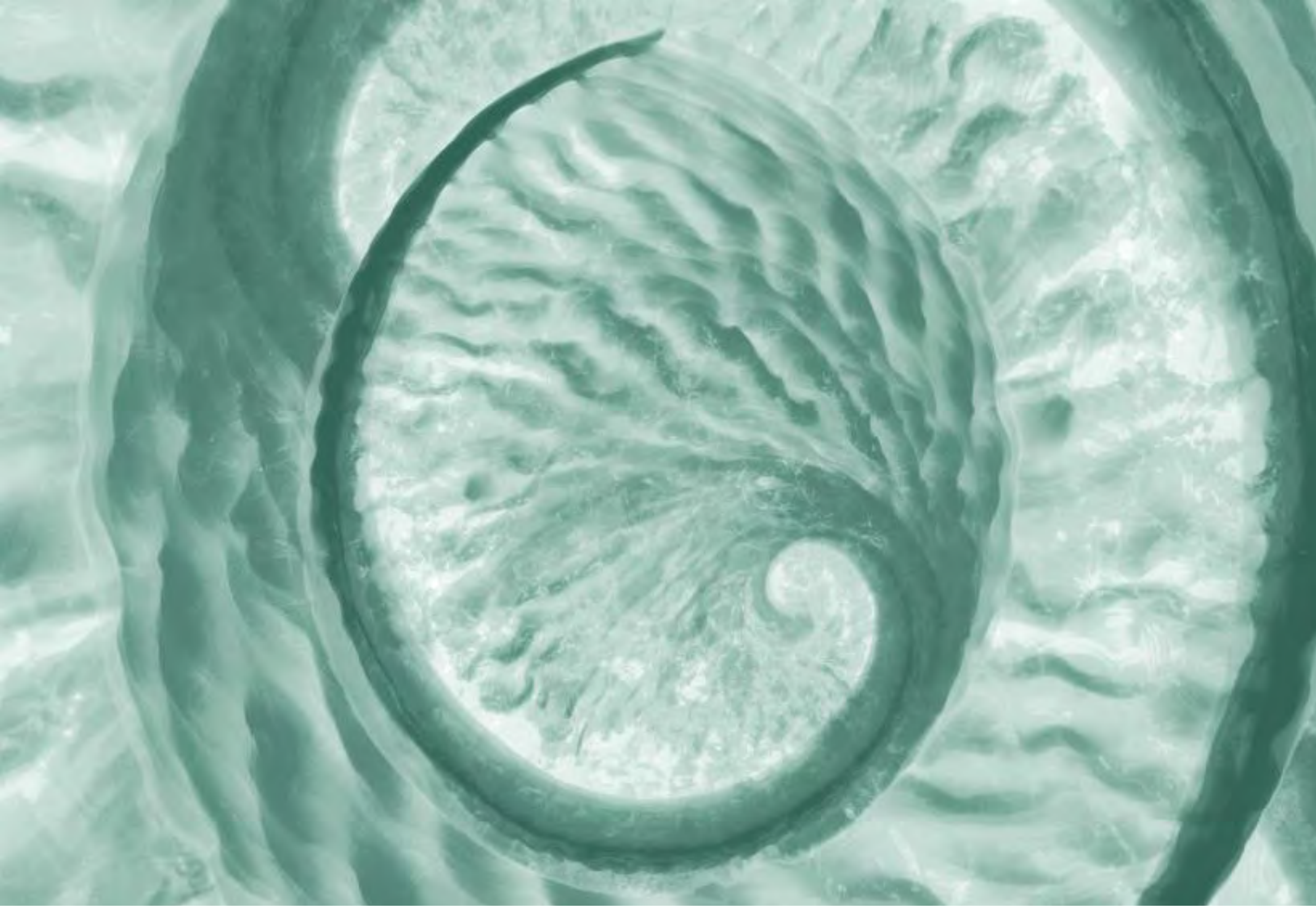
APPENDIX I

DUST DEPOSITION REPORT



Diavik Diamond Mine

2019 Dust Deposition Report

April 2020

Project No.: 0207514-0021

The business of sustainability

April 2020

Diavik Diamond Mine

2019 Dust Deposition Report

ERM Consultants Canada Ltd.

1111 West Hastings Street, 15th Floor
Vancouver, BC
Canada V6E 2J3

T: +1 604 689 9460
F: +1 604 687 4277

EXECUTIVE SUMMARY

Potential air and water quality concerns associated with airborne fugitive dust, which may result from Diavik Diamond Mine (the "Project") mining activities, were identified in the Diavik Diamond Mine Environmental Assessment (DDMI 1998). In accordance with the Environmental Assessment and requirements associated with the Aquatic Effects Monitoring Program (AEMP), a dust monitoring program was initiated in 2001. The program was designed to achieve the following objectives:

- determine dust deposition (dustfall) rates at various distances from the mine project footprint; and
- determine the chemical characteristics of dustfall that may be deposited onto, and subsequently into, Lac de Gras as a result of mining activities, in support of the AEMP.

In 2019, dustfall monitoring included three components, with sampling conducted at varying distances around the mine from 13 to 30,711 metres (m) away from infrastructure:

1. Dustfall gauges (12 monitoring and 2 control locations);
2. Dustfall from snow surveys (24 monitoring, 3 control locations and 4 control-assessment locations); and
3. Snow water chemistry from snow surveys (16 monitoring, 3 control locations and 4 control-assessment locations).

Overall, as expected, dustfall rates decreased with distance from the Project. The proximity to mine activity was the strongest indicator of dustfall deposition. In 2019, the annual dustfall estimated from each of the 14 dustfall gauges ranged from 65 to 982 mg/dm^2/y. Dust 3 (22 m from the Project) had the highest recorded dustfall followed by Dust 10 (42 m from the Project). Although it is expected that fugitive dust generation is higher during snow-free periods because of exposed road surfaces, the difference between summer and winter rates was minor in most cases with some sites recording a slightly higher summer rate (e.g., Dust 3 rate was 1,024 mg/dm^2/y in the summer and 940 mg/dm^2/y in the winter), and other sites a slightly higher winter rate (e.g. Dust 2 rate was 309 mg/dm^2/y in the summer and 399 mg/dm^2/y in the winter).

The annualized dustfall rates estimated from the 2019 snow survey data ranged from 12 to 1,114 mg/dm^2/y. Although there are no dustfall standards for the Northwest Territories, dustfall rates at all stations in 2019 were lower than the non-residential objective of 5.26 mg/dm^2/d (1,920 mg/dm^2/y) documented in the Alberta Ambient air Quality Objectives and Guidelines (Alberta Environment and Parks 2019), and only four sites (Dust 3, Dust 10, Dust 11, and SS1-1) exceeded the residential limit of these objectives. These objectives are used as general performance indicators only.

Snow water chemistry analytes of interest included those variables with effluent quality criteria (EQC; i.e., aluminum, ammonia, arsenic, cadmium, chromium, copper, lead, nickel, nitrite, and zinc) or a load limit (i.e., phosphorus) specified in the Type "A" Water Licence (W2015L2-0001, formerly W2007L2-0003). All 2019 sample concentrations were less than the EQC "maximum concentration of any grab sample" described in Water Licence W2015L2-0001. Concentrations in 2019 were generally lower than recent years for all parameters except ammonia, nitrite, and phosphorus. Typically, concentrations decreased with distance from the Project. The highest concentrations for all variables were less than their corresponding EQC.

ACKNOWLEDGEMENTS

This report was prepared for Diavik Diamond Mines (2012) Inc. (DDMI) by ERM Consultants Canada Ltd. (ERM). Fieldwork and on site sample analyses were completed by DDMI, and other sample analyses were completed by Maxxam Analytics. Data analyses and reporting were completed by Talaat Bakri (M.Sc.) and reviewed by Andres Soux (M.Sc.). The project was managed by Carol Adly (M.Sc., R.P.Bio.), and Marc Wen (M.Sc., R.P.Bio.) was the Partner in Charge.

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ACRONYMS AND ABBREVIATIONS

AEMP	Aquatic effects monitoring program
BC	British Columbia
BC MOE	British Columbia Ministry of Environment
CI	Confidence interval
DDMI	Diavik Diamond Mines (2012) Inc.
DL	Detection limit
Dustfall	Dust deposition
EQC	Effluent quality criteria
ERM	ERM Consultants Canada Ltd.
Fugitive Dust	Atmospheric dust arises from mechanical disturbance of granular material exposed to the air and is not discharged to the atmosphere in a confined flow stream.
IQR	The interquartile range of the box plot. In box plots, the middle 50% of data occurs within the limits of the interquartile range.
Q1	The lower quartile of the box plot. In box plots, 25% of data lie below than this value.
Q3	The upper quartile of the box plot. In box plots, 25% of data lie above than this value.
QA/QC	Quality assurance and quality control
the Project	Diavik Diamond Mine
RPD	Relative percent difference
SCRP	South Country Rock Pile
SOP	Standard operating procedure
WLWB	Wek’èezhìi Land and Water Board
WRSA	Waste Rock Storage Area: an elevated surface constructed from dumping waste rock.

1. INTRODUCTION

Potential air and water quality concerns associated with airborne fugitive dust, which may result from Diavik Diamond Mine (the Project) mining activities, were identified in the Diavik Diamond Mine Environmental Assessment (DDMI 1998). In accordance with the Environmental Assessment and requirement associated with the Aquatic Effects Monitoring Program (AEMP), a dust monitoring program was initiated in 2001. The program was designed to achieve the following objectives:

- determine dust deposition (dustfall) rates at various distances from the mine project footprint; and
- determine the chemical characteristics of dustfall that may be deposited onto, and subsequently into, Lac de Gras as a result of mining activities, in support of the AEMP.

Since 2001, the dustfall monitoring program has gone through various changes, including an increase in the number of sampling locations, the relocation of some sampling stations, and improvements to the dustfall sampling methodology. A description of annual changes is provided in Appendix A. This report includes a comparison between the 2019 observations of dustfall to all site-specific data collected between 2002 and 2019. Appendix A of the Dust Deposition Report summarizes the amendments and additions to the dustfall monitoring program since 2001. Historical dustfall monitoring results have been presented each year in the Diavik Diamond Mine Dust Deposition reports from 2001 to 2018 (DDMI 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019). The historical data presented are not considered to represent baseline conditions because construction of the mine began in 2001.

2. METHODOLOGY

The 2019 dustfall monitoring program incorporated three monitoring components:

1. Dustfall gauges (12 monitoring and two control locations);
2. Dustfall from snow surveys (24 monitoring, three control, and four control-assessment locations); and
3. Snow water chemistry from snow surveys (16 monitoring, three control, and four control-assessment locations).

Sampling was completed at varying distances around the mine along five transects, including three control locations. In addition, four more sites located further from the Project footprint were added to the 2019 monitoring program to assess the adequacy of the current control locations (hereafter called control-assessment locations; Table 2-1; Figure 2-1).

2.1 Dustfall Gauges

Dustfall gauges were placed at 14 stations (including two control stations) around the Project at distances ranging from approximately 13 m to 4,646 m from mining operations (Table 2-1; Figure 2-1). The 12 stations (plus two control stations) collected dustfall year-round, with samples collected approximately every three months. The average total sampling period for the 12 year-round locations was 361 days.

Dustfall gauges consisted of a hollow brass cylinder (52 cm length, 12.5 cm inner diameter) housed in a Nipher snow gauge (Photo 2.1-1). The cylinder collected dustfall, while the Nipher snow gauge reduced air turbulence around the gauge to increase dustfall catch efficiency. The cylinder was exchanged with an empty, clean cylinder at the end of each sampling period, and the content of the cylinder that was retrieved was processed in the Diavik Diamond Mines (2012) Inc. (DDMI) environment lab to determine the mass of collected dustfall. This processing involved filtration, drying in a high heat oven, and weighing of samples as specified in the Dust Gauge Collection Standard Operating Procedure (SOP; ENVR-508-0112; Appendix E) and the Quality Assurance/Quality Control SOP (ENVR-303-0112; Appendix G).

Once the mass of collected dustfall at a station was measured, the mean daily dustfall rate over the collection period was calculated as:

$$D = \frac{M}{A * T} \quad \text{[Equation 1]}$$

where: D = mean daily dustfall rate (mg/dm^2/d) during time period T
M = mass of dustfall collected (mg) during time period T
A = surface area of dustfall gauge collection cylinder orifice (dm^2; approximately 1.227 dm^2)
T = number of days of dustfall collection (d)

The mean daily dustfall rate (mg/dm^2/d) was then multiplied by 365 days to estimate the mean annual dustfall rate (mg/dm^2/y).

The Northwest Territories has no guidelines or objectives for dustfall deposition. The estimated dustfall rates are compared to the Alberta Ambient Air Quality Objectives and Guidelines for dustfall (Alberta Environment and Parks, 2019), which are used only as general performance indicators and are not a regulatory requirement in compliance evaluation. The Alberta Ambient Air Quality Guidelines for dustfall include a guideline for residential and recreation areas (53 mg/dm^2 per 30 days) and a guideline for commercial and industrial areas where higher dustfall rates are expected (158 mg/dm^2 per 30 days). To compare against the Alberta Ambient Air Quality Guidelines, the daily and annual thresholds are calculated based on the 30 days objectives. The daily threshold ranged from 1.77 mg/dm^2/d to 5.27 mg/dm^2/d, while the annual threshold ranged from 646 to 1,924 mg/dm^2/y. Snow water chemistry data were compared to effluent quality criteria (EQC) set out in Wek’èezhìi Land and Water Board (WLWB) Water Licence W2015L2-0001 (formerly W2007L2-0003).

