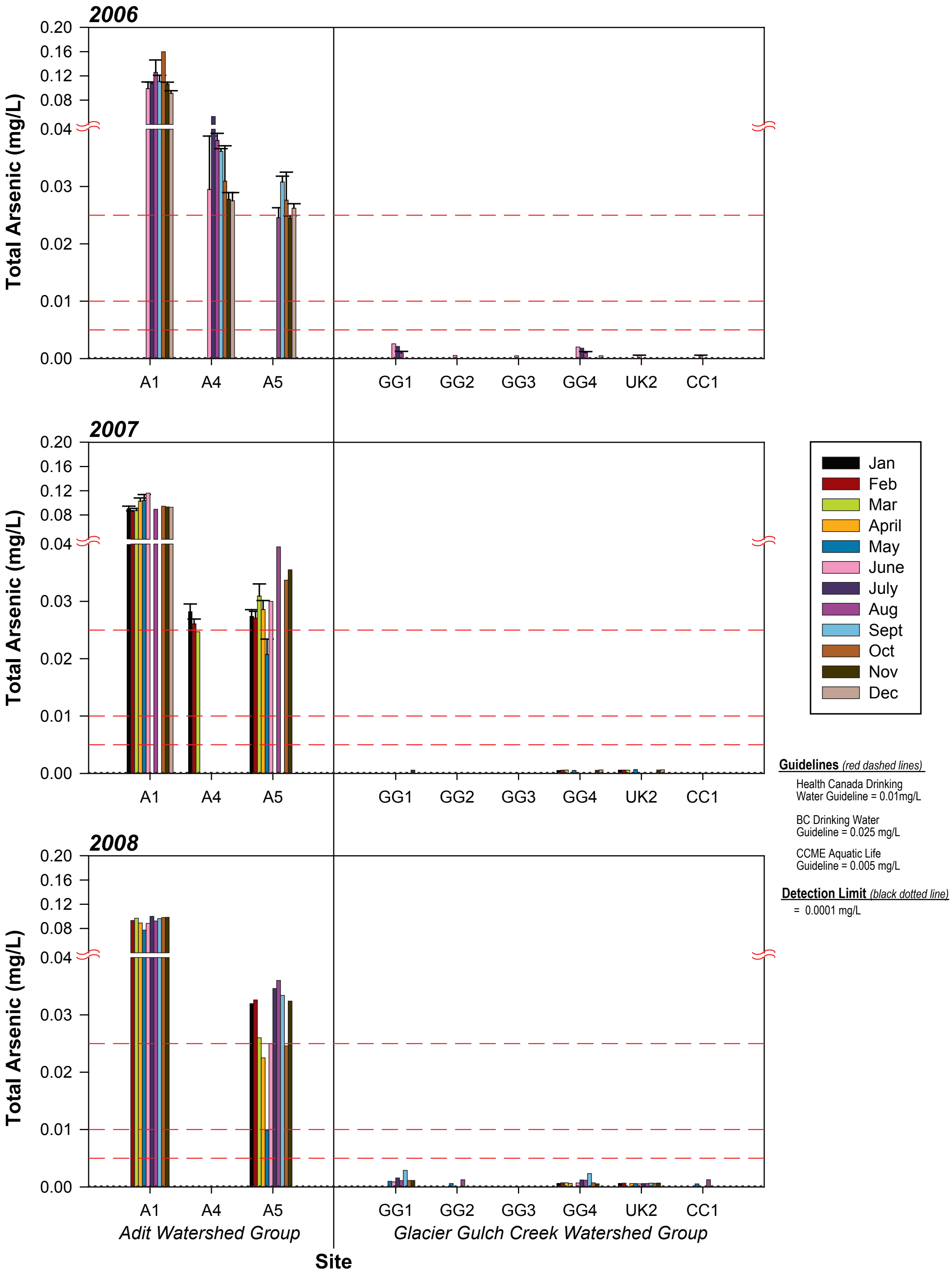
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

FIGURE 3.1-25

Total Antimony in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

Rescan™



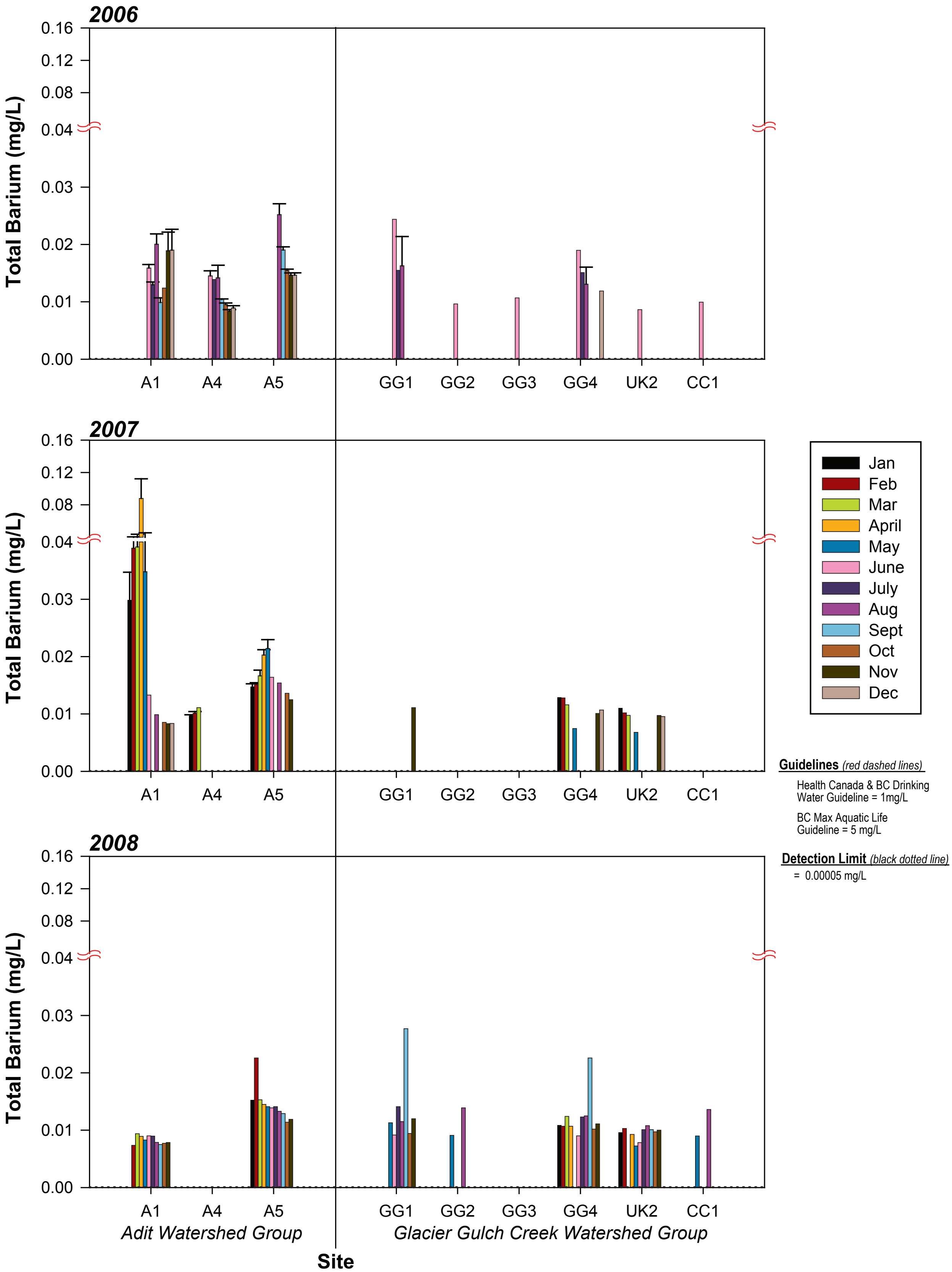
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

FIGURE 3.1-26

Total Arsenic in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

Rescan™



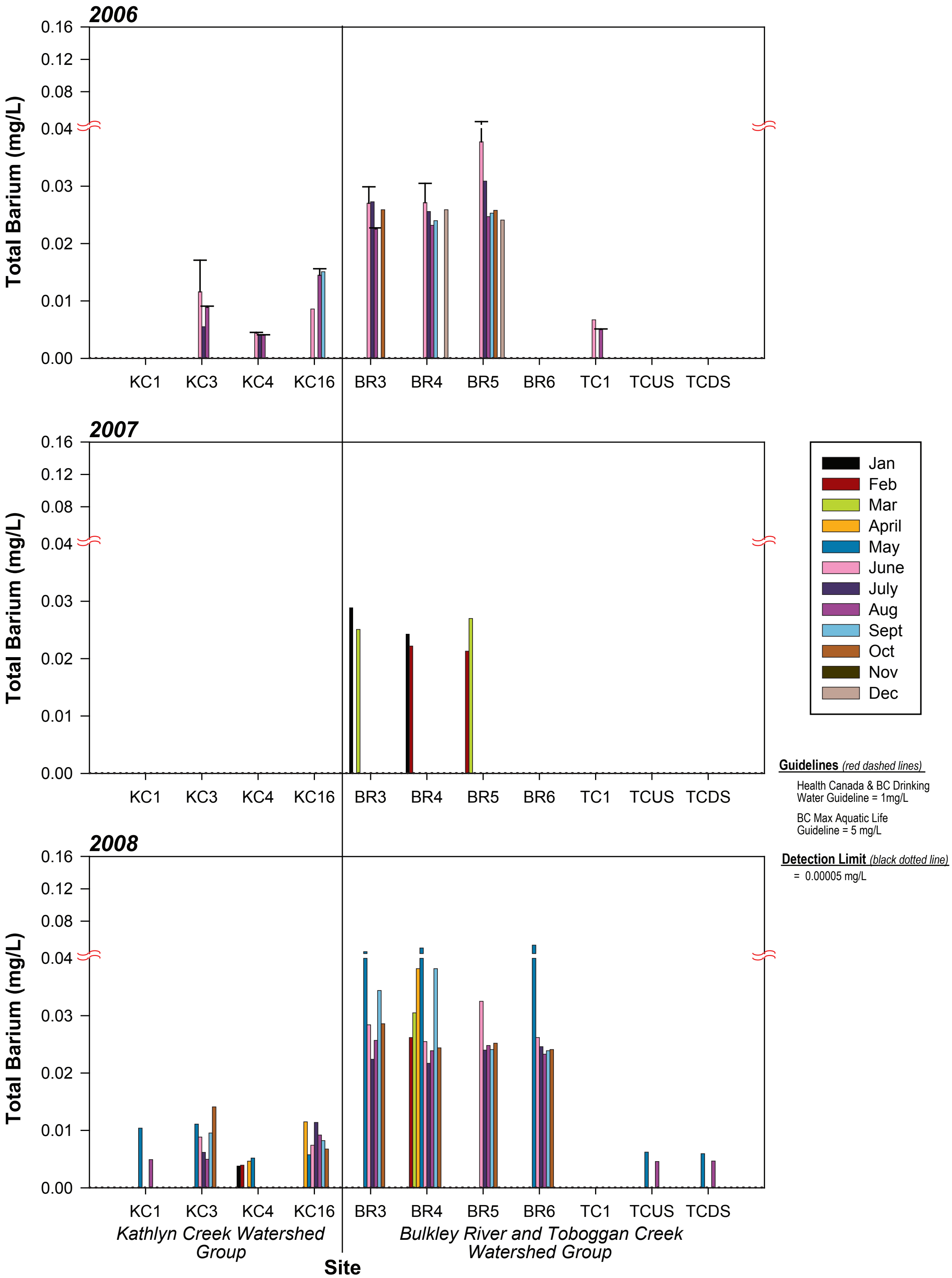
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

FIGURE 3.1-27

Total Barium in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

BLUE PEARL MINING

Rescan™



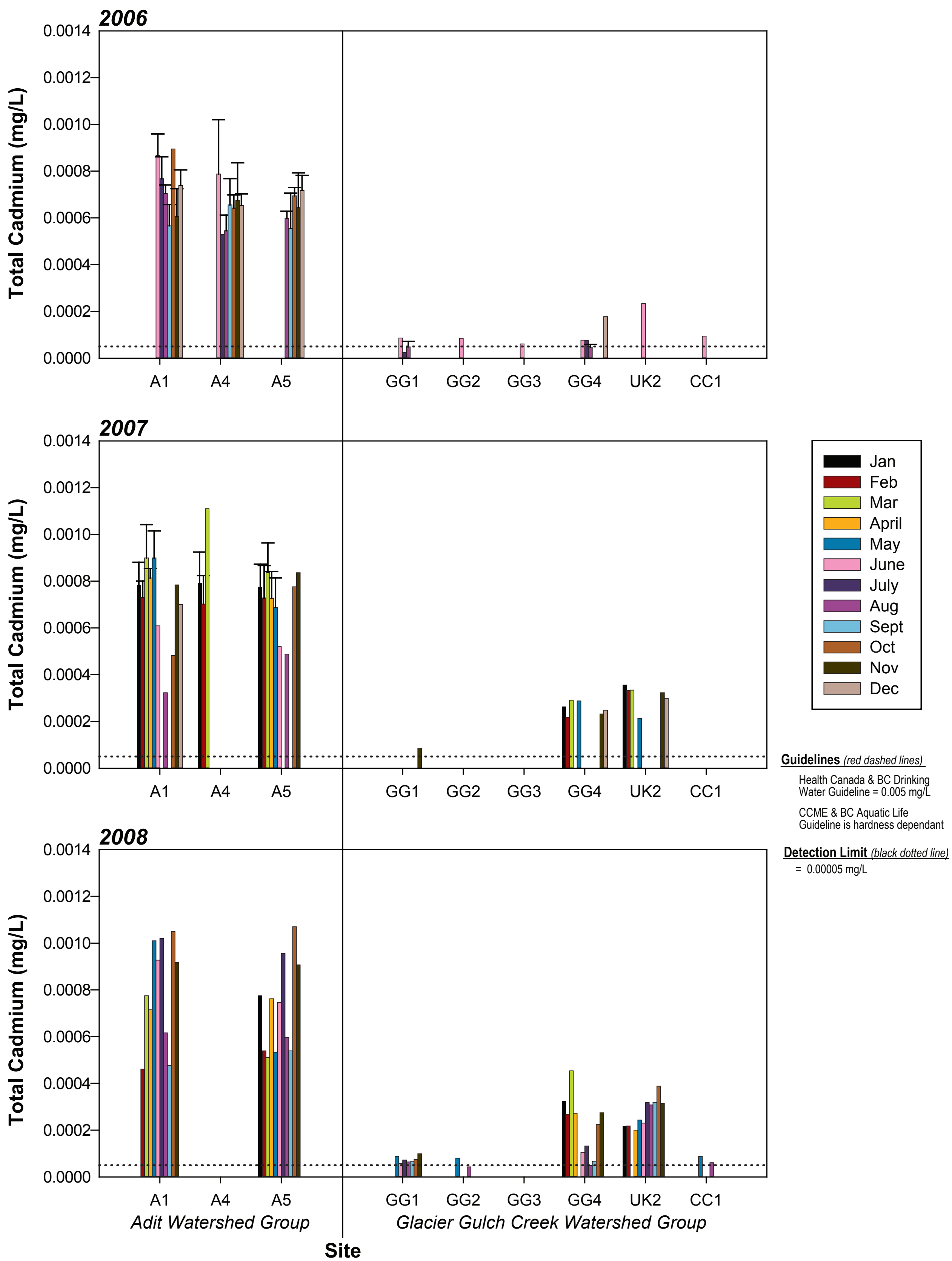
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

Total Barium in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

FIGURE 3.1-28

Rescan™



Note: Error bars represent standard error of the mean.

FIGURE 3.1-29

Total Cadmium in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

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The majority of total chromium samples were below the detection limit of 0.0005 mg/L (Figures 3.1-30 and 3.1-31). However, these data are graphed and discussed since several sites exceeded available guidelines. The greatest average total chromium concentration was seen at A1 in 2007 (0.005 mg/L). The BC Maximum guideline (0.001 mg/L) was exceeded at A1 and BR3, BR4 and BR5, primarily during spring sampling. All samples were well below the Health Canada and BC drinking water guidelines of 0.05 mg/L.

Total copper concentrations in the Kathlyn Creek, Bulkley River and Tobboggan Creek WGs were consistently below 0.01 mg/L (Figures 3.1-32 and 3.1-33). The highest average concentrations were seen at A1 in April 2007 (0.054 mg/L) and at GG1 and GG4 (between 0.025 and 0.050 mg/L). All samples fell below the Health Canada and BC drinking water guideline (1 mg/L) and the MMER guideline (0.60 mg/L). CCME and BC aquatic life guidelines are hardness dependent. The BC Maximum guideline was exceeded in 6% to 18% of samples collected each year (primarily within the Glacier Gulch Creek WG). The CCME guideline was exceeded in 20% to 63% of samples collected each year. These samples primarily came from the Glacier Gulch Creek WG and several samples from the Kathlyn Creek and Bulkley River WG.

Most samples had total iron concentrations below 0.3 mg/L, which is the value of the CCME and BC Maximum aquatic life and the Health Canada and BC drinking water guidelines (Figures 3.1-34 and 3.1-35). In either 2006 or 2008 most sites (except A4, GG3, UK2, KC4 and the Toboggan Creek sites) exceeded this guideline with one or more samples. The highest total iron concentration (4.9 mg/L) was seen at A1 in April 2007. This is almost five times higher than other relatively high samples collected at this site in 2007.

