Table 3.5: Median Concentrations from HCT Leachates compared to Screening Criteria

		pH	Hardness	SO4	F	Cl	Al	Sb	As	Cd	Cr	Co	Cu	Fe	Pb	Hg	Mo	Ni	Se	Ag	Tl	U	Zn
HCT ID	**Rock Type[1]**	**-**	**mg $CaCO_3$/l**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**µg/L**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
HC-7	1	8.6	34	1	0.05	0.5	0.08	0.0001	0.0002	0.00001	0.0002	0.0001	0.00072	0.01	0.00005	0.02	0.0001	0.0002	0.0002	0.00004	0.00002	0.00005	0.001
HC-42		8.9	20	1	0.02	0.5	0.08	0.00002	0.00017	0.000005	0.0001	0.000014	0.00051	0.01	0.00005	0.02	0.00009	0.00005	0.00009	0.000005	0.000002	0.000003	0.0003
HC-43		8.3	30	2	0.01	2.7	0.062	0.00002	0.0003	0.000005	0.0001	0.000021	0.0003	0.01	0.000041	0.02	0.0001	0.00008	0.00005	0.000005	0.000002	0.000004	0.0004
HC-49		8.7	29	2	0.01	0.5	0.18	0.00024	0.00027	0.000005	0.0001	0.000031	0.00033	0.02	0.00005	0.02	0.0004	0.00005	0.00004	0.000005	0.000002	0.000005	0.00035
HC-50		8.3	32	5	0.01	0.5	0.08	0.00024	0.0013	0.000005	0.0001	0.0002	0.00034	0.01	0.00005	0.02	0.00024	0.00006	0.00004	0.000005	0.000002	0.000006	0.001
HC-44	1 + 12q	8.9	30	4	0.02	0.5	0.08	0.00005	0.0025	0.000005	0.0001	0.00005	0.00052	0.01	0.000047	0.02	0.0003	0.00005	0.00009	0.000005	0.000002	0.000004	0.0002
HC-45		8	30	9	0.01	0.5	0.032	0.00013	0.0023	0.000005	0.0001	0.00027	0.00048	0.01	0.000044	0.02	0.00053	0.0003	0.00009	0.000005	0.000002	0.000004	0.0005
HC-53	12q	7.5	12	1	0.01	0.5	0.0072	0.00002	0.00021	0.000005	0.0001	0.000025	0.0004	0.003	0.000047	0.02	0.00009	0.00009	0.00004	0.000005	0.000002	0.000002	0.0007
HC-36		8	38	14	0.02	0.5	0.014	0.00006	0.0002	0.000005	0.0001	0.00012	0.00041	0.01	0.00005	0.02	0.0004	0.00014	0.00009	0.000005	0.000002	0.000018	0.0008
HC-52		8.1	28	6	0.01	0.5	0.021	0.00009	0.00036	0.000005	0.0001	0.000035	0.0004	0.01	0.000043	0.02	0.00028	0.00014	0.00004	0.000005	0.000002	0.000004	0.001
HC-54		8.1	29	2.2	0.01	1.6	0.017	0.00013	0.00021	0.000005	0.0001	0.000022	0.00035	0.001	0.000028	0.009	0.00027	0.00007	0.00004	0.000005	0.000002	0.000003	0.0005
HC-47	11	8.7	12	2	0.01	0.5	0.1	0.00007	0.004	0.000005	0.0001	0.000021	0.00074	0.02	0.00005	0.02	0.00024	0.00006	0.00005	0.000005	0.000002	0.000014	0.0007
HC-48		8.7	11	2	0.01	0.5	0.09	0.0001	0.0011	0.000005	0.0001	0.000037	0.001	0.04	0.00005	0.02	0.00018	0.00006	0.00015	0.000005	0.000002	0.000015	0.0003
HC-46	10a	8.6	20	2	0.01	0.5	0.072	0.00004	0.0002	0.000005	0.0001	0.000034	0.0004	0.01	0.00005	0.02	0.0003	0.00005	0.00005	0.000005	0.000002	0.000002	0.0003
HC-51		8.6	40	5	0.01	0.6	0.1	0.00065	0.012	0.000005	0.0001	0.00031	0.00032	0.0095	0.000049	0.02	0.0002	0.00019	0.00008	0.000005	0.000002	0.000002	0.0005
HC-65*		8.1	0.5	1.1	0.02	1.1	0.2	0.00014	0.0005	0.000005	0.0001	0.000029	0.00057	0.02	0.000026	0.002	0.00005	0.00005	0.00005	0.000005	0.000002	0.000002	0.0009
HC-6	7a mixed	8.7	33	2	0.05	0.5	0.09	0.0001	0.0002	0.00001	0.0002	0.0001	0.00048	0.01	0.000055	0.02	0.00011	0.0002	0.0002	0.00004	0.00002	0.00005	0.001
Screening Criteria		**> 6.5**	**-**	**-**	**0.12**	**120**	**0.1**	**-**	**0.005**	**VAR[2]**	**0.001**	**-**	**0.002**	**0.3**	**0.001**	**0.026**	**0.073**	**0.025**	**0.001**	**0.0001**	**0.0008**	**0.015**	**0.03**

