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APPENDICES

A.8 – AIR QUALITY

A.8.1 INTRODUCTION

Section 8 of the Proposal evaluated the potential effects of the Project on air quality. Air quality is defined in the Proposal for the Casino Project (the Project) as the composition of outdoor air. Air quality was selected by Casino Mining Corporation (CMC) as a Valued Component (VC) because mining activities such as fuel consumption, vehicle movement, and material transfer generate air emissions that could cause deterioration of ambient air quality. As well, clean air in the Yukon is valued unto itself, but additionally fugitive dust and particulate matter may affect receptors such as rare vegetation, wildlife, surface water quality, and soil. Major air pollutants that were assessed include sulphur dioxide, nitrogen dioxide, carbon monoxide and particulate matter, as well as Greenhouse Gases (GHG).

On January 27, 2015, the Executive Committee requested that CMC provide supplementary information to the Casino Project (YESAB Project No. 2014-0002) to enable the Executive Committee to commence Screening. The Executive Committee considered comments from various First Nations, Decision Bodies and regulators on the adequacy of the Project Proposal in the preparation of the Adequacy Review Report (ARR). Casino Mining Corporation is providing this Supplementary Information Report (SIR) to comply with the Executive Committee's Adequacy Review Report; CMC anticipates that the information in the SIR and Proposal, when considered together, is adequate to commence Screening.

The Executive Committee has 24 requests related to information presented in Section 8 Air Quality, Appendix 8A Baseline Climate Report, Appendix 8B Met, Dustfall, and Noise Data Summary Report 2011, Appendix 8C Air Quality Baseline Report 2013 and Appendix 20A Climate Change Report of the Proposal submitted on January 3, 2014. These requests, and the sections of the SIR where the responses can be found, are outlined in Table A.8.1-1. Some responses require detailed technical information, data, and figures. Where necessary, this additional supporting information is provided as appendices to the SIR.

Table A.8.1-1 Requests for Supplementary Information Related to Air Quality

Request #	Request for Supplementary Information	Response
R249	Reasons for missing data at regional climate stations (i.e. was the station not operated for budget considerations or did an extreme weather event destroy the station).	Section A.8.2.1.1
R250	Rationale for a linear orographic factor at the Project site for 24-hour extreme events considering available data and any terrain effects.	Section A.8.2.1.2
R251	Additional rationale for developing the precipitation return period events (e.g. extreme rainfall). Details should include the methodology for developing the 200 and 1 000-year return period events as well as rationale for using the Gumbel distribution.	Section A.8.2.1.3
R252	Discussion of the role of aspect in relation to climate variables at the Project site.	Section A.8.2.1.4
R253	Justify the use of only Pelly Ranch in building climate baseline data at the Project site for periods where data are unavailable for the Project location.	Section A.8.2.1.5
R254	Confirm that on-site meteorological data collection is ongoing. Provide raw and processed data and recalculate precipitation estimates and measures of variability.	Section A.8.2.1.6

Request #	Request for Supplementary Information	Response
R255	Clarification regarding the climate variables that have been utilized as part of project safety and design as well as an explanation for why those climate variables have been chosen.	Section A.8.2.1.7
R256	Clarification regarding the values used when considering climate change projections and their interactions with the project.	Section A.8.2.1.8
R257	Additional information on wind speed/direction sensor position and height.	Section A.8.2.1.9
R258	Develop a more robust estimate of evaporation and evapotranspiration using air temperature, relative humidity, wind speed and solar radiation.	Section A.8.2.1.10
R259	A discussion on how variability and uncertainty associated with the impacts of climate change was considered in Project safety and design and how those impacts will be mitigated, particularly with respect to permafrost thaw and hydrological changes.	Section A.8.3.1.1
R260	In planning the design and construction of the mine, a greater range of potential change should be considered (and not just the mean). For example, if the range of precipitation change is projected to be between 5 and 25 percent, design considerations should not be limited to a mean (15 percent) but should address the potential maximum (25 percent). Please clarify what values were used when considering climate change projections and their interactions with the Project.	Section A.8.3.1.2
R261	Clarification on the calculations related to the projected rate of increase of flow, including details on how historical trends for Big Creek have been taken into consideration in the projection as well as how the potential maximum increase has been addressed.	Section A.8.3.1.3
R262	The CALPUT and CALMET input files such that a recreation of the model is possible.	Section A.8.4.1.1 Appendix A.8A Emissions Inventory for Construction and Operations
R263	Details on the specifications of ambient air monitoring and meteorological equipment.	Section A.8.4.1.2
R264	An analysis of wind directions compared to other regional sites.	Section A.8.4.1.3
R265	A detailed emission inventory for construction and operational activities.	Section A.8.4.1.4 Appendix A.8A Emissions Inventory for Construction and Operations
R266	Clarification if mitigations, such as ultra-low sulphur fuel, proposed for air quality were reflected in model parameters. If not, results of the air quality model with the mitigations reflected in model parameters.	Section A.8.4.2.1
R267	If predicted air quality, after mitigations, results in exceedances, provide mitigations for identified exceedances.	Section A.8.4.2.2
R268	The raster data generated from the CALPUFF model in a standard GIS format.	Section A.8.4.3.1
R269	A description of predicted exceedances including concentrations and predicted frequency.	Section A.8.4.3.2