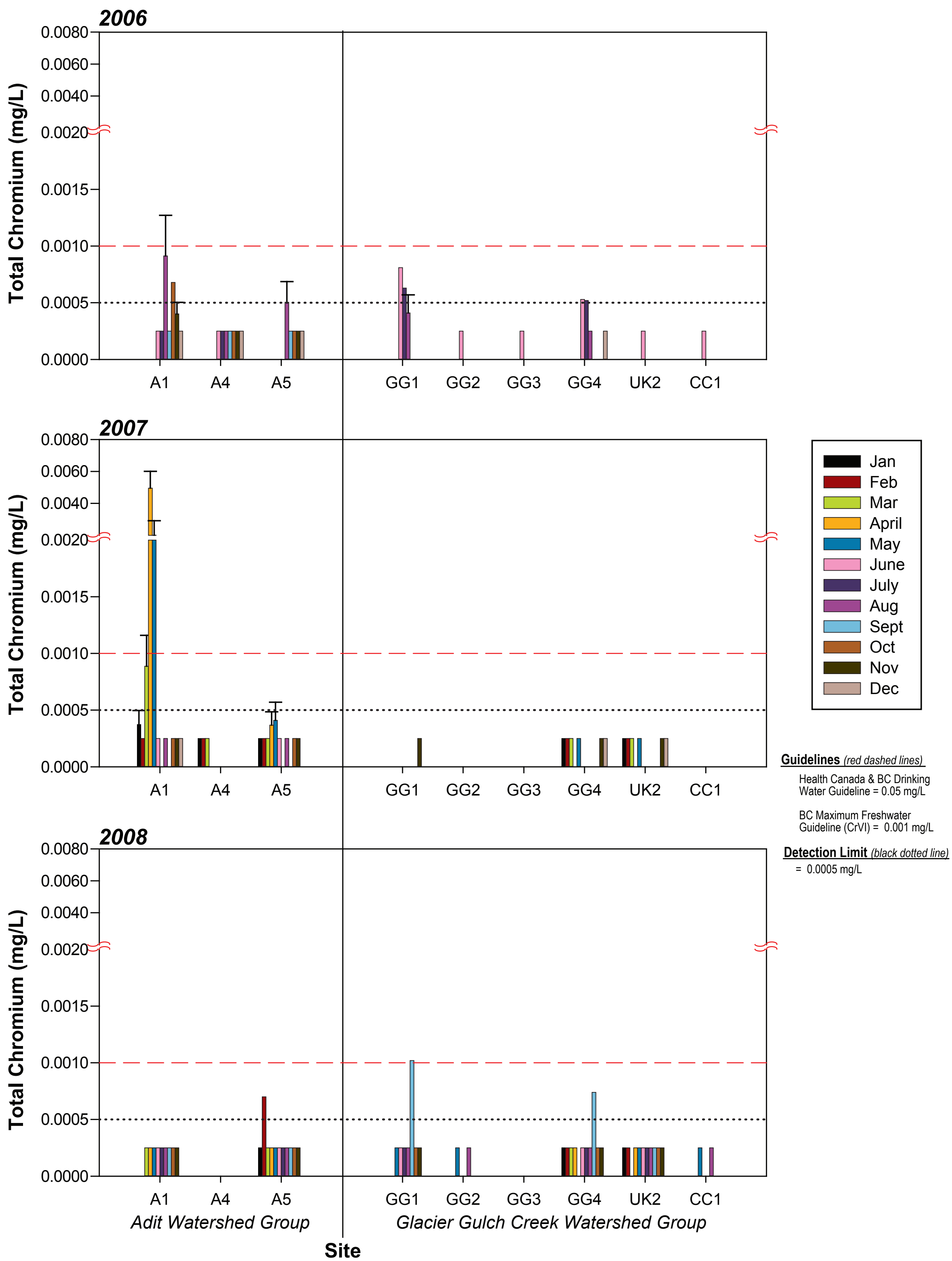
The highest average lead concentrations (between 0.002 and 0.003 mg/L) were seen at A1 in 2006 and 2007 (Figures 3.1-36 and 3.1-37). The Bulkley River sites also had a few samples with relatively high lead concentrations in 2008. All sites had total lead concentrations below the available MMER (0.40 mg/L) and Health Canada and BC drinking water guidelines (0.01 mg/L). The hardness dependent CCME and BC aquatic life guidelines were not exceeded by any sites during the sample period.

The Adit and the Bulkley River WGs had the highest total manganese concentrations with several samples exceeding the Health Canada and BC drinking water guideline of 0.05 mg/L (Figures 3.1-38 and 3.1-39). The highest average concentration was seen at BR6 in May of 2008 (0.14 mg/L). BC aquatic life guidelines (hardness dependent) were not exceeded by any sites during the sample period.

Total molybdenum concentrations were often between 3 and 5 mg/L within the Adit WG with the highest concentration being 4.6 mg/L (Figure 3.1-40) exceeding the BC Maximum guideline (2 mg/L). GG4 and UK2 also regularly had sample concentrations between 0.1 and 1.0 mg/L. The CCME (0.073 mg/L) guideline was often exceeded at GG4 and UK2.

Total uranium concentrations were either below detection (0.00001 mg/L) or below 0.0001 mg/L at all sites except the Adit WG (Figure 3.1-41). Most of the samples from the Adit sites were between 0.002 and 0.005 mg/L. All were well below the BC Maximum guideline (0.3 mg/L) and the Health Canada and BC drinking water guideline (0.02 mg/L).

Total zinc concentrations were generally below 0.01 mg/L at all sites (Figures 3.1-42 and 3.1-43). The primary exceptions to this occurred at A1 in 2006 and 2007 where average zinc concentrations reached 0.014 mg/L (August, 2006) and 0.018 mg/L (April, 2007). All concentrations were below the CCME aquatic life guideline of 0.030 mg/L, the Health Canada and BC drinking water guideline (5 mg/L) and the MMER maximum guideline (1 mg/L). The hardness dependent BC Maximum aquatic life guideline for zinc was not exceeded by any sites during the sample period.



Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

FIGURE 3.1-30

Total Chromium in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

BLUE PEARL MINING

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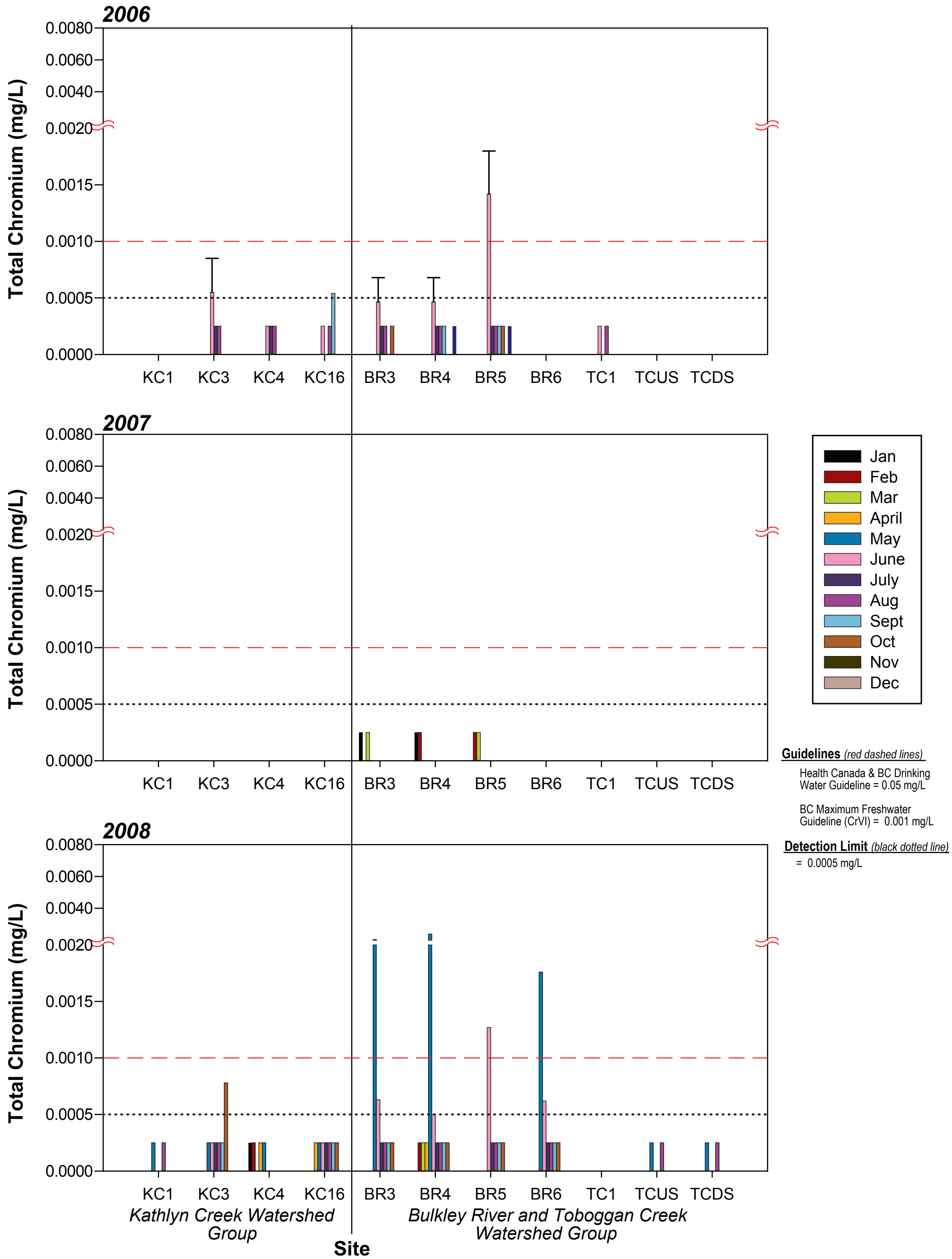


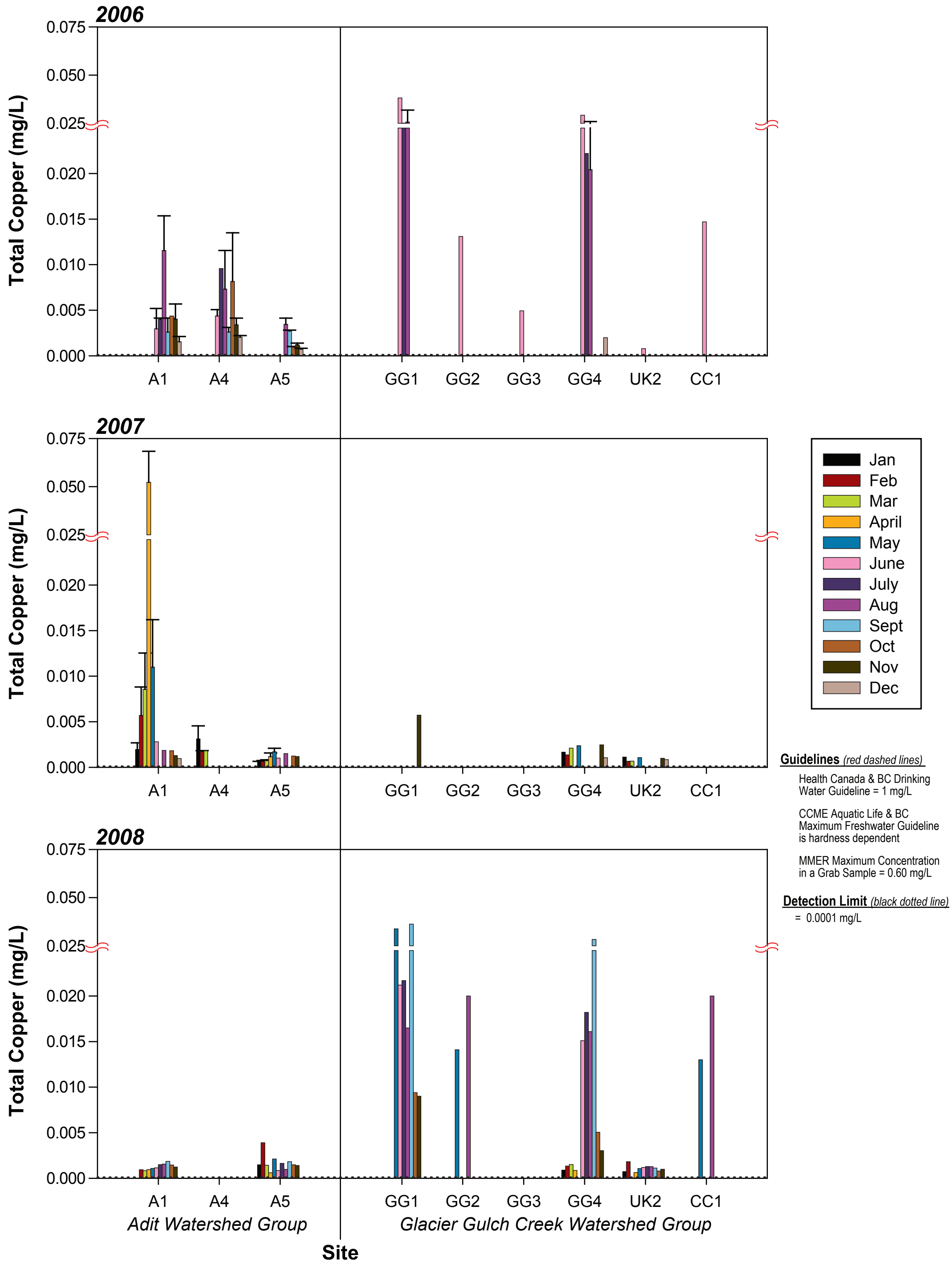
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

Total Chromium in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

FIGURE 3.1-31

Rescan™



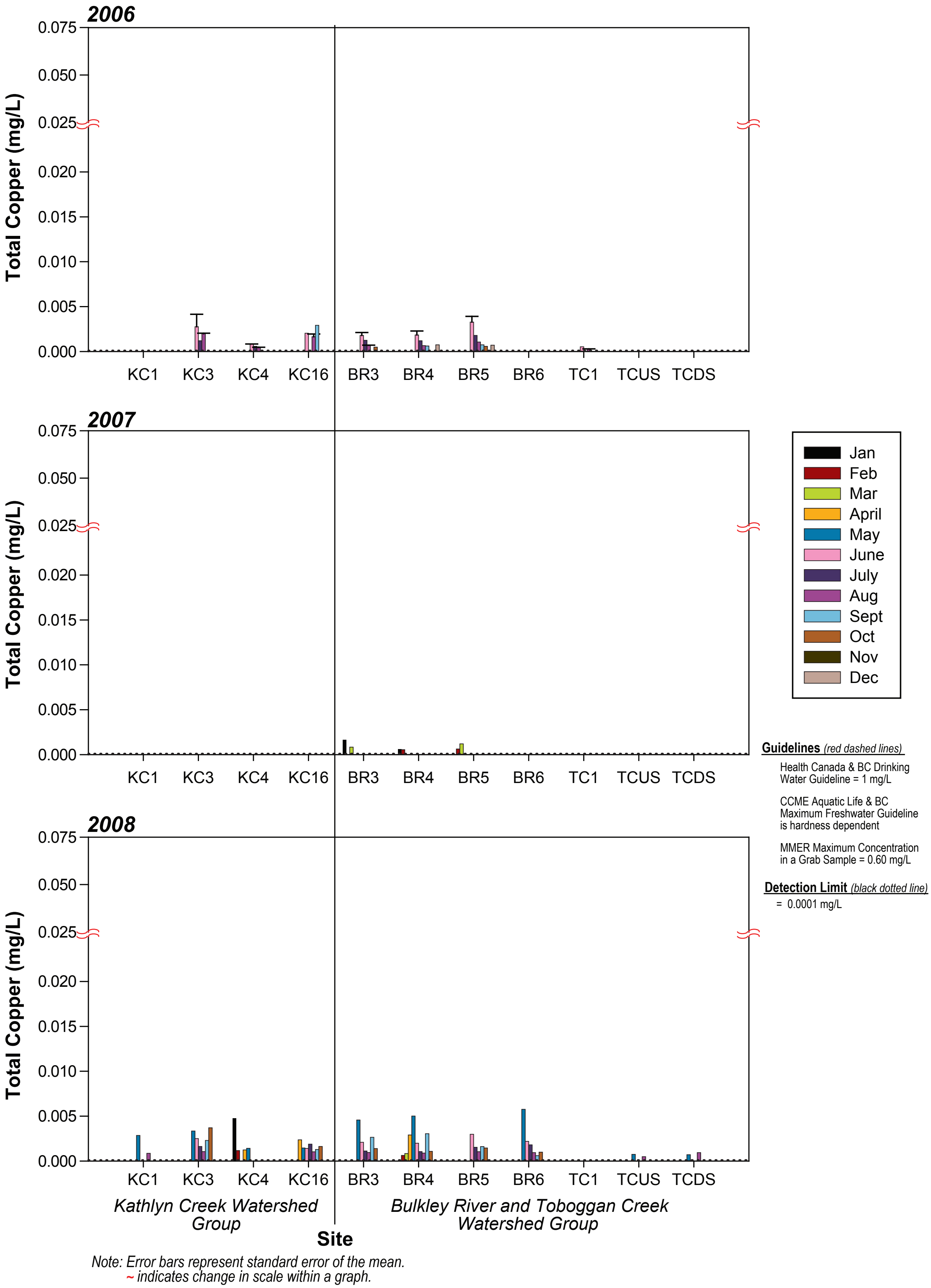
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