Rescan 2001 Program

		pH	Hardness	SO4	F	Cl	Al	Sb	As	Cd	Cr	Co	Cu	Fe	Pb	Hg	Mo	Ni	Se	Ag	Tl	U	Zn
DOP #12	1	9.1	41	3	-	-	0.1	0.1	0.1	0.005	0.005	0.005	0.005	0.015	0.025	-	0.015	0.025	0.1	0.005	0.1	-	0.0025
DUMV #5		9	56	13	-	-	0.1	0.1	0.1	0.005	0.005	0.005	0.005	0.015	0.025	-	0.015	0.025	0.1	0.005	0.1	-	0.0025
DUQ #1	12q	9.3	37	5	-	-	0.1	0.1	0.1	0.005	0.005	0.005	0.005	0.015	0.025	-	0.015	0.025	0.1	0.005	0.1	-	0.0025
DUG #6	10a	8.8	50	15	-	-	0.1	0.1	0.1	0.005	0.005	0.005	0.005	0.015	0.025	-	0.015	0.025	0.1	0.005	0.1	-	0.0025

Note: red highlight indicates value is elevated above the screening criteria, which is based on the long term CCME Water Quality Guideline for the protection of freshwater aquatic life.
[1] Rock types: 1=mafic volcanics; 1 w. 12q=mafic volcanics mixed with quartz vein; 7a mixed=early gabbro mixed; 10a=late gabbro (including low NP basalt); 11c=diabase; 12q=quartz vein
[2] The screening criteria for cadmium is calculated based on average hardness.
*HC-65 represents late gabbro that has been reclassified as low NP basalt in the vicinity of the decline, while HC-46 and HC-51 represent more typical late gabbro elsewhere in the deposit area.

Source: Y:\01_SITES\Hope.Bay\1CH008.005_Geochemistry (Doris, Madrid, Boston)\4.Kinetic program\WR HCs\Calculations\[HB_WR_Loadings.mc.REV09.xlsx]

Depletion Calculations

Depletion calculations are presented in Appendix E3 of SRK 2015b.

Depletion calculations based on stable release rates indicate that a number of humidity cell tests are likely to remain neutral, including HC-7, HC-42 and HC-49 (mafic volcanic, P20 to P60 sulphur), HC-44 (mafic volcanic with quartz vein, P29 sulphur), HC-6 (early gabbro), and HC-46 and HC-51 (late gabbro, P92 and P58 sulphur, respectively).

Depletion calculations for the other samples suggest that NP and/or TIC will be depleted prior to AP, including HC-43 and HC-50 (mafic volcanic, P85 to P99 sulphur), HC-45 (mafic volcanic with quartz vein, P86 sulphur), HC-47 and HC-48 (diabase, P95 and P98 sulphur, respectively), HC-53, HC-36, HC-52 and HC-54 (quartz vein, P49 to P100 sulphur), and HC-65 (late gabbro/low NP basalt, P58 sulphur). However, the generation of net acidic conditions for these samples is considered unlikely because of:

- Low AP depletion rates: sulphate release rates were low (stable rates of <6 mg/kg/week). These rates suggest that acidity production from sulphide oxidation will be limited.
- Overestimated NP depletion rates: at low rates of sulphide oxidation, leaching of calcium and magnesium are due primarily to simple dissolution of the carbonate minerals, rather than to production of acidity from sulphide oxidation. This can result in an overestimation of NP depletion rates, particularly in laboratory scale data where the water to rock ratios are very high. In contrast, under field conditions, where water to rock ratios are much lower, the rate of carbonate dissolution in the waste rock piles will be limited by equilibrium with carbonate minerals. The theoretical ratio of (Ca+Mg) depletion to sulphate generation in samples where Ca+Mg leaching is primarily in response to sulphide oxidation is between 1 and 2. Stable (Ca+Mg)/SO_4 values in these samples are between 3 and 14, suggesting that TIC dissolution, and therefore NP depletion, is in response to the weekly addition of water rather than sulphide oxidation. The exception is HC-65 (late gabbro/low NP basalt, P58 sulphur) which had stable (Ca+Mg)/SO_4 values below 1.

