Rio Tinto

Diavik Diamond Mines (2012) Inc.
P.O. Box 2498
Suite 300, 5201 – 50th Avenue
Yellowknife, NT X1A 2P8
Canada
T (867) 669 6500
F (867) 669 9058

Ms. Violet Camsell-Blondin
Chair
Wek'èezhìi Land and Water Board
Box 32
Wekweètì, NT X0E 1W0

26 May 2017

Dear Ms. Camsell-Blondin:

Subject: 2016 AEMP Annual Report, Dust Analysis Erratum

The 2016 Aquatic Effects Monitoring Plan (AEMP) Annual Report was submitted to the Wek'èezhìi Land and Water Board (WLWB) on 31 March 2017 to meet the requirements of Water License W2015L2-0001 Part J Item 8. Diavik Diamond Mines (2012) Inc. subsequently identified a portion of the required analysis that was regrettably not included in the 31 March submission.

The 2014 AEMP Annual Report Reasons for Decision (14 November 2016) required DDMI to consider the potential effects of dust on the receiving environment in the 2016 AEMP Annual Report. In this Decision, the WLWB notes that in DDMI's proposed AEMP Design Version 4.0 submission, a method to address concerns and earlier directives relating to the link between dust program results and potential effects to the receiving environment was discussed. This method was based on data already collected as part of the AEMP and did not require changes to the sampling Design (i.e., additional monitoring sites). The Board therefore directed DDMI to include the required subsection starting with the 2016 AEMP Annual Report:

> ***3. DDMI is to include the required subsection starting with the 2016 AEMP Annual Report.***

The attached erratum addresses this requirement and Section 4.0 provides a summary of the results of this analysis.

If you have any questions regarding the attached submission, please contact the undersigned at 867-669-6500 ext. 5536 or david.wells@riotinto.com.

Yours sincerely

David Wells
Superintendent – Environment

cc Anneli Jokela (WLWB)
Sarah Elsasser (WLWB)
Ryan Fequet (WLWB)

Attach: Technical Memorandum: Preliminary Assessment of Phosphorus Deposition to Lac de Gras

TECHNICAL MEMORANDUM

DATE May 26, 2017 **PROJECT No.** 1771843/SCO155

TO David Wells
Diavik Diamond Mines (2012) Inc.

CC Gord Macdonald; Cam McNaughton

FROM Rainie Sharpe **EMAIL** rsharpe@golder.com

PRELIMINARY ASSESSMENT OF PHOSPHORUS DEPOSITION TO LAC DE GRAS

1.0 INTRODUCTION

The Diavik Diamond Mines Inc. (DDMI) 2016 Aquatic Effects Monitoring Program (2016 AEMP) Report submitted to the Wek'eezhii Land and Water Board (WLWB) on 31 March 2016 did not include an analysis of phosphorus loadings to Lac de Gras from dustfall. Inclusion of an analysis estimating the timing and relative magnitude of phosphorus loadings to Lac de Gras was a requirement of the 2016 AEMP as directed by the Board following review of the 2014 AEMP.

This technical memorandum (1) summarizes methods used to compute total phosphorus (TP) loadings to Lac de Gras from all relevant sources, and (2) summarizes and discusses the results of this analysis.

2.0 METHODS

Phosphorus is delivered "naturally" to Lac de Gras directly via atmospheric deposition and indirectly via runoff from the Lac de Gras watershed. Phosphorus can also be delivered through chemical weathering of local rocks. However, weathering is typically slow and is not considered in this analysis due to lack of relevant data. Since rates of atmospheric deposition for TP are low, concentrations in Lac de Gras are also predicted to be low.

Lac de Gras is classified as an oligotrophic lake and is characterized by very low concentrations of nutrients, including TP. The median (and estimated range) of background concentrations of TP in Lac de Gras is 3.6 micrograms per litre (μg/L; 2.0 to 5.0 μg/L) during the winter, and 3.3 μg/L (2.0 to 5.3 μg/L) during the open water season (Table 3.2-12; Golder 2015).

