Holocene Palaeo-Climate Review

	Periodicity of cycles	Reference	Roman	Phase	Years Before	Detailed Period	Precipitation	Humidity/Fire	Temperature	Solar	Glaciers	Other	Circulation	Additional notes	Reference
	900 000 year period with approximately 90 000	Normani et al, 2009	Calendar		Present (YBP) From 900K	Period	Precipitation controls glacier		Once orbital cooling starts, cold	Reduced solar about 115000 BP	Glaciers up to 4 km thick to south		ENSO apparent in 130 K years of records.		Cane, 2005.
	year cycle for full glaciation and deglaciation. Some authors refer to this as the 100000 year glacial cycle	Bintanja and van de Wal, 2008 Rial et al, 2003					formation. If lower moisture conditions exist there is lower		periods may be started by an influx of fresh water into the Atlantic slowing warm water movement to the poles.	f reduces boreal forest, increases tundra and increases albedo and decreases spring and summer	of Canada US border. Deglaciation rapid (10000 years),		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		Normani et al, 2009 Gallimore and Kutzbach, 1996. Denton et al, 2010
	Climate is non linear which is driven by	Denton et al, 2010							the polar front and preventing northward movement of warm air.	temperatures, triggering glaciation over extreme north east of Canada. Appears to be trigger area for					Funder and Hjort, 1973
									warm water moving poleward, and liberating CO2 which has a feedback	further cooling occurs. Experiment based on current CO2 levels. Orbita					
									and displayed as rapid deglaciation	key. GCM Model tests.					
Company	400-500 and 900-1100 and 1500 yr cycle.	Viau et al, 2006.		Last Glacial Maximum	25000 14000		Beringa precipitation shows		ice age. Significant glacier growth					Magnitude of climate variation greater in last and	Williams, 1979
Companies Comp	Glacier retreats last 1750 years. strongest advances 200 to 350, 2800	Gajewski et al, 2007. Warner and Butikofer,					250 mm variation with drying		requires at least a 10-12C decrease ir summer temperature in NWT. (In Beringa Summer temperature 4C					late glacial periods than over last 8000 years	
Company	and 5300 BP. Solar possible trigger. Bond cycles peaked around 400, 1,400, 2,800, 4,300, 5,900, 8,100, 9,400, 10,300 and 11,100								lower and January temperature 2C lower than present. Temperature rise begins 16000 BP						
The content will be content	BP. Less sea ice than at present existed from 7300 to 3700 cal yr BP.								peaking at 12000BP).						
Company	2500 yr warming and cooling cycle, Saw tooth structure, alternating peaks and troughs:	Hu et al, 2003		Late Glacial Maximum	13000		-		3-4C Warming						Viau et al, 2006 Warner and Butikofer, 2008
	tooth" structure found in other Holocene palaeo-climate records, where a more gradual														
	early Holocene shows higher amplitude														
	At least 10 mini ice ages within Holocene and most have climate change rates and	Bluemel et al, 2009.		Holocene Starts	12.9 - 11.6		Dry summers wet winters	summers		Summer insolation higher than	influences climate of northern	Prior to 10000 BP water levels lower than today in South west Yukon.			Kaplan and Wolfe, 2006
The content will be content	magnitudes greater than what is currently being experienced.							and dry adiabatic winds from the residual Laurentide		responds to solar radiation except lags where Laurentide ice sheet					Anderson et al, 2005
The content of the										insolation from coincidence of precession and obliquity cycles at					
## Company of the com			8000	Pre Boreal	10000					Periods of decreasing insolation	Start of 50 000 year interglacial				Kutzbach and Guetter, 1986
										ice sheets not present insolation appears to be main driver.				orbitally induced insolation in the Northern Hemisphere and an unusual	
										cycle of insolation coupled with Milankovitch cycles is the				Sporer, Maunder, Dalton) which likely led to the lowest temperatures in this area since 8000 years BP. Cosmic rays and magnetic fluctuations also held	d