Table 2-1: Dustfall and Snow Chemistry Sampling Locations, Diavik Diamond Mine, 2019

Station ID	2019 Sampling Dates	Total Sample Exposure Duration (days)	UTM Coordinates[1]		Approx. Distance from Mining Operations (m)	Surface Description	Snow Water Chemistry Sampled[2]
			Easting (m)	Northing (m)			
Dustfall Gauges							
Dust 1	Dec. 28 (2018; start), Apr. 8, Jun. 26, Sep. 30, Dec. 26	363	533964	7154321	70	Land	n/a
Dust 2A	Jan. 3 (start), Apr. 7, Jun. 25, Sep. 29, Dec. 28	359	535678	7151339	425	Land	n/a
Dust 3	Dec. 28 (2018; start), Apr.3, Jun. 26, Sep. 30, Dec. 26	363	535024	7151872	22	Land	n/a
Dust 4	Dec 28 (2018; start), Apr.6, Jun. 27, Sep. 28, Dec. 26	363	531397	7152127	173	Land	n/a
Dust 5	Jan. 2 (start), Apr. 6, Jun. 25, Sep. 29, Dec. 28	360	535696	7155138	1183	Land	n/a
Dust 6	Dec. 28 (2018; start), Apr. 3, Jun. 26, Sep. 30, Dec. 26	363	537502	7152934	13	Land	n/a
Dust 7	Jan. 3 (start), Apr. 5, Jun. 25, Sep. 29, Dec. 27	358	536819	7150510	1147	Land	n/a
Dust 8	Jan. 2 (start), Apr. 6, Jun. 25, Sep. 29, Dec. 28	360	531401	7154146	1213	Land	n/a
Dust 9	Jan. 4 (start), Apr. 4, Jun. 25, Sep. 29, Dec. 27	357	541204	7152154	3796	Land	n/a
Dust 10	Dec. 28 (2018; start), Apr. 5, Jun. 27, Sep. 30, Dec. 26	363	532908	7148924	46	Land	n/a
Dust 11	Jan. 3 (start), Apr. 5, Jun. 25, Sep. 29, Dec. 28	359	531493	7150156	747	Land	n/a
Dust 12	Jan. 3 (start), Apr. 6, Jun. 25, Sep. 29, Dec. 28	359	529323	7151191	2326	Land	n/a

Station ID	2019 Sampling Dates	Total Sample Exposure Duration (days)	UTM Coordinates[1]		Approx. Distance from Mining Operations (m)	Surface Description	Snow Water Chemistry Sampled[2]
			Easting (m)	Northing (m)			
Dust C1	Jan. 4 (start), Apr. 5, Jun. 25, Sep. 29, Dec. 27	357	534979	7144270	4646	Land	n/a
Dust C2	Jan. 3 (start), Apr. 6, Jun. 26, Sep. 29, Dec. 28	359	528714	7153276	3031	Land	n/a
Snow Surveys							
SS1-1	Apr. 6	215	533912	7154298	30	Land	
SS1-2	Apr. 6	215	533909	7154382	115	Land	
SS1-3[3]	Apr. 6	215	533975	7154514	260	Land	
SS1-4	Apr. 6	155	534489	7155083	899	Ice	✓
SS1-5	Apr. 6	155	535096	7156290	2175	Ice	✓
SS2-1[4]	Apr. 7	156	537550	7153476	145	Ice	✓
SS2-2[5]	Apr. 7	156	537835	7153489	427	Ice	✓
SS2-3	Apr. 4	153	538492	7153940	1194	Ice	✓
SS2-4	Apr. 4	153	539169	7154694	2164	Ice	✓
SS3-4	Apr. 7	156	536585	7151002	585	Ice	✓
SS3-5	Apr. 7	156	537676	7150832	1325	Ice	✓
SS3-6	Apr. 7	156	536308	7151578	35	Ice	✓
SS3-7	Apr. 7	156	536343	7151359	239	Ice	✓
SS3-8	Apr. 7	156	536696	7150809	826	Ice	✓
SS4-1[6]	Apr. 4	213	531497	7152209	61	Land	
SS4-2	Apr. 4	213	531361	7152258	196	Land	
SS4-3	Apr. 4	213	531328	7152476	335	Land	
SS4-4	Apr. 4	153	531147	7153165	1022	Ice	✓
SS4-5	Apr. 4	153	531405	7154124	1214	Ice	✓

Station ID	2019 Sampling Dates	Total Sample Exposure Duration (days)	UTM Coordinates[1]		Approx. Distance from Mining Operations (m)	Surface Description	Snow Water Chemistry Sampled[2]
			Easting (m)	Northing (m)			
SS5-1	Apr. 5	214	533143	7148934	26	Land	
SS5-2	Apr. 5	214	533141	7148899	55	Land	
SS5-3[7]	Apr. 5	154	533155	7148687	259	Ice	✓
SS5-4	Apr. 5	154	533138	7147947	941	Ice	✓
SS5-5	Apr. 5	154	533141	7146959	1894	Ice	✓
Contorl-1[8]	Apr. 5	214	534941	7144103	4802	Land	✓[9]
Control-2	Apr. 6	215	528714	7153307	3042	Land	✓[9]
Control-3	Apr. 5	214	538636	7148753	3550	Land	✓[9]
FFA-4	May 8	187	503724	7154100	27909	Ice	
FFB-4	May 5	184	515668	7150029	16004	Ice	
FF1-2	May 4	183	526547	7159040	7614	Ice	
LDS-2	Apr. 26	175	546443	7161147	11897	Ice	

Notes:

[1] UTM Zone 12W, NAD83.

[2] n/a = not applicable.

[3] Duplicate sample for dustfall snow surveys was collected at station SS1-3 (SS1-3-4 & SS1-3-5).

[4] Blank samples were collected at station SS2-1 (SS2-1-1 & SS2-1-1B).

[5] Duplicate samples for dustfall snow surveys and snow water chemistry were collected at station SS2-2 (SS2-2-4 & SS2-2-5).

[6] Duplicate sample for dustfall snow surveys was collected at station SS4-1 (SS4-1-4 & SS4-1-5).

[7] Duplicate sample for snow water chemistry was collected at station SS5-3 (SS5-3-4 & SS5-3-5).

[8] Duplicate sample for snow water chemistry was collected at Control-1 station (Control-1-4 & Control-1-5).

[9] Snow water chemistry was sampled over ice, adjacent to the on-land control station; see Section 2.3 for further details.

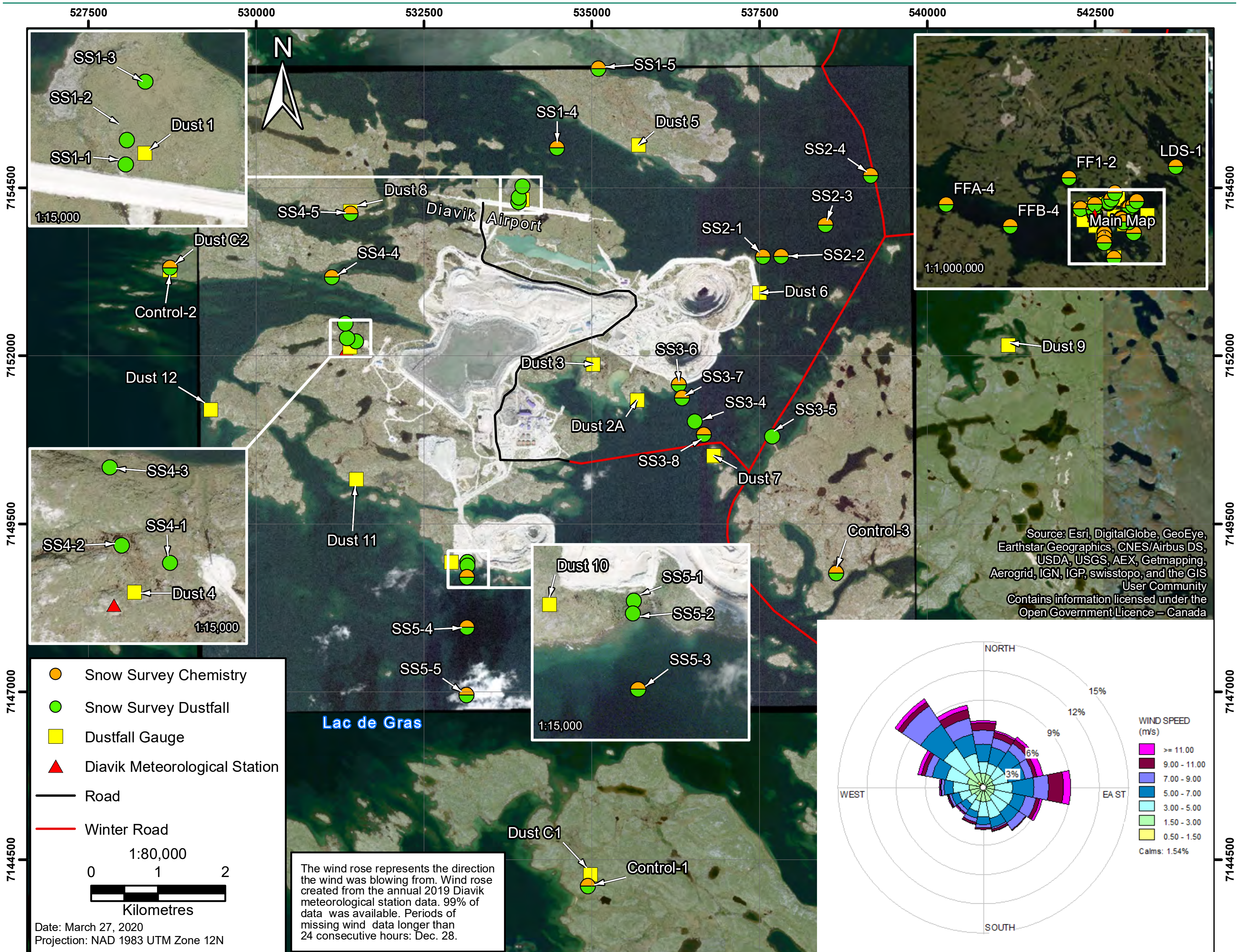


Figure 2-1: Dustfall Gauge and Snow Survey Locations, Diavik Diamond Mine, 2019

Photo 2.1-1: Dustfall gauge during sample collection. The dustfall gauge consisted of a hollow brass cylinder (centre) housed inside a Nipher snow gauge (right).

2.2 Dustfall Snow Surveys

Dustfall snow surveys were performed at 24 monitoring, three control, and four control-assessment stations along five transects around the Project (Table 2-1 and Figure 2-1). Across stations, the distance from mining operations ranged from approximately 26 m to 2,175 m for the monitoring stations, from 3,042 m to 4,802 m for the control stations and from 7,614 m, to 27,909 m for the control-assessment stations. The average total sampling period for the monitoring stations in 2019 was 214 and 155 days for the land and ice stations, respectively (control and control-assessment stations not included). The start dates correspond to the first snowfall for land stations (September 3, 2018), and shortly after freeze up of ice stations (November 2, 2018).

At each snow survey station, a snow corer was used to drill into the snow pack to retrieve a cylindrical snow core (6.1 cm inner diameter; Photo 2.2-1). Cores were extracted at each station and composited in the field to ensure a representative snow sample was obtained for the station. A minimum of three snow cores were collected at each (land and ice) of the snow sampling stations, as outlined in the Snow Core Survey SOP (ENVR-512-0213; Appendix F). Composited samples were bagged and brought to the DDMI environment lab for processing as specified in the Snow Core Survey SOP (ENVR-512-0213; Appendix F) and the Quality Assurance/Quality Control SOP (ENVR-303-0112; Appendix G). Processing of snow cores involved filtration, drying in a high heat oven, and weighing. For quality assurance and control (QA/QC), duplicate samples were collected at stations SS1-3, SS2-2, and SS4-1.

Mean daily dustfall rate (mg/dm^2/d) was then calculated over the collection period using Equation 1, with surface area (A) equal to the surface area of the snow corer tube orifice (0.2922 dm^2) multiplied by the number of snow cores used for the composited sample at the station. The mean annual dustfall rate (mg/dm^2/y) was estimated by multiplying the mean daily dustfall rate by 365 days.

Dustfall rates were compared to the Alberta Ambient Air Quality Objectives and Guidelines for dustfall (Table 2.2-1), which served as general performance indicators only.

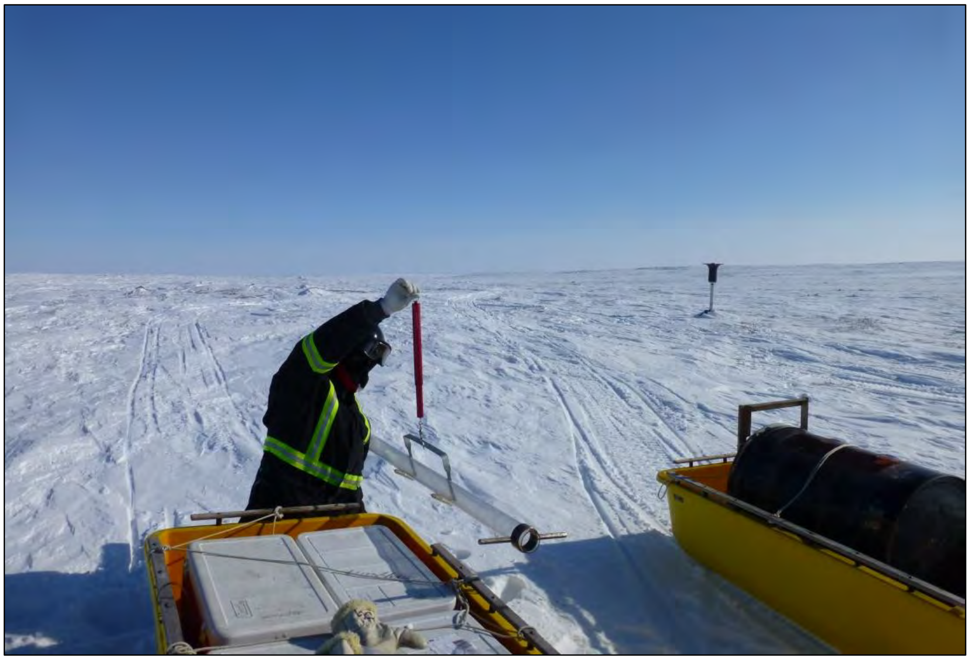


Photo 2.2-1: Snow core sample being weighed, with dustfall gauge in background.