Effluent from the Diavik mine and atmospheric deposition of phosphorus contained in mine-related fugitive dusts can both contribute additional "anthropogenic" phosphorus to Lac de Gras. We examine the relative magnitude of phosphorus potentially delivered to Lac de Gras in 2016 herein, and consider the following sources:

- Natural (i.e., background) atmospheric deposition of TP directly to Lac de Gras;
- Natural (i.e., background) contribution of TP from the Lac de Gras watershed delivered indirectly through runoff to Lac de Gras;
- Anthropogenic TP delivered directly to Lac de Gras via the Diavik mine effluent; and
- Anthropogenic TP delivered indirectly to Lac de Gras via atmospheric deposition of fugitive dust.

The following approach was used to estimate the above quantities:

1) Average rates of natural TP deposition in 2016 were calculated based on the concentrations of TP measured in snow samples collected at reference stations included in the Diavik dust monitoring program. Ancillary data collected with the snow cores enables the conversion of their concentration in snow (in μg/L) to a deposition rate (in milligrams per square metre per year; $mg/m^2/yr$).

2) Observed rates of anthropogenic TP deposition in 2016 were calculated using TP concentrations measured in non-reference snow samples collected along transects included in the Diavik dust monitoring program (Appendix I of the DDMI Aquatic Effects Monitoring Program, 2016 Annual Report).

3) The surface area of Lac de Gras (573 square kilometres; km^2) and the Lac de Gras watershed area (3,560 km^2), excluding Lac de Gras itself (2,987 km^2) (Golder 2017), were multiplied by the background rates of TP deposition to estimate the magnitude of natural, direct and indirect, TP loadings to Lac de Gras.

4) Diavik mine effluent TP loading in 2016 is that reported in the 2016 Project Environment Summary (i.e., 406 kg/yr; Golder 2017).

5) Spatial interpolation (i.e., kriging) of the 2016 dustfall TP observations using the ARCGIS software program were used to estimate anthropogenic TP loadings resulting from the deposition of fugitive mine dust.

The following assumptions are implicit to the analysis of TP loadings for Lac de Gras:

- Reference dustfall monitoring stations are unaffected by atmospheric deposition of fugitive mine dust (i.e., they are representative of the regional background rate of TP deposition).
- Atmospheric deposition of natural TP is spatially homogeneous throughout the Lac de Gras watershed (i.e., the mean/median values are valid and spatially representative).
- All atmospheric deposition of TP in the Lac de Gras watershed in 2016 is assumed to report to Lac de Gras. This explicitly ignores uptake of TP on land, its storage and eventual release (i.e., we assumed a steady-state, where the mass of TP deposited to the landscape is assumed to be in equilibrium with the mass of TP being delivered to the lake via runoff during a calendar year).
- For the spatial interpolation of anthropogenic phosphorus loadings:
  - TP deposition, as derived from TP concentrations measured in snow, is assumed to represent total deposition over an eight month period and, therefore, results are multiplied by 12/8 to compute total annual loading in $mg/m^2/yr$.
  - The zone-of-influence of fugitive dust deposition is assumed to be less than 1.5 km from the Diavik mine boundary (Golder 2016); however, spatial interpolation of the dust deposition data was carried out to a distance of 5 km from the mine boundary and includes deposition rates recorded at all snow sampling stations sampled as part of the Diavik dustfall monitoring program in 2016.
  - There are 21 valid TP observations from snow survey transects in 2016 (N_{obs} = 21). Twenty artificial data points (N_o = 20) were created along the mine boundary and assigned the average of the three highest TP deposition values observed in 2016. Another twenty artificial data points (N_{inf} = 20) were evenly spaced at 5 km from the mine boundary perimeter and assigned the background rate of TP deposition observed in 2016. These artificial data points are required as “boundary conditions” in order to perform the spatial interpolation of anthropogenic TP loadings. This should be a conservative estimate of TP

deposition at the mine boundary in all other directions because the three highest TP deposition values are those recorded downwind from the Diavik mine.

