Associated Environmental

REPORT

Environmental Emergencies and Land Remediation Branch

CRD Residual Treatment Facility End of Spill Report

JANUARY 2021

EXECUTIVE SUMMARY

On October 13, 2020, an unplanned release (spill) of partially dewatered municipal residual solids occurred at the Capital Regional District (CRD) Residual Treatment Facility (RTF), located at the Hartland Landfill (#DGIR202520). The spill area, referred to as the Site, is located entirely on CRD property, including Hartland Landfill and the receiving environment in Mount Work Regional Park (Figure 1-2). The spill extent is within the traditional territory of W̱SÁNEĆ First Nations. Emergency clean-up efforts began immediately with hydro-vac trucks being used to remove the spilled material. Clean-up was initially determined complete on October 26 based on visual and olfactory evidence. This End-of-Spill report presents discussion of the spill, clean-up efforts, monitoring, and potential effects. It was preceded by an Update to the Minister report, submitted December 3, 2020.

The spill originated at the RTF, where a temporary pipe ruptured. An estimated 100 m^3 of partially dewatered municipal residual solids flowed into a catch basin and then into the stormwater system. The spill then flowed into a ditch along the RTF's north access road, passing through a culvert underneath Willis Point Road, and terminating in a wetland area in the CRD's Mount Work Regional Park, approximately 265 m from where it originated. Surface flow from the wetland is impeded by a berm at its north end, which acts to contain water and other material in the wetted area with no visible surface connection to other waterbodies.

The effects from the spill on the environment have been determined based on extensive surface water, bedrock groundwater, shallow groundwater, soil and sediment sampling, and analytical review of sample results relative to the appropriate BC *Contaminated Sites Regulation* (CSR) standards and, as a second benchmark, the BC Approved and Working Water Quality Guidelines (WQG). The CSR criteria have been created to protect human health and the environment, and are based on defendable, scientifically based standards specific to exposure pathways and human health and ecological risk. The BC WQG are used to provide a basis for evaluation of water quality and environmental impact to water values, including aquatic life, wildlife, drinking water and recreation, and contribute to decision making. The applicable standards and guidelines have been used to complete a comprehensive review of potential spill effects and to develop recommendations for further action going forward. The long-term risk to human health and the environment is considered low for the following reasons discerned from sample collection and analysis:

- All sites are within BC CSR standards or attributed to background, and only BC WQG microbiological standards have been exceeded in some locations in the spill pathway, locations with a limited effects pathway to potential receptors.
- Bacteria concentrations (*E. coli* and fecal coliform) are decreasing based on results from initial sediment sampling compared to sediment sampling four and seven weeks after the spill event, with some variation based on trace residual solids still being in the receiving sediment. Under cool weather conditions and the absence of a host, this decrease is anticipated to continue.
- Spill material was contained in the wetland, with no evidence of material migration outside the spill pathway to other waterbodies, including an adjacent wetland to the north and Durrance Lake.
- Bacteria from the spill are not increasing and no additional residual solids are entering the environment.

Based on analytical results, no additional remediation efforts are recommended. However, a monitoring plan has been developed, with the objective of continuing to document the reduction in bacteria concentrations in the media sampled, confirming and low corresponding risk to human health and the environment. Confirmatory sampling has

been expanded to include shallow groundwater north of the wetland to further investigate bacteria that may be associated with the spill and confirm contaminants are not migrating from the wetland. Sampling will continue until two consecutive samples show results within guidelines and standards, and/or microbiological parameters are similar to background (in a qualitative analysis). Amphibian surveys will be completed during spring and summer 2021 to confirm continued use of the wetland during different life stages.

Results of ongoing sampling analysis will be summarized in quarterly reporting to the Ministry of Environment and Climate Change Strategy, Land Remediation Branch and other stakeholders including the CRD.

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On October 13, 2020, an unplanned release (spill) of partially dewatered residual material (i.e., sewage sludge combined with wastewater; residual solids) occurred at the Capital Regional District (CRD) Residual Treatment Facility (RTF), located at the Hartland Landfill (Figure 1-1) (#DGIR202520). The spill area, referred to as the Site, is located entirely on CRD property, including Hartland Landfill and the receiving environment in Mount Work Regional Park (Figure 1-2). The spill extent is within the traditional territory of W̱SÁNEĆ First Nations. Details about the volume, material characteristics, how the spill occurred, and efforts to contain and clean it up are found in Section 2. This report is an End-of-Spill report, as described in the BC Spill Reporting Regulation.

The RTF is permitted under Ministry of Environment and Climate Change Strategy Operational Certificate #109471.

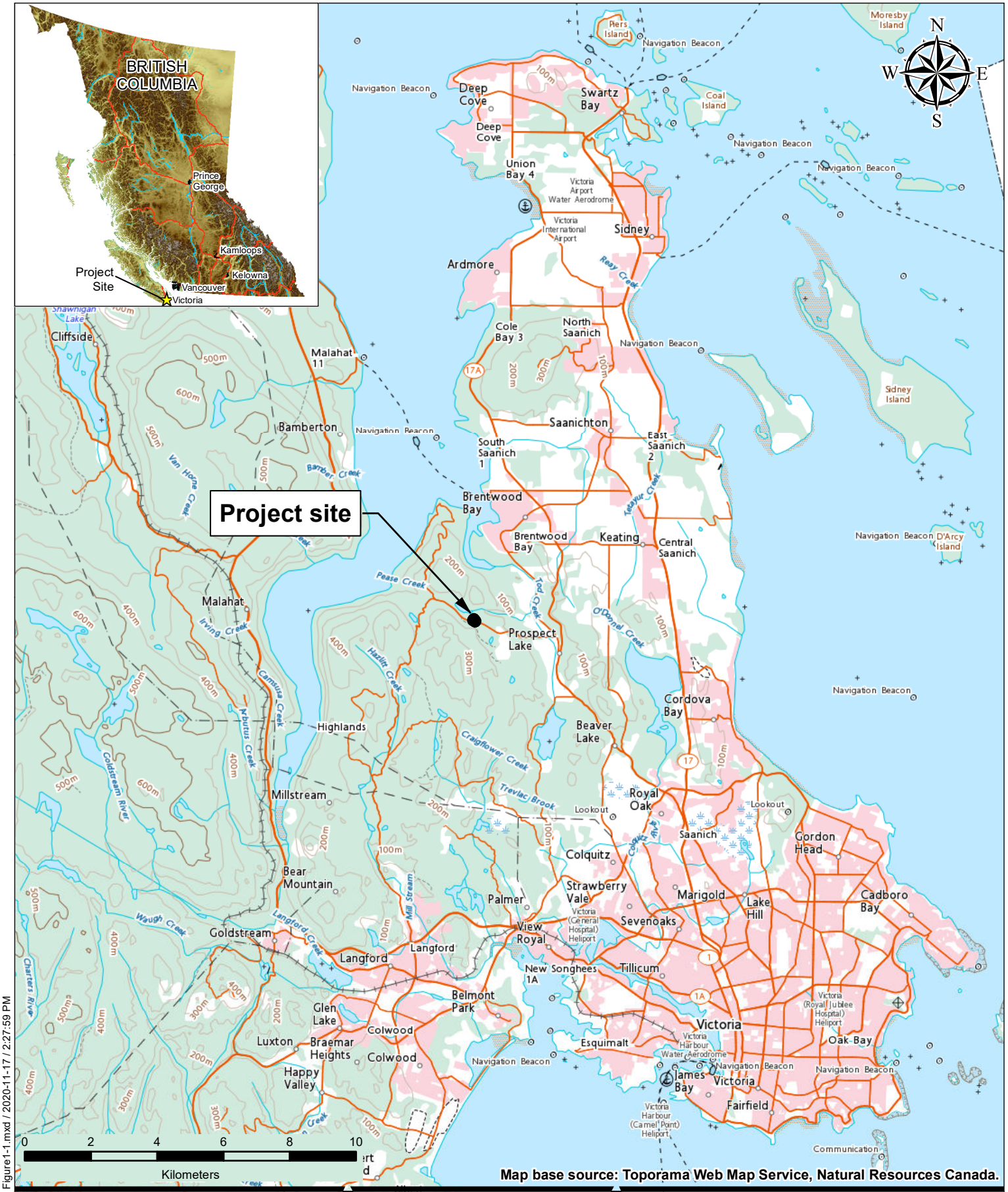
The RFT was recently constructed and is in early stages of start-up. The construction site is managed by Maple Reinders – Bird Joint Venture for the design build (MRBJV). Associated Environmental Consultants Inc. (Associated) is the environmental auditor, and Corvidae Environmental Consulting Inc. (Corvidae) is the environmental monitor on site. Matt Johnson, CTech, EP, of Corvidae contacted Associated on the morning of October 15 to inform about the spill and to seek input on how to manage the spill. In response, Associated created a team with Corvidae, which includes the following qualified professionals:

- Melanie Piorecky, P.Ag., Vegetation Ecologist and Project Manager;
- Matt Johnson, CTech, EP, Environmental Coordinator;
- Nicole Penner, P.Ag., Regulatory Specialist;
- Tony Friesen, M.Sc., GIT, Hydrogeologist;
- Gary Hamilton, P.Geo., Contaminated Sites Approved Professional (CSAP);
- Stacy Boczulak, M.Sc., R.P.Bio., Terrestrial Ecologist;
- Jamie Trottier, BIT, Environmental Monitor; and
- Brent Rutley, BIT, Environmental Monitor.

As per the Ministry of Environment and Climate Change Strategy (ENV) interim policy under the Professional Governance Act, qualified professional declaration forms, including a Declaration of Competency and a Conflict of Interest form, are attached.

This report is to fulfill the reporting requirements for the following:

- *Spill Reporting Regulation* (SRR) (B.C. Reg. 187/2017), End-of-Spill report;
- *Contaminated Sites Regulation* (CSR) (B.C. Reg. 375/96) detailed site investigation reporting;
- CRD's internal requirements related to spill remediation; and
- Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNR) requirements specific to the Site.



Map base source: Toporama Web Map Service, Natural Resources Canada.

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DATE: November 2020
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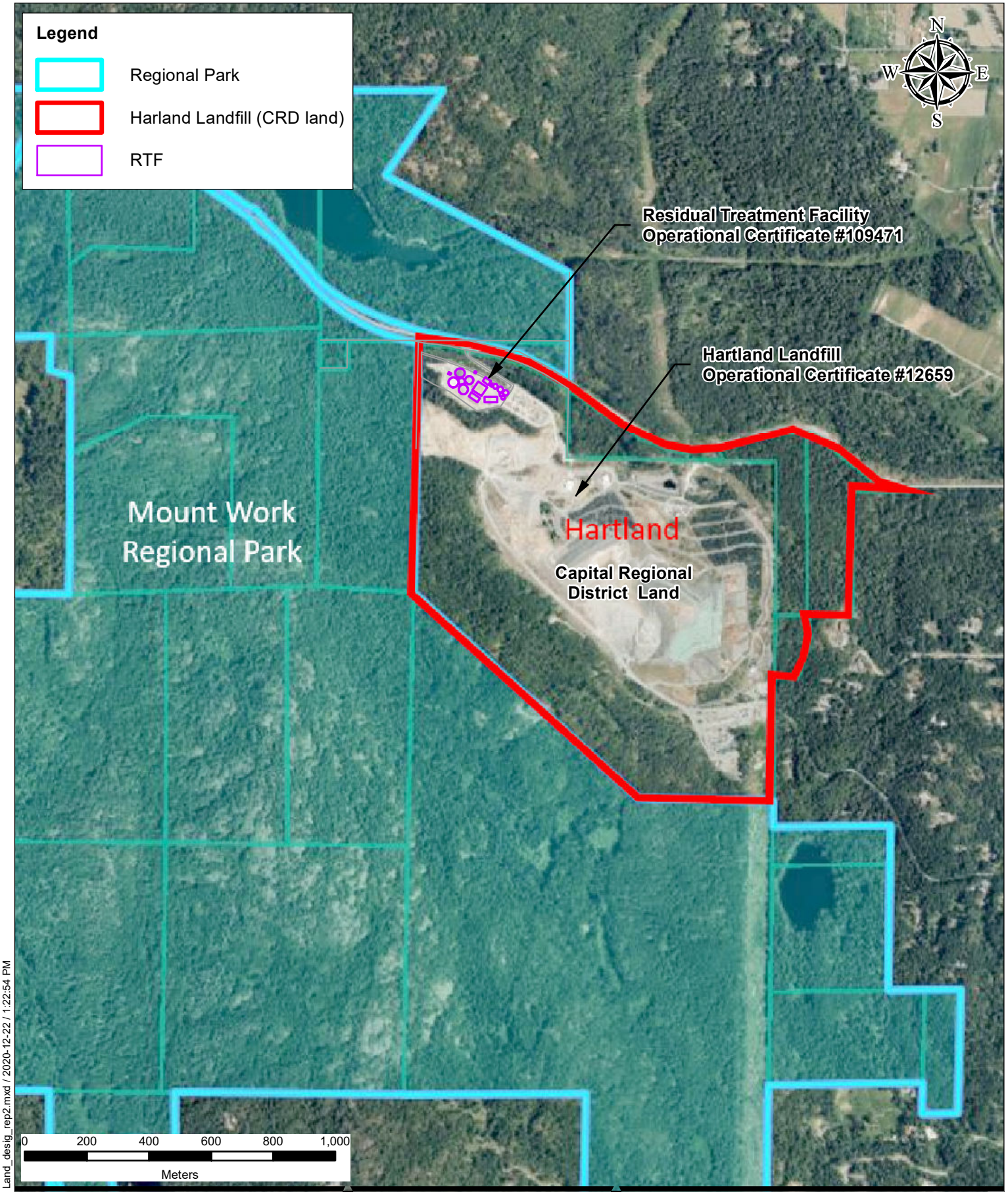
FIGURE 1-1: SITE LOCATION

Maple Rienders Bird Joint Venture
CRD Residual Treatment Facility Spill



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DATE: December 2020
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FIGURE 1-2: LAND DESIGNATION

Maple Reinders Bird Joint Venture
CRD Residual Treatment Facility Spill

1.1 Contact Information

The responsible person for the spill reporting is:

Braydon Pino
Project Manager
Maple Reinders – Bird Joint Venture
280 Willis Point Road, Saanich, BC
Phone: 780-799-1302
Email: braydon.pino@maple-bird.ca

The owner of the substance spilled has been identified as:

Capital Regional District (CRD)
625 Fisgard St., Victoria, BC
Contact: Kevin Simpson
Phone: 250-360-3621
Email: ksimpson@crd.bc.ca

The owner of the land where the spill occurred is the CRD.

1.2 Agencies Involved

No provincial or federal agencies attended the scene of the spill. The agencies advised of the spill were:

- Provincial Emergency Coordination Centre (PECC), BC Ministry of Environment and Climate Change Strategy (ENV), advised on October 13;
- Environmental Emergencies and Land Remediation Branch, advised on October 22; and
- Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNR) Ecosystem Biologist/Habitat Officers, advised on October 22.

The PECC provided the file number, DGIR202520.

The landowner informed W̱SÁNEĆ Leadership Council (WLC) of the spill on October 14 and attended a site inspection with CRD Liaison, Joni Olsen on October 16. As requested, the CRD continues to keep the WLC informed of the mitigation measures being implemented in response to the spill.

2 SPILL DETAILS

On October 13, 2020, at approximately 14:30 PST, a pipe ruptured at the CRD RTF located on Willis Point Road, Saanich, BC V9E 1J9 (48.543004°, -123.471499°), spilling an estimated 100,000 litres (100 m^3) of untreated, partially dewatered residual solids (i.e., sludge combined with wastewater). The spill volume was calculated by comparing the elevation of the residual solids in the tank immediately prior to the rupture and after the rupture had been isolated, and no more residual solids were leaving the tank. The flow was shut off at approximately 14:40 PST. The rupture location is at a central point at the RTF (Figure 2-1). At the time of the spill, the residual solids flowed overland approximately 15 m from the ruptured pipe to a catch basin leading to the RTF storm sewer system. From the catch basin, the residual solids entered the storm sewer system. From the RTF site, the storm sewer system discharges

through a Stormceptor[1] into a ditch next to the RTF's north access road and then crosses north under Willis Point Road, where the residual solids flowed overland, eventually entering a wetland located within Mount Work Regional Park (Figure 2-1). There is no surficial flow from the wetland to surrounding watercourses or Durrance Lake, located approximately 400 m to the north.

There were no reported effects on human health from the spill event, and the spill event resulted in no injuries, fatalities, or evacuations (A. Dias, personal communication, 2020). The potential adverse effects on the environment are described in Section 5.

[1] A Stormceptor is an underground unit that separates oils, grease, and sediment from stormwater runoff.

Spill area 3 - 656 m²

TOTAL SPILL AREA: 923m2

Culvert

WILLIS POINT ROAD

Spill area 2 - 79 m²

Stormceptor (surface then discharge to north access road ditch)

DIGESTER BLDG

DSST

Spill area 1 - 188 m²

DIGESTER #3

Catch basin

Meters
0 20 40 60 80 100

Capital Regional District, 2015, Capital Regional District

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Associated Environmental

Approximate rupture location

Spill areas

Berm

Plan data from McElhanney drawing 19515-00-V-1 SK

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FIGURE 2-1: SPILL FLOWPATH

Maple Reinders Bird Joint Venture

CRD Residual Treatment Facility Spill

2.1 Spill Materials

The material that spilled was untreated, partially dewatered municipal residual solids (i.e., sewage sludge combined with wastewater). Characteristics of the untreated material entering the RTF are shown in Table 2-1, as sampled on November 30, 2020. Complete results are found in Appendix A. The sample was of the liquid, as the incoming material is not a solid; therefore, units are not directly comparable to solid media samples (i.e. soil and sediment) but can be qualitatively contrasted.

Table 2-1
Characteristics of typical residual solids entering the RTF

Parameter*	Unit	Result
Hardness (as CaCO3)	mg/L	854
Sulphate (as SO_4)	mg/L	<6.0
Ammonia	mg/L	111
Fluoride	mg/L	<0.400
Total Nitrogen	mg/L	11600
Total Organic Nitrogen	mg/L	758
Total Phosphorus	mg/L	280
Ortho-Phosphate	mg/L	91.8
E.coli and Fecal Coliform Parameters		
E. coli	MPN/100 mL	41,100,000
Fecal coliforms	MPN/100 mL	72,700,000
Select Metals		
Aluminum, dissolved	mg/L	0.221
Arsenic, dissolved	mg/L	0.003
Chromium, dissolved	mg/L	0.003
Copper, dissolved	mg/L	0.115
Manganese, dissolved	mg/L	0.748
Iron, dissolved	mg/L	78.3
Nicol, dissolved	mg/L	0.012
Zinc, dissolved	mg/L	0.039

Note: *Only select parameters are presented that relate to findings.

2.2 Circumstances and Cause

The spill occurred during the transfer of thickened sludge through a temporary strain press to the digester. The pipe ruptured due to a valve control error causing over-pressure in the pipe during plant commissioning. This was followed by a signal causing the control valve on the digester to open again after the rupture of the attached pipe. The on-site containment measures, such as partially built retention ponds and the Stormceptor, could have contained the entire spill within the RTF; however, the Stormceptor was left in a bypass setting as per design, and the valve that isolates the Stormceptor from the north access road ditch was open. Going forward, the operating procedures have been changed to keep the Stormceptor valve closed, and to sample captured stormwater prior to release. Sample results will be contrasted to appropriate surface water standards and guidelines (see Section 4.1, discussed with RTF site manager). If water in the stormwater system is not within guidelines or standards, it will be removed with a hydro-vac truck and disposed at the neighbouring landfill.

2.3 Actions Taken

Spill response was directed by MRBJV and reported to Corvidae. It commenced at 15:45 PST on October 13, the day of the spill, and involved the use of hydro-vac trucks to clean up the Site. Hydro-vac works continued intermittently for 13 days, ending October 26. The efforts were to vacuum up as much of the residual solids along the spill pathway as possible. Wash water was used to flush the solids into suspension for removal with the hydro-vac in all areas that were accessible along the spill pathway, which was all of Spill Areas 1 and 2, and the southern approximate two-thirds of Spill Area 3 (Figure 2-1). This resulted in the removal of a significant volume of the residual solids from the Site. The volume of removed residual solids could not be measured because the wash water used in the clean-up process was not metered. MRBJV determined that spill response efforts were complete based on guidance from Gary Hamilton, CSAP, and based on visual and olfactory observations by Corvidae (i.e., could residual solids be seen or smelt on surfaces in any of the spill areas).

At the Willis Point Road area, an existing access road was reinforced to get the hydro-vac truck as close to the wetland area as possible for residual solids removal. The hydro-vac was equipped with a screen to avoid removing wildlife with the residual solids, and removal activities were monitored by Corvidae. Photos showing the areas before and after spill response, taken by Corvidae, are provided in Appendix B.

Within 48 hours of the spill, Corvidae was on site to sample medias within and outside of the spill pathway related to potential water and soil receptors, with the direction of Associated. A detailed site investigation is ongoing to assess any potential adverse effects on the environment (Section 4).

2.4 Waste Disposal Method

The waste removed by hydro-vac from the Site was disposed of at the Hartland Landfill. A total of 70 hydro-vac truckloads were disposed immediately after the waste was removed from the Site. The total volume was approximately 350 m^3. The disposed water included some surface water that was naturally in the wetland.

3 DESCRIPTION OF SITE AND AREAS AFFECTED

For the purposes of the investigation, the surface extent of the spill was divided into three spill areas (Figure 2-1):

- Spill Area 1 (RTF site, 188 m^2);
- Spill Area 2 (north access road ditch, 79 m^2); and

- Spill Area 3 (wetland area on north side of Willis Point Road, 656 m^2).

3.1 Physiography

The spill occurred in the upper reaches of the Tod Creek watershed on the north side of the Hartland Landfill within a shallow bedrock saddle. At the location of the spill, the topography generally slopes from southeast to northwest toward Durrance Lake and is surrounded with moderately rugged hills dominated by shallow bedrock and bedrock outcrops. The surficial geology is described as a thin veneer of glacial till composed of silty, gravelly sand underlain by Wark Diorite Gneiss (Env 2020c). Areas of localized bedrock depressions have narrow bands of fluvial deposits, consisting of well-sorted sands and gravels. The RTF site has a thin veneer of soil over bedrock. There are bedrock faults mapped in the area, which have resulted in joints, shear zones, and altered veins (AECOM 2019).

3.2 Ecological Conditions

Just south of Willis Point Road is a depression that collects localized groundwater seepage, which drains to a larger forested wetland north of the road (Figure 3-1) via a culvert. The locations and wetland areas identified in this report are based on field truthing with GPS completed by Corvidae. Based on Corvidae observations and input from CRD staff, the primary receiving wetland (directly north of Willis Point Road) lacks aquatic vegetation and is likely groundwater and surface water fed. Therefore, standing waters occur seasonally or persists for long periods, leaving the subsurface continuously saturated. The substrate consists of mineral and organic materials. The surrounding vegetation consists of dense coniferous forest. The wetland is a natural source of water supply as defined in the *Water Sustainability Act* and is classified as a swamp (mineral wetland with forest vegetation) by the Canadian Wetland Classification System (National Wetlands Working Group 1997). At the time of spill, there was low probability that amphibians were in their aquatic phase, as these species tend to seek suitable terrestrial overwintering habitat as temperatures become cooler in October. However, in October, Pacific Tree Frog (*Hyla regilla*) chorus was observed on the wetland margins, suggesting that this species overwinters here and likely uses the wetland for annual breeding (Wong, R. personal communication, November 2020). The surrounding riparian area is suitably complex with recumbent coarse woody debris and standing second-growth trees that provide canopy cover. Habitat features like coarse decaying woody debris that support hibernating amphibians are well represented in this wetland.

3.3 Surface Water

A waterbody that is potentially associated with natural groundwater seepage is located at the northwest corner of the north access road. This surface water is directed through a culvert under Willis Point Road where it enters the wetland (Figure 3-1). The berm at the north end of this wetland appears to be an old logging skid trail that has become an informal walking trail (Figure 3-1, see inset photo). The wetland has been identified in previous mapping as an ephemeral tributary of Durrance Lake, located approximately 400 m north of the spill site terminus; however, the berm at the north end obstructs surface water flow. This is consistent with observations by Corvidae during the spill timeframe (October through December), where they did not observe continuous surface water connection to the lake. Based on field observations, the water likely infiltrates to ground and through the berm, travelling underground as groundwater towards a second lower elevation wetland (Figure 3-1). Between the affected wetland and the second wetland there is a groundwater seepage that becomes surface water, flowing north into the second wetland. The second wetland is closer to Durrance Lake, and a surface water pathway exists from the second wetland to the lake as a small defined channel.

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Associated Environmental

- Berm
- Spill areas
- Approximate extent of wetland
- Surface drainage path
- Sub-surface drainage path

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DATE: January 2021
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FIGURE 3-1: MAPPED WETLANDS AND SURFACE FLOW

Maple Reinders Bird Joint Venture

CRD Residual Treatment Facility Spill

3.4 Groundwater

Regionally, two provincially mapped aquifers underlie the Site, identified as Aquifers 680 and 681.

Aquifer 680 is a partially confined Pleistocene bedrock aquifer that is classified as having moderate productivity, high demand, and moderate vulnerability to contamination (ENV 2020c). The aquifer is 209 km^2, and is the second largest aquifer in the CRD, extending from Saanich Inlet and covering most of Victoria. There are 1,276 registered wells within the aquifer (ENV 2020c). Well records indicate a wide range of reported yields from 0.19 to 946.4 L/min. The average recorded well completion depth is 73 m below ground.

Aquifer 681 is a partially confined bedrock aquifer that is classified as having low productivity, moderate demand, and high vulnerability to contamination due to a thin overburden and lack of confining materials in the majority of wells (Kenny 2004; ENV 2020c). The aquifer is about 7.9 km^2, extending from Saanich Inlet to Tod Creek; and near Willis Point Road it contacts Aquifer 680. There are 191 registered wells within the aquifer, with no current assigned groundwater use licences. Well records indicate an average yield of 29.1 L/min. The average recorded well completion depth is 65 m below ground (Kenny 2004; ENV 2020c).

At the location of the spill, five monitoring wells have been installed as part of the annual Hartland Landfill monitoring program (57-1-1, 56-1-1, 55-1-1, 44-1-1, and 41-1-1; see well logs provided in Update to the Minister report, Appendix B; Associated 2020). The borehole logs for the monitoring wells indicate that each well is completed in bedrock with depths to bedrock ranging from 1.2 m below ground surface (bgs) to 4.3 m bgs in 44-1-1 and 57-1-1, respectively. Therefore, the sampling is of water from the bedrock aquifer and not likely influenced by surface water on the site.

Bedrock groundwater flow at the Site is from south to north, and then trends to the northeast (AECOM 2019). Approximately 200 m east of the Site is an inferred fault, which may influence groundwater flow patterns, behaving as a barrier to east-west groundwater flow. This creates a compartmentalized groundwater flow system (AECOM 2019).

Shallow groundwater in the overburden overlying bedrock likely follows the topography travelling from the Site to the northwest. Shallow groundwater has been investigated through installation of drive point piezometers around the wetland, and observation and sampling of multiple seeps which are thought to represent localized groundwater flow in Spill Area 3.

3.5 Water Users

IMapBC indicates that two existing surface water licences are assigned to Durrance Lake. One licence is for irrigation purposes (C060783) and the other is intended for general land improvement (C060785) (ENV 2020d). This designated use means that these surface water licences are not intended to be used as a potable water source for human consumption, and it understood that the irrigation licence is not for producing hay, forage crops, pasture, cereal crops, vegetables and fruit, but rather for ornamental flowers.

IMapBC also indicates that all water supply wells within 1 km radius of the Site have been installed in Aquifer 681, which contacts Aquifer 680 in the local area (Figure 3-2). Six registered wells are located within 1 km of the Site (Table 3-1; Figure 3-2). The nearest registered groundwater well to the Site (Well Tag Number 65497) is located 795 m east of the spill limits and has a depth of 98 m bgs.

Table 3-1
Registered wells within one kilometre of the Site

Well Tag Number	Intended Water Use	Street Address	Finished Well Depth (m)	Water Depth (m bgs)	Well Yield (L/min)	Distance from the Site (m)*	Direction from the Site
79526	Private Domestic	400 Durrance Close	84	1.5	11.4	887	Northwest
14388	n/a	Durrance Close	21	n/a	25.4	931	Northwest
65497	n/a	Durrance Lake Road	98	12.2	45.4	795	East
65498	n/a	Durrance Lake Road	98	17.0	11.4	798	East
65499	n/a	Durrance Lake Road	99	n/a	12.5	800	East
112231	Private Domestic	n/a	145	n/a	17.0	952	Southwest

Notes: n/a = Not Available. *Based on the surveyed outer extent of the spill (Figure 3-1).
Source: ENV 2020d

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Associated Environmental

- Approximate rupture location
- Monitoring well
- Groundwater within 1 km of the rupture site and aquifers
- Spill areas
- 1 km buffer of rupture site

Aquifers

- 680 IB (14)
- 681 IA (11)

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FIGURE 3-2: REGISTERED WELLS AND AQUIFERS

Maple Reinders Bird Joint Venture

CRD Residual Treatment Facility Spill

4 SITE INVESTIGATION

The initial site investigation was carried out by Corvidae on October 14 (visually) and is still ongoing, with guidance from Associated and Gary Hamilton, P.Geo., CSAP. The investigation consists of surface water and groundwater quality sampling, sediment[2] sampling in the wetted areas of the wetland, and soil sampling in the non-wetted areas, as well as visual and olfactory documentation of the spill-affected areas. Approximately 106 samples have been taken. Sampling locations are informed by the understanding of the potential flow characteristics of the spill based on:

- Observations by Corvidae at the Site;
- Available borehole logs of the geologic formations under the spill;
- South Vancouver Island Beach Sampling Results (Island Health 2020); and
- Previous groundwater modelling reports (AECOM 2019).

The site investigation is focussed on the following:

- Surface water;
- Groundwater;
- Soil; and
- Wetland sediments.

4.1 Regulatory Context

This report is intended to meet the review requirements of the ENV Land Remediation Branch. Because the spill migrated to a wetland, there are regulatory implications governed by FLNR under the *Water Sustainability Act* and the *Wildlife Act.* Therefore, FLNR will also review the results in this report related to the wetland's ecosystem values.

The BC *Contaminated Sites Regulation* (CSR) provides standards for water, soil, and sediment that are legally enforceable. Additional detail on how the CSR applies to the investigation and remediation of the spill is provided in Appendix C. As a second benchmark, the BC Approved and Working Water Quality Guidelines (WQG) are guidelines used to evaluate ambient water quality, protect water values (such as aquatic life, wildlife, and drinking water), and inform decision making. It is important to note that as per ENV (2019a), "exceeding a water quality guideline does not imply that unacceptable risks exist, but rather that the potential for adverse effects may be increased and additional investigation may be required." Further, there are no BC CSR standards for microbiological parameters (i.e., *E. coli* and fecal coliforms), but there are applicable BC WQG. Therefore, both BC CSR and BC WQG have been used to complete a comprehensive review of spill effects and to develop recommendations for the Site going forward.

Surface water includes the water in the wetland and Durrance Lake as *potential* receptors. Durrance Lake is primarily used for recreation, and there are two surface water licences located on the east end of the lake, one for irrigation and one for land improvement. The wetland has potential to support aquatic life. The following guidelines were therefore applied to surface water data:

- BC Approved and Working Water Quality Guidelines (BCAWQG and BCWWQG) for Aquatic Life (AL) and Wildlife[3] (WL) (ENV 2019a, 2020a); and

[2] "Soil" includes unconsolidated mineral or organic material, rock, and/or fill in a terrestrial setting. "Sediment" means particulate material that usually lies below water.
[3] Although the guideline is for wildlife and agriculture, the agricultural component of this guideline was not applied because the Durrance Lake water license is not used for crop irrigation, it is used in for landscape watering.

- BC Recreational Water Quality Guidelines (ENV 2019b).

For groundwater, the BC CSR standards for aquatic life and drinking water apply, for the reasons detailed in Appendix C, and BC WQG for aquatic life were applied to the groundwater wells located within 10 m of an aquatic receiving environment (piezometers installed around the wetland to the north; RTF-W-DP# shown in Figure 4-2). The BC WQG were also applied for microbiological only, as there are no CSR standards for microbiological parameters. The following standards and guidelines were therefore applied to bedrock groundwater data:

- BC CSR groundwater standards for Aquatic Life (AW) (freshwater) and Drinking Water (ENV 2017a);
- BC Source Drinking Water Guidelines (BC SDWQG) (ENV 2020b) (*applied only for microbiological*).

The following standards and guidelines were therefore applied to shallow groundwater data:

- BC CSR groundwater standards for Aquatic Life (AW) (freshwater) and Drinking Water (DW) (ENV 2017a);
- BC Approved and Working Water Quality Guidelines (BCAWQG and BCWWQG) for Aquatic Life (AL) and Wildlife[3] (WL) (ENV 2019a, 2020a);
- BC Source Drinking Water Guidelines (BC SDWQG) (ENV 2020b) (*applied only for microbiological*); and
- BC Recreational Water Quality Guidelines (ENV 2019b) (*applied only for microbiological*).

For soil, the following standards were applied (see Appendix C for further details):

- BC CSR Industrial standards for soil/substrate; and
- BC CSR Urban Park soil standards.

For sediment, the following standards were applied, and microbiological concentrations were qualitatively reviewed (see Appendix C for further details):

- BC CSR Sensitive Sediment standards.

4.2 Sampling Procedures

Sample locations for surface water, groundwater, soil and sediments are shown in Figure 4-1. Sample codes correspond to locations as follows:

- Spill Area 1, RTF-P: RTF site location
- Spill Area 2, RTF-NAR: north access road (along ditch adjacent to road leaving the RTF)
- Spill Area 3, RTF-W: wetland area (all sites on north side of Willis Point Road)
- GW: Hartland Landfill monitoring well
- DL: Durrance Lake.

The soil, water, and sediment samples were obtained following procedures published by the BC government (technical guidance for site characterisation and confirmation testing [MOE 2009] and the field sampling manual for water and wastewater [MOE 2013]). The samples were placed in coolers with ice and shipped via chain-of-custody protocol to ALS Laboratories in Burnaby (an accredited laboratory). Additional information on procedures is provided in Sections 4.2.1 to 4.2.5. Location and elevation of sample locations were collected with a GPS. Due to dense forest canopy, cloud cover and GPS limitations, the elevation has an error of +/- 5 m.

4.2.1 Laboratory and Field Quality Assurance/Quality Control (QA/QC)

Laboratory analyses were completed by ALS Laboratories in Burnaby, BC. ALS laboratory quality control included:

- Laboratory duplicate (DUP);
- Matrix spike;
- Reference material;
- Method blank; and
- Laboratory control.

The field QA/QC procedures followed BC protocols (MOE 2009 and MOE 2013) and included:

- Using nitrile gloves and replacing gloves at each sample location.
- Cleaning the shovel and auger using distilled water, acetone and shop towels between each sample location (for soil and sediment sampling).
- Using ice to cool the samples during transport.
- Ensuring no headspace was remaining in the sample jars.
- Collecting one field duplicate for every 10 samples.