Table 2.2-1: Dustfall and Snow Water Chemistry Reference Values

Parameter	Value	Unit	Comment	Source
Dustfall Rate	53–158	mg/dm^2/ 30 day	Alberta Ambient Air Quality Guidelines for dustfall	(Alberta Environment and Parks, 2019).
Aluminum-Total	3,000	µg/L	Max. grab sample concentration	W2015L2-0001
Ammonia-N	12,000	µg/L	Max. grab sample concentration	W2015L2-0001
Arsenic-Total	100	µg/L	Max. grab sample concentration	W2015L2-0001
Cadmium-Total	3	µg/L	Max. grab sample concentration	W2015L2-0001
Chromium-Total	40	µg/L	Max. grab sample concentration	W2015L2-0001
Copper-Total	40	µg/L	Max. grab sample concentration	W2015L2-0001
Lead-Total	20	µg/L	Max. grab sample concentration	W2015L2-0001
Nickel-Total	100	µg/L	Max. grab sample concentration	W2015L2-0001
Nitrite-N	2,000	µg/L	Max. grab sample concentration	W2015L2-0001
Zinc-Total	20	µg/L	Max. grab sample concentration	W2015L2-0001

2.3 Snow Water Chemistry

Snow water chemistry analysis was performed on snow cores extracted from 23 locations, including 16 dustfall snow survey stations located on ice, three samples taken on ice adjacent to the three control locations, and four control-assessment stations located on ice (Table 2-1 and Figure 2-1). The distance of the snow survey stations from mining operations in 2019 ranged approximately 35 m to 2,175 m, while this distance ranged from 3,042 m to 4,802 m and from 7,614 m to 27,909 m for the control and control-assessment locations, respectively. The average total sampling period in 2019 for the snow survey stations was 155 days (control and control-assessment stations not included). At each station located over water, cores were collected for chemistry analysis immediately after the dustfall snow cores were extracted.

Snow water chemistry cores were extracted using a snow corer in accordance with the dustfall snow survey core extraction. A minimum of three cores at each site were extracted and composited to obtain the necessary 3 L of snow water required for the laboratory chemical analysis as required (see Appendix F). Snow cores were then processed and prepared for shipment to Maxxam where the chemical analysis was performed. For QA/QC purposes, duplicate samples were collected at stations SS2-2, SS5-3, and Control-1. An equipment blank sample was collected at station SS2-1. Snow water chemistry sampling methodology is detailed in SOP ENVR-512-0213 (see Appendix F).

EQC, including “maximum average concentration” and “maximum concentration of any grab sample,” are stipulated in DDMI’s Water Licence (W2015L2-0001) for aluminum, ammonia, arsenic, cadmium, chromium, copper, lead, nickel, nitrite, and zinc (Table 2.2-1). Snow water chemistry results for these variables were compared to the “maximum concentration of any grab sample.” These results are also presented as part of DDMI’s AEMP report.

DDMI measures the chemistry of snow samples as this assists with characterizing the chemical content of the particulate material deposited over time. This is measured as the total metals and nutrients concentrations of the melted snow sample and makes direct comparison to maximum grab sample concentrations for EQCs difficult. It is important to note that the dust monitoring program is not designed to assess effects in the context used for most other AEMP water quality components.

DDMI compares the measured total metals levels for dust with EQC only because these criteria provide concentrations that can serve as general performance indicators, in a similar way that dustfall rates are compared with the Alberta Ambient Air Quality Objectives and Guidelines for dustfall (Alberta Environment and Parks, 2019). There is no intention or requirement that snow samples must meet the EQC or Alberta dustfall objectives.

3. RESULTS

Dustfall and snow water chemistry results were grouped into zones based on their relative distance from the mine footprint (Table 3-1). Station groupings into zones were first established at the outset of the program; however, these groupings were re-established in 2013 using satellite imagery of the site.

In 2019, the primary sources of fugitive dust were associated with unpaved road and airstrip usage and construction and mining activities at A21. Due to construction and mining activities at A21, the distance to mining operations were recalculated in 2019. The revised distances to mining operations are shown in Tables 2-1 and 3-1.

Major waste rock material transfers in 2019 included the use of haul roads (7,644,984 tonnes) and the transfer of kimberlite ore to the crusher (2,454,964 tonnes). Another source of fugitive dust was truck traffic along the ice road to the Project. The higher deposition rate near the ice road (at Dust 7 station) during the winter is explained by dustfall associated with the ice road; however, other dustfall stations immediately downwind of the ice road (SS2-4, SS3-5, and SS3-8) did not show elevated readings, indicating that dustfall associated with the ice road is generally insignificant relative to other sources.
To suppress dust generation, roads, parking areas and the plant site were watered during the summer as needed. Between June and September 2019, approximately 656 m^3 of water was applied to the plant site and 19,797 m^3 of water was applied to haul roads. The exact impact of dust suppression could not be determined from the data collected in 2019; however, it is likely that road watering reduced the amount of dust generated at the Mine in 2019. In 2019, the Underground Mine production continued at A154 and A418, as well as stripping and production at the A21 open pit. Fugitive dust generation is expected to be greatest during snow-free periods where and when there is site activity. It was expected that the highest fugitive dust generation and resulting dustfall occurred in areas closest to the roads, the airstrip, and mine footprint such as near A21 between May and September. The difference between the summer and winter dustfall rate was generally minor with the summer rate being slightly higher at few sites (e.g. Dust 3 rate was 1,024 mg/dm^2/y in the summer and 940 mg/dm^2/y in the winter), while some sites recorded a higher winter dustfall rate (e.g. Dust 2A rate was 309 mg/dm^2/y in the summer and 399 mg/dm^2/y in the winter).

The predominant wind directions at the site in 2019 were from east and northwest although winds in general can be described as omnidirectional. Therefore, the expectation is that airborne material will be deposited in all directions around the mine with a southeast and west emphasis (Figures 2-1 and 3.1-1). The results show that the proximity to the mine activity is a stronger indicator of dust deposition than wind direction. This is supported by the fact that the three highest dust deposition rates in 2019 (Dust 3, 10, and 11) are located south or southwest of the mine footprint where wind speeds were relatively weak compared to other directions. Dust 3, which is located only 22 m from the mine, had the highest recorded dustfall rate of the dustfall gauges in 2019.

Results from the dustfall gauges, dustfall snow surveys, and the snow water chemistry analyses are presented below.

3.1 Dustfall Gauges

For each station, total dustfall collected throughout the year is summarized in Table 3-1. Annual 2019 dustfall and the station location relative to the Project is presented in Figure 3.1-1, and the historical records of annual dustfall are presented in Figures 3.1-2 and 3.1-3. A comparison of 2019 dustfall versus distance from the mine footprint is presented in Figure 3.1-4. Boxplots summarizing the dustfall magnitude distribution measured in each year are presented in Figure 3.1-5. Detailed information on 2019 measurements and calculations for each station are included in Appendix B.

Table 3-1: Dustfall and Snow Water Chemistry Results, Diavik Diamond Mine, 2019

Zone	Station	Approx. Distance from Mining (m)	Dustfall (mg/dm²/y)	Snow Water Chemistry (µg/L)										
				Aluminum	Ammonia	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Nitrite	Phosphorus	Zinc
0-100 m	Dust 1	70	260	-	-	-	-	-	-	-	-	-	-	-
	Dust 3	22	982	-	-	-	-	-	-	-	-	-	-	-
	Dust 6	13	266	-	-	-	-	-	-	-	-	-	-	-
	Dust 10	46	683	-	-	-	-	-	-	-	-	-	-	-
	SS1-1	30	1,114	-	-	-	-	-	-	-	-	-	-	-
	SS3-6	35	276	96.3	96.00	0.06	0.00	0.39	0.09	0.07	2.02	5.60	254.00	0.05
	SS4-1	61	164	-	-	-	-	-	-	-	-	-	-	-
	SS5-1	26	381	-	-	-	-	-	-	-	-	-	-	-
	SS5-2	55	425	-	-	-	-	-	-	-	-	-	-	-
Mean			**506**	**96.3**	**96.00**	**0.06**	**0.00**	**0.39**	**0.09**	**0.07**	**2.02**	**5.60**	**254.00**	**0.05**
Median			**381**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**
Standard Deviation			**342**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**
95% Confidence Interval (Mean +/-)			**263**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**
Upper Limit of 95% Confidence Interval			**769**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**
Lower Limit of 95% Confidence Interval			**242**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**

Zone	Station	Approx. Distance from Mining (m)	Dustfall (mg/dm^2/y)	Snow Water Chemistry (µg/L)										
				Aluminum	Ammonia	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Nitrite	Phosphorus	Zinc
101-250 m	Dust 4	173	392	-	-	-	-	-	-	-	-	-	-	-
	SS1-2	115	371	-	-	-	-	-	-	-	-	-	-	-
	SS2-1	145	34	19.40	72.00	0.05	0.00	0.06	0.03	0.01	1.18	0.50	30.00	0.64
	SS3-7	239	432	134.00	110.00	0.10	0.00	0.47	0.18	0.10	1.68	11.00	413.00	0.83
	SS4-2	196	179	-	-	-	-	-	-	-	-	-	-	-
Mean			**282**	**76.70**	**91.00**	**0.07**	**0.00**	**0.26**	**0.10**	**0.05**	**1.43**	**5.75**	**221.50**	**0.74**
Median			**371**	**76.70**	**91.00**	**0.07**	**0.00**	**0.26**	**0.10**	**0.05**	**1.43**	**5.75**	**221.50**	**0.74**
Standard Deviation			**169**	**81.03**	**26.87**	**0.03**	**0.00**	**0.29**	**0.11**	**0.06**	**0.35**	**7.42**	**270.82**	**0.13**
95% Confidence Interval (Mean +/-)			**210**	**728.07**	**241.42**	**0.30**	**0.00**	**2.61**	**0.97**	**0.54**	**3.18**	**66.71**	**2,433.24**	**1.21**
Upper Limit of 95% Confidence Interval			**492**	**804.77**	**332.42**	**0.38**	**0.00**	**2.88**	**1.07**	**0.60**	**4.61**	**72.46**	**2,654.74**	**1.94**
Lower Limit of 95% Confidence Interval			**71**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Zone	Station	Approx. Distance from Mining (m)	Dustfall (mg/dm^2/y)	Snow Water Chemistry (µg/L)										
				Aluminum	Ammonia	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Nitrite	Phosphorus	Zinc
251-1,000 m	Dust 2A	425	355	-	-	-	-	-	-	-	-	-	-	-
	Dust 11	747	667	-	-	-	-	-	-	-	-	-	-	-
	SS1-3	260	32	-	-	-	-	-	-	-	-	-	-	-
	SS1-4	899	95	53.30	80.00	0.03	0.01	0.13	0.13	0.05	1.12	4.30	95.40	1.48
	SS2-2	427	44	19.80	34.00	0.02	0.00	0.04	0.04	0.01	0.44	1.20	17.00	0.89
	SS3-4	585	248	50.30	68.00	0.04	0.00	0.20	0.12	0.08	2.69	4.20	144.00	0.59
	SS3-8	826	296	78.90	110.00	0.05	0.00	0.30	0.10	0.06	1.47	4.70	211.00	0.41
	SS4-3	335	162	-	-	-	-	-	-	-	-	-	-	-
	SS5-3	259	481	139.50	75.00	0.05	0.00	0.24	0.20	0.12	1.77	7.25	278.50	1.10
	SS5-4	941	101	67.30	43.00	0.04	0.00	0.18	0.16	0.06	1.49	1.20	111.00	1.33
Mean			**265**	**68.18**	**68.33**	**0.04**	**0.00**	**0.18**	**0.12**	**0.06**	**1.50**	**3.81**	**142.82**	**0.97**
Median			**248**	**60.30**	**71.50**	**0.04**	**0.00**	**0.19**	**0.13**	**0.06**	**1.48**	**4.25**	**127.50**	**0.99**
Standard Deviation			**212**	**40.21**	**27.34**	**0.01**	**0.00**	**0.09**	**0.05**	**0.04**	**0.74**	**2.31**	**91.82**	**0.42**
95% Confidence Interval (Mean +/-)			**163**	**42.20**	**28.69**	**0.01**	**0.00**	**0.09**	**0.06**	**0.04**	**0.78**	**2.42**	**96.35**	**0.44**
Upper Limit of 95% Confidence Interval			**428**	**110.38**	**97.02**	**0.05**	**0.00**	**0.27**	**0.18**	**0.10**	**2.27**	**6.23**	**239.17**	**1.40**
Lower Limit of 95% Confidence Interval			**102**	**25.99**	**39.64**	**0.03**	**0.00**	**0.09**	**0.07**	**0.02**	**0.72**	**1.39**	**46.46**	**0.53**

