Regional District of Nanaimo Biosolids Management Program

TimberWest Properties Surface Water Quality Report 2012-2017

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Prepared for:

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LIST OF ABBREVIATIONS

General abbreviations used in this document:

BC – British Columbia
BCAWQG – British Columbia Approved Water Quality Guidelines
CCME – Canadian Council of Ministers of the Environment
EC – electrical conductivity
OMRR – British Columbia Organic Matter Recycling Regulation
RDN – Regional District of Nanaimo
VIU – Vancouver Island University

Unit abbreviations used in this document:

cm – centimetre
L – litre
m – metre
mg – milligram
mL – millilitres
mm – millimetres
MPN – most probable number
ppm – parts per million
ppt – parts per thousand
µg – microgram
µS – microSiemens

EXECUTIVE SUMMARY

Biosolids from the Regional District of Nanaimo have been managed in a forest fertilization program on privately owned forest lands located along Weigles Road in Nanaimo, BC since 2003. Surface water quality is monitored in order to assess any potential adverse effect of biosolids fertilization on water quality. From 2012 to 2017, Vancouver Island University had responsibility for monitoring surface water quality at the site. As of November 2017, SYLVIS is undertaking responsibility for surface water monitoring at this site.

Surface water samples were collected biannually in the spring and fall from May 18th, 2012 to December 13th, 2017 from the following sampling locations:

- Flynfall Creek (upstream and downstream);
- Caillet Creek (upstream and downstream);
- Bonnell Creek (upstream and downstream);
- W1500 Creek (upstream and downstream); and
- W5100 (swamp).

Surface water samples were analyzed for a full suite of parameters including the following which can be useful for determining whether biosolids applications have impacted water quality:

1. Nitrogen (ammonia + ammonium, nitrate);
2. Phosphorus (total phosphorus and orthophosphate);
3. Chloride;
4. Electrical conductivity;
5. Trace elements regulated by the British Columbia *Organic Matter Recycling Regulation*; and,
6. Fecal coliforms.

Samples collected prior to November 23rd, 2017 were not analyzed for parameters groups 1-3.

There were no clear exceedances of guidelines except in one case out of more than 2,100 separate parameters analyses. Downstream samples generally showed lower concentrations of trace elements, electrical conductivity, and fecal coliforms. Nutrients (nitrogen and phosphorus) and chloride analyzed for in the winter of 2017 showed small differences between upstream and downstream samples and were generally below background reference concentrations.

Similar to the conclusions of other reports investigating surface and groundwater quality at this site, this report concludes that due to the low incidence of exceedances, the separation in time between exceedances and biosolids land applications, and the incidence and magnitude of downstream increases in parameter concentrations, it is unlikely that biosolids applications at this site are having an adverse effect on surface water quality.

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1 BACKGROUND

Biosolids from the Regional District of Nanaimo (RDN) have been managed in a forest fertilization program at privately owned forested lands owned by TimberWest Forest Corporation (TimberWest Properties) located along Weigles Road in Nanaimo, BC since 2003. The TimberWest Properties were formerly leased by Vancouver Island University (VIU) from 1988 to 2017. From 2013 to 2017, the biosolids forest fertilization program was managed under a tripartite agreement between the RDN, VIU, and SYLVIS Environmental (SYLVIS).

The *Organic Matter Recycling Regulation* (OMRR), the regulation governing biosolids management in British Columbia (BC), does not require monitoring of water bodies proximate to biosolids land application sites but rather specifies setback distances for biosolids applications from surface water bodies and groundwater wells. These setbacks are required in order to ensure that biosolids constituents (nutrients, pathogens, trace elements) are not able to travel either overland or through groundwater to sensitive water features. A surface water monitoring program, however, is advisable for sufficiently large and long-term projects in order to confirm the suitability and effectiveness of setback distances and other site management requirements and decisions in mitigating potential adverse effects on water quality from biosolids management.

During the period 2012 – spring 2017, VIU had responsibility for monitoring surface water quality at the site. In November 2017, the RDN entered into a land-use agreement with TimberWest as well as an agreement for biosolids management with SYLVIS, both expiring on May 31st, 2021. Under the biosolids management agreement, SYLVIS has responsibility for surface water monitoring at the TimberWest Properties.

This report summarizes surface water quality sampling at the TimberWest Properties between 2012 and 2017 based on sampling largely conducted by VIU and one sample set collected by SYLVIS.

2 BIOSOLIDS MANAGEMENT AND WATER QUALITY

The OMRR requires specific management techniques which are designed to protect surface and groundwater quality. These requirements are:

1. A setback distance of 30 metres (m) for biosolids applications from potable water sources, irrigation wells, lakes, rivers, and streams (OMRR Schedule 8(1)d(i));
2. A requirement to apply only when groundwater is more than 1 m below the soil surface (OMRR Schedule 8(1)b));
3. A requirement to locate biosolids storage 15-30 m from any watercourse, depending on the nature of the storage facility/site (OMRR Division 1, Section 18-19); and,
4. A requirement to cover stored biosolids from October 1st to March 31st in regions of the province where annual precipitation exceeds 600 millimetres (mm) (OMRR Division 1, Section 20).

3 WATER SAMPLING LOCATIONS AND FREQUENCY

Under the tripartite agreement (2013-2017) VIU monitored surface water quality at the TimberWest Properties. This data, along with some data from 2012, was provided to SYLVIS by VIU prior to the termination of the tripartite agreement. For continuity, SYLVIS continued sampling at the same locations (Figure 1):

Creek	Location	Coordinates	In Biosolids Area
Flynfall Creek	Upstream	49°11'50.24"N, 124° 7'8.61"W	Yes
	Downstream	49°11'30.86"N, 124° 6'13.96"W	Yes
Caillet Creek	Upstream	49°12'25.57"N, 124° 6'27.87"W	Yes
	Downstream	49°12'23.80"N, 124° 5'22.96"W	Yes
Bonnell Creek	Upstream	49°11'54.26"N, 124° 7'40.79"W	Yes
	Downstream	49°11'57.46"N, 124° 7'51.20"W	Yes
W1500 Creek	Upstream	49°12'22.78"N, 124° 7'13.78"W	Yes
	Downstream	49°12'39.87"N, 124° 6'34.74"W	Yes
W5100 (swamp)	-	49°11'51.61"N, 124° 6'54.30"W	Yes

Surface water was collected in the spring and fall of each year from sampling points where water flow was sufficient for sampling. Samples were collected as grab samples in sampling bottles from the creekside. A summary of sampling frequency at each location is given in Table 1, Appendix One. Total precipitation in the two weeks preceding sampling ranged from 2 to 213 mm (Table 2, Appendix One) and generally correlated with the sampling frequency. This record underlines the value of sampling following sufficient precipitation in order to ensure both adequate volume and adequate flow for representative and meaningful sampling.

3.1 Flynfall Creek

Flynfall Creek is a major drainage for the TimberWest Properties. The creek originates from an area of high elevation which serves as the headwaters to Flynfall and Bonnell Creeks and generally flows eastward roughly parallel to Weigles Road. Upstream samples were taken at the outflow of the headwaters and downstream samples were taken at a bridge crossing over the creek outside the property boundary and roughly due south of the MotoCross track. Flynfall Creek flows into Benson Creek before draining into Brannen Lake; no surface water diversion permits are in effect along Flynfall or Benson Creeks. Flynfall Creek and its sampling points are depicted in Figure 1, Appendix Two, and Photograph 1 and Photograph 2, Appendix Three.

3.2 Caillet Creek

Caillet Creek drains the northern portion of the TimberWest Properties. The creek originates from roughly the center of the northern third of the TimberWest Properties and generally flows eastward parallel to Weigles Road. Upstream samples were taken at the nearest location of suitable flow to the headwaters and downstream samples were taken downstream of the entire biosolids application area. Caillet Creek flows into Brannen Lake; no surface water diversion permits are in effect along the length of the creek. Caillet Creek and its sampling points are depicted in Figure 1, Appendix Two, and Photograph 3 and Photograph 4, Appendix Three.

3.3 Bonnell Creek

Bonnell Creek drains a small portion of the TimberWest Properties to the west. The creek originates from an area of high elevation which serves as the headwaters to Bonnell and Flynfall Creeks and generally flows westward out of the TimberWest Properties. Upstream samples were taken at the outflow of the headwaters and downstream samples were taken before the next tributary flows into the creek. Bonnell Creek flows off the TimberWest Properties and then turns north, eventually draining into Nanoose Bay; no known surface water diversion permits are in effect along the creek. Bonnell Creek and its sampling points are depicted in Figure 1, Appendix Two, and Photograph 5 and Photograph 6, Appendix Three.

3.4 W1500 Creek

W1500 Creek drains a small portion of the TimberWest Properties to the north of the Caillet drainage. The creek generally flows eastward out of the TimberWest Properties. Upstream samples were taken at the nearest location of suitable flow to the headwaters and downstream samples were taken before the next tributary flows into the creek. There are no known surface water diversion permits in effect along this portion of the creek and it later joins with Caillet Creek. W1500 Creek and its sampling points are depicted in Figure 1, Appendix Two, and Photograph 7 and Photograph 8, Appendix Three.

3.5 W5100 Swamp

W5100, also termed “the swamp”, is a water body located slightly to the northeast of the Upper Flynfall sampling location. The water feature appears to be adjacent to application areas which were applied in 2015 and 2016. Samples were collected at the outflow of the water body. This outflow creek appears to join with Flynfall Creek quite soon after originating from its headwaters. The W5100 swamp and its sampling point is depicted in Figure 1, Appendix Two, and Photograph 9, Appendix Three.

4 WATER QUALITY PARAMETERS

Data presented in this report are for a full suite of water quality parameters as received from the laboratory; however, only some of these parameters are relevant for determining the extent of potential effects of biosolids applications on surface water. Typically, these parameters include soluble nutrients, other soluble species linked to anthropogenic influence, microbiology associated with biosolids, and trace elements regulated in biosolids under the OMRR. Based on these categories, parameters selected for consideration in this report are:

1. Nitrogen forms (ammonia + ammonium, nitrate);
2. Phosphorus forms (total phosphorus, dissolved phosphorus, and orthophosphate);
3. Chloride;
4. Electrical conductivity;
5. Seven OMRR-regulated trace elements in RDN biosolids (arsenic, cadmium, copper, molybdenum, nickel, selenium, and zinc) which are the highest proportion of their respective limits; and,

6. Fecal coliforms.

Forms of nitrogen and phosphorus in surface water are typical indicator analytes used to assess surface water impacts following fertilization from chemical fertilizers, animal manures, or biosolids. Nutrients can enter surface water bound to fine soil particles via overland flow or as soluble species through groundwater or overland flow. Increased concentrations of nitrogen and phosphorus in surface waters can result in adverse environmental impacts such as eutrophication.

Increases in surface water nitrate concentrations are expected to occur in the fertilization of forests. Binkley (1999) summarizes studies on surface water nitrate concentrations following forest fertilization with chemical fertilizer on Vancouver Island with nitrate concentrations ranging between 0.1 and 9.3 milligram per litre (mg/L). This study suggests that an annual average nitrate concentration for surface water in fertilized forests is in the vicinity of 4 mg/L. Background surface water nitrate concentrations are in the vicinity of 2 mg/L and lower (Vancouver Island Health Authority, personal communication).

The chloride ion is highly mobile and concentrations in water are not affected by chemical reactions; chloride does not biodegrade, readily precipitate, volatilize, or bio-accumulate. Chloride in water is typically used as an indicator of increased urbanization in watersheds. Chloride does not adsorb readily onto mineral surfaces and therefore is a good indicator of anthropogenic influence. The Canadian Council of Ministers of the Environment (CCME), in the development of its water quality guidelines, identifies that ambient chloride concentrations in un-impacted water bodies in the Pacific Region are < 5 mg/L, with potentially higher values in water bodies located close to the ocean (CCME, 2011).

Electrical conductivity (EC) in biosolids is typically much higher than in natural soils or water. Movement of biosolids constituents which contribute to EC into surface water bodies could potentially be indicated by increases in surface water EC.

The mobility of most OMRR-regulated trace elements is highly dependent on soil pH. The acidic conditions of TimberWest Properties soils (pH ~5 – 5.5) represent an elevated potential for movement for most of these trace elements due to their tendency to become more soluble at lower pH.

Although biosolids are treated to reduce pathogen levels, they are not sterilized. Fecal coliform bacteria, which are used as an indicator for the potential presence of pathogenic microbiology in biosolids as well as in water, can be used to determine potential biosolids ingress into water bodies, although fecal coliforms can also originate from wildlife defecation into surface water.

Samples collected in November and December of 2017 were analyzed for a full suite of parameters which enable consideration of all the key parameters listed above, but samples collected prior to this were analyzed for a smaller set of parameters, eliminating consideration of parameter sets #1-3 above.

5 WATER QUALITY GUIDELINES

Data presented in this report are compared to guidelines from various sources including:

- The BC Approved Water Quality Guidelines (BCAWQG);
- The BC Working Water Quality Guidelines; and,
- The Canadian Council of Ministers of the Environment Water Quality Guidelines.

Approved Guidelines from BC for protection of freshwater aquatic life were used where possible, followed by Working Guidelines from BC, followed by national guidelines. For microbiological parameters, there are no guidelines for protection of freshwater aquatic life. Guidelines do exist for protection of drinking water and recreational use; however, there are no drinking water systems downstream from the TimberWest Properties and recreational use guidelines are tied to water contact and for activities occurring at the TimberWest Properties (e.g., mountain biking, hiking), no contact with water is assumed.

The source of an individual guideline is indicated within data tables in Appendix One. It should be noted that a guideline does not carry the same weight as a regulation and there are no formal consequences for guideline exceedances. Exceeding a guideline does not imply that unacceptable risk exists, but rather that the potential for adverse effects may be increased and additional investigation may be required.

6 WATER QUALITY SUMMARIES

Surface water quality is summarized by sampling location in the following sections.

6.1 Flynfall Creek

All water quality data for Flynfall Creek were below relevant guidelines with two exceptions. Chromium at the Lower Flynfall sampling location on May 8th, 2015 was 1.9 micrograms per litre (µg/L), above the recommended guideline of 1.0 µg/L. Biosolids applications had not occurred in the Flynfall watershed for six months prior to observing this value, and subsequent samples taken from this sampling location did not indicate elevated chromium. Water acidity (pH) at the Upper Flynfall sampling location on November 23rd, 2017 was below the recommended range of 6.5 – 9.0 for protection of aquatic freshwater life; however, due to the acidic soils and high precipitation in this region, surface water pH values below 6.5 are not uncommon. All analytical data for Flynfall Creek are presented in Table 3, Appendix One.