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Associated Environmental

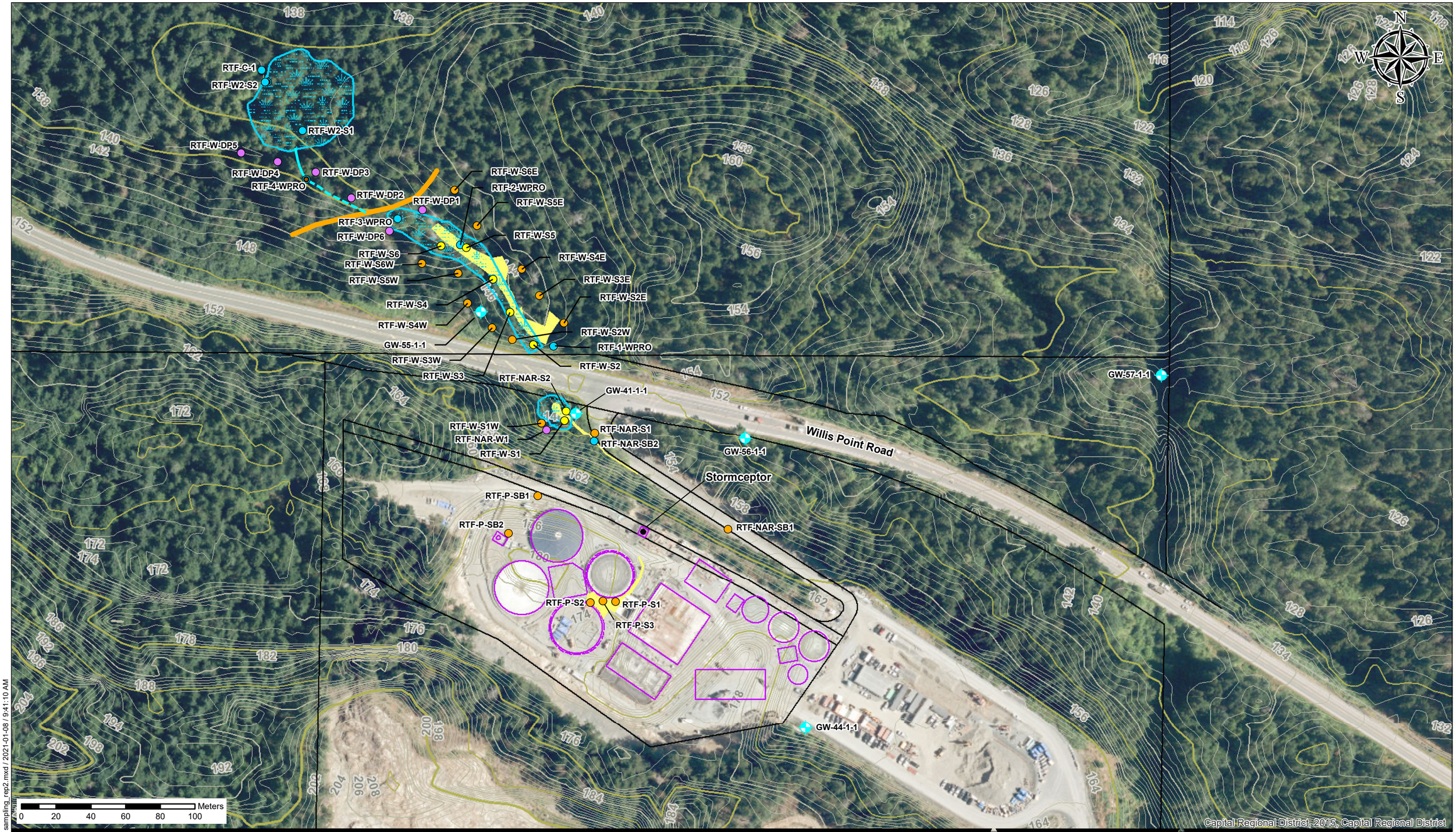
- Water sample
- Berm
- Spill areas
- Wetland extent

PROJECT NO.: 2020-8732
DATE: January 2021
DRAWN BY: BdJ

FIGURE 4-1: SURFACE WATER SAMPLE LOCATIONS OUTSIDE OF SPILL PATHWAY

Maple Reinders Bird Joint Venture

CRD Residual Treatment Facility Spill



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Associated Environmental

- Water sample
- Shallow groundwater
- Soil sample
- Sediment sample
- Monitoring well
- Spill areas
- Berm
- Surface drainage path
- Sub-surface drainage path
- Wetland extent

PROJECT NO.: 2020-8732
DATE: January 2021
DRAWN BY: BdJ

FIGURE 4-2: RTF SAMPLE LOCATIONS

Maple Reinders Bird Joint Venture
CRD Residual Treatment Facility Spill

4.2.2 Surface Water

Since October 14, 2020, 33 surface water samples have been collected at 12 locations. Initial sampling of lake water was reduced from four locations to one location at the south end of Durrance Lake (DL-SE; Figure 4-1). This reduction in sample locations is based on lab results showing that all lake water samples met the applicable guidelines, and the surface water location at the south shore of Durrance Lake, nearest to the spill pathway would be most representative of the surface water for Durrance Lake prior to dilution. Surface water was also collected in the affected wetland, and the second wetland to the north, as well as a seepage near the spill pathway, and between the affected wetland and second wetland to the north (Figure 4-2). Surface water samples were collected as grab samples from the upper 10 cm of the water column. Field parameters have been recorded for all samples taken since October 19, 2020.

Sample types are in one of three categories:

1. Receptor – areas outside the spill boundaries that could potentially be affected by the spill (e.g., Durrance Lake, and a second wetland and spring to the north of Spill Area 3).
2. Wetland – within the spill pathway area defined as wetland, and second wetland to the north of Spill Area 3.
3. Seepage – within the spill pathway but on the south side of Willis Point Road.

The water samples were collected by Corvidae in laboratory-supplied bottles, filtered and preserved in the field (where necessary), placed in coolers with ice, and shipped via chain-of-custody protocol to ALS Laboratories in Burnaby (an accredited laboratory). Based upon the constituents of typical wastewater (Table 4-1), the surface-water samples taken from Durrance Lake[4] were analyzed for ammonia-N, nitrate-N, nitrite-N, and microbiological analysis (*E. coli*, fecal coliforms and total coliforms), the primary parameters of concern related to the spill material and this receptor. The remaining surface water sample locations, listed in Table 4-2, were sampled and analyzed for:

- Microbiological (*E. coli*, fecal coliforms and total coliforms);
- Total and dissolved metals;
- Ammonia-N, nitrite-N, nitrate-N, TKN, organic nitrogen, and total nitrogen;
- Total phosphorus (P), total dissolved P, ortho-P;
- Anions (chloride, bromide, fluoride, sulphate);
- Alkalinity;
- Total dissolved solids; and
- Biochemical Oxygen Demand (5-day).

Petroleum hydrocarbons are not a major constituent of typical wastewater and not considered as a potential contaminant of concern.

[4] Including Durrance Beach, Durrance Lake SW, Durrance Lake SE, and Durrance Lake Inlet (Figure 4-1).

Table 4-1
Major constituents in typical wastewater

Constituent (mg/L)	Strong	Medium	Weak
Total solids	1200	700	350
Dissolved solids (TDS)	850	500	250
Suspended solids	350	200	100
Nitrogen (as N)	85	40	20
Phosphorus (as P)	20	10	6
Chloride	100	50	30
Alkalinity (as $CaCO_3$)	200	100	50
Grease	150	100	50
Biological oxygen demand (BOD5)	300	200	100

Source: Pescod, M.B. 1992

Table 4-2
Surface water sampling location details

Sample ID	Sample Type	UTM Coordinates (U 10)		Elevation (m asl)[1]	Date(s) Sampled (2020)
Durrance Beach (DL-B)	Receptor	464662.1 m E	5377439.0 m N	136	Oct 15 and 26
Durrance Lake Inlet (SE; DL-O)	Receptor	464999.0 m E	5377089.0 m N	137	Oct 26
Durrance Lake SW (DL-SW)	Receptor	464630.1 m E	5377241.0 m N	136	Oct 26
Durrance Lake SE (DL-SE)	Receptor	464969.0 m E	5377112.0 m N	136	Oct 15 and 26; Nov 3, 5, 10, 14 and 18, Dec 17
RTF-1-WPRO	Wetland[2]	465177.0 m E	5376891.0 m N	152	Oct 17
RTF-2-WPRO	Wetland[2]	465123.0 m E	5376949.0 m N	149	Oct 19 and 26
RTF-3-WPRO	Wetland[2]	465087.2 m E	5376964.4 m N	149	Dec 17
RTF-4-WPRO	Wetland[2]	465123.0 m E	5376949.0 m N	149	Dec 17
RTF-NAR-SB2	Seepage	465230.5 m E	5376815.7 m N	149	Nov 30 and Dec 3
RTF-W2-S1	Receptor (Wetland[3])	465017.2 m E	5377032.0 m N	154	Dec 9
RTF-W2-S2	Receptor (Wetland[3])	4650100.2 m E	5377020.0 m N	154	Dec 17
RTF-C-1	Receptor (Spring)	4650120.2 m E	5376985.0 m N	154	Dec 17

Notes: m asl = metres above sea level

[1] Due to dense forest canopy, cloud cover and GPS limitations, the elevation has an error of +/- 5 m.

[2] In the spill pathway, Spill Area 3

[3] In the second wetland to the north of Spill Area 3

4.2.3 Groundwater

Groundwater samples were collected by Corvidae from five nearby monitoring wells during four sampling events (October 17 and 19, 2020 and November 13 and 18, 2020) for a total of 10 samples. Table 4-3 presents the coordinates for the five groundwater wells and includes the relative location of the wells to the spill material (Figure 4-2). The groundwater wells are used as part of the ongoing landfill monitoring program. Well 44-1-1 is located approximately 115 m upgradient from the Site (Figure 4-2) and was sampled for comparison to background groundwater quality. It should be noted that all of the monitoring wells are completed into bedrock and as a result, represent the groundwater in the upper portion of the bedrock aquifer. Borehole logs indicate that at the time of drilling, no shallow groundwater was observed above the bedrock.

A natural groundwater seep proximal to Spill Area 2 (RTF-NAR-W1 and RTF-NAR-SB2 Figure 4-2) was also sampled during the initial sampling event and considered to represent localized groundwater flow associated with the ephemeral drainage ditch. It is being contrasted to surface water standards and guidelines because the seepage is within 10 m of a surface waterbody (i.e. the wetland). Additional shallow groundwater monitoring is being implemented, which includes the installation and sampling of piezometers (see additional details in Section 6).

Prior to sampling the bedrock groundwater, in general accordance with BC EMV Technical Guidance 8, Corvidae and CRD Hartland Landfill staff purged the monitoring wells to remove at least three well volumes, until field parameters stabilized, using a foot-valve inertial pumping system (as per standard practice). When groundwater monitoring wells are installed in relatively low permeability formations (such as fractured bedrock), purging such wells is sometimes difficult and results in purging the well dry. In such situations the recommended procedure is to carefully and slowly purge the well to avoid drawing the water level in the well to the well screen. Where water-level recovery may take several hours or days, it must be recognized that the sampled water has likely established partial or full equilibrium with atmospheric conditions and a truly representative groundwater sample may not be possible. Well 41-1-1 was sampled with a bailer after sufficient water had recharged (the next day). Field parameters (i.e., temperature, conductivity, pH, oxidation-reduction potential, and turbidity) were recorded by Corvidae for all groundwater sampling locations, including during the well purging.

In addition to groundwater well samples, six drive-point piezometers were installed from the north and west end of the upper wetland, to the south edge of the lower wetland. This was to evaluate the groundwater quality immediately downgradient of the wetland, prior to reaching Durrance Lake (Figure 4-2). They were installed to approximately 1 m depth or until refusal on December 8th and 11th. Once installed, the piezometers were purged three times before field parameters stabilized, then were sampled on December 15th (except RTF-W-DP2, which was dry and RTF-W-DP1, which had very slow recharge and could not be sampled). Corvidae returned to site on December 17th and completed an additional round of sampling. They were able to collect groundwater samples from all the piezometer location, with the exception of RTF-W-DP2 that was still dry. BC CSR technical guidance was generally followed during groundwater sampling; however, in some location the low permeability of the saturated formation prohibited the water-level in the well to be maintained above the screened interval during development and purging. It is not anticipated that the low permeability of the saturated formation would have substantially biased analytical results for groundwater sampled and analyzed for microbial parameters.

Groundwater samples were collected in laboratory-supplied bottles, filtered and preserved in the field (where necessary), placed in coolers with ice, and shipped via chain-of-custody protocol to ALS Laboratories in Burnaby (an accredited laboratory). The groundwater samples were analyzed for the following:

- Microbiological (*E. coli*, fecal coliforms and total coliforms);
- Total and dissolved metals;
- Ammonia-N, nitrite-N, nitrate-N, TKN, organic nitrogen, and total nitrogen;
- Total phosphorus (P), total dissolved P, ortho-P;
- Anions (chloride, bromide, fluoride, sulphate);
- Alkalinity;
- Total dissolved solids; and
- Biochemical Oxygen Demand (5-day).

Table 4-3
Groundwater sampling location details

Monitoring Well	UTM Coordinates (U 10)		Ground Elevation (m asl)[1]	Screen Depth (m btoc)	Static Water Level (m btoc) (Oct 17)	Well Location Relative to the Spill Material	Date(s) Sampled (2020)
57-1-1	465528.0 m E	5376873.0 m N	133	13.56	3.370	Downgradient	Oct 17 and Nov 18
56-1-1	465287.0 m E	5376838.0 m N	149	17.38	4.247	Cross gradient	Oct 17 and Nov 14
55-1-1	465136.0 m E	5376910.0 m N	148	13.11	6.362	Downgradient	Oct 17 and Nov 14
44-1-1	465322.3 m E	5376671.5 m N	162	11.00	1.540	Upgradient	Oct 19 and Nov 14
41-1-1	465190.0 m E	5376852.0 m N	150	9.07	2.675	Downgradient	Oct 17 and Nov 14
Shallow Groundwater (DP = piezometers)							
RTP-NAR-W1 (groundwater seep)	465184.0 m E	5376825.0 m N	159	N/A	N/A	Downgradient	Oct 19, Nov 30, Dec 3
RTF-W-DP1	465087.9 m E	5376970.0 m N	151	N/A	0.03	Downgradient	Dec 16
RTF-W-DP2	465048.6 m E	5376968.9 m N	153	N/A	DRY	Downgradient	Dec 17
RTF-W-DP3	465040.8 m E	5376992.7 m N	153	N/A	0.387	Downgradient	Dec 15 and 17
RTF-W-DP4	465018.3 m E	5376998.3 m N	154	N/A	0.276	Downgradient	Dec 15 and 17
RTF-W-DP5	464997.1 m E	5377003.2 m N	155	N/A	0.206	Downgradient	Dec 15 and 17
RTF-W-DP6	465087.1 m E	5376941.4 m N	150	N/A	0.505	Downgradient	Dec 15 and 17

Notes: m asl = metres above sea level; m bgs = metres below ground surface

[1] Due to dense forest canopy, cloud cover and GPS limitations, the elevation has an error of +/- 5 m.

4.2.4 Soil

Soil samples were collected by Corvidae from around the wetland area in the dry or not typically wetted locations (Table 4-4; Figure 4-1). Eighteen soils pits were advanced to 1 m depth where possible. Each soil sample was collected using the following guidance:

- Collected from similar *in situ* fill or soil at one location;
- Confined to collection within a contiguous volume of 1 m^3;

- Collected over a maximum depth of approximately 0.5 m within the upper 1 m from the existing site surface, or from an identifiable historical site surface; or collected over a maximum depth of 1 m at depths greater than 1 m from the surface;
- Not collected from two distinct fill or soil zones;
- Not collected on two sides of an air/water interface (or unsaturated/saturated soil zone interface); and
- Not made up of a mixture of obviously contaminated material and obviously noncontaminated material as determined by field observations such as sight and odour, even if these materials have similar physical characteristics (e.g., both are silty sands).

Within the soil pits, soil matrix characteristics (texture and visible horizons) were documented. The samples were taken approximately once every 10 m^2 within the Site.

All soil samples were collected in clean laboratory-supplied jars, placed in a cooler with ice (to maintain sample temperature at 4°C or lower) and shipped the same day using chain-of-custody protocol to ALS Laboratories in Burnaby, BC. Analysis included heavy metals, total nitrogen, nitrate, nitrite, ammonia, fecal coliforms, and *E. coli.*

Table 4-4
Soil sampling location details

Sample ID	Sample Type	UTM Coordinates (U 10)		Elevation (m asl)[1]	Date Sampled (2020)	Depth of Sample (composite m)
RTF-W-S1W	Soil	465170.2 m E	5376846.7 m N	155	Oct 21	0.51
RTF-W-S2E	Soil	465183.0 m E	5376904.3 m N	149	Oct 21	0.52
RTF-W-S2W	Soil	465159.6 m E	5376899.9 m N	151	Oct 21	0.60
RTF-W-S3E	Soil	465168.8 m E	5376920.2 m N	152	Oct 21	0.40
RTF-W-S3W	Soil	465141.6 m E	5376901.7 m N	152	Oct 21	0.50
RTF-W-S4E	Soil	465158.7 m E	5376935.5 m N	152	Oct 21	0.30
RTF-W-S4W	Soil	465127.3 m E	5376915.9 m N	152	Oct 21	0.20
RTF-W-S5E	Soil	465132.9 m E	5376960.4 m N	149	Oct 22	0.35
RTF-W-S5W	Soil	465122.1 m E	5376933.2 m N	150	Oct 22	0.28
RTF-W-S6E	Soil	465120.1 m E	5376981.0 m N	148	Oct 22	0.40
RTF-W-S6W	Soil	465101.2 m E	5376938.7 m N	150	Oct 22	0.30
RTF-P-S1	Soil	465213. 2 m E	5376740.0 m N	160	Oct 21 and Nov 18	0.32 (Oct) 0.30 (Nov)
RTF-P-S2	Soil	465198.2 m E	5376740.0 m N	160	Oct 21 and Nov 18	0.40 (Oct) 0.30 (Nov)
RTF-P-S3	Soil	465205.1 m E	5376740.0 m N	160	Oct 21 and Nov 18	0.35 (Oct) 0.30 (Nov)
RTF-P-SB1	Soil	465168.1 m E	5376810.0 m N	160	Oct 21	0.40

RTF-P-SB2	Soil	465151.1 m E	5376780.0 m N	160	Oct 21	0.35
RTF-NAR-SB1	Soil	465277.1 m E	5376790.0 m N	160	Oct 21	0.40
RTF-NAR-S1	Soil	465206.1 m E	5376840.0 m N	160	Oct 21 and Nov 18	0.25 (Oct) 0.20 (Nov)

Note: Samples from outside the wetted area are represented by a W in the sample name; samples from within the plant site are represented by a P in the sample name); and samples along the northwest access road are represented by NAR in the sample name.
[1] Due to dense forest canopy, cloud cover and GPS limitations, the elevation has an error of +/- 5 m.

4.2.5 Sediment

Seven sediment sample locations were sampled two to three times by Corvidae in the wetland area (Table 4-5; Figure 4-2), specifically below the high-water mark or areas that are typically wetted. Sediment samples were grab samples collected at the water-sediment interface.

All sediment samples were collected in clean laboratory-supplied jars, placed in a cooler with ice (to maintain sample temperature at 4°C or lower) and shipped the same day using chain-of-custody protocol to ALS Laboratory in Burnaby, BC. Samples were then sent to the lab for analysis of heavy metals, total nitrogen, nitrate, nitrite, ammonia, fecal coliforms, and *E. coli*.

Table 4-5
Sediment sampling location details

Sample ID	Sample Type	Coordinates (U 10)		Elevation (m asl)[1]	Date Sampled (2020)
RTF-NAR-S2	Sediment	465187.9 m E	5376854.7 m N	152	Oct 21, Nov 18, Dec 9
RTF-W-S1	Sediment	465190.0 m E	5376852.0 m N	155	Oct 21, Nov 18, Dec 9
RTF-W-S2	Sediment	465165.3 m E	5376891.9 m N	152	Oct 22, Nov 18, Dec 9
RTF-W-S3	Sediment	465151.9 m E	5376910.6 m N	153	Oct 22, Nov 18, Dec 9
RTF-W-S4	Sediment	465142.0 m E	5376929.6 m N	152	Oct 22, Nov 18, Dec 9
RTF-W-S5	Sediment	465126.7 m E	5376947.8 m N	155	Oct 22, Nov 18, Dec 9
RTF-W-S6	Sediment	465112.1 m E	5376948.9 m N	155	Oct 22, Nov 18, Dec 9

[1] Due to dense forest canopy, cloud cover and GPS limitations, the elevation has an error of +/- 5 m.

4.3 Investigation Results

The spill investigation results included in this report are up to December 15th, 2020. The summarized results are presented by sample media type in Section 4.3.1 to Section 4.3.4, and tabulated analytical results compared to standards and guidelines are provided in Appendix D.

4.3.1 Surface Water

Based on Site observations, there is no consistent surface water hydraulic connection between the downstream limits of the spill and Durrance Lake (Figure 3-1). The potential transport mechanism for the spill material could be a combination of surface water and groundwater flow. Groundwater travel times can vary substantially; but based on

initial site observations it was determined that it is highly unlikely that any material from the spill would have reached Durrance Lake within the first 48 hours following the spill. Therefore, the Durrance Lake surface water samples collected on October 15th, 2020 (Tables 4-6 and 4-7), and the August water quality sample results from Island Health can be considered as baseline samples. Island Health sampling results in September 2020 show *E. coli* levels of 15 per 100 mL of sample water (no other unit given) (Island Health 2020). October 15th samples show *E.coli* levels of 23 MPN/100mL and fecal coliform at 31 MPN/100mL (Table 4-6).

The results are provided in two tables, with Table 4-6 only showing the southernmost sampling location on Durrance Lake, which was sampled eight times (without exceedances), and Table 4-7 presenting exceedances from surface water locations closer to the spill. As expected *E. coli* and fecal coliform results taken from Durrance Lake are significantly lower then the results found in surface water sample locations in the spill pathway directly after the spill (RTF-1-WPRO and RTF-2-WPRO; Figure 4-3). Results from the most recent surface water sampling on December 17th in the affected wetland (RTF-3-WPRO) indicate that *E. coli* and fecal coliform concentrations met all applicable guidelines. The rise in fecal coliforms at the Durrance Lake location on November 3 (Table 4-6), was a sample taken after a significant rainfall event. It may be that the rainfall washed bacteria into the lake from the surface stream that enters the lake at that location, unrelated to the spill because there is not a surface water flow connection to Spill Area 3.

Parameter	Concentration or Range of Concentrations at Sample Location		Most stringent applicable guideline or standard	
	RTF-1-WPRO	RTF-2-WPRO	Guideline or standard value	Guideline or standard type
Turbidity (NTU)	NS	53.3-5.55	50	BC Recreational WQG
E. coli (MPN/100 mL)	>2420	>2420-461	200	BC Recreational WQG

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Associated Environmental

- Water sample - concentrations less than or equal to the applicable standard and/or guideline *
- Water sample - concentrations greater than the applicable standard and/or guideline *
- Wetland extent
- Spill areas

* Analyzed for metals, nitrogen, phosphorus, anions, pH, total dissolved solids, biological oxygen demand, fecal coliforms, and E. coli.

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FIGURE 4-3: SURFACE WATER SAMPLE RESULTS

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Table 4-6
E.coli and fecal coliform results in surface water at DL-SE

Parameter	Concentrations at Sample Location DL-SE								Most stringent applicable guideline or standard	
									Guideline or standard value	Guideline or standard type
Date Sampled (2020)	Oct 15	Oct 26	Nov 3	Nov 5	Nov 10	Nov 14	Nov 18	Dec 17	-	-
E. coli (MPN/100 mL)[1]	23	5	96	4	<1	10	2	3	200	BC Recreational WQQ
Fecal Coliforms (MPN/ 100/mL)[1]	31	8	345	5	<1	12	5	1	NG	NG

Notes: All results, tabulated and compared to guidelines, are shown in Appendix D.
NG = no guideline
[1] All results shown were reported in MPN/100 mL with the exception of the October 15 results, which were reported in CFU/100 mL.

Table 4-7
Concentrations of parameters that exceeded guidelines in surface water

Parameter	Concentration or Range of Concentrations at Sample Location		Most stringent applicable guideline or standard	
	RTF-1-WPRO	RTF-2-WPRO	Guideline or standard value	Guideline or standard type
Number of Sampling Events	1	2	-	-
Date Sampled (2020)	Oct 17	Oct 19 and Oct 26	-	-
Turbidity (NTU)	NS	53.3-5.55	50	BC Recreational WQG
E. coli (MPN/100 mL)	>2420	>2420-461	200	BC Recreational WQG

Notes: Does not include DL-SE sample results.
Table shows the range of values measured between October 15 and December 17, 2020 for any parameter that exceeded guidelines in at least one sample. All results, tabulated and compared to guidelines, are shown in Appendix D.
Bolded values indicate an exceedance of the applicable guidelines.
NS = Not Sampled

4.3.2 Groundwater

Bedrock groundwater sample results indicated no exceedances of the applicable standards or guidelines, with the exception of total metals, but not dissolved metals. Total metals do not move easily through the aquifer; therefore, only dissolved metals are considered when discussing potential threats to the groundwater and under BC CSR for drinking water. As well, all the results at the wellsite's met applicable standards and guidelines for bacteria (*E. coli* and fecal coliforms).

Prior to the spill, the water chemistry measured for the monitoring wells was specific to leachate monitoring. Results indicate that water in all monitoring wells was in compliance with BC CSR AW and DW standards (AECOM 2016).

It should be noted that the monitoring wells were designed to monitor the potential for leachate to be transported off site from Hartland landfill, and that the well screens are completed in the bedrock aquifer and not the shallow overburden. As a result, the groundwater sample results are not optimal to detect potential contamination in shallow groundwater, but they are suitable for the assessment of health risk because they enable sampling of the aquifer that nearby drinking water wells are completed in.

For shallow groundwater, the analytical results from samples obtained from the drive point piezometers completed in the overburden soils indicated metals concentrations similar to background, *E.coli* at <1 MPN/100mL, and fecal coliform concentrations that range from 1 to 67 MPH/100 mL, with one outlier that is >2420 MPH/100mL fecal coliform at DP5 during the second sampling event. At the DP 5 location, fluoride levels during both sampling events were elevated (3.2 and 5.8 mg/L) when compared to levels measured in the other drive points, as are a number of metals (Table 4-9). A 2007 BC Water Stewardship Report[5] states that the average concentration of inorganic fluoride from natural sources in BC drinking water is generally less than 0.050 mg/L, but concentrations can get higher than 10 mg/L. Most of the fluoride found in groundwater is naturally occurring from the breakdown of rocks and soils. High concentrations of fluoride in groundwater have been observed in rural wells on Gabriola Island and Saltspring Islands, and around Ladysmith and Nanaimo.

The DP5 location is the furthest shallow groundwater sample location from the spill, with five other sites closer to Spill Area 3, all with results that are within standards and guidelines, including fluoride levels that are three-fold lower than at DP5. Therefore, the elevated fluoride measured at DP5 is not likely associated with the spilled material. The reason for the variation at DP5 may be related to high sample turbidity (586 NTU[6]) and high total dissolved solids in the water (2,560 mg/L), associated with the heavy rain before sampling (16.6 mm of rainfall in the 48-hour period prior to the December 17th, 2020 sampling [Environment Canada 2020]). These factors may also have affected the fecal levels results. Studies have shown that if coliform bacteria are detected, but no *E. coli*, it is likely that the contamination may be from soil or vegetation (Brandt *et al.* 2017). Both fecal, fluoride and metal levels are *not* similar to the spill material characteristics or surrounding natural conditions, so are an anomaly. The DP5 site will continue to be monitored to confirm concepts listed here (see the outline for the monitoring program in Section 6).

[5] https://www.rdn.bc.ca/sites/default/files/inline-files/Flouride%20in%20Groundwater.pdf
[6] Nephelometric Turbidity Unit

Table 4-8
E.coli and fecal results in groundwater wells

Parameter	Concentration at Sample Location					Most stringent applicable guideline or standard	
	41-1-1	44-1-1	55-1-1	56-1-1	57-1-1	Guideline or standard value	Guideline or standard type
Number of Sampling Events	2	2	2	2	2	-	-
Date Sampled (2020)	Oct 17 and Nov 14	Oct 19 and Nov 14	Oct 17 and Nov 14	Oct 17 and Nov 14	Oct 17 and Nov 18		
E. coli (MPN/100 mL)	<1 <1	1 <1	<1 <1	<1 <1	<1 <1	10	BC SDWQG MAC
Fecal Coliforms (MPN/100 mL)	<1 <1	<1 1	<1 <1	<1 <1	1 <1	10	BC SDWQG MAC

Notes: Table shows both values measured on October 17 and November 14, 2020 for microbiological results and any parameter that exceeded guidelines and/or standards in at least one sample. All results, tabulated and compared to guidelines, are shown in Appendix D.
Bold values indicate an exceedance of the applicable guidelines or standards.
SDWQG = Source Drinking Water Quality Guideline
MAC = Maximum Acceptable Concentration

Table 4-9
Concentrations of parameters that exceeded guidelines or standards and *E.coli* and fecal results in shallow groundwater

Parameter	Concentration at Sample Location							Most stringent applicable guideline or standard	
	RTF-NAR-W1	RTF-W-DP1	RTF-W-DP2	RTF-W-DP3	RTF-W-DP4	RTF-W-DP5	RTF-W-DP6	Guideline or standard value	Guideline or standard type
Number of Sampling Events	3	1	1	2	2	2	2	-	-
Sample Dates	Oct 19, Nov 30, Dec 3	Dec 16	Dec 17	Dec 15 and 17	Dec 15 and 17	Dec 15 and 17	Dec 15 and 17	-	-
Fluoride (µg/L)	-	<20	474	81 57	42 27	3220 5880	30 22	1500	BC CSR DW
Aluminum (dissolved; µg/L)	-	38.4	51.2	116	22.9	398	16.1	100	BCAWQG AL
Chromium (dissolved, µg/L)	-	<0.50	<0.50	0.56	<0.50	21.4	<0.50	1 10	BCWWQG AL[1] BC CSR AW[2]
Iron (dissolved, µg/L)	-	1400	55	199	22	1140	19	350	BCAWQG AL
Nickel (dissolved, µg/L)	-	7.81	20.7	30.5	8.28	79.0	1.18	25	BCWWQG AL[3]
Zinc (dissolved, µg/L)	-	2470	6290	1810	1450	3870	129	3000	BC CSR DW
	E. coli and Fecal Coliform Results								
E. coli (MPN/100 mL)	117 <1	<1	<1	<1 1	<1 <1	<1 <1	<1 1	10	BC SDWQG MAC
Fecal Coliforms (MPN/100 mL)	236 1	2	51	<10	41 67	<10 >2420	63 25	NG[4]	BC SDWQG MAC

Notes: Table shows both values measured on December 17, 2020 for microbiological results and any parameter that exceeded guidelines and/or standards in at least one sample. December 15 samples were submitted but complete results were not supplied by the lab at the time this report was issued. All results, tabulated and compared to guidelines, are shown in Appendix D.
Bold values indicate an exceedance of the applicable guidelines or standards.

ND = No Data
AO = Aesthetic Objective
MAC = Maximum Acceptable Concentration
NG = No Guideline
[1] Guideline value of 1 µg/L is the BC guideline for Cr(VI). The guideline for Cr(III) is 8.9 µg/L. Because speciated chromium was not analyzed, results were compared with the more stringent of the two guidelines.
[2] Standard of 10 µg/L is the CSR AW standard for Cr(VI). The standard for Cr(III) is 90 µg/L. Because speciated chromium was not analyzed, results were compared with the more stringent of the two standards.
[3] Guideline is 25 µg/L when water hardness is unknown.
[4] Previously 10 MPN/100mL, but fecal coliform as an indicator was archived as they are a poor risk indicator for illness in humans (ENV 2020b).

RTF-W-DP5
RTF-W-DP4
RTF-W-DP3
RTF-W-DP2
RTF-W-DP1
RTF-W-DP6
GW-55-1-1
GW-57-1-1
GW-41-1-1
RTF-NAR-W1
GW-56-1-1
GW-44-1-1

N
W
E
S

0 20 40 60 80 100 Meters

Capital Regional District

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Associated Environmental

- Water sample - concentrations less than or equal to the applicable standard and/or guideline *
- Water sample - concentrations greater than the applicable standard and/or guideline *
- Wetland extent
- Spill areas

* Analyzed for metals, nitrogen, phosphorus, anions, pH, total dissolved solids, biological oxygen demand, fecal coliforms, and E. coli. Qualitatively contrasted to background.

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FIGURE 4-4: GROUNDWATER SAMPLE RESULTS

Maple Reinders Bird Joint Venture

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4.3.3 Soil

Samples taken outside of the spill pathway (labelled with E or W in the sample name, e.g. RTF-W-S3E), did not have olfactory or visible evidence of being impacted by the spill. All other sample locations were within the spill pathway and are considered affected soils.

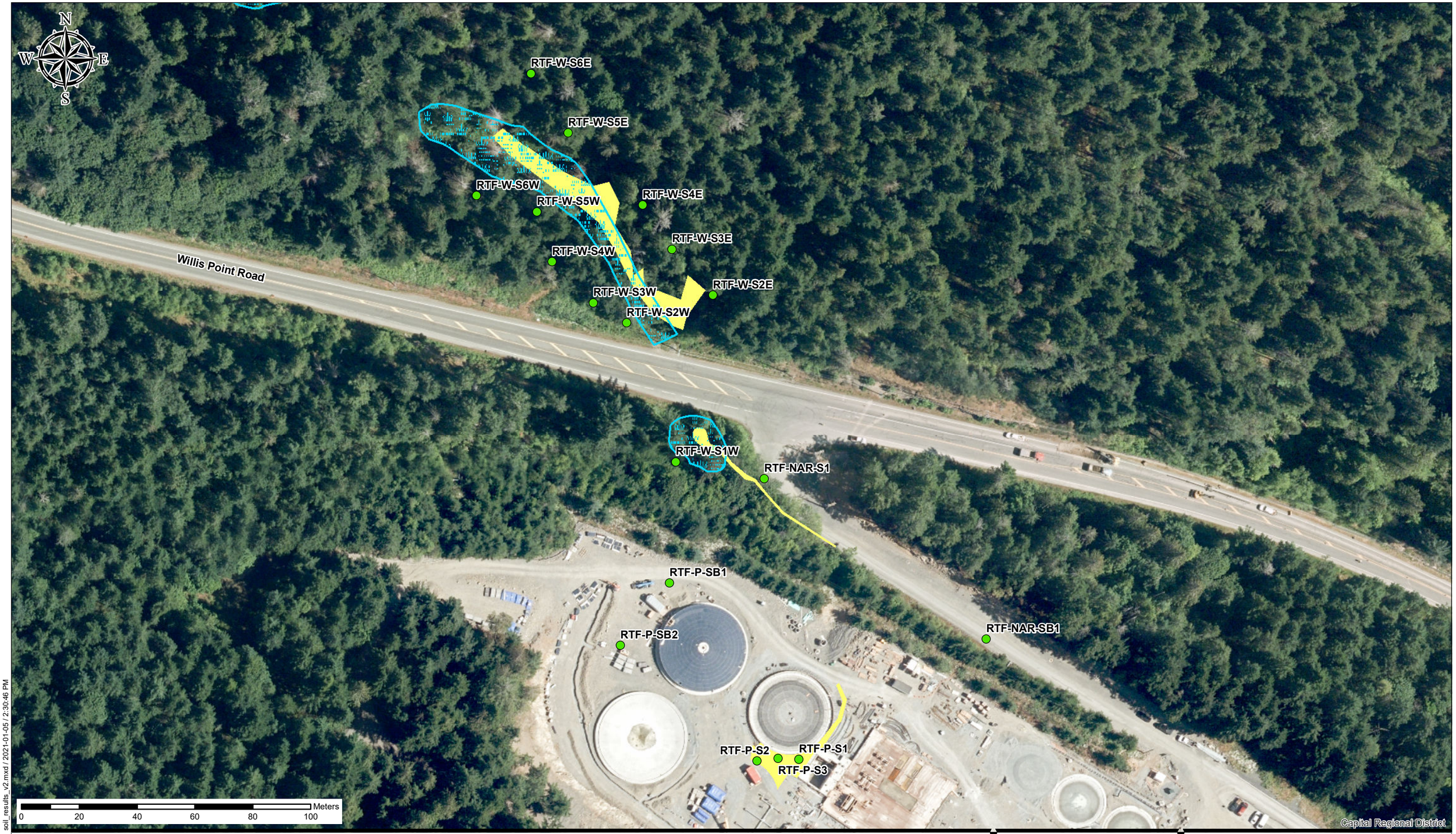
The CSR standards for barium, chromium, iron, manganese, selenium, sulphur, vanadium and/or zinc were contrasted to regional estimates for background concentrations on Vancouver Island (Table 4-10). Although these metals exceeded standards in several soil samples (Table 4-11), they are not very different from typical background and a few metals were elevated in both background and in the spill pathway, which indicates that these metals are naturally high in the soil locally (Table 4-11). However, a formal background determination was not completed under BC CSR Protocol 4. Iron concentrations were similar to natural background when compared to samples taken outside of the affected area (e.g. RTF-W-S3E, Table 4-11). The other exceedances appear to be isolated occurrences and likely due to localized and background conditions.