3.1.3 Post-Test Residue Characterization

After completion of the humidity cell tests, the remaining residues were geochemically analyzed for ABA and trace element content. Data are presented in Appendix F of SRK 2015b.

3.2 Barrel Tests

Characterization data for the barrel test samples are provided in Appendix C of SRK 2015b. As noted previously, humidity cell tests HC-6 and HC-7 were completed on the same samples that were used to charge barrel W1 and W5. Therefore, comparison of results from these two programs provides an indication of some of the types of differences that can be observed between the lab and field.

3.2.1 Sample Characterization

Mineralogy

Mineralogy data for the barrels are presented in Appendix B of SRK 2015b. XRD data is available for all barrel samples. MLA analysis and SEM analysis of the iron carbonates is available for W1 and W5 only.

XRD data are available for all samples characterized in recent testing programs by NMS and SRK (SRK 2011). The XRD results for the humidity cell tests were comparable to those results and showed the following:

- W10 (diabase) did not have any detectable levels of carbonate minerals.
- Carbonate minerals, where present were predominantly present as iron carbonates (ferroan dolomite ($Ca(Mg_{(x-1)}Fe_x)CO_3$) and magnesium-rich siderite ($(Mg_{(x-1)}Fe_x)CO_3$).
- Carbonate mineral levels were comparable to the humidity cell test samples, except for W13 (late gabbro), which contained low levels of ferroan dolomite (4%).
- Calcite was below detection for W1 (mafic volcanic), W10 (diabase) and W9 (quartz vein with mafic volcanic).
- Sulphides were detected in sample W9 only (quartz vein with mafic volcanic). Levels indicated by XRD for that sample were approximately half of those determined by ABA methods.

For the W1 and W9, the iron content (or x), as determined by SEM, was stoichiometrically 0.45 of the iron+magnesium content of the ferroan dolomite. Similarly, the iron content was roughly 0.8 of the iron+magnesium content of the siderite.

Acid-Base Accounting

All ABA data for the barrel test samples is provided in Appendix C1 of SRK 2015b, a selection is presented in Table 3.6, and the percentile rank for selected ABA parameters is presented in Table 3.7.

The ABA data for the SRK/NMS barrel test samples were consistent with the findings of SRK (2011). With the exception of sample W9 (quartz vein with mafic volcanic), sulphur content ranged from P26 to P59 with NP and TIC levels ranging from P39 to P75. NP and TIC content for samples W13 (late gabbro) and W10 (diabase) were lower than the other barrel samples with levels ranging from 4 to 80 kg $CaCO_3$ eq/t. For sample W9, the relative sulphur, NP and TIC content were higher than the other samples (P90). Sample W9 was classified as uncertain on the basis of NP to AP ratios, whereas all other samples were classified as non-PAG. The uncertain classification for sample W9 is related to high sulphur content.

Table 3.6: ABA Data for Barrel Samples

Barrel ID	Rock Type[1]	Paste pH	Total Sulphur	Sulphide Sulphur (%S)	NP	TIC	NP/AP	TIC/AP
					(kg $CaCO_3$/Tonne)			
W1	1	8.4	0.11	0.11	161	259	46.8	75.3
	1	8.3	0.17	0.16	173	244	35.5	50.0
W5	7a mixed	8.6	0.13	0.13	128	156	31.6	38.5
W13	10a	8.8	0.06	0.05	76	80	40.8	42.5
W10	11c	9.8	0.03	0.03	21	4	22.6	4.1
W9	12q with 1	9.2	2.05	2.04	180	350	2.8	5.5

P:\01_SITES\Hope.Bay\1CH008.005_Geochemistry (Doris, Madrid, Boston)\4.Kinetic program\Reports & Memos\20110630_Memo_WR_HCUpdate\Working Files\[2009Barrels_XRD_1CH008043_lnb.xls]

[1] Rock types: 1=mafic volcanic; 1 w. 12q=mafic volcanic mixed with quartz vein; 7a mixed=early gabbro mixed; 10a=late gabbro (including low NP basalt); 11c=diabase; 12q=quartz vein.