3.0 RESULTS

3.1 Phosphorus Concentrations in Snow

The concentrations of TP measured in 2016 as a function of distance to the Diavik mine boundary are presented in Figure 1. The data collected at the same locations from 2002 until 2013 are also presented. Two-tailed Student's T-tests (α = 0.05) were used to compare the mean concentrations of TP in snow in 2016 to the average near-field (<1.5 km) and far-field (>1.5 km) concentrations measured from 2002 to 2013 (note that near-field and far-field areas are defined differently herein compared to other AEMP components). These results are summarized in Table 1 and indicate no significant difference between average TP concentrations in 2016 to those measured between 2002 and 2013. Therefore, the 2016 results are considered representative of typical deposition rates for use in estimating mine-related TP deposition to Lac de Gras.

The following should be noted upon considering the analyses herein:

1) "Far-field" data in the 2002 to 2013 data set include some upwind locations at distances <1.5 km from the mine boundary which were previously determined to be statistically indistinguishable from the reference (background) stations.

2) 2014 and 2015 TP concentration in snow data are available but have not been integrated into the existing data set at this time; and

3) Small errors in the "distance to mine" parameter are due to the use of manually entered distances in the 2016 field report, as compared to GIS derived distances to the mine boundary for the previous years' data. These minor spatial displacements do not affect the results of this analysis.

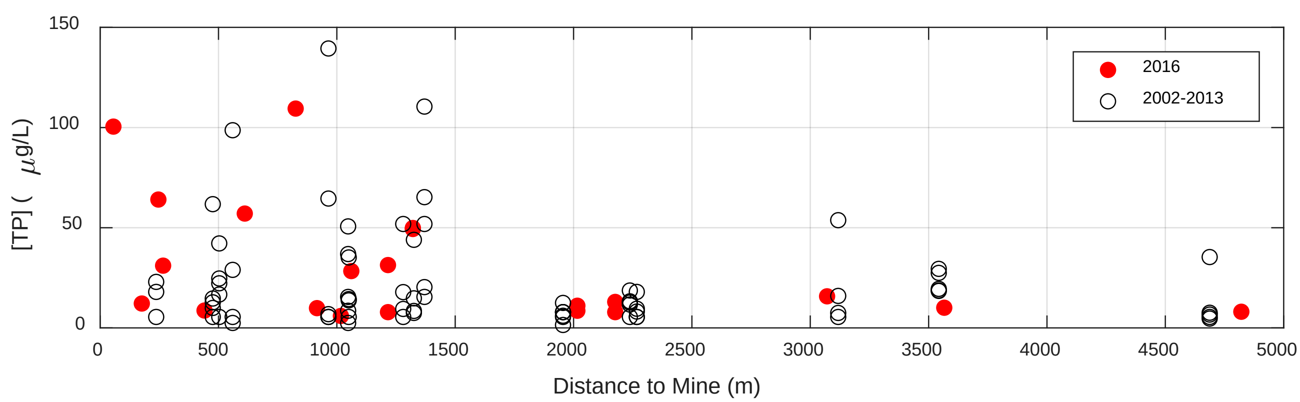


Figure 1: Total Phosphorus Concentrations as a Function of Distance to the Diavik Mine Boundary

Table 1: Summary of 2016 Total Phosphorus Concentrations in Snow

Region	Time Period	N	Arithmetic Mean (μg/L)	Median (μg/L)	Geometric Mean (μg/L)	T-test Result
Near Field[(a)] (<1.5 km)	2002 - 2013	26	28.2	18.7	17.3	P = 0.246
	2016	14	39.9	30.8	26.7	
Far Field[(a)] (>1.5 km)	2002 - 2013	49	17.8	9.5	11.2	P = 0.392
	2016	7	10.2	9.6	9.8	

(a) The near-field and far-field regions presented herein are defined differently than the other AEMP components; μg/L = micrograms per litre; km = kilometre.

3.2 Phosphorus Deposition Rates

Annual TP deposition rates (in mg/m^2/yr) can be computed from the TP concentrations in snow using the following information:

1) Total snow water equivalents in each snow sample, in litres (L);

2) Snow core sampler area ($A = \pi r^2$, where r = 0.0305 m) and number of snow cores combined to provide a single snow sample sent for off-site laboratory analysis (i.e., typically 1 to 3 cores per sample) (Appendix I of the DDMI Aquatic Effects Monitoring Program, 2016 Annual Report f); and

3) Assumption that snow samples represent 8 months of total annual dust/TP deposition.