										summer insolation in high Northern	1			responsible for decadal to multi-century long climate fluctuations along with reduced Milankovitch	
	9000 YBP considered as a possible analog for		7000	Boreal	9000		-	Low or neutral fire anomaly					ENSO weak in Early Holocene cause d by boreal	increased sea ice, and reduced deep convection in the north Atlantic. Final component is reduction of	Lorenz et al
	today. (radiation cycle)	1986	6000	Atlantic	8000	warming		High fire incidence		a de la companya de	related to collapse of Laurentide		summer perihelion.		
			5000		7000	8200 brief cooling	From 8000BP to 4000 BP lake	Decreasing fire incidence	8200 Variable decline		ice sheet.	7500 to 5000BP water levels fall to 5-6m below			Carcaillet and Richard, 2000
Part												current in south west Yukon		instability conducive to frequent lighting associated with the Ice Sheet could have provided ideal	1 Anderson et al, 2005 Fritz et al, 2001
	6500 BP a surrogate for a future warm climate		4000		6000		Fair winter rain. Moderate lake levels	Humidity starts to increase a about 5800	Warming starts				ENSO weak period ends, possibly increasingly negative North Atlantic Oscillation about 1000	Laurentide ice remnants too small to significantly	Wanner et al, 2008
The content of the		ĺ											BP	affect the atmospheric circulation so Atlantic Maritime Tropical humid air mass moves in over southern Quebec in summer - inhibiting fire	Fritz et al. 2001
The content of the			3000		5000		Precipitation control by		Variable warming and cooling.					occurrence. Low lake-levels occurred between 6.2±3.8 ka BP in	
The content of the				5000 to 2500			The middle Holocene was dominated by wet summers.	5800 to 3000 YBP	Millennial scale variation becomes apparent on top of long cycle +-0.2C. West Canada 1-2.5 C increase.						Diffenbaugh and Sloan, 2004
The content of the							Northwest Canada 200 yrs wet. High latitudes cold and wet		6000-2600 seen as optimal temperature period but with millennial scale cycle. Temperature						
March Marc							Centennial scale drought in		controlled by orbital cycles. Summer						
March Marc															
					4200	,						Possible volcanism	probably promoted the southward displacement of the polar jet stream, thus allowing more	t	
												Retween 4000 and 2000 water levels rise to ahove	and Eastern Canada. Similar to La Nina.		
			2000		4000				North UK Cool or wet Maximum warmth about 3000 YBP	increased GCR Possible amplification			enhanced, increased warmth in tropical oceans.	summers due to stability of the Atlantic air mass over eastern Canada.	
						dry 4000 wet			for central North America	changes. Milankovitch cycles				forest fires, long-term changes in forest composition	
														resembles that of the mid-latitudinal drought that occurred June 1998 /May 2002.	
Company Comp			1000		2000	2000	Colder wetter climate	Dre transition period amundation	About decrease and high variability			Increased regiment from this Increased lake Invelo	Tree line must be coincider with Bohr Ernet	Possible North Atlantic Cooling.	Alletal 2009
1			2000		3000	3300	Corder Wetter Climate	3000 BP. Humidity starts to decrease and level off at	Across decrease and high variability			and water table height. Most northerly extent of	The line looping consider with long from		Carcallet and Richard, 2000
The content of the				Subantlantic	2000	2500	Summers begin to become	fires at 3400BP	Slight dow warming			Water Levels stay below current by 1 to 7m in	More frequent incursions of day Coal Pacific or		Carcallet and Richard 2000
March Marc							drier					South West Yukon for 2000 years till current time.	Cold Arctic air masses over eastern Canada conducive to fire weather during late-spring or summer. The		Anderson et al., 2005
1	Millennial scale	Viau e t al, 2006	950	MWP	1050				Warming	Irradiance levels high		Possible high volcanic aerosol period	Atlantic Maritime Tropical humid air blocked.		Bradley, 2000
The content of the	Millennial scale variation		1010	MWP					, and the second						