Zone	Station	Approx. Distance from Mining (m)	Dustfall (mg/dm^2/y)	Snow Water Chemistry (µg/L)										
				Aluminum	Ammonia	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Nitrite	Phosphorus	Zinc
1,001-2,500 m	Dust 5	1,183	111	-	-	-	-	-	-	-	-	-	-	-
	Dust 7	1,147	298	-	-	-	-	-	-	-	-	-	-	-
	Dust 8	1,213	173	-	-	-	-	-	-	-	-	-	-	-
	Dust 12	2,326	212	-	-	-	-	-	-	-	-	-	-	-
	SS1-5	2,175	84	46.40	72.00	0.03	0.00	0.10	0.13	0.04	1.20	4.40	94.30	1.48
	SS2-3	1,194	41	31.00	77.00	0.02	0.00	0.06	0.09	0.02	0.79	0.50	40.00	1.00
	SS2-4	2,164	41	36.10	71.00	0.05	0.00	0.07	0.10	0.02	1.11	0.50	48.00	0.96
	SS3-5	1,325	50	23.50	65.00	0.03	0.00	0.08	0.03	0.02	3.03	2.80	52.10	0.53
	SS4-4	1,022	121	46.30	120.00	0.05	0.00	0.22	0.08	0.06	3.92	5.00	60.00	0.28
	SS4-5	1,214	137	52.80	87.00	0.03	0.00	0.20	0.08	0.05	3.40	2.40	77.30	0.45
	SS5-5	1,894	40	30.90	33.00	0.04	0.00	0.03	0.08	0.03	1.14	0.50	46.40	1.60
+2,500 m	Dust 9	3,796	84	-	-	-	-	-	-	-	-	-	-	-
Mean			**114**	**38.14**	**75.00**	**0.04**	**0.00**	**0.11**	**0.08**	**0.03**	**2.08**	**2.30**	**59.73**	**0.90**
Median			**98**	**36.10**	**72.00**	**0.03**	**0.00**	**0.08**	**0.08**	**0.03**	**1.20**	**2.40**	**52.10**	**0.96**
Standard Deviation			**80**	**10.58**	**26.02**	**0.01**	**0.00**	**0.07**	**0.03**	**0.02**	**1.31**	**1.90**	**19.44**	**0.51**
95% Confidence Interval (Mean +/-)			**51**	**9.78**	**24.06**	**0.01**	**0.00**	**0.07**	**0.03**	**0.01**	**1.21**	**1.76**	**17.98**	**0.47**
Upper Limit of 95% Confidence Interval			**166**	**47.93**	**99.06**	**0.04**	**0.00**	**0.18**	**0.11**	**0.05**	**3.30**	**4.06**	**77.70**	**1.37**
Lower Limit of 95% Confidence Interval			**63**	**28.36**	**50.94**	**0.03**	**0.00**	**0.04**	**0.06**	**0.02**	**0.87**	**0.54**	**41.75**	**0.43**

Zone	Station	Approx. Distance from Mining (m)	Dustfall (mg/dm²/y)	Snow Water Chemistry (µg/L)										
				Aluminum	Ammonia	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Nitrite	Phosphorus	Zinc
Control	Dust C1	4,646	115	-	-	-	-	-	-	-	-	-	-	-
	Dust C2	3,031	82	-	-	-	-	-	-	-	-	-	-	-
	Control 1	4,802	28	12.90	31.50	0.02	0.00	0.08	0.06	0.02	0.76	0.50	22.70	1.40
	Control 2	3,042	68	24.70	56.00	0.01	0.01	0.08	0.05	0.03	0.75	1.60	28.80	1.16
	Control 3	3,550	73	47.70	13.00	0.11	0.00	0.19	0.26	0.06	3.28	4.00	81.40	0.86
Mean			**73**	**28.43**	**33.50**	**0.05**	**0.00**	**0.12**	**0.12**	**0.03**	**1.60**	**2.03**	**44.30**	**1.14**
Median			**73**	**24.70**	**31.50**	**0.02**	**0.00**	**0.08**	**0.06**	**0.03**	**0.76**	**1.60**	**28.80**	**1.16**
Standard Deviation			**31**	**17.70**	**21.57**	**0.05**	**0.00**	**0.06**	**0.12**	**0.02**	**1.46**	**1.79**	**32.27**	**0.27**
95% Confidence Interval (Mean +/-)			**39**	**43.96**	**53.58**	**0.13**	**0.01**	**0.16**	**0.29**	**0.06**	**3.62**	**4.45**	**80.17**	**0.67**
Upper Limit of 95% Confidence Interval			**112**	**72.40**	**87.08**	**0.18**	**0.01**	**0.28**	**0.42**	**0.09**	**5.22**	**6.48**	**124.47**	**1.80**
Lower Limit of 95% Confidence Interval			**34**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.47**
Control-assessment	FFA-4	27,909	12	20.00	65.00	0.01	0.00	0.14	0.11	0.05	0.36	-	2.00	1.10
	FFB-4	16,004	50	126.00	61.00	0.04	0.00	1.48	0.33	0.17	5.41	-	11.80	1.37
	FF1-2	7,614	24	119.00	170.00	0.02	0.00	0.60	0.20	0.14	1.58	-	6.80	1.69
	LDS-1	11,897	20	16.60	29.00	0.01	0.00	0.07	0.09	0.05	0.20	-	1.00	1.10
Mean			**26**	**70.40**	**81.25**	**0.02**	**0.00**	**0.57**	**0.18**	**0.10**	**1.89**	**-**	**5.40**	**1.32**
Median			**22**	**69.50**	**63.00**	**0.02**	**0.00**	**0.37**	**0.16**	**0.10**	**0.97**	**-**	**4.40**	**1.24**
Standard Deviation			**16**	**60.24**	**61.32**	**0.01**	**0.00**	**0.65**	**0.11**	**0.06**	**2.43**	**-**	**4.96**	**0.28**
95% Confidence Interval (Mean +/-)			**26**	**95.86**	**97.58**	**0.02**	**0.00**	**1.03**	**0.17**	**0.10**	**3.86**	**-**	**7.89**	**0.45**
Upper Limit of 95% Confidence Interval			**52**	**166.26**	**178.83**	**0.04**	**0.00**	**1.60**	**0.35**	**0.21**	**5.75**	**-**	**13.29**	**1.76**
Lower Limit of 95% Confidence Interval			**0.5**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**-**	**0.00**	**0.87**

Notes:

Dash (-) = not available (snow water chemistry not sampled)

n/a = not applicable

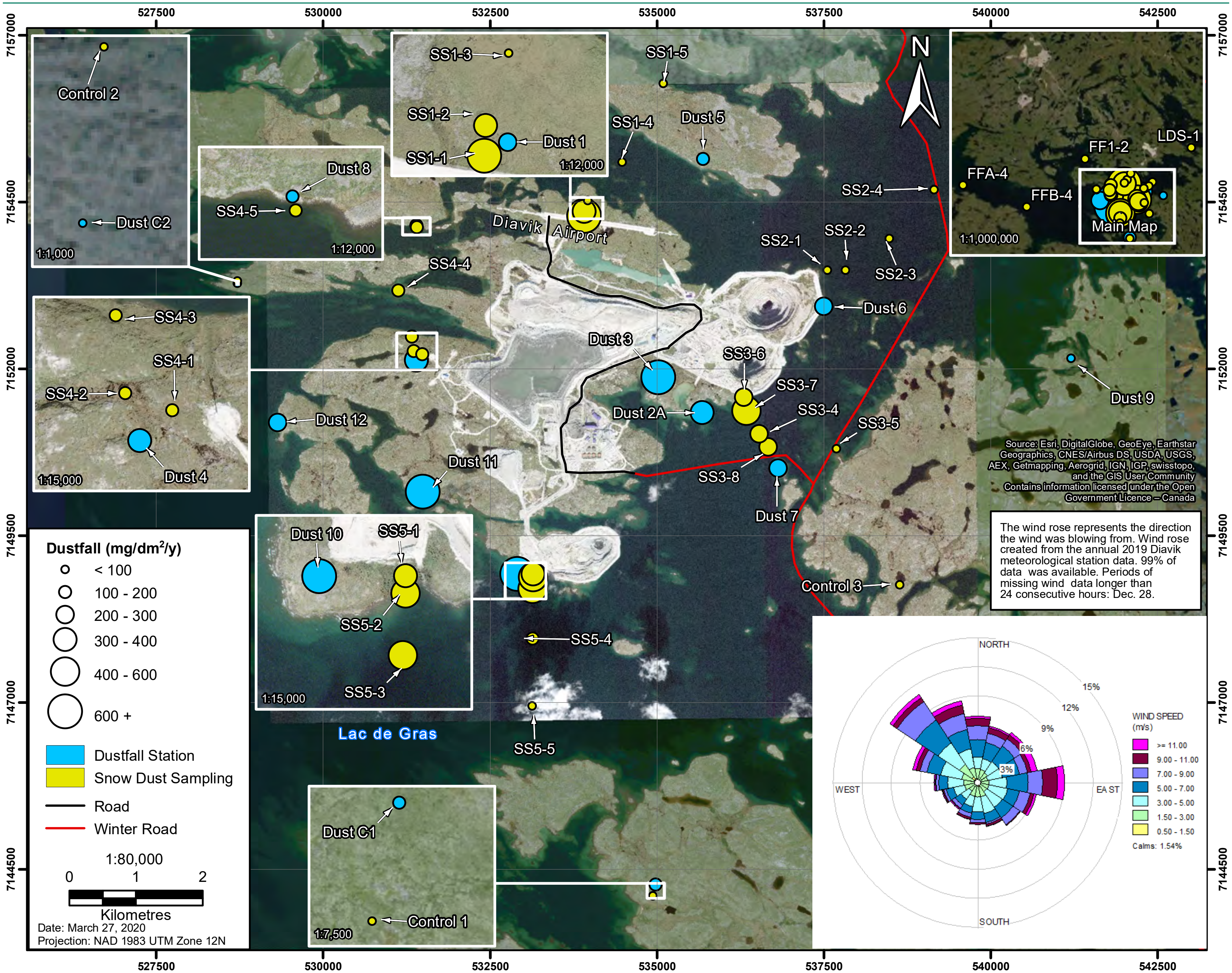
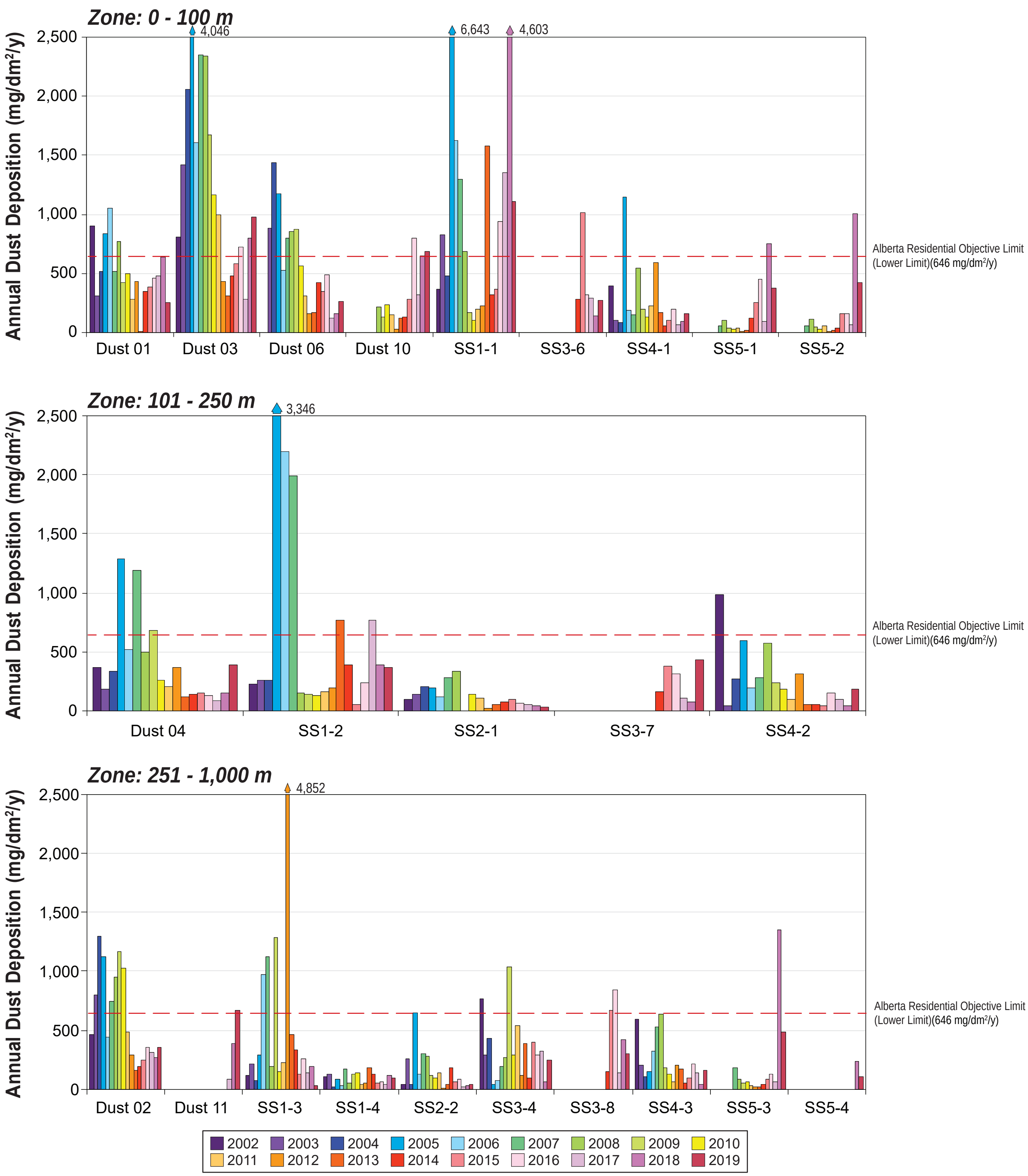
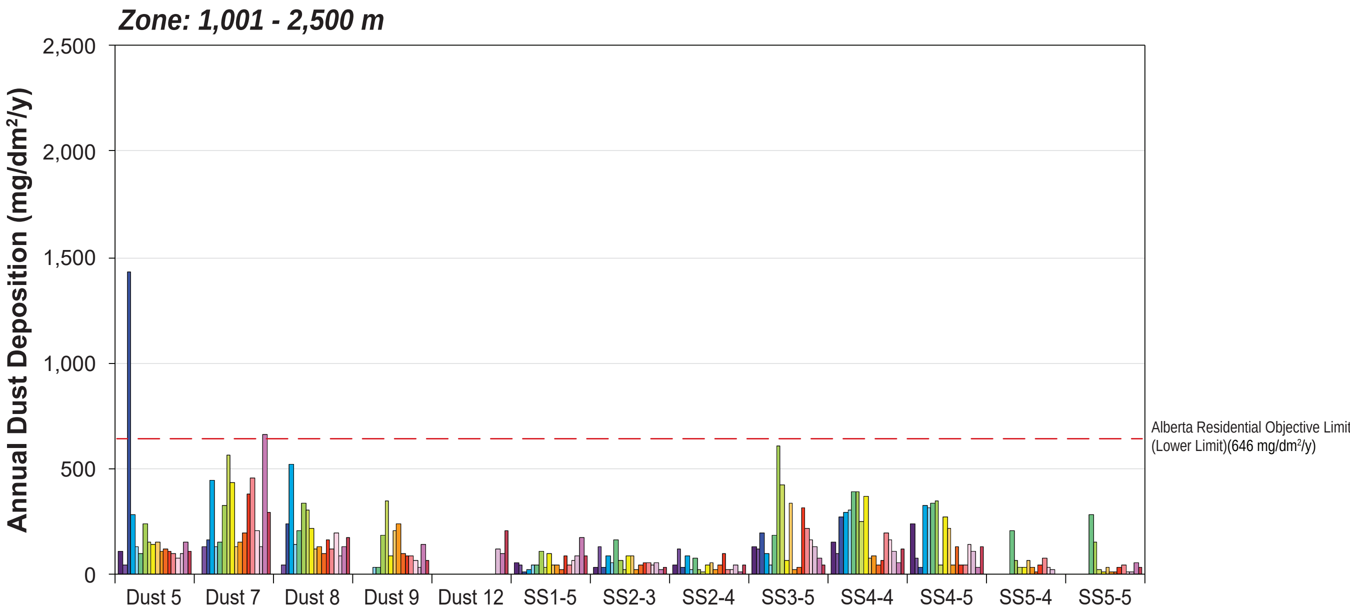


