

APPENDIX E.11
GROUNDWATER MONITORING REPORT
2017 PILOT PROGRAM



BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

2017 GROUNDWATER MONITORING PILOT PROGRAM REPORT

March 31, 2018

TABLE OF CONTENTS

SECTION 1.0 - INTRODUCTION.....	1
SECTION 2.0 - METHODS.....	2
2.1 MONITORING LOCATIONS AND SCHEDULE	2
2.2 SAMPLE COLLECTION AND ANALYSIS.....	2
2.3 QUALITY ASSURANCE AND QUALITY CONTROL	2
SECTION 3.0 - RESULTS AND DISCUSSION	3
SECTION 4.0 - CONCLUSIONS AND RECOMMENDATIONS	4

LIST OF TABLES

TABLE 1 – MONITORING WELL LOCATIONS AND DEPTH

TABLE 2 – WATER QUALITY RESULTS – 2017 GROUNDWATER MONITORING PILOT PROGRAM

LIST OF FIGURES

FIGURE 1 – 2017 GROUNDWATER MONITORING PROGRAM

SECTION 1.0 - INTRODUCTION

In accordance with Condition 23 of the Project Certificate No. 005 – Amendment 1 issued to Baffinland Iron Mines Corporation (Baffinland) by the Nunavut Impact Review Board (NIRB) for the Mary River Project (the Project), Baffinland conducted a pilot groundwater monitoring program (pilot program) in 2017. The monitoring program focused on establishing groundwater monitoring well locations up-gradient and down-gradient of the Project's Non-Hazardous Waste Landfill Facility (Landfill Facility) located at the Mary River Mine Site (Mine Site). The objective of the pilot program was to assess the feasibility of monitoring groundwater quality near Project infrastructure using drive-point piezometers. The following sections discuss the methods and results of the 2017 pilot program conducted at the Landfill Facility and provides recommendations for future groundwater monitoring at the Project.

SECTION 2.0 - METHODS

2.1 MONITORING LOCATIONS AND SCHEDULE

The 2017 pilot program consisted of establishing groundwater monitoring well locations approximately down-gradient and up-gradient of the Landfill Facility at the Mine Site. Groundwater monitoring locations were established to the depth of permafrost (approx. 1 – 1.5 metres) using drive-point piezometers. Drive-point piezometers used in the 2017 pilot program were Solinst Model 615 Drive-Point Piezometers. Three (3) monitoring locations (MS-LF-GW1, MS-LF-GW2, and MS-LF-GW3) were established down-gradient of the Landfill Facility and one (1) monitoring location (MS-LF-REF2) was established up-gradient of the Landfill Facility. Surface topography and drainage paths near the Landfill Facility were used to estimate the groundwater flow direction and determine the monitoring well locations. All down-gradient monitoring locations were established within 30 metres of the limits of the Landfill Facility.

Table 1 provides the coordinates and depths for the monitoring locations established at the Landfill Facility during the 2017 pilot program. Figure 1 presents the monitoring locations and their position in relation to the Landfill Facility.

The 2017 pilot program was conducted in early September; the time at which the permafrost active layer at the Project should be at its maximum depth during the year.

2.2 SAMPLE COLLECTION AND ANALYSIS

Monitoring locations were accessed by foot and established using drive-point piezometers, advanced by hand driving a stainless steel Solinst Model 615 Drive-Point Piezometers into the ground until the depth of refusal was reached. Upon reaching the depth of refusal, the depth was recorded in a field note book and the location was assigned a well ID.

Because it was anticipated that water availability would be a concern, a predetermined one (1) litre volume was purged from each monitoring well location to remove standing water from screened zone of the piezometer. Purging and sample collection was completed using a Grundfos peristaltic pump and sections of 1/2" outside diameter (OD) low density polyethylene (LDPE) open tube.