The content of the		Viau et al, 2006		LIA	500			Begin in sharp decrease of fires.	Long term cooling trend related to		•	Decadal and longer variations in the strength of			Cane, 2005
The content of the		Viau et al, 2006	1510	LIA	400			fires.	Long term cooling trend related to orbital cycles or insolation.	by 4Wm2 in July and increase January by 2 Wm2 (High Northern		the ENSO cycle within the past 1000 yr; may be			Cane, 2005 Bradley, 2000
The content of the		Viau et al, 2006	1510 1610 1710	UA UA UA	400 300		winter	fires. Decreasing fire in eastern	Long term cooling trend related to orbital cycles or insolation.	by 4Wm2 in July and increase January by 2 Wm2 (High Northern		the ENSO cycle within the past 1000 yr; may be			Cane, 2005 Bradley, 2000
Column		Viau et al, 2006	1510 1610 1710	UA UA UA	300 300 200		winter Increasing precipitation in eastern Canada (c1850)	fires. Decreasing fire in eastern	Long term cooling trend related to orbital cycles or insolation.	by 4Wm2 in July and increase January by 2 Wm2 (High Northern		the ENSO cycle within the past 1000 yr; may be			Cane, 2005 Bradley, 2000 All et al, 2009
Company Comp		Viau et al, 2006	1510 1610 1710 1810 1910 1920 1930	UA UA UA	200 200 100 90		winter Increasing precipitation in eastern Canada (c1850)	fires. Decreasing fire in eastern	Long term cooling trend related to orbital cycles or insolation.	by 4Wm2 in July and increase January by 2 Wm2 (High Northern		the ENSO cycle within the past 1000 yr; may be			Cane, 2005 Bradley, 2000 All et al, 2009 Viau etal 2006
March Marc		Viau et al, 2006	1510 1610 1710 1810 1910 1920 1930 1940	UA UA UA	400 300 200 100 90 80 70		winter Increasing precipitation in eastern Canada (c1850) onwards. Drought 1950-2006 Decrease in Winter and Autumn storm	fires. Decreasing fire in eastern	Long term cooling trend related to orbital cycles or issolation.	by 4Wm2 in July and increase January by 2 Wm2 (High Northern		the ENSO cycle within the past 1000 yr; may be			Cane, 2005 Bradley, 2000 All et al, 2009 Viau et al 2006 Coutillot, 2006
The content of the		Viau et al, 2006	1510 1610 1710 1810 1910 1920 1930 1940	UA UA UA	500 400 300 200 100 80 70 60		winter increasing precipitation in eastern Canada (c1850) onwards. Orought 1950-2006 Decrease in Winter and Autumn storm activity and decrease in	fires. Decreasing fire in eastern	Long term cooling trend related to orbital cycles or insolation.	by 4Wm2 in July and increase January by 2 Wm2 (High Northern		the ENSO cycle within the past 1000 yr; may be			Cane, 2005 Bradley, 2000 All et al, 2009 Viau et al 2006 Coutillot, 2006
Service of the control of the contro		Viau et al., 2006	1510 1610 1710 1810 1910 1920 1930 1940 1950	UA UA UA	\$00 \$00 \$00 \$00 \$00 \$00 \$00 \$00 \$00 \$00		winter increasing precipitation in eastern Canada (c1850) onwards. Orought 1950-2006 Decrease in Winter and Autumn storm activity and decrease in	fires. Decreasing fire in eastern	orbital cycles or insolation.	by 4Wm2 in July and increase January by 2 Wm2 (High Northern		the ENSO cycle within the past 1000 yr; may be	of the sub-tropical high pressure centers The		Cane, 2005 Rail et al., 2009 All et al., 2009 Value et al., 2006 Guedellice, 2006 Gascon et al., 2010. Countility, 2006 Countility, 2006
The content of the		Viau et al. 2006	1510 1610 1710 1810 1910 1920 1930 1940 1950	UA UA UA	400 300 200 1000 90 80 70 60		winter increasing precipitation in eastern Canada (c1850) onwards. Orought 1950-2006 Decrease in Winter and Autumn storm activity and decrease in	fires. Decreasing fire in eastern	orbital cycles or insolation.	by 4Wm2 in July and increase January by 2 Wm2 (High Northern		the ENSO cycle within the past 1000 yr; may be	of the sub-tropical high pressure centers The		Cane, 2005 Rail et al., 2009 All et al., 2009 Value et al., 2006 Guedellice, 2006 Gascon et al., 2010. Countility, 2006 Countility, 2006