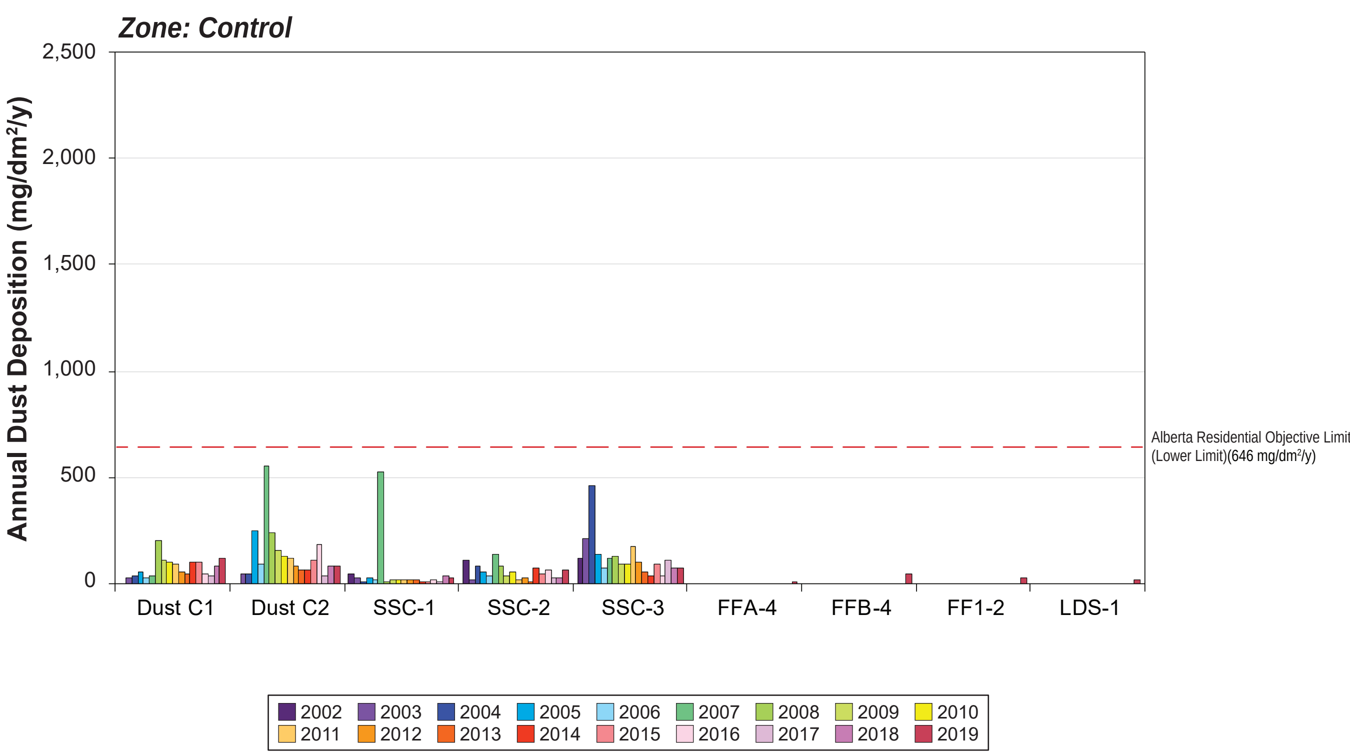
Figure 3.1-1: Dustfall Results, Diavik Diamond Mine, 2019



Notes: *Annual deposition was calculated using the methodology described in Section 2.*
See Table 2-1 for actual 2019 sample exposure times.
Station locations have been grouped into zones based on their distance from the 2019 Project footprint (see Section 3 for further details).
SS5-4 moved to 251-1,000 m zone in 2018

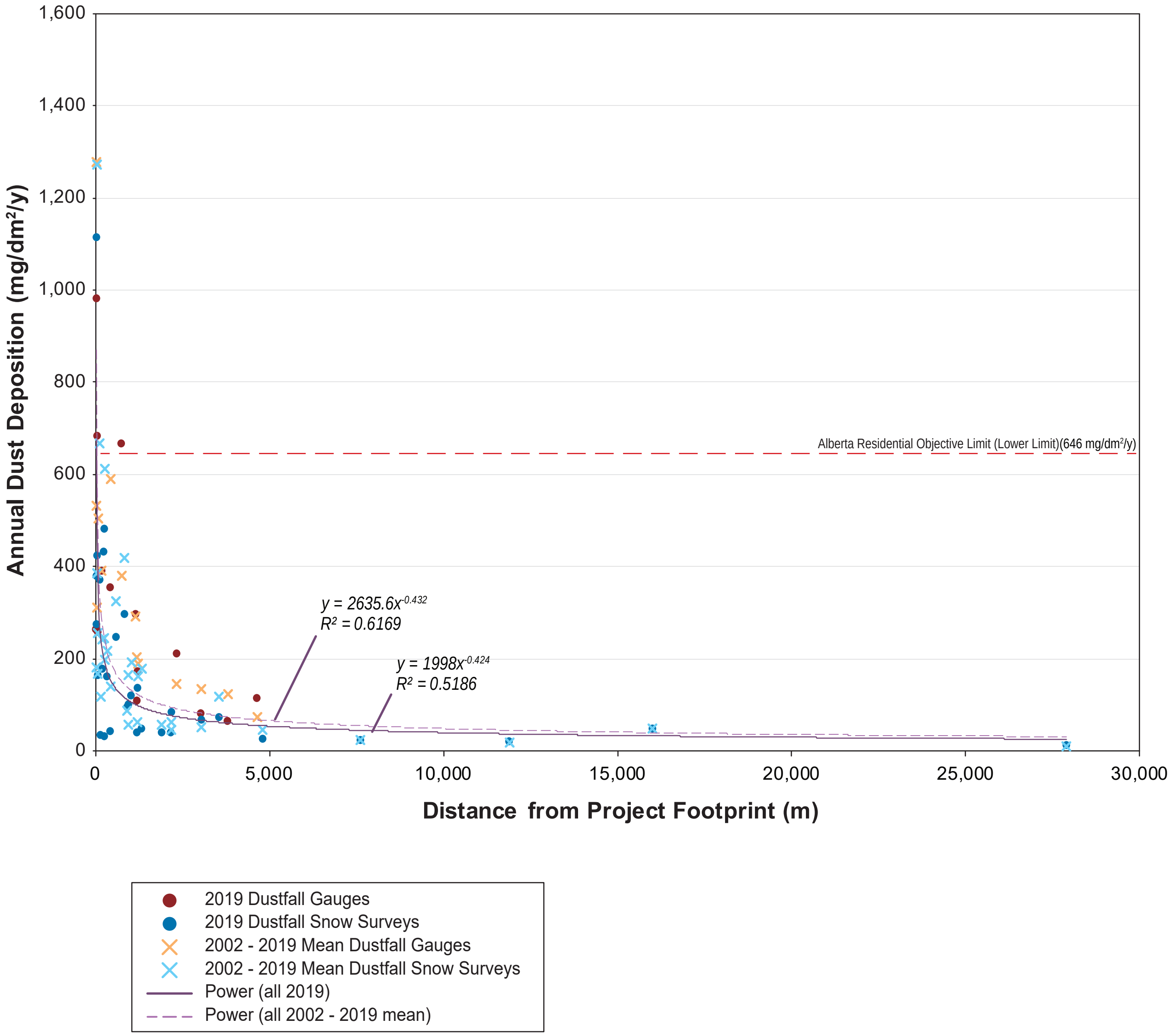
Figure 3.1-2: Calculated Annual Dust Deposition Rates at Dustfall Gauges and Snow Survey Locations up to 1,000 m from the Project Footprint, Diavik Diamond Mine, 2002 to 2019





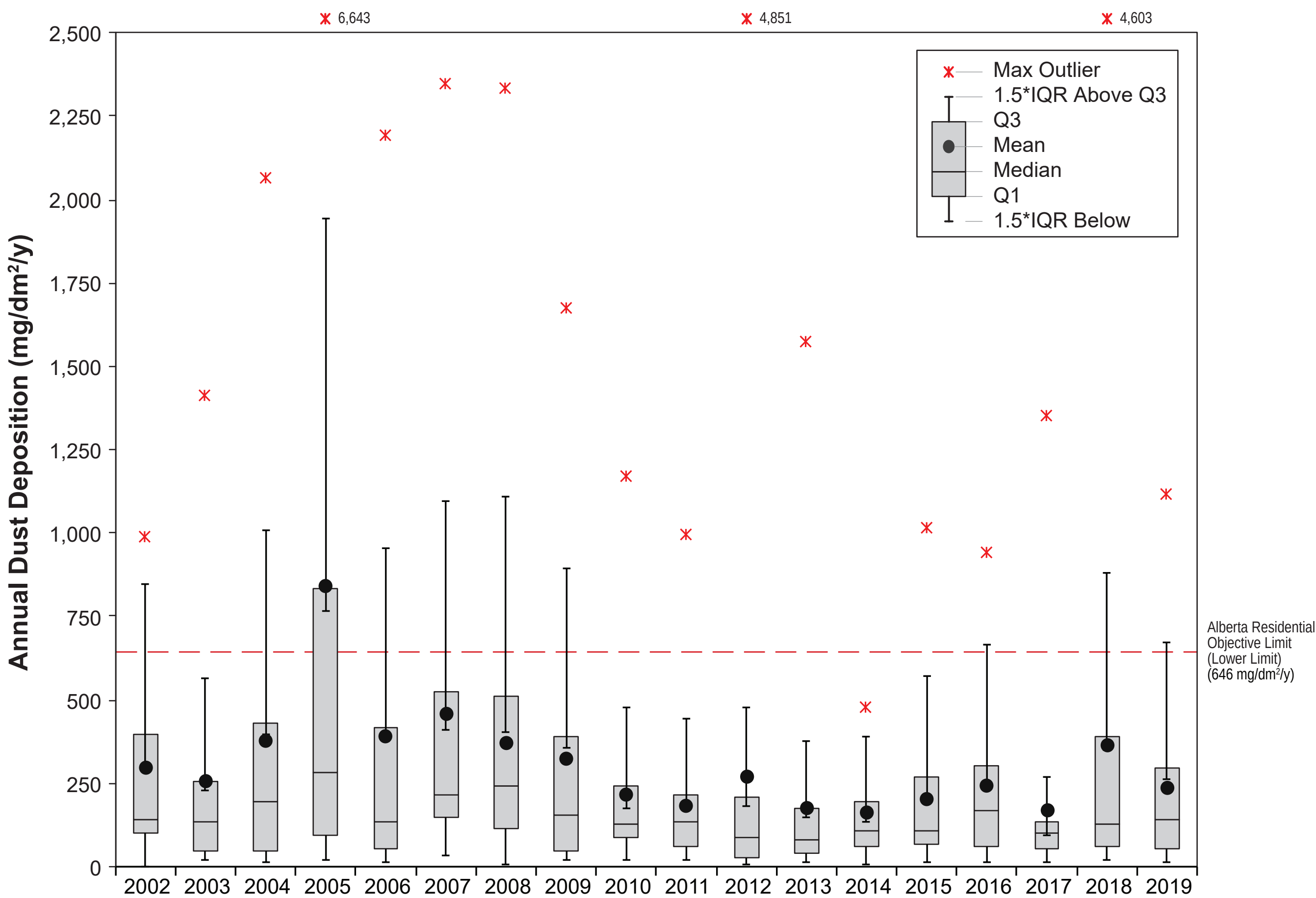
Notes: *Annual deposition was calculated using the methodology described in Section 2.*
See Table 2-1 for actual 2019 sample exposure times.
Station locations have been grouped into zones based on their distance from the 2019 Project footprint (see Section 3 for further details).
New locations added in 2019 include FFA-4, FFB-4, FF1-2 and LDS-1
SS5-4 moved to 251-1,000 m zone in 2018

Figure 3.1-3: Calculated Annual Dust Deposition Rates at Dustfall Gauges and Snow Survey Locations greater than 1,000 m from the Project Footprint, Diavik Diamond Mine, 2002 to 2019



Notes: Annual deposition was calculated using the methodology described in Section 2.
See Table 2-1 for actual 2019 sample exposure times.