Samples were collected in bottle sets provided by ALS Canada Ltd. (ALS). Sample bottle sets collected were labelled with the company name, well ID, date, time and if field filtration or preservatives were applied to the samples. The samples were packed in coolers with ice and shipped off-site for analysis to ALS Environmental located in Waterloo, ON. Sample preservation, storage and holding times were conducted as outlined by ALS lab requirements.

2.3 QUALITY ASSURANCE AND QUALITY CONTROL

Samples collected during the 2017 pilot program were collected following the water sampling principles outlined in the Project's Surface Water Sampling Program - Quality Assurance and Quality Control Plan (QA/QC Plan). No QA/QC samples were collected during the 2017 pilot program.

SECTION 3.0 - RESULTS AND DISCUSSION

Water samples were collected at three (3) monitoring locations down-gradient of the Landfill Facility and at one (1) monitoring location up-gradient of the Landfill Facility. Water quality results for the samples collected at the monitoring wells are provided in Table 2.

Due to very limited water quality data set for groundwater at the Project, Project specific guidelines for groundwater quality, based on baseline data and/or Canadian environmental guidelines, have not been developed for the Project. In comparing the water quality results for the 2017 pilot program with the water quality discharge criteria outlined in Table 7 – Effluent Quality Discharge Limits for the Landfill Facilities of Baffinland's Type A Water Licence (2AM-MRY1325 – Amend. No. 1), no exceedances of criteria were noted.

SECTION 4.0 - CONCLUSIONS AND RECOMMENDATIONS

The objective of the pilot program was to assess the feasibility of monitoring groundwater near Project infrastructure using drive-point piezometers. While challenges to implementing a groundwater monitoring program in shallow soils do exist, the results of the 2017 pilot program demonstrate that groundwater monitoring may be feasible using drive-point piezometers at the Project. Due to the limited data set, further groundwater monitoring is required to gain a better understanding of natural groundwater water quality at the Project. As additional monitoring is conducted in future years, Baffinland will be able to better characterize groundwater quality at the Project site and identify any trends, including potential impacts from Project activities or infrastructure. Consideration will be given to the development of site-specific groundwater quality parameters based on background (reference) conditions (if available) and potentially utilizing groundwater quality guidelines from other jurisdictions, as appropriate.

Baffinland plans to continue the groundwater monitoring program in 2018 using a consistent methodology to the 2017 pilot program and implementing any lessons learned. The 2018 groundwater monitoring program will utilize existing monitoring locations and potentially establish groundwater monitoring wells near Project infrastructure with a focus on the Landfill Facility at the Mine Site.

During 2018, Baffinland will consider implementing the following actions:

- Development of a Standard Operating Procedure (SOP) outlining the procedure for monitoring groundwater at the Project using drive-point piezometers.
- Updating the Project's Surface Water Sampling Program - Quality Assurance and Quality Control Plan (QA/QC Plan) to outline additional QA/QC protocols for groundwater sampling at the Project.
- Collection of groundwater elevation data at groundwater monitoring well locations to better characterize sub-surface flows.

Following the 2018 year, Baffinland will provide further recommendations to relevant parties regarding Baffinland's proposed path forward.

FIGURES

SAVED: I:\1020018144\GIS\Figs\A03_00 - GROUNDWATER MONITORING PROGRAM.mxd; Mar 22, 2018 1:32 PM; rlatina



LEGEND

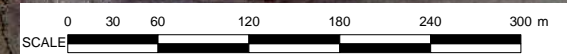
GROUNDWATER MONITORING PROGRAM

- DOWNGRADIENT LOCATION
- UPGRADIENT LOCATION

NOTES:

1. ORTHO-IMAGERY PROVIDED BY BAFFINLAND IRON MINES CORPORATION, DATED AUGUST 2016.

0	22MAR'18	ISSUED WITH TRANSMITTAL	AV	RF	RAC
REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED



MARY RIVER PROJECT

2017 GROUNDWATER MONITORING PROGRAM

Knight Piésold
CONSULTING

PIA NO. NB102-181/44	REF NO. NB18-00172
-------------------------	-----------------------

FIGURE 1

REV
0

TABLES

TABLE 1 - MONITORING WELL LOCATIONS AND DEPTH

Monitoring Well ID	Location Coordinates (UTM, NAD 83, Zone 17W)		Monitoring Well Depth (mbgs)	Location Description
	Northing (m)	Easting (m)		
MS-LF-GW1	7912608	560809	1.3	Down-gradient of Landfill Facility
MS-LF-GW2	7912487	560811	1.3	Down-gradient of Landfill Facility
MS-LF-GW3	7912467	560825	1.1	Down-gradient of Landfill Facility
MS-LF-GW-REF2	7912248	561118	1.5	Up-gradient of Landfill Facility

TABLE 2: WATER QUALITY RESULTS- 2017 GROUNDWATER MONITORING PILOT PROGRAM

Sample ID			MS-LF-GW1	MS-LF-GW2	MS-LF-GW3	LF-GW-REF2
ALS Sample ID			L1988863-1	L1988863-2	L1988863-3	L1988863-4
Sample Date and Time			2017 09 07 12:36	2017 09 07 14:28	2017 09 07 15:15	2017 09 12 16:20
Parameter	LDL	Unit				
General Parameters						
Dissolved Organic Carbon	1	mg/L	6.9	11.4	4.4	7.1
pH	0.1	pH units	6.95	7.37	8.05	7.94
Conductivity	1	uS/cm	2360	1120	379	314
Anions and Nutrients						
Alkalinity, Total (as CaCO ₃)	10	mg/L	243	291	200	165
Alkalinity, Bicarbonate (as CaCO ₃)	10	mg/L	243	291	200	165
Alkalinity, Carbonate (as CaCO ₃)	10	mg/L	<10	<10	<10	<10
Alkalinity, Hydroxide (as CaCO ₃)	10	mg/L	<10	<10	<10	<10
Bromide (Br)	0.1	mg/L	0.94	0.54	<0.10	<0.50
Calcium (Ca)-Dissolved	0.05	mg/L	315	80.8	31.3	34.3
Chloride (Cl)	0.5	mg/L	639	126	6.33	<2.5
Fluoride (F)	0.02	mg/L	<0.10	<0.020	0.021	<0.10
Magnesium (Mg)-Dissolved	0.05	mg/L	67.3	61.5	26.4	20.2
Sulfate (SO ₄)	0.3	mg/L	15.1	64.2	10.3	1.8
Phosphorus (P)-Dissolved	0.05	mg/L	<0.050	<0.050	<0.050	<0.050
Potassium (K)-Dissolved	0.05	mg/L	5.61	5.09	1.51	0.823
Silicon (Si)-Dissolved	0.05	mg/L	4.89	5.46	5.06	1.86
Sodium (Na)-Dissolved	0.5	mg/L	34	50.5	5.48	0.69
Sulfur (S)-Dissolved	0.5	mg/L	6.23	28.9	3.41	0.78
Ammonia, Total (as N)	0.02	mg/L	<0.020	0.091	<0.020	<0.020
Nitrate (as N)	0.02	mg/L	<0.10	0.402	0.422	<0.10
Phosphorus, Total	0.003	mg/L	0.0597	0.145	0.147	0.0363
Total Kjeldahl Nitrogen	0.15	mg/L	0.59	1	0.17	0.22
General Organics						
Oil and Grease, Total	2	mg/L	6.1	<2.0	2.7	<2.0
F2 (C10-C16)	0.1	mg/L	<100	<100	<100	<100
F3 (C16-C34)	0.1	mg/L	<250	<250	<250	<250
F4 (C34-C50)	0.1	mg/L	<250	<250	<250	<250