The *Environmental Management Act* defines pollution as the presence in the environment of substances or contaminants that substantially alter or impair the usefulness of the environment. No standards exist for *E. coli* or fecal coliforms in soil, but the soils were analyzed for these parameters to gain a better understanding of the Site conditions and how they change. Remediation is defined as the action to eliminate, limit, correct, counteract, mitigate or remove any contaminant or the adverse effects on the environment or human health of any contaminant. Therefore, although there are no CSR standards for *E. coli* or fecal coliforms in soil, the presence of these parameters needs to be considered in assessing the human health and ecological risks associated with the spill. Background sites (i.e., those outside of the spill pathway, e.g. RTF-W-SE) had values between <2 and 80 MPN/g for both *E. coli* and fecal coliforms. For all sites in the spill pathway that are not normally wetted (i.e., soil sites not sediment), the October 21 and 22 sampling results were elevated compared to background, ranging from 1710 to 2630 MPN/g of both *E. coli* and fecal coliforms. During the November 18 sampling event, *E. coli* and fecal coliforms decreased at all plant locations (RTF-P) and along the north access road at one location (RTF-NAR-1), by as much as 87% at RTF-P-S2 relative to the October values. RTF-NAR-S2 was the only soil sampled on December 9 to confirm that bacteria were not going up in this part of the spill pathway, and all parameters remained below CSR standards, the same as with previous samples taken in October and November. Sample locations that were above CSR standards are continuing to be monitored.

Table 4-10
Typical background value of metals in soils in the Saanich area compared to samples

Parameter (mg/kg)	Average value in undisturbed soils in Saanich Region	Average value in sampled soils
Barium	90	85.1
Chromium	23	54.7
Iron	2,4116	3,4858
Manganese	544	1,276
Selenium	<8	0.7
Sulfur	247	2,800
Vanadium	70	94.2
Zinc	54	78.9

Source: ENV 2017b



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Associated Environmental

- Soil sample - concentrations less than or equal to the applicable standard *
- Soil sample - concentrations greater than the applicable standard *
- Wetland extent
- Spill areas

* Analyzedfor heavy metals, total nitrogen, nitrate, nitrite, ammonia, fecal coliforms, and E. coli.

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FIGURE 4-5: SOIL SAMPLE RESULTS

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Table 4-11
Concentrations of parameters that exceeded standards and *E.coli* and fecal coliform results in soil

Parameter	Concentration at Sample Location											CSR Standards (most stringent)[1]
	RTF-NAR-SB1	RTF-P-S1	RTF-P-S2	RTF-P-S3	RTF-P-SB1	RTF-P-SB2	RTF-W-S1W	RTF-W-S3E	RTF-W-S4W	RTF-W-S6E	RTF-W-S6W	
Number of Sampling Events	1	2	2	2	1	1	1	1	1	1	1	-
Dates Sampled (2020)	Oct 21	Oct 21 and Nov 18	Oct 21 and Nov 18	Oct 21 and Nov 18	Oct 21	Oct 21	Oct 21	Oct 21	Oct 21	Oct 22	Oct 22	-
Barium (µg/g)	22.4	25.4	18.6	21.4	18.6	21.6	34.9	117	369	192	144	350
Chromium (µg/g)	49.9	77.5	93.4	76.0	62.3	70.4	56.7	38.0	29.4	26.4	37.0	60
Iron (µg/g)	36800	38800	35800	39000	36100	38100	26200	35800	25000	36700	37200	35000
Manganese (µg/g)	581	669	631	712	608	675	774	1020	5160	2120	1540	2000
Selenium (µg/g)	<0.20	<0.20	<0.20	<0.20	<0.20	0.22	2.43	<0.20	0.32	<0.20	0.26	1
Vanadium (µg/g)	94.0	113	96.0	113	84.7	99.7	77.9	103	61.4	96.1	102	100
Zinc (µg/g)	66.9	54.9	54.4	59.9	55.4	59.3	49.1	74.2	182	74.8	88.1	150-350[3]
E.coli and Fecal Coliform Results												
E. coli (MPN/g)[4]	3	>1740->1670	1710-231	>1750-372	14	8	<2	4	80	44	37	NS
Fecal Coliforms (MPN/g)[4]	8	>1740->1670	>1710-231	>1750-372	14	8	2	4	80	44	37	NS

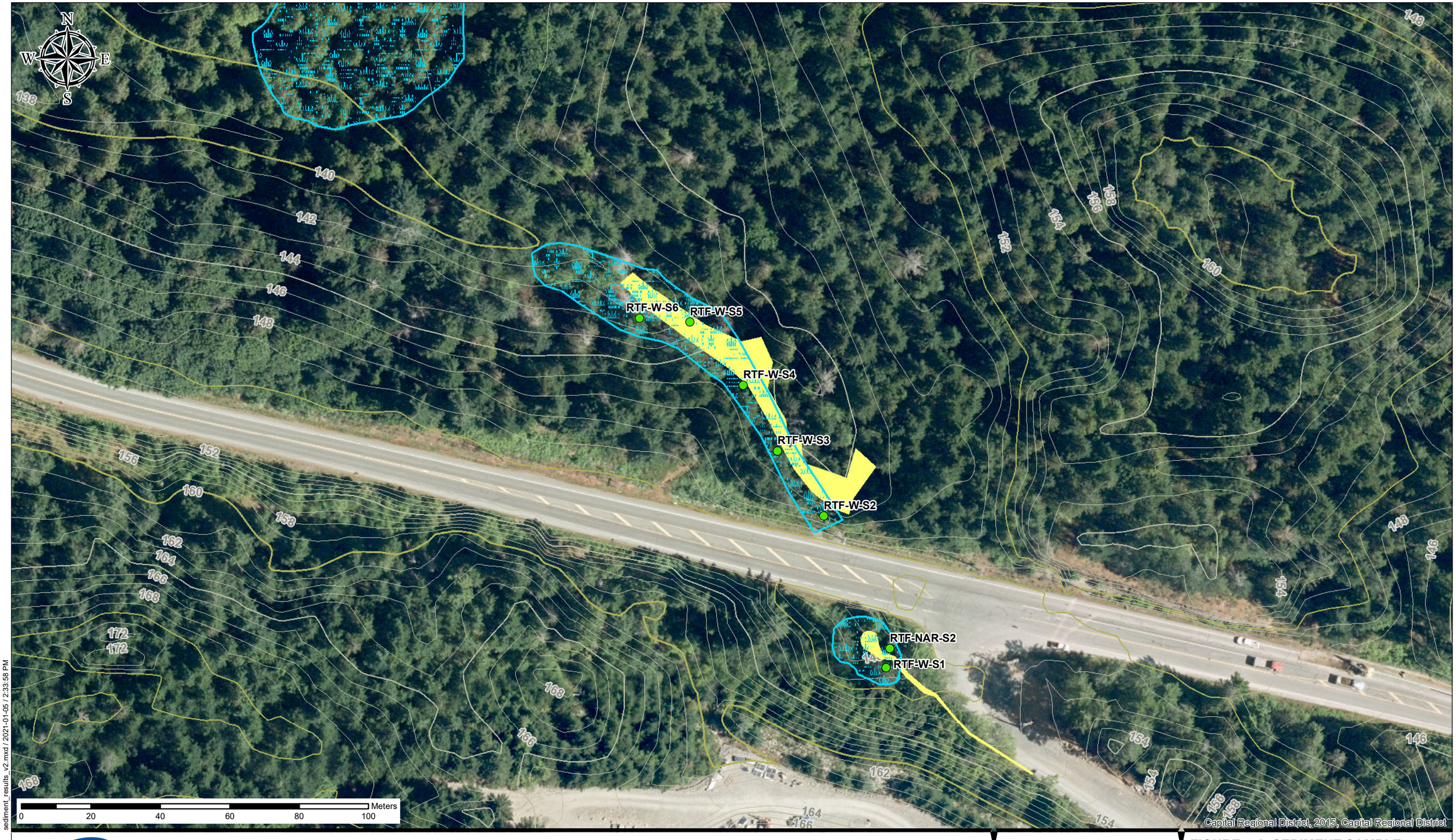
Notes: Table shows the range of values measured between October 21 and November 18, 2020 for any parameter that exceeded standards in at least one sample. All results, tabulated and compared to guidelines, are shown in Appendix D.
Bolded values indicate an exceedance of the applicable guidelines or standards.
[1]Applicable CSR standards include Industrial Land Use and Urban Park Land Use.
[2]Metals were only sampled during the October sampling event
[3]Standard varies by pH; 150 µg/g if pH < 6.0; 250 µg/g if 6.0 ≤ pH < 6.5; 350 µg/g if 6.5 ≤ pH < 7.0.
[4] Presented as October-November results, as relevant.
NS = No standard

4.3.4 Sediment

Initial results from sediment sample locations in the wetted areas had exceedances for copper and zinc at two locations (Table 4-11; Figure 4-8). Based on the initial analyses, there does not appear to be elevated ammonia, nitrate or metals concentrations associated with the elevated microbials; therefore, *E. coli* appears to be the best indicator for the presence of residual solids in the sediment, so is discussed below in spite of the fact that concentrations do not exceed guidelines.

E. coli and fecal coliform counts in the sediment samples increased at four of the seven sample sites between the October 21 and November 18. However, results from the December sampling event show a decrease in *E. coli* and fecal coliforms at five of the seven locations. Slight increases were observed in RTF-W-S3 and RTF-W-S4. All locations still have presence of both *E. coli* and fecal coliforms that are greater than outside of the spill pathway (Table 4-11), indicating the residual solids-impacted sediment are still present in the wetted areas.

Concentrations of copper and zinc were above BC CSR standards in the October sample from RTF-W-S4 and both the October and December samples in RTF-W-S2, respectively. The average copper concentration in all the sediment samples was 72 mg/kg, below the 120 mg/kg CSR standard. The average concentration of zinc in the 13 samples was 144 mg/kg, also below the 200 mg/kg CSR standard, and the zinc concentrations may be affected because of the galvanized metal culvert adjacent and upstream to RTF-W-S2 (metals culverts typically have a zinc coating). While copper results have decreased from the October sampling events, zinc results have increased, but are consistently lower than the levels found in the soil samples outside of the spill pathway, which is assumed to a result of being adjacent to the galvanized culvert, a source of zinc.



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Associated Environmental

- Sediment sample - concentrations less than or equal to the applicable standard *
- Sediment sample - concentrations greater than the applicable standard *
- Wetland extent
- Spill areas

* Analyzed for heavy metals, total nitrogen, nitrate, nitrite, ammonia, fecal coliforms, and E. coli.

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FIGURE 4-6: SEDIMENT SAMPLE RESULTS

Maple Reinders Bird Joint Venture

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Table 4-12
Concentrations of parameters that exceeded standards in sediment and *E.coli* and fecal coliform results

Parameter	Concentration at Sample Location							CSR Sensitive Sediment Standards (SedSSS)
	RTF-NAR-S2	RTF-W-S1	RTF-W-S2	RTF-W-S3	RTF-W-S4	RTF-W-S5	RTF-W-S6	
Number of Sampling Events	3	3	3	3	3	3	3	-
Date Sampled (2020)	Oct 21, Nov 18, Dec 9	Oct 21, Nov 18, Dec 9	Oct 22, Nov 18, Dec 9	Oct 22, Nov 18, Dec 9	Oct 22, Nov 18, Dec 9	Oct 22, Nov 18, Dec 9	Oct 22, Nov 18, Dec 9	-
Arsenic (µg/g)[1]	5.60 5.53	5.94 12.9	9.93 9.32	8.23 6.40	5.66 6.39	6.44 1.28	10.7 1.42	11.0
Copper (µg/g)[1]	43.4 51.8	54.8 44.1	60.0 53.1	42.1 40.2	265 102	68.1 32.1	87.2 48.1	120
Zinc (µg/g)[1]	156 196	182 85.3	330 256	149 168	89.2 96.9	37.4 187	41.8 103	200
E.coli and Fecal Coliform Results								
E. coli (MPN/g)[2]	>2380, >2790, 375	>2630, 2710, 298	>2460, >3400, 1050	>2100, >2290, >2670	>2090, 349, 2740	>1960, 86, 15	167, 112, 3	NS
Fecal Coliforms (MPN/g)[2]	>2380, >2790 2520	>2630, 2710, 298	>2460, >4630, 1050	>2100, >2290, >2670	>2090, 349, >2740	>1960, 86, 38	167, 112, 5	NS

Notes:
Bolded values indicate an exceedance of the applicable standards.
[1] Metals were only tested during the October and December sampling event; therefore, only two values are shown.
[2] Presented as October (first number), November (second number) and December (third number) results.
NS= no standard

5 POTENTIAL ADVERSE EFFECTS

This section provides a discussion of the potential effects of the spill, updated from the previous Update to the Minister Report (Associated 2020). Typically, when adverse effects of a spill are assessed the source, pathway and receptors are evaluated. For the Site, the source of the potential adverse effect is any remaining microbial matter in the residuals solids that may be present in the soil and sediment after clean-up. The contaminant transport pathway would be groundwater and surface water flow, or direct contact with soil or sediment. Potential receptors include human (water consumption and direct contact) and ecological (aquatic and wildlife). Potential adverse effects of residual microbial matter from the residual solids that may be present are discussed below. Overall, based on sampling results the potential adverse effects from the spill relative to human and ecological receptors are specific to microbiological factors, specifically *E.coli* and fecal coliforms.

A combination of abiotic (i.e., availability of energy and nutrient sources, pH, moisture, and temperature) and biotic (i.e., indigenous microflora, including protozoa) factors determine *E. coli* population survival rates in open environments. Extreme or fluctuating values of these variables stress the bacterial cells, leading to different survival times ranging from one day to one year (van Elsas et al. 2011). It has been found that some *E. coli* colonies can survive in excrement for up to 21 months, but individual bacteria usually survive 24 hrs to 40 days (Kudva et al. 1998). Hence, the Site conditions will influence *E. coli* survivability in the spill pathway. In general, the cool winter conditions and the lack of warm-blooded hosts are not favorable for their survival, which correlates to a slowly decreasing concentration in the spill pathway.

5.1 Spill Area 1

In Spill Area 1, the RTF site soil was the receiving and sampled media. Initial sample results showed *E. coli* and fecal coliform levels above 1,800 MPN/g, but these decreased between sampling events. No parameters in the soils exceeded BC CSR standards, except for some metals, the concentrations of which were similar to un-affected areas or natural background[7]. However, soil samples were only collected to a depth of 0.5 m below grade, and *E. coli* and fecal coliform may be present below this depth. The possible presence of residual contamination in the soil below a depth of 0.5 m may act as an ongoing source of microbial contamination of the groundwater and surface water. Based on the topography of the ground surface and the bedrock, shallow groundwater is anticipated to flow towards the north and a seepage discharge at sample location RTF-NAR-W1 (Figure 4-2). Prior to identifying and sampling the seepage at RTF-NAR-W1, there was a plan to install a groundwater well at the north end of the RTF to monitor potential subsurface flow from the spill location to the north. However, the sample location RTF-NAR-W1 is considered representative of shallow groundwater flow from Spill Area 1. Results from RTF-NAR-W1 are within standards and guidelines; however, this site will be sampled monthly during January and February 2021 (at a minimum) to confirm no migration of spill material over time. Based on the seepage being representative of shallow flow to the north, and results within standards and guidelines, the installation of groundwater monitoring wells at the north end of the RTF is not deemed necessary at this time.

In Spill Area 1, the source of contaminants was reduced through hydro-vac clean-up efforts, and potential receptors are from direct human contact with the residual contaminated soil. Because it is a managed industrial site requiring check-in and safety adherence by all personnel, the risk of human contact with residual contaminated soil is very low. A potential transport pathway of bacteria in shallow groundwater from this area to the north, offsite, has not been demonstrated but will continue to be monitored.

[7] A formal background determination was not completed under BC CSR Protocol 4.

5.2 Spill Area 2

In Spill Area 2, the north access road, soil, sediment, surface water and groundwater were the receiving and sampled media. Most recent soil and surface water results are within all standards and guidelines. This includes a seepage from the ground in the bank north of the RTF (RTF-NAR-W1), as discussed in Section 5.1. In the spill pathway, sediments show *E. coli* and fecal coliforms concentrations that are higher than concentrations found outside of the spill pathway but show an average decline over two sampling events. All other sample media do not show exceedances or levels higher than those found outside of the spill pathway.

In Spill Area 2, the source of contaminants was reduced through hydro-vac clean-up efforts, and aquatic life is the primary receptor because wetted sediment is the main exposure pathway. Aquatic life includes invertebrates and amphibians potentially burrowing in sediment in the ditch along the north access road, and in the small wetland south of Willis Point Road (see figures). There are not guidelines specific to invertebrates or amphibians and microbiological contamination, and no indication that the level of bacteria present that are decreasing over time (source) would have an adverse effect on either of these receptors.

5.3 Spill Area 3

In Spill Area 3, the terminal swamp wetland, soil, sediment, groundwater and surface water were the receiving and sampled media. The sediment results were within standards for metals except for a copper exceedance in RTF-W-S4 on the November 18th, 2020 sampling event, and zinc exceedance during both sampling events are RTF-W-S2 (this is potentially an effect from the galvanized steel culvert, directly adjacent and upstream). In the most recent sampling event on December 9th, 2020 sediment samples (in the wetted area) at four of the six the sampling locations have shown a decrease in *E. coli* and fecal coliform concentrations since the October sampling event (represented graphically in Figures 5-1 and 5-2). The average *E. coli* and fecal concentration for all sediment sampling locations decreased from October to December, and this decrease in concentration of *E. coli* is expected to continue over time. At two location there was an increase. This variability in results demonstrates that some residual solids are still present in the sediment. Sediment sampling locations will continue to be monitored. Groundwater and surface water samples do not show bacteria concentrations associated with the spill material.

In Spill Area 3, the source of contaminants was reduced through hydro-vac clean-up efforts, and aquatic life is the primary receptor because wetted sediment is the main exposure pathway. Dogs swimming in the wetland and having extensive contact with the sediment below the water is not considered an operable exposure pathway. As stated, there are not guidelines specific to invertebrates or amphibians and microbiological contamination, and no indication that the level of bacteria present that is decreasing over time (source) would have an adverse effect on either of these receptors.

Outside of the spill flow path, no exceedances have been recorded that can be correlated to the spill. Based on the analytical results, the spill material was contained in the wetland, likely because of the berm at the north end of the wetland blocking surface flow, and the spill response reduced the volume of material in the environment.

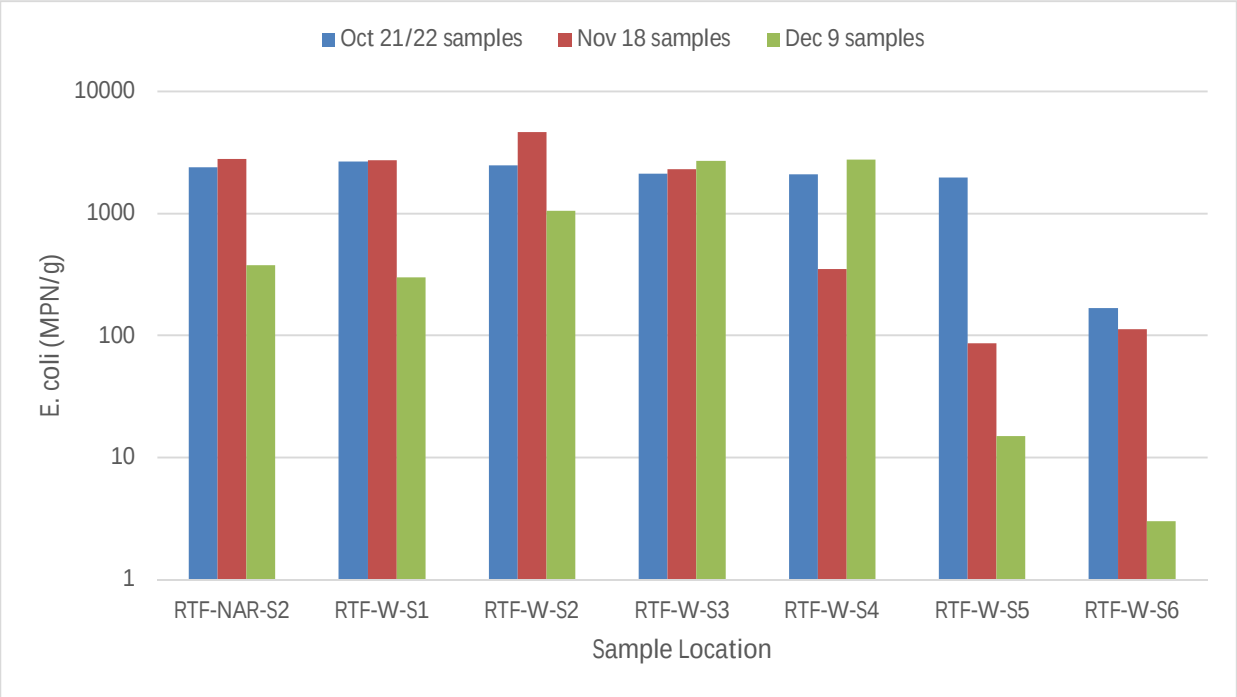


Figure 5-1
E. coli concentrations for all sediment sampling events

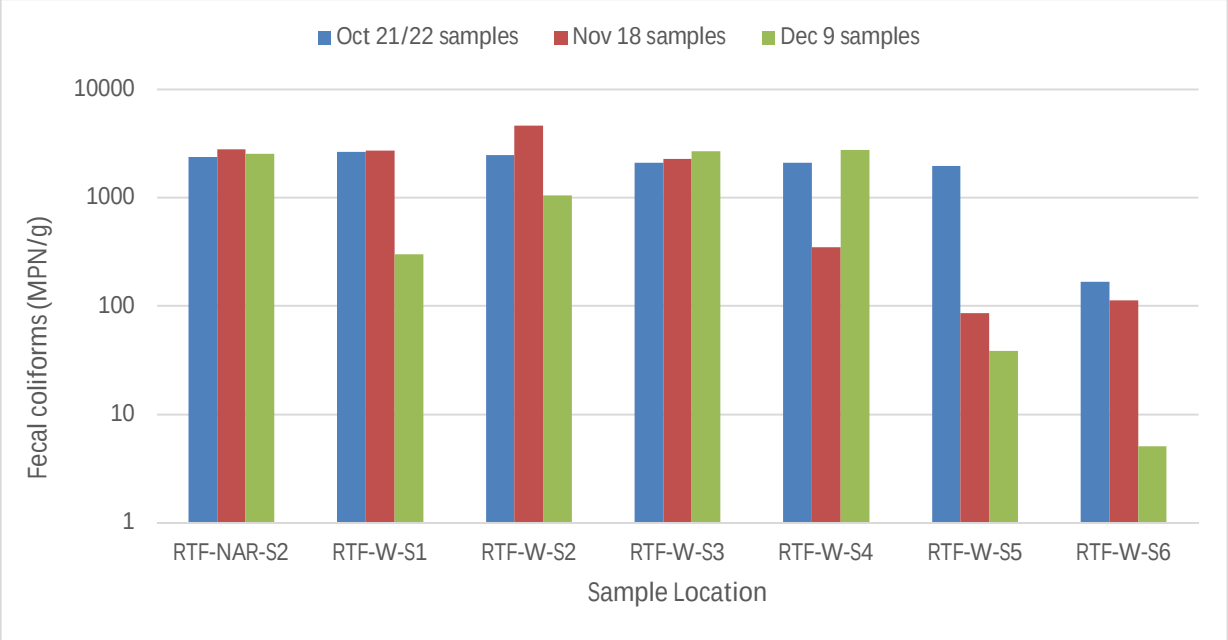


Figure 5-2
Fecal coliform concentrations for all sediment sampling events

5.4 Qualitative Summary of Potential Adverse Effects

Overall, the most notable effects from the soil and sediment sample results in the spill pathway indicate that *E. coli* and fecal coliform concentrations are higher than would be typical (e.g. over 10 MPN/g) but are generally decreasing. The residual solids from the spill have not left the spill pathway through ground or surface water; therefore, effects are limited to Spill Areas 1, 2 and 3 (Figure 2-1). The presence of these bacteria in soil and sediment at levels detected are considered a residual effect from the spill. Table 5-1 provides a qualitative summary of potential adverse effects using BC Environmental Assessment Office criteria, typical of an effects assessment, with *E. coli* and fecal coliform ("bacteria") as the primary contaminants of concern. As demonstrated in the reasoning provided below, the potential adverse effects and corresponding residual effects are considered low now and long-term.

Table 5-1
Qualitative summary of potential adverse effects

Criteria	Description	Result and Reasoning
Extent	The geographic spatial scale (e.g. local, regional, landscape)	Local: Spill extent is 923 m^2.
Magnitude	Severity relative to contaminants, pathways and potential receptors	Low: Limited to bacteria in the spill pathway, specifically in the sediment and standing water, which is an effects pathway to aquatic life (invertebrates and amphibians burrowed in the sediment).
Duration	Length of time the effect may persist	Short: The cool winter temperatures and absence of available warm-blooded hosts for *E.coli* colonies to grow will likely continue to result in reduction in bacteria concentrations. A return to normal levels is anticipated over the next 3 to 6 months.
Frequency	How often the adverse effect will occur	One time: There is no additional spill material entering the environment.
Reversibility	If adverse effects can be reversed	Reversible: Bacteria are now limited to the soil and sediment locations and average concentrations are decreasing overtime.
Context	An industrial site and wetland in a public park	Resilient: The industrial area of the Site is not open to the public and is managed proactively for contamination following their Operational Certificate (#109471) and Environmental Management Plan during construction. The wetland in Mount Work Regional Park is contained by a berm and subject to light recreational use (e.g. biking and hiking), with no other foreseeable contaminant source.

Source: BC EAO 2013

As detailed in Table 5-1, residual bacteria detected is not anticipated to have a persistent adverse effect on groundwater or surface water quality and will continue to decrease in concentration in sediment and soil in the spill pathway. Also, wetlands function to filter water naturally, including municipal wastewater, and are routinely constructed for this purpose. Physical, chemical, and biological processes combine in wetlands to remove contaminants from wastewater (Brix and Schierup 1989). The receiving wetland has functioned to contain the spill material, and ongoing monitoring will be to confirm the decrease overtime of bacteria parameters and no migration.

6 MONITORING PLAN

Monitoring will continue to assess whether adverse effects on the environment persist, i.e. any exceedances to guidelines that can be attributed to the spill. Sampling will include surface water, groundwater (shallow and bedrock), soil and sediment, as described in Sections 6.1 to 6.5 and summarized in Table 6-1. Sampling locations are shown in Figure 6-1. In general, monitoring will continue at the Site until two consecutive samples show results within guidelines and standards, and/or microbiological parameters are similar to background (in a qualitative analysis).

6.1 Surface Water

The south end of Durrance Lake, where surface flow enters from the potential spill pathway, has had no exceedances to date, but will continue to be monitored monthly. The seepage at the north end of the RTF will also be sampled again (RTF-NAR-W1, Figure 6-1), to confirm that spill material from the Site is not migrating downslope.

6.2 Groundwater

The existing groundwater monitoring wells are in bedrock, sampling deep groundwater in the aquifers. These will continue to be sampled by the Hartland Landfill staff, with the addition of microbial parameters to the analysis as necessary.

Drive-point piezometers have been installed around the north end of the wetland, north of Spill Area 3 (Figure 6-1). These will monitor the shallow groundwater around the Site. They will be sampled monthly until two consecutive results are below standards, and/or microbiological parameters are similar to background (in a qualitative analysis).

6.3 Soil

Soil sample results only show exceedances for metals, but they are comparable to natural anomalies and background, based on sampled taken outside of affected areas. Quarterly sampling of select locations are proposed until the results demonstrate that the microbiological input from the residual solids spill is no longer present (i.e. a qualitative comparison to background).

6.4 Sediment

The sediment locations with *E.coli* and fecal >1000 MPN/g will be sampled again (Figure 6-1), until the results demonstrate that the microbiological input from the residual solids spill is no longer present (i.e. a qualitative comparison to background).

6.5 Wetland

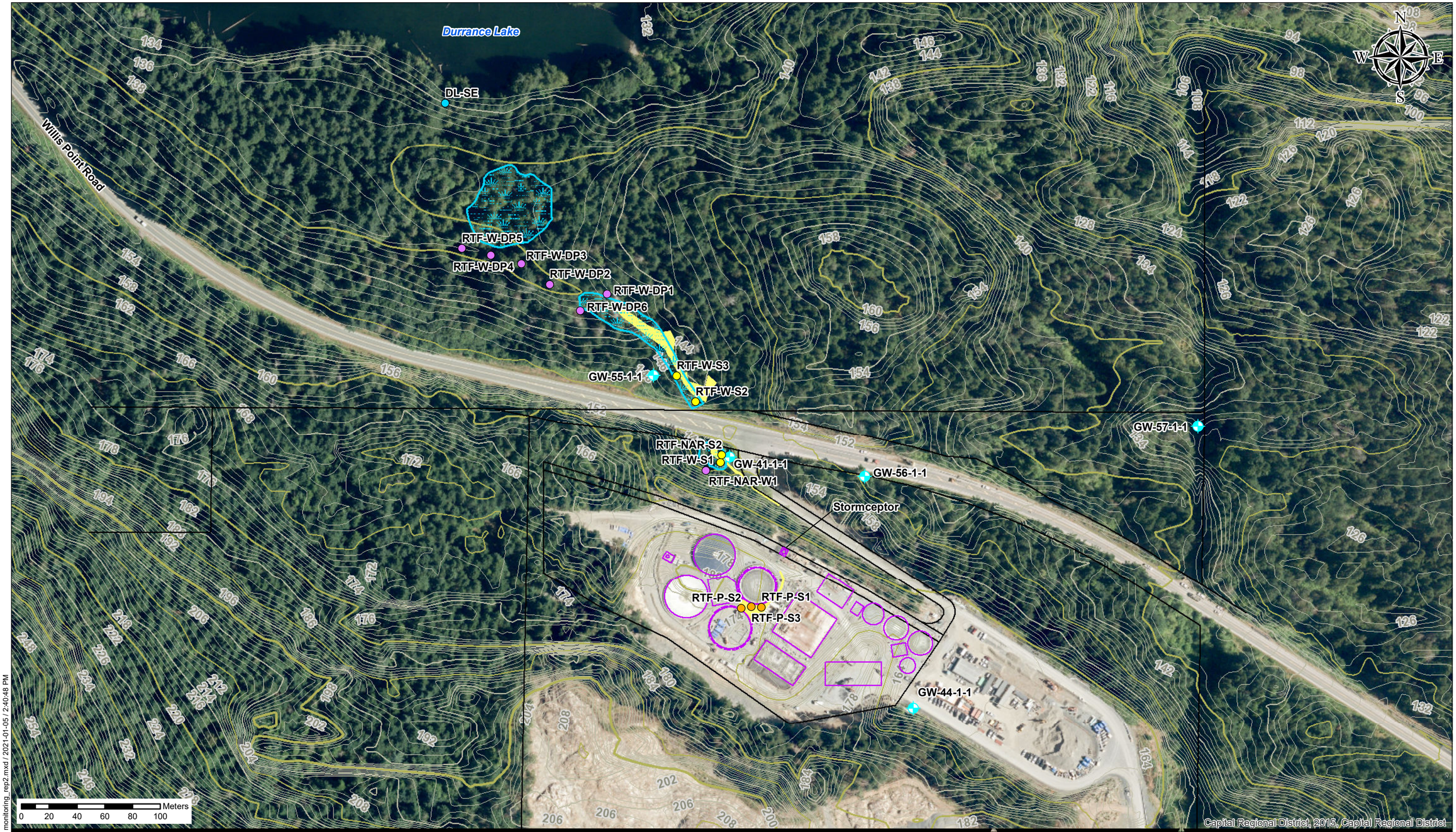
In the wetland area, a Pacific Tree Frog (*Hyla regilla*) chorus was heard on the wetland margins in October, suggesting that this species overwinters and likely uses the wetland for annual breeding. Therefore, amphibian monitoring will be completed in spring 2021. Surveys will be used to confirm breeding and juvenile development are not being impaired. These will include auditory surveys and monitoring amphibian egg masses development until successful hatching. In addition, Corvidae will monitor for the introduction of any invasive species to the Site and will direct their removal as warranted.

Sampling results will be summarised in reporting provided to the ENV Land and Remediation Branch, frequency to be determined, but assuming quarterly.

Table 6-1
Monitoring plan summary

Sample Media	Location[1]	Parameters for Analysis	Frequency	Duration
Surface Water	Durrance Lake (DL-SE) RTF-1-WRPO and RTF-2-WPRO	• Microbiological (*E. coli*, fecal coliforms and total coliforms) • Total and dissolved metals • Ammonia-N, nitrite-N, nitrate-N, TKN, organic nitrogen, and total nitrogen • Total phosphorus (P), total dissolved P, ortho-P • Anions (chloride, bromide, fluoride, sulphate) • Alkalinity • Total dissolved solids • Biological Oxygen Demand (5-day)	Monthly	6 months TBD
Groundwater (in bedrock)[2]	57-1-1, 56-1-1, 55-1-1, 44-1-1, and 41-1-1	Current analysis plus microbiological (*E. coli* and fecal coliforms)	Quarterly	During RTF operations
Groundwater (shallow; dry piezometers)	RTF-W-DP1 to DP5, and RTF-NAR-W1,	Same as DL-SE	Monthly	TBD
Soil	RTF-P-S1, S2 and S3; additional sites TBD	Heavy metals, total nitrogen, nitrate, nitrite, ammonia, fecal coliforms, and *E. coli*	Quarterly	TBD
Sediment	RTF-W-S1 to S6, RTF-NAR-S2	Heavy metals, total nitrogen, nitrate, nitrite, ammonia, fecal coliforms, and *E. coli*	Quarterly	TBD

Notes: TBD – to be determined based on two consecutive sampling results within guidelines and standards.
[1] See Figure 6-1 for sample locations.
[2] Hartland Landfill monitoring wells that are sampled by the CRD Hartland Landfill staff quarterly.



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Associated Environmental

- Water sample
- Shallow groundwater
- Soil sample
- Sediment sample
- Monitoring well
- Spill areas
- Wetland extent

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FIGURE 6-1: MONITORING SAMPLE LOCATIONS

Maple Reinders Bird Joint Venture

CRD Residual Treatment Facility Spill

7 TEMPORARY ROAD RESTORATION

The MRBJV has conducted restoration efforts beyond the spill response to ensure that the area within Mount Work Regional Park affected by spill response efforts (i.e., hydro-vac access trails) are rehabilitated to their previous state. Initial restoration has been completed, with additional efforts taken based on how well the Site naturally regenerates over the next year. Additional effort will focus on invasive species management, revegetation of trails, and rehabilitation of the access road where it is not required for long-term use.

7.1 Invasive Species Management

Invasive species are likely to move into the areas disturbed by the spill response effort, if not properly managed. Any tools, equipment or vehicles used in the spill area were confirmed as clean before entering the site. In the future, clothing, boots and gear that may retain invasive plant material should also be cleaned before entering the site. These measures will help prevent the introduction and spread of invasive species from other areas.

Additionally, invasive species observed on site should be removed to prevent further spread. Invasive plants should be removed using mechanical controls such as hand pulling and bagged before disposal (if the plant has already gone to seed). Bio-controls such as herbicides can be used in addition to mechanical controls to prevent the further spread of invasive species. As stated in Section 6, the Site will be monitored by Corvidae in spring 2021, and any new invasive plant species removed.

7.2 Revegetation and Trail Impacts

Temporary access trails into the Site and paths where hoses were laid have been decommissioned to discourage use by the public. Logs and wood debris will be moved on to the trampled areas, to block and cover them from view. The trails will then be allowed to revegetate naturally, and if in the spring they are not revegetating, enhancement planting will be required.

If the trails do not revegetate naturally by spring, MRBJV will plant native species in the area to encourage revegetation.

7.3 Rehabilitation of Temporary Road

The temporary access road was previously a vegetated access road and used for accessing groundwater well 55-1-1 near the wetland. Additional material (e.g., timber and road base gravel) was brought in to ensure the hydro-vac trucks would not get stuck or be working on unstable ground. The road has been restored to its previous condition and cleared for access to the groundwater well.

8 SUMMARY

The spill of 100 m^3 of untreated, partially dewatered residual solids originated at the RTF, where a temporary pipe ruptured. Residual solids flowed into a catch basin and then into the stormwater system. The spill then flowed into a ditch along the RTF's north access road, passing through a culvert underneath Willis Point Road, and terminating in a wetland area in the CRD's Mount Work Park, approximately 265 m from where it originated. Surface flow from the wetland is impeded by a berm at its north end, which acts to contain water in the wetted area with no visible surface

connection to other waterbodies. Spill clean-up with hydro-vac trucks commenced immediately and continued for 13 days to remove residuals solids from the spill pathway.