Table 3.7: Percentile Rank of Total Sulphur, NP and TIC for Barrel Tests

Barrel ID	Rock Type[1]	Total Sulphur									NP		TIC		ARD Classification	
		%S	All Zones		North		Connector		Central		(kg$CaCO_3$/t)	All Zones	(kg$CaCO_3$/t)	All Zones	NP/AP	TIC/AP
			%Rank	n	%Rank	n	%Rank	n	%Rank	n		%Rank		%Rank		
W1	1	0.11	26%	361	34%	168	30%	51	16%	142	161	39%	259	49%	non-PAG	non-PAG
	1	0.17	59%	361	71%	168	61%	51	45%	142	173	50%	244	45%	non-PAG	non-PAG
W5	7a mixed	0.13	49%	6	#N/A	0	#N/A	0	#N/A	0	128	49%	156	49%	non-PAG	non-PAG
W13	10a	0.06	36%	60	38%	41	>100%	7	15%	12	76	75%	80	74%	non-PAG	non-PAG
W10	11c	0.03	48%	41	>100%	33	>100%	1	17%	7	21	57%	4	61%	non-PAG	non-PAG
W9	12q w. 1	2.05	90%	27	89%	13	#N/A	0	92%	14	180	91%	350	98%	Uncertain	non-PAG

P:\01_SITES\Hope.Bay\1CH008.005_Geochemistry (Doris, Madrid, Boston)\4.Kinetic program\Reports & Memos\20110630_Memo_WR_HCUpdate\Working Files\[WRHCPercentRank_Doris_1CH008043_lnb_rev01.xlsx

Statistical analysis by rock type and preliminary economic classification
[1] Rock types: 1=mafic volcanic; 1 w. 12q=mafic volcanic mixed with quartz vein; 7a mixed=early gabbro mixed; 10a=late gabbro (including low NP basalt); 11c=diabase; 12q=quartz vein.

Trace Elements

Trace element data is presented in Appendix C2 of SRK 2015b.

Trace element data are available for the overall Doris sample set, as discussed in SRK (2011). Data were compared with ten times the average crustal abundance for basalt (Price 1997) to determine if any parameters were elevated. Arsenic levels were elevated for W9 only (quartz vein with mafic volcanic), with levels a magnitude higher compared to the other barrel samples. Arsenic levels for each barrel test sample were statistically compared with the ABA samples corresponding to the equivalent rock type and economic classification in the static testing database for Hope Bay (Table 3.8).

Table 3.8: Percentile Rank of Arsenic Levels, Barrel Test Samples

Barrel ID	Rock Type[1]	As	
		ppm	%Rank
W1	1	1.7	24
W5	7a mixed	3.2	2
W13	10a	3	79
W10	11	1.1	80
W9	12q with 1	36.5	82

[1] Rock types: 1=mafic volcanic; 1 w. 12q=mafic volcanic mixed with quartz vein; 7a mixed=early gabbro mixed; 10a=late gabbro (including low NP basalt); 11c=diabase; 12q=quartz vein.

3.2.2 Barrel Leachate Data

Table 2.9 presents details of the five barrel tests from Doris. A complete set of concentration data for the barrel leachate samples is provided in Appendix H of SRK 2015b.

The sampling frequency of each barrel was variable for a number of reasons, including inaccessibility and the absence of leachate. In September 2010, the leachate for some tests was partially frozen and as a result, parameter levels may be higher due to concentration of the leachate.

Both the field and lab pHs for all tests were neutral to alkaline. Sulphate concentrations were lower (4 to 15 mg/L) for the samples of late gabbro (W13) and diabase (W10) as compared with the samples of mafic volcanic (W1), early gabbro (W5) and quartz vein with mafic volcanic (W9) (15 to 46 mg/L).

The following observations were made for concentrations of selected trace elements (see Appendix G of SRK 2015b for graphs of concentration data):

- Antimony levels were similar for all tests and ranged from 0.0001 to 0.01 mg/L. One sample (0.03 mg/L) from the diabase barrel (W10) was not included in this range because it deviated from the trend for that barrel by more than an order of magnitude. Antimony concentrations were generally highest from the late gabbro barrel (W13).