TABLE 2: WATER QUALITY RESULTS- 2017 GROUNDWATER MONITORING PILOT PROGRAM

Sample ID			MS-LF-GW1	MS-LF-GW2	MS-LF-GW3	LF-GW-REF2
ALS Sample ID			L1988863-1	L1988863-2	L1988863-3	L1988863-4
Sample Date and Time			2017 09 07 12:36	2017 09 07 14:28	2017 09 07 15:15	2017 09 12 16:20
Parameter	LDL	Unit				
Dissolved Metals						
Aluminum (Al)-Dissolved	0.005	mg/L	<0.0050	<0.0050	<0.0050	0.0062
Antimony (Sb)-Dissolved	0.0001	mg/L	0.00015	0.00026	<0.00010	<0.00010
Arsenic (As)-Dissolved	0.0001	mg/L	0.00024	0.00073	0.00018	0.00012
Barium (Ba)-Dissolved	0.0001	mg/L	0.216	0.0782	0.0183	0.0116
Beryllium (Be)-Dissolved	0.0001	mg/L	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth (Bi)-Dissolved	0.00005	mg/L	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	0.01	mg/L	0.787	0.28	<0.010	<0.010
Cadmium (Cd)-Dissolved	0.00001	mg/L	0.000041	0.000177	0.000011	<0.000010
Cesium (Cs)-Dissolved	0.00001	mg/L	0.000173	0.000062	0.000019	0.00001
Chromium (Cr)-Dissolved	0.0005	mg/L	0.00113	0.00237	0.00153	<0.00050
Cobalt (Co)-Dissolved	0.0001	mg/L	0.00047	0.00034	0.0001	<0.00010
Copper (Cu)-Dissolved	0.0002	mg/L	0.00172	0.00763	0.00176	0.00248
Iron (Fe)-Dissolved	0.01	mg/L	<0.010	<0.010	0.014	<0.010
Lead (Pb)-Dissolved	0.00005	mg/L	0.000053	0.000474	<0.000050	<0.000050
Lithium (Li)-Dissolved	0.001	mg/L	0.49	0.0089	0.0017	0.0015
Manganese (Mn)-Dissolved	0.0005	mg/L	0.0184	0.00472	0.00346	0.00066
Mercury (Hg)-Dissolved	0.00001	mg/L	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Dissolved	0.00005	mg/L	0.000701	0.000733	0.000505	0.000124
Nickel (Ni)-Dissolved	0.0005	mg/L	0.0407	0.0203	0.0122	0.00254
Rubidium (Rb)-Dissolved	0.0002	mg/L	0.0202	0.0185	0.00524	0.00248
Selenium (Se)-Dissolved	0.00005	mg/L	0.000104	0.000175	0.000051	<0.000050
Silver (Ag)-Dissolved	0.00005	mg/L	<0.000050	<0.000050	<0.000050	<0.000050
Strontium (Sr)-Dissolved	0.001	mg/L	0.24	0.0453	0.0162	0.0166
Tellurium (Te)-Dissolved	0.0002	mg/L	<0.00020	<0.00020	<0.00020	<0.00020
Thallium (Tl)-Dissolved	0.00001	mg/L	0.000104	0.000096	0.000026	0.000014
Thorium (Th)-Dissolved	0.0001	mg/L	<0.00010	<0.00010	<0.00010	<0.00010
Tin (Sn)-Dissolved	0.0001	mg/L	<0.00010	0.00013	<0.00010	<0.00010
Titanium (Ti)-Dissolved	0.0003	mg/L	<0.00030	<0.00030	0.00041	<0.00030
Tungsten (W)-Dissolved	0.0001	mg/L	<0.00010	<0.00010	<0.00010	<0.00010
Uranium (U)-Dissolved	0.00001	mg/L	0.00625	0.0117	0.000848	0.00064
Vanadium (V)-Dissolved	0.0005	mg/L	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	0.001	mg/L	0.0024	0.0024	0.0036	<0.0010
Zirconium (Zr)-Dissolved	0.0003	mg/L	<0.00030	0.00066	<0.00030	0.00068