Results from extensive surface water, bedrock and shallow groundwater, soil and sediment sampling to determine potential adverse effects in and around the spill areas demonstrate a low risk to ecological and human health from the spill. This conclusion is based on sample results contrasted to the appropriate BC CSR standards and, as a second benchmark, the BC Approved and Working WQG. The standards have been created to protect human health and the environment, and are based on defendable, scientifically based standards specific to exposure pathways and risk. The data demonstrate that all sample sites from most recent sample events are within BC CSR standards, or if metals are in exceedance, they are qualitatively comparable to background. Only bacteria (*E. coli* and fecal coliform) levels relative to BC Water Quality Guidelines have been exceeded or, when there are no guidelines, are higher than found outside of the spill pathway. Initial sampling results show a fraction of the *E. coli* and fecal coliform concentration in the environment relative to those found in residual entering the facility (approximately 0.01% bacteria concentrations relative to typical residual concentrations), and ongoing sample results show an overall decrease in bacteria concentrations overtime in the spill pathway. Sampling results also demonstrate containment of the spill material in the wetland, with no evidence of material migration to other waterbodies, including Durrance Lake or the wetland between Durrance Lake and the affected wetland. In summary, the receiving wetland is functioning to contain the spill material, and contaminants from the spill are limited to bacteria in the soil and sediment, which are naturally decreasing. There is no evidence of additional residual solids entering the environment from the RTF.

Based on BC CSR regulation, the Site is not contaminated. Specific to bacterial contamination, the low adverse effects are due to immediate action to clean-up with hydro-vac trucks that removed as much residual solids as possible, containment of the spill material in the terminal swamp wetland, and the spill being a one-time event. As a qualitative assessment, the current and long-term adverse effects are low because they are:

- Localized in extent, with no pathway to sensitive receptors such as drinking water or recreational water sources that could interface with humans;
- Low in magnitude, limited to bacteria persisting in soil and sediment in the spill pathway, resulting in a limited effects pathway to aquatic life potentially burrowing in the sediment;
- Short in duration, with conditions that do not support sustained bacteria concentrations and a general decrease in *E.*coli and fecal coliforms overtime;
- Limited in frequency, a one-time event; and
- Reversible through clean-up, natural wetland containment and natural environmental processes.

Based on analytical results, no additional remediation efforts are recommended. However, a monitoring plan has been developed, with the objective of continuing to assess the potential for adverse effects from spill. Amphibian surveys will be completed during spring and summer 2021 to confirm continued use of the wetland during different life stages.

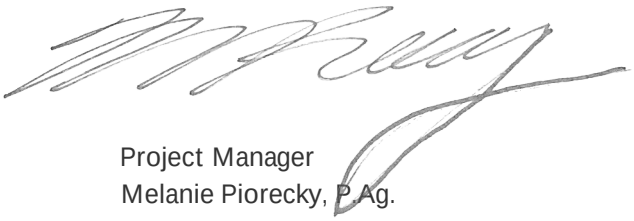
Results of ongoing sampling analysis will be summarized in quarterly reporting to the ENV.

CLOSURE

This report was prepared for the Environmental Emergencies and Land Remediation Branch to provide an update of the spill, monitoring and next steps at the CRD RTF.

The services provided by Associated Environmental Consultants Inc. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,
Associated Environmental Consultants Inc.



Project Manager
Melanie Piorecky, P.Ag.

See Declaration of Compentancy
Project Advisory
Gary Hamilton, P.Geo., CSAP

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APPENDIX A – DETAILED ANALYSIS OF RESIDUAL ENTERING THE RTF

Analytical Results

Sub-Matrix: **Sanitary Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID	RTF-P-SLI	-----	-----	-----	-----
					Client sampling date / time	30-Nov-2020 12:45	---	---	---	---
					VA20C2170-001	--------	--------	--------	--------	--------
					Result	---	---	---	---	---
Physical Tests										
hardness (as CaCO3), from total Ca/Mg	---	EC100A	0.60	mg/L		854	---	---	---	---
hardness (as CaCO3), dissolved	---	EC100	0.60	mg/L		297	---	---	---	---
Anions and Nutrients										
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L		111	---	---	---	---
bromide	24959-67-9	E235.Br-L	0.050	mg/L		<1.00 DLDS	---	---	---	---
chloride	16887-00-6	E235.Cl	0.50	mg/L		180	---	---	---	---
fluoride	16984-48-8	E235.F	0.020	mg/L		<0.400 DLDS	---	---	---	---
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L		<0.100 DLDS	---	---	---	---
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L		0.0676	---	---	---	---
nitrogen, total	7727-37-9	E366	0.030	mg/L		11600	---	---	---	---
nitrogen, total organic	---	EC363	0.050	mg/L		758	---	---	---	---
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L		91.8	---	---	---	---
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L		280	---	---	---	---
phosphorus, total dissolved	7723-14-0	E375-T	0.0020	mg/L		97.3	---	---	---	---
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L		<6.00 DLDS	---	---	---	---
Kjeldahl nitrogen, total [TKN]	---	E318	0.200	mg/L		869	---	---	---	---
Bacteriological Tests										
coliforms, Escherichia coli [E. coli]	---	E010.EC	1	MPN/100mL		41100000	---	---	---	---
coliforms, thermotolerant [fecal]	---	E010.FC	1	MPN/100mL		72700000	---	---	---	---
Total Metals										
aluminum, total	7429-90-5	E420	0.0030	mg/L		18.7	---	---	---	---
antimony, total	7440-36-0	E420	0.00010	mg/L		0.00387	---	---	---	---
arsenic, total	7440-38-2	E420	0.00010	mg/L		0.0228	---	---	---	---
barium, total	7440-39-3	E420	0.00010	mg/L		1.71	---	---	---	---
beryllium, total	7440-41-7	E420	0.000100	mg/L		0.000594	---	---	---	---
bismuth, total	7440-69-9	E420	0.000050	mg/L		0.111	---	---	---	---
boron, total	7440-42-8	E420	0.010	mg/L		0.251	---	---	---	---
cadmium, total	7440-43-9	E420	0.0000050	mg/L		0.00997	---	---	---	---
calcium, total	7440-70-2	E420	0.050	mg/L		263	---	---	---	---
cesium, total	7440-46-2	E420	0.000010	mg/L		0.000635	---	---	---	---

Analytical Results

Sub-Matrix: Sanitary Water (Matrix: Water)					Client sample ID	RTF-P-SLI	----	----	----	----
					Client sampling date / time	30-Nov-2020 12:45	---	---	---	---
Analyte	CAS Number	Method	LOR	Unit		VA20C2170-001	--------	--------	--------	--------
						Result	---	---	---	---
Total Metals										
chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L		0.0906	---	---	---	---
cobalt, total	7440-48-4	E420	0.00010	mg/L		0.0248	---	---	---	---
copper, total	7440-50-8	E420	0.00050	mg/L		5.19	---	---	---	---
iron, total	7439-89-6	E420	0.010	mg/L		316	---	---	---	---
lead, total	7439-92-1	E420	0.000050	mg/L		0.214	---	---	---	---
lithium, total	7439-93-2	E420	0.0010	mg/L		0.0140	---	---	---	---
magnesium, total	7439-95-4	E420	0.0050	mg/L		48.2	---	---	---	---
manganese, total	7439-96-5	E420	0.00010	mg/L		2.69	---	---	---	---
mercury, total	7439-97-6	E508	0.0000050	mg/L		0.00156	---	---	---	---
molybdenum, total	7439-98-7	E420	0.000050	mg/L		0.0198	---	---	---	---
nickel, total	7440-02-0	E420	0.00050	mg/L		0.0869	---	---	---	---
phosphorus, total	7723-14-0	E420	0.050	mg/L		225	---	---	---	---
potassium, total	7440-09-7	E420	0.050	mg/L		81.7	---	---	---	---
rubidium, total	7440-17-7	E420	0.00020	mg/L		0.0556	---	---	---	---
selenium, total	7782-49-2	E420	0.000050	mg/L		0.0172	---	---	---	---
silicon, total	7440-21-3	E420	0.10	mg/L		25.4	---	---	---	---
silver, total	7440-22-4	E420	0.000010	mg/L		0.00711	---	---	---	---
sodium, total	17341-25-2	E420	0.050	mg/L		45.8	---	---	---	---
strontium, total	7440-24-6	E420	0.00020	mg/L		1.52	---	---	---	---
sulfur, total	7704-34-9	E420	0.50	mg/L		55.0	---	---	---	---
tellurium, total	13494-80-9	E420	0.00020	mg/L		<0.00040 DLA	---	---	---	---
thallium, total	7440-28-0	E420	0.000010	mg/L		0.000346	---	---	---	---
thorium, total	7440-29-1	E420	0.00010	mg/L		0.00067	---	---	---	---
tin, total	7440-31-5	E420	0.00010	mg/L		0.00866	---	---	---	---
titanium, total	7440-32-6	E420	0.00030	mg/L		0.127	---	---	---	---
tungsten, total	7440-33-7	E420	0.00010	mg/L		0.00261	---	---	---	---
uranium, total	7440-61-1	E420	0.000010	mg/L		0.00265	---	---	---	---
vanadium, total	7440-62-2	E420	0.00050	mg/L		0.0886	---	---	---	---
zinc, total	7440-66-6	E420	0.0030	mg/L		5.37	---	---	---	---
zirconium, total	7440-67-7	E420	0.00020	mg/L		0.00574	---	---	---	---
Dissolved Metals										

Analytical Results

Sub-Matrix: **Sanitary Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID	RTF-P-SLI	----	----	----	----
					Client sampling date / time	30-Nov-2020 12:45	---	---	---	---
						VA20C2170-001	--------	--------	--------	--------
						Result	---	---	---	---
Dissolved Metals										
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L		0.221	---	---	---	---
antimony, dissolved	7440-36-0	E421	0.00010	mg/L		0.00037	---	---	---	---
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L		0.00303	---	---	---	---
barium, dissolved	7440-39-3	E421	0.00010	mg/L		0.0154	---	---	---	---
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L		<0.000200 DLA	---	---	---	---
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L		0.00136	---	---	---	---
boron, dissolved	7440-42-8	E421	0.010	mg/L		0.199	---	---	---	---
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L		0.0000663	---	---	---	---
calcium, dissolved	7440-70-2	E421	0.050	mg/L		79.7	---	---	---	---
cesium, dissolved	7440-46-2	E421	0.000010	mg/L		0.000168	---	---	---	---
chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L		0.00308	---	---	---	---
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L		0.00250	---	---	---	---
copper, dissolved	7440-50-8	E421	0.00020	mg/L		0.115	---	---	---	---
iron, dissolved	7439-89-6	E421	0.010	mg/L		78.3	---	---	---	---
lead, dissolved	7439-92-1	E421	0.000050	mg/L		0.00212	---	---	---	---
lithium, dissolved	7439-93-2	E421	0.0010	mg/L		0.0026	---	---	---	---
magnesium, dissolved	7439-95-4	E421	0.0050	mg/L		23.8	---	---	---	---
manganese, dissolved	7439-96-5	E421	0.00010	mg/L		0.748	---	---	---	---
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L		<0.0000100 DLM	---	---	---	---
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L		0.000921	---	---	---	---
nickel, dissolved	7440-02-0	E421	0.00050	mg/L		0.0120	---	---	---	---
phosphorus, dissolved	7723-14-0	E421	0.050	mg/L		75.8	---	---	---	---
potassium, dissolved	7440-09-7	E421	0.050	mg/L		55.6	---	---	---	---
rubidium, dissolved	7440-17-7	E421	0.00020	mg/L		0.0391	---	---	---	---
selenium, dissolved	7782-49-2	E421	0.000050	mg/L		0.00146	---	---	---	---
silicon, dissolved	7440-21-3	E421	0.050	mg/L		7.05	---	---	---	---
silver, dissolved	7440-22-4	E421	0.000010	mg/L		0.000129	---	---	---	---
sodium, dissolved	17341-25-2	E421	0.050	mg/L		45.3	---	---	---	---
strontium, dissolved	7440-24-6	E421	0.00020	mg/L		0.417	---	---	---	---
sulfur, dissolved	7704-34-9	E421	0.50	mg/L		6.58	---	---	---	---
tellurium, dissolved	13494-80-9	E421	0.00020	mg/L		<0.00040 DLA	---	---	---	---

Analytical Results

Sub-Matrix: **Sanitary Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID	RTF-P-SLI	----	----	----	----
					Client sampling date / time	30-Nov-2020 12:45	---	---	---	---
						VA20C2170-001	--------	--------	--------	--------
						Result	---	---	---	---
Dissolved Metals										
thallium, dissolved	7440-28-0	E421	0.000010	mg/L		<0.000020 DLA	---	---	---	---
thorium, dissolved	7440-29-1	E421	0.00010	mg/L		<0.00020 DLA	---	---	---	---
tin, dissolved	7440-31-5	E421	0.00010	mg/L		0.00167	---	---	---	---
titanium, dissolved	7440-32-6	E421	0.00030	mg/L		0.0330	---	---	---	---
tungsten, dissolved	7440-33-7	E421	0.00010	mg/L		<0.00020 DLA	---	---	---	---
uranium, dissolved	7440-61-1	E421	0.000010	mg/L		0.000182	---	---	---	---
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L		0.00116	---	---	---	---
zinc, dissolved	7440-66-6	E421	0.0010	mg/L		0.0394	---	---	---	---
zirconium, dissolved	7440-67-7	E421	0.00020	mg/L		0.00656	---	---	---	---
dissolved mercury filtration location	---	EP509	-	-		Laboratory	---	---	---	---
dissolved metals filtration location	---	EP421	-	-		Laboratory	---	---	---	---

Please refer to the General Comments section for an explanation of any qualifiers detected.

APPENDIX B - PHOTOS OF THE SITE

Photo 1: • Wetland before spill clean-up

Photo 2: • Wetland before spill clen-up

Photo 3:. • Spill pathway before spill clean-up

Photo 4: Spill pathway before spill clean-up

Photo 5: • **Spill pathway before spill clean-up**

Photo 6: • Spill pathway before spill clean-up

Photo 7:. • Spill pathway before spill clean-up

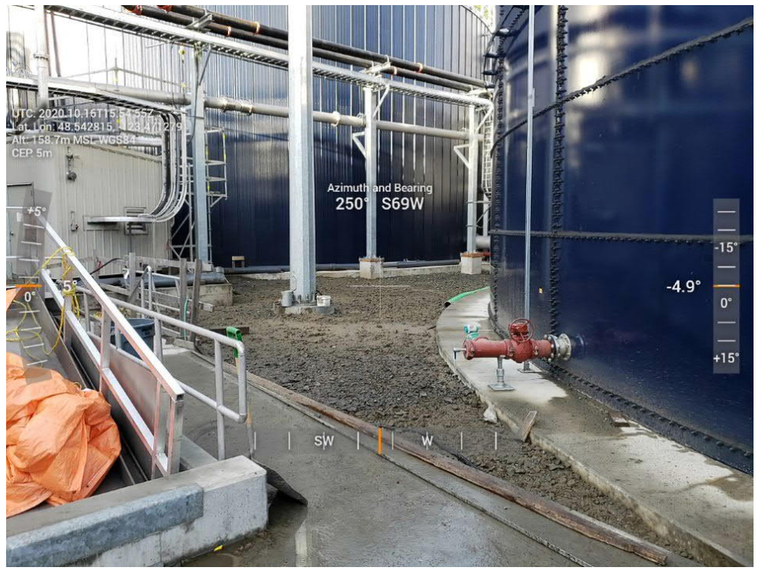

Photo 8: • Spill pathway before spill clean-up

Photo 9: • Wetland after spill clean-up

Photo 10 • Wetland after spill clean-up

Photo 11:. • Spill pathway after spill clean-up

Photo 12 • Spill Pathway after spill clean-up

Photo 13: • **Spill pathway after spill clean-up**

Photo 14 • Spill pathway after spill clean-up

Photo 15:. • Spill pathway after spill clean-up

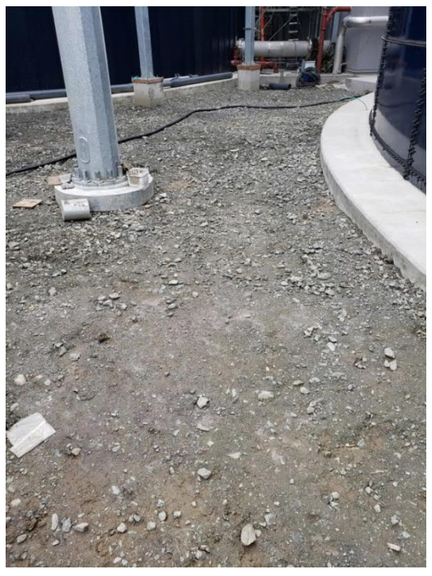

Photo 16 • Spill Pathway after spill clean-up

APPENDIX C – BC CSR DETAILED REASONING

Water

Aquatic Life (AW) Standards

As per Protocol 21 (ENV 2017), CSR Aquatic Life (AW) standards apply to all groundwater located within 500 m of an aquatic receiving body (freshwater and/or marine), unless it can be demonstrated that groundwater does not flow to that receiving body. Where the potential exists for contaminated groundwater to flow beyond 500 m of a receiving waterbody, or to flow within 500 m of an aquatic receiving body, such as a migrating contamination in bedrock or shallow groundwater, CSR AW standards also apply. The spill terminated in a surface waterbody; therefore, freshwater aquatic life (AW_F) standards apply to the Site.

Drinking Water (DW) Standards

An evaluation of current and future drinking water use is required to determine if Drinking Water (DW) standards are applicable to a site. If an aquifer is present beneath a site that is either currently being used, or could be used in the future, and there is no suitable confining unit to protect it (as define in Protocol 21; ENV 2017) from shallow groundwater contamination sources, then drinking water use applies to the shallow aquifer.

Future Use – Aquifer Hydraulic Properties

As per Protocol 21 (ENV 2017), if a suitable aquifer (i.e., hydraulic conductivity greater than $1x10^{-6}$ m/s and aquifer yield greater than 1.3 L/min) is present beneath a site, DW standards may apply and further evaluation is required. If not, DW standards do not apply. DW use does not apply to confined aquifers where the average saturated thickness is less than 1 metre, or to unconfined aquifers where the average saturated thickness is less than 2 metres as they are considered unlikely to provide sufficient yield. If an unconfined aquifer comprises only imported fill, or is present only seasonally, DW use does not apply to that aquifer. As there is an aquifer below the Site that is inferred to produce more than 1.3 L/min and there is no continuous confining unit, DW standards apply to the site based on hydraulic properties. See aquifer descriptions in Section 3.4.

Future Use – Aquifer Ambient Water Quality

The groundwater of an aquifer is considered unsuitable for domestic water supply by the BC ENV under Protocol 21 if the natural water quality is poor (i.e., total dissolved solids (TDS) concentration is greater than 4,000 mg/L) or the aquifer is contained within organic soils or muskeg (ENV 2017). DW standards would therefore not apply to that aquifer. For aquifers that are located within or below filled former marine or estuarine foreshore or are within 500 m of marine or estuarine foreshore and contain naturally occurring chloride and sodium concentrations greater than the DW standards, DW use does not apply. The groundwater of Aquifers 680 and 681 does not have a TDS concentration greater than 4,000 mg/L or meet the other elimination characteristics; therefore, DW standards apply to the Site (see aquifer descriptions in Section 3.4).

Irrigation (IW) and Livestock (LW) Standards

Irrigation (IW) standards are applicable to a site where the groundwater or surface water at or near the site (i.e., within 500 m of the site or the leading edge of a groundwater contamination source) is currently used for irrigation. The Site is currently not used for agricultural purposes; therefore, CSR LW standards do not apply. If groundwater flow direction has been demonstrated, nearby current uses of irrigation may be limited to include distances of 100 m upgradient and 500 m cross gradient and downgradient of the site or leading edge of a groundwater contamination source (ENV 2017). Furthermore, irrigation and livestock water wells and/or agricultural properties were not identified within 500 m of the Site. Surface water licence C060783 is for irrigation purposes, and surface water licence C060785 is intended for general land improvement; both are located on the east end of Durrance Lake, which is north of the contamination source. Irrigation water use means the use of water for the purpose of producing hay, forage crops,

pasture, cereal crops, vegetables and fruit. As surface water licence C060783 is not for the purpose of producing hay, forage crops, pasture, cereal crops, vegetables and fruit the CSR IW standards would not apply to the Site.

Soil

Soil standards are classified into eight categories based on the type of land use. Sites that contain substances in soil at concentrations greater than the standard for the land use applicable to the site are contaminated. The land use categories are as follows:

- Wildlands Natural (WLN)
- Wildlands Reverted (WLR)
- Agricultural Land Use (AL)
- Urban Park Land Use (PL)
- Residential Land Use Low Density (RLLD)
- Residential Land Use High Density (RLHD)
- Commercial Land Use (CL)
- Industrial Land Use (IL)

The CSR has two types of numerical standards for soil: matrix numerical standards (Schedule 3.1 Part 1); and generic numerical standards (Schedule 3.1 Parts 2 and 3). Matrix numerical standards are provided for certain substances in soil and are determined based on the evaluation of potential site-specific factors including the following:

- Human Health:
  - Intake of contaminated soil (applicable at all sites)
  - Groundwater used for drinking water
- Environmental Protection:
  - Toxicity to soil invertebrates and plants (applicable at all sites)
  - Livestock ingesting soil and fodder
  - Major microbial functional impairment
  - Groundwater flow to surface water used by aquatic life (freshwater and marine)
  - Groundwater used for livestock watering
  - Groundwater used for irrigation

Once the applicable site-specific soil matrix factors are determined, the lowest standard from those applicable factors is defined as the matrix numerical standard that will apply to the site. The area of the Site located within Mount Work Regional Park is currently used for recreational purposes; therefore, the CSR Urban Park Land Use (PL) soil standards apply to this area. The industrial land use soil standards apply to the plant site and the roadway.

Site-specific standards applicable to the Site are as follows:

- Human Health:
  - Intake of contaminated soil (applicable at all sites)
  - Groundwater used for drinking water
- Environmental Protection:
  - Toxicity to soil invertebrates and plants (applicable at all sites)
  - Groundwater flow to surface water used by aquatic life (freshwater and marine)

The remaining matrix soil standards are not applicable to the Site, based on the water use evaluation following BC CSR Protocol 21 (ENV 2017a).

Sediment

CSR Schedule 3.4 Sediment Standards (SedS) are generic numerical criteria that have been developed for the protection of aquatic life in sediments of aquatic receiving environments. This is because the sediments sampled are from within the wetted part of the wetland (i.e., usually in standing water). SedS are separated into standards for sensitive (SedSSS) and typical use (SedSTS) sediments based on the level of protection needed to support the designated uses of the ecosystem and meet ENV sediment management objectives. As the effluent spilled into uncontaminated areas or areas not impacted by human activity, the appropriate sediment standards and/or guidelines would be the SedSSS.

APPENDIX D - TABULATED ANALYTICAL SAMPLING RESULTS

End of Spill Report
Surface Water Quality Results - Legend

<	Less than reported detection limit
>	Greater than reported upper detection limit
BCAWQG AL (ST)	BC Approved Water Quality Guidelines for freshwater aquatic life (Short-term acute)
BCWWQG AL	Working Water Quality Guidelines for British Columbia for freshwater aquatic life
BCAWQG WL	BC Approved Water Quality Guidelines for wildlife
BC RWQG	BC Recreational Water Quality Guidelines
Calc	Calculated guideline or standard. The guideline or standard is dependent on the value of one or more other analytes, and is calculated from a formula or table.
N	Narrative type of guideline or standard, or Result Note.
NG	No Guideline
	The maximum guideline/standard value cannot be determined because a result for a dependent analyte is not available for the sample.
BCAWQG AL (ST)	Highlighted value exceeds BCAWQG AL (ST)
BCWWQG AL	Highlighted value exceeds BCWWQG AL
BCAWQG WL	Highlighted value exceeds BCAWQG WL
BC RWQG	Highlighted value exceeds BC RWQG

End of Spill Report
Surface Water Quality Results

Analyte	Unit	Guideline				Sampling Location	Durrance Lake Inlet	Durrance Beach	Durrance Beach	Durrance Lake SW	RTF-1-WPRO	RTF-2-WPRO	RTF-2-WPRO	RTF-3-WPRO	RTF-4-WPRO	RTF-C-1	RTF-NAR-SB2	RTF-NAR-SB2	RTF-W2-S1
						Date Sampled	26-Oct-20	15-Oct-20	26-Oct-20	26-Oct-20	17-Oct-20	19-Oct-20	26-Oct-20	17-Dec-20	17-Dec-20	17-Dec-20	30-Nov-20	03-Dec-20	09-Dec-20
						Lab Sample ID	VA20B9185-002	YQ8973	VA20B9185-001	VA20B9185-003	VA20B8427-005	VA20B8516-003	VA20B9185-005	VA20C3702-003	VA20C3702-004	VA20C3702-001	VA20C2279-002	VA20C2502-002	VA20C3013-008
		BCAWQG AL (ST)	BCWWQG AL	BCAWQG WL	*BC RWQG*														
Lab Results																			
General and Inorganic Parameters																			
Alkalinity (total, as CaCO3)	mg/L	NG	N [2.1]	NG	NG									121	118	80.2			
Ammonia (total, as N)	µg/L	Calc [1.1]	NG	NG	NG		16.9		13.7	13.8	26.0	1210	210	49.6	<5.0	<5.0	7.8	<5.0	
Ammonia, total (dissolved as N)	µg/L	NG	NG	NG	NG		22.9		27.8	17.7	41.9		229	48.4	<5.0	<10.0			
Bromide	µg/L	NG	NG	NG	NG		<50		<50	<50			<50	<50	<50	<50			<50
Chloride	mg/L	600 [1.2]	NG	600	NG		7.84		7.83	7.95			7.61	12.9	11.0	6.76			7.76
Conductivity	µS/cm	NG	NG	NG	NG		187		187	188		321	520						
Fluoride	µg/L	Calc [1.3]	NG	1500 [3.1]	NG		23		22	22			28	22	21	<20			26
Nitrate (as N)	mg/L	32.8 [1.4]	NG	100 [3.2]	10		<0.0050		<0.0050	0.0065	0.359	<0.0050	0.0098	<0.0050	0.0908	0.0220	0.0544	0.0404	0.0277
Nitrate + Nitrite (as N) (calculated)	mg/L	32.8 [1.5]	NG	100 [3.3]	NG		<0.0051		<0.0051	0.0065	0.360	<0.0051	0.0109	<0.0051	0.0908	0.0220	0.0544	0.0404	0.0288
Nitrite (as N)	µg/L	Calc [1.6]	NG	10000	1000		<1.0		<1.0	<1.0	1.4	2.0	1.1	<1.0	<1.0	<1.0	<1.0	<5.0	1.1
Dissolved kjeldahl nitrogen	µg/L	NG	NG	NG	NG		313		583	270	203		545						
Total kjeldahl nitrogen	µg/L	NG	NG	NG	NG		289		261	295	222	5570	845	264	90	93			
Nitrogen, dissolved inorganic	µg/L	NG	NG	NG	NG									53	93	23			
Nitrogen, dissolved organic	µg/L	NG	NG	NG	NG		277		570	256	127		271	161	64	<50			
Nitrogen, total	µg/L	NG	NG	NG	NG		312		249	283	498	5870	1100	254	156	147			
Nitrogen, total dissolved	µg/L	NG	NG	NG	NG		302		600	280	529	1640	511	214	157	64			
Total organic nitrogen	mg/L	NG	NG	NG	NG		0.272		0.247	0.281	0.196	4.36	0.635						
Orthophosphate (dissolved, as P)	µg/L	NG	NG	NG	NG		<1.0		<1.0	1.1			46.0	36.0	<1.0	1.6			
Oxidation reduction potential	mV	NG	NG	NG	NG							171		266	249	254			
pH		N [1.7]	NG	NG	5.0 - 9.0		7.79		7.85	7.81		6.81	7.40	7.36	7.50	7.71			
Sulphate	mg/L	Calc [1.8]	NG	NG	NG		8.15		8.17	8.22			103	78.5	74.1	15.6			46.3
Temperature when received by lab	°C	NG	NG	NG	NG														
Total dissolved solids	mg/L	NG	NG	NG	NG		102		117	110			334	270	251	134			
Total suspended solids	mg/L	N [1.9]	NG	N [3.4]	NG		10.0		<3.0	<3.0	<3.0	63.8	81.0	<3.0	4.9	<3.0			
Turbidity	NTU	N [1.10]	NG	N [3.5]	50 [4.1]		0.83		0.24	0.31		*53.3*	5.55						
Microbiological																			
E. coli (counts)	CFU/100 mL	N [1.11]	NG	NG	200 [4.2]			26											
E. coli (MPN)	MPN/100 mL	N [1.12]	NG	NG	200 [4.3]		19		1	<1	***>2420***	***>2420***	***461***	5	<1	2		<1	1
Fecal coliforms (counts)	CFU/100 mL	N [1.13]	NG	NG	NG			34											
Fecal coliforms (MPN)	MPN/100 mL	N [1.14]	NG	NG	NG		12		2	10	1730	>2420	299	2	4	<1		<1	3
Total coliforms (MPN)	MPN/100 mL	NG	NG	NG	NG		205		291	548	>2420	>2420	12100	291	186	270		>2420	5100
Total Metals																			
Aluminum (total)	µg/L	NG	NG	5000	NG		34.0		6.6	7.3			144						
Antimony (total)	µg/L	NG	9 [2.2]	NG	NG		<0.10		<0.10	<0.10			0.14						
Arsenic (total)	µg/L	5	NG	25	NG		0.15		0.15	0.14			0.90						
Barium (total)	µg/L	NG	1000	NG	NG		3.96		3.98	3.82			8.02						
Beryllium (total)	µg/L	NG	0.13	NG	NG		<0.100		<0.100	<0.100			<0.100						
Bismuth (total)	µg/L	NG	NG	NG	NG		<0.050		<0.050	<0.050			<0.050						
Boron (total)	µg/L	1200	NG	5000	NG		42		43	42			22						
Cadmium (total)	µg/L	NG	NG	NG	NG		<0.0050		<0.0050	<0.0050			0.0255						
Calcium (total)	mg/L	NG	NG	NG	NG		27.3		26.9	25.8			82.8						
Cesium (total)	µg/L	NG	NG	NG	NG		<0.010		<0.010	<0.010			<0.010						
Chromium (total)	µg/L	NG	1 [2.3]	NG	NG		<0.10		<0.10	<0.10			0.27						
Cobalt (total)	µg/L	110 [1.15]	NG	NG	NG		<0.10		<0.10	<0.10			0.50						
Copper (total)	µg/L	NG	NG	300	NG		<0.50		<0.50	<0.50			6.32						
Hardness, Total (total as CaCO3)	mg/L	NG	NG	NG	NG		80.3		79.7	76.8			246						
Iron (total)	µg/L	1000	NG	NG	NG		48		29	24			231						
Lead (total)	µg/L	Calc [1.16]	NG	100	NG		0.080		<0.050	0.051			0.215						
Lithium (total)	µg/L	NG	NG	NG	NG		<1.0		<1.0	<1.0			<1.0						
Magnesium (total)	mg/L	NG	NG	NG	NG		2.96		3.04	2.98			9.61						

End of Spill Report
Surface Water Quality Results

Analyte	Unit	Guideline				Sampling Location	Durrance Lake Inlet	Durrance Beach	Durrance Beach	Durrance Lake SW	RTF-1-WPRO	RTF-2-WPRO	RTF-2-WPRO	RTF-3-WPRO	RTF-4-WPRO	RTF-C-1	RTF-NAR-SB2	RTF-NAR-SB2	RTF-W2-S1
						Date Sampled	26-Oct-20	15-Oct-20	26-Oct-20	26-Oct-20	17-Oct-20	19-Oct-20	26-Oct-20	17-Dec-20	17-Dec-20	17-Dec-20	30-Nov-20	03-Dec-20	09-Dec-20
						Lab Sample ID	VA20B9185-002	YQ8973	VA20B9185-001	VA20B9185-003	VA20B8427-005	VA20B8516-003	VA20B9185-005	VA20C3702-003	VA20C3702-004	VA20C3702-001	VA20C2279-002	VA20C2502-002	VA20C3013-008
		BCAWQG AL (ST)	BCWWQG AL	BCAWQG WL	*BC RWQG*														
Manganese (total)	µg/L	Calc [1.17]	NG	NG	NG		12.4		12.6	12.2			642						
Mercury (total)	µg/L	0.020 [1.18]	NG	0.020 [3.6]	NG		<0.0050		<0.0050	<0.0050			0.0097						
Molybdenum (total)	µg/L	2000 [1.19]	NG	50	NG		0.163		0.166	0.165			2.11						
Nickel (total)	µg/L	NG	Calc [2.4]	NG	NG		<0.50		<0.50	<0.50			<0.50						
Phosphorus (total, by ICPMS/ICPOES)	µg/L	N [1.20]	NG	NG	N [4.4]		<50		<50	<50			133						
Phosphorus (total, APHA 4500-P)	µg/L	N [1.21]	NG	NG	N [4.5]		16.9		7.7	7.6			134	55.6	<2.0	4.6			
Potassium (total)	µg/L	NG	NG	NG	NG		411		406	402			2230						
Rubidium (total)	µg/L	NG	NG	NG	NG		0.43		0.40	0.36			0.45						
Selenium (total)	µg/L	2 [1.22]	NG	2 [3.7]	NG		<0.050		<0.050	<0.050			0.167						
Silicon (total, as Si)	µg/L	NG	NG	NG	NG		2750		2760	2740			7220						
Silver (total)	µg/L	Calc [1.23]	NG	NG	NG		<0.010		<0.010	<0.010			0.035						
Sodium (total)	mg/L	NG	NG	NG	NG		5.31		5.48	5.50			9.51						
Strontium (total)	µg/L	NG	NG	NG	NG		70.6		69.7	65.6			200						
Sulphur (total)	µg/L	NG	NG	NG	NG		2820		3220	2880			42800						
Tellurium (total)	µg/L	NG	NG	NG	NG		<0.20		<0.20	<0.20			<0.20						
Thallium (total)	µg/L	NG	0.8 [2.5]	NG	NG		<0.010		<0.010	<0.010			<0.010						
Thorium (total)	µg/L	NG	NG	NG	NG		<0.10		<0.10	<0.10			<0.10						
Tin (total)	µg/L	NG	NG	NG	NG		<0.10		<0.10	<0.10			<0.10						
Titanium (total)	µg/L	NG	NG	NG	NG		2.26		<0.30	0.31			<6.00						
Tungsten (total)	µg/L	NG	NG	NG	NG		<0.10		<0.10	<0.10			<0.10						
Uranium (total)	µg/L	NG	8.5	NG	NG		0.016		0.017	0.017			0.776						
Vanadium (total)	µg/L	NG	NG	NG	NG		<0.50		<0.50	<0.50			1.09						
Zinc (total)	µg/L	Calc [1.24]	NG	NG	NG		<3.0		<3.0	<3.0			3.4						
Zirconium (total)	µg/L	NG	NG	NG	NG		<0.20		<0.20	<0.20			<0.20						
Dissolved Metals																			
Aluminum (dissolved)	µg/L	Calc [1.25]	NG	5000	NG		3.1		4.3	1.9			6.4	5.8	3.8	5.3			
Antimony (dissolved)	µg/L	NG	9 [2.6]	NG	NG		<0.10		<0.10	<0.10			0.12	<0.10	<0.10	<0.10			
Arsenic (dissolved)	µg/L	5 [1.26]	NG	25	NG		0.16		0.16	0.16			0.85	0.16	0.15	<0.10			
Barium (dissolved)	µg/L	NG	1000	NG	NG		3.91		4.34	3.94			5.44	6.72	5.31	1.35			
Beryllium (dissolved)	µg/L	NG	0.13	NG	NG		<0.100		<0.100	<0.100			<0.100	<0.020	<0.020	<0.020			
Bismuth (dissolved)	µg/L	NG	NG	NG	NG		<0.050		<0.050	<0.050			<0.050	<0.050	<0.050	<0.050			
Boron (dissolved)	µg/L	1200 [1.27]	NG	5000	NG		43		42	41			21	17	26	23			
Cadmium (dissolved)	µg/L	Calc [1.28]	NG	NG	NG		<0.0050		<0.0050	<0.0050			0.0082	<0.0050	<0.0050	<0.0050			
Calcium (dissolved)	mg/L	NG	N [2.7]	NG	NG		27.6		27.5	25.6			79.2	63.4	59.2	30.4			
Cesium (dissolved)	µg/L	NG	NG	NG	NG		<0.010		<0.010	<0.010			<0.010	<0.010	<0.010	<0.010			
Chromium (dissolved)	µg/L	NG	1 [2.8]	NG	NG		<0.10		<0.10	<0.10			<0.10	<0.50	<0.50	<0.50			
Cobalt (dissolved)	µg/L	110 [1.29]	NG	NG	NG		<0.10		<0.10	<0.10			0.36	<0.10	<0.10	<0.10			
Copper (dissolved)	µg/L	N [1.30]	NG	300 [3.8]	NG		0.71		1.13	0.35			3.17	0.36	0.42	0.31			
Hardness, Total (dissolved as CaCO3)	mg/L	NG	NG	NG	NG		82.0		81.3	76.2			237						
Iron (dissolved)	µg/L	350	NG	NG	NG		11		14	<10			68	33	<10	<10			
Lead (dissolved)	µg/L	Calc [1.31]	NG	100	NG		<0.050		<0.050	<0.050			<0.050	<0.050	<0.050	<0.050			
Lithium (dissolved)	µg/L	NG	NG	NG	NG		<1.0		<1.0	<1.0			<1.0	<1.0	<1.0	<1.0			
Magnesium (dissolved)	mg/L	NG	NG	NG	NG		3.15		3.05	2.97			9.55	8.26	7.74	3.75			
Manganese (dissolved)	µg/L	Calc [1.32]	NG	NG	NG		7.91		9.66	7.00			616	109	6.91	1.40			
Mercury (dissolved)	µg/L	0.020 [1.33]	NG	0.020 [3.9]	NG		<0.0050		<0.0050	<0.0050			0.0059						
Molybdenum (dissolved)	µg/L	2000 [1.34]	NG	50 [3.10]	NG		0.169		0.173	0.160			2.29	0.359	0.440	0.296			
Nickel (dissolved)	µg/L	NG	Calc [2.9]	NG	NG		<0.50		<0.50	<0.50			<0.50	<0.50	<0.50	<0.50			
Phosphorus (dissolved, by ICPMS/ICPOES)	µg/L	N [1.35]	NG	NG	N [4.6]		<50		<50	<50			72	53	<50	<50			
Phosphorus (dissolved, APHA 4500-P)	µg/L	N [1.36]	NG	NG	N [4.7]		10.2		10.8	5.6			75.8	43.5	<2.0	<2.0			
Potassium (dissolved)	µg/L	NG	NG	NG	NG		468		508	402			2230	1930	1710	326			
Rubidium (dissolved)	µg/L	NG	NG	NG	NG		0.42		0.52	0.36			0.43	0.62	0.60	0.22			
Selenium (dissolved)	µg/L	2 [1.37]	NG	2 [3.11]	NG		0.114		0.050	<0.050			0.136	0.090	0.086	0.077			
Silicon (dissolved, as Si)	µg/L	NG	NG	NG	NG		2560		2600	2590			6430	6290	5850	6180			