- Arsenic, cobalt and copper levels were variable but generally ranged between 0.0001 and 0.009 mg/L (arsenic), 0.0001 to 0.003 mg/L (cobalt), and 0.001 to 0.01 mg/L (copper). These ranges do not include data points that appeared to be anomalous spikes in concentrations. Excluding these spikes, for arsenic and copper, concentrations were generally highest for W10 (diabase) and W13 (quartz vein with mafic volcanic). For cobalt, concentrations were generally highest for W1 (mafic volcanic) and W0 (quartz with mafic volcanic).
- Aluminum and iron levels were below 0.1 mg/L, except for the diabase barrel (W10), which had concentrations ranging from 0.13 to 0.30 mg/L and 0.2 to 0.5 mg/L, respectively. These elevated levels for W10 suggest colloids may be in the leachate, which would elevate the dissolved levels.
- Lead exhibited a similar trend to aluminum and iron. Concentrations for the diabase barrel (W10) were elevated (0.002 to 0.004 mg/L) relative to the other samples (less than 0.0005 mg/L).

Overall, concentrations are comparable to the HCTs.

4 Conclusions

The kinetic test program for Doris included 21 HCTs and 5 barrel tests. Four HCTs were operated by Rescan (2001) and the remaining 17 samples were from more recent geochemical characterization programs by SRK in collaboration with NMS. Sample selection was based on lithology, economic classification (ore or waste), and ABA characteristics. Trace elements (i.e. arsenic) were a secondary consideration.

The leachates from all samples were neutral to alkaline. Stable sulphate release rates were low and ranged between the limit of analytical detection (0.4 mg/kg/week) to 6 mg/kg/week. Samples with higher total sulphur contents tended to exhibit higher stable sulphate release rates.

Generally, trace element concentrations were low in the HCT leachates. One of the late gabbro samples with elevated sulphur levels had elevated concentrations of arsenic, while a number of samples had elevated concentrations of aluminum and copper.

All samples were predicted to be non-PAG on the basis of AP and NP depletion times and/or low stable sulphate release rates (less than 6 mg/kg/week).

Leachate concentrations from the barrel tests were comparable to the HCTs.

The data from the kinetic test program has been used to validate inputs used for the water quality predictions from waste rock and ore. In general, the stable trace element release rates are less than those used to predict source concentrations from the waste rock, indicating that the input data used in the predictions are conservative.

This report, "Kinetic Testing of Waste Rock and Ore from the Doris Deposits, Hope Bay", has been prepared by SRK Consulting (Canada) Inc.

Original Signed

Saskia Nowicki, BSc
Consultant (Environmental Geochemistry)

and reviewed by

Original Signed

Kelly Sexsmith, MS, PGeo
Principal Consultant (Environmental Geochemistry)

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

5 References

AMEC 2005. *ARD and Metal Leaching Characterization Studies in 2003 – 2005, Doris North Project, Nunavut, Canada*. Report prepared for Miramar Hope Bay Ltd. by AMEC Earth & Environmental (Burnaby), October 2005.

ASTM 2001. Standard Test Method for Accelerated Weathering of Solid Materials Using a Modified Humidity Cell. D 5744 – 96 (Reapproved 2001).

Canadian Council of Ministers of the Environment (CCME), 2015. Canadian Environmental Quality Guidelines Summary Table. http://st-ts.ccme.ca/. Accessed April 2015.

MEND 1991. Acid Rock Drainage Prediction Manual. Mine Environment Neutral Drainage Program. Report 1.16.1b.

Price, W.A. 1997. *DRAFT Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia*, British Columbia Ministry of Employment and Investment, Energy and Minerals Division, Smithers, BC, April 1997.

Rescan 2001. *2000 Supplemental Environmental Baseline Data Report, Hope Bay Belt Project, Nunavut, Canada.* Report prepared for Hope Bay Joint Venture by Rescan Environmental Services, March 2001.

SRK 2007. *Geochemical Characterization of Portal Development Rock, Doris North Project, Hope Bay, Nunavut Canada (Revised March 2007)*. Report prepared for Miramar Hope Bay Ltd. by SRK Consulting (Canada) Inc., March 2007.

SRK 2015a. Static Testing and Mineralogical Characterization of Waste Rock and Ore from the Doris Deposits, Hope Bay Report prepared for Hope Bay Mining Ltd. by SRK Consulting (Canada) Inc., June 2015.

SRK 2015b. Kinetic Testing of Waste Rock and Ore from the Doris Deposits, Hope Bay – Supporting Data. Report prepared for Hope Bay Mining Ltd. by SRK Consulting (Canada) Inc., June 2015.