A comparison of selected parameters between upstream and downstream locations has been made in order to characterize the pattern of differences between the two sampling locations and the potential for biosolids applications to have influenced surface water quality.

Fecal coliforms, where above analytical detection limits, were consistently lower in downstream samples compared to upstream samples where comparisons were possible. Electrical conductivity tended to increase in downstream samples, although the highest observed value occurred at the upstream sampling location. Copper was lower in all downstream samples except in one case where it was four times greater. This particular copper concentration in the

downstream sample was 72% of the calculated guideline, and biosolids applications had not occurred in the Flynfall watershed for four months prior to this sampling event. Comparisons of upstream and downstream data for these parameters is presented in Figure 2, Appendix Two. Comparisons of sampling data where both values are below detection limits should be interpreted as representing no measureable difference between upstream and downstream locations.

Zinc concentrations, where above detection limits, tended to be lower in downstream samples. Notably, the November 23rd, 2017 downstream sample was almost three times higher than the upstream sample, although still only 8% of the guideline. Selenium and molybdenum were below detection limits for all water samples over the entire period. Comparisons of upstream and downstream data for these parameters are presented in Figure 3, Appendix Two. Comparisons of sampling data where both values are below detection limits should be interpreted as representing no measureable difference between upstream and downstream locations.

Cadmium concentrations, where above detection limits, were either higher (fall 2012) or lower (spring 2015) in downstream samples, although all values remained below the guideline. Arsenic concentrations, where above detection limits, were lower in downstream samples with all values remaining below the guideline. Nickel concentrations, where above detection limits, were lower in downstream samples with all values remaining below the guideline. Comparisons of upstream and downstream data for these parameters are presented in Figure 4, Appendix Two. Comparisons of sampling data where both values are below detection limits should be interpreted as representing no measureable difference between upstream and downstream locations.

Overall, and including samples where the concentration was less than the detection limit, the selected parameters were observed to be higher in downstream samples in 9 out of 59 paired sample sets, or 15% of the total.

Parameters of interest which were not analyzed for in samples between May of 2012 and April of 2017 but which are available for samples collected in the winter of 2017 include nitrogen, phosphorus, and chloride. Nitrogen forms, phosphorus forms, and chloride were very low or below detection limits and well below guidelines. Nitrate was slightly higher in the downstream sample and below the regional background reference concentration of 2 mg/L. Chloride was similar in both samples and was below the regional unimpacted reference value of 5 mg/L. All other parameters were similar in downstream as compared to upstream samples (Table 3, Appendix One).

6.2 Caillet Creek

All water quality data for Caillet Creek were below relevant guidelines with one exception. Water acidity (pH) at the Upper Caillet sampling location on November 23rd, 2017 was below the recommended range of 6.5 – 9.0 for protection of aquatic freshwater life; however, due to the acidic soils and high precipitation in this region, surface water pH values below 6.5 are not uncommon. All analytical data for Caillet Creek are presented in Table 4, Appendix One.

A comparison of selected parameters between upstream and downstream locations has been made in order to characterize the pattern of differences between the two sampling locations.

Fecal coliforms, where above analytical detection limits, were lower in downstream samples compared to upstream samples except in one case. Electrical conductivity showed very little variation between upstream and downstream locations. Copper also showed very little variation except during the November 23rd, 2017 downstream sampling event, where the concentration was 75% higher than the upstream value (but still only 17% of the guideline). Comparisons of upstream and downstream data for these parameters are presented in Figure 5, Appendix Two. Comparisons of sampling data where both values are below detection limits should be interpreted as representing no measureable difference between upstream and downstream locations.

Zinc concentrations showed little variation between upstream and downstream sampling locations, except on November 23rd, 2017 where the downstream value was almost five times higher (but still only 7% of the guideline). Selenium and molybdenum were below detection limits for virtually all water samples over the entire period. Comparisons of upstream and downstream data for these parameters are presented in Figure 6, Appendix Two. Comparisons of sampling data where both values are below detection limits should be interpreted as representing no measureable difference between upstream and downstream locations.

Cadmium concentrations were below detection limits for all water samples over the entire period. Arsenic concentrations, where above detection limits, were lower in downstream samples with all values remaining below the guideline. Nickel concentrations, where above detection limits, were lower in downstream samples with one exception on November 23rd, 2017 where the downstream sample was 50% higher (0.9 µg/L) than the upstream sample (0.6 µg/L); this downstream value was lower than the five-year average of 1.0 µg/L. Comparisons of upstream and downstream data for these parameters are presented in Figure 7, Appendix Two. Comparisons of sampling data where both values are below detection limits should be interpreted as representing no measureable difference between upstream and downstream locations.

Overall, and including samples where the concentration was less than the detection limit, the selected parameters were observed to be higher in downstream samples in 11 out of 73 paired sample sets, or 15% of the total.

Parameters of interest which were not analyzed for in samples between May of 2012 and April of 2017 but which are available for samples collected in the winter of 2017 include nitrogen, phosphorus, and chloride. Nitrogen forms, phosphorus forms, and chloride were very low / below detection limits and well below guidelines. Nitrate was slightly higher in the downstream sample, which was 20% higher than the regional background reference concentration of 2 mg/L, remaining below the reference value for fertilized forests of 4 mg/L. Chloride was also slightly higher in the downstream sample but was below the regional unimpacted reference value of 5 mg/L. All other parameters were similar in downstream as compared to upstream samples (Table 4, Appendix One).

6.3 Bonnell Creek

All water quality data for Bonnell Creek were below relevant guidelines with two groups of exceptions. Beryllium, chromium, and silver at the Upper Bonnell sampling location on November 13th, 2013 were in excess of the guidelines; however, the reported values indicated that the

concentrations were below the analytical detection limit, so it is unclear whether these are true exceedances or not. Water acidity (pH) at both sampling locations at numerous sampling dates was below the recommended range of 6.5 – 9.0 for protection of aquatic freshwater life; however, due to the acidic soils and high precipitation in this region, surface water pH values below 6.5 are not uncommon. All analytical data for Bonnell Creek are presented in Table 5, Appendix One.

A comparison of selected parameters between upstream and downstream locations has been made in order to characterize the pattern of differences between the two sampling locations.

Fecal coliforms, where above analytical detection limits, were similar or lower in downstream samples compared to upstream samples where comparisons were possible. Of note is the December 5th, 2014 value from the Upper Bonnell sampling location, which was 200 most probable number per 100 millilitres (MPN/100 mL); however, there is no guideline for recreation with no water contact (assumed for TimberWest Properties recreational activities such as mountain biking or hiking). Electrical conductivity was consistently lower in downstream samples; the highest value recorded over the sampling period also occurred on December 5th, 2014. Copper was similar or lower in all downstream samples. Comparisons of upstream and downstream data for these parameters is presented in Figure 8, Appendix Two. Comparisons of sampling data where both values are below detection limits should be interpreted as representing no measureable difference between upstream and downstream locations.

Zinc concentrations, where above detection limits, were consistently lower in downstream samples. Selenium and molybdenum were at or below detection limits for all water samples over the entire period. Comparisons of upstream and downstream data for these parameters are presented in Figure 9, Appendix Two. Comparisons of sampling data where both values are below detection limits should be interpreted as representing no measureable difference between upstream and downstream locations.

Cadmium concentrations, where above detection limits, were lower in downstream samples. Arsenic concentrations were lower in downstream samples except in one case on December 5th, 2014. Nickel concentrations, where above detection limits, were lower in downstream samples except for on November 23rd, 2017, when the downstream sample was slightly higher than the analytical detection limit. Comparisons of upstream and downstream data for these parameters are presented in Figure 10, Appendix Two. Comparisons of sampling data where both values are below detection limits should be interpreted as representing no measureable difference between upstream and downstream locations.

Overall, and including samples where the concentration was less than the detection limit, the selected parameters were observed to be higher in downstream samples in 2 out of 36 sample pairs, or 6% of the total.

Parameters of interest which were not analyzed for in samples between May of 2012 and April of 2017 but which are available for samples collected in the winter of 2017 include nitrogen, phosphorus, and chloride. Nitrogen forms, phosphorus forms, and chloride were very low / below detection limits and well below guidelines. Nitrate was lower in the downstream sample and lower than the regional background reference concentration of 2 mg/L. Chloride was similar in both

upstream and downstream samples and was below the regional unimpacted reference value of 5 mg/L. All other parameters were similar or lower in downstream as compared to upstream samples (Table 5, Appendix One).

6.4 W1500 Creek

All water quality data for W1500 Creek were below relevant guidelines with one exception. Water acidity (pH) at both sampling locations during the November 23rd, 2017 sampling event was below the recommended range of 6.5 – 9.0 for protection of aquatic freshwater life; however, due to the acidic soils and high precipitation in this region, surface water pH values below 6.5 are not uncommon. All analytical data for W1500 Creek are presented in Table 6, Appendix One.

A comparison of selected parameters between upstream and downstream locations has been made in order to characterize the pattern of differences between the two sampling locations.

Fecal coliforms, where above analytical detection limits, were consistently lower in downstream samples compared to upstream samples where comparisons were possible. Electrical conductivity was consistently lower in downstream samples. Copper was higher in downstream samples in half of the sample pairs; copper concentrations were on average 15% of the guideline. Comparisons of upstream and downstream data for these parameters is presented in Figure 8, Appendix Two. Comparisons of sampling data where both values are below detection limits should be interpreted as representing no measureable difference between upstream and downstream locations.

Zinc concentrations, where above detection limits, were higher in the downstream sample, although still only 3% of the guideline. Selenium and molybdenum were below detection limits for all water samples over the entire period. Comparisons of upstream and downstream data for these parameters are presented in Figure 9, Appendix Two. Comparisons of sampling data where both values are below detection limits should be interpreted as representing no measureable difference between upstream and downstream locations.

Cadmium concentrations were below detection limits in all samples but one, which was only marginally higher. Arsenic and nickel concentrations were at or below detection limits in all samples. Comparisons of upstream and downstream data for these parameters are presented in Figure 10, Appendix Two. Comparisons of sampling data where both values are below detection limits should be interpreted as representing no measureable difference between upstream and downstream locations.

Overall, and including samples where the concentration was less than the detection limit, the selected parameters were observed to be higher in downstream samples in 3 out of 36 sample pairs, or 8% of the total.

Parameters of interest which were not analyzed for in samples between May of 2012 and April of 2017 but which are available for samples collected in the winter of 2017 include nitrogen, phosphorus, and chloride. Nitrogen forms, phosphorus forms, and chloride were very low / below detection limits and well below guidelines. Nitrate was higher in the upstream sample as compared to the downstream sample and was also 5% above the regional background reference

concentration of 2 mg/L, remaining below the reference value for fertilized forests of 4 mg/L. Chloride was lower in the downstream sample and both values were below the regional unimpacted reference value of 5 mg/L. All of these parameters were lower in downstream samples as compared to upstream samples (Table 6, Appendix One).

6.5 W5100 Swamp

All water quality data for W1500 Creek were below relevant guidelines with one exception. Water acidity (pH) during the November 23rd, 2017 sampling event was below the recommended range of 6.5 – 9.0 for protection of aquatic freshwater life; however, due to the acidic soils and high precipitation in this region, surface water pH values below 6.5 are not uncommon. All analytical data for W1500 Creek are presented in Table 7, Appendix One.

Since 2012 only three samples have been collected at this location, and there is only one sampling location rather than an upstream/downstream pair. As such, there are no useful comparisons to be made using these data. Nitrogen forms, phosphorus forms, and chloride were well below guidelines and in some cases below analytical detection limits. Nitrate in November 2017 was higher than for any other sample taken on the same day, although only 10% of the guideline for protection of freshwater aquatic life and 34% of the drinking water guideline of 10 mg/L, remaining below the reference value for fertilized forests of 4 mg/L

7 WATER QUALITY DATA INTERPRETATIONS

Exceedances detailed in the data described above fell into three groups:

1. Water acidity (pH) below guideline range;
2. Analytical detection limit above guideline; or,
3. Parameter concentration above guideline.

Water pH tended to be higher in upstream samples. As previously mentioned, low pH surface water is common on Vancouver Island in forest environments due to the high precipitation and the acidic nature of forest soils. While the BC Approved Water Quality Guidelines for pH recommends the range of 6.5 – 9.0 as a range over which unrestricted change in pH is permitted without risking harm to aquatic freshwater life, it also recognizes that many areas of Coastal BC have naturally occurring pH below this range.

On November 13th, 2013 in Bonnell Creek, values for three parameters were below analytical detection limits but above guidelines (Table 5, Appendix One). These detection limits are higher than for other samples at this location and likely resulted from dilution of the sample by the lab, a routine procedure which has the effect of increasing detection limits. Based on other data for these parameters collected at this location, it is reasonable to assume that parameter concentrations would have been similar as for other sampling events and below guidelines.

Therefore, discounting water pH and detection limit exceedances, out of a total of 2,180 separate measurements, only one parameter was found to be at or above guidelines: chromium at the Lower Flynfall sampling location on May 8th, 2015 was 1.9 µg/L, above the recommended guideline of 1.0 µg/L. Samples taken prior to and following this exceedance did not show any

trends which suggested that a consistent effect was operating. The chromium exceedance at the Flynfall Creek downstream sampling location had the potential to be indicative of an effect from biosolids; however, the last nearby biosolids application was six months prior. Had overland movement of biosolids chromium through a setback distance and into a water body occurred, it is likely that other parameters would be elevated as well; instead, OMRR-regulated trace elements in this sample are below detection limits or are lower when compared to other samples with values above detection limits (Table 3, Appendix One).

Even with the majority of surface water quality parameters below guidelines, comparison of upstream and downstream data may shed light on potential adverse effect of biosolids management. In the comparison of selected parameters between upstream and downstream samples, only 12% of paired samples demonstrated an increase in parameter concentration in downstream samples. A rate of 50% would indicate that the occurrence of downstream samples of higher concentration was random. At a rate of 12%, the suggestion is that water quality actually *increases* at downstream sampling locations with respect to these parameters.