FIGURE 3.1-32

Total Copper in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

Rescan™

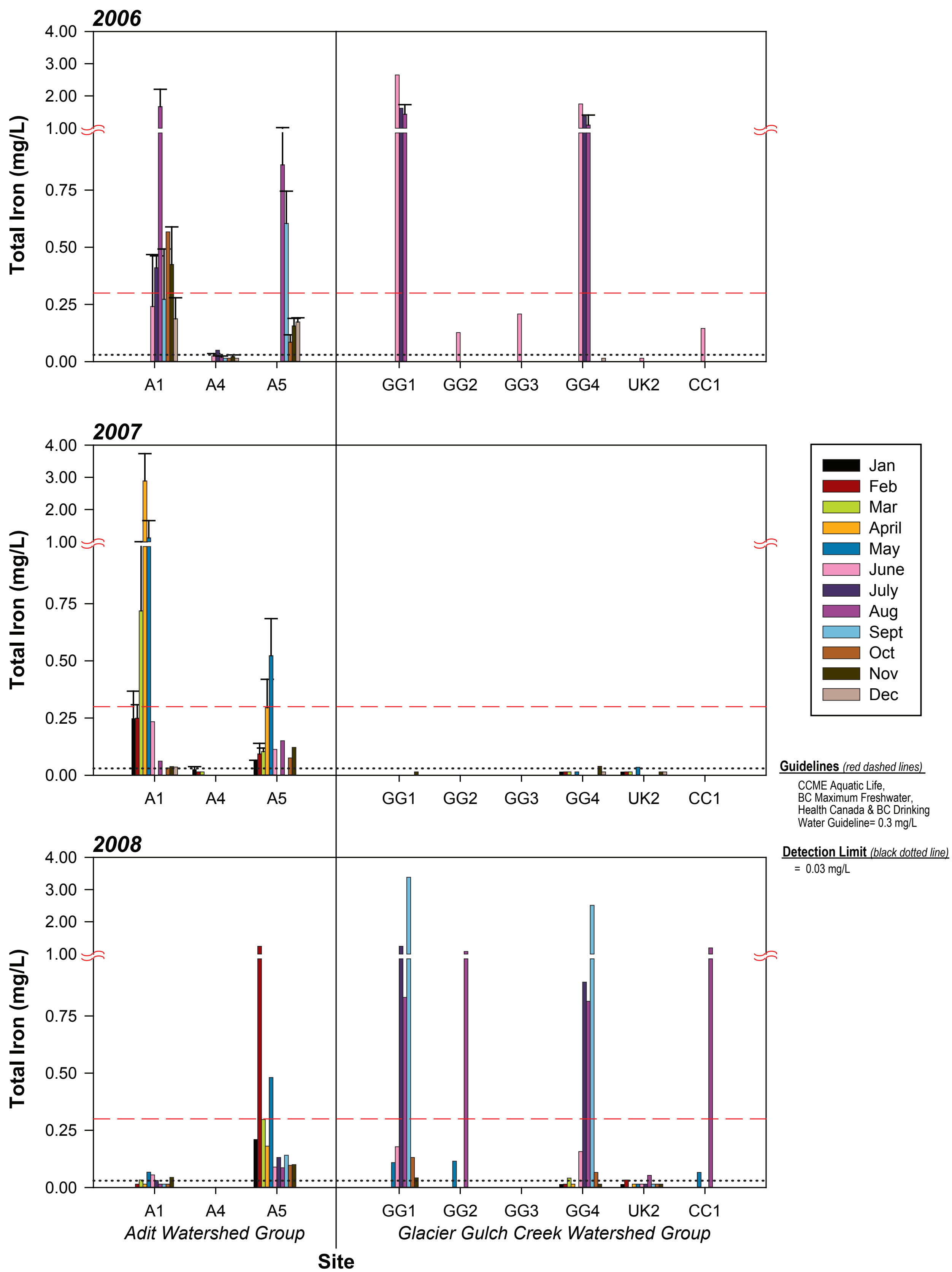


BLUE PEARL MINING

Total Copper in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

FIGURE 3.1-33

Rescan™



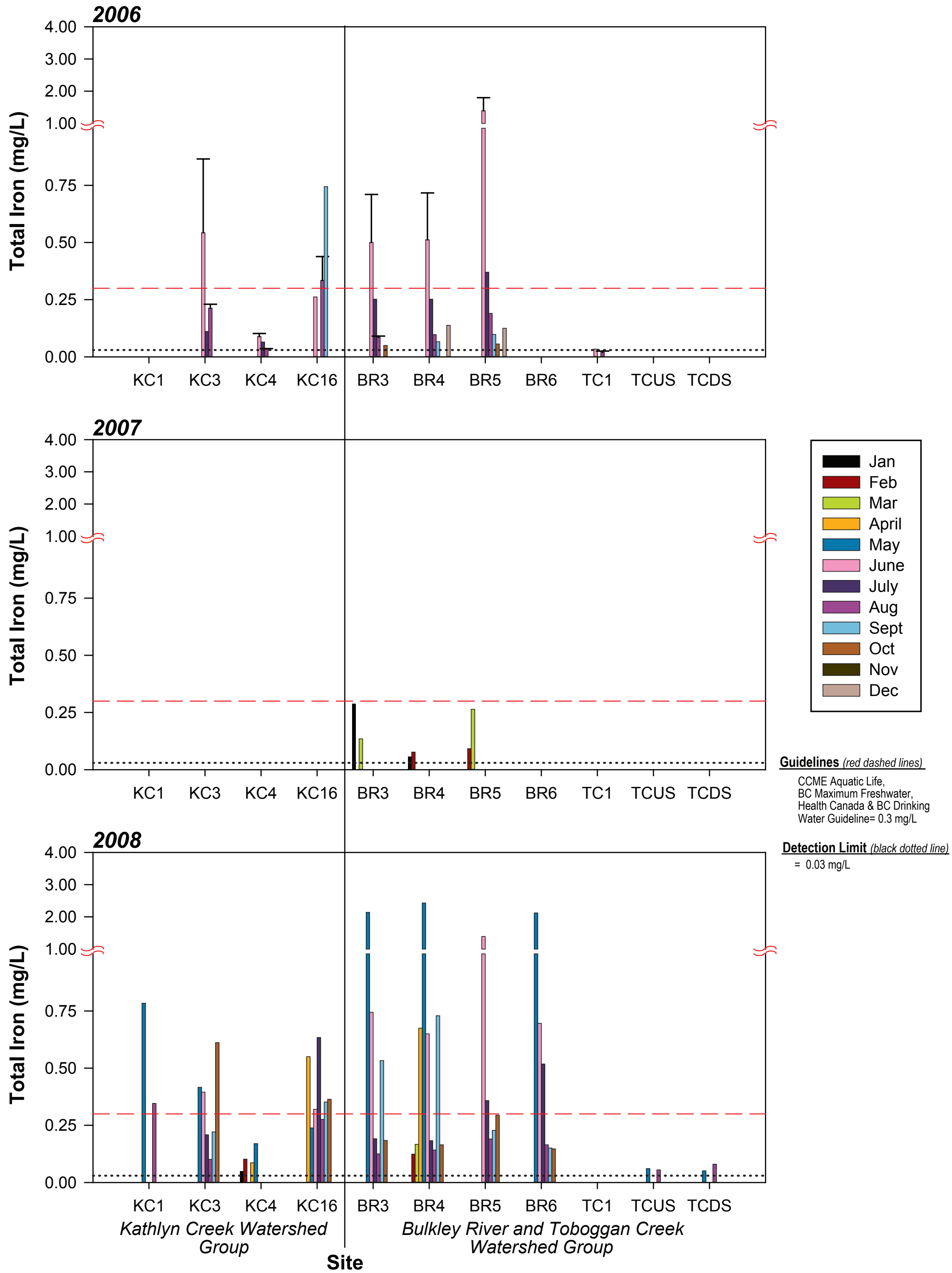
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

FIGURE 3.1-34

Total Iron in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

Rescan™



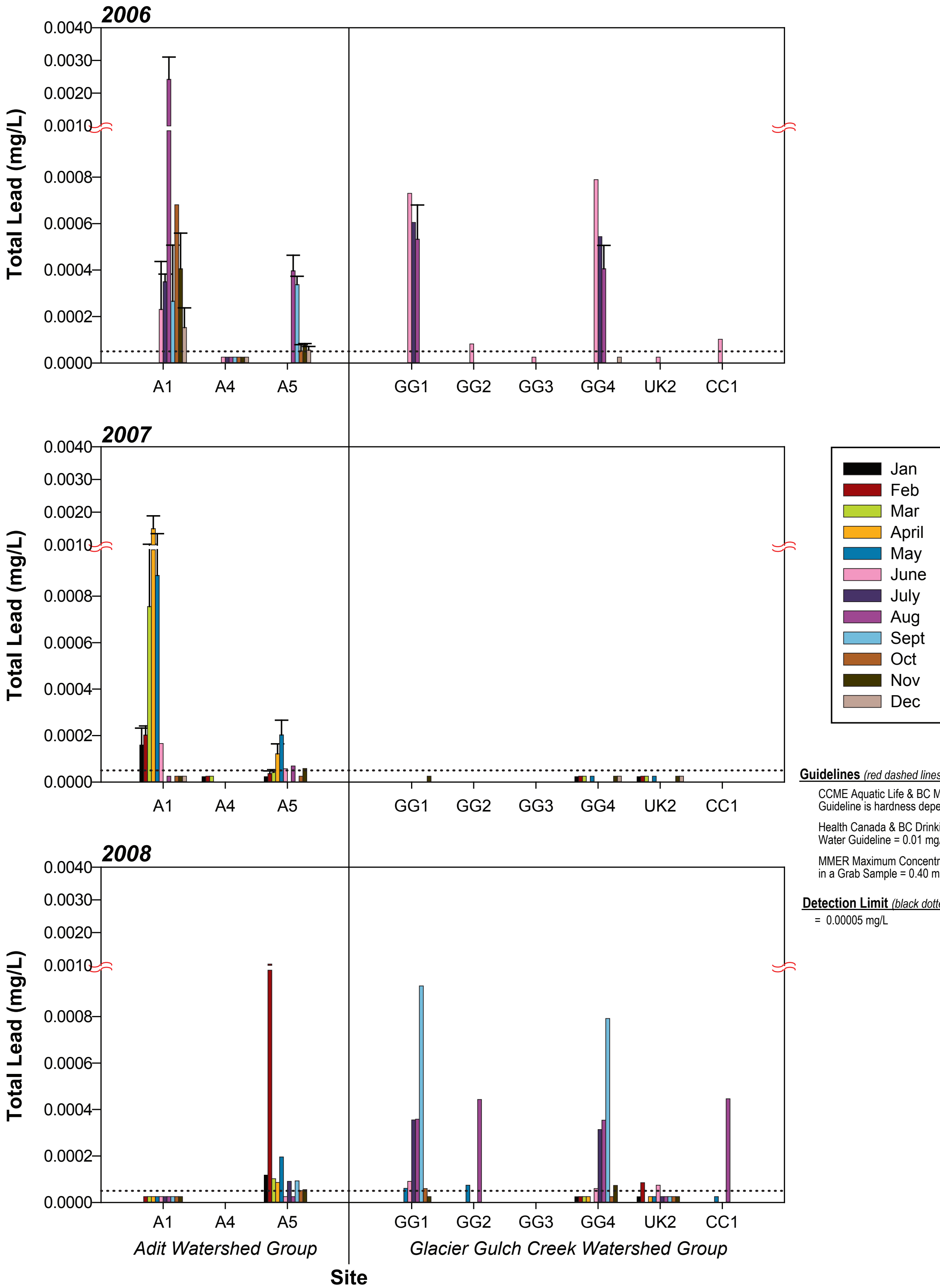
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

Total Iron in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

FIGURE 3.1-35

Rescan™



Guidelines *(red dashed lines)*

CCME Aquatic Life & BC Maximum Guideline is hardness dependent

Health Canada & BC Drinking Water Guideline = 0.01 mg/L

MMER Maximum Concentration in a Grab Sample = 0.40 mg/L

Detection Limit *(black dotted line)*

= 0.00005 mg/L

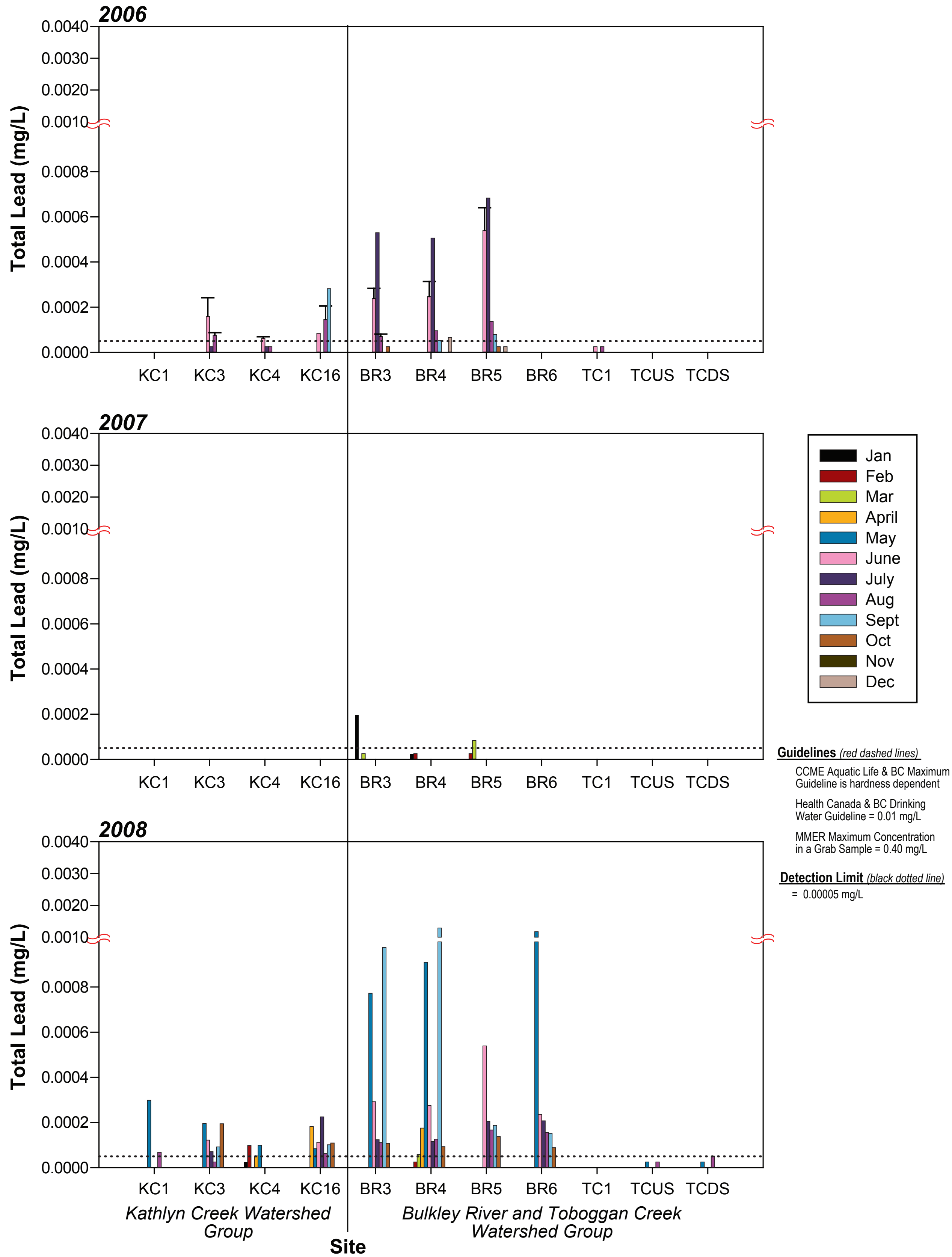
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

FIGURE 3.1-36

BLUE PEARL MINING

Total Lead in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

Rescan™



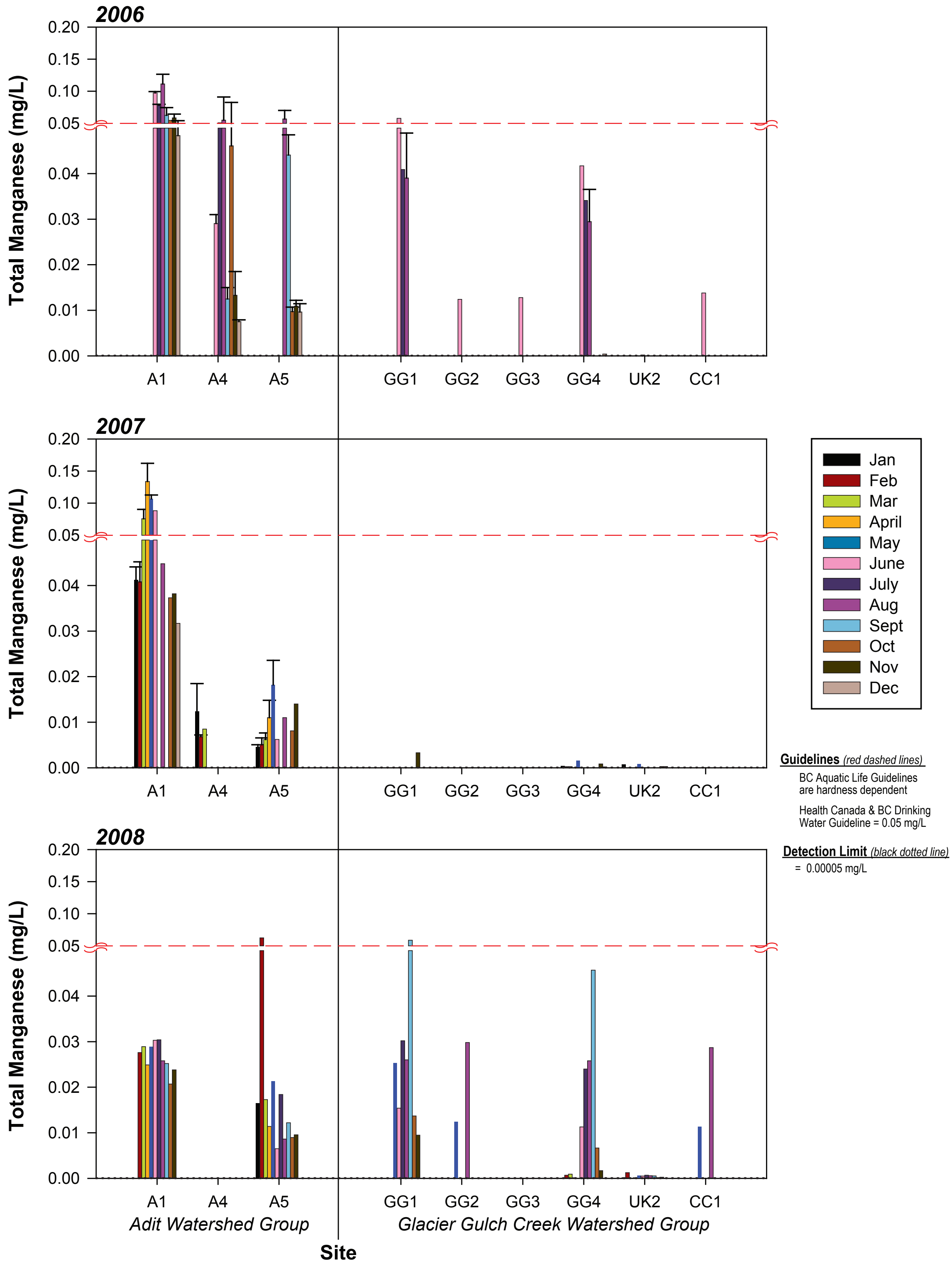
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