The 2016 TP deposition rates for the near-field and far-field areas defined above are presented in Table 2. The arithmetic mean TP deposition rate in the far-field area is 1.9 mg/m^2/yr (Table 2). The 95th confidence interval for the far-field arithmetic mean is 1.2 to 2.6 mg/m^2/yr. The wide confidence interval is the result of a single outlier with a recorded deposition rate of 0.03 mg/m^2/yr.

When this outlier is removed, the arithmetic mean, geometric mean and median deposition rates converge to a value of 2.2 mg/m^2/yr. However, for conservatism, the natural "background" rate of TP deposition was assigned a value of only 1.9 mg/m^2/yr, which corresponds to the lower 95th confidence interval for the arithmetic mean, excluding the outlier. This background deposition rate is applied to the 20 N_{inf} data points used for spatial interpolation, and to Lac de Gras and its watershed for calculation of background TP loadings.

Similarly, the three highest observed TP deposition rates were: 17.9, 18.1 and 25.4 mg/m^2/yr. For the purpose of the spatial interpolation, an average deposition rate of 20.5 mg/m^2/yr was assigned to the 20 N_o data points spaced evenly around the perimeter of the Diavik mine boundary.

Table 2: Summary of 2016 Total Phosphorus Deposition Rates

Region	N	Arithmetic Mean ($mg/m^2/yr$)	Median ($mg/m^2/yr$)	Geometric Mean ($mg/m^2/yr$)	Range ($mg/m^2/yr$)
Near-field[(a)] (<1.5 km)	14	9.5	8.4	6.4	1.5 – 25.4
Far-field[(a)] (>1.5 km)	7	1.9	2.1	1.2	0.03 – 3.3
Far-field[(a)] (no outlier)	6	2.2	2.2	2.2	1.9 – 2.7

(a) The near-field and far-field regions presented herein are defined differently than the other AEMP components; $mg/m^2/yr$ = milligrams per square metre per year; km = kilometre.

3.3 Phosphorus Loadings

Natural TP loadings to Lac de Gras and to the Lac de Gras watershed, excluding Lac de Gras, were computed by multiplying a background TP deposition rate of 1.9 $mg/m^2/yr$ (Table 2) with the surface areas of the lake, and the watershed excluding the lake. The area of Lac de Gras is 573 km^2 and the area of the watershed, excluding the lake is 2,987 km^2 for a total watershed area of 3,560 km^2. Thus, direct background TP loading to the lake is estimated at 1.09 tonnes per year (t/yr). The background TP loading to the watershed excluding the lake is 5.68 t/yr for a total watershed loading of 6.76 t/yr (Table 3).

Anthropogenic TP loadings due to Diavik Mine effluent are those reported in the *Project Environment Summary – 2016* (Golder 2017). Effluent is assumed to include any TP captured in runoff collected on-site that may be affected by the local deposition of fugitive dust within the mine boundary. The TP load from the Diavik mine effluent is 0.41 t/yr.