Figure 3.1-4: Dust Deposition Versus Distance from Project Footprint, Diavik Diamond Mine, 2019



Notes: *Annual deposition is calculated using the methodology described in Section 2.*
See Table 2-1 for actual 2019 sample exposure times.
Q1: Lower quartile (25% of data are less than this value) ,
Q3: Upper quartile (25% of data are greater than this value),
IQR = Q3 – Q1 (the interquartile range).

Figure 3.1-5: Dust Deposition Box Plot, Diavik Diamond Mine, 2002 to 2019

Similar to 2018, the greatest estimated dustfall rate in 2019 measured using gauges occurred at Dust 3 (22 m from the Project). The Dust 3 measured dustfall rate in 2019 was 982 mg/dm^2/y. Dust 10 (683 mg/dm^2/y) and Dust 11 (667 mg/dm^2/y) recorded the second and third highest dustfall rates measured using gauges, respectively. Dust 10 site is adjacent to the A21 open pit, while Dust 11 is located west to the South Country Rock Pile – Waste Rock Storage Area (SCRP-WRSA; Figure 2-1). The lowest dustfall rate was recorded at Dust 9 (65 mg/dm^2/y). Both control stations Dust C1 (115 mg/dm^2/y; 4,646 m to the south) and Dust C2 (82 mg/dm^2/y; 3,031 m to the west) recorded higher dustfall rates than Dust 9 (Table 3-1; Figures 3.1-3 and 3.1-4). This is explained by the distance of Dust 9 from the Project footprint (3,796 m to the east), which places it within the control stations zone.

The dustfall rates estimated from dustfall gauges in 2019 were comparable to the 2018 rates. Four locations recorded lower deposition rates in 2019 than 2018, while all other locations recorded higher rates in 2019 (Figures 3.1-2 to 3.1-4). 2018 rates were generally the highest recorded since 2008 (DDMI 2019). The higher recorded dustfall values in both 2018 and 2019 suggest that dustfall rates in these two years were likely influenced by the surface activity at the mine, particularly at the A21 open pit, which began in December 2017, while the dustfall rates in 2017 were related mainly to the airstrip (DDMI 2018, 2019).

The annualized dustfall rates estimated from gauges at all stations were less than the upper limit of the Alberta Ambient Air Quality Objectives and Guidelines for dustfall (1,922 mg/dm^2/y), which is applied to industrial locations. The lower limit of these objectives (646 mg/dm^2/y) that is applied to residential and recreational areas was exceeded at the three sites that recorded the highest dustfall rates in 2019 (Dust 3, 10, and 11). The Alberta Ambient Air Quality Objectives and Guidelines recommends that dustfall objectives be used as general performance indicators only with no compliance requirement; thus, these objectives are used here for comparison purposes only, particularly as there are currently no standards or objectives for the Northwest Territories.

3.2 Dustfall Snow Surveys

Annual dustfall rates estimated from each snow survey station in 2019 are summarized in Table 3-1. Historical records of annual snow survey dustfall rates for each station are presented in Figures 3.1-2 and 3.1-3. The relationships between annual snow survey dustfall rates and distance from the mine footprint are shown in Figures 3.1-1 and 3.1-4. Boxplots summarizing dustfall rates measured in each year are presented in Figure 3.1-5. 2019 snow survey field datasheets and laboratory results are included in Appendix B. Duplicate samples collected at stations SS1-3, SS2-2, and SS4-1 for QA/QC purposes are discussed in Section 3.4.

Annualized dustfall rates estimated from 2019 snow survey data ranged from 12 to 1,114 mg/dm^2/y (Table 3-1; Figures 3.1-2 and 3.1-3). The maximum dust deposition rate was recorded at SS1-1 followed by SS5-3 (481 mg/dm^2/y). SS1-1 consistently recorded the highest dustfall rates from 2017 to 2019. The station is located due north of the airstrip, which explains the higher levels of dustfall found here. The higher levels of dustfall rates at SS5-3 is associated with the mine activity at A21 open pit (Figure 3.1-1).

In general, snow survey dustfall rates decreased with increasing distance from the Project. Mean dustfall rates estimated using both dustfall gauges and snow surveys within the 0 m to 100 m, 101 m to 250 m, 251 m to 1,000 m, 1,001 m to 2,500 m, control, and control–assessment zones were 506, 282, 265, 114, 73, and 26 mg/dm^2/y, respectively (Table 3-1). Dustfall rates at stations SS1-1, Dust 3, Dust 11, SS5-3, Dust 7, Dust 8, Dust 12, and Dust C1 were greater than the upper limit of the 95% confidence interval (CI) for their respective zones in 2019. A sample that exceeds the 95% confidence interval (CI) has a probability of occurrence of 5% or less, which indicating a particularly high dust deposition. In the 0 m to 100 m zone, the 95% CI was exceeded at the two sites adjacent to the air strip (SS1-1 and Dust 3), while in the 251 m to 1,000 m zone the 95% CI was exceeded at Dust 11 and SS5-3, which is likely explained by the proximity to the A21 open pit. Three exceedances of the 95% CI occurred in zone

1,001 m to 2,500 m (Dust 7, Dust 8, and Dust 12), while once exceedance occurred in the control zone (Dust C1). The exceedance of the 95% CI at Dust 7 is associated with dust from the ice road. Although the dustfall rates at Dust 8, Dust 12, and Dust C1 were relatively low in comparison to other dustfall gauges, they exceeded the 95% CI of their respective zone. This is mainly a result of the very low dustfall rates at all other sites of each zone except Dust 7 within the 1,001 to 2,500 m zone (Figure 3.1-1 and Table 3-1).

Annualized dustfall estimated from snow survey stations in 2019 were generally lower than 2018 dustfall estimates (Figure 3.1-5); although several stations recorded higher rates in 2019 than 2018 (Figures 3.1-2 and 3.1-3). The annualized dustfall rates estimated from snow surveys never exceeded the upper limit (applied to industrial locations) of the Alberta Ambient Air Quality Objectives and Guidelines at any station, while only SS1-1 exceeded the lower limit of these guidelines, which applies to residential and recreational areas.

3.3 Snow Water Chemistry

A summary of the snow water chemistry results for each variable of interest (i.e., variables with EQC and phosphorus) is provided below. The full suite of analytical results for snow water chemistry is included in Appendix D. For QA/QC purposes, duplicate samples were collected at stations SS2-2, SS5-3, and Control-1. An equipment blank sample was collected at station SS2-1. Results of QA/QC samples are discussed in Section 3.4.

All 2019 sample concentrations were less than their associated reference levels as specified by the “maximum concentration of any grab sample” in Water Licence W2015L2-0001.

In general, average concentrations of snow water chemistry variables of interest decreased with increasing distance from the Project (Figures 3.3-1 to 3.3-4). Concentrations of all parameters except ammonia, nitrite, and phosphorus were lower in 2019 compared to recent years. It should be noted that the 0 m to 100 m zone contains only one sampling location; therefore, no median was reported in Figures 3.3-1 to 3.3-4.

3.3.1 Aluminum

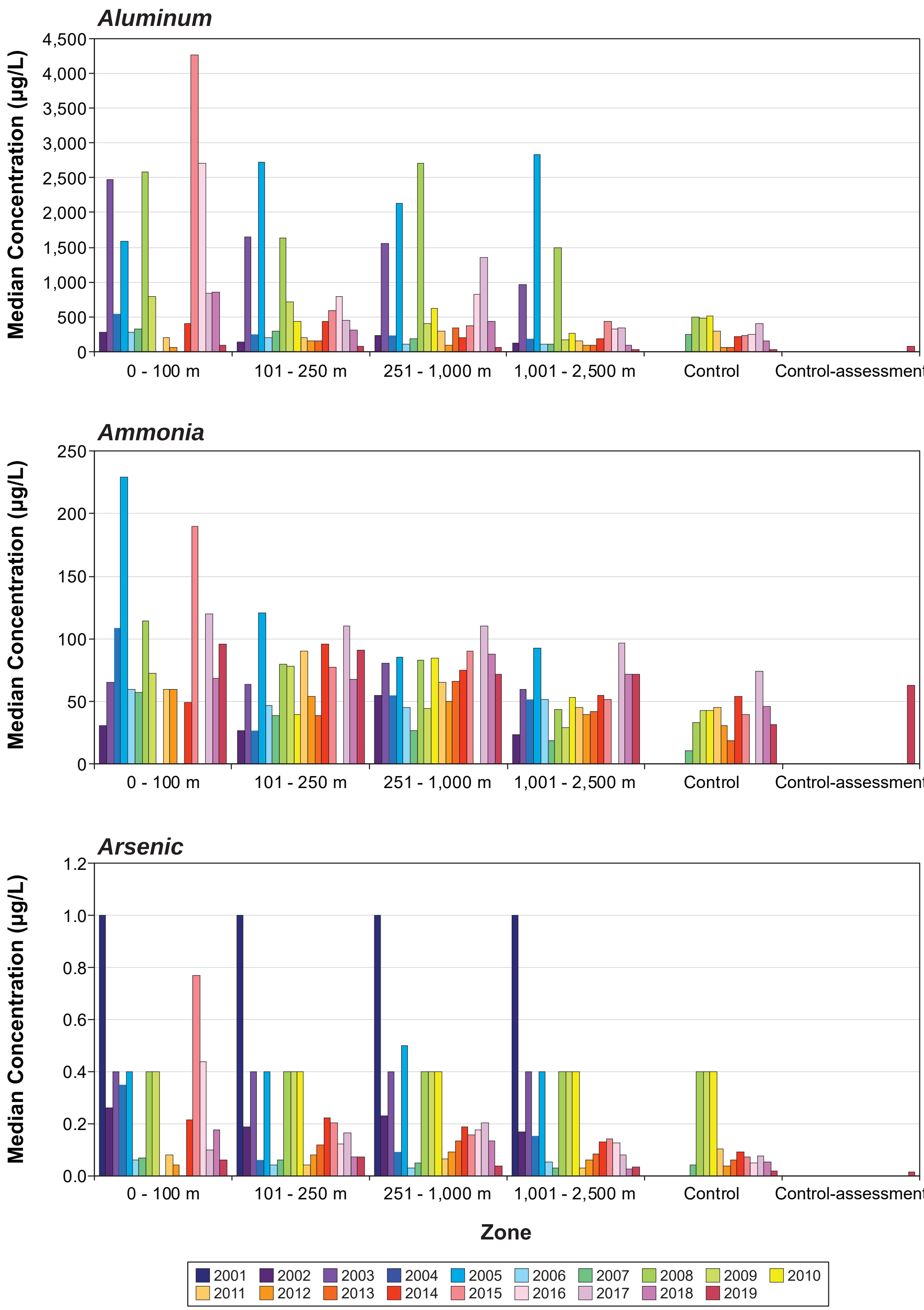
Aluminum concentrations measured in 2019 ranged from 13 µg/L at Control-1 station to 140 µg/L at station SS5-3 in the 251 m to 1,000 m zone (Table 3-1). Aluminum concentrations in 2019 were slightly higher in the 0 m to 100 m zone than other zones, where only one sample is available (Figure 3.3-1). The median concentrations in all other zones were much lower in 2019 compared to historical records (2001 to 2018). All the locations were well below the EQC concentration of 3,000 µg/L specified in the Water Licence (Table 3-1; Figure 3.3-1).

3.3.2 Ammonia

Ammonia concentrations measured in 2019 ranged from 13 µg/L at Control-3 station to 170 µg/L at FF1-2 Control-assessment station (Table 3-1). The second highest concentration of ammonia in 2019 was recorded at station SS4-4 in the 1,001 m to 2,500 m zone. The 2019 median concentrations in all zones were generally similar to historical data. All 2019 and historical ammonia measurements were well below the EQC of 12,000 µg/L specified in the Water Licence for grab sample concentrations.