This observation is countered somewhat by some observations of increases in nutrients or chloride in downstream samples from the winter of 2017, where one-third of sample pairs showed increases, one-third showed no change, and one-third showed decreases. However, differences between upstream and downstream samples were generally quite small. Nitrate concentrations in all samples ranged between 0.24 and 2.4 mg/L, well below the guideline for protection of aquatic life of 32.8 mg/L and the drinking water guideline of 10 mg/L. This range is also below the average concentration of 4 mg/L in surface water at forest fertilization sites cited by Binkley (1999); most samples were also below the background reference concentration of 2 mg/L (Vancouver Island Health Authority, personal communication). Although the sampling frequency is not sufficient to meet the requirements of the 30-day nitrate BCAWQG, all nitrate values were also below this guideline (3 mg/L). Chloride concentrations at all sampling locations in the winter of 2017 ranged from 1.42 to 2.36 mg/L and remained below the CCME's description of un-impacted water bodies in the Pacific Region at < 5 mg/L chloride.

Based on the low incidence and pattern of clear guideline exceedances, the separation in time between exceedances and biosolids land applications, and the low incidence and magnitude of downstream increases in parameter concentrations, it is unlikely that biosolids applications at the TimberWest Properties are having an adverse effect on surface water quality.

8 OTHER WATER QUALITY ASSESSMENTS

Assessments of potential effects of biosolids on groundwater quality have been made twice in the past, in 2003 and 2012. Both reports concluded that application of biosolids had low potential for impact on groundwater wells located in the vicinity of the TimberWest Properties.

In 2014, SYLVIS completed an enhanced surface water quality monitoring project in response to a concern from a property owner directly east (downhill) from the TimberWest Properties. Water quality in Caillet Creek and in a ditch on the neighboring property were sampled over a five-month period to investigate whether there were any effects from biosolids stockpiles and applications.

Similar to results presented in this summary, all parameters investigated (nutrients, chloride, and caffeine) were all below relevant guidelines while some parameters (nitrate, chloride) showed small increases in downstream samples (SYLVIS Environmental, 2014).

9 CONCLUSION AND RECOMMENDATIONS

Data from five years of surface water monitoring at the TimberWest Properties suggest that there is no adverse effect on surface water quality from biosolids stockpiling or land application. This conclusion is bolstered by the findings of three other water quality investigations at the TimberWest Properties which also found no adverse effect on water quality from biosolids fertilization activities.

The utility of the W5100 sampling location is questionable since the sample is collected just downstream from an area of pooled water where conditions may vary and affect some quality parameters; there is also no downstream sampling pair for this location. It is recommended to discontinue sampling at this location. There has been some variability in the sampling location for the W1500 Creek in the past as one sampling location became unusable in April of 2017. SYLVIS will investigate whether there is a more suitable upstream/downstream sampling location in this section of the TimberWest Properties.

10 REFERENCES

BC Ministry of Environment. 2017a. British Columbia Approved Water Quality Guidelines.

BC Ministry of Environment. 2017b. British Columbia Working Water Quality Guidelines. Available at https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/wqgs-wqos/bc_env_working_water_quality_guidelines.pdf.

Brady, N.C., and R.R. Weil. 1990. The Nature and Properties of Soils. 13th ed. Macmillan ; Collier Macmillan, New York : London.

Cleary, M.L., and D.J. Tiplady. 2012. Hydrogeological Assessment of Land Application of Biosolids - Vancouver Island University Forest (WL 20), Nanaimo, BC. Piteau Associates: Geotechnical and Hydrogeological Consultants, North Vancouver, BC.

Dunne, T., and L.B. Leopold. 1978. Water in environmental planning. Macmillan.

Government of British Columbia. 2002. Organic Matter Recycling Regulation.

R. Allan, D. 2003. Hydrogeological Assessment of Land Application of Biosolids - Malaspina University-College Forest, Nanaimo, BC. Piteau Associates: Geotechnical and Hydrogeological Consultants, North Vancouver, BC.

SYLVIS Environmental. 2014. RDN/VIU Woodlot - Enhanced Water Quality Monitoring Program. SYLVIS Environmental, New Westminster, BC.

United States Environmental Protection Agency Office of Water Regulations and Standards. 1986. Quality criteria for water, 1986. U.S. Environmental Protection Agency, Office of Water Regulations and Standards.

APPENDIX ONE – TABLES

Table 1: Frequency of sampling at TimberWest Properties surface water sampling points, 2012-2017.

Location	Period											
	2012		2013		2014		2015		2016		2017	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Caillet Creek Upper	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓
Caillet Creek Lower	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓
Flynfall Creek Upper		✓	✓	✓		✓	✓				✓	✓
Flynfall Creek Lower	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Bonnell Creek Upper		✓		✓		✓						✓
Bonnell Creek Lower		✓		✓		✓	✓					✓
W1500 Creek Upper									✓	✓	✓	✓
W1500 Creek Lower								✓	✓	✓	✓	✓
W5100 (swamp)			✓					✓				✓

Note: No details are available for the failure to collect samples on specific dates from spring 2012 to spring 2017.

Table 2: Precipitation during two weeks prior to sampling event. (Nanaimo City Yard weather data)

Sampling Date	Previous 14 days of precipitation
18-May-12	2.2 mm
13-Nov-12	51.0 mm
7-May-13	2.2 mm
13-Nov-13	96.4 mm
5-Dec-14	82.3 mm
8-May-15	20.4 mm
1-Dec-15	31.1 mm
16-May-16	2.6 mm
19-Dec-16	49.9 mm
25-Apr-17	54.5 mm
23-Nov-17	213.4 mm
13-Dec-17	22.6 mm

Table 3: Surface water quality data from Flynfall Creek, 2012-2017.

Date	Units	18-May-12	13-Nov-12		7-May-13		13-Nov-13		5-Dec-14		8-May-15		1-Dec-15	16-May-16	19-Dec-16	25-Apr-17		23-Nov-17		Water Quality Guidelines
Sample Location		**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Lower Flynfall**	**Lower Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	
Field Parameters																				
Temperature - field	°C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.7	7.9	-
Electrical Conductivity - field	µS cm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	51.2	59.5	-
Salinity - Field	ppt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21.8	25	-
pH - field	pH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**6.1**	6.9	6.5 - 9.0[a]
TDS - Field	ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36.4	36.4	-
Inorganic Nonmetallic Parameters																				
Total Kjeldahl Nitrogen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.23	0.19	-
Total Organic Carbon	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	2.9	-
Ammonia + Ammonium - N	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	< 0.01 (26.0)	< 0.01 (23.4)	calculated[a]
Nitrate - N	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.51	0.76	32.8[a]
Nitrite - N	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.003 (0.06)	0.05 (0.06)	calculated[a]
Nitrate + Nitrite - N	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.52	0.76	-
Orthophosphate-P (dissolved)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	< 0.002	< 0.002	0.05[b]
Phosphorus (total dissolved)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.004	< 0.003	0.03[c]
Phosphorus (total)	mg/L	< 0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.006	0.006	0.03[d]
Trace Elements Total																				
Aluminum Al - total	µg/L	9	54	20	-	-	35	18	59	24	52	11.1	14.3	8.8	16.3	33.2	14.8	62	38	-
Antimony Sb - total	µg/L	< 0.2	< 0.1	< 0.1	-	-	< 0.2	< 0.2	< 0.1	< 0.1	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	0.02	0.02	-
Arsenic As - total	µg/L	< 0.2	0.06	< 0.05	-	-	< 0.10	< 0.10	0.08	< 0.05	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.1	< 0.1	5[a]
Barium Ba - total	µg/L	2	2.64	2.37	-	-	3.8	2.8	3.29	2.75	2.6	2.2	3.1	2.0	2.0	2.3	1.9	2.8	2.7	1,000[e]
Beryllium Be - total	µg/L	< 0.04	< 0.05	< 0.05	-	-	< 0.10	< 0.10	< 0.05	< 0.05	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.05	< 0.05	0.13[e]
Bismuth Bi - total	µg/L	< 1	< 0.1	< 0.1	-	-	< 0.2	< 0.2	< 0.1	< 0.1	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 0.1	< 0.1	-
Boron B - total	µg/L	34	5	22	-	-	6	30	4	23	< 50	< 50	< 50	63	< 50	< 50	< 50	4	13	1,200[a]
Cadmium Cd - total	µg/L	< 0.01 (0.47)	< 0.01 (0.49)	0.04 (0.35)	-	-	< 0.02 (0.58)	< 0.02 (0.64)	< 0.01 (0.35)	< 0.01 (0.51)	0.276 (0.33)	0.029 (0.48)	< 0.010 (0.67)	< 0.010 (0.46)	< 0.010 (0.40)	< 0.010 (0.40)	< 0.010 (0.40)	< 0.01 (0.33)	0.01 (0.41)	calculated[f]
Chromium Cr - total	µg/L	< 0.4	< 0.5	< 0.5	-	-	< 1.0	< 1.0	< 0.5	< 0.5	< 1.0	**1.9**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	0.13	0.09	1[f]

Note: Exceedances of guidelines are shown in bold type. Calculated limits are show in brackets next to the analytical value.

a - British Columbia Approved Water Quality Guideline for protection of freshwater aquatic life.

b - Dunne and Leopold, 1978, for control of algal growth in freshwater

c - Brady and Weil, 1990, limit for eutrophication risk

d - EPA, 1986, control of algal growth

e - British Columbia Working Water Quality Guideline for protection of freshwater aquatic life.

f - Canadian Council of Ministers of the Environment Water Quality Guideline for protection of freshwater aquatic life.

Table 3 (continued): Surface water quality data from Flynfall Creek, 2012-2017.

Date	Units	18-May-12	13-Nov-12		7-May-13		13-Nov-13		5-Dec-14		8-May-15		1-Dec-15	16-May-16	19-Dec-16	25-Apr-17		23-Nov-17		Water Quality Guidelines
Sample Location		**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Lower Flynfall**	**Lower Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	
Trace Elements Total																				
Cobalt Co - total	µg/L	< 0.02	< 0.1	< 0.1	-	-	< 0.2	< 0.2	< 0.1	< 0.1	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.20	< 0.20	0.06	0.05	110[a]
Copper Cu - total	µg/L	< 1 (4.16)	1 (4.26)	1 (3.60)	-	-	1.4 (4.63)	1.2 (4.91)	1 (3.60)	0.7 (4.35)	2.32 (3.53)	0.65 (4.22)	< 0.50 (5.07)	< 0.50 (4.10)	< 0.50 (3.84)	< 0.50 (3.83)	< 0.50 (3.84)	0.7 (3.50)	2.8 (3.88)	calculated[a]
Iron Fe - total	µg/L	< 10	27	9	-	-	10	15	31	16	99	27	< 10	< 10	< 10	13	< 10	17	21	1,000[a]
Lead Pb - total	µg/L	< 0.1 (12.6)	0.8 (13.3)	1.8 (8.6)	-	-	< 0.2 (16.1)	< 0.2 (18.4)	< 0.1 (8.6)	0.2 (14.0)	< 0.20 (8.1)	< 0.20 (13.0)	< 0.20 (19.7)	< 0.20 (12.1)	< 0.20 (10.3)	< 0.20 (10.2)	< 0.20 (10.3)	0.06 (7.9)	0.14 (10.5)	calculated[a]
Lithium Li - total	µg/L	< 1	1.1	< 0.5	-	-	< 1.0	< 1.0	0.9	0.5	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 2.0	< 2.0	0.9	< 0.5	-
Manganese Mn - total	µg/L	< 5 (793)	1.6 (804)	0.6 (727)	-	-	2.1 (849)	< 2.0 (882)	3.5 (727)	< 1.0 (816)	23.5 (720)	< 1.0 (800)	< 1.0 (900)	< 1.0 (786)	< 1.0 (756)	< 1.0 (755)	< 1.0 (756)	1 (716)	2 (760)	calculated[a]
Mercury Hg - total	µg/L	< 0.01	< 0.1	< 0.1	-	-	< 0.01	< 0.01	-	-	-	-	-	-	-	-	-	< 0.01	< 0.01	-
Molybdenum Mo - total	µg/L	< 0.1	< 0.05	< 0.05	-	-	< 0.10	< 0.10	< 0.05	< 0.05	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 0.02	< 0.02	2,000[a]
Nickel Ni - total	µg/L	< 1	0.6	< 0.2	-	-	0.6	< 0.4	0.9	< .2	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	0.7	0.4	-
Selenium Se - total	µg/L	< 0.6	< 0.1	< 0.1	-	-	< 0.2	< 0.2	< 0.1	< 0.1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.2	< 0.2	2[a]
Silver Ag - total	µg/L	< 0.01	0.01	0.02	-	-	< 0.10	< 0.10	< 0.05	< 0.05	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	0.01	0.01	0.1[a]
Strontium Sr - total	µg/L	28	20	31.1	-	-	38.3	34.8	23.1	36.8	20.4	28.1	42.5	27.6	24.4	23.5	22.6	20	26	-
Thallium Tl - total	µg/L	< 0.01	< 0.01	< 0.01	-	-	< 0.02	< 0.02	< 0.01	< 0.01	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.010	< 0.010	< 0.01	< 0.01	-
Thorium Th - total	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	< 0.05	< 0.05	-
Tin Sn - total	µg/L	< 0.1	0.4	0.2	-	-	< 0.2	< 0.2	0.3	0.1	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 0.1	0.1	-
Titanium Ti - total	µg/L	< 0.4	< 0.5	< 0.5	-	-	< 1.0	< 1.0	< 0.5	< 0.5	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 0.002	< 0.002	-
Uranium U - total	µg/L	< 0.4	< 0.01	< 0.01	-	-	< 0.02	< 0.02	< 0.01	< 0.01	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.01	< 0.01	-
Vanadium V - total	µg/L	0.2	0.3	0.4	-	-	0.4	0.6	0.3	0.4	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	0.17	0.31	-
Zinc Zn - total	µg/L	< 1 (33.0)	2.3 (33.0)	2.3 (33.0)	-	-	4.3 (33.0)	3 (33.0)	6 (33.0)	6.8 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	0.96 (33.0)	2.7 (33.0)	calculated[a]
Zirconium Zr - total	µg/L	-	-	-	-	-	-	-	-	-	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.10	< 0.10	0.1	< 0.1	-

Note: Exceedances of guidelines are shown in bold type. Calculated limits are show in brackets next to the analytical value.
a - British Columbia Approved Water Quality Guideline for protection of freshwater aquatic life.

Table 3 (continued): Surface water quality data from Flynfall Creek, 2012-2017.