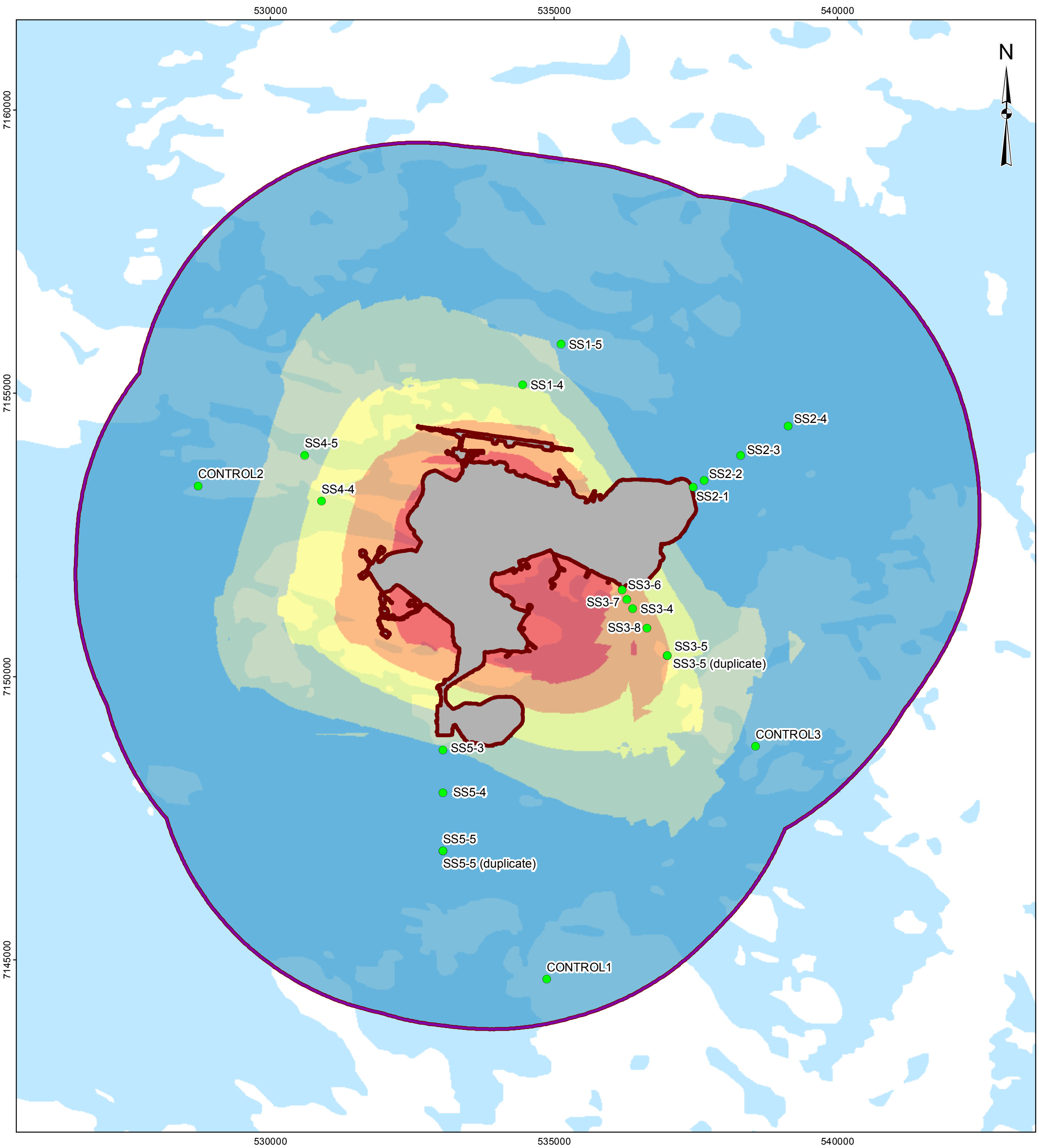
Anthropogenic TP loadings due to dust deposition were computed by spatially interpolating the observed deposition rates from all 21 snow sample locations in a domain that begins at the mine boundary and extends to 5 km from the mine boundary. Twenty locations along the mine boundary (N_o) were assigned a TP deposition rate of 20.5 $mg/m^2/yr$ and twenty locations at 5 km from the mine boundary (N_{inf}) were assigned a TP deposition rate of 1.9 $mg/m^2/yr$. The TP outlier deposition rate (i.e., 0.03 $mg/m^2/yr$) was reassigned a deposition rate of 2.2 $mg/m^2/yr$, consistent with the observed mean/median values in the far-field area.