Total Lead in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

FIGURE 3.1-37

Rescan™

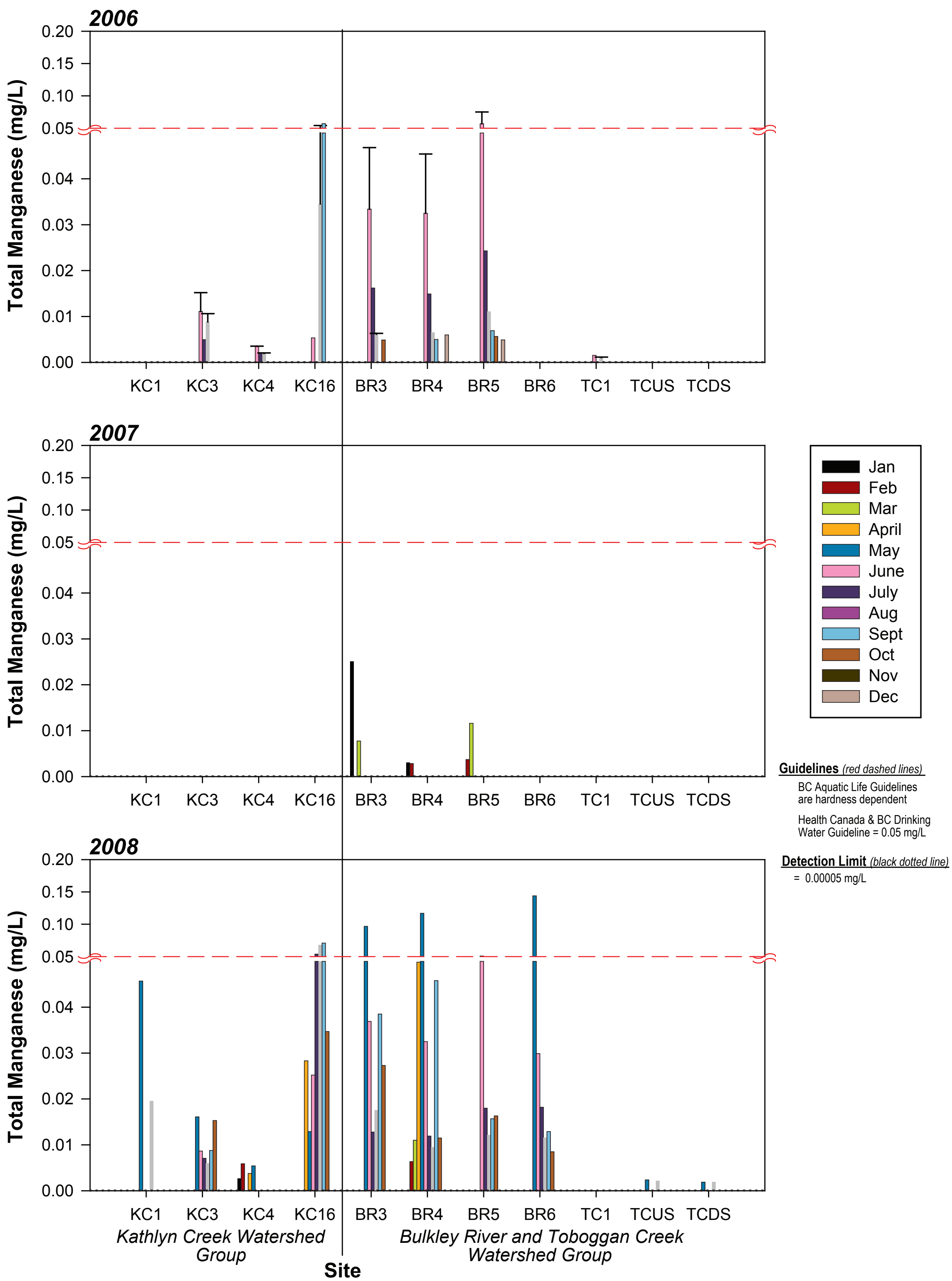


Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

FIGURE 3.1-38

Total Manganese in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

BLUE PEARL MINING



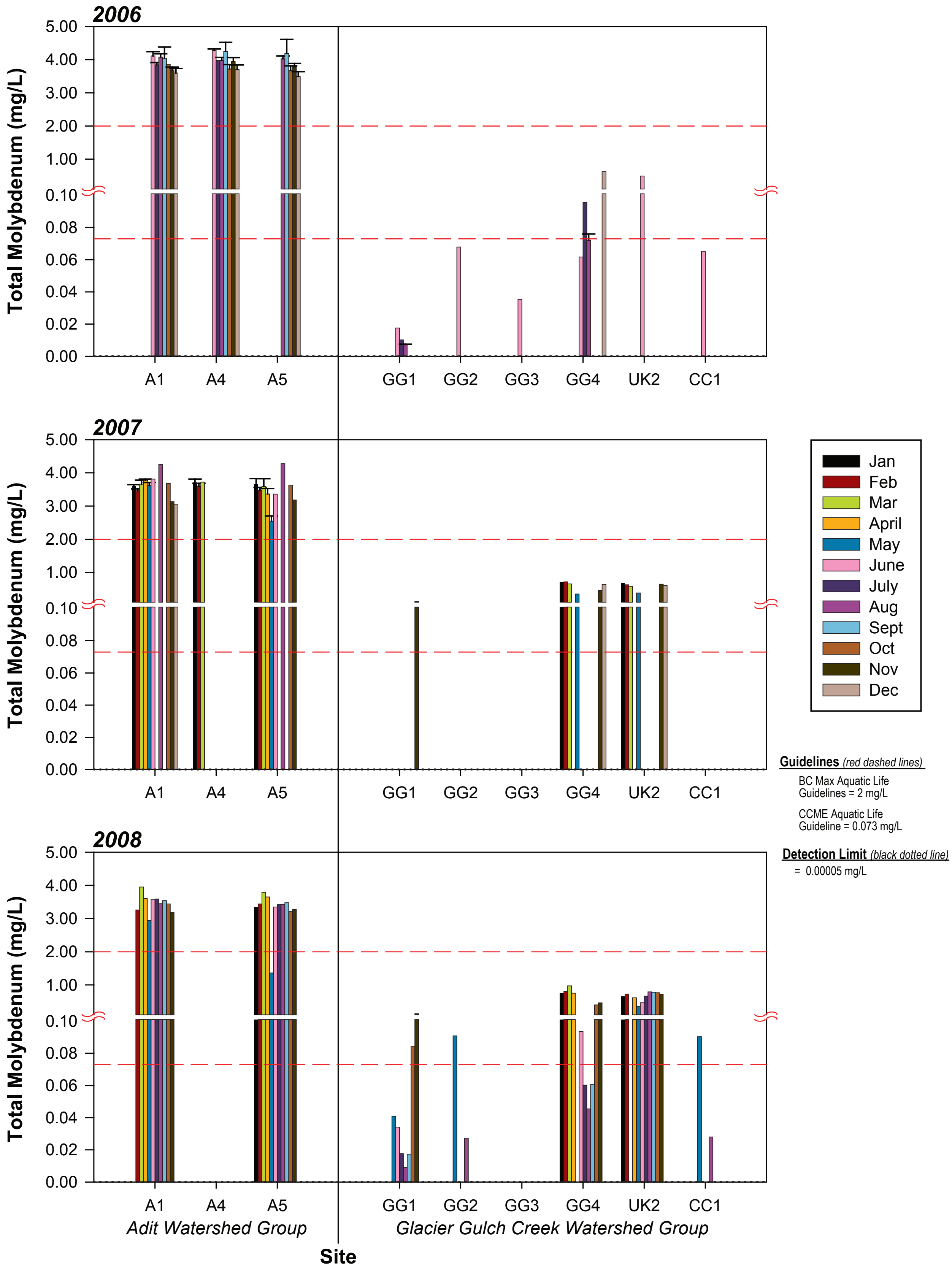
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

FIGURE 3.1-39

Total Manganese in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

Rescan™



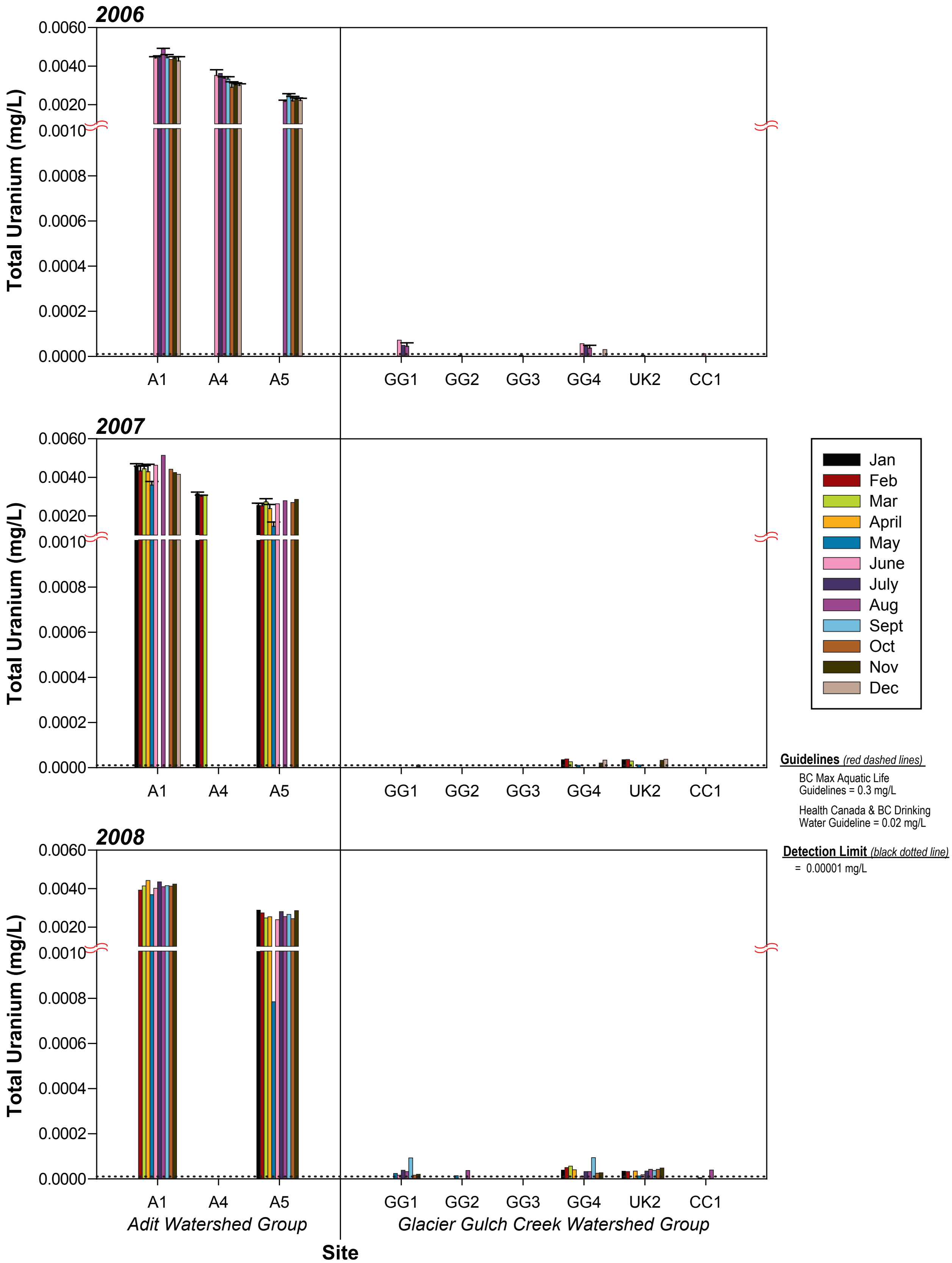
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

FIGURE 3.1-40

Total Molybdenum in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

Rescan™



Guidelines *(red dashed lines)*

BC Max Aquatic Life Guidelines = 0.3 mg/L

Health Canada & BC Drinking Water Guideline = 0.02 mg/L

Detection Limit *(black dotted line)*

= 0.00001 mg/L

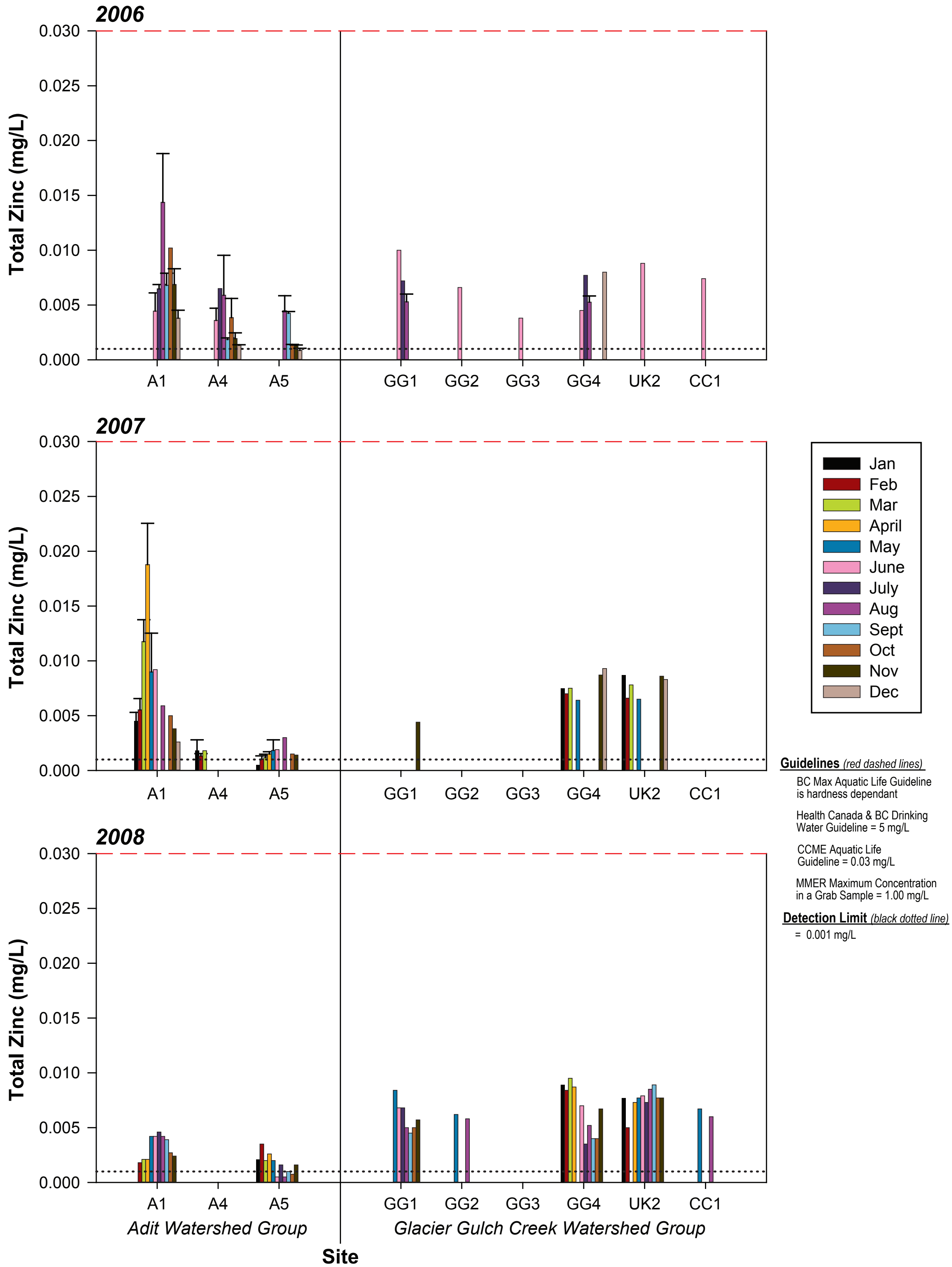
Note: Error bars represent standard error of the mean.
~ indicates change in scale within a graph.

BLUE PEARL MINING

FIGURE 3.1-41

Total Uranium in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

Rescan™



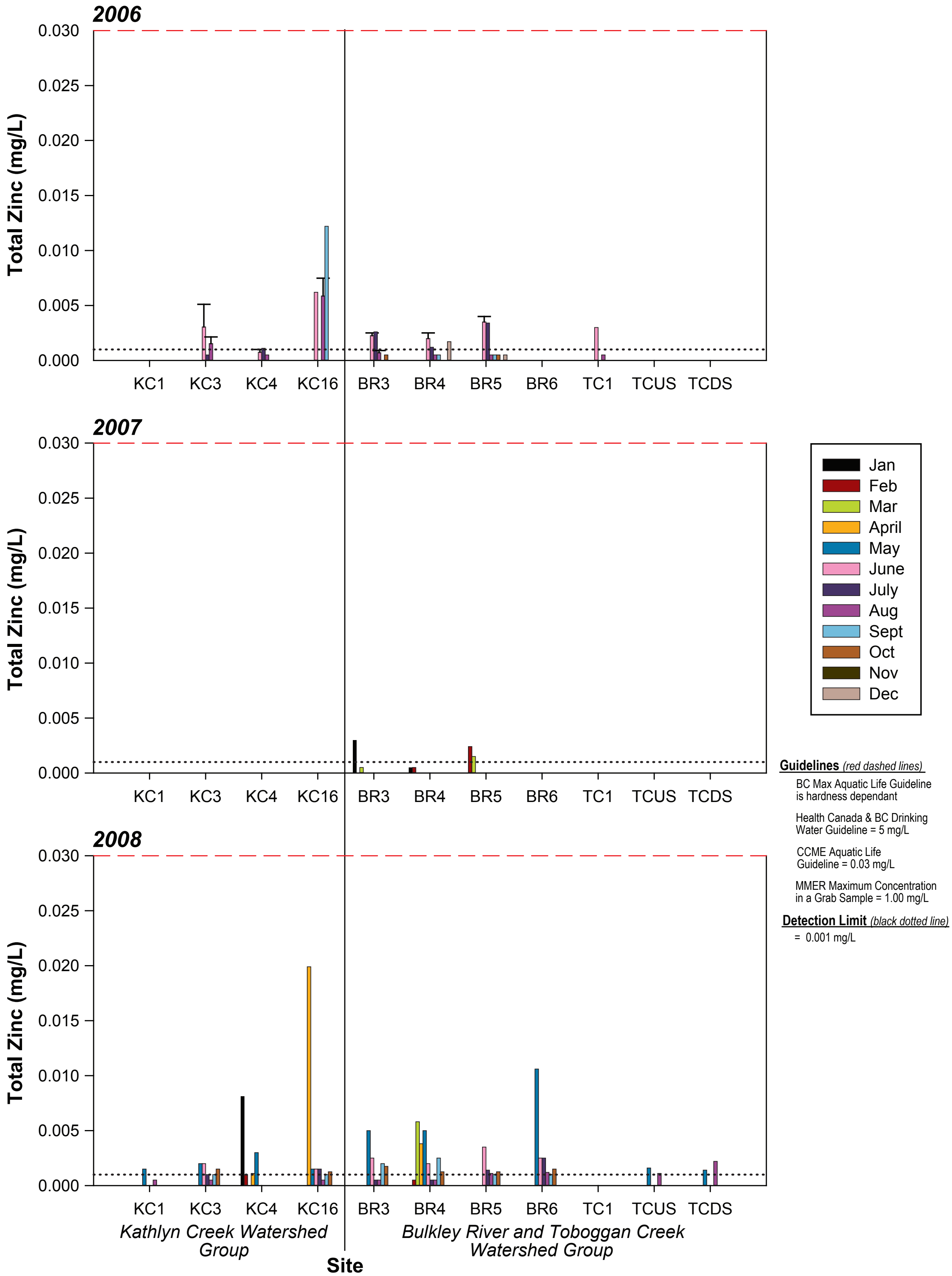
Note: Error bars represent standard error of the mean.