Date	Units	18-May-12	13-Nov-12		7-May-13		13-Nov-13		5-Dec-14		8-May-15		1-Dec-15	16-May-16	19-Dec-16	25-Apr-17		23-Nov-17		Water Quality Guidelines
Sample Location		**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Lower Flynfall**	**Lower Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	**Upper Flynfall**	**Lower Flynfall**	
Routine Water																				
pH (Laboratory)	pH at 25° C	7	6.5	7	-	-	**6.3**	7.0	6.7	7.1	7.05	7.56	7.56	7.63	7.2	7.0	7.2	**6.5**	7.0	6.5 - 9.0[a]
Electrical Conductivity	µS/cm at 25° C	67.1	46	62	-	-	83	69	49	68	43.7	64.5	74.3	60.9	52	48	50	43	50	-
Calcium (total)	mg/L	6.49	4.84	6.81	-	-	8.93	8.15	4.93	7.35	4.77	6.91	9.41	6.5	5.43	5.65	5.66	4.5	5.6	-
Magnesium (total)	mg/L	1.54	1.09	1.64	-	-	2.14	1.96	1.06	1.68	1.07	1.55	2.24	1.47	1.47	1.3	1.33	1.1	1.4	-
Potassium (total)	mg/L	0.1	0.1	0.1	-	-	0.2	< 0.2	0.1	0.2	0.081	0.085	0.089	0.089	0.087	0.097	0.085	0.17	0.2	-
Silicon (total)	mg/L	4.39	4.17	4.75	-	-	4.35	4.84	4.14	4.51	4.23	4.73	5.94	5.08	4.22	4.19	4.5	3.5	4.1	-
Sodium (total)	mg/L	2.3	2.4	2.8	-	-	4.6	4.9	1.8	2.2	2.19	2.55	3.28	2.64	2.01	2.2	2.04	2.1	2.2	-
Sulphur (total)	mg/L	-	-	-	-	-	-	-	-	-	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	2.1	2.0	-
Chloride (dissolved)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.56	1.57	600[a]
Hardness (total)	mg $CaCO_3$/L	23	17	24	-	-	31	28	17	25	16.3	23.6	32.7	22.3	19.6	19.5	19.6	16	20	-
Total Suspended Solids	mg/L	-	-	-	-	-	-	-	6.0	< 5.0	< 4.0	< 4.0	< 4.0	< 4.0	< 2	< 1	< 1	-	-	-
Microbiological Analysis																				
Total Coliforms	MPN/100 ml	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	921	435	-
Escherichia coli	MPN/100 ml	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4	-
Fecal Coliforms	MPN/100 ml	< 1	< 1	5	< 1	< 1	< 1	8	47	< 1	< 1	< 1	< 1	< 1	< 2	< 1	< 1	2	1	-

Note: Exceedances of guidelines are shown in bold type.
a - British Columbia Approved Water Quality Guideline for protection of freshwater aquatic life.

Table 4: Surface water quality data from Caillet Creek, 2012-2017.

Date	Units	18-May-12		13-Nov-12		7-May-13		13-Nov-13		5-Dec-14		8-May-15		1-Dec-15		19-Dec-16		25-Apr-17		23-Nov-17		Water Quality Guidelines
Sample Location		**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	
Field Parameters																						
Temperature - field	°C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	8.3	-
Conductivity - field	µS cm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	75.1	82	-
Salinity - Field	ppt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	31.1	34.1	-
pH - field	pH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**6.3**	7.0	6.5 - 9.0[a]
TDS - Field	ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	53.3	58.2	-
Inorganic Nonmetallic Parameters																						
Total Kjeldahl Nitrogen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.34	0.21	-
Total Organic Carbon	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	-
Ammonia + Ammonium - N	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	< 0.01 (26.0)	< 0.01 (19.3)	calculated[a]
Nitrate - N	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.7	2.4	32.8[a]
Nitrite - N	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	< 0.003 (0.12)	< 0.003 (0.12)	calculated[a]
Nitrate + Nitrite - N	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.7	2.4	-
Orthophosphate-P (dissolved)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	< 0.002	0.003	0.05[b]
Phosphorus (total dissolved)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.004	0.005	0.03[c]
Phosphorus (total)	mg/L	< 0.01	< 0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.006	0.005	0.03[d]
Trace Elements Total																						
Aluminum Al - total	µg/L	65	7	41	16	-	-	33	17	39	14	190	16	47	11	157	10	24	26	31	23	-
Antimony Sb - total	µg/L	< 0.2	< 0.2	< 0.1	< 0.1	-	-	< 0.2	< 0.2	< 0.1	< 0.1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.03	0.03	-
Arsenic As - total	µg/L	< 0.20	< 0.20	0.08	< 0.05	-	-	< 0.10	< 0.10	0.09	0.09	0.13	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.1	< 0.1	5[a]
Barium Ba - total	µg/L	5	2	4.7	2.61	-	-	5.06	2.86	5.35	3.46	5.4	3.2	6.1	3.0	5.6	2.4	4.7	1.2	4.5	3.2	1,000[e]
Beryllium Be - total	µg/L	< 0.04	< 0.04	< 0.05	< 0.05	-	-	< 0.10	< 0.10	< 0.05	< 0.05	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.05	< 0.05	0.13[e]
Bismuth Bi - total	µg/L	< 1.0	< 1.0	< 0.1	< 0.1	-	-	< 0.2	< 0.2	< 0.1	< 0.1	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 0.1	< 0.1	-
Boron B - total	µg/L	< 5	< 5	6	6	-	-	6	< 6	7	5	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	6	8	1,200[a]
Cadmium Cd - total	µg/L	< 0.01 (0.53)	< 0.01 (0.49)	< 0.01 (0.47)	< 0.01 (0.45)	-	-	< 0.02 (0.55)	< 0.02 (0.53)	< 0.01 (0.53)	< 0.01 (0.53)	0.07 (0.52)	< 0.01 (0.56)	< 0.01 (0.63)	< 0.01 (0.61)	< 0.01 (0.59)	< 0.01 (0.48)	< 0.01 (0.55)	< 0.01 (0.43)	< 0.01 (0.47)	< 0.01 (0.53)	calculated[f]
Chromium Cr - total	µg/L	< 0.4	< 0.4	< 0.5	< 0.5	-	-	< 1.0	< 1.0	< 0.5	< 0.5	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	0.1	0.096	1[f]

Note: Exceedances of guidelines are shown in bold type. Calculated limits are show in brackets next to the analytical value.

a - British Columbia Approved Water Quality Guideline for protection of freshwater aquatic life.

b - Dunne and Leopold, 1978, for control of algal growth in freshwater

c - Brady and Weil, 1990, limit for eutrophication risk

d - EPA, 1986, control of algal growth

e - British Columbia Working Water Quality Guideline for protection of freshwater aquatic life.

f - Canadian Council of Ministers of the Environment Water Quality Guideline for protection of freshwater aquatic life.

Table 4 (continued): Surface water quality data from Caillet Creek, 2012-2017.

Date	Units	18-May-12		13-Nov-12		7-May-13		13-Nov-13		5-Dec-14		8-May-15		1-Dec-15		19-Dec-16		25-Apr-17		23-Nov-17		Water Quality Guidelines
Sample Location		**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	
Trace Elements Total																						
Cobalt Co - total	µg/L	0.1	< 0.02	< 0.1	< 0.1	-	-	< 0.2	< 0.2	< 0.1	< 0.1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.2	< 0.2	0.03	0.04	110[a]
Copper Cu - total	µg/L	< 1.0 (4.44)	< 1.0 (4.26)	1.4 (4.16)	1.4 (4.07)	-	-	1.2 (4.54)	1 (4.44)	0.7 (4.44)	0.7 (4.44)	1.2 (4.40)	0.6 (4.56)	0.7 (4.87)	0.8 (4.76)	0.8 (4.68)	< 0.5 (4.18)	< 0.5 (4.50)	< 0.6 (3.98)	0.4 (4.16)	0.7 (4.44)	calculated[a]
Iron Fe - total	µg/L	103	< 10	42	8	-	-	48	7	48	10	278	22	31	< 10	186	< 10	26	< 10	18	12	1,000[a]
Lead Pb - total	µg/L	< 0.10 (14.7)	< 0.10 (13.3)	3.1 (12.6)	3.7 (11.9)	-	-	< 0.2 (15.4)	< 0.2 (14.7)	0.1 (14.7)	< 0.1 (14.7)	0.22 (14.3)	< 0.20 (15.6)	< 0.20 (18.0)	< 0.20 (17.2)	0.21 (16.5)	< 0.20 (12.7)	< 0.20 (15.1)	< 0.20 (11.3)	< 0.01 (12.6)	0.02 (14.7)	calculated[a]
Lithium Li - total	µg/L	2	< 1.0	1.6	0.9	-	-	1.4	< 1.0	1.9	0.8	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 2.0	< 2.0	1.2	1.2	-
Manganese Mn - total	µg/L	< 5.0	< 5.0	1.3	< 0.2	-	-	2.4 (838)	< 2.0 (827)	1.2 (827)	< 1.0 (827)	15.1 (821)	< 1.0 (840)	< 1.0 (876)	< 1.0 (864)	15.6 (854)	< 1.0 (796)	1.8 (833)	< 1.0 (773)	1 (793)	< 1 (827)	calculated[a]
Mercury Hg - total	µg/L	< 0.01	< 0.01	< 0.10	< 0.10	-	-	< 0.01	< 0.01	-	-	-	-	-	-	-	-	-	-	< 0.01	< 0.01	-
Molybdenum Mo - total	µg/L	< 0.10	< 0.10	< 0.05	< 0.05	-	-	< 0.10	< 0.10	< 0.05	< 0.05	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 0.02	0.02	2,000[a]
Nickel Ni - total	µg/L	1	< 1.0	0.8	0.3	-	-	1	< 0.4	1.1	0.4	1.9	< 1.0	1.3	< 1.0	1.4	< 1.0	< 1.0	< 1.0	0.6	0.9	-
Selenium Se - total	µg/L	< 0.6	< 0.6	< 0.1	< 0.1	-	-	< 0.2	< 0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.2	< 0.2	2[a]
Silver Ag - total	µg/L	< 0.01	< 0.01	0.01	0.02	-	-	< 0.10	< 0.10	< 0.05	< 0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.01	0.02	0.1[a]
Strontium Sr - total	µg/L	34	32	30	30	-	-	33	33	36	38	33	36	42	40	35	32	32	26	30	37	-
Thallium Tl - total	µg/L	< 0.01	< 0.01	< 0.01	< 0.01	-	-	< 0.02	< 0.02	< 0.01	< 0.01	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.01	< 0.01	< 0.01	< 0.01	-
Thorium Th - total	µg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	< 0.05	< 0.05	-
Tin Sn - total	µg/L	< 0.1	< 0.1	0.1	0.2	-	-	< 0.2	< 0.2	0.1	0.5	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 0.1	< 0.1	-
Titanium Ti - total	µg/L	2.5	< 0.4	0.9	< 0.5	-	-	< 1.0	< 1.0	0.9	< 0.5	6.4	< 5.0	< 5.0	< 5.0	5.2	< 5.0	< 5.0	< 5.0	< 0.002	< 0.002	-
Uranium U - total	µg/L	< 0.40	< 0.40	< 0.01	< 0.01	-	-	< 0.02	< 0.02	< 0.01	< 0.01	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.01	< 0.01	-
Vanadium V - total	µg/L	0.3	< 0.1	0.3	0.2	-	-	0.7	0.7	0.4	0.3	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	0.12	0.09	-
Zinc Zn - total	µg/L	< 1.0 (33.0)	< 1.0 (33.0)	2.6 (33.0)	2.5 (33.0)	-	-	3.4 (33.0)	1.6 (33.0)	5.7 (33.0)	7 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	0.5 (33.0)	2.4 (33.0)	calculated[a]
Zirconium Zr - total	µg/L	-	-	-	-	-	-	-	-	-	-	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.1	< 0.1	< 0.1	< 0.1	-

Note: Calculated limits are show in brackets next to the analytical value.

a - British Columbia Approved Water Quality Guideline for protection of freshwater aquatic life.

Table 4 (continued): Surface water quality data from Caillet Creek, 2012-2017.

Date	Units	18-May-12		13-Nov-12		7-May-13		13-Nov-13		5-Dec-14		8-May-15		1-Dec-15		19-Dec-16		25-Apr-17		23-Nov-17		Water Quality Guidelines
Sample Location		**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	**Upper Caillet**	**Lower Caillet**	
Routine Water																						
pH (Laboratory)	pH at 25° C	7.1	6.6	6.7	6.8	-	-	6.8	6.9	6.8	7.0	7.5	7.4	7.4	7.4	7.1	7.0	7.1	7	6.6	7.1	6.5 - 9.0[a]
Electrical Conductivity	µS/cm at 25° C	68	63	62	62	-	-	71	70	71	73	70	76	71	77	72	67	71	56	62	68	-
Calcium (total)	mg/L	7.44	7.01	6.52	6.44	-	-	7.64	7.48	7.5	7.73	7.52	7.96	8.64	8.39	8.07	6.79	7.65	6.3	6.6	7.3	-
Magnesium (total)	mg/L	1.78	1.61	1.58	1.44	-	-	1.87	1.71	1.71	1.67	1.64	1.79	2.17	2.06	2.03	1.51	1.83	1.29	1.7	1.8	-
Potassium (total)	mg/L	0.2	0.2	0.3	0.2	-	-	0.2	0.2	0.2	0.2	0.12	0.13	0.25	0.16	0.21	0.14	0.16	0.1	0.24	0.24	-
Silicon (total)	mg/L	4	4.2	4.9	4.5	-	-	4.8	4.4	4.8	4.5	4.1	4.4	6.4	4.9	4.8	4	4.4	4.6	4.2	4.1	-
Sodium (total)	mg/L	2.59	2.61	3	2.8	-	-	4.8	4.4	2.6	2.6	2.54	2.69	3.75	3.32	2.64	2.37	2.73	2.33	2.7	2.7	-
Sulphur (total)	mg/L	-	-	-	-	-	-	-	-	-	-	< 3.0	< 3.0	4.7	4.7	3.6	< 3.0	3.8	3.2	3.0	3.0	-
Chloride (dissolved)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.02	2.13	600[a]
Hardness (total)	mg $CaCO_3$/L	26	24	23	22	-	-	27	26	26	26	26	27	31	29	29	23	27	21	23	26	-
Total Suspended Solids	mg/L	-	-	-	-	-	-	-	-	< 5.0	< 5.0	< 4.0	< 4.0	< 4.0	< 4.0	12	< 2.0	< 1.0	< 1.0	-	-	-
Microbiological Analysis																						
Total Coliforms	MPN/100 ml	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	770	345	-
Escherichia coli	MPN/100 ml	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	11	-
Fecal Coliforms	MPN/100 ml	8	< 1	2	3	8	< 1	4	< 1	2	1	6	< 1	10	< 1	24	< 2	< 1	< 1	26	12	-

a - British Columbia Approved Water Quality Guideline for protection of freshwater aquatic life.