Results of the spatial interpolation of TP deposition are illustrated in Figure 2. The area of the mine footprint is 11.6 km^2 and the area of the modelled domain, excluding the mine footprint, is 178 km^2. Integration of the interpolated TP deposition surface within the model domain results in a TP loading of 0.88 t/yr. However, this loading includes the background deposition of 1.9 $mg/m^2/yr$ over the 178 km^2 area (i.e., a loading of 0.34 t/yr). Subtracting the background loading of TP within the model domain results in an estimated anthropogenic contribution of 0.54 t/yr of TP from aerial deposition of mine-related fugitive dust.

Table 3: Summary of Estimated Total Phosphorus Loading to Lac de Gras, 2016

Total Phosphorus Source	Area (km^2)	TP Loading (t/yr)	Percent Increase (relative to Total Background Load)
Background deposition to Lac de Gras	573	1.09	–
Background deposition to watershed excluding lake	2,987	5.68	–
Total background load	**3,560**	**6.76**	–
Diavik mine effluent	–	0.41	6.1%
Mine Footprint (at 20.5 $mg/m^2/yr$)	11.6	0.24	–
Fugitive dust from mine plus background (from spatial interpolation within model domain)	178	0.88	–
Fugitive dust from mine (less background at 1.9 $mg/m^2/yr$)	178	0.54	8.0%
Total mine-related TP load (effluent plus fugitive dust from mine)	**–**	**0.95**	**14.1%**

km^2 = square kilometre; t/yr = tonnes per year; $mg/m^2/yr$ = milligrams per square metre per year; TP = total phosphorus; – = not applicable.



LEGEND

- SNOW SURVEY STATION (CHEMISTRY)
- 2016 MINE PERIMETER
- MODEL EXTENT (5 km BUFFER)
- 2016 DIAVIK FOOTPRINT
- WATERBODY

TOTAL PHOSPHORUS DEPOSITION (mg/m^2/yr)

- 1.6 - 5
- 5.1 - 10
- 10.1 - 15
- 15.1 - 20
- 20.1 - 26.8

REFERENCE

CANVEC BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. END OF YEAR (2016) MINE PERIMETER PROVIDED BY DIAVIK.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

2 0 2

SCALE 1:100,000 KILOMETRES

PROJECT

DIAVIK™ DIAMOND MINES INC.

TITLE

SNOW SURVEY LOCATIONS AND MODELLED TOTAL PHOSPHORUS DEPOSITION

Golder Associates

PROJECT		1771843	FILE No.
DESIGN	TD	04/26/16	SCALE AS SHOWN / REV. 0
GIS	VGV	05/25/17	
CHECK	CMc	05/25/17	FIGURE: 2
REVIEW	ZK	05/25/17	

I:\CLIENTS\DIAVIK\1771843\Mapping\MXD\Air\1771843_Snow_Survey_modelled_Total_Phosphorus_Rev0.mxd Date: 2017-05-25 4:19:05 PM

4.0 DISCUSSION

Results of this initial evaluation of the annual TP load to Lac de Gras from various sources suggest that the contribution of TP from mine-related dust deposition is similar to the total annual TP load from effluent. Based on 2016 data, the Diavik mine effluent has the potential to increase the TP load in Lac de Gras by approximately 6%, and contributions from fugitive dust could add an additional 8%. The conservatively estimated 2016 total mine-related TP input from effluent and dust deposition is 0.95 tonnes, or 950 kg, which is slightly lower than the Effluent Quality Criterion (EQC) defined in the Water Licence (WLWB 2015) of an average annual load of 1,000 kg/yr from effluent alone. Water quality data collected under the AEMP allows an evaluation of potential effects from all mine-related sources of phosphorus to Lac de Gras.

Atmospheric deposition tends to be episodic in nature, occurring mostly during dry and windy conditions, and will be limited in its spatial extent (i.e., highest closest to the mine). Since Lac de Gras is ice-covered for approximately 8 months of the year, spring breakup results in a relatively large pulse of TP being delivered over a short period of time. As a result, local changes to TP concentration in Lac de Gras may be higher near the mine (i.e., around the east island) at the time of spring breakup. Since the mine effluent is also released near the east island, there is limited opportunity to separately evaluate the potential effects of these two sources; however, that is being undertaken by a qualitative analysis of spatial trends in water quality at selected stations in the mid-field area (see Section 3.7 in the 2016 Effluent and Water Chemistry Report; Appendix II to the 2016 AEMP Annual Report).