End of Spill Report
Surface Water Quality Results

Analyte	Unit	Guideline				Sampling Location	Durrance Lake Inlet	Durrance Beach	Durrance Beach	Durrance Lake SW	RTF-1-WPRO	RTF-2-WPRO	RTF-2-WPRO	RTF-3-WPRO	RTF-4-WPRO	RTF-C-1	RTF-NAR-SB2	RTF-NAR-SB2	RTF-W2-S1
						Date Sampled	26-Oct-20	15-Oct-20	26-Oct-20	26-Oct-20	17-Oct-20	19-Oct-20	26-Oct-20	17-Dec-20	17-Dec-20	17-Dec-20	30-Nov-20	03-Dec-20	09-Dec-20
						Lab Sample ID	VA20B9185-002	YQ8973	VA20B9185-001	VA20B9185-003	VA20B8427-005	VA20B8516-003	VA20B9185-005	VA20C3702-003	VA20C3702-004	VA20C3702-001	VA20C2279-002	VA20C2502-002	VA20C3013-008
		BCAWQG AL (ST)	BCWWQG AL	BCAWQG WL	*BC RWQG*														
Silver (dissolved)	µg/L	Calc [1.38]	NG	NG	NG		<0.010		<0.010	<0.010			0.019	<0.010	<0.010	<0.010			
Sodium (dissolved)	mg/L	NG	NG	NG	NG		5.64		5.56	5.52			9.62	7.25	7.63	5.01			
Strontium (dissolved)	µg/L	NG	NG	NG	NG		76.2		74.8	74.0			225	173	160	70.5			
Sulphur (dissolved)	µg/L	NG	NG	NG	NG		2580		2540	2550			33300	27700	26300	5540			
Tellurium (dissolved)	µg/L	NG	NG	NG	NG		<0.20		<0.20	<0.20			<0.20	<0.20	<0.20	<0.20			
Thallium (dissolved)	µg/L	NG	0.8 [2.10]	NG	NG		<0.010		<0.010	<0.010			<0.010	<0.010	<0.010	<0.010			
Thorium (dissolved)	µg/L	NG	NG	NG	NG		<0.10		<0.10	<0.10			<0.10	<0.10	<0.10	<0.10			
Tin (dissolved)	µg/L	NG	NG	NG	NG		<0.10		0.11	<0.10			<0.10	<0.10	<0.10	<0.10			
Titanium (dissolved)	µg/L	NG	NG	NG	NG		<0.30		<0.30	<0.30			<0.30	<0.30	<0.30	<0.30			
Tungsten (dissolved)	µg/L	NG	NG	NG	NG		<0.10		<0.10	<0.10			<0.10	<0.10	<0.10	<0.10			
Uranium (dissolved)	µg/L	NG	8.5	NG	NG		0.016		0.013	0.014			0.538	0.128	0.149	0.059			
Vanadium (dissolved)	µg/L	NG	NG	NG	NG		<0.50		<0.50	<0.50			0.54	<0.50	<0.50	0.76			
Zinc (dissolved)	µg/L	Calc [1.39]	NG	NG	NG		1.2		3.5	<1.0			1.3	<1.0	<1.0	<1.0			
Zirconium (dissolved)	µg/L	NG	NG	NG	NG		<0.20		<0.20	<0.20			<0.20	<0.30	<0.30	<0.30			

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Surface Water Quality Results

Analyte	Unit	Guideline				Sampling Location	DL-SE	DL-SE	DL-SE	DL-SE	DL-SE	DL-SE	DL-SE	DL-SE
						Date Sampled	17-Dec-20	15-Oct-20	26-Oct-20	03-Nov-20	05-Nov-20	10-Nov-20	14-Nov-20	18-Nov-20	17-Dec-20
						Lab Sample ID	VA20C3702-005	YQ8974	VA20B9185-004	VA20B9931-001	VA20C0175-001	VA20C0468-001	VA20C0822-005	VA20C1162-002	VA20C3702-002
		BCAWQG AL (ST)	BCWWQG AL	BCAWQG WL	*BC RWQG*										
Lab Results															
General and Inorganic Parameters															
Alkalinity (total, as CaCO3)	mg/L	NG	N [2.1]	NG	NG	29.9									79.4
Ammonia (total, as N)	µg/L	Calc [1.1]	NG	NG	NG	<5.0		7.4						<5.0	<5.0
Ammonia, total (dissolved as N)	µg/L	NG	NG	NG	NG	<5.0		14.6						<5.0	<5.0
Bromide	µg/L	NG	NG	NG	NG	<50		<50	<50	<50	<50	<50	<50	<50	<50
Chloride	mg/L	600 [1.2]	NG	600	NG	3.93		8.34	10.3	11.8	11.7	12.1	7.71	7.06	
Conductivity	µS/cm	NG	NG	NG	NG			206	238	314	338	321	172		
Fluoride	µg/L	Calc [1.3]	NG	1500 [3.1]	NG	<20		24	22	<20	21	<20	<20	<20	
Nitrate (as N)	mg/L	32.8 [1.4]	NG	100 [3.2]	10	<0.0050		0.0051	0.0581	0.0343	0.0349	0.0559	0.0334	0.0207	
Nitrate + Nitrite (as N) (calculated)	mg/L	32.8 [1.5]	NG	100 [3.3]	NG	<0.0051		0.0051	0.0594	0.0343	0.0349	0.0559	0.0334	0.0219	
Nitrite (as N)	µg/L	Calc [1.6]	NG	10000	1000	<1.0		<1.0	1.3	<1.0	<1.0	<1.0	<1.0	1.2	
Dissolved kjeldahl nitrogen	µg/L	NG	NG	NG	NG			239							
Total kjeldahl nitrogen	µg/L	NG	NG	NG	NG	412		316						138	
Nitrogen, dissolved inorganic	µg/L	NG	NG	NG	NG	<20								26	
Nitrogen, dissolved organic	µg/L	NG	NG	NG	NG	202		205					83	<50	
Nitrogen, total	µg/L	NG	NG	NG	NG	396		314	748	153	116	346	180	138	
Nitrogen, total dissolved	µg/L	NG	NG	NG	NG	202		225	305	148	106	193	121	75	
Total organic nitrogen	mg/L	NG	NG	NG	NG			0.308					<0.2		
Orthophosphate (dissolved, as P)	µg/L	NG	NG	NG	NG	8.5		<1.0	2.4	2.3	3.1	1.7	1.1	1.5	
Oxidation reduction potential	mV	NG	NG	NG	NG	46.0								253	
pH		N [1.7]	NG	NG	5.0 - 9.0	7.49		7.72	7.25	7.41	7.35			7.72	
Sulphate	mg/L	Calc [1.8]	NG	NG	NG	5.53		10.7	24.1	32.9	34.7	32.5	12.0	15.2	
Temperature when received by lab	°C	NG	NG	NG	NG				20.8	21.3	21.5				
Total dissolved solids	mg/L	NG	NG	NG	NG	61		128						126	
Total suspended solids	mg/L	N [1.9]	NG	N [3.4]	NG	7.9		3.0	12.1	<3.0	4.7	<3.0	<3.0	<3.0	
Turbidity	NTU	N [1.10]	NG	N [3.5]	50 [4.1]			2.23	20.5	0.95	3.39				
Microbiological															
E. coli (counts)	CFU/100 mL	N [1.11]	NG	NG	200 [4.2]		23								
E. coli (MPN)	MPN/100 mL	N [1.12]	NG	NG	200 [4.3]	1		5	96	4	<1	10	2	3	
Fecal coliforms (counts)	CFU/100 mL	N [1.13]	NG	NG	NG		31								
Fecal coliforms (MPN)	MPN/100 mL	N [1.14]	NG	NG	NG	9		8	345	5	<1	12	5	1	
Total coliforms (MPN)	MPN/100 mL	NG	NG	NG	NG	>2420		365	>2420	1050	127	378	387	328	
Total Metals															
Aluminum (total)	µg/L	NG	NG	5000	NG			64.5							
Antimony (total)	µg/L	NG	9 [2.2]	NG	NG			<0.10							
Arsenic (total)	µg/L	5	NG	25	NG			0.17							
Barium (total)	µg/L	NG	1000	NG	NG			3.77							
Beryllium (total)	µg/L	NG	0.13	NG	NG			<0.100							
Bismuth (total)	µg/L	NG	NG	NG	NG			<0.050							
Boron (total)	µg/L	1200	NG	5000	NG			43							
Cadmium (total)	µg/L	NG	NG	NG	NG			<0.0050							
Calcium (total)	mg/L	NG	NG	NG	NG			28.7							
Cesium (total)	µg/L	NG	NG	NG	NG			<0.010							
Chromium (total)	µg/L	NG	1 [2.3]	NG	NG			0.13							
Cobalt (total)	µg/L	110 [1.15]	NG	NG	NG			<0.10							
Copper (total)	µg/L	NG	NG	300	NG			0.62							
Hardness, Total (total as CaCO3)	mg/L	NG	NG	NG	NG			84.5							
Iron (total)	µg/L	1000	NG	NG	NG			71							
Lead (total)	µg/L	Calc [1.16]	NG	100	NG			0.106							
Lithium (total)	µg/L	NG	NG	NG	NG			<1.0							
Magnesium (total)	mg/L	NG	NG	NG	NG			3.12							

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Analyte	Unit	Guideline				Sampling Location	RTF-W2-S2	DL-SE	DL-SE	DL-SE	DL-SE	DL-SE	DL-SE	DL-SE
						Date Sampled	17-Dec-20	15-Oct-20	26-Oct-20	03-Nov-20	05-Nov-20	10-Nov-20	14-Nov-20	18-Nov-20	17-Dec-20
						Lab Sample ID	VA20C3702-005	YQ8974	VA20B9185-004	VA20B9931-001	VA20C0175-001	VA20C0468-001	VA20C0822-005	VA20C1162-002	VA20C3702-002
		BCAWQG AL (ST)	BCWWQG AL	BCAWQG WL	*BC RWQG*										
Manganese (total)	µg/L	Calc [1.17]	NG	NG	NG			17.8							
Mercury (total)	µg/L	0.020 [1.18]	NG	0.020 [3.6]	NG			<0.0050							
Molybdenum (total)	µg/L	2000 [1.19]	NG	50	NG			0.173							
Nickel (total)	µg/L	NG	Calc [2.4]	NG	NG			<0.50							
Phosphorus (total, by ICPMS/ICPOES)	µg/L	N [1.20]	NG	NG	N [4.4]			<50							
Phosphorus (total, APHA 4500-P)	µg/L	N [1.21]	NG	NG	N [4.5]	41.8		15.9	56.1	5.6	8.2	23.0	8.5	8.8	
Potassium (total)	µg/L	NG	NG	NG	NG			450							
Rubidium (total)	µg/L	NG	NG	NG	NG			0.43							
Selenium (total)	µg/L	2 [1.22]	NG	2 [3.7]	NG			0.084							
Silicon (total, as Si)	µg/L	NG	NG	NG	NG			2920							
Silver (total)	µg/L	Calc [1.23]	NG	NG	NG			<0.010							
Sodium (total)	mg/L	NG	NG	NG	NG			5.50							
Strontium (total)	µg/L	NG	NG	NG	NG			70.2							
Sulphur (total)	µg/L	NG	NG	NG	NG			3440							
Tellurium (total)	µg/L	NG	NG	NG	NG			<0.20							
Thallium (total)	µg/L	NG	0.8 [2.5]	NG	NG			<0.010							
Thorium (total)	µg/L	NG	NG	NG	NG			<0.10							
Tin (total)	µg/L	NG	NG	NG	NG			<0.10							
Titanium (total)	µg/L	NG	NG	NG	NG			<3.00							
Tungsten (total)	µg/L	NG	NG	NG	NG			<0.10							
Uranium (total)	µg/L	NG	8.5	NG	NG			0.051							
Vanadium (total)	µg/L	NG	NG	NG	NG			0.59							
Zinc (total)	µg/L	Calc [1.24]	NG	NG	NG			<3.0							
Zirconium (total)	µg/L	NG	NG	NG	NG			<0.20							
Dissolved Metals															
Aluminum (dissolved)	µg/L	Calc [1.25]	NG	5000	NG	8.2		3.5							6.2
Antimony (dissolved)	µg/L	NG	9 [2.6]	NG	NG	<0.10		<0.10							<0.10
Arsenic (dissolved)	µg/L	5 [1.26]	NG	25	NG	<0.10		0.18							<0.10
Barium (dissolved)	µg/L	NG	1000	NG	NG	1.98		3.77							1.33
Beryllium (dissolved)	µg/L	NG	0.13	NG	NG	<0.020		<0.100							<0.020
Bismuth (dissolved)	µg/L	NG	NG	NG	NG	<0.050		<0.050							<0.050
Boron (dissolved)	µg/L	1200 [1.27]	NG	5000	NG	10		42							24
Cadmium (dissolved)	µg/L	Calc [1.28]	NG	NG	NG	<0.0050		<0.0050							<0.0050
Calcium (dissolved)	mg/L	NG	N [2.7]	NG	NG	13.1		28.8							30.3
Cesium (dissolved)	µg/L	NG	NG	NG	NG	<0.010		<0.010							<0.010
Chromium (dissolved)	µg/L	NG	1 [2.8]	NG	NG	<0.50		<0.10							<0.50
Cobalt (dissolved)	µg/L	110 [1.29]	NG	NG	NG	<0.10		<0.10							<0.10
Copper (dissolved)	µg/L	N [1.30]	NG	300 [3.8]	NG	0.21		0.29							0.31
Hardness, Total (dissolved as CaCO3)	mg/L	NG	NG	NG	NG			84.9							
Iron (dissolved)	µg/L	350	NG	NG	NG	<10		20							<10
Lead (dissolved)	µg/L	Calc [1.31]	NG	100	NG	<0.050		<0.050							<0.050
Lithium (dissolved)	µg/L	NG	NG	NG	NG	<1.0		<1.0							<1.0
Magnesium (dissolved)	mg/L	NG	NG	NG	NG	1.14		3.13							3.70
Manganese (dissolved)	µg/L	Calc [1.32]	NG	NG	NG	0.52		13.5							1.54
Mercury (dissolved)	µg/L	0.020 [1.33]	NG	0.020 [3.9]	NG			<0.0050							
Molybdenum (dissolved)	µg/L	2000 [1.34]	NG	50 [3.10]	NG	0.174		0.192							0.323
Nickel (dissolved)	µg/L	NG	Calc [2.9]	NG	NG	<0.50		<0.50							<0.50
Phosphorus (dissolved, by ICPMS/ICPOES)	µg/L	N [1.35]	NG	NG	N [4.6]	<50		<50							<50
Phosphorus (dissolved, APHA 4500-P)	µg/L	N [1.36]	NG	NG	N [4.7]	18.8		5.3	11.6	4.4	2.8	6.1	<2.0		2.3
Potassium (dissolved)	µg/L	NG	NG	NG	NG	1010		452							325
Rubidium (dissolved)	µg/L	NG	NG	NG	NG	1.10		0.43							0.22
Selenium (dissolved)	µg/L	2 [1.37]	NG	2 [3.11]	NG	<0.050		<0.050							0.086
Silicon (dissolved, as Si)	µg/L	NG	NG	NG	NG	1420		2800							6090

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Surface Water Quality Results

Analyte	Unit	Guideline				Sampling Location	DL-SE	DL-SE	DL-SE	DL-SE	DL-SE	DL-SE	DL-SE	DL-SE
						Date Sampled	17-Dec-20	15-Oct-20	26-Oct-20	03-Nov-20	05-Nov-20	10-Nov-20	14-Nov-20	18-Nov-20	17-Dec-20
						Lab Sample ID	VA20C3702-005	YQ8974	VA20B9185-004	VA20B9931-001	VA20C0175-001	VA20C0468-001	VA20C0822-005	VA20C1162-002	VA20C3702-002
		BCAWQG AL (ST)	BCWWQG AL	BCAWQG WL	*BC RWQG*										
Silver (dissolved)	µg/L	Calc [1.38]	NG	NG	NG		<0.010		<0.010						<0.010
Sodium (dissolved)	mg/L	NG	NG	NG	NG		2.25		5.55						5.00
Strontium (dissolved)	µg/L	NG	NG	NG	NG		36.5		78.7						71.6
Sulphur (dissolved)	µg/L	NG	NG	NG	NG		1910		3050						5270
Tellurium (dissolved)	µg/L	NG	NG	NG	NG		<0.20		<0.20						<0.20
Thallium (dissolved)	µg/L	NG	0.8 [2.10]	NG	NG		<0.010		<0.010						<0.010
Thorium (dissolved)	µg/L	NG	NG	NG	NG		<0.10		<0.10						<0.10
Tin (dissolved)	µg/L	NG	NG	NG	NG		<0.10		<0.10						<0.10
Titanium (dissolved)	µg/L	NG	NG	NG	NG		<0.30		<0.30						<0.30
Tungsten (dissolved)	µg/L	NG	NG	NG	NG		<0.10		<0.10						<0.10
Uranium (dissolved)	µg/L	NG	8.5	NG	NG		<0.010		0.029						0.057
Vanadium (dissolved)	µg/L	NG	NG	NG	NG		<0.50		<0.50						0.77
Zinc (dissolved)	µg/L	Calc [1.39]	NG	NG	NG		<1.0		<1.0						<1.0
Zirconium (dissolved)	µg/L	NG	NG	NG	NG		<0.30		<0.20						<0.30

End of Spill Report
Surface Water Quality Results – Guideline Notes

1. Notes for BC Approved Water Quality Guidelines for freshwater aquatic life (Short-term acute) (BCAWQG AL (ST))

General Notes:

For some parameters, there are two water quality guidelines: the short-term acute guideline (i.e. maximum), and the long-term chronic guideline (i.e. average). The short-term acute guideline was used in this criteria set for parameters that have both guideline values.

Note 1.1 for Ammonia (total, as N):

The maximum guideline for ammonia varies as a function of pH and temperature. See Table 3 in Overview Report Update September 2009.
The 30-day average guideline for ammonia varies as a function of pH and temperature. See Table 4 in Overview Report Update September 2009. /
The lab pH and field temperature results were used for determining the maximum ammonia for this report. If a lab pH result was not available then the field pH result was used.

Note 1.2 for Chloride:

To protect freshwater aquatic life from acute and lethal effects, the maximum concentration of chloride (mg/L as NaCl) at any time should not exceed 600 mg/L.
To protect freshwater aquatic life from chronic effects, the average (arithmetic mean computed from five weekly samples collected over a 30-day period) concentration of chloride (mg/L as NaCl) should not exceed 150 mg/L.

Note 1.3 for Fluoride:

Correction by BC MOE Sept. 2011: The criteria for Fluoride (total) in mg/L is 0.4 as a maximum where the water hardness (as CaCO3) is less than or equal to 10 mg/L. Otherwise use the equation:
LC50 fluoride = -51.73 + 92.57 log10 (Hardness) and multiply by 0.01.
Hardness is as CaCO3 in units mg/L.

Note 1.4 for Nitrate (as N):

The guideline maximum for nitrate (as N) is 32.8 mg/l.
The 30-day average guideline for nitrate (as N) is 3.0 mg /L. The 30-day average (chronic) concentration is based on 5 weekly samples collected within a 30-day period.
Where nitrate and nitrite are present, the total nitrate+nitrite nitrogen should not exceed these values.

Note 1.5 for Nitrate + Nitrite (as N) (calculated):

The guideline maximum for nitrate (as N) is 32.8 mg/l.
The 30-day average guideline for nitrate (as N) is 3.0 mg /L. The 30-day average (chronic) concentration is based on 5 weekly samples collected within a 30-day period.
Where nitrate and nitrite are present, the total nitrate+nitrite nitrogen should not exceed these values.

Note 1.6 for Nitrite (as N):

The guideline maximum for nitrite as N is:
0.06 mg/L if chloride less than 2 mg/L
0.12 mg/L if chloride is 2 to 4 mg/L
0.18 mg/L if chloride is 4 to 6 mg/L
0.24 mg/L if chloride is 6 to 8 mg/L
0.30 mg/L if chloride is 8 to 10 mg/L
0.60 mg/L if chloride is greater than 10 mg/L.
The guideline 30-day average for nitrite as N is:
0.02 mg/L if chloride less than 2 mg/L
0.04 mg/L if chloride is 2 to 4 mg/L
0.06 mg/L if chloride is 4 to 6 mg/L
0.08 mg/L if chloride is 6 to 8 mg/L
0.10 mg/L if chloride is 8 to 10 mg/L
0.20 mg/L if chloride is greater than 10 mg/L.

Note 1.7 for pH:

pH less than 6.5: No statistically significant decrease in pH from background.
pH from 6.5 to 9.0: Unrestricted change permitted within this range.
pH over 9.0: No statistically significant increase in pH from background.
See BC MOE Overview Report for additional details.

Note 1.8 for Sulphate:

The approved 30-day average (minimum of 5 evenly-spaced samples collected in 30 days) water quality guidelines to protect aquatic life in BC for sulphate are:
128 mg/L at hardness of 0 to 30 mg/L as CaCO3
218 mg/L at hardness of 31 to 75 mg/L as CaCO3
309 mg/L at hardness of 76 to 180mg/L as CaCO3
429 mg/L at hardness 181 to 250 mg/L as CaCO3
Need to determine guideline based on site water for hardness greater than 250 mg/L as CaCO3.
For screening purposes in this report, exceedance were flagged for sulphate greater than 429 mg/L at hardness greater than 250 mg/L as CaCO3.

Note 1.9 for Total suspended solids:

Maximum Induced Suspended Sediments - mg/L or % of background:
- 25 mg/L in 24 hours when background is less than or equal to 25;
- Mean of 5 mg/L in 30 days when background is less than or equal to 25;
- 25 mg/L when background is between 25 and 250;
- 10% when background is greater than or equal to 250.

End of Spill Report
Surface Water Quality Results – Guideline Notes

Note 1.10 for Turbidity:

When background is less than or equal to 8 NTU:
- Maximum Induced Turbidity of 8 NTU in 24 hours.
- For sediment inputs that last between 24 hours and 30 days (daily sampling preferred) the mean turbidity should not exceed background by more than 2 NTU.
Maximum Induced Turbidity of 5 NTU when background is between 8 and 50 NTU.
Maximum Induced Turbidity of 10% when background is greater than 50 NTU.

Note 1.11 for E. coli (counts):

The escherichia coli density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.

Note 1.12 for E. coli (MPN):

The escherichia coli density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.

Note 1.13 for Fecal coliforms (counts):

The guideline for fecal coliforms is as follows: "The fecal coliform density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL."

Note 1.14 for Fecal coliforms (MPN):

The guideline for fecal coliforms is as follows: "The fecal coliform density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL."

Note 1.15 for Cobalt (total):

The interim maximum concentration for total cobalt is 110 µg/L to protect aquatic life in the freshwater environment from acute effects of cobalt.
The interim 30-day average concentration for total cobalt (based on five weekly samples) is 4 µg/L to protect aquatic life from chronic effects of cobalt.

Note 1.16 for Lead (total):

The maximum guideline for total lead in water, at a water hardness less than or equal to 8 mg/L as CaCO3 is set at 3.0 µg/L. When water hardness exceeds 8.0 mg/L CaCO3 the maximum guideline for lead at any time is given by the following equation:
Maximum Criteria (µg/L) = exp (1.273 ln(hardness) - 1.460).
The 30-day average guideline for total lead in water, when water hardness exceeds 8 mg/L as CaCO3, is as follows:
30-Day Average (µg/L) is less than or equal to 3.31 + exp (1.273 ln (mean hardness) - 4.704).
For hardness less than or equal to 8.0 mg/L there is no 30-day average guideline; hence the maximum concentration of 3.0 µg/L is used.

Note 1.17 for Manganese (total):

The maximum concentration of total manganese in mg/L at any time should not exceed the value as determined by the following relationship:
0.01102 hardness + 0.54
where water hardness is reported as mg/L of CaCO3.
The 30-day mean concentration of total manganese in mg/L should be less than or equal to the value as determined by the following relationship:
0.0044 hardness + 0.605
where water hardness is reported as mg/L of CaCO3.

Note 1.18 for Mercury (total):

The average concentration of total mercury in water as measured over a 30-day period (based on five weekly samples) should not exceed 0.02 µg/L when the methyl mercury (MeHg) constitutes less than or equal to 0.5% of the total mercury concentration. When the proportion of MeHg is greater than 0.5%, the guideline should be adjusted as indicated in the Table 1 and Table 4 of the BC MOE Overview Report - First Update, February 2001.
There is no guideline maximum for total mercury in water, for freshwater aquatic life.

Note 1.19 for Molybdenum (total):

The maximum concentration for total molybdenum is 2 mg/L.
The 30-day average concentration for total molybdenum (based on at least five weekly samples in a period of 30 days) is less than or equal to 1 mg/L.

Note 1.20 for Phosphorus (total, by ICPMS/ICPOES):

Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.

Note 1.21 for Phosphorus (total, APHA 4500-P):

Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.

Note 1.22 for Selenium (total):

The 30-day average water quality guideline for protection of aquatic life is 2 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.
The 30-day average alert concentration for the protection of aquatic life in sensitive ecosystems is 1 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.

End of Spill Report
Surface Water Quality Results – Guideline Notes

Note 1.23 for Silver (total):

The guideline maximum for total silver is:
0.1 µg/L maximum if hardness less than or equal to 100 mg/L
3.0 µg/L maximum if hardness greater than 100 mg/L.
The guideline 30-day average for total silver is:
0.05 µg/L as 30-day mean if hardness less than or equal to 100 mg/L
1.5 µg/L as 30-day mean if hardness greater than 100 mg/L.

Note 1.24 for Zinc (total):

The maximum concentration of total zinc (µg/L) at any time should not exceed 33 µg/L when water hardness is less than or equal to 90 mg/L as CaCO3.
When water hardness exceeds 90 mg/L CaCO3, the guideline maximum in µg/L for total zinc is the value determined by the following relationship:
33 + 0.75 * (hardness - 90)
where water hardness is reported as mg/L of CaCO3.
The 30-day average concentration of total zinc (µg/L) at any time should not exceed 7.5 µg/L when water hardness is less than or equal to 90 mg/L as CaCO3.
When water hardness exceeds 90 mg/L CaCO3, the guideline maximum in µg/L for total zinc is the value determined by the following relationship:
7.5 + 0.75 * (hardness - 90)
where water hardness is reported as mg/L of CaCO3.

Note 1.25 for Aluminum (dissolved):

The maximum concentration of dissolved aluminum at any time should not exceed:
1. 0.10 mg/L when the pH is greater than or equal to 6.5
2. The value (in mg/L) determined by the following relationship if pH less than 6.5
Dissolved Aluminum = e (1.209-2.426 (pH) + 0.286 $(pH)^2$)
The 30-day average concentration of dissolved aluminum (based on a minimum of 5 approximately weekly samples) should not exceed:
1. 0.05 mg/L when the median pH over 30 days is greater than or equal to 6.5
2. the value determined by the following relationship at median pH less than 6.5
Dissolved Aluminum = e (1.6-3.327 (median pH) + 0.402 (median $pH)^2$)

Note 1.26 for Arsenic (dissolved):

The recommended guideline is for total arsenic.

Note 1.27 for Boron (dissolved):

The recommended guideline is for total boron.

Note 1.28 for Cadmium (dissolved):

The guideline for cadmium is determined on a site-specific basis according to the local water hardness. The guideline for cadmium (dissolved) in µg/L is determined by the following equations for short term exposure:
1. If hardness (as CaCO3) is less than 7 mg/L then maximum is 0.0380 µg/L
2. If hardness (as CaCO3) is from 7 to 45 mg/L then maximum is based on equation:
e to the power of {1.03[ln(hardness)] - 5.274}
3. If hardness (as CaCO3) is greater than 455 mg/L then maximum is 2.8 µg/L.
When water hardness is greater than the upper bound (i.e., highest water hardness tested), a site-specific assessment may be required.

Note 1.29 for Cobalt (dissolved):

The interim maximum concentration for total cobalt is 110 µg/L to protect aquatic life in the freshwater environment from acute effects of cobalt.
The interim 30-day average concentration for total cobalt (based on five weekly samples) is 4 µg/L to protect aquatic life from chronic effects of cobalt.

Note 1.30 for Copper (dissolved):

The guideline is for dissolved copper and is dependent on the specific chemistry of the water body and can only be calculated using the British Columbia Biotic Ligand Model (BC BLM) software. (Update August 2019)

Note 1.31 for Lead (dissolved):

The maximum guideline for total lead in water, at a water hardness less than or equal to 8 mg/L as CaCO3 is set at 3.0 µg/L. When water hardness exceeds 8.0 mg/L CaCO3 the maximum guideline for lead at any time is given by the following equation:
Maximum Criteria (µg/L) = exp (1.273 ln(hardness) - 1.460).
The 30-day average guideline for total lead in water, when water hardness exceeds 8 mg/L as CaCO3, is as follows:
30-Day Average (µg/L) is less than or equal to 3.31 + exp (1.273 ln (mean hardness) - 4.704).
For hardness less than or equal to 8.0 mg/L there is no 30-day average guideline; hence the maximum concentration of 3.0 µg/L is used.

Note 1.32 for Manganese (dissolved):

The maximum concentration of total manganese in mg/L at any time should not exceed the value as determined by the following relationship:
0.01102 hardness + 0.54
where water hardness is reported as mg/L of CaCO3.
The 30-day mean concentration of total manganese in mg/L should be less than or equal to the value as determined by the following relationship:
0.0044 hardness + 0.605
where water hardness is reported as mg/L of CaCO3.

Note 1.33 for Mercury (dissolved):

The average concentration of total mercury in water as measured over a 30-day period (based on five weekly samples) should not exceed 0.02 µg/L when the methyl mercury (MeHg) constitutes less than or equal to 0.5% of the total mercury concentration. When the proportion of MeHg is greater than 0.5%, the guideline should be adjusted as indicated in the Table 1 and Table 4 of the BC MOE Overview Report - First Update, February 2001.
There is no guideline maximum for total mercury in water, for freshwater aquatic life.

Note 1.34 for Molybdenum (dissolved):

The maximum concentration for total molybdenum is 2 mg/L.
The 30-day average concentration for total molybdenum (based on at least five weekly samples in a period of 30 days) is less than or equal to 1 mg/L.

Note 1.35 for Phosphorus (dissolved, by ICPMS/ICPOES):

Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.

Note 1.36 for Phosphorus (dissolved, APHA 4500-P):

Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.

Note 1.37 for Selenium (dissolved):

The 30-day average water quality guideline for protection of aquatic life is 2 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.
The 30-day average alert concentration for the protection of aquatic life in sensitive ecosystems is 1 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.

Note 1.38 for Silver (dissolved):

The guideline maximum for total silver is:
0.1 µg/L maximum if hardness less than or equal to 100 mg/L
3.0 µg/L maximum if hardness greater than 100 mg/L.
The guideline 30-day average for total silver is:
0.05 µg/L as 30-day mean if hardness less than or equal to 100 mg/L
1.5 µg/L as 30-day mean if hardness greater than 100 mg/L.

Note 1.39 for Zinc (dissolved):

The Short-term Maximum concentration of total zinc (µg/L) at any time should not exceed 33 µg/L when water hardness is less than or equal to 90 mg/L as CaCO3.
When water hardness exceeds 90 mg/L CaCO3, the Short-term Maximum guideline in µg/L for total zinc is the value determined by the following relationship:
33 + 0.75 * (hardness - 90)
where water hardness is reported as mg/L of CaCO3.
Short-term maximum WQG formula applies to water hardness between 90 – 500 mg/L CaCO3.
The Long-term Average concentration of total zinc (µg/L) at any time should not exceed 7.5 µg/L when water hardness is less than or equal to 90 mg/L as CaCO3.
When water hardness exceeds 90 mg/L CaCO3, the Long-term Average guideline in µg/L for total zinc is the value determined by the following relationship:
7.5 + 0.75 * (hardness - 90)
where water hardness is reported as mg/L of CaCO3.
Long-term average WQG formula applies to water hardness between 90 – 330 mg/L CaCO3.

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2. Notes for Working Water Quality Guidelines for British Columbia for freshwater aquatic life (BCWWQG AL)

General Notes:

Reference: Working Water Quality Guidelines for British Columbia (2015). WWQG values are long-term (i.e. average) concentrations unless identified as a short-term maximum in the "Notes" for a specific analyte. Long-term WWQGs represent average substance concentrations calculated from 5 samples in 30 days. WWQG are given for total substance concentrations unless otherwise noted.

Note 2.1 for Alkalinity (total, as CaCO3):

The guideline for alkalinity (total as CaCO3) is as follows:
- Less than 10 mg/L, highly sensitive to acid inputs
- 10 to 20 mg/L, moderately sensitive to acid inputs
- Greater than 20 mg/L, low sensitivity to acid inputs.

Note 2.2 for Antimony (total):

The guideline is for antimony (III).

Note 2.3 for Chromium (total):

The guideline for Cr(VI) is 1 µg/L (total). The guideline for Cr(III) is 8.9 µg/L (total). The guideline of 1 µg/L for Cr(VI) was used, in this report, to identify exceedances for dissolved chromium, and total chromium as a means for determining the potential for exceeding the Cr(VI) and/or Cr(III) guidelines.

Note 2.4 for Nickel (total):

The guideline for nickel in µg/L is determined as follows:
When the water hardness is 0 to ≤ 60 mg/L, the maximum is 25 µg/L
At hardness > 60 to ≤ 180 mg/L the maximum is calculated using the equation:
e raised to the power of {0.76[ln(hardness)] + 1.06}
At hardness >180 mg/L, the maximum is 150 µg/L
Where water hardness is reported as mg/L CaCO3.
If the water hardness is unknown, the maximum is 25 µg/L.

Note 2.5 for Thallium (total):

30-day average, site-specific objective for the lower Columbia River, BC

Note 2.6 for Antimony (dissolved):

The guideline is for antimony (III).

Note 2.7 for Calcium (dissolved):

The guideline for dissolved calcium in mg/L is as follows:
- Less than 4, highly sensitive to acid inputs
- 4 to 8, moderately sensitive
- Greater than 8, low sensitivity.

Note 2.8 for Chromium (dissolved):

The guideline for Cr(VI) is 1 µg/L (total). The guideline for Cr(III) is 8.9 µg/L (total). The guideline of 1 µg/L for Cr(VI) was used, in this report, to identify exceedances for dissolved chromium, and total chromium as a means for determining the potential for exceeding the Cr(VI) and/or Cr(III) guidelines.