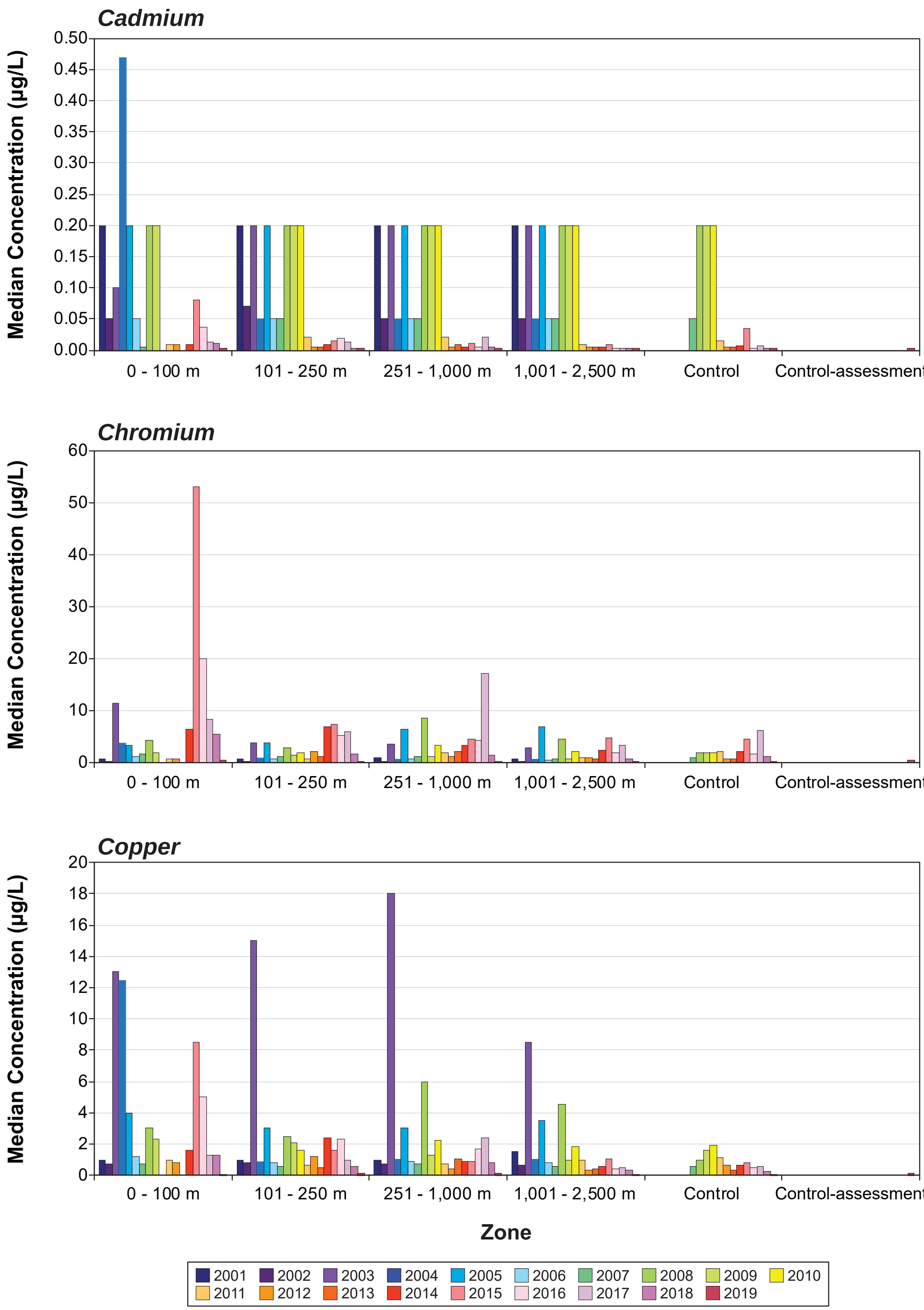
3.3.3 Arsenic

Arsenic concentrations measured in 2019 ranged from 0.01 µg/L at control-assessment stations FFA-4 and LDS-1 to 0.11 µg/L at Control-3 station (Table 3-1). Median 2019 arsenic concentrations generally decreased with increasing distance from the Project (Figure 3.3-1). 2019 median concentrations were generally lower than historical median concentrations in all zones (Figure 3.3-1). All measurements were well below the EQC of 100 µg/L specified in the Water Licence for grab sample concentrations.



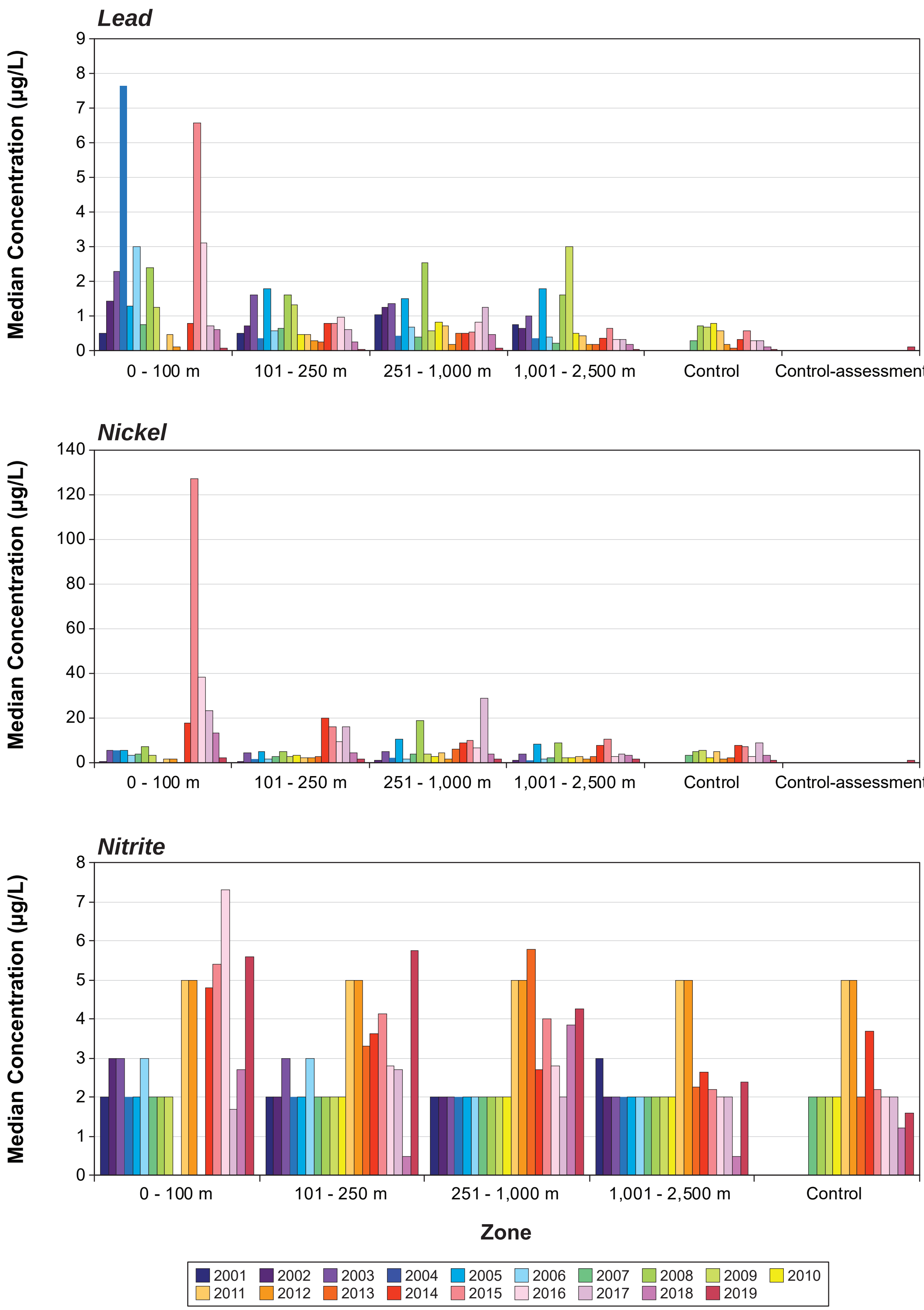
Notes: *The value used for the 0-100 m zone in 2019 represents one sample rather than the median.*
EQC (µg/L) = 3000 for Aluminum, 12000 for Ammonia, and 100 for Arsenic
Control-assessment locations added in 2019

Figure 3.3-1: Snow Water Chemistry Results: Aluminum, Ammonia and Arsenic, 2001 to 2019



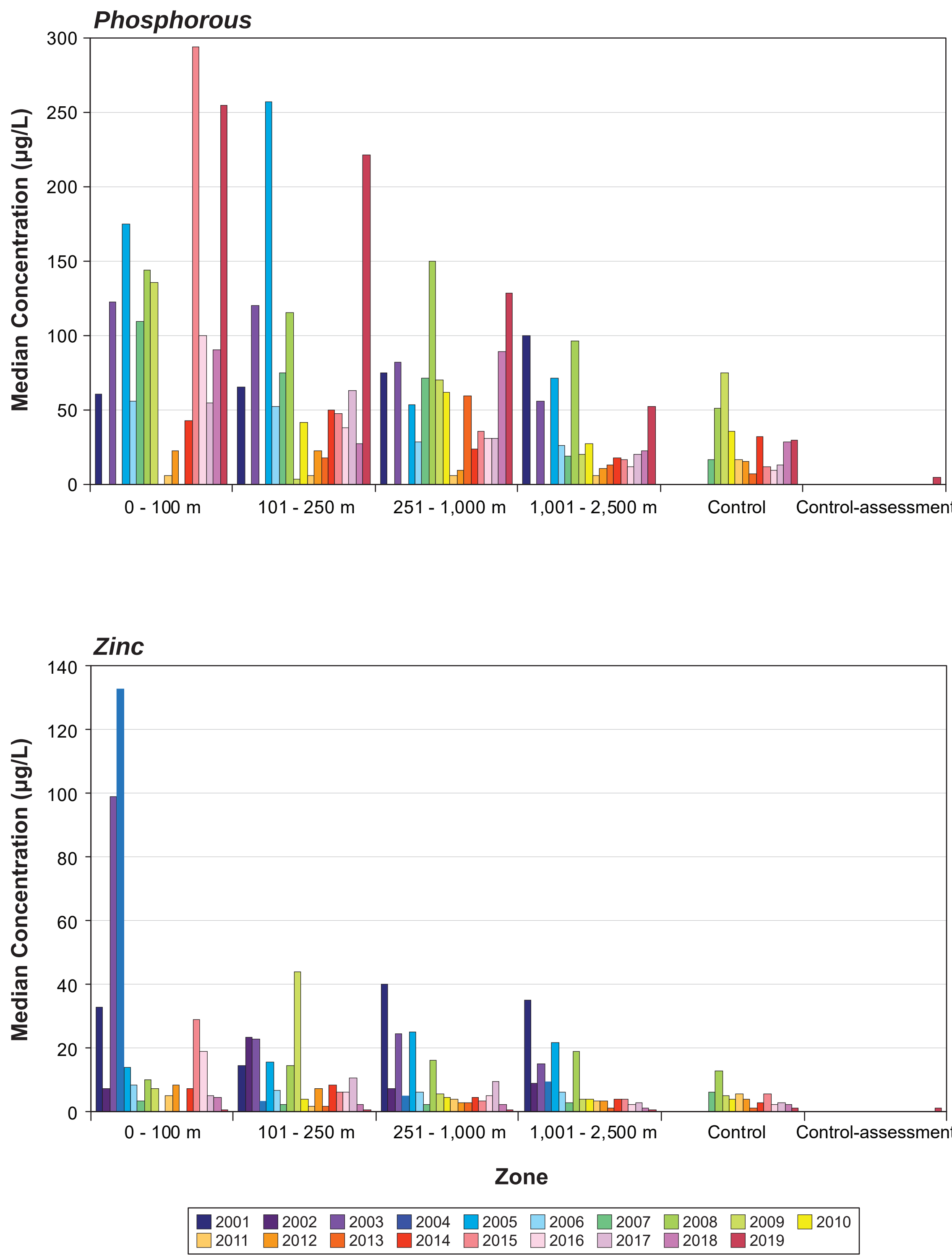
Notes: *The value used for the 0-100 m zone in 2019 represents one sample rather than the median.*
EQC (µg/L) = 3 for Cadmium, 40 for Chromium, and 40 for Copper
Control-assessment locations added in 2019

Figure 3.3-2: Snow Water Chemistry Results: Cadmium, Chromium and Copper, 2001 to 2019



Notes: *The value used for the 0-100 m zone in 2019 represents one sample rather than the median.*
EQC (µg/L) = 20 for Lead, 100 for Nickel, and 2000 for Nitrite
Control-assessment locations added in 2019

Figure 3.3-3: Snow Water Chemistry Results: Lead, Nickel and Nitrite, 2001 to 2019



Notes: *The value used for the 0-100 m zone in 2019 represents one sample rather than the median.*
EQC (µg/L) = 20 for Zinc, no EQC specified for Phosphorus
Control-assessment locations added in 2019

Figure 3.3-4: Snow Water Chemistry Results: Phosphorous and Zinc, 2001 to 2019

3.3.4 Cadmium

Cadmium concentrations measured in 2019 ranged from less than the analytical detection limit (< 0.0025 µg/L) at multiple stations in all zones to 0.006 µg/L at the Control-2 station (Table 3-1). Median 2019 cadmium concentrations were near or below analytical detection limits and were similar for all distance ranges (Figure 3.3-2). Medians and overall cadmium concentrations in 2019 were generally less than historical medians and concentrations. (Figure 3.3-2). All measurements were well below than the EQC of 3 µg/L specified in the Water Licence for grab sample concentrations.

3.3.5 Chromium

Chromium concentrations measured in 2019 ranged from less than the analytical detection limit (< 0.05 µg/L) at multiple stations to 1.5 µg/L at the control-assessment station FFB-4 (Table 3-1). The 2019 median concentration in each zone was generally lower than historical concentrations and well below 2018 and 2017 median concentrations (Figure 3.3-2). None of the measurements exceeded the EQC of 40 µg/L specified in the Water Licence for grab sample concentrations.