The control of the	Oscillatory modes with the period of approximately 7 to 8 years were detected in	Fashus and Novetna, 2009.	1510 1610 1710 1810 1920 1930 1940 1950 1960 1970 1980	UA UA UA	\$00 \$00 \$00 \$00 \$00 \$00 \$00 \$00 \$00 \$00		worter morrossing precipitation in extenter Canada (c1850) senantics. Disaget 1950-2000 Decrease in Worter and Autumn storm sactivity and decrease in amount of precipitation. Autumn of precipitation.	fires. Decreasing fire in eastern	orbital cycles or insolation.	by 4Wm2 in July and increase January by 2 Wm2 (High Northern		the ENSO cycle within the past 1000 yr; may be	of the sub-tropical high pressure centers 1560-2000 Maritime air from Hudson Bay affect Bater Lalls Area. At Lujan expoporation ranges 220 to 320 mm per year or about 70 to 100% of human perceptation.	permafrost zone are generally above -3°C, and	Cane, 2005 Bradley, 2000 All et al, 2009 Valu et al, 2006 Gascinitor, 2006 Gascon et al, 2010 Gascon et al, 1996 Gascon et al, 2010
Part	approximately 7 to 8 years were detected in monthly time series of sunspot numbers, geomagnetic activity an index, NAO index and near-surface air temperature from several mid-	Fashus and Novetna, 2009.	1510 1610 1710 1810 1920 1930 1940 1950 1960 1970 1980	UA UA UA	\$00 400 200 100 90 80 70 60 50 40 40 20 20 20 20 20 20 20 20 20 2		worder County (1850) Monophic Mon	fires. Decreasing fire in eastern	orbital cycles or insolation.	by 4Wm2 in July and increase January by 2 Wm2 (High Northern		the ENSO cycle within the past 1000 yr; may be	of the sub-tropical high pressure centers 1980-2000 Maritime air from Husbon Bay affect. Bater Lake Area. At Lupin exporation range is 220 to 320 mm per year or about 70 to 2000 of annual programme air from the control of the policy in stream, from the control of the control of the policy in stream, from the control of the control of the policy in stream, from the control of the control of the policy in stream, from the control of the control of the policy in stream, from the control of the control of the policy in stream, from the control of the control of the policy in stream, from the control of the policy	permafrost zone are generally above -3°C, and range down to -15°. Eastern Canada permafrost warming since early 1990s. Rate of permafrost	Cane, 2005 Bradley, 2000 All et al, 2009 Valu et al, 2006 Gascinitor, 2006 Gascon et al, 2010 Gascon et al, 1996 Gascon et al, 2010
**************************************	approximately 7 to 8 years were detected in monthly time series of sunspot numbers, geomagnetic actively as index, NAO index and near-surface air temperature from several mid- latitude European locations (Data from 1950 onwards). Statistical evidence for a coupling	Fashus and Novetna, 2009.	1510 1610 1710 1810 1920 1930 1940 1950 1960 1970 1980	UA UA UA	\$00 400 200 200 90 80 70 60 50 40 30		worder County (1850) Monophic Mon	fires. Decreasing fire in eastern	orbital cycles or insolation.	by 4Wm2 in July and increase January by 2 Wm2 (High Northern		the ENSO cycle within the past 1000 yr; may be	of the sub-tropical high pressure centers 1898-1000 Maritime air from Heuton Bay affect 1898-1000 Maritime air from Heuton Bay affect 2001 to 200 mm per year or about 70 to 100% of somial presipation 1007-1008 air annibura probably visilated to somial presipation 1007-1008 air annibura probably visilated to somial presipation 1007-1008 air annibura probably visilated to somial presipation or 1007-1008 air annibura probably visilated to somial presipation or 1007-1008 air annibura probably visilated to 1007-1008 air annibura probably visilated to 1007-1008 air annibura probably visilated 1007-1008 air annibura	permafrost zone are generally above -3°C, and range down to -15°. Eastern Canada permafrost warming since early 1990s. Rate of permafrost	Cane, 2005 Bradley, 2000 All et al, 2009 Valu et al, 2006 Gascinitor, 2006 Gascon et al, 2010 Gascon et al, 1996 Gascon et al, 2010
March Marc	approximately 7 to 8 years were detected in northly time series of susspot numbers, geomagnetic activity as index, NAO index and near surface air temperature from several institude European locations (Data from 1950 onwards). Statistical evidence for a coupling statement surface of the companyers activity and climate variability. NAO also displays a 78 year period. Phase coherence shown, causality inferred but not shown by Paulus. Courtill of shows possible machanism and show primary firther is orbital machanism.	