Table 5: Surface water quality data from Bonnell Creek, 2012-2017.

Date	Units	13-Nov-12		13-Nov-13		5-Dec-14		8-May-15	23-Nov-17		Water Quality Guidelines
Sample Location		**Upper Bonnell**	**Lower Bonnell**	**Upper Bonnell**	**Lower Bonnell**	**Upper Bonnell**	**Lower Bonnell**	**Lower Bonnell**	**Upper Bonnell**	**Lower Bonnell**	
Field Parameters											
Temperature - field	°C	-	-	-	-	-	-	-	7	7.1	-
Conductivity - field	µS cm	-	-	-	-	-	-	-	49.4	39.7	-
Salinity - Field	ppt	-	-	-	-	-	-	-	20.9	17.0	-
pH - field	pH	-	-	-	-	-	-	-	**5.7**	6.5	6.5 - 9.0[a]
TDS - Field	ppm	-	-	-	-	-	-	-	34.8	28.1	-
Inorganic Nonmetallic Parameters											
Total Kjeldahl Nitrogen	mg/L	-	-	-	-	-	-	-	0.32	0.26	-
Total Organic Carbon	mg/L	-	-	-	-	-	-	-	7.4	6.3	-
Ammonia + Ammonium - N	mg/L	-	-	-	-	-	-	-	< 0.01 (26.2)	< 0.01 (25.2)	calculated[a]
Nitrate - N	mg/L	-	-	-	-	-	-	-	0.53	0.24	32.8[a]
Nitrite - N	mg/L	-	-	-	-	-	-	-	0.006 (0.06)	0.004 (0.06)	calculated[a]
Nitrate + Nitrite - N	mg/L	-	-	-	-	-	-	-	0.54	0.25	-
Orthophosphate-P (dissolved)	mg/L	-	-	-	-	-	-	-	< 0.002	< 0.002	0.05[b]
Phosphorus (total dissolved)	mg/L	-	-	-	-	-	-	-	0.009	0.005	0.03[c]
Phosphorus (total)	mg/L	-	-	-	-	-	-	-	0.011	0.009	0.03[d]
Trace Elements Total											
Aluminum Al - total	µg/L	175	147	107	193	97	133	154	82	90	-
Antimony Sb - total	µg/L	< 0.1	< 0.1	< 0.5	< 0.2	< 0.1	< 0.1	< 0.5	< 0.02	< 0.02	-
Arsenic As - total	µg/L	0.23	0.16	0.31	0.23	0.12	0.13	0.18	< 0.1	0.1	5[a]
Barium Ba - total	µg/L	4.38	3.26	5.07	3.9	12.2	4.08	3.1	3.1	2.6	1,000[e]
Beryllium Be - total	µg/L	< 0.05	< 0.05	**< 0.25**	< 0.10	< 0.05	< 0.05	< 0.10	< 0.05	< 0.05	0.13[e]
Bismuth Bi - total	µg/L	< 0.1	< 0.1	0.3	< 0.2	< 0.1	< 0.1	< 1.0	< 0.1	< 0.1	-
Boron B - total	µg/L	4	5	< 10	8	5	8	< 50	4	5	1,200[a]
Cadmium Cd - total	µg/L	0.01 (0.45)	< 0.01 (0.39)	< 0.05 (0.53)	< 0.02 (0.39)	-	-	0.04 (0.32)	< 0.01 (0.31)	< 0.01 (0.26)	calculated[f]
Chromium Cr - total	µg/L	< 0.5	< 0.5	**< 2.5**	< 1.0	< 0.5	< 0.5	< 1.0	0.16	0.14	1[f]
Cobalt Co - total	µg/L	0.2	< 0.1	< 0.5	0.2	0.2	< 0.1	< 0.5	0.07	0.04	110[a]
Copper Cu - total	µg/L	1.4 (4.07)	1.2 (3.79)	3.6 (4.44)	1.7 (3.79)	-	-	0.9 (3.48)	0.5 (3.41)	0.5 (3.18)	calculated[a]
Iron Fe - total	µg/L	248	122	251	260	80	113	167	49	47	1,000[a]
Lead Pb - total	µg/L	0.6 (11.9)	0.6 (9.9)	< 0.5 (14.7)	0.4 (9.9)	-	-	< 0.20 (7.7)	0.07 (7.3)	0.03 (5.8)	calculated[a]
Lithium Li - total	µg/L	< 0.5	< 0.5	< 2.5	< 1.0	< 0.5	< 0.5	< 5.0	< 0.5	< 0.5	-
Manganese Mn - total	µg/L	20.1 (782)	3.3 (749)	24 (827)	39.5 (749)	30.3 (992)	< 4.2 (782)	22.3 (713)	6 (705)	2 (679)	calculated[a]

Note: Exceedances of guidelines are shown in bold type. Calculated limits are show in brackets next to the analytical value.
a - British Columbia Approved Water Quality Guideline for protection of freshwater aquatic life.
b - Dunne and Leopold, 1978, for control of algal growth in freshwater
c - Brady and Weil, 1990, limit for eutrophication risk
d - EPA, 1986, control of algal growth
e - British Columbia Working Water Quality Guideline for protection of freshwater aquatic life.
f - Canadian Council of Ministers of the Environment Water Quality Guideline for protection of freshwater aquatic life.

Table 5 (continued): Surface water quality data from Bonnell Creek, 2012-2017.

Date	Units	13-Nov-12		13-Nov-13		5-Dec-14		8-May-15	23-Nov-17		Water Quality Guidelines
Sample Location		**Upper Bonnell**	**Lower Bonnell**	**Upper Bonnell**	**Lower Bonnell**	**Upper Bonnell**	**Lower Bonnell**	**Lower Bonnell**	**Upper Bonnell**	**Lower Bonnell**	
Trace Elements Total											
Mercury Hg – total	µg/L	< 0.1	< 0.1	0.01	< 0.01	-	-	-	< 0.01	< 0.01	-
Molybdenum Mo - total	µg/L	< 0.05	< 0.05	< 0.25	< 0.10	< 0.05	< 0.05	< 1.00	< 0.02	< 0.02	2,000[a]
Nickel Ni - total	µg/L	0.3	0.3	< 1.0	< 0.4	0.4	0.3	< 1.0	< 0.2	0.3	-
Selenium Se - total	µg/L	0.2	0.1	< 0.5	< 0.2	< 0.1	< 0.1	< 0.1	< 0.2	< 0.2	2[a]
Silver Ag - total	µg/L	0.02	0.02	**< 0.25**	< 0.10	< 0.05	< 0.05	< 0.02	0.02	0.01	0.1[a]
Strontium Sr - total	µg/L	26	22	29	21	61	29	18	17	15	-
Thallium Tl - total	µg/L	< 0.01	< 0.01	< 0.05	< 0.02	< 0.01	< 0.01	< 0.05	< 0.01	< 0.01	-
Thorium Th - total	µg/L	-	-	-	-	-	-	-	0.098	< 0.05	-
Tin Sn - total	µg/L	0.3	0.1	< 0.5	< 0.2	< 0.1	0.3	< 5.0	< 0.1	< 0.1	-
Titanium Ti - total	µg/L	1.2	1.2	< 2.5	3.1	0.8	1.5	5.6	< 0.002	< 0.002	-
Uranium U - total	µg/L	< 0.01	< 0.01	< 0.05	< 0.02	< 0.01	< 0.01	< 0.10	< 0.01	< 0.01	-
Vanadium V - total	µg/L	0.7	0.5	0.9	1	0.4	0.5	< 5.0	0.29	0.38	-
Zinc Zn - total	µg/L	2.2 (33.0)	1.9 (33.0)	9.3 (33.0)	3 (33.0)	17.1 (33.0)	5.6 (33.0)	< 5.0 (33.0)	0.8 (33.0)	< 0.5 (33.0)	calculated[a]
Zirconium Zr - total	µg/L	-	-	-	-	-	-	< 0.5	0.2	0.2	-
Routine Water											
pH (Laboratory)	pH at 25° C	**6.0**	**6.4**	**5.9**	6.5	**6.0**	6.5	7.3	**6.1**	**6.4**	6.5 - 9.0[a]
Electrical Conductivity	µS/cm at 25° C	55	48	63	43	114	59	41	40	33	-
Calcium (total)	mg/L	6.26	5.35	7.05	5.44	11.4	6.15	4.48	4.2	3.5	-
Magnesium (total)	mg/L	1.57	1.31	2.06	1.36	3.1	1.48	1.1	1.2	0.94	-
Potassium (total)	mg/L	0.2	0.1	< 1.00	< 0.20	0.2	0.1	0.06	0.09	0.09	-
Silicon (total)	mg/L	4.4	4.2	4.6	4.5	4.0	4.0	3.5	3.0	2.9	-
Sodium (total)	mg/L	2.7	2.4	4.3	4.2	3.2	2.1	2.2	1.6	1.5	-
Sulphur (total)	mg/L	-	-	-	-	-	-	< 3.0	2.1	1.4	-
Chloride (dissolved)	mg/L	-	-	-	-	-	-	-	1.42	1.46	600[a]
Hardness (total)	mg $CaCO_3$/L	22	19	26	19	41	22	16	15	12.6	-
Total Suspended Solids	mg/L	-	-	-	-	6	< 5.0	< 4.0	-	-	-
Microbiology											
Total Coliforms	MPN/100 ml	-	-	-	-	-	-	-	1,986	378	-
Escherichia coli	MPN/100 ml	**-**	**-**	**-**	**-**	**-**	**-**	**-**	1	1	-
Fecal Coliforms	MPN/100 ml	16	2	< 1	< 1	200	27	< 1	3	3	-

Note: Exceedances of guidelines are shown in bold type. Calculated limits are show in brackets next to the analytical value.
a - British Columbia Approved Water Quality Guideline for protection of freshwater aquatic life.

Table 6: Surface water quality data from W1500 Creek, 2012-2017.

Date	Units	1-Dec-15	16-May-16		19-Dec-16		25-Apr-17		13-Dec-17		Water Quality Guidelines
Sample Location		**Lower W1500**	**Upper W1500**	**Lower W1500**	**Upper W1500**	**Lower W1500**	**Upper W1500**	**Lower W1500**	**Upper W1500**	**Lower W1500**	
Field Parameters											
Temperature - field	°C	-	-	-	-	-	-	-	5.5	5.5	-
Conductivity - field	µS cm	-	-	-	-	-	-	-	92.2	68.2	-
Salinity - Field	ppt	-	-	-	-	-	-	-	36.5	27.0	-
pH - field	pH	-	-	-	-	-	-	-	6.9	6.7	6.5 - 9.0[a]
TDS - Field	ppm	-	-	-	-	-	-	-	65.5	48.3	-
Inorganic Nonmetallic Parameters											
Total Kjeldahl Nitrogen	mg/L	-	-	-	-	-	-	-	0.35	< 0.07	-
Total Organic Carbon	mg/L	-	-	-	-	-	-	-	2.2	3.6	-
Ammonia + Ammonium - N	mg/L	-	-	-	-	-	-	-	0.02 (23.9)	0.01 (25.8)	calculated[a]
Nitrate - N	mg/L	-	-	-	-	-	-	-	2.1	0.95	32.8[a]
Nitrite - N	mg/L	-	-	-	-	-	-	-	< 0.003 (0.06)	< 0.003 (0.12)	calculated[a]
Nitrate + Nitrite - N	mg/L	-	-	-	-	-	-	-	2.1	0.95	-
Orthophosphate-P (dissolved)	mg/L	-	-	-	-	-	-	-	< 0.002	< 0.002	0.05[b]
Phosphorus (total dissolved)	mg/L	-	-	-	-	-	-	-	0.01	0.006	0.03[c]
Phosphorus (total)	mg/L	-	-	-	-	-	-	-	0.006	0.005	0.03[d]
Trace Elements Total											
Aluminum Al - total	µg/L	84.8	28.4	26.2	34.6	43	34	48	25	24	-
Antimony Sb - total	µg/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.5	< 0.5	0.05	< 0.02	-
Arsenic As - total	µg/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.1	< 0.1	5[a]
Barium Ba - total	µg/L	1.8	1.8	1.9	1.2	1.3	2.7	1.4	1.9	1.8	1,000[b]
Beryllium Be - total	µg/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.05	< 0.05	0.13[b]
Bismuth Bi - total	µg/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 0.1	< 0.1	-
Boron B - total	µg/L	< 50	< 50	81	< 50	< 50	< 50	< 50	8	6	1,200[a]
Cadmium Cd - total	µg/L	< 0.010 (0.39)	< 0.010 (0.60)	< 0.010 (0.55)	< 0.010 (0.47)	< 0.010 (0.42)	< 0.01 (0.51)	< 0.01 (0.44)	0.02 (0.62)	< 0.01 (0.60)	calculated[c]
Chromium Cr - total	µg/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	0.09	0.1	1[c]
Cobalt Co - total	µg/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.2	< 0.2	0.09	0.03	110[a]
Copper Cu - total	µg/L	1.13 (3.80)	< 0.50 (4.74)	0.69 (4.50)	0.52 (4.17)	0.62 (3.91)	0.6 (4.32)	0.5 (4.03)	0.6 (4.82)	0.6 (4.73)	calculated[a]
Iron Fe - total	µg/L	32	< 10	13	< 10	28	< 10	39	9	17	1,000[a]
Lead Pb - total	µg/L	< 0.20 (10.0)	< 0.20 (17.0)	< 0.20 (15.1)	< 0.20 (12.6)	< 0.20 (10.7)	< 0.20 (13.8)	< 0.20 (11.6)	0.05 (17.6)	0.03 (16.9)	calculated[a]
Lithium Li - total	µg/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 2.0	< 2.0	< 0.5	< 0.5	-

Note: Calculated limits are show in brackets next to the analytical value.
a - British Columbia Approved Water Quality Guideline for protection of freshwater aquatic life.
b - Dunne and Leopold, 1978, for control of algal growth in freshwater
c - Brady and Weil, 1990, limit for eutrophication risk
d - EPA, 1986, control of algal growth
b - British Columbia Working Water Quality Guideline for protection of freshwater aquatic life.
c - Canadian Council of Ministers of the Environment Water Quality Guideline for protection of freshwater aquatic life.

Table 6 (continued): Surface water quality data from W1500 Creek, 2012-2017.