The analysis presented above is subject to uncertainty. Deposition estimates assume a conservative background rate of TP deposition of 1.9 mg/m^2/yr, which is the lower limit of the 95% confidence interval for the 2016 TP deposition rate in the far-field area. The average rate of background TP deposition may be as high as 2.7 mg/m^2/yr, which would result in a natural total watershed loading of TP of 9.61 t/yr. Using this background deposition rate of 2.7 mg/m^2/yr results in an estimated 0.40 t/yr of deposition from fugitive dust and, therefore, a 4.3% and 4.2% increase in TP loading to Lac de Gras as a result of Diavik mine effluent and aerial deposition of fugitive dust, respectively.

The potential of TP loading from mine-related dust deposition to contribute to nutrient enrichment in Lac de Gras is difficult to evaluate based on existing information, but available information suggests that it is substantially lower than that from effluent input. Although the estimated relative annual TP loads from effluent (6%) and dust (8%) are similar, TP from effluent contains a large proportion of soluble reactive phosphorus (SRP) (i.e., approximately 50%), which is the bioavailable form of this nutrient. TP input from dust is associated with particulate material, and although it is expected to release a small proportion of SRP, the greater fraction of this TP load is likely to remain in particulate form and settle to the lake bottom. Bottom sediments in Lac de Gras contain a relatively high concentration of TP (i.e., mean of 913 mg/kg dry weight across all AEMP stations in 2016); however, since Lac de Gras bottom waters are oxygenated through the year, dissolved phosphorus release from bottom sediments is unlikely, as also indicated by the low TP concentrations measured in lake water. Therefore, the sediments are expected to act as a sink for the majority of particulate-associated phosphorus deposited from dust deposition.

The seasonality of phosphorus input to lake water from dust deposition also suggests a limited effect on lake productivity. As noted above, the phosphorus load accumulated on ice from dust deposition during the winter months is released as a pulse during spring break-up. At that time, water temperature is close to the annual minimum, which limits biological productivity.

5.0 CLOSURE

This technical memorandum used TP deposition data collected as part of the 2016 Diavik dust fall monitoring program and Diavik mine effluent data to provide an estimate of phosphorus loadings to Lac de Gras. Future AEMP reports will include a similar analysis to provide supporting information for the evaluation of potential effects of phosphorus inputs from the Diavik mine on Lac de Gras.

Golder trusts that this technical memorandum meets the needs of Diavik Diamond Mines Inc. and the Wek'eezhii Land and Water Board. Should you have any questions regarding this memo or its contents, please contact Dr. Cameron McNaughton via phone (306-220-4235) or email (csmcnaug@golder.com).

Original Signed
Cameron S. McNaughton, PhD, P.Eng
Environmental Engineer

Original Signed
Zsolt Kovats, M.Sc.
Associate, Senior Aquatic Ecologist

CM/ZK/RLS

\\golder.gds\calgary\active_2016\3 proj\1648005 ddmi_2016_environmental projects\14000 2016 aemp annual report\13. 14950 2016 aemp - addendum for dust loading\1771843_diavik_tpdeposition2016_no-recommendations.docx

6.0 REFERENCES

Golder Associates Ltd. (Golder), 2015. AEMP Reference conditions Report Version 1.1, prepared for Diavik Diamond Mines (2012) Inc. Document No.: RPT-1433 Ver 1.1.

Golder Associates Ltd. (Golder), 2016. 2011 to 2013 Aquatic Effects Re-evaluation Report Version 3.2. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT. June 2016.

Golder Associates Ltd. (Golder), 2017. Diavik Diamond Mines (2012) Inc. Project Environmental Summary – 2016. Prepared for Diavik Diamond Mines (2012) Inc. Document No. RPT-1579 Ver. 1.0.

WLWB (Wek'èezhìı Land and Water Board). 2015. Wek'èezhìı Land and Water Board Type A Water Licence #W2015L2 0001, effective October 19, 2015. Yellowknife, NT, Canada.