Note 2.9 for Nickel (dissolved):

The guideline for nickel in µg/L is determined as follows:
When the water hardness is 0 to ≤ 60 mg/L, the maximum is 25 µg/L
At hardness > 60 to ≤ 180 mg/L the maximum is calculated using the equation:
e raised to the power of {0.76[ln(hardness)] + 1.06}
At hardness >180 mg/L, the maximum is 150 µg/L
Where water hardness is reported as mg/L $CaCO_3$.
If the water hardness is unknown, the maximum is 25 µg/L.

Note 2.10 for Thallium (dissolved):

30-day average, site-specific objective for the lower Columbia River, BC

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3. Notes for BC Approved Water Quality Guidelines for wildlife (BCAWQG WL)

General Notes:

The Water Quality Guidelines (Criteria) Reports by BC Ministry of Environment were used as references for the guidelines. (Internet address: http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html). Overview Reports (BC MOE) were used as the references for the guidelines unless the note for specific analyte indicates that the Technical Appendix (BC MOE) was used.

Note 3.1 for Fluoride:

Total fluoride should not exceed 1.0 mg/L as a 30-day average or 1.5 mg/L as a maximum in fresh water used by wildlife.

Note 3.2 for Nitrate (as N):

The guideline maximum for Wildlife for nitrate as nitrogen is 100 mg/l. Where nitrate and nitrite are present, the total nitrate+nitrite nitrogen should not exceed this value.

Note 3.3 for Nitrate + Nitrite (as N) (calculated):

The guideline maximum for Wildlife for nitrate as nitrogen is 100 mg/l. Where nitrate and nitrite are present, the total nitrate+nitrite nitrogen should not exceed this value.

Note 3.4 for Total suspended solids:

Induced suspended sediments should not exceed 20 mg/L when background suspended sediments is less than or equal to 100 mg/L, nor should induced suspended sediments be more than 20 % of background when background is greater than 100 mg/L.

Note 3.5 for Turbidity:

Induced turbidity should not exceed 10 NTU when background turbidity is less than or equal to 50 NTU, nor should induced turbidity be more than 20 % of background when background is greater than 50 NTU.

Note 3.6 for Mercury (total):

The average concentration of total mercury in water as measured over a 30-day period (based on five weekly samples) should not exceed 0.02 µg/L when the methyl mercury (MeHg) constitutes less than or equal to 0.5% of the total mercury concentration. When the proportion of MeHg is greater than 0.5%, the guideline should be adjusted as indicated in the Table 1 and Table 4 of the BC MOE Overview Report - First Update, February 2001.

Note 3.7 for Selenium (total):

The water column (aquatic life) guideline of 2 µg/L, and the dietary guideline of 4 µg/g in food items, are applicable to wildlife species. The 30-day average water quality guideline for protection of aquatic life is 2 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.
The chronic tissue guideline for the protection of wildlife, using birds as a surrogate, is 6 µg/g (dw) in bird egg tissue, calculated as the mean concentration of at least 8 eggs (from 8 individual nests) in a representative area, reported as dry weight.

Note 3.8 for Copper (dissolved):

The guideline maximum is for total copper.

Note 3.9 for Mercury (dissolved):

The average concentration of total mercury in water as measured over a 30-day period (based on five weekly samples) should not exceed 0.02 µg/L when the methyl mercury (MeHg) constitutes less than or equal to 0.5% of the total mercury concentration. When the proportion of MeHg is greater than 0.5%, the guideline should be adjusted as indicated in the Table 1 and Table 4 of the BC MOE Overview Report - First Update, February 2001.

Note 3.10 for Molybdenum (dissolved):

The guideline maximum is for total molybdenum.

Note 3.11 for Selenium (dissolved):

The water column (aquatic life) guideline of 2 µg/L, and the dietary guideline of 4 µg/g in food items, are applicable to wildlife species. The 30-day average water quality guideline for protection of aquatic life is 2 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.
The chronic tissue guideline for the protection of wildlife, using birds as a surrogate, is 6 µg/g (dw) in bird egg tissue, calculated as the mean concentration of at least 8 eggs (from 8 individual nests) in a representative area, reported as dry weight.

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4. Notes for BC Recreational Water Quality Guidelines (BC RWQG)

General Notes:

The guidelines are for primary contact recreational uses. Primary contact is defined as activities, such as swimming (this includes bathing/wading for the purposes of this document), windsurfing and waterskiing, as well as secondary contact activities, such as canoeing or fishing, in natural waters through intentional or incidental immersion.

Note 4.1 for Turbidity:

The guideline for turbidity is an aesthetic objective of 50 NTU.

Note 4.2 for E. coli (counts):

The geometric mean guideline is ≤ 200 E. coli /100 mL and is a geometric mean of a minimum of 5 samples in 30 days.
The single sample maximum concentration guideline is ≤ 400 E. coli /100 mL. / The most stringent guideline was used in this report.

Note 4.3 for E. coli (MPN):

The geometric mean guideline is ≤ 200 E. coli /100 mL and is a geometric mean of a minimum of 5 samples in 30 days.
The single sample maximum concentration guideline is ≤ 400 E. coli /100 mL. / The most stringent guideline was used in this report.

Note 4.4 for Phosphorus (total, by ICPMS/ICPOES):

The guideline for lakes is 0.01 mg/L.

Note 4.5 for Phosphorus (total, APHA 4500-P):

The guideline for lakes is 0.01 mg/L.

Note 4.6 for Phosphorus (dissolved, by ICPMS/ICPOES):

The guideline for lakes is 0.01 mg/L.

Note 4.7 for Phosphorus (dissolved, APHA 4500-P):

The guideline for lakes is 0.01 mg/L.

End of Spill Report
Bedrock Groundwater Quality Results - Legend

<	Less than reported detection limit
>	Greater than reported upper detection limit
CSR AW	BC CSR Generic Numerical Water Standards for Freshwater Aquatic Life
CSR DW	BC CSR Generic Numerical Water Standards for Drinking Water
BC SDWQG MAC	BC Source Drinking Water Quality Guidelines - Maximum Acceptable Concentrations (*applied only for microbiological parameters)*
Calc	Calculated guideline or standard. The guideline or standard is dependent on the value of one or more other analytes, and is calculated from a formula or table.
N	Narrative type of guideline or standard, or Result Note.
NS	No Standard
NA	Not Applicable
CSR AW	Highlighted value exceeds CSR AW
CSR DW	Highlighted value exceeds CSR DW
BC SDWQG MAC	Highlighted value exceeds BC Source Drinking Water Quality Guidelines - Maximum Acceptable Concentrations for microbiological parameters

End of Spill Report
Bedrock Groundwater Quality Results

Analyte	Unit	Standard			Sampling Location	41-1-1	41-1-1	44-1-1	44-1-1	55-1-1	55-1-1	56-1-1	56-1-1	57-1-1	57-1-1
					Date Sampled	17-Oct-20	14-Nov-20	19-Oct-20	14-Nov-20	17-Oct-20	14-Nov-20	17-Oct-20	14-Nov-20	17-Oct-20	18-Nov-20
					Lab Sample ID	VA20B8427-003	VA20C0822-002	VA20B8516-001	VA20C0822-001	VA20B8427-002	VA20C0822-003	VA20B8427-004	VA20C0822-004	VA20B8427-001	VA20C1162-001
		CSR AW	CSR DW	*BC SDWQG MAC*											
Lab Results															
General and Inorganic Parameters															
Ammonia (total, as N)	µg/L	Calc [1.1]	NS	NA		6.1		<5.0		<5.0		<5.0		<5.0	<5.0
Ammonia, total (dissolved as N)	µg/L	Calc [1.2]	NS	NA		13.9				<5.0		<5.0		<5.0	<5.0
Biochemical oxygen demand	mg/L	NS	NS	NA		<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Bromide	µg/L	NS	NS	NA		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Chloride	mg/L	1500	250 [2.1]	NA		4.55	4.45	5.43	5.36	12.1	11.7	8.88	11.0	13.8	13.2
Conductivity	µS/cm	NS	NS	NA			448		464		562		419		254
Fluoride	µg/L	Calc [1.3]	1500	NA		29	26	34	37	24	24	23	<20	21	<20
Nitrate (as N)	mg/L	400 [1.4]	10 [2.2]	NA		0.0386	<0.0050	<0.0050	0.0453	0.235	0.149	<0.0050	<0.0050	<0.0050	<0.0050
Nitrate + Nitrite (as N) (calculated)	mg/L	400 [1.5]	10 [2.3]	NA		0.0386	<0.0051	<0.0051	0.0465	0.235	0.149	<0.0051	<0.0051	<0.0051	<0.0051
Nitrite (as N)	µg/L	Calc [1.6]	1000	NA		<1.0	<1.0	<1.0	1.2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dissolved kjeldahl nitrogen	µg/L	NS	NS	NA		<50				<50		<50		<50	
Dissolved organic nitrogen	mg/L	NS	NS	NA		<0.050				<0.050		<0.050		<0.050	<0.050
Total organic nitrogen	mg/L	NS	NS	NA		<0.05		<0.2		<0.05		<0.05		<0.05	<0.2
Nitrogen (dissolved)	mg/L	NS	NS	NA		0.082	0.049	0.092	0.138	0.259	0.172	<0.030	0.218	0.032	<0.030
Total nitrogen	µg/L	NS	NS	NA		66	282	60	140	248	156	<30	<30	<30	82
Total kjeldahl nitrogen	µg/L	NS	NS	NA		<50		66		<50		<50		<50	
Orthophosphate (dissolved, as P)	µg/L	NS	NS	NA		1.0	<1.0	6.3	5.6	1.4	<1.0	4.7	4.3	1.6	<1.0
Oxidation reduction potential	mV	NS	NS	NA			338		362		324		313		265
Sulphate	mg/L	Calc [1.7]	500 [2.4]	NA		62.7	53.8	19.1	20.8	86.1	90.8	53.1	53.9	81.5	89.3
Total dissolved solids	mg/L	NS	NS	NA		288	270	380	265	321	338	270	274	333	360
Microbiological															
E. coli (MPN)	MPN/100 mL	NS	NS	10 [3.1]		<1	<1	1	<1	<1	<1	<1	<1	<1	<1
Fecal coliforms (MPN)	MPN/100 mL	NS	NS	10 [3.2]		<1	<1	<1	1	<1	<1	<1	<1	1	<1
Total coliforms (MPN)	MPN/100 mL	NS	NS	NS		23	2	17	328	23	6	105	23	261	26
Total Metals															
Aluminum (total)	µg/L	NS	NS	NA		191	86.0	170	169	45.2	69.4	146	68.2	11.9	268
Antimony (total)	µg/L	NS	NS	NA		0.11	0.13	0.15	0.20	0.15	0.29	<0.10	<0.10	<0.10	<0.10
Arsenic (total)	µg/L	NS	NS	NA		3.49	15.2	0.10	0.11	0.29	0.42	0.26	0.20	0.11	0.16
Barium (total)	µg/L	NS	NS	NA		4.21	8.92	10.6	11.8	6.00	13.8	24.0	26.7	10.9	13.3
Beryllium (total)	µg/L	NS	NS	NA		<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Bismuth (total)	µg/L	NS	NS	NA		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Boron (total)	µg/L	NS	NS	NA		27	28	84	91	16	18	16	17	36	35
Cadmium (total)	µg/L	NS	NS	NA		0.0079	0.0147	0.0273	0.0463	0.0598	0.364	0.0152	0.0164	0.0314	0.108
Calcium (total)	mg/L	NS	NS	NA		75.0	70.7	72.4	77.9	81.9	86.2	73.9	74.5	91.5	89.0
Cesium (total)	µg/L	NS	NS	NA		0.026	0.028	<0.010	<0.010	0.035	0.040	0.013	<0.010	<0.010	0.034
Chromium (total)	µg/L	NS	NS	NA		0.16	<0.20	0.22	<0.30	0.17	<0.30	0.18	<0.20	<0.10	0.75
Cobalt (total)	µg/L	NS	NS	NA		0.61	1.88	0.26	0.45	0.40	2.48	0.38	0.15	<0.10	0.48
Copper (total)	µg/L	NS	NS	NA		0.62	0.82	1.10	1.97	1.26	5.88	<0.50	<0.50	<0.50	0.99
Hardness, Total (total as CaCO3)	mg/L	NS	NS	NA		223	210	201	217	239	250	211	211	258	250
Iron (total)	µg/L	NS	NS	NA		426	1420	340	464	83	205	249	145	37	736
Lead (total)	µg/L	NS	NS	NA		0.166	0.091	0.614	1.71	0.071	0.224	0.098	<0.050	<0.050	0.240
Lithium (total)	µg/L	NS	NS	NA		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Magnesium (total)	mg/L	NS	NS	NA		8.78	8.11	4.95	5.48	8.44	8.39	6.40	6.09	7.12	6.79
Manganese (total)	µg/L	NS	NS	NA		248	1850	11.9	32.7	187	2010	12.9	10.3	22.8	50.0
Mercury (total)	µg/L	NS	NS	NA		<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Molybdenum (total)	µg/L	NS	NS	NA		1.28	2.70	1.00	1.56	0.386	0.926	1.08	1.02	0.273	0.328
Nickel (total)	µg/L	NS	NS	NA		<0.50	<0.50	0.66	0.61	0.87	10.6	<0.50	<0.50	<0.50	1.49
Phosphorus (total, by ICPMS/ICPOES)	µg/L	NS	NS	NA		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Phosphorus (total, APHA 4500-P)	µg/L	NS	NS	NA		2.7	11.6	23.2	26.5	2.6	<2.0	10.0	8.1	<2.0	11.1
Potassium (total)	µg/L	NS	NS	NA		1120	896	397	469	1730	1490	330	299	458	494
Rubidium (total)	µg/L	NS	NS	NA		0.78	0.86	0.50	0.64	0.82	0.70	1.09	0.94	0.56	0.95
Selenium (total)	µg/L	NS	NS	NA		0.062	<0.050	<0.050	0.053	0.268	0.179	<0.050	<0.050	<0.050	<0.050
Silicon (total, as Si)	µg/L	NS	NS	NA		8180	8040	8950	8680	6040	5760	6770	6360	6560	6910
Silver (total)	µg/L	NS	NS	NA		<0.010	<0.010	<0.010	<0.010	<0.010	0.013	<0.010	<0.010	<0.010	<0.010
Sodium (total)	mg/L	NS	NS	NA		5.13	4.92	6.97	8.95	13.2	13.1	4.16	4.53	9.51	10.2
Strontium (total)	µg/L	NS	NS	NA		210	213	192	194	245	259	257	266	244	244

End of Spill Report
Bedrock Groundwater Quality Results

Analyte	Unit	Standard			Sampling Location	41-1-1	41-1-1	44-1-1	44-1-1	55-1-1	55-1-1	56-1-1	56-1-1	57-1-1	57-1-1
					Date Sampled	17-Oct-20	14-Nov-20	19-Oct-20	14-Nov-20	17-Oct-20	14-Nov-20	17-Oct-20	14-Nov-20	17-Oct-20	18-Nov-20
					Lab Sample ID	VA20B8427-003	VA20C0822-002	VA20B8516-001	VA20C0822-001	VA20B8427-002	VA20C0822-003	VA20B8427-004	VA20C0822-004	VA20B8427-001	VA20C1162-001
		CSR AW	CSR DW	*BC SDWQG MAC*											
Sulphur (total)	µg/L	NS	NS	NA		22200	19300	8130	7240	31000	32700	18600	18600	29400	32400
Tellurium (total)	µg/L	NS	NS	NA		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Thallium (total)	µg/L	NS	NS	NA		<0.010	<0.010	<0.010	<0.010	<0.010	0.042	<0.010	<0.010	<0.010	0.024
Thorium (total)	µg/L	NS	NS	NA		0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Tin (total)	µg/L	NS	NS	NA		<0.10	<0.10	<0.10	0.18	<0.10	<0.10	<0.10	<0.10	<0.10	0.19
Titanium (total)	µg/L	NS	NS	NA		3.70	1.51	11.1	9.84	1.87	3.67	8.05	4.44	0.43	24.8
Tungsten (total)	µg/L	NS	NS	NA		<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Uranium (total)	µg/L	NS	NS	NA		0.293	0.260	0.173	0.263	0.266	0.313	0.119	0.108	0.033	0.061
Vanadium (total)	µg/L	NS	NS	NA		0.52	<0.50	0.97	1.11	0.69	1.11	0.59	<0.50	<0.50	0.88
Zinc (total)	µg/L	NS	NS	NA		<3.0	<3.0	<3.0	5.4	<3.0	4.9	<3.0	<3.0	<3.0	7.4
Zirconium (total)	µg/L	NS	NS	NA		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Dissolved Metals															
Aluminum (dissolved)	µg/L	NS	9500 [2.5]	NA		<1.0		<1.0		<1.0		1.1		1.0	
Antimony (dissolved)	µg/L	90	6	NA		<0.10		0.13		0.12		<0.10		<0.10	
Arsenic (dissolved)	µg/L	50	10	NA		3.02		<0.10		0.17		0.15		<0.10	
Barium (dissolved)	µg/L	10000	1000	NA		2.29		9.82		4.81		24.0		11.0	
Beryllium (dissolved)	µg/L	1.5	8	NA		<0.100		<0.100		<0.100		<0.100		<0.100	
Bismuth (dissolved)	µg/L	NS	NS	NA		<0.050		<0.050		<0.050		<0.050		<0.050	
Boron (dissolved)	µg/L	12000	5000	NA		25		90		17		15		34	
Cadmium (dissolved)	µg/L	Calc [1.8]	5	NA		<0.0050		0.0229		<0.0050		0.0079		0.0274	
Calcium (dissolved)	mg/L	NS	NS	NA		71.6		74.7		81.7		70.8		90.3	
Cesium (dissolved)	µg/L	NS	NS	NA		0.017		<0.010		0.030		<0.010		<0.010	
Chromium (dissolved)	µg/L	10 [1.9]	50 [2.6]	NA		<0.10		<0.10		<0.10		<0.10		<0.10	
Cobalt (dissolved)	µg/L	40	20 [2.7]	NA		<0.10		<0.10		<0.10		<0.10		<0.10	
Copper (dissolved)	µg/L	Calc [1.10]	1500 [2.8]	NA		<0.20		0.64		0.30		<0.20		<0.20	
Hardness, Total (dissolved as CaCO3)	mg/L	NS	NS	NA		214		208		238		203		255	
Iron (dissolved)	µg/L	NS	6500 [2.9]	NA		<10		<10		<10		<10		16	
Lead (dissolved)	µg/L	Calc [1.11]	10	NA		<0.050		<0.050		<0.050		<0.050		<0.050	
Lithium (dissolved)	µg/L	NS	8	NA		<1.0		<1.0		<1.0		<1.0		<1.0	
Magnesium (dissolved)	mg/L	NS	NS	NA		8.54		5.11		8.25		6.36		7.11	
Manganese (dissolved)	µg/L	NS	1500 [2.10]	NA		115		3.28		4.19		<0.10		19.4	
Mercury (dissolved)	µg/L	0.25	1	NA		<0.0050		<0.0050		<0.0050		<0.0050		<0.0050	
Molybdenum (dissolved)	µg/L	10000	250	NA		1.56		1.33		0.314		1.09		0.272	
Nickel (dissolved)	µg/L	Calc [1.12]	80	NA		<0.50		<0.50		<0.50		<0.50		<0.50	
Phosphorus (dissolved, by ICPMS/ICPOES)	µg/L	NS	NS	NA		<50		<50		<50		<50		<50	
Phosphorus (dissolved, APHA 4500-P)	µg/L	NS	NS	NA		<2.0		16.6		<2.0		3.8		<2.0	
Potassium (dissolved)	µg/L	NS	NS	NA		1020		400		1700		309		455	
Rubidium (dissolved)	µg/L	NS	NS	NA		0.75		0.48		0.72		0.93		0.53	
Selenium (dissolved)	µg/L	20	10	NA		0.051		<0.050		0.289		<0.050		<0.050	
Silicon (dissolved, as Si)	µg/L	NS	NS	NA		7660		7940		5820		6310		6470	
Silver (dissolved)	µg/L	Calc [1.13]	20	NA		<0.010		<0.010		<0.010		<0.010		<0.010	
Sodium (dissolved)	mg/L	NS	200 [2.11]	NA		5.03		7.80		12.8		4.01		9.55	
Strontium (dissolved)	µg/L	NS	2500	NA		203		185		242		261		248	
Sulphur (dissolved)	µg/L	NS	NS	NA		21200		7370		29600		18600		28800	
Tellurium (dissolved)	µg/L	NS	NS	NA		<0.20		<0.20		<0.20		<0.20		<0.20	
Thallium (dissolved)	µg/L	3	NS	NA		<0.010		<0.010		<0.010		<0.010		<0.010	
Thorium (dissolved)	µg/L	NS	NS	NA		<0.10		<0.10		<0.10		<0.10		<0.10	
Tin (dissolved)	µg/L	NS	2500	NA		<0.10		<0.10		<0.10		<0.10		<0.10	
Titanium (dissolved)	µg/L	1000	NS	NA		<0.30		<0.30		<0.30		<0.30		<0.30	
Tungsten (dissolved)	µg/L	NS	3	NA		<0.10		<0.10		<0.10		<0.10		<0.10	
Uranium (dissolved)	µg/L	85	20	NA		0.244		0.229		0.259		0.096		0.030	
Vanadium (dissolved)	µg/L	NS	20	NA		<0.50		<0.50		<0.50		<0.50		<0.50	
Zinc (dissolved)	µg/L	Calc [1.14]	3000 [2.12]	NA		<1.0		<1.0		<1.0		<1.0		1.4	
Zirconium (dissolved)	µg/L	NS	NS	NA		<0.20		<0.20		<0.20		<0.20		<0.20	

WIRELESS WATER

End of Spill Report
Bedrock Groundwater Quality Results – Guideline Notes

1. Notes for BC CSR Generic Numerical Water Standards for Freshwater Aquatic Life (CSR AW)

General Notes:

BC Contaminated Sites Regulation, Generic Numerical Water Standards, Schedule 3.2; includes amendments up to B.C. Reg. 13/2019, January 24, 2019.
Aquatic life standards assume minimum 1:10 dilution available, and are to protect freshwater life.
Standards for all organic substances are for total substance concentrations. Any water sample to be analyzed for organic substances should not be filtered.
Standards for surface water samples to be analyzed for heavy metals, metalloids and inorganic ions are total substance concentrations. In addition, it is recommended that surface water samples being analyzed for heavy metals, metalloids and inorganic ions should also be analyzed for dissolved substance concentrations.
Standards for groundwater samples for heavy metals, metalloids and inorganic ions are for dissolved substance concentrations. In addition, it is recommended that groundwater samples being analyzed for heavy metals, metalloids and inorganic ions should also be analyzed for total substance concentrations.

Note 1.1 for Ammonia (total, as N):

Standard varies with pH and temperature. 10 degrees C is assumed. Consult a director for further advice.
The standard for ammonia, total (as N) is:
1,310 µg/L @ pH ≥ to 8.5
3,700 µg/L @ pH 8.0 - < 8.5
11,300 µg/L @ pH 7.5 - < 8.0
18,500 µg/L @ pH 7.0 - < 7.5
18,400 µg/L @ pH < 7.0

Note 1.2 for Ammonia, total (dissolved as N):

Standard varies with pH and temperature. 10 degrees C is assumed. Consult a director for further advice.
The standard for ammonia, total (as N) is:
1,310 µg/L @ pH ≥ to 8.5
3,700 µg/L @ pH 8.0 - < 8.5
11,300 µg/L @ pH 7.5 - < 8.0
18,500 µg/L @ pH 7.0 - < 7.5
18,400 µg/L @ pH < 7.0

Note 1.3 for Fluoride:

The standard for fluoride is:
2000 µg/L @ H < 50
3000 µg/L @ H ≥ 50
Where H means water hardness in mg/L as CaCO3.

Note 1.4 for Nitrate (as N):

Standard may not protect all amphibians. Consult director for further advice.

Note 1.5 for Nitrate + Nitrite (as N) (calculated):

Standard may not protect all amphibians. Consult director for further advice.

Note 1.6 for Nitrite (as N):

Standard varies with chloride concentration. Consult a director for further advice.
The standard for nitrite (as N) is:
200 µg/L (Cl < 2 mg/L)
400 µg/L (Cl 2 - < 4 mg/L)
600 µg/L (Cl 4 - < 6 mg/L)
800 µg/L (Cl 6 - < 8 mg/L)
1,000 µg/L (Cl 8 - < 10 mg/L)
2,000 µg/L (Cl ≥ 10 mg/L)

Note 1.7 for Sulphate:

The standard for sulfate is:
1280 mg/L @ H ≤ 30
2180 mg/L @ H 31 - 75
3090 mg/L @ H 76 - 180
4290 mg/L @ H > 180
Where H means water hardness in mg/L as CaCO3.

Note 1.8 for Cadmium (dissolved):

The standard for cadmium is as follows:
0.5 µg/L @ H < 30
1.5 µg/L @ H 30 - < 90
2.5 µg/L @ H 90 - < 150
3.5 µg/L @ H 150 - < 210
4 µg/L @ H ≥ 210
Where H means water hardness in mg/L as CaCO3.

Note 1.9 for Chromium (dissolved):

Analytical results for chromium (all species) in water may be used to demonstrate compliance with the standards. Where the standards cannot be met based on analytical results for chromium (all species), chromium speciation may be necessary.
Standard is 10 µg/L for chromium, hexavalent. Standard is 90 µg/L for chromium, trivalent. The standard of 10 µg/L was used to identify exceedances for dissolved chromium in order to demonstrate compliance with the standards.

Note 1.10 for Copper (dissolved):

The standard for copper is as follows:
20 µg/L @ H < 50
30 µg/L @ H 50 - < 75
40 µg/L @ H 75 - < 100
50 µg/L @ H 100 - < 125
60 µg/L @ H 125 - < 150
70 µg/L @ H 150 - < 175
80 µg/L @ H 175 - < 200
90 µg/L @ H ≥ 200
Where H means water hardness in mg/L as CaCO3.

Note 1.11 for Lead (dissolved):

The standard for lead is as follows:
40 µg/L @ H < 50
50 µg/L @ H 50 - < 100
60 µg/L @ H 100 - < 200
110 µg/L @ H 200 - < 300
160 µg/L @ ≥ 300
Where H means water hardness in mg/L as CaCO3.

Note 1.12 for Nickel (dissolved):

The standard for nickel is as follows:
250 µg/L @ H < 60
650 µg/L @ H 60 - < 120
1,100 µg/L @ H 120 - < 180
1,500 µg/L @ H ≥ 180
Where H means water hardness in mg/L as CaCO3.

Note 1.13 for Silver (dissolved):

The standard for silver is:
0.5 µg/L @ H ≤ 100
15 µg/L @ H > 100
Where H means water hardness in mg/L as CaCO3.

Note 1.14 for Zinc (dissolved):

The standard for zinc is as follows:
75 µg/L @ H < 90
150 µg/L @ H = 90 - < 100
900 µg/L @ H = 100 - < 200
1,650 µg/L @ H = 200 - < 300
2,400 µg/L @ H = 300 - < 400
3,150 µg/L @ H = 400 - < 500
If H ≥ 500 then use following formula:
Standard (µg/L) = 10 x [7.5 +{(0.75)(H – 90)}]
Where H means water hardness in mg/L as CaCO3.
There are special ministry approval and data reporting requirements for water hardness values ≥ 500 mg/L as CaCO3.
Reference is Schedule 3.2 and Protocol 10.

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2. Notes for BC CSR Generic Numerical Water Standards for Drinking Water (CSR DW)

General Notes:

Drinking water standards are for unfiltered samples obtained at the point of consumption. Heavy metals, metalloids and inorganic ions are expressed as total substance concentrations unless otherwise indicated.

Note 2.1 for Chloride:

Standard to protect against taste and odour concerns.

Note 2.2 for Nitrate (as N):

Where nitrate and nitrite are present, total nitrate plus nitrite-nitrogen should not exceed this value.

Note 2.3 for Nitrate + Nitrite (as N) (calculated):

Where nitrate and nitrite are present, total nitrate plus nitrite-nitrogen should not exceed this value.

Note 2.4 for Sulphate:

Standard to protect against taste and odour concerns.

Note 2.5 for Aluminum (dissolved):

Standard is specific to protection of human health. Standard is derived with TRV protective of adults. Standard may not adequately protect other age groups.
Standard may not address aesthetic (organoleptic) concerns related to drinking water quality. Water treatment may be required.

Note 2.6 for Chromium (dissolved):

Analytical results for chromium (all species) in water may be used to demonstrate compliance with the standards. Where the standards cannot be met based on analytical results for chromium (all species), chromium speciation may be necessary.
Standard is 50 µg/L for chromium, hexavalent. Standard is 6000 µg/L for chromium, trivalent. The standard of 50 µg/L was used to identify exceedances for dissolved chromium in order to demonstrate compliance with the standards.

Note 2.7 for Cobalt (dissolved):

The standard in Schedule 3.2 is 1 µg/L. However the BC Ministry of Environment and Climate Change Strategy has set an interim background groundwater concentration estimate of 20 ug/L for Cobalt at sites in the Province. Therefore a standard of 20 ug/L has been used for this criteria set.

Note 2.8 for Copper (dissolved):

Standard is specific to protection of human health. Standard is derived with TRV protective of adults. Standard may not adequately protect other age groups.
Standard may not address aesthetic (organoleptic) concerns related to drinking water quality. Water treatment may be required.

Note 2.9 for Iron (dissolved):

Standard applies to a site used for an industrial or commercial purpose or activity set out in Schedule 2 as
(a) item A6, A7, A8 or A11
(b) item C1, C2, C3, C4 or C6,
(c) item D2, D3, D5, or D6
(d) item E4, or
(e) item H14.
Standard applies to a site used for an industrial or commercial purpose or activity set out in Schedule 2 as item H11 or H20, but only if the site was used for the purpose or activity in conjunction with or as a result of the site also being used for at least one of the purposes or activities set out above.
Standard is specific to protection of human health. Standard is derived with TRV protective of adults. Standard may not adequately protect other age groups. Standard may not address aesthetic (organoleptic) concerns related to drinking water quality. Water treatment may be required.

Note 2.10 for Manganese (dissolved):

Standard applies to a site used for an industrial or commercial purpose or activity set out in Schedule 2 as
(a) item B1
(b) item C1, C3 or C4
(c) item D2, D3, D5, or D6
(d) item E4, or
(e) item H3 or H14.
Standard applies to a site used for an industrial or commercial purpose or activity set out in Schedule 2 as item H11 or H20, but only if the site was used for the purpose or activity in conjunction with or as a result of the site also being used for at least one of the purposes or activities set out above.
Standard is specific to protection of human health. Standard is derived with TRV protective of adults. Standard may not adequately protect other age groups.
Standard may not address aesthetic (organoleptic) concerns related to drinking water quality. Water treatment may be required.

Note 2.11 for Sodium (dissolved):

Standard is specific to protection of human health. Standard is derived with TRV protective of adults. Standard may not adequately protect other age groups.

Note 2.12 for Zinc (dissolved):

Standard is specific to protection of human health. Standard is derived with TRV protective of adults. Standard may not adequately protect other age groups.

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3. Notes for BC Source Drinking Water Quality Guidelines - Maximum Acceptable Concentrations (2020 and updates) (BC SDWQG MAC)

Note 3.1 for E. coli (MPN):

The MAC is ≤ 10 E. coli /100 mL; 90th percentile (minimum of 5 samples).

Note 3.2 for Fecal coliforms (MPN):

The MAC is ≤ 10 coliforms/100 mL; 90th percentile (minimum of 5 samples).