Fashus and Novetna, 2009.	1516 1510 1710 1810 1911 1920 1930 1940 1950 1970 1970 1980	UA UA UA	500 400 300 300 300 300 300 300 300 300 3		worder County (1850) Monophic Mon	fires. Decreasing fire in eastern	orbital cycles or insolation. Cacoling Warmang Warmang	by 6Wm2 in July and increase January by 2 Wm2 (High Northern Listtudes) Preak of solar cycle and some argue	Retract or militing	the EREO (cise within the past 1000 yr, may be done to close and occlusive sortions in solar medicates and occlusive sortions in solar medicates.	of the sub-tropical high pressure centers 1560-2000 Martinne air from hudson bay affect Bater Lisk Area. At Lipin exponsition range is 2020 to 300 may per you should not be already a few and proprietation. Notes in monitorium probabily related to enculturate of the poly is stream, because of the poly is stream, because the proprietation of the poly is stream, because the monitorium and significant of the poly is stream, because of the south Participation (common probability related to enculturate and significant to should be marked to stream the south of the significant stream the significant stream to see the significant stream to	permafrost zone are generally above -3°C, and range down to -15°C. Scatern Canada permafrost warming since early 1990s. Rate of permafrost warming greater north of tree line. Permafrost Thaw - key feature of this period is	Cone, 2005 Bradley, 2000 All et al, 2009 Value etal 2006 Countilist, 2006 Gascon et al, 2010. Countilist, 2006 Gascon et al, 2010 Wiffen, undated. Altimison et al, 2010 Altimison et al, 2010
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Company Comp	approximately 7 to 8 years were detected in monthly time series of susport number, genomagnetic activity as index, NAO index and an acruatica air temperature from several mid-attende frampean locations (Data from 1550 cities fr	Fashus and Novetna, 2009.	1510 1510 1710 1811 1811 1812 1822 1822 1822 1822 18	UA UA UA	5000 5000 5000 5000 5000 5000 5000 500		worder Transledge procipitation in incurrencing procipitation in incurrencing procipitation in incurrencing	fires. Decreasing fire in eastern	warm pack or Canadian north 12CC. Cooling Warming Warmi	by eWin7 in July and increase July 2 Win2 (High Northern Lattrudes) Peak of solar sycle and some argue of the solar maximum	Autrest or melting	the REGO (cise within the past 1000 yr, may be due to losis and voltame; and voltame; and voltame is sold in the sold and voltame; and voltame is sold in sold and voltame; and voltame is sold in sold and voltame;	of the sub-tropical high pressure centers 1900-2000 Maritime at in from sederin larg affects 1900-2000 Maritime at in from sederin larg affects 1900-2000 Maritime at in from sederin larg affects 1900-2000 Maritime at in from sederin large affects 1900-2000 Maritime at in from sederin large affects 1900-2000 to 1900-2000 maritime at 1900-2000 de annual proceptation 1900-2000 to 1900-2000 maritime at 1900-2000 de annual proceptation 1900-2000-2000-2000-2000-2000-2000-2000-	permating care are generally above-3°C, and range down to 3°C, issue of a making processor are strong time, and the strong processor are strong time, and the strong processor are strong time, and the strong processor are strong processor are strong processor and the strong processor are strong processor are strong processor and the strong pro	Cana. 2005 Brandey. 2000 All et al. 2009 All et al. 2009 All et al. 2009 Countillot. 2006 Gascon et al. 2010 Gascon et al. 2010 Gascon et al. 2010 Wriffen, undated. Gascon et al. 2010 Wriffen, undated.
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Appendix 2
Review Comments and Short Responses