BLUE PEARL MINING

FIGURE 3.1-42

Total Zinc in Adit and Glacier Gulch Watershed Groups, Davidson Project Area

Rescan™



Note: Error bars represent standard error of the mean.

BLUE PEARL MINING

Total Zinc in Kathlyn Creek, Bulkley River and Toboggan Creek Watershed Groups, Davidson Project Area

FIGURE 3.1-43

Rescan™

3.1.2 Lake Kathlyn

All data available for Lake Kathlyn are available in Appendix 3-1-3. One site in Lake Kathlyn (S2) was sampled in 2008: once in May and once in September. When comparing the available data for Lake Kathlyn to guideline values, most concentrations were relatively low and close to or below detection limits. The remaining data were below available guideline values with three exceptions. Total cadmium concentrations (May-5.2 mg/L; September-6.6 mg/L) exceeded the CCME and the BC maximum aquatic life guidelines (hardness dependent). The total iron concentration in September (0.359 mg/L) was just slightly above the CCME and BC aquatic life and Health Canada and BC drinking water guidelines (0.3 mg/L). Total manganese concentrations (May-0.062 mg/L; September-0.067 mg/L) were also above the Health Canada and BC drinking water guidelines (0.05 mg/L).

3.1.3 Quality Assurance and Quality Control (QA/AC)

All field and travel blank data for 2008 are available in Appendix 3.1-5. Of the field and travel blanks were collected between June 2006 and October 2008, all were below method detection limits (MDL) except for 1.7%. Those samples that did exceed the MDL were just above the detection limit. The exceptions to this include total organic carbon, ammonia, total copper and dissolved copper occasionally exceeding the MDL by one order of magnitude (these instances are highlighted with red text in Appendix 3.1-4).

Relative percent difference (RPD) calculations between sample duplicates are presented in Appendix 3.1-6. Thirty-five duplicate pairs of samples were compared for 90 variables, using the RPD between the replicates as a measure of the variability inherent in field sampling (environmental heterogeneity). Approximately 70% of the analytical results were below MDL. Of the remaining results, 8% (73 out of 942 RPD calculations) were greater than the threshold of 20% indicated by provincial guidelines. In most of these cases the calculated RPD only marginally exceeded the threshold of 20%. Exceptions to this include total manganese (153%), dissolved manganese (82%), dissolved cadmium (44%), ammonia (50%), dissolved aluminum (64%) and total aluminum (72%).

3.2 AQUATIC TOXICITY

The results of the fish, invertebrate, plant and algae toxicity bioassays are discussed below for the two river water samples collected from the Bulkley River (Table 3.2-1; Appendix 3.2-1). It should be noted than any observed effects are not related to the Davidson Project since construction or development activity has not begun. Any observed toxicity is related to existing conditions in the Bulkley River prior to project initiation.

3.2.1 Rainbow Trout Embryos

Both the BR3 and BR4 samples showed moderate reductions in viability of trout embryos. The reported EC_{25} values were 78% and 48% test water, respectively. Some toxicity was seen at most concentrations for both samples. However, the EC_{50} was >100% test water, indicating that although some mortality was detected at low test water concentrations, the magnitude of toxicity was limited since over half the fish did not show effects even at the highest concentration.

Table 3.2-1. Summary of Toxicity Results for Bulkley River Water Samples, October 27 2008

Test Species	Test Duration	Endpoint	BR-3	BR-4	Comment
O. mykiss	7 days	Viability (EC25)	77.9 (16.5 - 100) %	48.0 (24.1-96.1) %	◦ Reduced viability in both samples.
(fish embryo)		Viability (EC50)	> 100%	> 100%	◦ Effect limited (moderate strength; EC50 >100%).
C. dubia	7 days	Survival (LC50)	> 100%	> 100%	◦ No adult lethality in either sample.
(invertebrate)		Reproduction (IC25)	> 100%	> 100%	◦ Variable results, but no overall dose response.
L. minor	7 days	Growth (# new fronds; IC25)	3.1 (1.7 - 6.6) %	>97%	◦ Reduced reproduction and growth in BR-3.
(plant)		Growth (# new fronds; IC50)	>97%	>97%	◦ Effect limited (moderate strength; IC50 >100%).
		Growth (dry weight; IC25)	3.0 (1.6 – 62.2) %	>97%	◦ No effect in BR-4 sample.
		Growth (dry weight; IC50)	>97%	>97%	◦ Slight stimulated growth observed for BR-4.
P. subcapitata	72 hours	Growth (# cells produced; IC25 & IC50)	>95.2%	>95.2%	◦ Stimulated growth observed for both samples.
(algae)					

Values are test water concentrations (%); numbers in parentheses are 95% confidence intervals.
EC25 is the concentration of test water required to cause an effect in 25% of the fish tested.

EC50 is the concentration of test water required to cause an effect in 50% of the fish tested.
LC50 is the concentration of test water required to cause lethality in 50% of the invertebrates tested.
IC25 is the concentration of test water required to cause 25% reduction in growth or reproduction.
IC50 is the concentration of test water required to cause 50% reduction in growth or reproduction.

3.2.2 Aquatic Invertebrate

Survival of the spiny waterflea was not affected at any concentration for either sample. The LC_{50}s were both >100% test water. Production of young was generally not inhibited at any concentration in either sample, with IC_{25} values >100% (IC_{25} is the concentration of test water required to cause inhibition of reproductive output by 25%). There was a reduction in reproductive output for BR3 (25% treatment). However, no inhibition was seen at 50% and 100% test concentrations. The variation within the 25% treatment was quite high and the standard deviation of its mean overlapped the mean of the controls. Therefore this result is considered spurious, and no overall toxic effect to invertebrates is attributed to the samples.

3.2.3 Duckweed

The BR3 sample showed inhibition of production of new leaves (fronds), with an IC_{25} of 3% and very low variation among replicates. Growth (biomass) showed the same IC_{25} for BR3, although biomass was more variable among replicates. However, toxicity was only moderate, since IC_{50} were above the highest treatment concentration.

No effect on production of fronds or biomass was observed for the BR4 sample, with IC_{25} and IC_{50} values all above 97% test water. Slight stimulation was shown in all treatments of BR4 relative to control.

3.2.4 Green Algae

No toxicity to green algae was detected during testing, based on cell yield (all IC_{25} and IC_{50} values > 95.2%). Conversely, algal growth was stimulated in both BR3 and BR4 sample treatments, resulting in a positive dose-response. This is common and relates to higher nutrient concentrations in test water stimulating the growth of the test organisms.

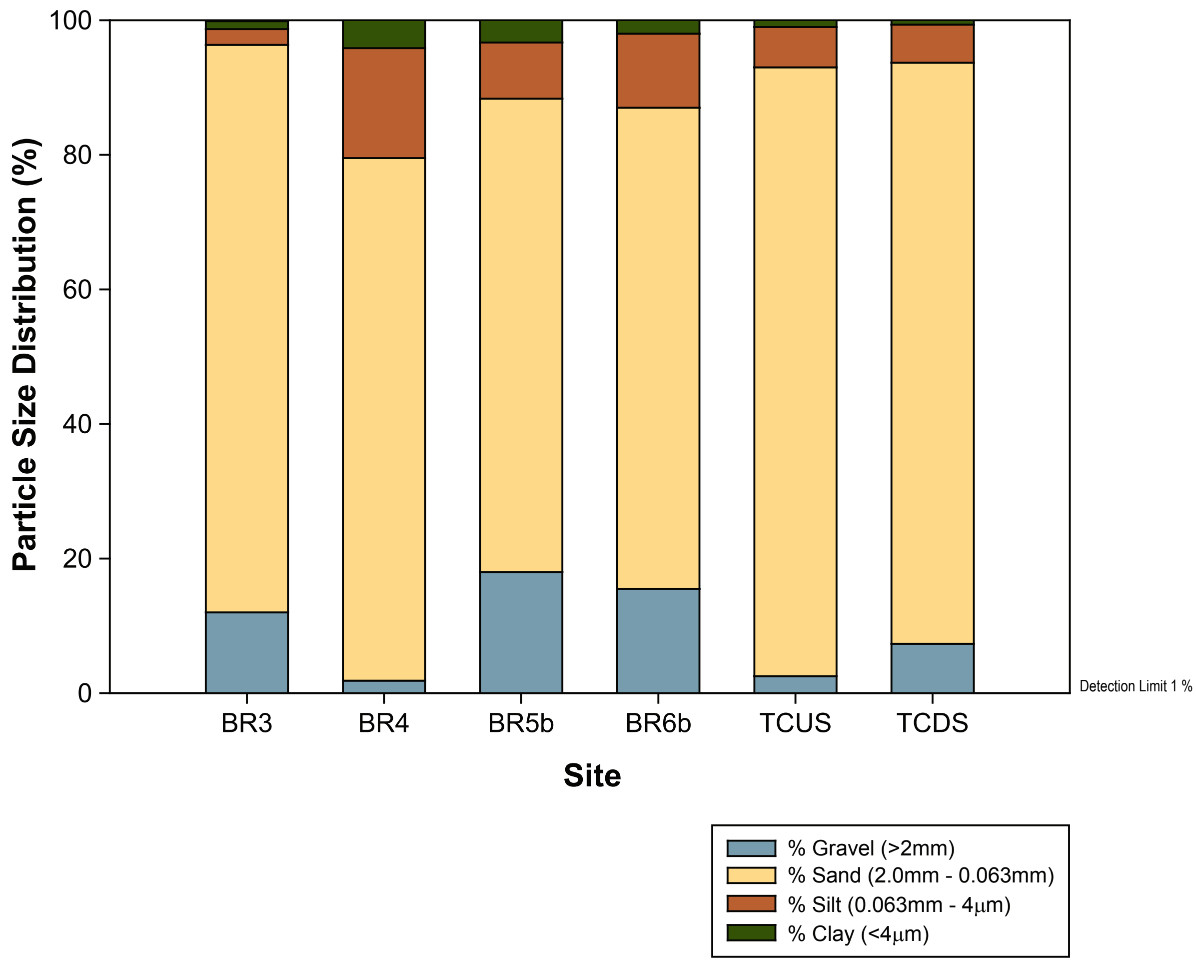
3.3 SEDIMENT QUALITY

3.3.1 Streams

3.3.1.1 Particle Size, Total Organic Carbon, Nutrients and Cyanide

All stream sediment data are presented in Appendix 3.3-1. Sand was the dominant substrate type at all six sampling locations, comprising 70 to 90% of the substrate (Figure 3.3-1). Gravel and silt composed less than 20% of the substrate at each site. Clay occurred very sparsely, comprising 0.8 to 4.3% of the substrate. Substrate composition was similar across all sites, although compositions were quite different than compositions found in previous years. In both 2005 and 2006, gravel was the dominant substrate at all sites, with sand sub-dominant (Rescan 2006a and Rescan 2007).

Results for total organic carbon (TOC), total nitrogen, available phosphate and total phosphorus are presented in Figure 3.3-2. TOC concentrations were low at all sites ranging from below detection limits at the Toboggan Creek sites to 0.5 % at BR4. Total nitrogen and phosphorus concentrations showed the same pattern, with the highest concentrations at BR4. Available phosphate had the highest concentrations at the Toboggan Creek sites (2.66 mg/kg) and lowest at BR4 and BR5b, which were at the detection limit of 1 mg/kg. Values for TOC, nitrogen, phosphate and phosphorus were all similar to values found in 2005 and 2006. All cyanide concentrations were below the analytical detection limit of 3.0 mg/kg (no figure).

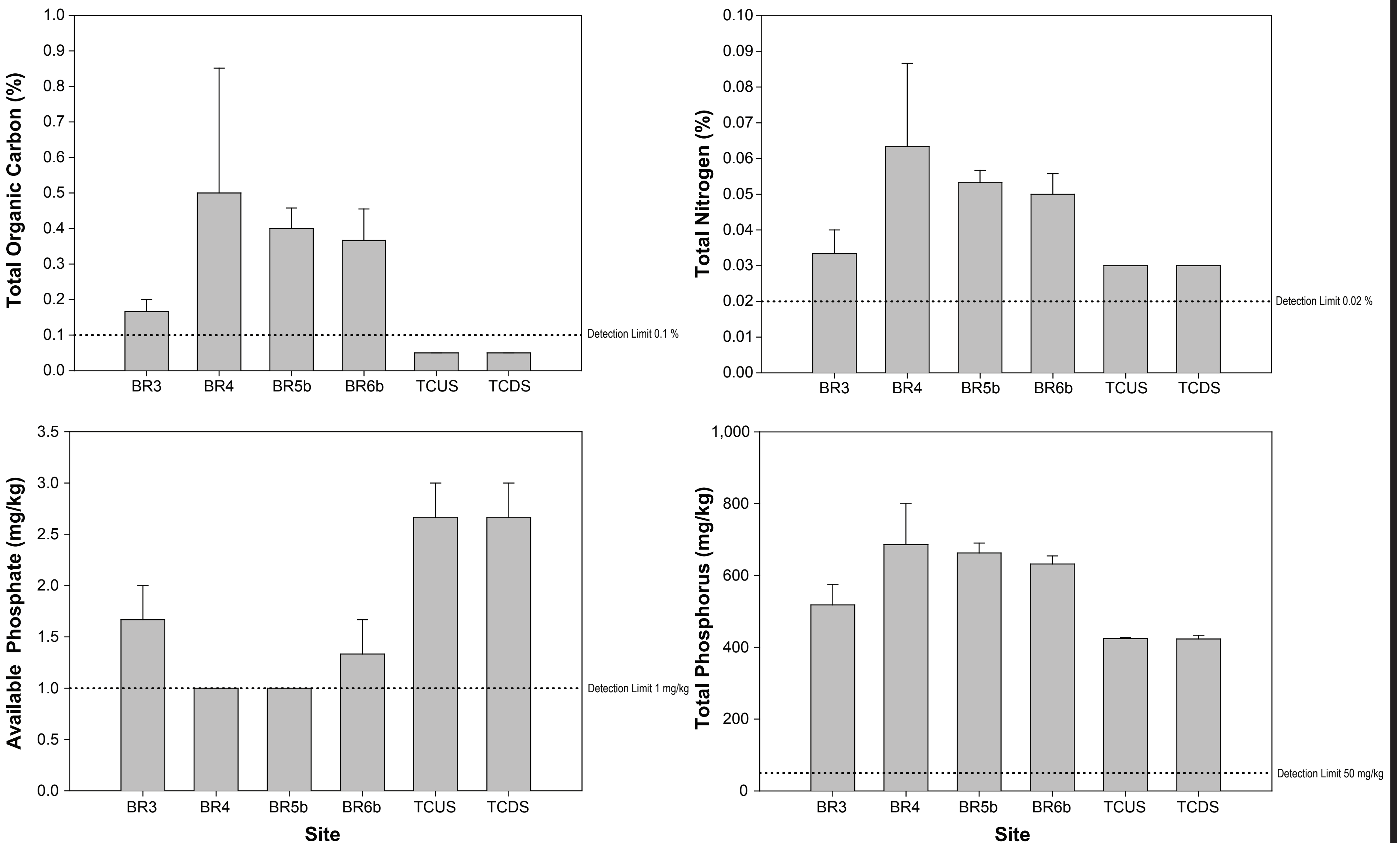


BLUE PEARL MINING

FIGURE 3.3-1

Particle Size Distribution of Sediments in Davidson Study Area Streams, September 2008

Rescan™



Note: Error bars represent standard error of the mean

BLUE PEARL MINING

FIGURE 3.3-2

Total Organic Carbon, Total Nitrogen, Available Phosphorus and Total Phosphorus Concentrations in Stream Sediments, Davidson Study Area, September 2008