Date	Units	1-Dec-15	16-May-16		19-Dec-16		25-Apr-17		13-Dec-17		Water Quality Guidelines
Sample Location		**Lower W1500**	**Upper W1500**	**Lower W1500**	**Upper W1500**	**Lower W1500**	**Upper W1500**	**Lower W1500**	**Upper W1500**	**Lower W1500**	
Trace Elements Total											
Manganese Mn - total	µg/L	9.2 (752)	< 1.0 (862)	< 1.0 (833)	< 1.0 (795)	< 1.0 (764)	< 1.0 (812)	1.5 (778)	3 (860)	< 1 (871)	calculated[a]
Mercury Hg – total	µg/L	-	-	-	-	-	-	-	< 0.01	< 0.01	-
Molybdenum Mo - total	µg/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 0.02	< 0.02	2,000[a]
Nickel Ni - total	µg/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1	< 0.2	< 0.2	-
Selenium Se - total	µg/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.1	< 0.1	< 0.2	< 0.2	2[a]
Silver Ag - total	µg/L	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.02	< 0.02	0.02	< 0.01	0.1[a]
Strontium Sr - total	µg/L	23.3	34.1	29.1	27.2	22.7	32	22	40	38	-
Thallium Tl - total	µg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.01	< 0.01	0.04	< 0.01	-
Thorium Th - total	µg/L	-	-	-	-	-	-	-	< 0.05	< 0.05	-
Tin Sn - total	µg/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	0.2	< 0.1	-
Titanium Ti - total	µg/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 0.002	< 0.002	-
Uranium U - total	µg/L	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	0.04	< 0.01	-
Vanadium V - total	µg/L	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	0.34	0.23	-
Zinc Zn - total	µg/L	< 6.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	< 5.0 (33.0)	0.5 (33.0)	0.9 (33.0)	calculated[a]
Zirconium Zr - total	µg/L	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.1	< 0.1	< 0.1	< 0.1	-
Routine Water											
pH (Laboratory)	pH at 25° C	7.2	7.61	7.73	7.0	7.2	7.1	7.3	**6.4**	**6.2**	6.5 - 9.0[a]
Electrical Conductivity	µS/cm at 25° C	50.3	73.9	66.1	58	51	63	52	75	56	-
Calcium (total)	mg/L	5.42	8.59	7.86	6.66	5.71	7.22	6.44	8.8	8.5	-
Magnesium (total)	mg/L	1.37	1.89	1.69	1.56	1.47	1.62	1.33	1.9	1.9	-
Potassium (total)	mg/L	0.082	0.085	0.105	0.112	0.091	0.17	0.09	0.18	0.2	-
Silicon (total)	mg/L	5.69	5.79	5.39	5.04	4.79	4.6	4.9	4.5	4.5	-
Sodium (total)	mg/L	2.71	2.55	2.53	2.27	2.00	2.76	2.06	2.8	2.8	-
Sulphur (total)	mg/L	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	4.1	< 3.0	3.5	3.6	-
Chloride (dissolved)	mg/L	-	-	-	-	-	-	-	2.36	1.85	600[a]
Hardness (total)	mg $CaCO_3$/L	19.2	29.2	26.6	23.1	20.3	25	22	30	29	-
Total Suspended Solids	mg/L	< 4.0	< 4.0	< 4.0	< 2	< 2	< 1.0	< 1.0	-	-	-
Microbiology											
Total Coliforms	MPN/100 ml	-	-	-	-	-	-	-	260	866	-
Escherichia coli	MPN/100 ml	**-**	**-**	**-**	**-**	**-**	**-**	**-**	24	4	-
Fecal Coliforms	MPN/100 ml	21	< 1	1	8	6	< 1	1	15	7	-

Note: Exceedances of guidelines are shown in bold type. Calculated limits are show in brackets next to the analytical value.
a - British Columbia Approved Water Quality Guideline for protection of freshwater aquatic life.

Table 7: Surface water quality data from W5100 (swamp), 2013-2017.

Date	Units	7-May-13	1-Dec-15	23-Nov-17	Water Quality Guidelines
Sample Location		**W5100**	**W5100**	**W5100**	
Field Parameters					
Temperature - field	°C	-	-	7.8	-
Conductivity - field	µS cm	-	-	89.5	-
Salinity - Field	ppt	-	-	37.4	-
pH - field	pH	-	-	**5.8**	6.5 - 9.0[a]
TDS - Field	ppm	-	-	64.5	-
Inorganic Nonmetallic Parameters					
Total Kjeldahl Nitrogen	mg/L	-	-	1.1	-
Total Organic Carbon	mg/L	-	-	4.6	-
Ammonia + Ammonium - N	mg/L	-	-	< 0.01 (26.0)	calculated[a]
Nitrate - N	mg/L	-	-	3.4	32.8[a]
Nitrite - N	mg/L	-	-	0.005 (0.06)	calculated[a]
Nitrate + Nitrite - N	mg/L	-	-	3.4	-
Orthophosphate-P (dissolved)	mg/L	-	-	< 0.002	0.05[b]
Phosphorus (total dissolved)	mg/L	-	-	0.005	0.03[c]
Phosphorus (total)	mg/L	-	-	0.006	0.03[d]
Trace Elements Total					
Aluminum Al - total	µg/L	-	84	86	-
Antimony Sb - total	µg/L	-	< 0.5	< 0.02	-
Arsenic As - total	µg/L	-	< 0.10	< 0.1	5[a]
Barium Ba - total	µg/L	-	10	6.4	1,000[e]
Beryllium Be - total	µg/L	-	< 0.10	< 0.05	0.13[e]
Bismuth Bi - total	µg/L	-	< 1.0	< 0.1	-
Boron B - total	µg/L	-	< 50	4	1,200[a]
Cadmium Cd - total	µg/L	-	0.01 (0.99)	< 0.01 (0.60)	calculated[f]
Chromium Cr - total	µg/L	-	< 1.0	0.14	1[f]
Cobalt Co - total	µg/L	-	< 0.5	0.08	110[a]
Copper Cu - total	µg/L	-	2.3 (6.47)	0.6 (4.73)	calculated[a]
Iron Fe - total	µg/L	-	40	35	1,000[a]
Lead Pb - total	µg/L	-	< 0.20 (31.7)	0.02 (16.9)	calculated[a]
Lithium Li - total	µg/L	-	< 5.0	1.3	-
Manganese Mn - total	µg/L	-	22.3 (1,065)	5 (860)	calculated[a]
Mercury Hg - total	µg/L	-	-	< 0.01	-
Molybdenum Mo - total	µg/L	-	< 1.0	< 0.02	2,000[a]
Nickel Ni - total	µg/L	-	1.6	1.0	-
Selenium Se - total	µg/L	-	< 0.1	< 0.2	2[a]
Silver Ag - total	µg/L	-	< 0.02	< 0.01	0.1[a]
Strontium Sr - total	µg/L	-	59	38	-
Thallium Tl - total	µg/L	-	< 0.05	< 0.01	-
Thorium Th - total	µg/L	-	-	< 0.05	-
Tin Sn - total	µg/L	-	< 5.0	< 0.1	-
Titanium Ti - total	µg/L	-	< 5.0	< 0.002	-
Uranium U - total	µg/L	-	< 0.10	< 0.01	-
Vanadium V - total	µg/L	-	< 5.0	0.15	-
Zinc Zn - total	µg/L	-	< 5.0 (33.0)	1.1 (33.0)	calculated[a]
Zirconium Zr - total	µg/L	-	< 0.5	0.1	-
Routine Water					
pH (Laboratory)	pH at 25° C	-	7.2	**6.2**	6.5 - 9.0[a]
Electrical Conductivity	µS/cm at 25° C	-	134	78	-
Calcium (total)	mg/L	-	13.6	8.1	-
Magnesium (total)	mg/L	-	3.29	2.1	-
Potassium (total)	mg/L	-	0.36	0.22	-
Silicon (total)	mg/L	-	4.7	3.7	-
Sodium (total)	mg/L	-	3.25	2.7	-
Sulphur (total)	mg/L	-	3.8	3.4	-
Chloride (dissolved)	mg/L	-	-	1.98	600[a]
Hardness (total)	mg $CaCO_3$/L	-	48	29	-
Total Suspended Solids	mg/L	-	< 4.0	-	-
Microbiological Analysis					
Total Coliforms	MPN/100 ml	-	-	1,733	-
Escherichia coli	MPN/100 ml	-	-	3	-
Fecal Coliforms	MPN/100 ml	2	54	7	-

Note: Exceedances of guidelines are shown in bold type. Calculated limits are show in brackets next to the analytical value.
a - British Columbia Approved Water Quality Guideline for protection of freshwater aquatic life.
b - Dunne and Leopold, 1978, for control of algal growth in freshwater
c - Brady and Weil, 1990, limit for eutrophication risk
d - EPA, 1986, control of algal growth
e - British Columbia Working Water Quality Guideline for protection of freshwater aquatic life.
f - Canadian Council of Ministers of the Environment Water Quality Guideline for protection of freshwater aquatic life.

APPENDIX TWO – FIGURES

Figure 1: Overview of sampling locations at the TimberWest Properties.

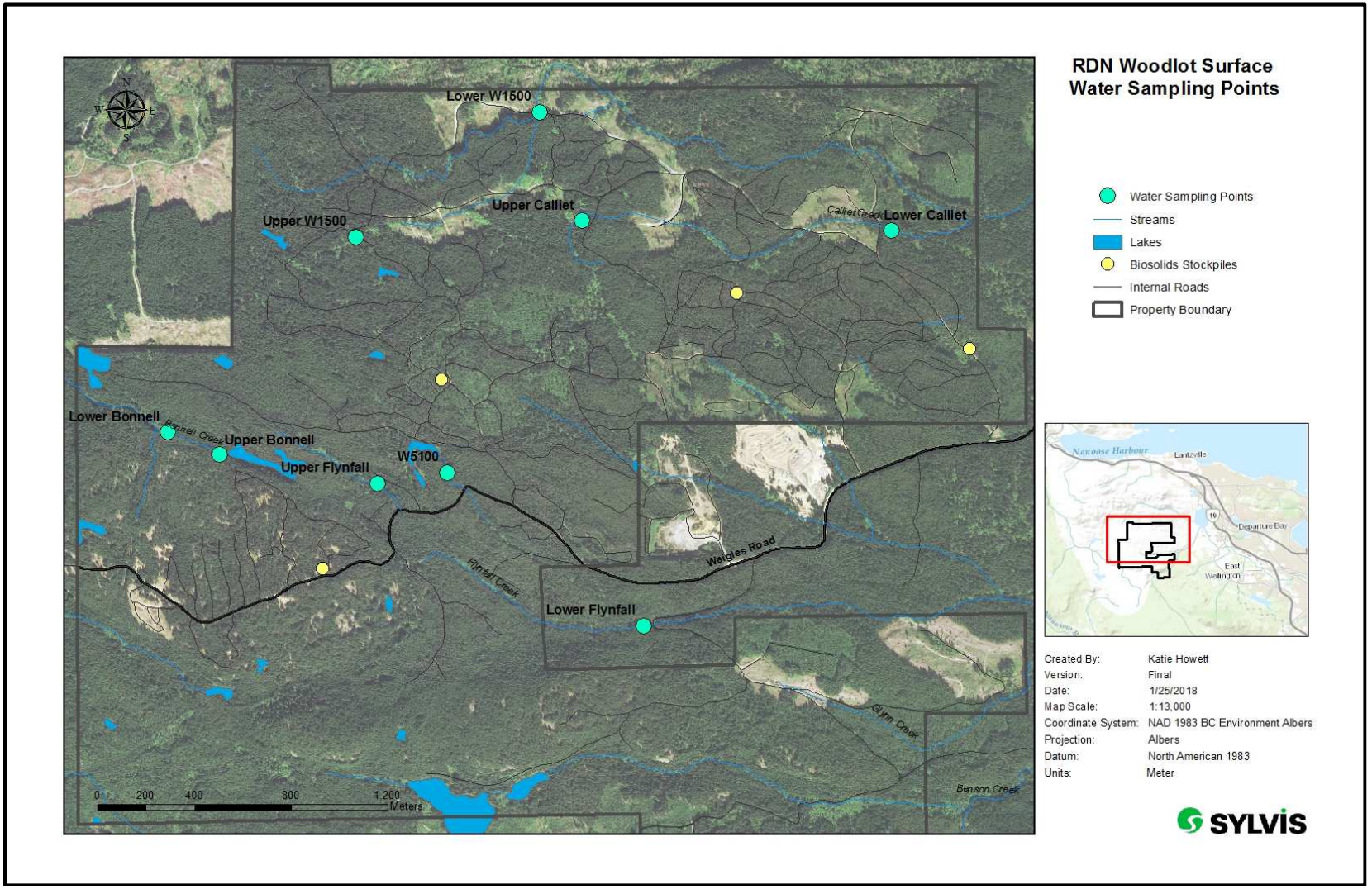
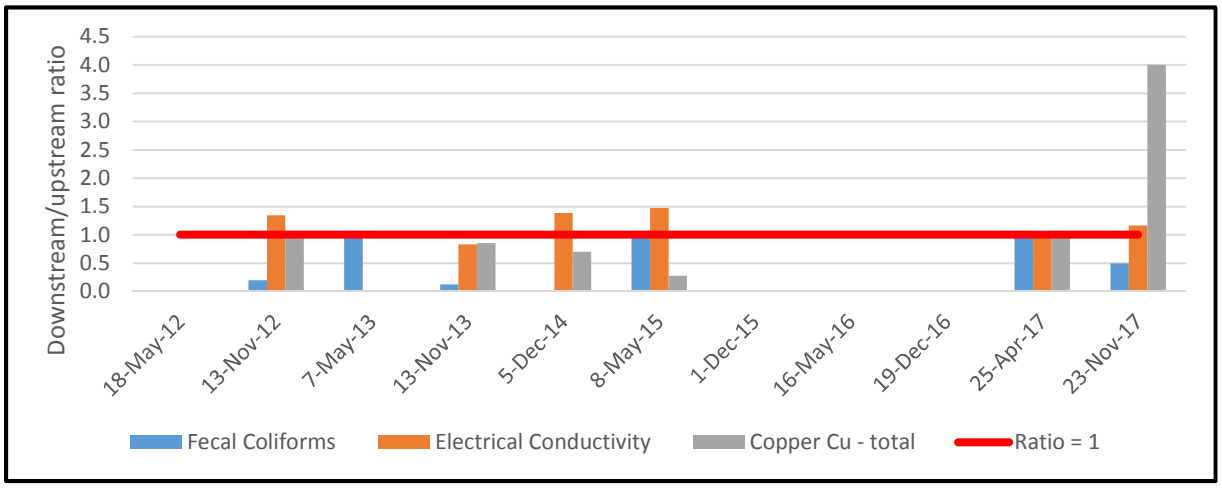


Figure 2: Selected parameters in Flynfall Creek upstream and downstream of biosolids application areas.