End of Spill Report
Shallow Groundwater Quality Results - Legend

<	Less than reported detection limit
>	Greater than reported upper detection limit
CSR AW	BC CSR Generic Numerical Water Standards for Freshwater Aquatic Life
CSR DW	BC CSR Generic Numerical Water Standards for Drinking Water
BCAWQG AL (ST)	BC Approved Water Quality Guidelines for freshwater aquatic life (Short-term acute)
BCWWQG AL	Working Water Quality Guidelines for British Columbia for freshwater aquatic life
BCAWQG WL	BC Approved Water Quality Guidelines for wildlife
BC SDWQG MAC	BC Source Drinking Water Quality Guidelines - Maximum Acceptable Concentrations (*applied only for microbiological parameters)*
BC RWQG	BC Recreational Water Quality Guidelines (*applied only for microbiological parameters)*
Calc	Calculated guideline or standard. The guideline or standard is dependent on the value of one or more other analytes, and is calculated from a formula or table.
N	Narrative type of guideline or standard, or Result Note.
NS	No Standard
NG	No Guideline
NA	Not Applicable
	The maximum guideline/standard value cannot be determined because a result for a dependent analyte is not available for the sample (see guideline notes for further details).
CSR AW	Highlighted value exceeds CSR AW
CSR DW	Highlighted value exceeds CSR DW
BCAWQG AL (ST)	Highlighted value exceeds BCAWQG AL (ST)
BCWWQG AL	Highlighted value exceeds BCWWQG AL
BCAWQG WL	Highlighted value exceeds BCAWQG WL
BC SDWQG MAC	Highlighted value exceeds BC SDWQG MAC for microbiological parameters
BC RWQG	Highlighted value exceeds BC RWQG for microbiological parameters

End of Spill Report
Shallow Groundwater Quality Results

Analyte	Unit	Standard or Guideline							Sampling Location	RTF-NAR-W1	RTF-NAR-W1	RTF-NAR-W1	RTF-W-DP1	RTF-W-DP1	RTF-W-DP2	RTF-W-DP3	RTF-W-DP4	RTF-W-DP5	RTF-W-DP6
									Date Sampled	19-Oct-20	30-Nov-20	03-Dec-20	16-Dec-20	17-Dec-20	17-Dec-20	17-Dec-20	17-Dec-20	17-Dec-20	17-Dec-20
									Lab Sample ID	VA20B8516-002	VA20C2279-001	VA20C2502-001	VA20C3702-006	VA20C3702-012	VA20C3702-013	VA20C3702-008	VA20C3702-009	VA20C3702-010	VA20C3702-011
		CSR AW	CSR DW	BCAWQG AL (ST)	BCWWQG AL	BCAWQG WL	*BC SDWQG MAC*	BC RWQG											
Lab Results																			
General and Inorganic Parameters																			
Alkalinity (total, as CaCO3)	mg/L	NS	NS	NG	N [4.1]	NG	NA	NA					72.0		171	112	136	170	107
Ammonia (total, as N)	µg/L	Calc [1.1]	NS	Calc [3.1]	NG	NG	NA	NA		16.0	<5.0	<5.0	14.1		<5.0	<250	<250	<25.0	<5.0
Ammonia, total (dissolved as N)	µg/L	Calc [1.2]	NS	NG	NG	NG	NA	NA					14.6		12.3	19.4	<5.0	<5.0	<5.0
Bromide	µg/L	NS	NS	NG	NG	NG	NA	NA					<50		<50	<50	<50	<250	<50
Chloride	mg/L	1500	250 [2.1]	600 [3.2]	NG	600	NA	NA					6.49		7.94	12.8	11.7	18.3	12.3
Conductivity	µS/cm	NS	NS	NG	NG	NG	NA	NA		453									
Fluoride	µg/L	Calc [1.3]	1500	Calc [3.3]	NG	1500 [5.1]	NA	NA					<20		474	57	27	**5880**	22
Nitrate (as N)	mg/L	400 [1.4]	10 [2.2]	32.8 [3.4]	NG	100 [5.2]	NA	NA		0.212	0.340	0.220	<0.0050		0.0153	0.0954	0.0540	<0.0250	0.0564
Nitrate + Nitrite (as N) (calculated)	mg/L	400 [1.5]	10 [2.3]	32.8 [3.5]	NG	100 [5.3]	NA	NA		0.212	0.340	0.220	<0.0051		0.0207	0.1028	0.0540	<0.025	0.0564
Nitrite (as N)	µg/L	Calc [1.6]	1000	Calc [3.6]	NG	10000	NA	NA		<1.0	<1.0	<1.0	<1.0		5.4	7.4	<1.0	13.8	<1.0
Total kjeldahl nitrogen	µg/L	NS	NS	NG	NG	NG	NA	NA		10400			218		1920	1470	1720	15100	196
Nitrogen, dissolved inorganic	µg/L	NS	NS	NG	NG	NG	NA	NA					<20		33	122	58	<26	57
Nitrogen, dissolved organic	µg/L	NS	NS	NG	NG	NG	NA	NA					140		<50	382	66	<50	130
Organic nitrogen, total	mg/L	NS	NS	NG	NG	NG	NA	NA		10.3									
Nitrogen, total	µg/L	NS	NS	NG	NG	NG	NA	NA		13600			212		829	1430	1350	12000	220
Nitrogen, total dissolved	µg/L	NS	NS	NG	NG	NG	NA	NA		333			140		77	504	124	<300	187
Orthophosphate (dissolved, as P)	µg/L	NS	NS	NG	NG	NG	NA	NA					<1.0		2.8	<1.0	<1.0	<1.0	3.2
Oxidation reduction potential	mV	NS	NS	NG	NG	NG	NA	NA		271			191		153	177	181	171	170
pH		NS	NS	N [3.7]	NG	NG	NA	NA		7.68			6.83		7.49	6.83	7.13	6.87	7.39
Sulphate	mg/L	Calc [1.7]	500 [2.4]	Calc [3.8]	NG	NG	NA	NA					33.8		77.4	70.8	63.0	106	66.1
Total dissolved solids	mg/L	NS	NS	NG	NG	NG	NA	NA					143		379	272	254	2560	244
Total suspended solids	mg/L	NS	NS	N [3.9]	NG	N [5.4]	NA	NA		121			57.7		108	248	667	89.3	19.7
Turbidity	NTU	NS	NS	N [3.10]	NG	N [5.5]	NA	NA		75.0									
Microbiological																			
E. coli (MPN)	MPN/100 mL	NS	NS	N [3.11]	NG	NG	10 [6.1]	200 [7.1]		*117*		<1		<1	<1	1	<1	<1	1
Fecal coliforms (MPN)	MPN/100 mL	NS	NS	N [3.12]	NG	NG	10 [6.2]	NG		*236*		<1		2	*51*	1	*67*	*>2420*	*25*
Total coliforms (MPN)	MPN/100 mL	NS	NS	NG	NG	NG	NS	NS		>2420		192		179	88	>2420	1990	>2420	178
Total Metals																			
Phosphorus (total, APHA 4500-P)	µg/L	NS	NS	N [3.13]	NG	NG	NA	NA					25.1		5.3	182	219	90.3	20.1
Dissolved Metals																			
Aluminum (dissolved)	µg/L	NS	9500 [2.5]	Calc [3.14]	NG	5000	NA	NA					38.4		51.2	**116**	22.9	**398**	16.1
Antimony (dissolved)	µg/L	90	6	NG	9 [4.2]	NG	NA	NA					<0.10		0.14	0.11	<0.10	<0.10	<0.10
Arsenic (dissolved)	µg/L	50	10	5 [3.15]	NG	25	NA	NA					0.13		0.19	0.32	0.16	1.67	0.14
Barium (dissolved)	µg/L	10000	1000	NG	1000	NG	NA	NA					8.06		24.7	16.1	5.54	14.9	5.39
Beryllium (dissolved)	µg/L	1.5	8	NG	0.13	NG	NA	NA					<0.020		<0.020	<0.020	<0.020	0.022	<0.020
Bismuth (dissolved)	µg/L	NS	NS	NG	NG	NG	NA	NA					<0.050		<0.050	<0.050	<0.050	<0.050	<0.050
Boron (dissolved)	µg/L	12000	5000	1200 [3.16]	NG	5000	NA	NA					13		22	19	41	60	17
Cadmium (dissolved)	µg/L	Calc [1.8]	5	Calc [3.17]	NG	NG	NA	NA					0.0052		0.0177	0.0072	0.0194	0.0584	<0.0050
Calcium (dissolved)	mg/L	NS	NS	NG	N [4.3]	NG	NA	NA					32.1		73.4	53.6	60.1	88.4	55.4
Cesium (dissolved)	µg/L	NS	NS	NG	NG	NG	NA	NA					<0.010		<0.010	<0.010	<0.010	0.182	<0.010
Chromium (dissolved)	µg/L	10 [1.9]	50 [2.6]	NG	1 [4.4]	NG	NA	NA					<0.50		<0.50	0.56	<0.50	**21.4**	<0.50
Cobalt (dissolved)	µg/L	40	20 [2.7]	110 [3.18]	NG	NG	NA	NA					2.42		4.11	2.10	1.08	3.89	<0.10
Copper (dissolved)	µg/L	Calc [1.10]	1500 [2.8]	N [3.19]	NG	300 [5.6]	NA	NA					0.44		1.15	0.83	0.43	6.32	0.50
Iron (dissolved)	µg/L	NS	6500 [2.9]	350	NG	NG	NA	NA					**1400**		55	199	22	**1140**	19
Lead (dissolved)	µg/L	Calc [1.11]	10	Calc [3.20]	NG	100	NA	NA					<0.050		<0.050	<0.050	<0.050	<0.050	<0.050
Lithium (dissolved)	µg/L	NS	8	NG	NG	NG	NA	NA					<1.0		<1.0	<1.0	<1.0	<1.0	<1.0
Magnesium (dissolved)	mg/L	NS	NS	NG	NG	NG	NA	NA					4.54		10.3	7.22	6.76	7.92	7.20
Manganese (dissolved)	µg/L	NS	1500 [2.10]	Calc [3.21]	NG	NG	NA	NA					176		165	117	22.6	166	2.33
Molybdenum (dissolved)	µg/L	10000	250	2000 [3.22]	NG	50 [5.7]	NA	NA					0.649		1.34	1.16	0.685	2.47	0.360

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Shallow Groundwater Quality Results

Analyte	Unit	Standard or Guideline							Sampling Location	RTF-NAR-W1	RTF-NAR-W1	RTF-NAR-W1	RTF-W-DP1	RTF-W-DP1	RTF-W-DP2	RTF-W-DP3	RTF-W-DP4	RTF-W-DP5	RTF-W-DP6
									Date Sampled	19-Oct-20	30-Nov-20	03-Dec-20	16-Dec-20	17-Dec-20	17-Dec-20	17-Dec-20	17-Dec-20	17-Dec-20	17-Dec-20
									Lab Sample ID	VA20B8516-002	VA20C2279-001	VA20C2502-001	VA20C3702-006	VA20C3702-012	VA20C3702-013	VA20C3702-008	VA20C3702-009	VA20C3702-010	VA20C3702-011
		CSR AW	**CSR DW**	**BCAWQG AL (ST)**	**BCWWQG AL**	BCAWQG WL	*BC SDWQG MAC*	BC RWQG											
Nickel (dissolved)	µg/L	Calc [1.12]	80	NG	Calc [4.5]	NG	NA	NA					7.81		20.7	**30.5**	8.28	**79.0**	1.18
Phosphorus (dissolved, by ICPMS/ICPOES)	µg/L	NS	NS	N [3.23]	NG	NG	NA	NA					<50		<50	<50	<50	<50	<50
Phosphorus (dissolved, APHA 4500-P)	µg/L	NS	NS	N [3.24]	NG	NG	NA	NA					3.3		6.9	14.4	<2.0	<20.0	7.0
Potassium (dissolved)	µg/L	NS	NS	NG	NG	NG	NA	NA					1640		7930	1580	1110	92500	1760
Rubidium (dissolved)	µg/L	NS	NS	NG	NG	NG	NA	NA					1.32		2.64	1.19	0.69	68.0	0.60
Selenium (dissolved)	µg/L	20	10	2 [3.25]	NG	2 [5.8]	NA	NA					0.091		0.209	0.496	0.107	0.130	0.071
Silicon (dissolved, as Si)	µg/L	NS	NS	NG	NG	NG	NA	NA					4330		5830	5380	5830	8660	5620
Silver (dissolved)	µg/L	Calc [1.13]	20	Calc [3.26]	NG	NG	NA	NA					<0.010		<0.010	<0.010	<0.010	<0.010	<0.010
Sodium (dissolved)	mg/L	NS	200 [2.11]	NG	NG	NG	NA	NA					4.12		7.71	13.4	9.20	3.97	6.56
Strontium (dissolved)	µg/L	NS	2500	NG	NG	NG	NA	NA					96.1		192	157	176	213	140
Sulphur (dissolved)	µg/L	NS	NS	NG	NG	NG	NA	NA					11900		26400	25600	22900	12700	24000
Tellurium (dissolved)	µg/L	NS	NS	NG	NG	NG	NA	NA					<0.20		<0.20	<0.20	<0.20	<0.20	<0.20
Thallium (dissolved)	µg/L	3	NS	NG	0.8 [4.6]	NG	NA	NA					<0.010		<0.010	<0.010	<0.010	<0.010	<0.010
Thorium (dissolved)	µg/L	NS	NS	NG	NG	NG	NA	NA					<0.10		<0.10	<0.10	<0.10	<0.10	<0.10
Tin (dissolved)	µg/L	NS	2500	NG	NG	NG	NA	NA					<0.10		<0.10	<0.10	<0.10	0.14	<0.10
Titanium (dissolved)	µg/L	1000	NS	NG	NG	NG	NA	NA					<0.30		<0.30	8.64	0.72	0.82	<0.30
Tungsten (dissolved)	µg/L	NS	3	NG	NG	NG	NA	NA					<0.10		<0.10	<0.10	<0.10	0.13	<0.10
Uranium (dissolved)	µg/L	85	20	NG	8.5	NG	NA	NA					0.013		0.333	0.350	0.271	0.334	0.092
Vanadium (dissolved)	µg/L	NS	20	NG	NG	NG	NA	NA					<0.50		0.78	0.82	0.66	1.26	<0.50
Zinc (dissolved)	µg/L	Calc [1.14]	3000 [2.12]	Calc [3.27]	NG	NG	NA	NA					2470		**6290**	1810	1450	**3870**	129
Zirconium (dissolved)	µg/L	NS	NS	NG	NG	NG	NA	NA					<0.30		<0.30	<0.30	<0.30	<0.30	<0.30

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Shallow Groundwater Quality Results – Guideline Notes

1. Notes for BC CSR Generic Numerical Water Standards for Freshwater Aquatic Life (CSR AW)

General Notes:

BC Contaminated Sites Regulation, Generic Numerical Water Standards, Schedule 3.2; includes amendments up to B.C. Reg. 13/2019, January 24, 2019.
Aquatic life standards assume minimum 1:10 dilution available, and are to protect freshwater life.
Standards for all organic substances are for total substance concentrations. Any water sample to be analyzed for organic substances should not be filtered.
Standards for surface water samples to be analyzed for heavy metals, metalloids and inorganic ions are total substance concentrations. In addition, it is recommended that surface water samples being analyzed for heavy metals, metalloids and inorganic ions should also be analyzed for dissolved substance concentrations.
Standards for groundwater samples for heavy metals, metalloids and inorganic ions are for dissolved substance concentrations. In addition, it is recommended that groundwater samples being analyzed for heavy metals, metalloids and inorganic ions should also be analyzed for total substance concentrations.

Note 1.1 for Ammonia (total, as N):

Standard varies with pH and temperature. 10 degrees C is assumed. Consult a director for further advice.
The standard for ammonia, total (as N) is:
1,310 µg/L @ pH ≥ to 8.5
3,700 µg/L @ pH 8.0 - < 8.5
11,300 µg/L @ pH 7.5 - < 8.0
18,500 µg/L @ pH 7.0 - < 7.5
18,400 µg/L @ pH < 7.0

Note 1.2 for Ammonia, total (dissolved as N):

Standard varies with pH and temperature. 10 degrees C is assumed. Consult a director for further advice.
The standard for ammonia, total (as N) is:
1,310 µg/L @ pH ≥ to 8.5
3,700 µg/L @ pH 8.0 - < 8.5
11,300 µg/L @ pH 7.5 - < 8.0
18,500 µg/L @ pH 7.0 - < 7.5
18,400 µg/L @ pH < 7.0

Note 1.3 for Fluoride:

The standard for fluoride is:
2000 µg/L @ H < 50
3000 µg/L @ H ≥ 50
Where H means water hardness in mg/L as CaCO3.

Note 1.4 for Nitrate (as N):

Standard may not protect all amphibians. Consult director for further advice.

Note 1.5 for Nitrate + Nitrite (as N) (calculated):

Standard may not protect all amphibians. Consult director for further advice.

Note 1.6 for Nitrite (as N):

Standard varies with chloride concentration. Consult a director for further advice.
The standard for nitrite (as N) is:
200 µg/L (Cl < 2 mg/L)
400 µg/L (Cl 2 - < 4 mg/L)
600 µg/L (Cl 4 - < 6 mg/L)
800 µg/L (Cl 6 - < 8 mg/L)
1,000 µg/L (Cl 8 - < 10 mg/L)
2,000 µg/L (Cl ≥ 10 mg/L)

Note 1.7 for Sulphate:

The standard for sulfate is:
1280 mg/L @ H ≤ 30
2180 mg/L @ H 31 - 75
3090 mg/L @ H 76 - 180
4290 mg/L @ H > 180
Where H means water hardness in mg/L as CaCO3.

Note 1.8 for Cadmium (dissolved):

The standard for cadmium is as follows:
0.5 µg/L @ H < 30
1.5 µg/L @ H 30 - < 90
2.5 µg/L @ H 90 - < 150
3.5 µg/L @ H 150 - < 210
4 µg/L @ H ≥ 210
Where H means water hardness in mg/L as CaCO3.

Note 1.9 for Chromium (dissolved):

Analytical results for chromium (all species) in water may be used to demonstrate compliance with the standards. Where the standards cannot be met based on analytical results for chromium (all species), chromium speciation may be necessary.
Standard is 10 µg/L for chromium, hexavalent. Standard is 90 µg/L for chromium, trivalent. The standard of 10 µg/L was used to identify exceedances for dissolved chromium in order to demonstrate compliance with the standards.

Note 1.10 for Copper (dissolved):

The standard for copper is as follows:
20 µg/L @ H < 50
30 µg/L @ H 50 - < 75
40 µg/L @ H 75 - < 100
50 µg/L @ H 100 - < 125
60 µg/L @ H 125 - < 150
70 µg/L @ H 150 - < 175
80 µg/L @ H 175 - < 200
90 µg/L @ H ≥ 200
Where H means water hardness in mg/L as CaCO3.

Note 1.11 for Lead (dissolved):

The standard for lead is as follows:
40 µg/L @ H < 50
50 µg/L @ H 50 - < 100
60 µg/L @ H 100 - < 200
110 µg/L @ H 200 - < 300
160 µg/L @ ≥ 300
Where H means water hardness in mg/L as CaCO3.

Note 1.12 for Nickel (dissolved):

The standard for nickel is as follows:
250 µg/L @ H < 60
650 µg/L @ H 60 - < 120
1,100 µg/L @ H 120 - < 180
1,500 µg/L @ H ≥ 180
Where H means water hardness in mg/L as CaCO3.

Note 1.13 for Silver (dissolved):

The standard for silver is:
0.5 µg/L @ H ≤ 100
15 µg/L @ H > 100
Where H means water hardness in mg/L as CaCO3.

Note 1.14 for Zinc (dissolved):

The standard for zinc is as follows:
75 µg/L @ H < 90
150 µg/L @ H = 90 - < 100
900 µg/L @ H = 100 - < 200
1,650 µg/L @ H = 200 - < 300
2,400 µg/L @ H = 300 - < 400
3,150 µg/L @ H = 400 - < 500
If H ≥ 500 then use following formula:
Standard (µg/L) = 10 x [7.5 +{(0.75)(H – 90)}]
Where H means water hardness in mg/L as CaCO3.
There are special ministry approval and data reporting requirements for water hardness values ≥ 500 mg/L as CaCO3.
Reference is Schedule 3.2 and Protocol 10.

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2. Notes for BC CSR Generic Numerical Water Standards for Drinking Water (CSR DW)

General Notes:

Drinking water standards are for unfiltered samples obtained at the point of consumption. Heavy metals, metalloids and inorganic ions are expressed as total substance concentrations unless otherwise indicated.

Note 2.1 for Chloride:

Standard to protect against taste and odour concerns.

Note 2.2 for Nitrate (as N):

Where nitrate and nitrite are present, total nitrate plus nitrite-nitrogen should not exceed this value.

Note 2.3 for Nitrate + Nitrite (as N) (calculated):

Where nitrate and nitrite are present, total nitrate plus nitrite-nitrogen should not exceed this value.

Note 2.4 for Sulphate:

Standard to protect against taste and odour concerns.

Note 2.5 for Aluminum (dissolved):

Standard is specific to protection of human health. Standard is derived with TRV protective of adults. Standard may not adequately protect other age groups.
Standard may not address aesthetic (organoleptic) concerns related to drinking water quality. Water treatment may be required.

Note 2.6 for Chromium (dissolved):

Analytical results for chromium (all species) in water may be used to demonstrate compliance with the standards. Where the standards cannot be met based on analytical results for chromium (all species), chromium speciation may be necessary.
Standard is 50 µg/L for chromium, hexavalent. Standard is 6000 µg/L for chromium, trivalent. The standard of 50 µg/L was used to identify exceedances for dissolved chromium in order to demonstrate compliance with the standards.

Note 2.7 for Cobalt (dissolved):

The standard in Schedule 3.2 is 1 µg/L. However the BC Ministry of Environment and Climate Change Strategy has set an interim background groundwater concentration estimate of 20 ug/L for Cobalt at sites in the Province. Therefore a standard of 20 ug/L has been used for this criteria set.

Note 2.8 for Copper (dissolved):

Standard is specific to protection of human health. Standard is derived with TRV protective of adults. Standard may not adequately protect other age groups.
Standard may not address aesthetic (organoleptic) concerns related to drinking water quality. Water treatment may be required.

Note 2.9 for Iron (dissolved):

Standard applies to a site used for an industrial or commercial purpose or activity set out in Schedule 2 as
(a) item A6, A7, A8 or A11
(b) item C1, C2, C3, C4 or C6,
(c) item D2, D3, D5, or D6
(d) item E4, or
(e) item H14.
Standard applies to a site used for an industrial or commercial purpose or activity set out in Schedule 2 as item H11 or H20, but only if the site was used for the purpose or activity in conjunction with or as a result of the site also being used for at least one of the purposes or activities set out above.
Standard is specific to protection of human health. Standard is derived with TRV protective of adults. Standard may not adequately protect other age groups. Standard may not address aesthetic (organoleptic) concerns related to drinking water quality. Water treatment may be required.

Note 2.10 for Manganese (dissolved):

Standard applies to a site used for an industrial or commercial purpose or activity set out in Schedule 2 as
(a) item B1
(b) item C1, C3 or C4
(c) item D2, D3, D5, or D6
(d) item E4, or
(e) item H3 or H14.
Standard applies to a site used for an industrial or commercial purpose or activity set out in Schedule 2 as item H11 or H20, but only if the site was used for the purpose or activity in conjunction with or as a result of the site also being used for at least one of the purposes or activities set out above.
Standard is specific to protection of human health. Standard is derived with TRV protective of adults. Standard may not adequately protect other age groups.
Standard may not address aesthetic (organoleptic) concerns related to drinking water quality. Water treatment may be required.

Note 2.11 for Sodium (dissolved):

Standard is specific to protection of human health. Standard is derived with TRV protective of adults. Standard may not adequately protect other age groups.

Note 2.12 for Zinc (dissolved):

Standard is specific to protection of human health. Standard is derived with TRV protective of adults. Standard may not adequately protect other age groups.

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3. Notes for BC Approved Water Quality Guidelines for freshwater aquatic life (Short-term acute) (BCAWQG AL (ST))

General Notes:

For some parameters, there are two water quality guidelines: the short-term acute guideline (i.e. maximum), and the long-term chronic guideline (i.e. average). The short-term acute guideline was used in this criteria set for parameters that have both guideline values.

Note 3.1 for Ammonia (total, as N):

The maximum guideline for ammonia varies as a function of pH and temperature. See Table 3 in Overview Report Update September 2009.
The 30-day average guideline for ammonia varies as a function of pH and temperature. See Table 4 in Overview Report Update September 2009. / The lab pH and field temperature results were used for determining the maximum ammonia for this report. If a lab pH result was not available then the field pH result was used.

Note 3.2 for Chloride:

To protect freshwater aquatic life from acute and lethal effects, the maximum concentration of chloride (mg/L as NaCl) at any time should not exceed 600 mg/L.
To protect freshwater aquatic life from chronic effects, the average (arithmetic mean computed from five weekly samples collected over a 30-day period) concentration of chloride (mg/L as NaCl) should not exceed 150 mg/L.

Note 3.3 for Fluoride:

Correction by BC MOE Sept. 2011: The criteria for Fluoride (total) in mg/L is 0.4 as a maximum where the water hardness (as CaCO3) is less than or equal to 10 mg/L. Otherwise use the equation:
LC50 fluoride = -51.73 + 92.57 log10 (Hardness) and multiply by 0.01.
Hardness is as CaCO3 in units mg/L.

Note 3.4 for Nitrate (as N):

The guideline maximum for nitrate (as N) is 32.8 mg/l.
The 30-day average guideline for nitrate (as N) is 3.0 mg /L. The 30-day average (chronic) concentration is based on 5 weekly samples collected within a 30-day period.
Where nitrate and nitrite are present, the total nitrate+nitrite nitrogen should not exceed these values.

Note 3.5 for Nitrate + Nitrite (as N) (calculated):

The guideline maximum for nitrate (as N) is 32.8 mg/l.
The 30-day average guideline for nitrate (as N) is 3.0 mg /L. The 30-day average (chronic) concentration is based on 5 weekly samples collected within a 30-day period.
Where nitrate and nitrite are present, the total nitrate+nitrite nitrogen should not exceed these values.

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Note 3.6 for Nitrite (as N):

The guideline maximum for nitrite as N is:
0.06 mg/L if chloride less than 2 mg/L
0.12 mg/L if chloride is 2 to 4 mg/L
0.18 mg/L if chloride is 4 to 6 mg/L
0.24 mg/L if chloride is 6 to 8 mg/L
0.30 mg/L if chloride is 8 to 10 mg/L
0.60 mg/L if chloride is greater than 10 mg/L.
The guideline 30-day average for nitrite as N is:
0.02 mg/L if chloride less than 2 mg/L
0.04 mg/L if chloride is 2 to 4 mg/L
0.06 mg/L if chloride is 4 to 6 mg/L
0.08 mg/L if chloride is 6 to 8 mg/L
0.10 mg/L if chloride is 8 to 10 mg/L
0.20 mg/L if chloride is greater than 10 mg/L.

Note 3.7 for pH:

pH less than 6.5: No statistically significant decrease in pH from background.
pH from 6.5 to 9.0: Unrestricted change permitted within this range.
pH over 9.0: No statistically significant increase in pH from background.
See BC MOE Overview Report for additional details.

Note 3.8 for Sulphate:

The approved 30-day average (minimum of 5 evenly-spaced samples collected in 30 days) water quality guidelines to protect aquatic life in BC for sulphate are:
128 mg/L at hardness of 0 to 30 mg/L as CaCO3
218 mg/L at hardness of 31 to 75 mg/L as CaCO3
309 mg/L at hardness of 76 to 180mg/L as CaCO3
429 mg/L at hardness 181 to 250 mg/L as CaCO3
Need to determine guideline based on site water for hardness greater than 250 mg/L as CaCO3.
For screening purposes in this report, exceedance were flagged for sulphate greater than 429 mg/L at hardness greater than 250 mg/L as CaCO3.

Note 3.9 for Total suspended solids:

Maximum Induced Suspended Sediments - mg/L or % of background:
- 25 mg/L in 24 hours when background is less than or equal to 25;
- Mean of 5 mg/L in 30 days when background is less than or equal to 25;
- 25 mg/L when background is between 25 and 250;
- 10% when background is greater than or equal to 250.

Note 3.10 for Turbidity:

When background is less than or equal to 8 NTU:
- Maximum Induced Turbidity of 8 NTU in 24 hours.
- For sediment inputs that last between 24 hours and 30 days (daily sampling preferred) the mean turbidity should not exceed background by more than 2 NTU.
Maximum Induced Turbidity of 5 NTU when background is between 8 and 50 NTU.
Maximum Induced Turbidity of 10% when background is greater than 50 NTU.

Note 3.11 for E. coli (MPN):

The escherichia coli density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.

Note 3.12 for Fecal coliforms (MPN):

The guideline for fecal coliforms is as follows: “The fecal coliform density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.”

Note 3.13 for Phosphorus (total, APHA 4500-P):

Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.

Note 3.14 for Aluminum (dissolved):

The maximum concentration of dissolved aluminum at any time should not exceed:
1. 0.10 mg/L when the pH is greater than or equal to 6.5
2. The value (in mg/L) determined by the following relationship if pH less than 6.5
Dissolved Aluminum = e (1.209-2.426 (pH) + 0.286 (pH)^2)
The 30-day average concentration of dissolved aluminum (based on a minimum of 5 approximately weekly samples) should not exceed:
1. 0.05 mg/L when the median pH over 30 days is greater than or equal to 6.5
2. the value determined by the following relationship at median pH less than 6.5
Dissolved Aluminum = e (1.6-3.327 (median pH) + 0.402 (median pH)^2)

Note 3.15 for Arsenic (dissolved):

The recommended guideline is for total arsenic.

Note 3.16 for Boron (dissolved):

The recommended guideline is for total boron.

Note 3.17 for Cadmium (dissolved):

The guideline for cadmium is determined on a site-specific basis according to the local water hardness. The guideline for cadmium (dissolved) in µg/L is determined by the following equations for short term exposure:
1. If hardness (as CaCO3) is less than 7 mg/L then maximum is 0.0380 µg/L
2. If hardness (as CaCO3) is from 7 to 45 mg/L then maximum is based on equation:
e to the power of {1.03[ln(hardness)] - 5.274}
3. If hardness (as CaCO3) is greater than 455 mg/L then maximum is 2.8 µg/L.
When water hardness is greater than the upper bound (i.e., highest water hardness tested), a site-specific assessment may be required.

Note 3.18 for Cobalt (dissolved):

The interim maximum concentration for total cobalt is 110 µg/L to protect aquatic life in the freshwater environment from acute effects of cobalt.
The interim 30-day average concentration for total cobalt (based on five weekly samples) is 4 µg/L to protect aquatic life from chronic effects of cobalt.

Note 3.19 for Copper (dissolved):

The guideline is for dissolved copper and is dependent on the specific chemistry of the water body and can only be calculated using the British Columbia Biotic Ligand Model (BC BLM) software. (Update August 2019)

Note 3.20 for Lead (dissolved):

The maximum guideline for total lead in water, at a water hardness less than or equal to 8 mg/L as CaCO3 is set at 3.0 µg/L. When water hardness exceeds 8.0 mg/L CaCO3 the maximum guideline for lead at any time is given by the following equation:
Maximum Criteria (µg/L) = exp (1.273 ln(hardness) - 1.460).
The 30-day average guideline for total lead in water, when water hardness exceeds 8 mg/L as CaCO3, is as follows:
30-Day Average (µg/L) is less than or equal to 3.31 + exp (1.273 ln (mean hardness) - 4.704).
For hardness less than or equal to 8.0 mg/L there is no 30-day average guideline; hence the maximum concentration of 3.0 µg/L is used.

Note 3.21 for Manganese (dissolved):

The maximum concentration of total manganese in mg/L at any time should not exceed the value as determined by the following relationship:
0.01102 hardness + 0.54
where water hardness is reported as mg/L of CaCO3.
The 30-day mean concentration of total manganese in mg/L should be less than or equal to the value as determined by the following relationship:
0.0044 hardness + 0.605
where water hardness is reported as mg/L of CaCO3.

Note 3.22 for Molybdenum (dissolved):

The maximum concentration for total molybdenum is 2 mg/L.
The 30-day average concentration for total molybdenum (based on at least five weekly samples in a period of 30 days) is less than or equal to 1 mg/L.

Note 3.23 for Phosphorus (dissolved, by ICPMS/ICPOES):

Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.

Note 3.24 for Phosphorus (dissolved, APHA 4500-P):

Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.

Note 3.25 for Selenium (dissolved):

The 30-day average water quality guideline for protection of aquatic life is 2 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.
The 30-day average alert concentration for the protection of aquatic life in sensitive ecosystems is 1 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.

Note 3.26 for Silver (dissolved):

The guideline maximum for total silver is:
0.1 µg/L maximum if hardness less than or equal to 100 mg/L
3.0 µg/L maximum if hardness greater than 100 mg/L.
The guideline 30-day average for total silver is:
0.05 µg/L as 30-day mean if hardness less than or equal to 100 mg/L
1.5 µg/L as 30-day mean if hardness greater than 100 mg/L.

Note 3.27 for Zinc (dissolved):

The Short-term Maximum concentration of total zinc (µg/L) at any time should not exceed 33 µg/L when water hardness is less than or equal to 90 mg/L as CaCO3.
When water hardness exceeds 90 mg/L CaCO3, the Short-term Maximum guideline in µg/L for total zinc is the value determined by the following relationship:
33 + 0.75 * (hardness - 90)
where water hardness is reported as mg/L of CaCO3.
Short-term maximum WQG formula applies to water hardness between 90 – 500 mg/L CaCO3.
The Long-term Average concentration of total zinc (µg/L) at any time should not exceed 7.5 µg/L when water hardness is less than or equal to 90 mg/L as CaCO3.
When water hardness exceeds 90 mg/L CaCO3, the Long-term Average guideline in µg/L for total zinc is the value determined by the following relationship:
7.5 + 0.75 * (hardness - 90)
where water hardness is reported as mg/L of CaCO3.
Long-term average WQG formula applies to water hardness between 90 – 330 mg/L CaCO3.

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4. Notes for Working Water Quality Guidelines for British Columbia for freshwater aquatic life (BCWWQG AL)

General Notes:

End of Spill Report
Shallow Groundwater Quality Results – Guideline Notes

Reference: Working Water Quality Guidelines for British Columbia (2015). WWQG values are long-term (i.e. average) concentrations unless identified as a short-term maximum in the "Notes" for a specific analyte. Long-term WWQGs represent average substance concentrations calculated from 5 samples in 30 days. WWQG are given for total substance concentrations unless otherwise noted.

Note 4.1 for Alkalinity (total, as CaCO3):

The guideline for alkalinity (total as CaCO3) is as follows:
- Less than 10 mg/L, highly sensitive to acid inputs
- 10 to 20 mg/L, moderately sensitive to acid inputs
- Greater than 20 mg/L, low sensitivity to acid inputs.

Note 4.2 for Antimony (dissolved):

The guideline is for antimony (III).

Note 4.3 for Calcium (dissolved):

The guideline for dissolved calcium in mg/L is as follows:
- Less than 4, highly sensitive to acid inputs
- 4 to 8, moderately sensitive
- Greater than 8, low sensitivity.

Note 4.4 for Chromium (dissolved):

The guideline for Cr(VI) is 1 µg/L (total). The guideline for Cr(III) is 8.9 µg/L (total). The guideline of 1 µg/L for Cr(VI) was used, in this report, to identify exceedances for dissolved chromium, and total chromium as a means for determining the potential for exceeding the Cr(VI) and/or Cr(III) guidelines.

Note 4.5 for Nickel (dissolved):

The guideline for nickel in µg/L is determined as follows:
When the water hardness is 0 to ≤ 60 mg/L, the maximum is 25 µg/L
At hardness > 60 to ≤ 180 mg/L the maximum is calculated using the equation:
e raised to the power of {0.76[ln(hardness)] + 1.06}
At hardness >180 mg/L, the maximum is 150 µg/L
Where water hardness is reported as mg/L CaCO3.
If the water hardness is unknown, the maximum is 25 µg/L.

Note 4.6 for Thallium (dissolved):

30-day average, site-specific objective for the lower Columbia River, BC

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5. Notes for BC Approved Water Quality Guidelines for wildlife (BCAWQG WL)

General Notes:

The Water Quality Guidelines (Criteria) Reports by BC Ministry of Environment were used as references for the guidelines. (Internet address: http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html). Overview Reports (BC MOE) were used as the references for the guidelines unless the note for specific analyte indicates that the Technical Appendix (BC MOE) was used.

Note 5.1 for Fluoride:

Total fluoride should not exceed 1.0 mg/L as a 30-day average or 1.5 mg/L as a maximum in fresh water used by wildlife.

Note 5.2 for Nitrate (as N):

The guideline maximum for Wildlife for nitrate as nitrogen is 100 mg/l. Where nitrate and nitrite are present, the total nitrate+nitrite nitrogen should not exceed this value.

Note 5.3 for Nitrate + Nitrite (as N) (calculated):

The guideline maximum for Wildlife for nitrate as nitrogen is 100 mg/l. Where nitrate and nitrite are present, the total nitrate+nitrite nitrogen should not exceed this value.

Note 5.4 for Total suspended solids:

Induced suspended sediments should not exceed 20 mg/L when background suspended sediments is less than or equal to 100 mg/L, nor should induced suspended sediments be more than 20 % of background when background is greater than 100 mg/L.

Note 5.5 for Turbidity:

Induced turbidity should not exceed 10 NTU when background turbidity is less than or equal to 50 NTU, nor should induced turbidity be more than 20 % of background when background is greater than 50 NTU.

Note 5.6 for Copper (dissolved):

The guideline maximum is for total copper.

Note 5.7 for Molybdenum (dissolved):

The guideline maximum is for total molybdenum.

Note 5.8 for Selenium (dissolved):

The water column (aquatic life) guideline of 2 µg/L, and the dietary guideline of 4 µg/g in food items, are applicable to wildlife species. The 30-day average water quality guideline for protection of aquatic life is 2 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.
The chronic tissue guideline for the protection of wildlife, using birds as a surrogate, is 6 µg/g (dw) in bird egg tissue, calculated as the mean concentration of at least 8 eggs (from 8 individual nests) in a representative area, reported as dry weight.

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6. Notes for BC Source Drinking Water Quality Guidelines - Maximum Acceptable Concentrations (2020 and updates) (BC SDWQG MAC)

Note 6.1 for E. coli (MPN):

The MAC is ≤ 10 E. coli /100 mL; 90th percentile (minimum of 5 samples).

Note 6.2 for Fecal coliforms (MPN):

The MAC is ≤ 10 coliforms/100 mL; 90th percentile (minimum of 5 samples).

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7. Notes for BC Recreational Water Quality Guidelines (BC RWQG)

Note 7.1 for E. coli (counts):

The geometric mean guideline is ≤ 200 E. coli /100 mL and is a geometric mean of a minimum of 5 samples in 30 days.
The single sample maximum concentration guideline is ≤ 400 E. coli /100 mL. / The most stringent guideline was used in this report.