Rescan™

3.3.1.2 Total Metals

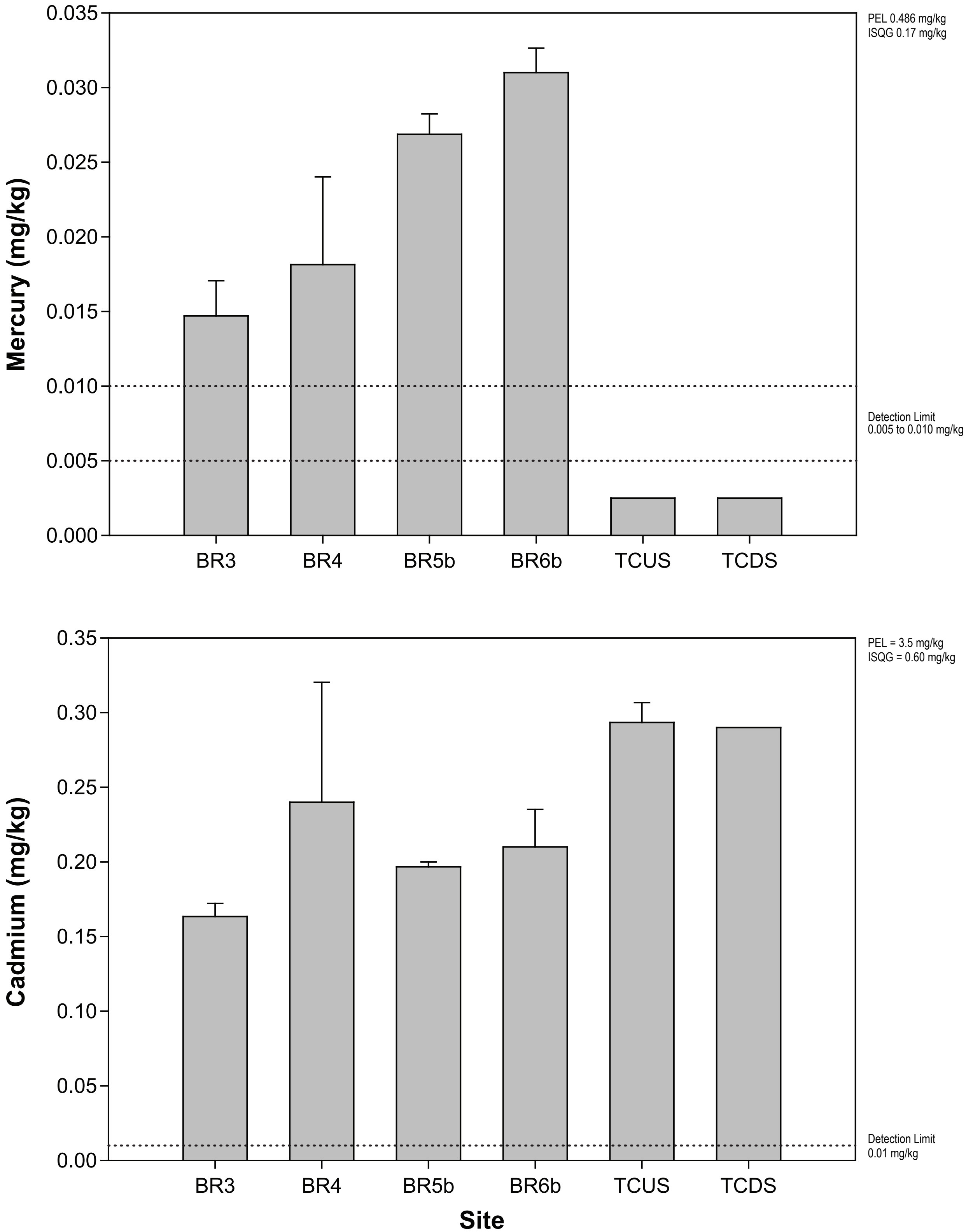
Of the 30 metals that were analyzed at the stream sites, 8 (antimony, beryllium, bismuth, lead, selenium, silver, thallium and tin) had values (at least 50%) below detection limits, and are not included in further analysis. Provincial and federal sediment quality guidelines are available for 9 of the 30 metals analysed. Federal guidelines exist for arsenic, cadmium, chromium, copper, lead, mercury, and zinc, while provincial guidelines exist for iron and nickel. Guidelines for cadmium, chromium, lead, mercury and zinc were not exceeded at any site. Results for metals of interest or metals with provincial/federal guidelines are graphed as follows: mercury and cadmium (Figure 3.3-3), chromium and nickel (Figure 3.3-4), molybdenum, aluminum and iron (Figure 3.3-5), arsenic, copper and zinc (Figure 3.3-6).

As with previous years, mercury and lead concentrations were well below guidelines at all sites, especially at the two Toboggan Creek sites. Cadmium concentrations were also well below guidelines at all sites, although highest concentrations were found at the Toboggan Creek sites. Chromium showed the same pattern as mercury, with higher concentrations at the Bulkley River sites than at the Toboggan Creek sites. Nickel concentrations were below detection limits at the two Toboggan Creek sites, however concentrations were moderately high at the remaining 4 sites, with at least one replicate above the BC LEL guideline of 16 mg/kg at each site. The BC SEL was not exceeded by any site. Molybdenum concentrations show a different pattern with all Bulkley River sites below detection limits and higher values (67 to 76 mg/kg) found in the Toboggan Creek area. Aluminum concentrations were similar across all sites ranging from 14,067 mg/kg (TCDS) to 21,267 mg/kg (BR4). Iron concentrations were high across all sites ranging from 28,833 mg/kg (TCDS) to 45,300 mg/kg (BR4). All sites exceeded the BC LEL sediment quality guideline and three Bulkley River sites exceeded the BC SEL guideline. Arsenic concentrations exceeded the ISQG of 5.9 mg/kg at all sites except BR3, while no sites exceeded the PEL of 17 mg/kg. Concentrations were highest in the Toboggan Creek sites. Copper concentrations were also highest at the Toboggan Creek sites (more than three times the concentrations at the Bulkley River sites) with both sites exceeding the ISQG of 35.7 mg/kg. The PEL (197 mg/kg) was not exceeded at any site. Zinc concentrations were similar across all sites ranging from 39.5 mg/kg (TCDS) to 88.3 mg/kg (BR4).

Overall, metal concentrations were similar to values found in 2005 and 2006 (Rescan, 2006 and Rescan, 2007). Iron was the only major exception, as concentrations varied widely between years. In 2005 iron concentrations were at their lowest, 2006 showed quite high concentrations, while 2008 values were in between those found in the two previous years.

3.3.2 Lake Kathlyn

Sediment quality data from Lake Kathlyn are presented in Appendix 3.3-1, and summarized in Table 3.3-1. Silt was the dominant substrate in one replicate (74%) while silt and sand were co-dominant at the other 2 replicates, at 47 to 38% and 43 to 53% of the composition, respectively. Clay was found at all replicates, ranging from 14 to 8% of the substrate composition. Gravel comprised less than 1% of all samples.



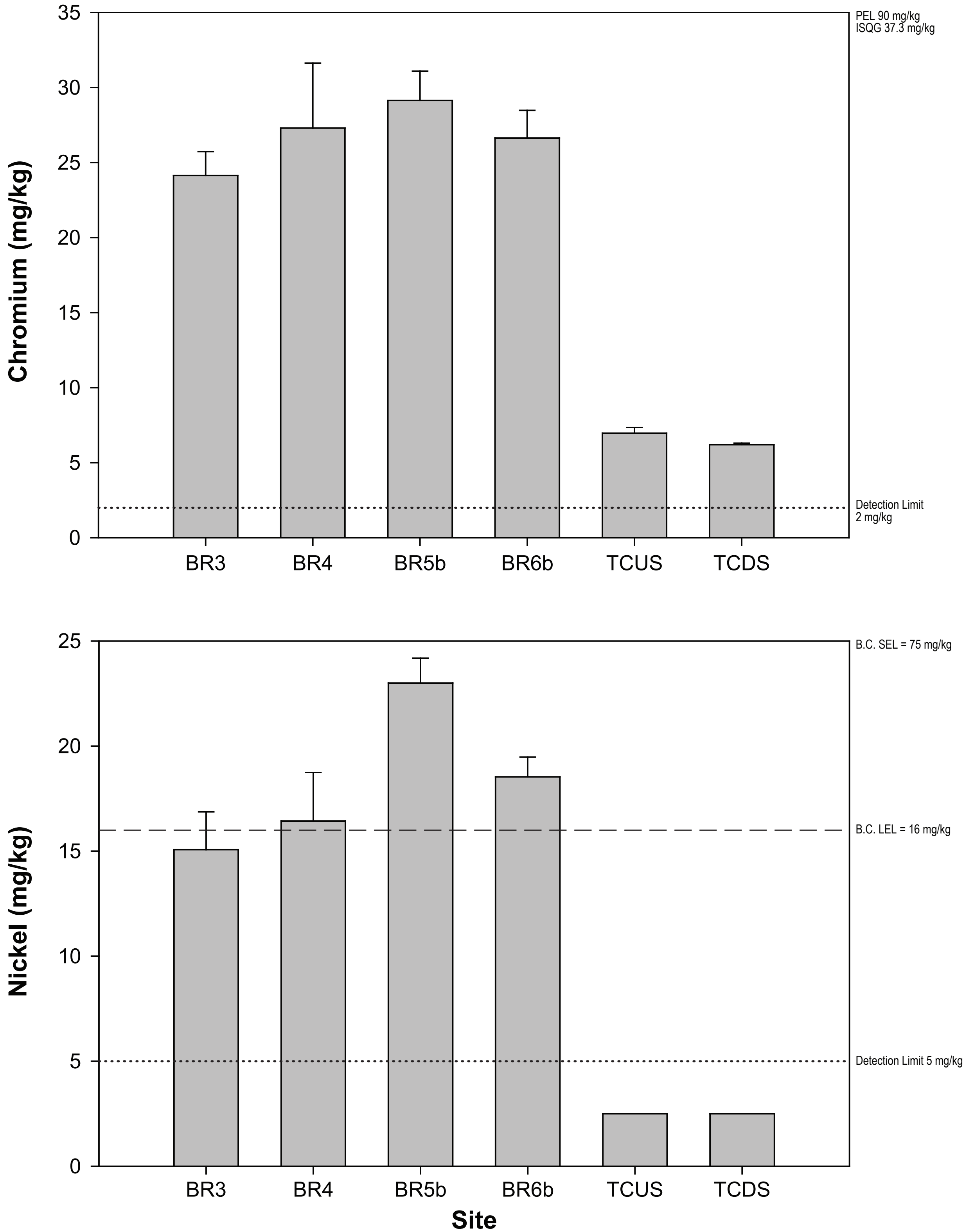
Notes: Error bars represent standard error of the mean
Dashed horizontal lines indicate sediment quality guidelines:
ISQG = Interim Sediment Quality Guideline, PEL = Probable Effects Level

FIGURE 3.3-3

Total Mercury and Cadmium Concentrations in Stream Sediments, Davidson Study Area, September 2008

BLUE PEARL MINING

Rescan™



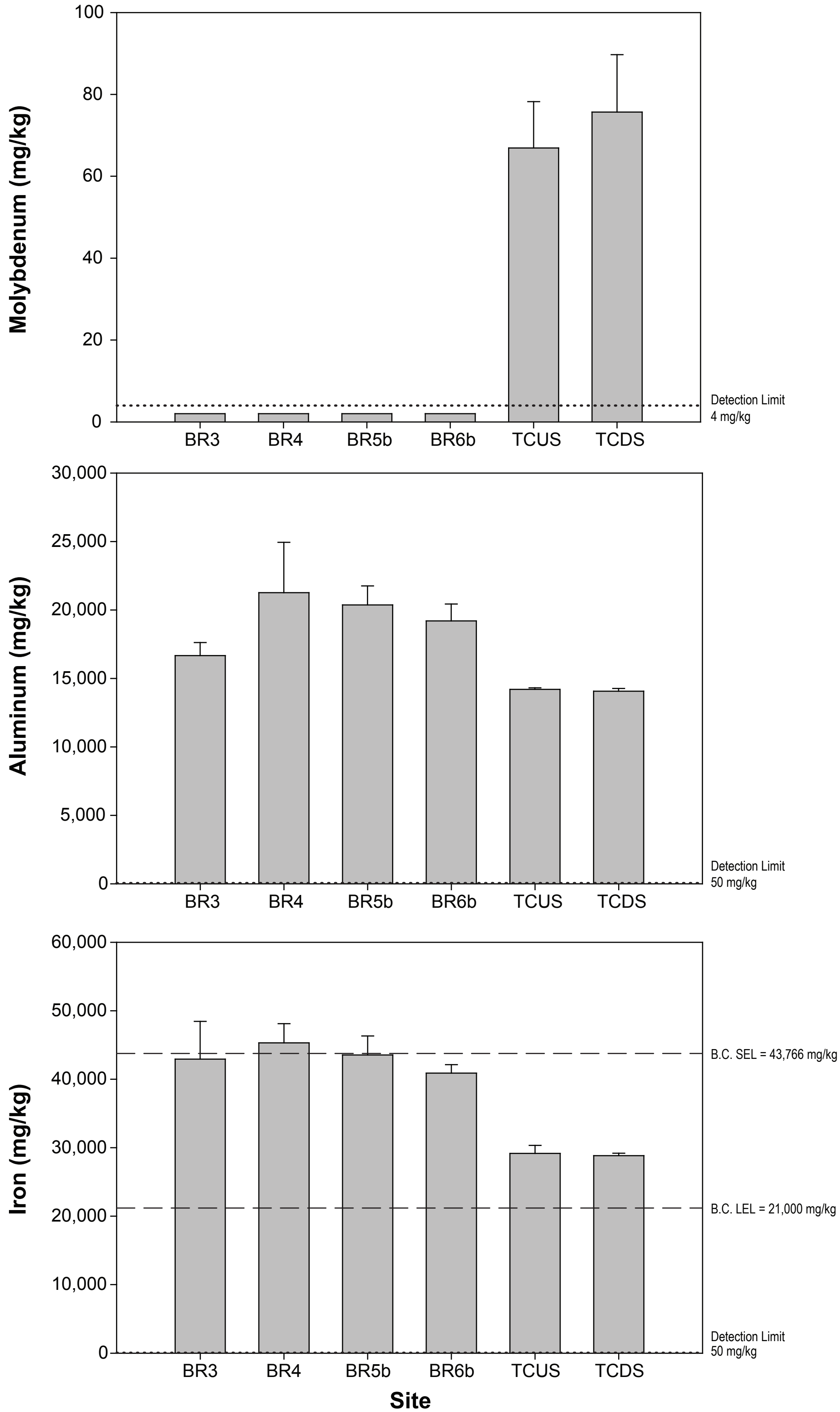
Notes: Error bars represent standard error of the mean
Dashed horizontal lines indicate sediment quality guidelines:
ISQG = Interim Sediment Quality Guideline, PEL = Probable Effects Level,
LEL = Lowest Effects Level, SEL = Severe Effects Level.

FIGURE 3.3-4

Total Chromium and Nickel Concentrations in Stream Sediments, Davidson Study Area, September 2008

BLUE PEARL MINING

Rescan™



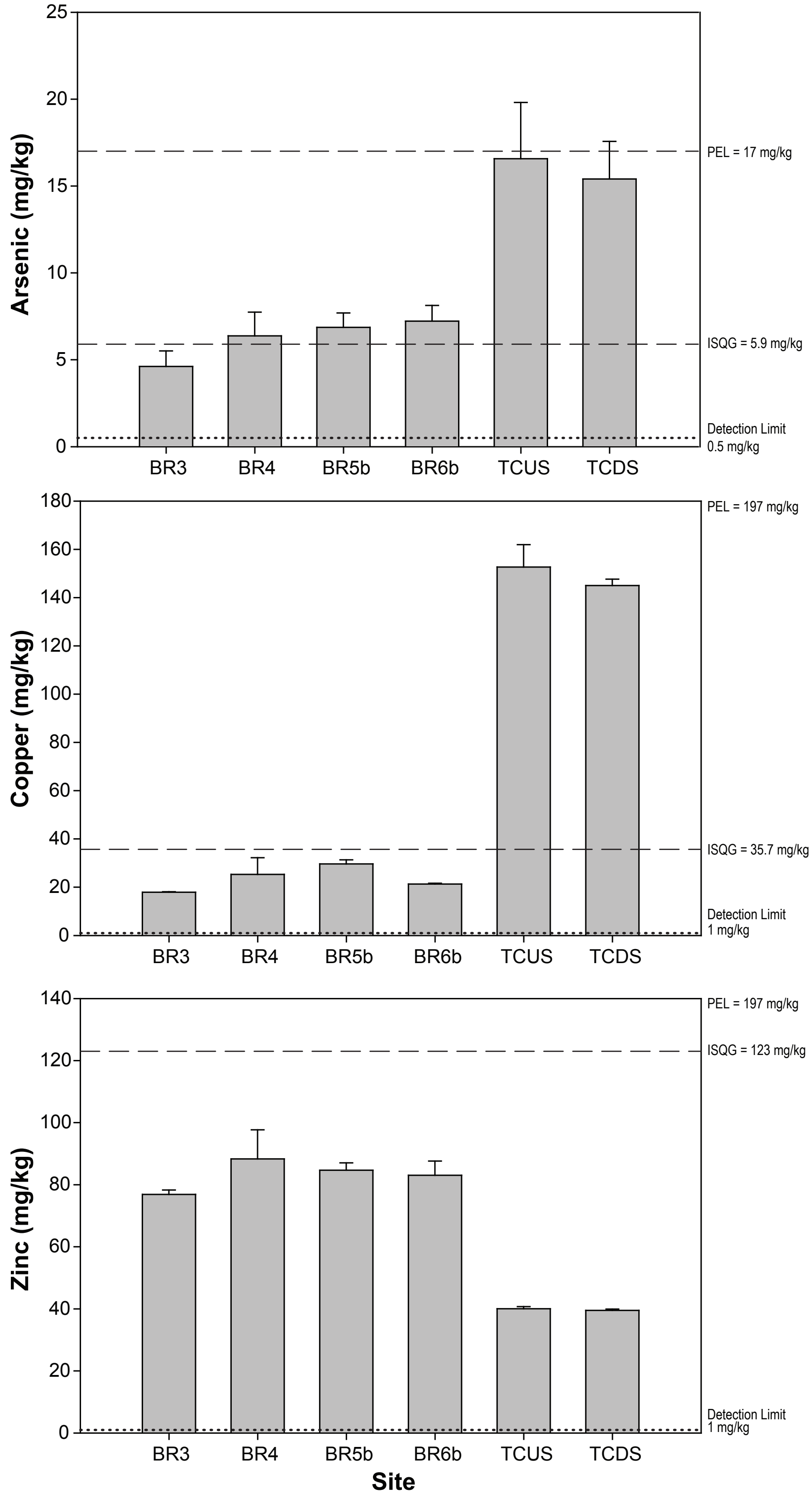
Notes: Error bars represent standard error of the mean
Dashed horizontal lines indicate sediment quality guidelines:
LEL = Lowest Effects Level, SEL = Severe Effects Level.

FIGURE 3.3-5

Total Molybdenum, Aluminum and Iron Concentrations in Stream Sediments, Davidson Study Area, September 2008

BLUE PEARL MINING

Rescan™



Notes: Error bars represent standard error of the mean
Dashed horizontal lines indicate sediment quality guidelines:
ISQG = Interim Sediment Quality Guideline, PEL = Probable Effects Level.