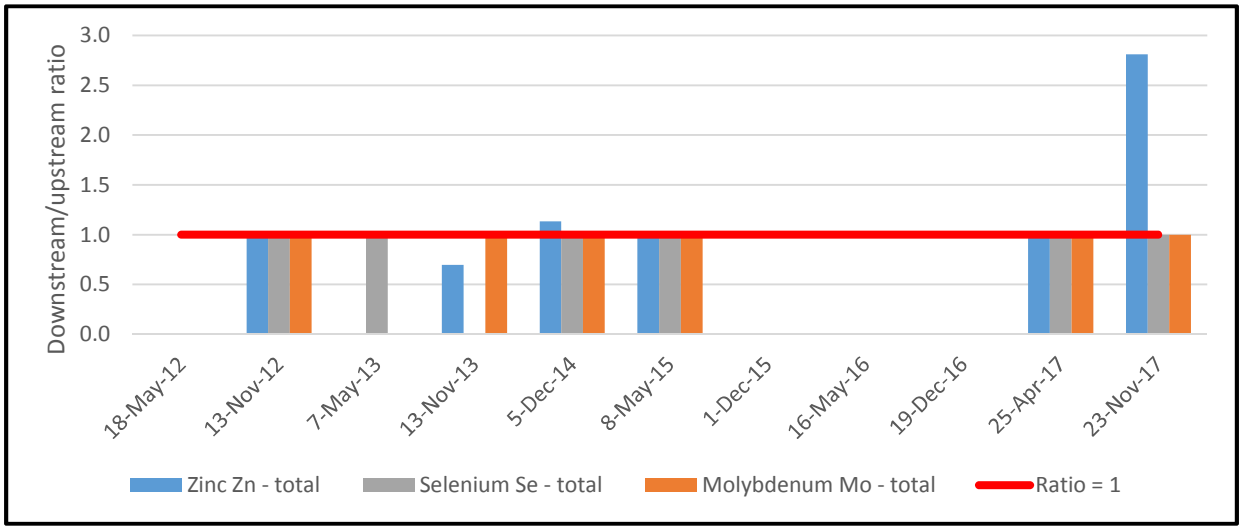
Note: Values > 1 represent sample pairs where the downstream value was higher than the upstream value.

Fecal coliform values ranged from < 1 MPN/100 mL to 47 MPN/100 mL at both sample locations at all dates.

Electrical conductivity values ranged from 43 µS/cm to 83 µS/cm at both sample locations at all dates.

Copper values ranged from < 0.5 µg/L to 2.8 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life ranged from 3.5 µg/L to 5.1 µg/L at both sample locations at all dates.

Figure 3: Selected parameters in Flynfall Creek upstream and downstream of biosolids application areas.



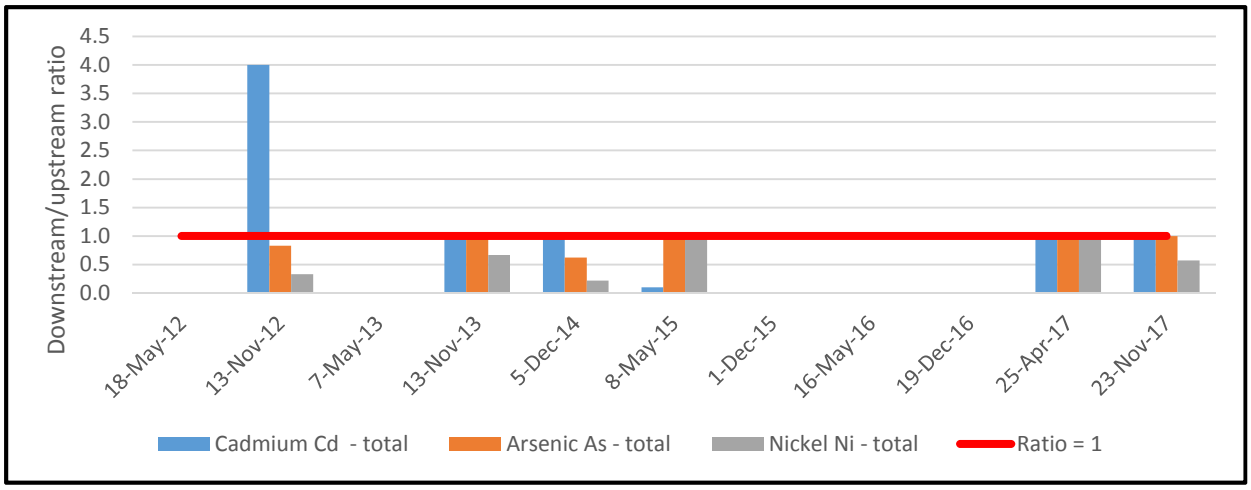
Note: Values > 1 represent sample pairs where the downstream value was higher than the upstream value.

Zinc values ranged from 0.96 µg/L to 6.8 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 33 µg/L.

Selenium values ranged from < 0.1 µg/L to < 0.6 µg/L (all values below detection limits) at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 2 µg/L.

Molybdenum values ranged from < 0.02 µg/L to < 1 µg/L (all values below detection limits) at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 2,000 µg/L.

Figure 4: Selected parameters in Flynfall Creek upstream and downstream of biosolids application areas.



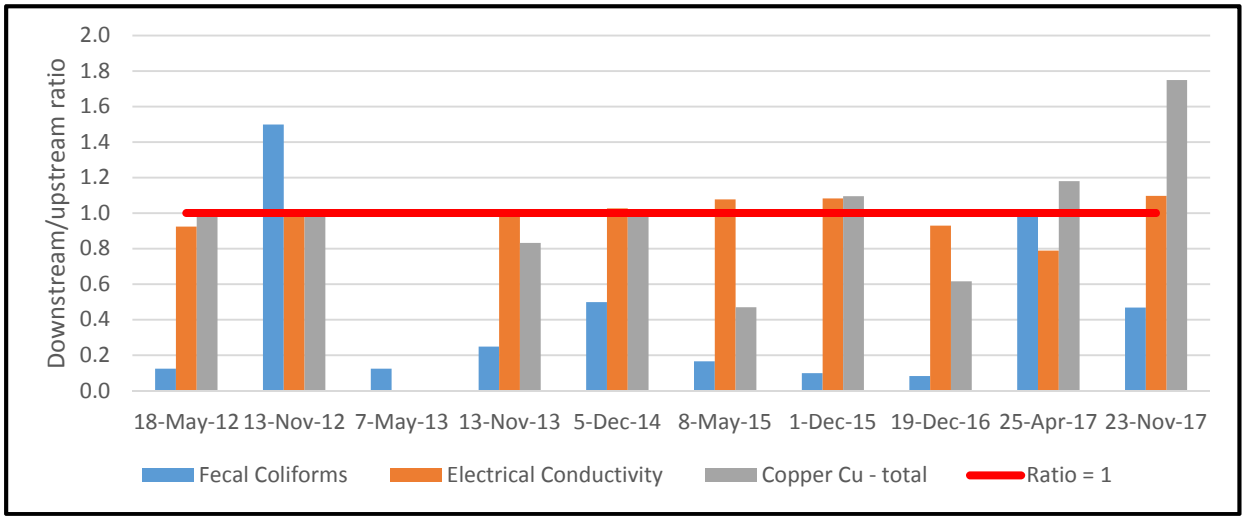
Note: Values > 1 represent sample pairs where the downstream value was higher than the upstream value.

Cadmium values ranged from < 0.01 µg/L to 0.28 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life ranged from 0.3 µg/L to 0.7 µg/L at both sample locations at all dates.

Arsenic values ranged from < 0.05 µg/L to < 0.2 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 5 µg/L.

Nickel values ranged from < 0.2 µg/L to < 1 µg/L at both sample locations at all dates.

Figure 5: Selected parameters in Caillet Creek upstream and downstream of biosolids application areas.



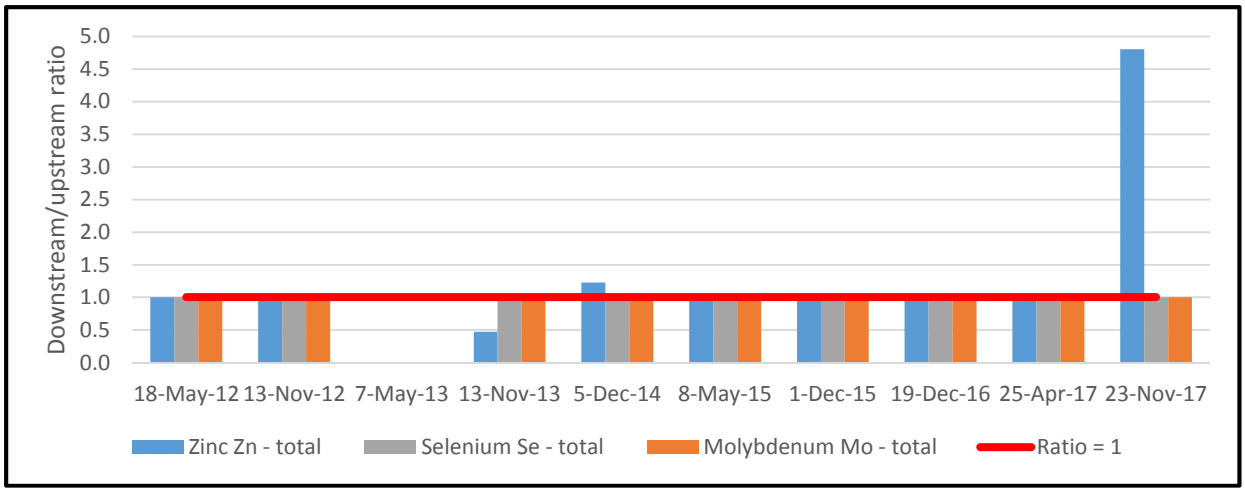
Note: Values > 1 represent sample pairs where the downstream value was higher than the upstream value.

Fecal coliform values ranged from < 1 MPN/100 mL to 26 MPN/100 mL at both sample locations at all dates.

Electrical conductivity values ranged from 56 µS/cm to 77 µS/cm at both sample locations at all dates.

Copper values ranged from 0.4 µg/L to 1.4 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life ranged from 4.0 µg/L to 4.9 µg/L at both sample locations at all dates.

Figure 6: Selected parameters in Caillet Creek upstream and downstream of biosolids application areas.



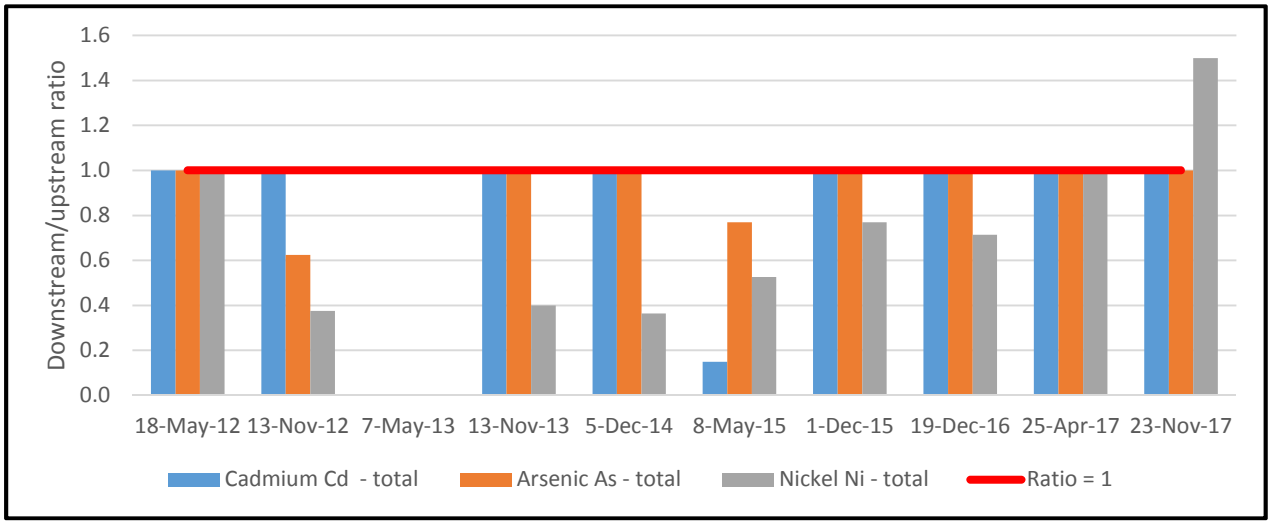
Note: Values > 1 represent sample pairs where the downstream value was higher than the upstream value.

Zinc values ranged from 0.5 µg/L to 7 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 33 µg/L.

Selenium values ranged from < 0.1 µg/L to < 0.6 µg/L (all values below detection limits) at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 2 µg/L.

Molybdenum values ranged from 0.02 µg/L to < 1 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 2,000 µg/L.

Figure 7: Selected parameters in Caillet Creek upstream and downstream of biosolids application areas.



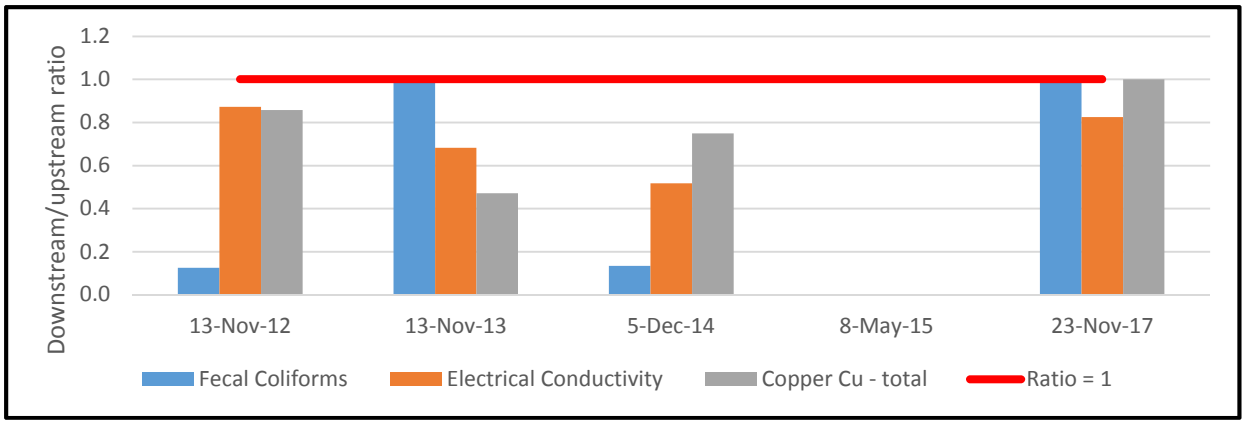
Note: Values > 1 represent sample pairs where the downstream value was higher than the upstream value.