End of Spill Report
Soil Quality Results – Legend

<	Less than reported detection limit
>	Greater than reported upper detection limit
Calc	Calculated guideline or standard. The guideline or standard is dependent on the value of one or more other analytes, and is calculated from a formula or table.
CSR IL	BC Contaminated Sites Regulation, Soil Standards for Industrial Land Use
CSR PL	BC Contaminated Sites Regulation, Soil Standards for Urban Park Land Use
N	Narrative type of guideline or standard, or Result Note.
NS	No Standard
CSR IL	Highlighted value exceeds CSR IL
CSR PL	Highlighted value exceeds CSR PL

End of Spill Report
Soil Quality Results

Analyte	Unit	Standard		Sampling Location	RTF-NAR-S1	RTF-NAR-S1	RTF-NAR-SB1	RTF-P-S1	RTF-P-S1	RTF-P-S2	RTF-P-S2	RTF-P-S3	RTF-P-S3	RTF-P-SB1	RTF-P-SB2	RTF-W-S1W	RTF-W-S2E	RTF-W-S2W
				Date Sampled	21-Oct-20	18-Nov-20	21-Oct-20	21-Oct-20	18-Nov-20	21-Oct-20	18-Nov-20	21-Oct-20	18-Nov-20	21-Oct-20	21-Oct-20	21-Oct-20	21-Oct-20	21-Oct-20
				Lab Sample ID	VA20B8814-007	VA20C1155-004	VA20B8814-006	VA20B8814-001	VA20C1155-001	VA20B8814-002	VA20C1155-002	VA20B8814-003	VA20C1155-003	VA20B8814-004	VA20B8814-005	VA20B8814-010	VA20B8935-002	VA20B8935-003
		CSR PL	CSR IL															
Lab Results																		
General																		
Moisture	% wet	NS	NS		14.4	14.9	8.09	7.66	6.44	6.40	8.98	8.10	8.03	6.64	6.51	73.8	20.4	29.6
Water-soluble nitrate (as N) (mass/mass)	µg/g	50000	400000		3.41		0.139	0.328		0.191		0.211		<0.050	<0.050	0.404	<0.050	1.17
Water-soluble nitrite (as N) (mass/mass)	µg/g	3000	25000		<0.010		<0.010	0.014		0.014		<0.010		<0.010	<0.010	0.014	0.044	0.177
pH (in 2:1 water:soil mixture)		NS	NS		7.30		8.23	7.60		7.96		7.68		7.89	7.91	6.48	5.80	5.95
Soluble ammonia (as N)	mg/L	NS	NS		<1.0		<1.0	<1.0		<2.5		<1.0		<1.0	<1.0	<5.0	<1.0	<1.0
Microbiological																		
E. coli (MPN)	MPN/g	NS	NS		>1860	1840	3	>1740	>1670	1710	231	>1750	372	14	8	<2	3	15
Fecal coliforms (MPN)	MPN/g dry	NS	NS		>1860	1840	8	>1740	>1670	>1710	231	>1750	372	14	8	2	3	15
Total coliforms (MPN)	MPN/g	NS	NS		>1860	>1840	118	>1740	>1670	>1710	>1750	>1750	>1720	370	97	267	2010	336
Metals																		
Aluminum	µg/g	40000	250000		25400		26800	34800		29900		34700		27000	31300	24500	27900	27000
Antimony	µg/g	20 [1.1]	40 [2.1]		0.22		0.21	0.30		0.24		0.21		0.13	0.23	0.37	0.29	0.25
Arsenic	µg/g	10 [1.2]	10 [2.2]		3.54		2.35	2.95		3.06		3.11		3.38	3.07	4.61	5.15	4.57
Barium	µg/g	350 [1.3]	350 [2.3]		35.7		22.4	25.4		18.6		21.4		18.6	21.6	34.9	179	74.1
Beryllium	µg/g	Calc [1.4]	Calc [2.4]		0.31		0.24	0.38		0.35		0.36		0.29	0.32	0.40	0.36	0.42
Bismuth	µg/g	NS	NS		<0.20		<0.20	<0.20		<0.20		<0.20		<0.20	<0.20	<0.20	<0.20	<0.20
Boron	µg/g	15000	1000000		<5.0		<5.0	8.5		5.6		12.0		<5.0	7.0	8.1	<5.0	6.0
Cadmium	µg/g	Calc [1.5]	Calc [2.5]		0.086		0.072	0.064		0.050		0.104		0.050	0.054	0.320	0.155	0.171
Calcium	µg/g	NS	NS		14500		15900	22400		17400		17000		15800	17600	17200	9190	7440
Chromium	µg/g	60 [1.6]	60 [2.6]		39.8		49.9	*77.5*		*93.4*		*76.0*		*62.3*	*70.4*	56.7	29.6	34.6
Cobalt	µg/g	25 [1.7]	25 [2.7]		18.0		19.8	22.1		20.9		23.3		19.6	21.6	13.7	12.6	13.9
Copper	µg/g	Calc [1.8]	Calc [2.8]		62.4		81.0	71.0		59.9		71.9		85.3	71.9	34.1	19.6	28.9
Iron	µg/g	35000	150000		32800		*36800*	*38800*		*35800*		*39000*		*36100*	*38100*	26200	29700	29000
Lead	µg/g	120 [1.9]	Calc [2.9]		4.48		2.25	2.92		2.92		2.96		2.02	3.10	9.31	10.9	8.72
Lithium	µg/g	65	450		8.1		8.4	8.3		7.8		7.8		8.3	9.0	7.9	10.2	10.2
Magnesium	µg/g	NS	NS		11000		14600	17200		15600		17000		16200	16200	9060	7460	6490
Manganese	µg/g	2000 [1.10]	2000 [2.10]		825		581	669		631		712		608	675	774	1900	853
Mercury	µg/g	25 [1.11]	75 [2.11]		<0.0500		<0.0500	<0.0500		<0.0500		<0.0500		<0.0500	<0.0500	0.0955	0.0562	<0.0500
Molybdenum	µg/g	3 [1.12]	15 [2.12]		0.74		0.71	0.42		0.45		0.39		0.33	0.69	1.43	0.67	1.22
Nickel	µg/g	Calc [1.13]	Calc [2.13]		30.0		38.0	43.1		43.3		45.2		42.4	43.3	34.0	21.2	26.7
Phosphorus	µg/g	NS	NS		719		575	853		892		909		874	815	548	888	537
Potassium	µg/g	NS	NS		540		410	650		460		460		420	490	360	540	700
Selenium	µg/g	1 [1.14]	1 [2.14]		0.33		<0.20	<0.20		<0.20		<0.20		<0.20	0.22	*2.43*	<0.20	0.20
Silver	µg/g	20 [1.15]	40 [2.15]		<0.10		<0.10	<0.10		<0.10		<0.10		<0.10	<0.10	0.15	<0.10	<0.10
Sodium	µg/g	NS	NS		343		516	303		183		187		147	219	166	147	164
Strontium	µg/g	20000	150000		37.7		36.9	46.0		32.9		35.8		24.8	37.8	46.8	39.6	31.8
Sulphur	µg/g	NS	NS		<1000		<1000	<1000		<1000		<1000		<1000	<1000	2800	<1000	<1000
Thallium	µg/g	9 [1.16]	25 [2.16]		<0.050		<0.050	<0.050		<0.050		<0.050		<0.050	<0.050	<0.050	0.063	0.051
Tin	µg/g	50 [1.17]	300 [2.17]		<2.0		<2.0	<2.0		<2.0		<2.0		<2.0	<2.0	<2.0	<2.0	<2.0
Titanium	µg/g	NS	NS		1740		1880	2040		1540		1630		1090	1660	1300	1360	1430
Tungsten	µg/g	25	200		<0.50		<0.50	<0.50		<0.50		<0.50		<0.50	<0.50	<0.50	<0.50	<0.50
Uranium	µg/g	15 [1.18]	30 [2.18]		0.352		0.231	0.338		0.317		0.346		0.244	0.299	3.95	0.310	0.496
Vanadium	µg/g	100 [1.19]	100 [2.19]		89.4		94.0	*113*		96.0		*113*		84.7	99.7	77.9	79.4	80.7
Zinc	µg/g	Calc [1.20]	Calc [2.20]		128		66.9	54.9		54.4		59.9		55.4	59.3	49.1	80.7	69.6
Zirconium	µg/g	NS	NS		3.2		4.9	2.5		2.0		2.4		1.8	3.1	2.3	2.7	3.0

WIRELESS WATER

End of Spill Report
Soil Quality Results

Analyte	Unit	Standard		Sampling Location	RTF-W-S3E	RTF-W-S3W	RTF-W-S4E	RTF-W-S4W	RTF-W-S5E	RTF-W-S5W	RTF-W-S6E	RTF-W-S6W
				Date Sampled	21-Oct-20	21-Oct-20	21-Oct-20	21-Oct-20	22-Oct-20	22-Oct-20	22-Oct-20	22-Oct-20
				Lab Sample ID	VA20B8935-005	VA20B8935-006	VA20B8935-008	VA20B8935-009	VA20B8935-011	VA20B8935-012	VA20B8935-014	VA20B8935-015
		CSR PL	CSR IL									
Lab Results												
General												
Moisture	% wet	NS	NS		18.8	28.5	23.3	32.4	19.6	23.9	21.9	27.5
Water-soluble nitrate (as N) (mass/mass)	µg/g	50000	400000		<0.050	4.72	<0.050	<0.050	<0.050	<0.050	<0.050	0.096
Water-soluble nitrite (as N) (mass/mass)	µg/g	3000	25000		0.022	0.155	<0.010	0.046	<0.010	<0.010	<0.010	<0.010
pH (in 2:1 water:soil mixture)		NS	NS		5.62	6.07	5.88	5.09	5.61	5.73	5.58	5.80
Soluble ammonia (as N)	mg/L	NS	NS		<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0
Microbiological												
E. coli (MPN)	MPN/g	NS	NS		4	75	<2	80	<2	<2	44	37
Fecal coliforms (MPN)	MPN/g dry	NS	NS		4	75	<2	80	<2	<2	44	37
Total coliforms (MPN)	MPN/g	NS	NS		133	222	119	2370	42	10	44	215
Metals												
Aluminum	µg/g	40000	250000		34000	31000	37400	21600	32700	36400	29100	34900
Antimony	µg/g	20 [1.1]	40 [2.1]		0.23	0.26	0.28	0.43	0.22	0.28	0.29	0.49
Arsenic	µg/g	10 [1.2]	10 [2.2]		3.77	4.34	4.28	8.68	3.08	4.18	4.69	5.52
Barium	µg/g	350 [1.3]	350 [2.3]		117	86.5	126	*369*	109	89.9	192	144
Beryllium	µg/g	Calc [1.4]	Calc [2.4]		0.50	0.50	0.54	0.38	0.50	0.48	0.59	0.55
Bismuth	µg/g	NS	NS		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron	µg/g	15000	1000000		<5.0	5.6	5.8	5.3	<5.0	<5.0	<5.0	5.3
Cadmium	µg/g	Calc [1.5]	Calc [2.5]		0.136	0.186	0.184	0.578	0.121	0.167	0.167	0.174
Calcium	µg/g	NS	NS		6990	8680	8160	9780	5420	6400	6820	8590
Chromium	µg/g	60 [1.6]	60 [2.6]		38.0	38.6	34.7	29.4	34.6	38.7	26.4	37.0
Cobalt	µg/g	25 [1.7]	25 [2.7]		14.8	15.0	14.4	13.8	12.4	13.8	13.6	16.2
Copper	µg/g	Calc [1.8]	Calc [2.8]		31.6	41.9	20.9	33.9	12.4	28.1	11.0	20.3
Iron	µg/g	35000	150000		*35800*	29700	33900	25000	34800	32300	*36700*	*37200*
Lead	µg/g	120 [1.9]	Calc [2.9]		8.03	10.2	11.6	25.9	9.52	11.1	13.9	12.4
Lithium	µg/g	65	450		10.8	10.6	11.8	6.5	11.7	9.4	12.4	11.4
Magnesium	µg/g	NS	NS		8670	7700	7590	4950	6250	7340	5640	7950
Manganese	µg/g	2000 [1.10]	2000 [2.10]		1020	923	1160	*5160*	456	766	*2120*	1540
Mercury	µg/g	25 [1.11]	75 [2.11]		<0.0500	<0.0500	0.0638	0.101	<0.0500	0.0727	0.0712	0.0812
Molybdenum	µg/g	3 [1.12]	15 [2.12]		0.58	0.96	0.69	0.35	0.87	0.61	0.52	0.58
Nickel	µg/g	Calc [1.13]	Calc [2.13]		28.1	31.0	27.9	21.4	26.0	28.9	21.5	30.4
Phosphorus	µg/g	NS	NS		524	747	495	2090	323	734	992	1340
Potassium	µg/g	NS	NS		620	910	710	1030	480	510	640	590
Selenium	µg/g	1 [1.14]	1 [2.14]		<0.20	0.26	<0.20	0.32	<0.20	0.33	<0.20	0.26
Silver	µg/g	20 [1.15]	40 [2.15]		0.10	<0.10	<0.10	0.17	<0.10	<0.10	<0.10	<0.10
Sodium	µg/g	NS	NS		174	234	161	192	142	155	138	169
Strontium	µg/g	20000	150000		31.3	35.6	39.5	62.6	30.4	28.9	33.6	41.0
Sulphur	µg/g	NS	NS		<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000
Thallium	µg/g	9 [1.16]	25 [2.16]		0.059	0.054	0.079	0.121	0.055	0.070	0.082	0.082
Tin	µg/g	50 [1.17]	300 [2.17]		<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium	µg/g	NS	NS		2090	1700	1950	1140	1940	1770	2100	1850
Tungsten	µg/g	25	200		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Uranium	µg/g	15 [1.18]	30 [2.18]		0.374	0.904	0.350	0.268	0.234	0.463	0.269	0.357
Vanadium	µg/g	100 [1.19]	100 [2.19]		*103*	86.0	97.8	61.4	96.5	87.1	96.1	*102*
Zinc	µg/g	Calc [1.20]	Calc [2.20]		74.2	118	75.6	*182*	68.0	74.3	74.8	88.1
Zirconium	µg/g	NS	NS		6.1	3.2	6.4	1.2	3.2	6.7	4.0	2.2

End of Spill Report
Soil Quality Results – Guideline Notes

1. Notes for BC Contaminated Sites Regulation, Soil Standards for Urban Park Land Use (CSR PL)

General Notes:

BC Contaminated Sites Regulation, Soil Standards for Urban Park Land Use; includes amendments up to B.C. Reg. 13/2019, January 24, 2019. Soil Standards from Schedule 3.1 for urban park land use have been applied. Schedule 3.1 includes three parts: Part 1 – Matrix numerical soil standards; Part 2 – Generic numerical soil standards to protect human health; and Part 3 – Generic numerical soil standards to protect environmental health.
The most stringent standards in Schedule 3.1 were used based on applicable site-specific factors.
The Schedule 3.1 – Part 1 standards that were used, along with the site-specific factor, are included in the notes for the relevant analytes. For generic numerical soil standards, the Schedule 3.1 – Part 2 generic numerical soil standards were used unless noted otherwise in the notes for the relevant analytes.

Note 1.1 for Antimony:

Schedule 3.1, Part 3, Standard to Protect Ecological Health.

Note 1.2 for Arsenic:

Schedule 3.1, Part 1. The most stringent standards are as follows:
Human Health Protection, Groundwater used for drinking water: 10 µg/g
Environmental Protection, Groundwater flow to surface water used by aquatic life: 10 µg/g
Environmental Protection, Groundwater used for irrigation: 10 µg/g

Note 1.3 for Barium:

Schedule 3.1, Part 1, Human Health Protection, Groundwater used for drinking water.

Note 1.4 for Beryllium:

Schedule 3.1, Part 1. The most stringent combination of standards is as follows:
The standard for Beryllium varies with the pH of the soil at a site, as follows.
Human Health Protection, Intake of contaminated soil: 150 µg/g
Human Health Protection, Groundwater used for drinking water:
1 µg/g if pH < 5.5
Environmental Protection, Groundwater flow to surface water used by freshwater aquatic life:
1 µg/g if pH < 6.5;
4 µg/g if 6.5 ≤ pH < 7.0;
30 µg/g if 7.0 ≤ pH < 7.5;

Note 1.5 for Cadmium:

Schedule 3.1, Part 1. The most stringent combination of standards is as follows.
The standard for cadmium varies with the pH of the soil at a site, as follows.
Human Health Protection, Groundwater used for drinking water:
1 µg/g if pH < 7.0
Environmental Protection, Toxicity to soil invertebrates and plants: 30 µg/g
Environmental Protection, Groundwater flow to surface water used by freshwater aquatic life:
1 µg/g if pH < 7.0;
3 µg/g if pH 7.0 - < 7.5;
20 µg/g if pH 7.5 - < 8.0;
Standard varies with receiving water hardness (H). H = 150 to < 210 mg/L as CaCO3 is assumed. Consult a director for further advice.
Environmental Protection, Groundwater used for irrigation:
1 µg/g if pH < 7.0

Note 1.6 for Chromium:

Schedule 3.1, Part 1, Matrix 9 - Chromium provides standards for chromium, hexavalent; chromium, trivalent; and chromium (all species).
The most stringent standards for chromium, hexavalent are:
Human Health Protection, Groundwater used for drinking water: 60 µg/g
Environmental Protection, Groundwater flow to surface water used by aquatic life: 60 µg/g
Environmental Protection, Groundwater used for irrigation: 60 µg/g
The most stringent standards for chromium, trivalent are:
Environmental Protection, Toxicity to soil invertebrates and plants: 200 µg/g
The standard of 60 µg/g was used for chromium in this report to demonstrate compliance with the standards of this matrix.

Note 1.7 for Cobalt:

Schedule 3.1, Part 1. The most stringent standards are as follows:
Human Health Protection, Intake of contaminated soil: 25 µg/g
Human Health Protection, Groundwater used for drinking water: 25 µg/g
Environmental Protection, Groundwater flow to surface water used by aquatic life: 25 µg/g
Environmental Protection, Groundwater used for irrigation: 25 µg/g

Note 1.8 for Copper:

Schedule 3.1, Part 1. The most stringent combination of standards is as follows:
The standard for copper varies with the pH of the soil at a site, as follows.
Environmental protection, Toxicity to soil invertebrates and plants:
150 µg/g
Environmental Protection, Groundwater flow to surface water used by freshwater aquatic life:
75 µg/g if pH < 5.5;
100 µg/g if 5.5 ≤ pH < 6.0;
Standard varies with receiving water hardness (H). H ≥ 200 mg/L as CaCO3 is assumed. Consult a director for further advice.
Environmental Protection, Groundwater used for irrigation:
75 µg/g if pH < 5.5

Note 1.9 for Lead:

Schedule 3.1, Part 1. The most stringent combination of standards is as follows:
Human Health Protection, Intake of contaminated soil:

120 µg/g
Human Health Protection, Groundwater used for drinking water:
120 µg/g if pH < 5.5

Note 1.10 for Manganese:

Schedule 3.1, Part 1. The most stringent standards are as follows:
Human Health Protection, Groundwater used for drinking water: 2,000 µg/g.
Standard applies to a site used for an industrial or commercial purpose or activity set out in Schedule 2 as (a) item B1, or (b) item C1, C3 or C4, (c) item D2, D3, D5 or D6, (d) item E4, or (e) item H3 or H14.
Standard applies to a site used for an industrial or commercial purpose or activity set out in Schedule 2 as item H11 or H20 but only if the site was used for that purpose or activity in conjunction with or as a result of the site being used for at least one of the purposes or activities set out in the above note.
Environmental Protection, Toxicity to soil invertebrates and plants: 2,000 µg/g
Environmental Protection, Groundwater used for irrigation: 2,000 µg/g

Note 1.11 for Mercury:

Schedule 3.1, Part 1, Human Health Protection, Intake of contaminated soil

Note 1.12 for Molybdenum:

Schedule 3.1, Part 1, Environmental Protection, Groundwater used for irrigation

Note 1.13 for Nickel:

Schedule 3.1, Part 1. The most stringent combination of standards is as follows:
The standard for nickel varies with the pH of the soil at a site, as follows.
Human Health Protection, Groundwater used for drinking water:
70 µg/g if pH < 7.5;
Environmental Protection, Toxicity to soil invertebrates and plants:
150 µg/g
Environmental Protection, Groundwater used for irrigation:
70 µg/g if pH < 7.0

Note 1.14 for Selenium:

Schedule 3.1, Part 1. The most stringent standards are as follows:
Human Health Protection, Groundwater used for drinking water: 1 µg/g
Environmental Protection, Groundwater flow to surface water used by aquatic life: 1 µg/g
Environmental Protection, Groundwater used for irrigation: 1 µg/g

Note 1.15 for Silver:

Schedule 3.1, Part 3, Standard to Protect Ecological Health.

Note 1.16 for Thallium:

Schedule 3.1, Part 3, Standard to Protect Ecological Health.

Note 1.17 for Tin:

Schedule 3.1, Part 3, Standard to Protect Ecological Health.

Note 1.18 for Uranium:

Schedule 3.1, Part 1, EP, Groundwater used for irrigation.

Note 1.19 for Vanadium:

Schedule 3.1, Part 1, Human Health Protection, Groundwater used for drinking water.

Note 1.20 for Zinc:

Schedule 3.1, Part 1. The most stringent combination of standards is as follows:
The standard for zinc varies with the pH of the soil at a site, as follows.
Environmental Protection, Toxicity to soil invertebrates and plants:
450 µg/g
Environmental Protection, Groundwater flow to surface water used by freshwater aquatic life:
150 µg/g if pH < 6.0;
250 µg/g if 6.0 ≤ pH < 6.5;
350 µg/g if 6.5 ≤ pH < 7.0;
Standard varies with receiving water hardness (H). H = 200 to < 300 mg/L as CaCO3 is assumed. Consult director for further advice.
Environmental Protection, Groundwater used for irrigation: 150 µg/g if pH < 6.0

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2. Notes for BC Contaminated Sites Regulation, Soil Standards for Industrial Land Use (CSR IL)

General Notes:

BC Contaminated Sites Regulation, Soil Standards for Industrial Land Use; includes amendments up to B.C. Reg. 13/2019, January 24, 2019. Soil Standards from Schedule 3.1 for industrial land use have been applied. Schedule 3.1 includes three parts: Part 1 – Matrix numerical soil standards; Part 2 – Generic numerical soil standards to protect human health; and Part 3 – Generic numerical soil standards to protect environmental health. The most stringent standards in Schedule 3.1 were used based on applicable site-specific factors.
The Schedule 3.1 – Part 1 standards that were used, along with the site-specific factor, are included in the notes for the relevant analytes. For generic numerical soil standards, the Schedule 3.1 – Part 2 generic numerical soil standards were used unless noted otherwise in the notes for the relevant analytes.

Note 2.1 for Antimony:

Schedule 3.1, Part 3, Standard to Protect Ecological Health.

Note 2.2 for Arsenic:

Schedule 3.1, Part 1. The most stringent standards are as follows:
Human Health Protection, Groundwater used for drinking water: 10 µg/g
Environmental Protection, Groundwater flow to surface water used by aquatic life: 10 µg/g

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Note 2.3 for Barium:

Schedule 3.1, Part 1, Human Health Protection, Groundwater used for drinking water.

Note 2.4 for Beryllium:

Schedule 3.1, Part 1. The most stringent combination of standards is as follows:
The standard for Beryllium varies with the pH of the soil at a site, as follows.
Human Health Protection, Groundwater used for drinking water:
1 µg/g if pH < 5.5
Environmental Protection, Groundwater flow to surface water used by freshwater aquatic life:
1 µg/g if pH < 6.5;
4 µg/g if 6.5 ≤ pH < 7.0;
30 µg/g if 7.0 ≤ pH < 7.5;
250 µg/g if 7.5 ≤ pH < 8.0;
Environmental protection, Toxicity to soil invertebrates and plants:
350 µg/g

Note 2.5 for Cadmium:

Schedule 3.1, Part 1. The most stringent combination of standards is as follows.
The standard for cadmium varies with the pH of the soil at a site, as follows.
Human Health Protection, Groundwater used for drinking water:
1 µg/g if pH < 7.0
Environmental Protection, Groundwater flow to surface water used by freshwater aquatic life:
1 µg/g if pH < 7.0;
3 µg/g if 7.0 ≤ pH < 7.5;
20 µg/g if 7.5 ≤ pH < 8.0;
50 µg/g if pH ≥ 8.0
Standard varies with receiving water hardness (H). H = 150 to < 210 mg/L as CaCO3 is assumed. Consult a director for further advice.

Note 2.6 for Chromium:

Schedule 3.1, Part 1, Matrix 9 - Chromium provides standards for chromium, hexavalent; chromium, trivalent; and chromium (all species).
The most stringent standards for chromium, hexavalent are:
Human Health Protection, Groundwater used for drinking water: 60 µg/g;
Environmental Protection, Groundwater flow to surface water used by aquatic life: 60 µg/g.
The most stringent standard for chromium, trivalent is:
Environmental Protection, Toxicity to soil invertebrates and plants: 250 µg/g
The standard of 60 µg/g was used for chromium in this report to demonstrate compliance with the standards of this matrix.

Note 2.7 for Cobalt:

Schedule 3.1, Part 1. The most stringent standards are as follows:
Human Health Protection, Groundwater used for drinking water: 25 µg/g
Environmental Protection, Groundwater flow to surface water used by aquatic life: 25 µg/g

Note 2.8 for Copper:

Schedule 3.1, Part 1. The most stringent combination of standards is as follows:
The standard for copper varies with the pH of the soil at a site, as follows.
Environmental Protection, Groundwater flow to surface water used by freshwater aquatic life:
75 µg/g if pH < 5.5;
100 µg/g if 5.5 ≤ pH < 6.0;
Standard varies with receiving water hardness (H). H ≥ 200 mg/L as CaCO3 is assumed. Consult a director for further advice.
Environmental protection, Toxicity to soil invertebrates and plants:
300 µg/g

Note 2.9 for Lead:

Schedule 3.1, Part 1. The most stringent combination of standards is as follows:
The standard for lead varies with the pH of the soil at a site, as follows.
Human Health Protection, Groundwater used for drinking water:
120 µg/g if pH < 5.5;
150 µg/g if 5.5 ≤ pH < 6.0;
800 µg/g if 6.0 ≤ pH < 6.5;
Environmental Protection, Toxicity to soil invertebrates and plants
1,000 µg/g

Note 2.10 for Manganese:

Schedule 3.1, Part 1. The most stringent standards are as follows:
Human Health Protection, Groundwater used for drinking water: 2,000 µg/g.
Standard applies to a site used for an industrial or commercial purpose or activity set out in Schedule 2 as (a) item B1, or (b) item C1, C3 or C4, (c) item D2, D3, D5 or D6, (d) item E4, or (e) item H3 or H14.
Standard applies to a site used for an industrial or commercial purpose or activity set out in Schedule 2 as item H11 or H20 but only if the site was used for that purpose or activity in conjunction with or as a result of the site being used for at least one of the purposes or activities set out in the above note.
Environmental Protection, Toxicity to soil invertebrates and plants: 2,000 µg/g

Note 2.11 for Mercury:

Schedule 3.1, Part 1, Environmental Protection, Toxicity to soil invertebrates and plants.

Note 2.12 for Molybdenum:

Schedule 3.1, Part 1, Human Health Protection, Groundwater used for drinking water.

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Note 2.13 for Nickel:

Schedule 3.1, Part 1. The most stringent combination of standards is as follows:
The standard for nickel varies with the pH of the soil at a site, as follows.
Human Health Protection, Groundwater used for drinking water:
70 µg/g if pH < 7.5;
250 µg/g if 7.5 ≤ pH < 8.0;
Environmental Protection, Toxicity to soil invertebrates and plants:
250 µg/g

Note 2.14 for Selenium:

Schedule 3.1, Part 1. The most stringent standards are as follows:
Human Health Protection, Groundwater used for drinking water: 1 µg/g
Environmental Protection, Groundwater flow to surface water used by aquatic life: 1 µg/g

Note 2.15 for Silver:

Schedule 3.1, Part 3, Standard to Protect Ecological Health.

Note 2.16 for Thallium:

Schedule 3.1, Part 3, Standard to Protect Ecological Health.

Note 2.17 for Tin:

Schedule 3.1, Part 3, Standard to Protect Ecological Health.

Note 2.18 for Uranium:

Schedule 3.1, Part 1, Human Health Protection, Groundwater used for drinking water.

Note 2.19 for Vanadium:

Schedule 3.1, Part 1, Human Health Protection, Groundwater used for drinking water.

Note 2.20 for Zinc:

Schedule 3.1, Part 1. The most stringent combination of standards is as follows:
The standard for zinc varies with the pH of the soil at a site, as follows.
Environmental Protection, Groundwater flow to surface water used by freshwater aquatic life:
150 µg/g if pH < 6.0;
250 µg/g if 6.0 ≤ pH < 6.5;
350 µg/g if 6.5 ≤ pH < 7.0;
Standard varies with receiving water hardness (H). H = 200 to < 300 mg/L as CaCO3 is assumed. Consult director for further advice.
Environmental Protection, Toxicity to soil invertebrates and plants:
450 µg/g

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Sediment Quality Results - Legend

<	Less than reported detection limit
>	Greater than reported upper detection limit
>=	Greater than or equal to
A	Absent
Calc	Calculated guideline or standard. The guideline or standard is dependent on the value of one or more other analytes, and is calculated from a formula or table.
CSR SedSSS(F)	BC Contaminated Sites Regulation, Freshwater Sediment Standard for Sensitive Use (2017 and updates)[1]
N	Narrative type of guideline or standard, or Result Note.
NG	No Guideline
NS	No Standard
NT	Not Tested
OG	Overgrown
P	Present
PR	Presumptive
TNTC	Too numerous to count
	Highlighted value has a lower detection limit that is greater than the guideline/standard maximum and/or the guideline/standard minimum, or has an upper detection limit that is less than the guideline/standard maximum and/or the guideline/standard minimum.
CSR SedSSS(F)	Highlighted value exceeds CSR SedSSS(F)

Guideline notes:
[1]Sediment standards from BC CSR Schedule 3.4 - Generic Numerical Sediment Standards, Freshwater Sediment Standard for Sensitive Use have been applied.
Standards are specific to the protection of freshwater life. It is the responsibility of the responsible person for the site to ensure that use of the standards of this schedule does not constitute a significant risk or hazard to human health.
Sensitive sediment use means the use of a site containing sediment as habitat for sensitive components of freshwater, marine or estuarine aquatic ecosystems. Consult a director for further advice.

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Sediment Quality Results

Analyte	Unit	Guideline	Sampling Location	RTF-NAR-S2	RTF-NAR-S2	RTF-NAR-S2	RTF-W-S1	RTF-W-S1	RTF-W-S1	RTF-W-S2	RTF-W-S2	RTF-W-S2	RTF-W-S2	RTF-W-S3	RTF-W-S3	RTF-W-S3	RTF-W-S4	RTF-W-S4	RTF-W-S4	RTF-W-S5	RTF-W-S5	RTF-W-S5	RTF-W-S6	RTF-W-S6	RTF-W-S6
			Date Sampled	21-Oct-20	18-Nov-20	09-Dec-20	21-Oct-20	18-Nov-20	09-Dec-20	22-Oct-20	18-Nov-20	18-Nov-20	09-Dec-20	22-Oct-20	18-Nov-20	09-Dec-20	22-Oct-20	18-Nov-20	09-Dec-20	22-Oct-20	18-Nov-20	09-Dec-20	22-Oct-20	18-Nov-20	09-Dec-20
			Lab Sample ID	VA20B8814-008	VA20C1155-005	VA20C3013-007	VA20B8814-009	VA20C1155-006	VA20C3013-001	VA20B8935-001	VA20C1155-007	VA20C1155-012	VA20C3013-002	VA20B8935-004	VA20C1155-008	VA20C3013-003	VA20B8935-007	VA20C1155-009	VA20C3013-004	VA20B8935-010	VA20C1155-010	VA20C3013-005	VA20B8935-013	VA20C1155-011	VA20C3013-006
Lab Results																									
General																									
Moisture	% wet	NS		33.4	42.8	36.2	40.6	41.1	69.6	35.0	65.4	52.2	67.2	23.4	30.5	40.4	24.3	30.8	41.4	19.2	72.0	54.3	24.4	52.3	76.2
Water-soluble nitrate (as N) (mass/mass)	µg/g	NS		0.419			0.703			0.129				0.938			0.338			0.424			0.421		
Water-soluble nitrite (as N) (mass/mass)	µg/g	NS		<0.010			0.033			0.021				0.161			0.033			<0.010			<0.010		
pH (in 2:1 water:soil mixture)		NS		6.79		6.79	6.84		6.68	6.92			7.11	7.08		7.32	7.15		6.80	7.15		6.92	7.32		6.56
Soluble ammonia (as N)	mg/L	NS		<5.0			<5.0			<10.0				<5.0			<1.0			<1.0			<1.0		
Microbiological																									
E. coli (MPN)	MPN/g	NS		>2380	>2790	375	>2630	2710	298	>2460	>4630	>3400	1050	>2100	>2290	>2670	>2090	349	2740	>1960	86	15	167	112	3
Fecal coliforms (MPN)	MPN/g dry	NS		>2380	>2790	2520	>2630	2710	298	>2460	>4630	>3400	1050	>2100	>2290	>2670	>2090	349	>2740	>1960	86	38	167	112	5
Total coliforms (MPN)	MPN/g	NS		>2380	>2790	>2520	>2630	>2710	2980	>2460	>4630	>3400	>4870	>2100	>2290	>2670	>2090	>2340	>2740	>1960	>5760	1180	447	>3330	665
Metals																									
Aluminum	µg/g	NS		29500		27100	31500		20100	28000			21900	32100		23400	37400		28600	24700		21700	25800		12300
Antimony	µg/g	NS		0.42		0.54	0.42		0.61	0.57			0.53	0.41		0.42	0.45		0.58	0.33		0.48	0.41		0.70
Arsenic	µg/g	11.0		5.60		5.53	5.94		**12.9**	9.93			9.32	8.23		6.40	5.66		6.39	6.44		1.28	10.7		1.42
Barium	µg/g	NS		64.7		62.5	69.2		67.2	78.1			64.4	90.0		84.2	89.6		75.6	46.7		64.7	50.0		48.3
Beryllium	µg/g	NS		0.46		0.38	0.50		0.35	0.46			0.37	0.71		0.48	1.08		0.64	0.40		0.36	0.48		0.20
Bismuth	µg/g	NS		<0.20		<0.20	<0.20		<0.20	<0.20			<0.20	<0.20		<0.20	<0.20		<0.20	<0.20		<0.20	<0.20		<0.20
Boron	µg/g	NS		7.6		7.2	7.9		7.9	8.4			7.5	5.0		6.4	<5.0		7.3	<5.0		10.7	<5.0		11.4
Cadmium	µg/g	2.2		0.185		0.208	0.209		0.325	0.465			0.522	0.328		0.284	0.102		0.240	0.107		0.413	0.138		0.541
Calcium	µg/g	NS		13000		13200	14300		15900	15200			16500	9880		12300	7440		13600	10200		24500	9910		29400
Chromium	µg/g	56.0		35.2		35.8	36.2		30.6	39.5			33.8	37.2		32.2	54.3		40.8	39.0		25.7	51.9		14.6
Cobalt	µg/g	NS		18.5		19.4	21.7		17.0	22.7			19.9	21.5		18.6	17.1		15.7	10.8		7.33	9.55		3.82
Copper	µg/g	120.0		43.4		51.8	54.8		44.1	60.0			53.1	42.1		40.2	**265**		102	68.1		32.1	87.2		48.1
Iron	µg/g	NS		33100		32000	35700		29700	32800			31300	34900		31200	28900		28900	31500		9680	29700		5930
Lead	µg/g	57.0		11.0		11.5	10.3		12.1	10.2			10.0	8.56		9.23	6.62		12.4	3.04		19.0	3.15		23.9
Lithium	µg/g	NS		11.2		9.9	10.7		7.8	11.3			8.3	17.4		12.3	25.3		15.4	10.5		15.0	10.0		5.6
Magnesium	µg/g	NS		7660		7260	9260		5140	7850			6320	6710		6240	6600		5460	6650		4090	6300		2660
Manganese	µg/g	NS		1070		1320	1410		836	1550			1620	2910		2830	380		900	335		169	300		107
Mercury	µg/g	0.3		0.0604		0.0559	0.0753		0.0845	0.0826			0.0751	<0.0500		<0.0500	0.0559		0.0605	<0.0500		0.0727	0.0675		0.121
Molybdenum	µg/g	NS		0.86		0.94	1.05		1.29	1.28			1.00	2.32		1.66	1.36		1.67	2.67		0.59	2.15		1.28
Nickel	µg/g	NS		30.6		32.4	34.3		24.8	35.4			30.2	33.7		30.0	71.6		38.6	22.6		14.9	24.1		11.5
Phosphorus	µg/g	NS		610		631	1050		715	757			754	352		446	339		360	346		874	679		868
Potassium	µg/g	NS		690		680	750		410	590			460	500		500	590		550	390		480	540		250
Selenium	µg/g	NS		0.77		0.88	0.84		2.22	1.76			2.16	0.36		0.59	0.27		0.85	0.25		1.54	0.22		1.85
Silver	µg/g	NS		<0.10		<0.10	0.10		0.11	0.13			0.13	0.12		0.10	0.36		0.19	<0.10		0.11	0.11		0.16
Sodium	µg/g	NS		231		221	222		170	232			196	204		211	288		260	291		198	235		127
Strontium	µg/g	NS		46.8		49.3	48.7		44.9	47.8			49.0	43.0		45.6	44.1		49.4	51.6		80.8	49.9		82.7
Sulphur	µg/g	NS		<1000		<1000	<1000		2600	<1000			1500	<1000		<1000	<1000		<1000	<1000		5100	<1000		6600
Thallium	µg/g	NS		0.066		0.072	0.067		0.069	0.114			0.091	0.099		0.086	0.172		0.089	<0.050		0.080	<0.050		<0.050
Tin	µg/g	NS		<2.0		<2.0	<2.0		<2.0	<2.0			<2.0	<2.0		<2.0	<2.0		<2.0	<2.0		<2.0	<2.0		<2.0
Titanium	µg/g	NS		1740		1550	1720		928	1360			1040	1430		1300	1370		1490	1610		1040	1500		384
Tungsten	µg/g	NS		<0.50		<0.50	<0.50		<0.50	<0.50			<0.50	<0.50		<0.50	<0.50		<0.50	<0.50		<0.50	<0.50		<0.50
Uranium	µg/g	NS		0.715		0.802	0.750		1.59	1.16			1.33	0.744		0.685	1.41		1.65	1.59		3.85	1.00		2.67
Vanadium	µg/g	NS		90.8		87.8	98.4		74.5	90.6			80.3	101		89.1	77.8		91.7	105		43.1	94.5		34.5
Zinc	µg/g	200.0		156		196	182		85.3	**330**			**256**	149		168	89.2		96.9	37.4		187	41.8		103
Zirconium	µg/g	NS		3.4		3.0	3.3		2.8	2.6			2.2	4.9		3.1	3.4		3.6	5.0		2.7	3.4		2.2

WIRELESS WATER