FIGURE 3.3-6

Total Arsenic, Copper and Zinc Concentrations in Stream Sediments, Davidson Study Area, September 2008

BLUE PEARL MINING

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Table 3.3-1. Sediment Quality Data from Lake Kathlyn, September 2008

		Detection		S2		Sediment Quality Guideline			
	Units	**Limits**	**Rep 1**	**Rep 2**	**Rep 3**	**ISQG**	**PEL**	**B.C. LEL**	**B.C. SEL**
Particle Size									
Gravel (>2mm)	%	1	<1	<1	<1	-	-	-	-
Sand (2.0mm - 0.063mm)	%	1	12	43	53	-	-	-	-
Silt (0.063mm - 4um)	%	1	74	47	38	-	-	-	-
Clay (<4um)	%	1	14	9	8	-	-	-	-
Nutrient, Inorganic and Organic Variables									
Available Phosphate	mg/kg	1	1	1	1	-	-	-	-
Total Nitrogen	%	0.02	0.36	0.23	0.18	-	-	-	-
Total Organic Carbon	%	0.1	4.9	3.3	2.7	-	-	-	-
Total Cyanide	mg/kg	3	<3.0	9.3	<3.0	-	-	-	-
Metals									
Aluminum (Al)	mg/kg	50	29800	26900	27800	-	-	-	-
Antimony (Sb)	mg/kg	20	<20	<20	<20	-	-	-	-
Arsenic (As)	mg/kg	0.5 / 50	**40.5**	**53**	**64**	5.9	17	-	-
Barium (Ba)	mg/kg	1	232	199	196	-	-	-	-
Beryllium (Be)	mg/kg	0.5	0.58	0.53	0.52	-	-	-	-
Bismuth (Bi)	mg/kg	20	<20	<20	<20	-	-	-	-
Cadmium (Cd)	mg/kg	0.1	0.75	0.64	0.52	0.6	3.5	-	-
Calcium (Ca)	mg/kg	50	4900	5030	4950	-	-	-	-
Chromium (Cr)	mg/kg	2	28	25	25.5	37.3	90	-	-
Cobalt (Co)	mg/kg	2	16.4	15.4	14.6	-	-	-	-
Copper (Cu)	mg/kg	1	104	81.3	72.5	35.7	197	-	-
Iron (Fe)	mg/kg	50	42300	**44600**	**47800**	-	-	21,200	43,766
Lead (Pb)	mg/kg	30	<30	<30	<30	35	91	-	-
Lithium (Li)	mg/kg	2	19.5	18.2	19.3	-	-	-	-
Magnesium (Mg)	mg/kg	50	6510	6050	6410	-	-	-	-
Manganese (Mn)	mg/kg	1	808	875	1070	-	-	-	-
Mercury (Hg)	mg/kg	0.005 / 0.01	0.07	0.0579	0.0519	0.17	0.486	-	-
Molybdenum (Mo)	mg/kg	4	30.6	18.4	16	-	-	-	-
Nickel (Ni)	mg/kg	5	20.9	17.9	17.8	-	-	16	75
Phosphorus (P)	mg/kg	50	828	768	766	-	-	-	-
Potassium (K)	mg/kg	200	3710	3340	3500	-	-	-	-
Selenium (Se)	mg/kg	50	<50	<50	<50	-	-	-	-
Silver (Ag)	mg/kg	2	<2.0	<2.0	<2.0	-	-	-	-
Sodium (Na)	mg/kg	200	530	490	500	-	-	-	-
Strontium (Sr)	mg/kg	0.5	49.1	50.5	52	-	-	-	-
Thallium (Tl)	mg/kg	50	<50	<50	<50	-	-	-	-
Tin (Sn)	mg/kg	10	<10	<10	<10	-	-	-	-
Titanium (Ti)	mg/kg	1	1290	1140	1080	-	-	-	-
Vanadium (V)	mg/kg	2	79.6	75.7	78.6	-	-	-	-
Zinc (Zn)	mg/kg	1	132	108	103	123	315	-	-

Notes:

Detection limits vary with the amount of sediment collected. Where more than one values exists, both are listed.

ISQG = Interim Sediment Quality Guidelines, PEL = Probable Effects Level (CCME, 2002)

LEL = Lowest Effects Level, SEL = Severe Effects Level (BCMWLAP, 1999)

Outlined value exceeds the most stringent guideline.

Bolded value exceeds the least stringent guideline.

Nutrients were generally found in low concentrations. Total organic carbon ranged from 2.7 to 4.9%, while total nitrogen ranged from 0.18 to 0.36%. Cyanide concentrations were below detection limits in two replicates and was 9.3 mg/kg in one replicate. Of the 30 metals analyzed for S2, 7 (antimony, bismuth, lead, selenium, silver, thallium, and tin) were below detection limits for all replicate samples. Provincial and federal guidelines exist for 8 of the metals analyzed. Guidelines for chromium, lead and molybdenum were not exceeded at any replicate. Arsenic concentrations were high, exceeding both the CCME ISQG and PEL for all replicates. Cadmium concentrations marginally exceeded the lower CCME ISQG at two replicates, while the PEL guideline was not exceeded. Copper concentrations exceeded the CCME ISQG for all replicates, while the PEL was not exceeded. Iron concentrations were very high, with all replicates exceeding the BC LEL and two replicates exceeding the BC SEL. Nickel concentrations were moderate with all replicates exceeding the BC LEL, although none exceeded the higher BC SEL. Zinc concentrations were generally low, with only one replicate exceeding the CCME ISQG and no replicated exceeding the PEL.

3.4 BENTHIC INVERTEBRATES

3.4.1 Overview

Benthic invertebrates (benthos) were sampled at six stream sites and one lake site. All lake and stream data are presented together to facilitate discussion and all original data can be found in Appendix 3.4-1. Two different sampling methods (Section 2.4) were used at each of the Bulkley River sites. The richness and diversity data discussed below has been considered at the genus level of taxonomic resolution (i.e., species counts from one genus have been pooled). However, for a strict examination of how effectively each method captured the available benthic community a direct comparison of the total number of taxa found using all taxonomic data for each site is best. Table 3.4-1 summarizes this comparison.

Table 3.4-1. Comparison of Benthos Sampling Methods

	Number of Taxa (Hess)	Mean	SE	Number of Taxa (Kicknet)
BR3	27	25	3.1	36
	15			
	34			
	25			
	23			
BR4	10	17	2.1	19
	17			
	17			
	21			
	22			
BR5b	32	29	1.4	29
	29			
	31			
	29			
	24			
BR6b	33	29	1.9	32
	35			
	25			
	28			
	26			

Sampling took place on September 11 (TCUS, TCDS and S2) and September 12, 2008 (all Bulkley River sites). Rainfall in the Project area was quite heavy on the evening of September 10 and continued into the afternoon of September 11. During sampling the water level at the Toboggan Creek sites (TCUS and TCDS) was relatively high and moving fast. The main channels had flooded at several locations forming new braided channels (Plate 3.4-1). This made it difficult to identify and safely reach pre-flood channels at many locations and likely contributed to the low densities of organisms found at these sites.

Plate 3.4-1. Toboggan Creek, upstream (TCUS) on September 11, 2008.

3.4.2 Genus Richness and Density

In the case of all four sites, the number of taxa identified using either sampling method was not considerably different (Table 3.4-1). In three of the four sites the difference between the number of taxa found via the kick-net method and the mean number of taxa via the Hess method was less than three. At BR3 the kick net sample yielded more taxa (36) compared to the Hess sample mean (25 taxa).

Genus richness in the Bulkley River sites was greater than the Toboggan Creek sites, as would be expected since this higher order river captures a considerably greater proportion of the watershed's productivity. Average benthos community genus richness ranged from 5 (TCDS) to 33 (BR3-Kick) taxa (Figure 3.4-1). At most of the Bulkley River sites the kick-net samples produced slightly greater richness values than the Hess samples. This difference was more pronounced at BR3 (an average of 22 taxa versus 33 taxa).

It is important to note that benthos density for the Hess and Eckman (S2 in Lake Kathlyn) samples are reported as number of organisms/m^2, while the kick-net samples are reported as total number of organisms collected during a timed (three minute) disturbance of the substrate.

Average density of benthos (Figure 3.4-1) was lowest at the two Toboggan Creek sites (92 and 24 organisms/m^2) and highest at S2, the Lake Kathlyn site (14,316 organisms/m^2). The primary contribution to the high density of organisms at S2 came from worms (Oligochaeta) and insect larva (Diptera). Within the Bulkley River sites, densities were greater at each site using the kick-net method, as would be expected since a greater area is covered. Among the Bulkley River sites benthos density at BR4, just upstream (approximately 200 m) of the sewage outfall, was the lowest. Density increased slightly at BR3, just downstream of the sewage outfall, and considerably greater further downstream at BR5b and BR6b.

3.4.3 Relative Abundance

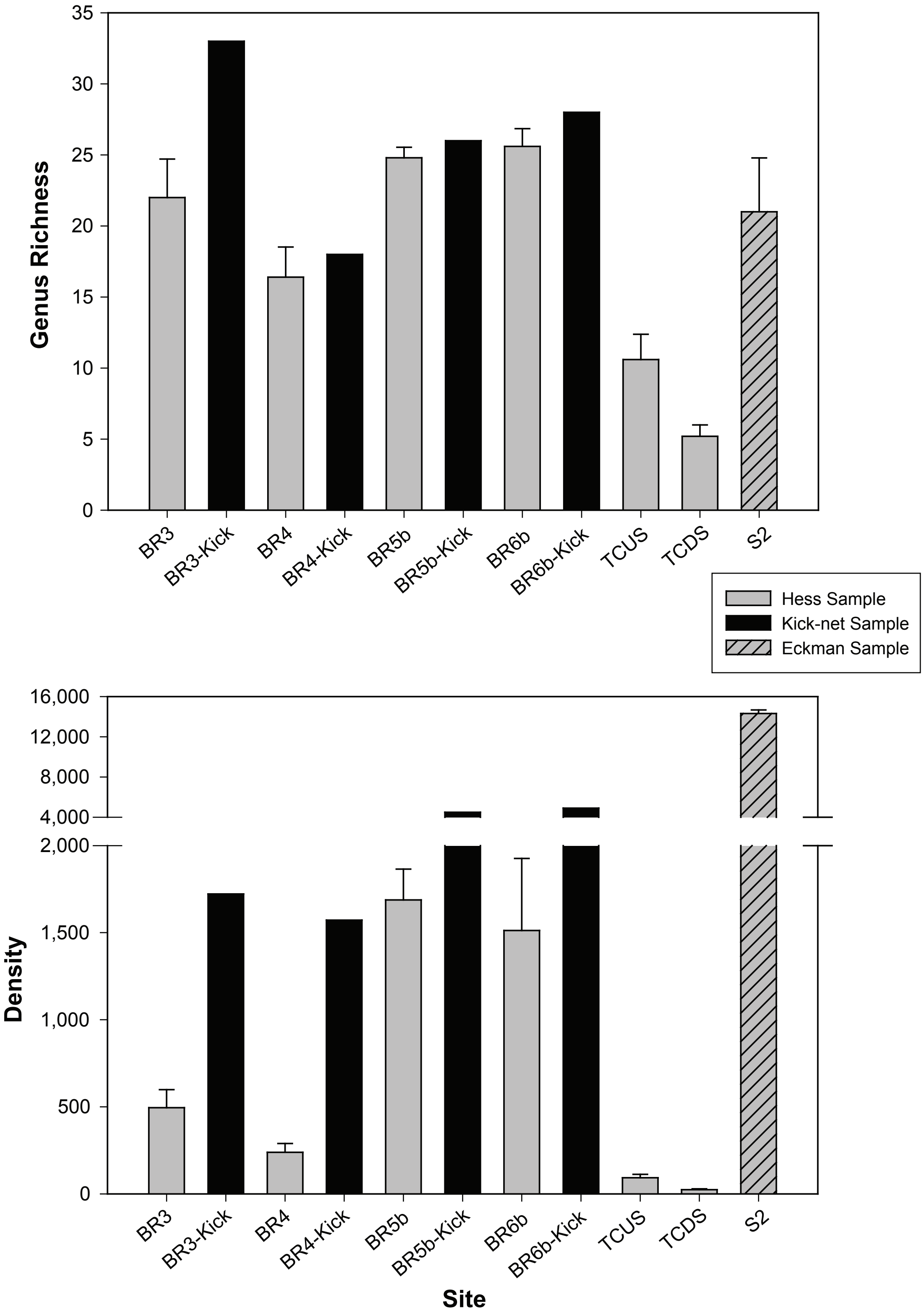
The data presented in Figures 3.4-2a and 3.4-2b show the most dominant taxonomic group were Diptera (8-68%), primarily at BR5b and BR6b. Ephemeroptera (15-50%), dominant at BR3 and BR4, Trichoptera (<1-34%) and Plecoptera (4-31%) were also very well represented at most sites. The Kathlyn Lake (S2) benthos community was primarily composed of oligochaetes (40%), dipterans (32%) and molluscs (17%), as would be expected in fine silt substrates. Smaller proportions of Nematoda, Arachnida, Coleoptera, and Collembola composed the remainder of these communities.

A high percent composition of ephemeropterans, plecopterans, and trichopterans (EPT) in the benthic invertebrate community generally indicates a relatively healthy stream ecosystem. All stream sites were found to have at least 43% EPT. The only exception to this was BR5b (Hess sampler), which had an average of 30% EPT. Several sites were composed of close to 70% or greater EPT (i.e., BR3, BR4, BR4-Kick and BR6b-Kick).

3.4.4 Diversity and Similarity

Both the Shannon and Simpson Diversity indices are presented in Figure 3.4-3. Both indices are presented to highlight that an opposite response can be found by each index. Simpson Diversity ranged from 0.76 at BR5b to 0.92 at TCDS while Shannon Diversity ranged from 1.54 at TCDS to 2.77 at BR3-Kick. The problem of conflicting results between these two metrics revolves around the point that taxa richness and evenness are emphasized differently in each metric. The Shannon Diversity Index emphasizes the richness component of diversity and is affected more by the addition of rare species with increasing sample size, whereas the Simpson Diversity Index emphasizes the evenness component of diversity (Gimaret-Carpentier 1998, Nagendra 2002). This explains why TCDS, a site with such low richness but number of individuals very evenly distributed, was found to be the most diverse according to the Simpson Index.

Evenness data and results from analysing similarity are presented in Figure 3.4-4. It can be seen that average evenness ranged from 0.61 at BR5b to 0.96 at TCDS. The Bray-Curtis Similarity Index was calculated for the Bulkley River sites. Since BR4 is the reference site, the calculated percent similarity of each site is compared to the percent similarity for the median values at BR4 (Environment Canada 2003). As would be expected BR4 had the greatest percent similarity (73%). The average similarity of the remaining Bulkley River sites to BR4 was almost equivalent (BR3-47%; BR5b-44%; BR6b-41%).



Note: Error bars represent standard error of the mean.

BLUE PEARL MINING

Benthic Invertebrate Genus Richness and Density in Davidson Study Area Streams, 2008