Review Comments From Golder Associates

1. Additional climatic parameters will be necessary for effectively modeling groundwater transport at the Kiggavik site. We suggest that additional climatic parameters, such as precipitation, evaporation, seasonal temperature trends and permafrost conditions also be examined. The University of Victoria's Canadian Institute for Climate Studies provides a good interface for modeling climatic trends in Canada until the 2080s. A number of models and emission scenarios are available and results are obtainable at localized scales. We suggest that a specific climate model and emission scenario (or a select few climate models and scenarios) be established so that environmental conditions are well defined and additional information and data can be acquired when necessary. This will not only aid in modeling groundwater transport but will also make the data presented in this report applicable to a wider range of modeling efforts that involve climatic and/or hydrological components.

Response: Additional parameters added in Appendix. Section 5.6. Using computer models is discussed in Section 2.2, no further modelling undertaken but Appendix 1 created to detail parameters.

2. Provide Kiggavik site-specific data, particularly for short-term predictions. The report does not always indicate the specific scale or location at which the data are applicable. Climate change is a spatially variable occurrence and predictions vary considerably with respect to regional characteristics. For example, high latitudes are particularly susceptible to the effects of climate change; the Arctic is expected to undergo preferential warming (Kattsov et al., 2005). It is therefore necessary that data are specific to the Kiggavik site. Regional data are provided for the models available through the Canadian Institute for Climate Studies website.

Response: Climate is now specified to Baker Lake region, Systems remain global. Appendix 1 specifies spatial scale where possible.

 Although the report provides a summary of the major climate forcing mechanisms and the scales at which they operate, it fails to indicate the relative influence of each mechanism. This information will help indicate the sensitivity of the proposed model and how different greenhouse gas scenarios may affect the results.

Response: The climate forcing mechanisms are global scale. Sensitivity is not described as the resolution of the models and the temperature record are too coarse to detect changes reliably.

4. The report indicates a cooling trend over the next 50 years. However, we have run 12 global circulation models under a variety of Intergovernmental Panel on Climate Change (IPCC) derived emission scenarios for the Kiggavik site. The mean, 1st quartile, 3rd quartile, minimum and maximum temperature values for the 61 experiments are indicated in Figure 1. All models present a significant and consistent warming trend over the next 50 years. We therefore suggest the short term climatic trends in this report be further examined.

Response: Cooling over the next 50 years is now broadly anticipated by many groups due to the reduction in solar radiation and the strong negative Arctic Oscillation. The model data has deviated from the real temperatures experienced.

5. It is necessary to provide original sources and cross references in the report. This information will help confirm credibility and allow supplementary data to be obtained when necessary.

Response: Although not all references are referenced within the text a larger proportion have been cross referenced.

Review Comments from Sennes

1. The primary weakness of the report, in my opinion, is that the report does not focus in on the climate in the vicinity of the Kiggavik mine and reaches no specific conclusions relative to the long-term effects on mine tailings storage.