3.3.6 Copper

Copper concentrations measured in 2019 ranged from below the analytical detection limit (< 0.05 µg/L) at multiple locations to 0.33 µg/L at the control-assessment station FFB-4 (Table 3-1). Median 2019 copper concentrations were the lowest in the record (2001-2019; Figure 3.3-2), with very little variance between zones. All measurements were less than the EQC of 40 µg/L specified in the Water Licence for grab sample concentrations.

3.3.7 Lead

Lead concentrations measured in 2019 ranged from 0.01 µg/L at SS2-1 station in the 101-250 zone and station SS2-2 in the 251-1,000 m zone to 0.2 µg/L at station SS3-8 in the 251-1,000 m zone (Table 3-1). Similar to copper, the 2019 lead median concentrations in all zones were below all historical medians (2001-2018) with very little variance between zones (Figure 3.3-3). All measurements were well below than the EQC of 20 µg/L specified in the Water Licence for grab sample concentrations.

3.3.8 Nickel

Nickel concentrations measured in 2019 ranged from 0.2 µg/L at the control-assessment station LDS-1 to 5.4 µg/L at the Control-assessment station FFB-4 (Table 3-1). Median 2019 nickel concentrations were generally comparable or below historical concentrations (2002-2018) with little variance between the zones. All measurements were well below than the EQC of 100 µg/L specified in the Water Licence for grab sample concentrations.

3.3.9 Nitrite

Nitrite concentrations measured in 2019 ranged from less than the analytical detection limit (<1.0 µg/L) at multiple stations to 11 µg/L at station SS3-7 in the 101-250 m zone (Table 3-1). Median 2019 nitrite concentrations decreased with increasing distance down to below the detection limit (Figure 3.3-3). Nitrite concentrations at the control-assessment sites were not available in 2019. The 2019 median concentrations were higher than 2018 concentrations in all zones but still comparable to historical medians (Figure 3.3-3). All measurements were well below the EQC of 2,000 µg/L specified in the Water Licence for grab sample concentrations.

3.3.10 Phosphorus

Phosphorus concentrations measured in 2019 ranged from below the analytical detection limit (<2.0 µg/L) at the control-assessment station LDS-1 to 413 µg/L at station SS3-7 in the 101-250 m zone (Table 3-1). Median 2019 phosphorus concentrations decreased with increasing distance from the Project (Figure 3.3-4) and were higher than 2016 to 2018 concentrations in all zones (Figure 3.3-4). Although the Water Licence has a load limit for phosphorus, there is no EQC specified for this parameter.

3.3.11 Zinc

Zinc concentrations measured in 2019 ranged from 0.3 µg/L at SS4-4 station in the 1,001-2,500 zone to 1.7 µg/L at the Control-assessment station FF1-2 (Table 3-1). Median 2019 zinc concentrations were generally less than historical records (2001-2018) with little variance between all zones (Figure 3.3-4). All measurements were well below the EQC of 20 µg/L specified in the Water Licence for grab sample concentrations.

3.4 Evaluation of Existing Control Sites

The three lowest dustfall rates in 2019 were recorded at the newly added far-field control-assessment sites FFA-4 (11 $mg/dm^2/y$), LDS-1 (20 $mg/dm^2/y$) and FF1-2 (24 $mg/dm^2/y$). These sites are located furthest away from the mine footprint (7,614 to 27,909 m away from footprint); thus, they likely represent background values. The SS2 transect stations (SS2-1, SS2-2, SS2-3, and SS2-4), in addition to stations SS1-3 and SS5-5, all recorded low dustfall rates. Stations SS1-3, SS5-5, and SS2, as well as the control-assessment sites (except FFB-4), recorded lower dustfall rates than the control sites SSC-2 and SSC-3, indicating that the rates at these two control sites may not be representative of background values, suggesting that dustfall rates at the control sites are potentially affected by the Project. However, the potential effects of the Project on the dustfall in the control zone have marginal impacts on the dustfall monitoring program since dustfall rates at the control zone are significantly lower than rates within zones closer to the Project area (e.g., zones 0 m to 100 m, 101 m to 250 m, 251 m to 1,000 m). The highest concentration of several snow water chemistry variables were recorded at the FF1-2 and FFB-4 control-assessment sites (FF1-2 recorded the highest Ammonia and Zinc concentrations, while FFB-4 recorded the highest Chromium, Copper and Nickel concentration). The distant location of both FF1-2 and FFB-4 from the Project footprint indicates that the higher snow chemistry concentrations at these sites are likely not related to the Project activity.

3.5 Quality Assurance and Control

Dustfall gauge, dustfall snow survey and snow water chemistry sampling and analysis were conducted by experienced technicians following SOPs ENVR-508-0112, ENVR-512-0213, and ENVR-303-0112 to ensure proper field sampling and laboratory analysis. As part of SOP ENVR-512-0213, duplicate and blank samples were taken for some snow survey and snow water chemistry sample sites (Table 2-1). The results from these samples are summarized in Tables 3.5-1 and 3.5-2.

The relative percent difference (RPD) of duplicate samples from a site represents the amount of variation between duplicates. According to the Project AEMP, the data quality objective for duplicate water quality samples is a RPD of 40% when concentrations are ≥ 5 times the detection limit (DL; AEMP 2017). RPD values are only calculated when concentrations are ≥ 5 times the DL (BC MOE 2013). The calculated RPD values exceeded 40% at two occasions.

Table 3.5-1: Sample Duplicates

Parameter	Duplicate Analytical Results (DUPW1/DUPW2; mg/dm²/y; µg/L)					Analytical Detection Limit (µg/L)	Relative Percent Difference [a] (%)				
	SS1-3	SS4-1	SS2-2	Control-1	SS5-3		SS1-3	SS4-1	SS2-2	Control-1	SS5-3
Dustfall	50/39	254/208	26/38	-	-	0.1	25%	20%	37%	-	-
Aluminum	-	-	17.9/21.7	13.1/12.7	128/151	0.2	-	-	19%	3%	16%
Ammonia	-	-	37/31	23/40	72/78	5	-	-	18%	54%	8%
Arsenic	-	-	0.01/0.027	0.027/0.01	0.051/0.054	0.02	-	-	n/a	n/a	n/a
Cadmium	-	-	*0.0025/0.0025*	*0.0025/0.0025*	*0.0025/0.0025*	0.005	-	-	n/a	n/a	n/a
Chromium	-	-	0.053/0.025	0.025/0.128	0.236/0.235	0.05	-	-	n/a	n/a	n/a
Copper	-	-	0.025/0.052	0.054/0.065	0.154/0.245	0.05	-	-	n/a	n/a	n/a
Lead	-	-	0.0074/0.0077	0.0182/0.0166	0.11/0.126	0.005	-	-	n/a	n/a	14%
Nickel	-	-	0.414/0.47	0.685/0.839	1.79/1.74	0.02	-	-	13%	20%	3%
Nitrite	-	-	1.9/0.5	0.5/0.5	7.2/7.3	1	-	-	n/a	n/a	1%
Phosphorus	-	-	18/16	25.4/20	189/368	2	-	-	12%	24%	64%
Zinc	-	-	0.87/0.91	1.18/1.61	0.92/1.27	0.1	-	-	4%	31%	32%

Notes:

n/a = RPD is not applicable since concentration is less than 5 times the detection limit.

"-" = parameter is not measured.

For measurements that were less than the detection limit, half the detection limit was used for calculations and are italicized.

[a] Relative difference between duplicates, with respect to their mean: RPD = 100 × |rep1 − rep2| / [(rep1 + rep2)/2].

Table 3.5-2: Analytical Blanks for QA/QC Program

Parameter	SS2-1 Equipment Blank Sample (µg/L)	Percent of Equipment Blank Sample below SS2-1 Sample	Detection Limit (µg/L)
Aluminum	0.10	99%	0.2
Ammonia	*2.50*	97%	5
Arsenic	*0.01*	79%	0.02
Cadmium	*0.003*	0%	0.005
Chromium	*0.03*	58%	0.05
Copper	*0.03*	0%	0.05
Lead	*0.003*	79%	0.005
Nickel	0.02	98%	0.02
Nitrite	*0.50*	0%	1
Phosphorus	*1.00*	97%	2
Zinc	0.46	29%	0.1

Note:

For measurements that were less than the detection limit, half the detection limit was used for calculations and are italicized.

The results of the QA/QC duplicates indicate that snow chemistry is spatially variable on the scale of metres within which the duplicates are collected. The data quality objective from the AEMP (i.e., RPD less than 40%) is designed for surface *liquid* water samples. Surface water in a stream or lake will mix more readily than snow, particularly once snow has settled and has been compacted by wind. Site-specific differences between snow core sampling replicates may not be visible to the sampling team, but may result in differences in the chemical composition of the snow. RPD exceeded 40% once at each of Control-1 station and SS5-3 station. The absolute differences between observations were similar in magnitude for both duplicates from both locations. The similarity in the magnitude of the variability is consistent with small-scale spatial variation, rather than data quality issues. The results of the sampling network of 23 sites has been demonstrated to detect and quantify Project effects on snow water chemistry (Section 3.3), and these results are concluded to be reliable despite the small-scale variation identified in the QA/QC program.

Dustfall RPD at SS1-3 was 25%, SS4-1 was 20%, and SS2-2 was 37% which shows that small scale variation for dustfall and snow water chemistry measures was similar. There is no similar data quality objective for RPD related to dustfall, although spatial variability in dustfall rates similar to snow chemistry is expected.

The equipment blank sample was processed at station SS2-1, thus the blank sample concentrations are compared against SS2-1 concentrations. Most of the blank parameters were much less than those from the SS2-1 sample, suggesting the data were of good quality. The cadmium, copper and nitrite samples were at the detection limit, while the cause of the relatively small difference in zinc is unknown.

4. SUMMARY

Median dustfall rates from dustfall gauges measured in 2019 were slightly higher than 2018 results, with most dustfall gauges recording higher rates in 2019, while 2019 rates from snow surveys were comparable to 2018 results. Similar to historical results, dustfall rates in 2019 decreased with distance from the Project. Annual dustfall estimated from each of the 14 dustfall gauges ranged from 65 to 982 mg/dm^2/y. The annualized dustfall rates estimated from the 2019 snow survey data ranged from 12 to 1,114 mg/dm^2/y. Because dustfall gauges continuously collect dust throughout the year, and the snow surveys are only representative of dustfall accumulated over the snow-covered period, the reported annual dustfall results from the dustfall gauges are expected to provide a better estimate of annual dustfall compared to snow survey results for similar geographic areas. However, results obtained from both methods showed similar patterns. Dustfall rates in 2019 were generally within the historical data range collected for the Project. Annualized dustfall rates estimated from each snow survey station in 2019 were less than some historical dustfall estimates.

In 2019, four new locations were added to the snow survey monitoring network to assess the performance of the existing control sites (control-assessment stations). The new sites are located at greater distances from the project footprint (7,614 m to 27,909 m) than the existing monitoring network (13 m to 4,802 m). Overall, as expected, dustfall rates generally decreased with distance from the Project with the lowest dustfall rate recorded at station FFA-4 (a new added site at 27,909 m west of the Project) with the three lowest dustfall rates recorded at the newly added control-assessment sites. Two of the existing control sites recorded higher dustfall rates than the control-assessment sites, and higher than all the SS2 transect stations (SS2-1, SS2-2, SS2-3, and SS2-4) and stations SS1-3 and SS5-5, which suggests that dustfall rates at the control sites are potentially affected by the Project. Thus, the rates at the control sites may not represent background values. However, the potential effects of the Project on the dustfall in the control zone have marginal impacts on the dustfall monitoring program since dustfall rates at the control zone are significantly lower than rates within zones closer to the Project area (e.g., zones 0 m to 100 m, 101 m to 250 m, 251 m to 1,000 m).

Areas that were closer to the Project, roads, and airstrip received more dustfall than other areas. Mean dustfall rates estimated using both dustfall gauges and snow surveys within the 0 m to 100 m, 101 m to 250 m, 251 m to 1,000 m, 1,001 m to 2,500 m and control and control-assessment zones were 506, 282, 265, 114, 73, and 26 mg/dm^2/y, respectively. Although there are no dustfall standards for the Northwest Territories, all the 2019 dustfall rates were well below the non-residential 5.26 mg/dm^2/d (1,920 mg/dm^2/y) Alberta Ambient Air Quality Objective for dustfall (Alberta Environment and Parks 2019). Dust 3, Dust 10, Dust 11, and SS1-1 stations were higher than the residential limit of the Alberta Ambient air Quality Objective for dustfall (1.76 mg/dm^2/d; 646 mg/dm^2/y). This objective is used only as a general performance indicator.

Snow water chemistry analytes of interest included those variables with EQC (i.e., aluminum, ammonia, arsenic, cadmium, chromium, copper, lead, nickel, nitrite, and zinc) or a load limit (i.e., phosphorus) specified in the Type “A” Water Licence (W2015L2-0001, formerly W2007L2 0003). All 2019 sample concentrations were well below their associated reference levels as specified by the “maximum concentration of any grab sample” specified in Water Licence W2015L2 0001. Concentrations in 2019 were generally lower than recent years for all parameters except ammonia, nitrite and phosphorus. Typically, concentrations decreased with distance from the Project. The highest concentrations of six variables of interest were recorded at three of the control-assessment sites (FFB-4, LDS-1, and FF1-2) and one was recorded at Control-2 station. The highest concentrations for all variables were less than their corresponding EQC.

5. REFERENCES

Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

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