FIGURE 3.4-1

Rescan™

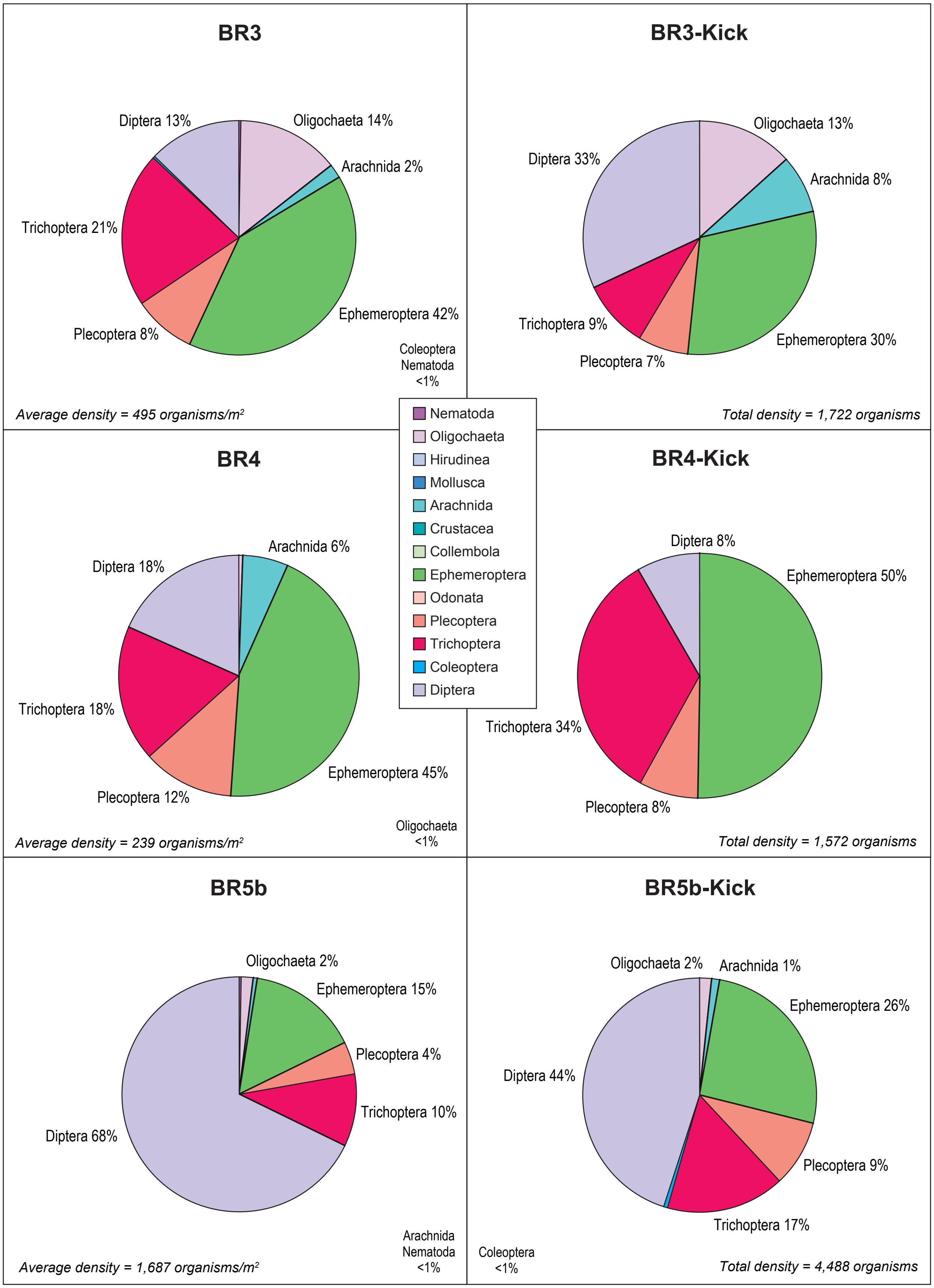
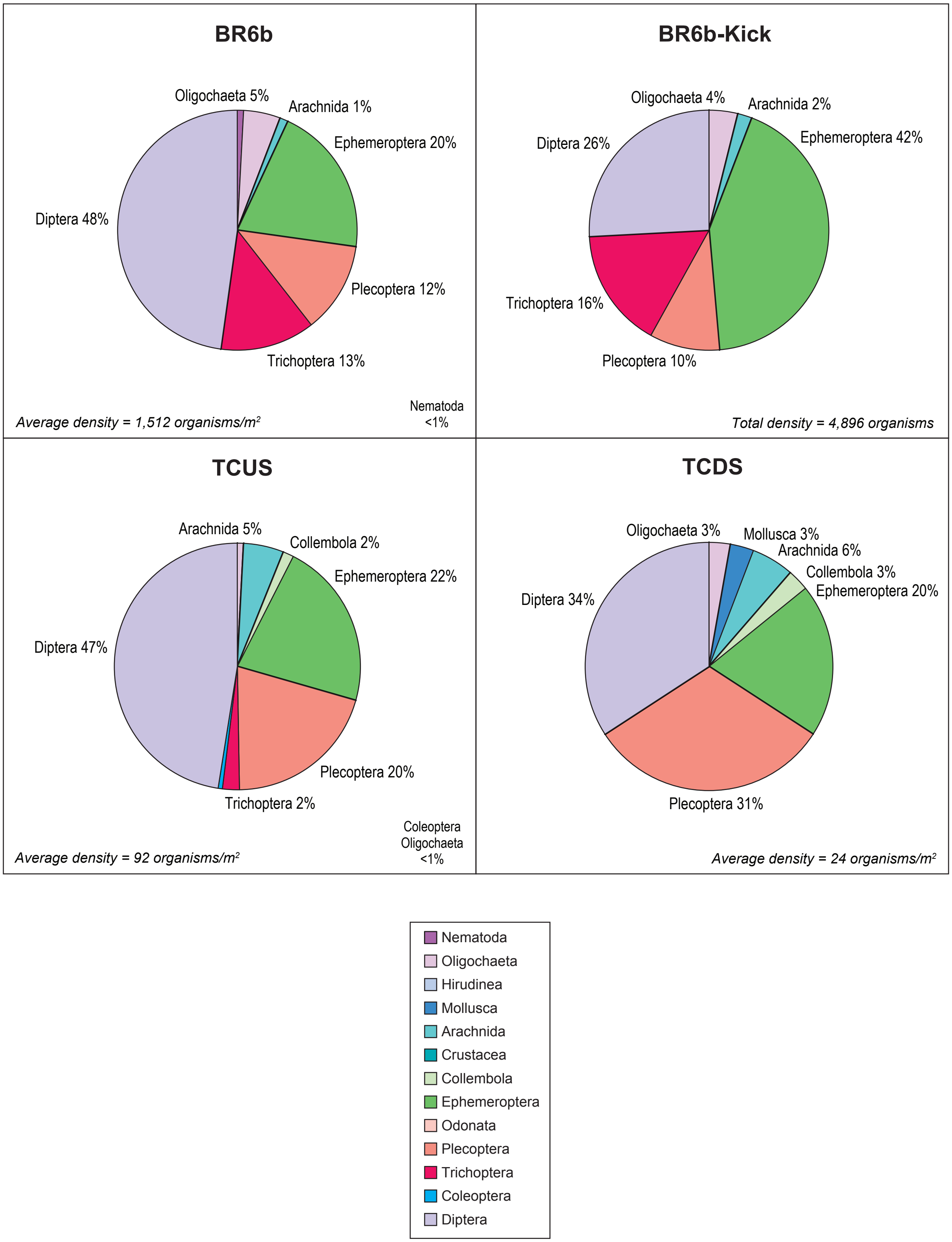


FIGURE 3.4-2a

Taxonomic Distribution of Benthic Invertebrates in Davidson Study Area Streams, 2008

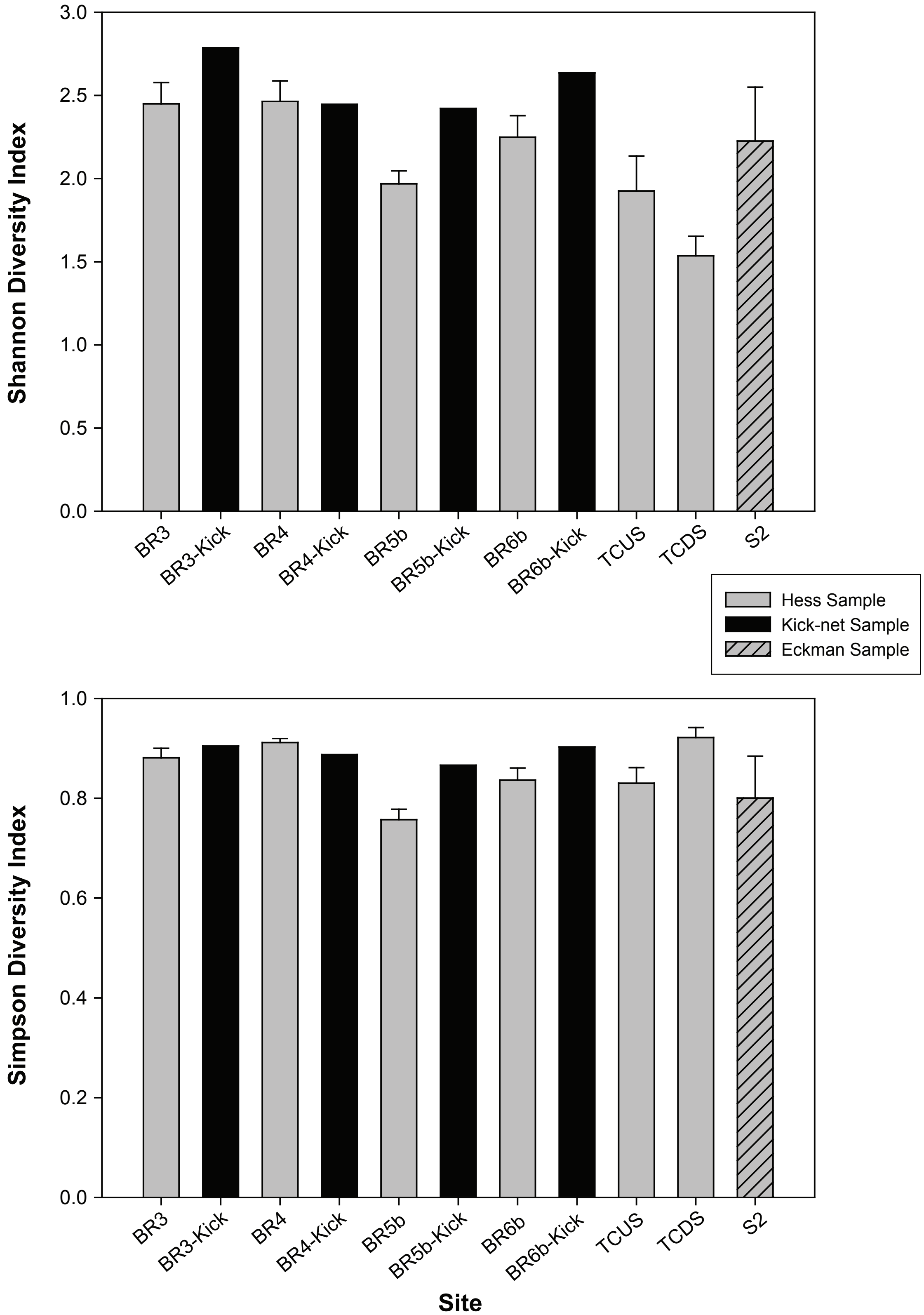


BLUE PEARL MINING

FIGURE 3.4-2b

Taxonomic Distribution of Benthic Invertebrates in Davidson Study Area Streams, 2008

Rescan™



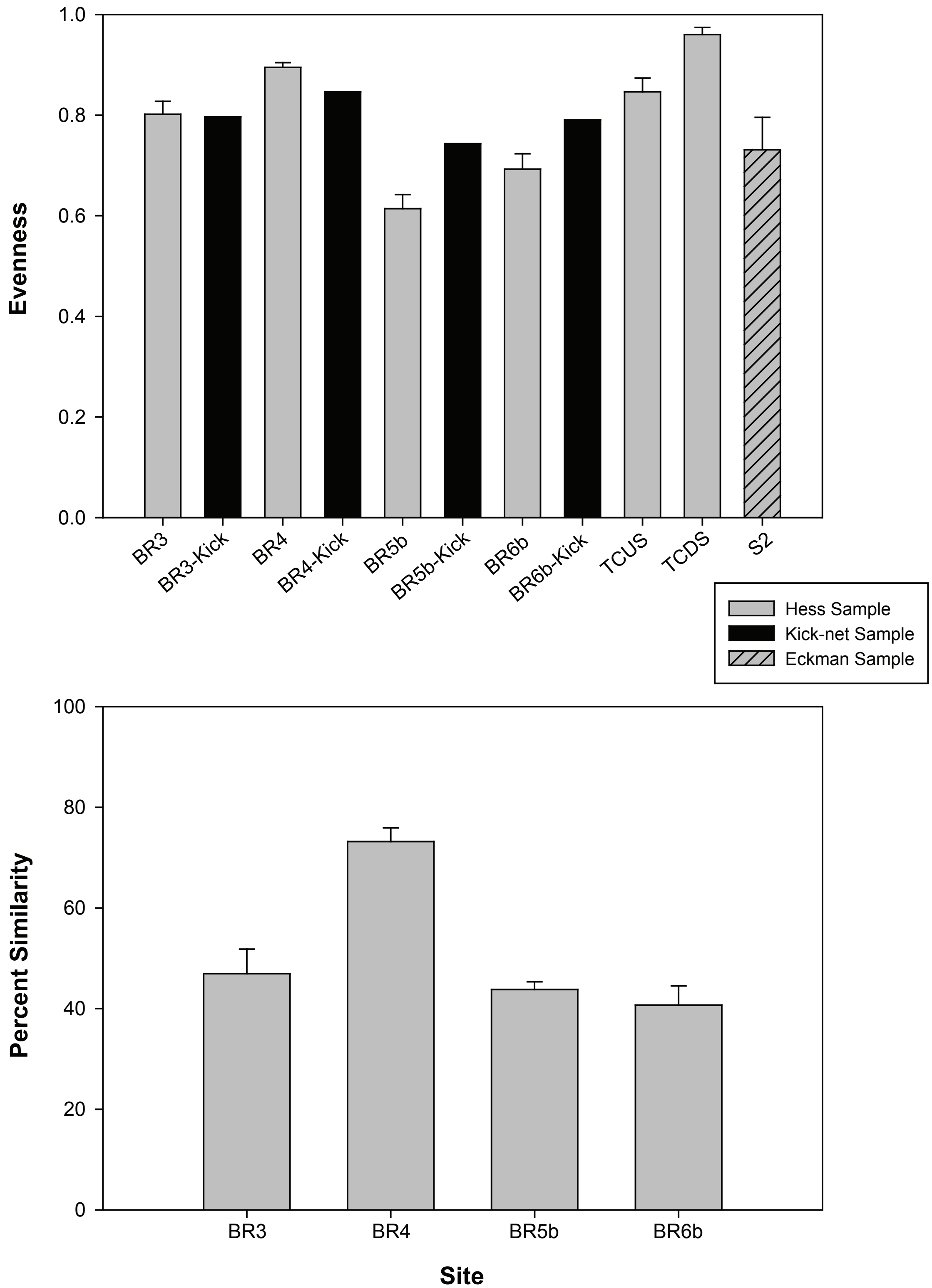
Note: Error bars represent standard error of the mean.

BLUE PEARL MINING

Benthic Invertebrate Simpson and Shannon Diversity in Davidson Study Area Streams, 2008

FIGURE 3.4-3

Rescan™



Note: Error bars represent standard error of the mean.

BLUE PEARL MINING

Benthic Invertebrate Evenness and Bray-Curtis Similarity in Davidson Study Area Streams, 2008

FIGURE 3.4-4

Rescan™

4. Summary and Conclusions

4. Summary and Conclusions

4.1 WATER QUALITY

4.1.1 Streams

Throughout 2006, 2007 and 2008 many physical variables and total metals had their highest concentrations within the Adit WG. Most often concentrations at GG4 and UK2 were the next highest. These high concentrations within the Adit and adjacent Glacier Gulch Creek Watershed Group are a reflection of the high mineralization in the area. Several variables often had the most similar concentrations in 2006 and 2008 than compared to the 2007 data.

Seasonal trends for nutrients (total phosphate, nitrate and total organic carbon) were apparent at several sites with peak concentrations occurring during the spring. In addition to the high concentrations in the Adit WG, the Bulkley River WG also had samples containing relatively high concentrations of several metals (i.e., aluminum, barium, chromium and manganese). The Health Canada and BC drinking water guidelines were exceeded by several variables including turbidity, aluminum, antimony, iron and manganese concentrations. The BC Maximum guideline for the protection of aquatic life was exceeded (most often within the Adit WG) for fluoride, sulphate, cadmium, chromium, copper and molybdenum. Total antimony concentrations at A1 exceeded the BC working aquatic life guideline. Total arsenic, cadmium, copper, iron and molybdenum concentrations also exceeded the CCME guidelines at several sites. The only MMER discharge limit that was exceeded was for total suspended solids, which was exceeded by several samples in all WGs except Toboggan Creek WG.

4.1.2 Lake Kathlyn

In Lake Kathlyn most concentrations were relatively low and close to or below available detection limits. The remaining data were below available guideline values with the exception of total cadmium (exceeded the CCME and the BC maximum aquatic life guidelines), total iron (just slightly above the CCME and BC aquatic life and Health Canada and BC drinking water guidelines) and total manganese concentrations (exceeded the Health Canada and BC drinking water guidelines).

4.2 AQUATIC TOXICITY

Any observed toxicity is related to existing conditions in the Bulkley River prior to project initiation. Both the BR3 and BR4 samples showed moderate reductions in viability of trout embryos. However, the magnitude of toxicity was limited since over half the fish did not show effects even at the highest concentration. Survival of the spiny waterflea was not affected at any concentration for either sample. Production of young was generally not inhibited at any concentration in either sample. There was a reduction in reproductive output for BR3 (25% treatment), however no overall toxic effect to invertebrates is attributed to the samples. The BR3 sample showed inhibition of production of new duckweed leaves (fronds) and growth (biomass) showed the same IC_{25} for BR3. However, toxicity was only moderate, since IC_{50} were above the highest treatment concentration. No effect on production of fronds or biomass was observed for the BR4 sample. No toxicity to green algae was detected during testing, based on cell yield.

4.3 SEDIMENT QUALITY

4.3.1 Streams

Sand was the dominant substrate type at all stream sampling locations. Gravel and silt composed less than 20% of the substrate at each site. In previous years (2005 and 2006) gravel was the dominant substrate at all sites, with sand sub-dominant.

Values for TOC, nitrogen, phosphate and phosphorus were all similar to values found in 2005 and 2006. TOC concentrations were relatively low at all sites. Total nitrogen and phosphorus concentrations showed the same pattern, with the highest concentrations at BR4. Available phosphate had the highest concentrations at the Toboggan Creek sites. All cyanide concentrations were below the analytical detection limit.

Guidelines for cadmium, chromium, lead, mercury and zinc were not exceeded at any site. Several metals (chromium, mercury, lead, nickel, aluminum, iron and zinc) were found in their highest concentrations within the Bulkley River sites. The Toboggan Creek sites had the highest concentrations of arsenic, cadmium, copper and molybdenum.

Overall, metal concentrations were similar to amounts found in 2005 and 2006 (Rescan 2006 and Rescan 2007). Iron was the only major exception. In 2005, iron concentrations were at their lowest, 2006 showed quite high concentrations, while 2008 values were in between those found in the two previous years.

4.3.2 Lake Kathlyn

Silt and sand were the dominant substrates in Lake Kathlyn sediment. Nutrients were generally found in low concentrations. Cyanide concentrations were below detection limits in two replicates and 9.3 mg/kg in one replicate. Antimony, bismuth, lead, selenium, silver, thallium, and tin were below detection limits for all replicate samples. Arsenic concentrations were high, exceeding both the CCME ISQG and PEL for all replicates. Cadmium and copper concentrations exceeded the CCME ISQG. Iron concentrations were relatively high with replicates exceeding the BC LEL and the BC SEL. Nickel concentrations were moderate with all replicates exceeding the BC LEL. Zinc concentrations were generally low, with only one replicate exceeding the CCME ISQG. All sediment concentrations represent natural background environmental conditions and will be used to monitor effects in the future.

4.4 BENTHIC INVERTEBRATES

Average density of benthos was lowest at the two Toboggan Creek sites and highest at S2, the Lake Kathlyn site. Densities at the Bulkley River sites were greater at each site using the kick-net method, as would be expected. Among the Bulkley River sites density was greater at the downstream sites.

The most dominant taxonomic group were Diptera, primarily at BR5b and BR6b. Ephemeroptera, Trichoptera and Plecoptera (EPT) were also very well represented at most stream sites. Most stream sites were found to have at least 43% EPT. Several sites were composed of close to 70% or greater EPT (i.e., BR3, BR4, BR4-Kick and BR6b-Kick). The Kathlyn Lake (S2) benthos community was primarily composed of oligochaetes and dipterans.

Genus richness was greatest in the Bulkley River sites. At most of the Bulkley River sites the kick-net samples produced slightly greater richness values than the Hess samples. Simpson Diversity was greatest at TCDS while Shannon Diversity was greatest at BR3-Kick. Average evenness was highest at TCDS.

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Engineers and Scientists

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