Cadmium values ranged from < 0.01 µg/L to 0.07 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life ranged from 0.4 µg/L to 0.6 µg/L at both sample locations at all dates.

Arsenic values ranged from < 0.05 µg/L to < 0.2 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 5 µg/L.

Nickel values ranged from 0.3 µg/L to 1.9 µg/L at both sample locations at all dates.

Figure 8: Selected parameters in Bonnell Creek upstream and downstream of biosolids application areas.



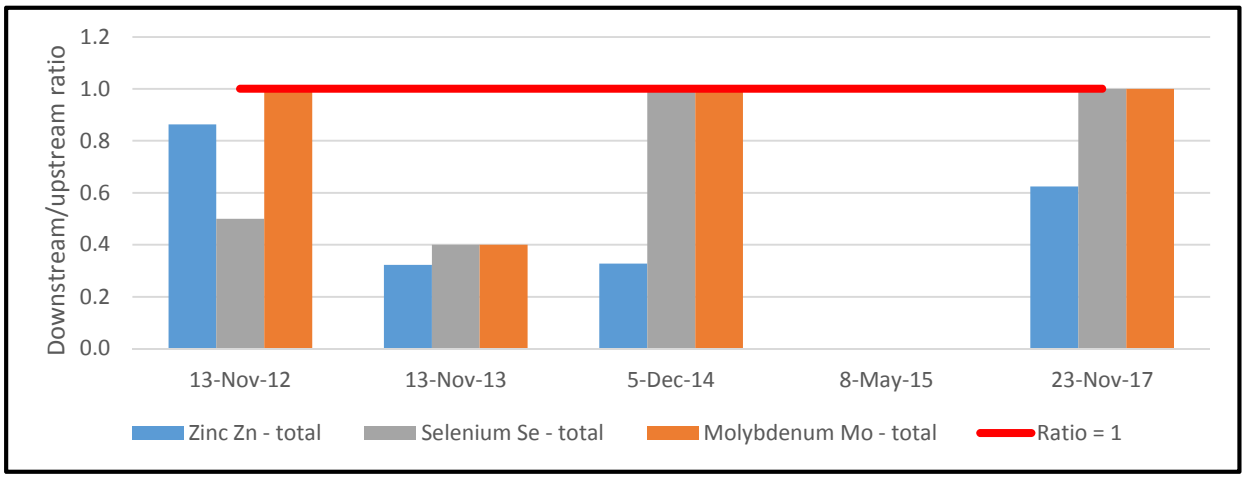
Note: Values > 1 represent sample pairs where the downstream value was higher than the upstream value.

Fecal coliform values ranged from < 1 MPN/100 mL to 200 MPN/100 mL at both sample locations at all dates.

Electrical conductivity values ranged from 33 µS/cm to 114 µS/cm at both sample locations at all dates.

Copper values ranged from 0.5 µg/L to 3.6 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life ranged from 3.2 µg/L to 5.9 µg/L at both sample locations at all dates.

Figure 9: Selected parameters in Bonnell Creek upstream and downstream of biosolids application areas.



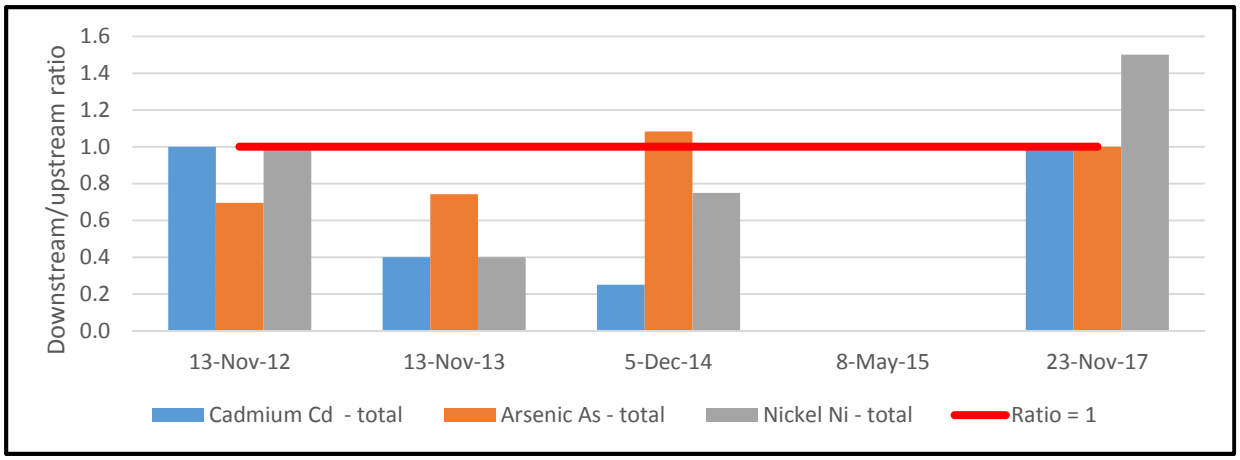
Note: Values > 1 represent sample pairs where the downstream value was higher than the upstream value.

Zinc values ranged from < 0.5 µg/L to 17.1 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 33 µg/L.

Selenium values ranged from < 0.1 µg/L to < 0.5 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 2 µg/L.

Molybdenum values ranged from < 0.02 µg/L to < 1 µg/L (all values below detection limits) at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 2,000 µg/L.

Figure 10: Selected parameters in Bonnell Creek upstream and downstream of biosolids application areas.



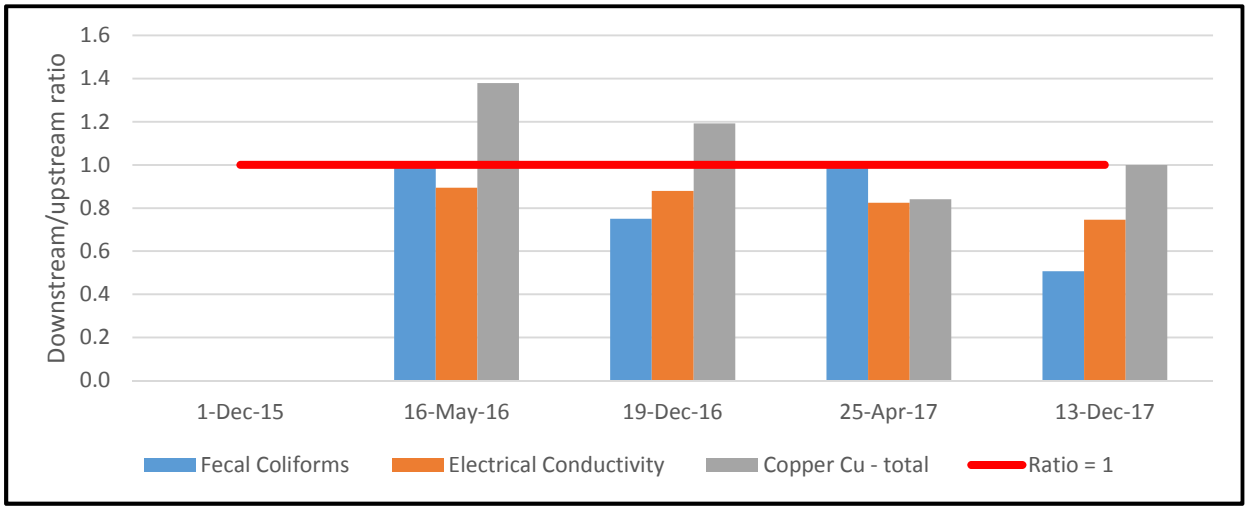
Note: Values > 1 represent sample pairs where the downstream value was higher than the upstream value.

Cadmium values ranged from < 0.01 µg/L to < 0.05 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life ranged from 0.3 µg/L to 0.8 µg/L at both sample locations at all dates.

Arsenic values ranged from < 0.1 µg/L to 0.31 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 5 µg/L.

Nickel values ranged from < 0.2 µg/L to < 1 µg/L at both sample locations at all dates.

Figure 11: Selected parameters in W1500 Creek upstream and downstream of biosolids application areas.



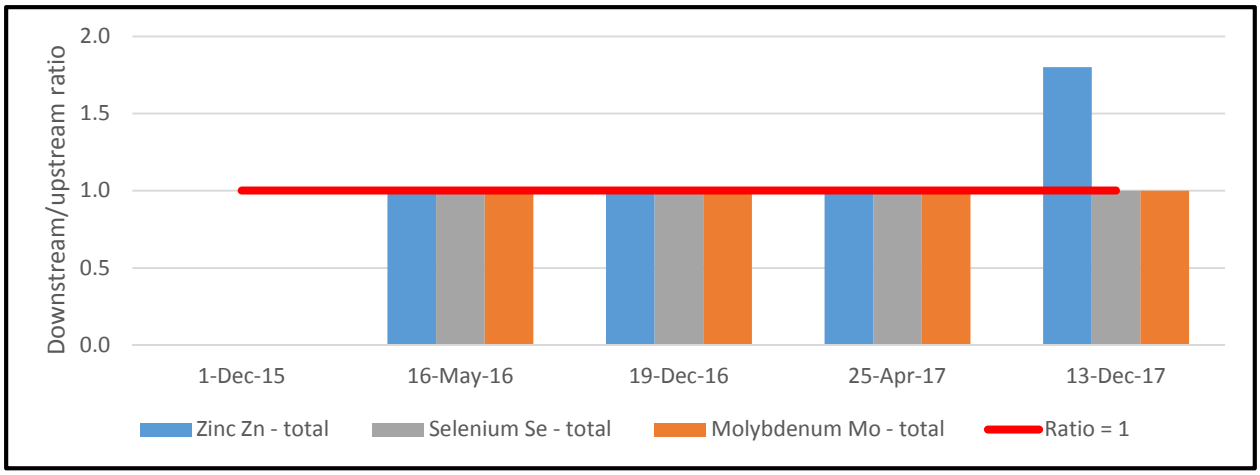
Note: Values > 1 represent sample pairs where the downstream value was higher than the upstream value.

Fecal coliform values ranged from < 1 MPN/100 mL to 21 MPN/100 mL at both sample locations at all dates.

Electrical conductivity values ranged from 50.3 µS/cm to 75 µS/cm at both sample locations at all dates.

Copper values ranged from < 0.5 µg/L to 1.13 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life ranged from 3.8 µg/L to 4.8 µg/L at both sample locations at all dates.

Figure 12: Selected parameters in W1500 Creek upstream and downstream of biosolids application areas.



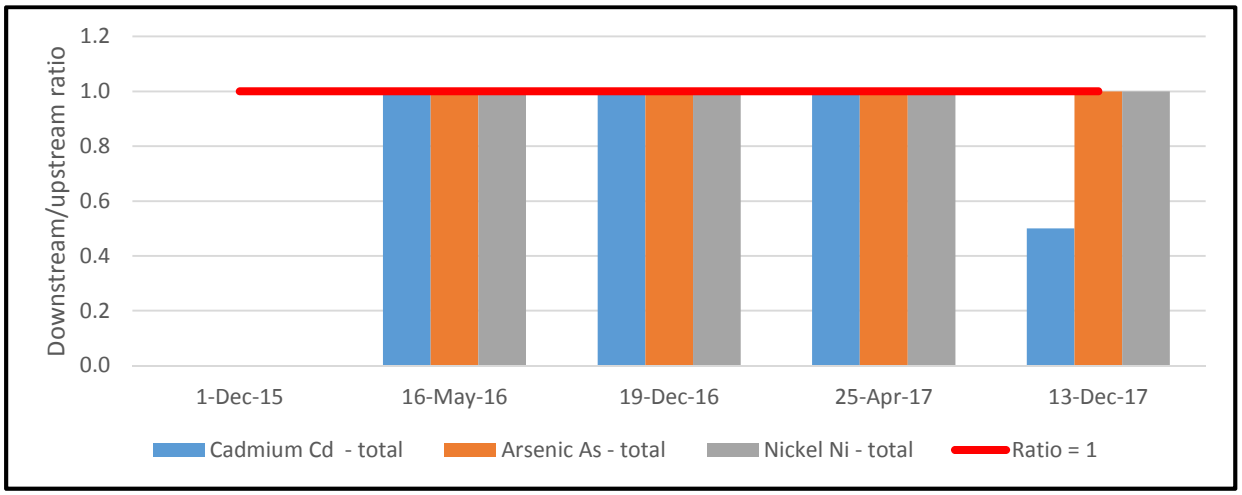
Note: Values > 1 represent sample pairs where the downstream value was higher than the upstream value.

Zinc values ranged from 0.5 µg/L to < 6 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 33 µg/L.

Selenium values ranged from < 0.1 µg/L to < 0.2 µg/L (all values below detection limits) at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 2 µg/L.

Molybdenum values ranged from < 0.02 µg/L to < 1 µg/L (all values below detection limits) at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 2,000 µg/L.

Figure 13: Selected parameters in W1500 Creek upstream and downstream of biosolids application areas.



Note: Values > 1 represent sample pairs where the downstream value was higher than the upstream value.

Cadmium values ranged from < 0.01 µg/L to 0.02 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life ranged from 0.4 µg/L to 0.6 µg/L at both sample locations at all dates.

Arsenic values were below an analytical detection limit of 0.1 µg/L at both sample locations at all dates. The BC Approved Water Quality Guideline for protection of freshwater aquatic life is 5 µg/L.

Nickel values ranged from < 0.2 µg/L to 1 µg/L at both sample locations at all dates.

APPENDIX THREE – PHOTOGRAPHS

Photograph 1: Upper Flynfall Creek sampling location.
(November 2017)

Photograph 2: Lower Flynfall Creek sampling location.
(November 2017)

Photograph 3: Upper Caillet Creek sampling location.
(November 2017)

Photograph 4: Lower Caillet Creek sampling location.
(November 2017)

Photograph 5: Upper Bonnell Creek sampling location.
(November 2017)

Photograph 6: Lower Bonnell Creek sampling location.
(November 2017)

Photograph 7: Upper W1500 Creek sampling location.
(December 2017)

Photograph 8: Lower W1500 Creek sampling location.
(December 2017)

Photograph 9: W5100 (swamp) sampling location.
(November 2017)