Response: The scenario has been refined to the Baker Lake area, but it should not be refined too much as there is too much uncertainty (Section 5.6). No comment is made on the tailings as that was not part of the initial requirement. Was requested only to define the future climate for modelling purposes on ground freezing.

2. In short, what the report states is that the effects of greenhouse gases on climate forcing will be limited to the next 500 years, after which everything goes back to normal and the primary influences on climate change are the same ones that have been operating on the earth's climate in the past 10,000 years. There is reason to question this fundamental assumption in the report.

Response: This part is correctly understood. A future energy scenario is added to the document in Section 2.2. In addition the return to CO₂ in balance with earth temperature is discussed. CO₂ logarithmic relationship with CO₂ is discussed. The cyclical nature of the drivers for climate change must be considered and are not adequately dealt with in the IPCC models – this is also discussed.

3. However, the underlying premise for this projection of future climate assumes that once the effect of current climate warming due to greenhouse gases is over in the next 500 years, the Arctic ice cap will reform and that everything returns to the same state that is was in after the last ice age.

Response: This part is not correctly understood. A return to ice age conditions will start at some point between now and a time of 50000 years into the future. The decline into an ice age is a slow saw tooth process with both warm and cool periods. The scenario that has been developed clearly shows that after the cooling in the near future there will be warming and then a long period with variable warming and cooling. This is anticipated to be similar to the period 5000YBP in Appendix 1.

4. As for the long-term climate projection present in SRK's Figure 4.7, the projection is remarkably stable over the next 50,000 years. The past 10,000 years have exhibited an unusually stable climate relative to what has happened in previous interglacial periods, and the SRK report projects that the future climate will remain stable for another 50,000 years. This does not seem credible in view of the evidence from ice cores and ocean sediment data used to reconstruct climate change over the past 800,000 years. Therefore, while I credit SRK for having pulled together a good summary of the climate change cycles that may influence our climate over the next 10,000 years, I am sceptical about their application of those cycles to project the potential changes in the 1,000-10,000 year and longer time frame.

Response: The interglacials are typically 10000 years and we are currently at a point where we are roughly 10000 years from the last glacial period. This interglacial is however anticipated to last for 10000 to 30000 years as originally indicated in Section 5.3.1. There may well be small cold and warm periods during this time, but Berger et al (2008) who focussed on this point think this is likely to be a very long interglacial. As the whole area of knowledge is still under development the Berger et al paper was considered to be one of the likely options as they could demonstrate a causal link with solar radiation and therefore it fits with the base assumption in this report that the main climate driver is the sun.

5. It seems to me that this is perhaps the most critical issue for the near term climate change scenario presented by SRK. What happens to the Kiggavik tailings storage if the permafrost is lost in the next 1,000 years?

Response: The point is accepted but the original briefing was to provide possible climate parameters that could be used for modelling the freeze operation at Kiggavik. No requirement was made for describing the tailings as part of this report.

Review Comments from AREVA

1. We would like your report to incorporate a reference to the Arctic Ensemble Scenarios (http://yukon.cccsn.ca/?page=ensemblescenarios) and the proposed temperature change at Baker Lake for the 2011- 2100 period.

Response: The Arctic ensembles have been included. Baker Lake data and Ensemble data are plotted and presented along with a description of the data and an extraction of the rate changes expected. To ensure this data is in context I have also added a section comparing IPCC predictions against observed records for Baker Lake for the past 25 years where these are available. Section 5.6.

2. It would be also appropriate to include reference to The Nunavut Climate Change Strategy 2003.

Response: This has been added and the guiding principles and climate change map have been included in the text. It also refers to an earlier section where the Nunavut people's perception of climate change is reported. Section 5.6.

3. Please make sure that the conclusion of your report (including Figure 70) includes the climate change scenario we have been using to estimate permafrost degradation and tailings thermal behavior; that is a 5 degree rise over 100 years from a mean annual surface temperature of -7 °C to -2 °C.

Response: The trend line has been added to the final graph. Section 5.6.