Request #	Request for Supplementary Information	Response
R270	Details on the compositions of dust generated by the mine and how this is expected to compare with the proposal's baseline data.	Section A.8.5.1.1
R271	Details on volumes of water required for dust management and clarification if this water was accounted for in overall water use requirements.	Section A.8.5.1.2
R272	Update to Table 22.3-2 to include a conclusive list of proposed mitigation measures for potential project effects on air quality.	Section A.8.6.1.1

Notes:

1. Request # refers to the assigned identification number in the YESAB Adequacy Review Report January 27, 2015 prepared by the Executive Committee of the Yukon Environmental and Socio-economic Assessment Board.
2. Response refers to the location of CMC's response to the YESAB request for supplementary information.

A.8.2 BASELINE CLIMATE REPORT

A.8.2.1.1 R249

R249. Reasons for missing data at regional climate stations (i.e. was the station not operated for budget considerations or did an extreme weather event destroy the station).

The operation of regional climate stations is the responsibility of Environment Canada, and as such, the continuity of their operation is subject to budgetary and other constraints that are outside the control of this Project and CMC. The site specific Casino climate station was continuously operated with data collected on an hourly basis from November 2008 to September 2012.

A.8.2.1.2 R250

R250. Rationale for a linear orographic factor at the Project site for 24-hour extreme events considering available data and any terrain effects.

The orographic factor applied is not linear, but rather is a power function. The precipitation is increased 7% per 100 m increase in elevation. For instance, as presented in the climate report, 34.8 mm at Pelly Ranch (el. 454 m) equates to 58 mm at the Casino site (el. 1200 m) according to the equation:

$$P_{Casino} = 34.8 \text{ mm} \times 1.07^{((1200 \text{ m} - 454 \text{ m})/100 \text{ m})} = 58 \text{ mm}$$

This equation is typically used to translate mean annual precipitation (MAP) from one location to another, but experience has shown that it also commonly applies well to 24 hour extreme precipitation, as there is typically a strong correlation between MAP and 24 hour extreme precipitation.

The 34.8 mm value at Pelly Ranch was the largest daily rainfall event recorded in a 30 year period, giving it a return period of approximately 30 years. Accordingly, if the orographic equation is reasonably appropriate, the corresponding 58 mm value for the Casino site should also have a return period in the order of 30 years. A review of the return period 24 hour precipitation values presented in Table 2.3-3 of the Baseline Climate Report (Appendix 8A) demonstrates that this is the case, with a 24 hour precipitation of 58 mm assigned a return period of 25 years.

For the above reasons, CMC believes that the orographic factor utilized for the Project's 24-hour extreme events is appropriate.

A.8.2.1.3 R251

R251. Additional rationale for developing the precipitation return period events (e.g. extreme rainfall). Details should include the methodology for developing the 200 and 1,000-year return period events as well as rationale for using the Gumbel distribution.

The methodology for developing the return period 24 hour precipitation events for the Report on the Feasibility Design of the Tailings Management Facility (Appendix A.4D) and the Baseline Climate Report (Appendix 8A) were estimated for the Project site using a statistical method approach, as presented in the Rainfall Frequency Atlas for Canada (Atlas) (Hogg 1985). This approach involves using estimates of the mean and standard deviation of the annual 24-hour extreme precipitation, and utilizes frequency factors based on the Extreme Value Type I (Gumbel) distribution. The Gumbel distribution is a distribution of maxima that is the most commonly accepted distribution to describe the frequency of extreme rainfall events, according to the Atlas.

Estimates of the mean and standard deviation were derived directly from the Atlas. A factor of 1.2 was applied, as recommended in the Atlas, in recognition of potential orographic effects and the fact that the Atlas values are largely based on data from valley stations. The resulting mean and standard deviation values are 25 mm and 6 mm, respectively. The following equations are used to calculate the extreme event rainfall and frequency factors shown in Table A.8.2-1.

$$X_T = X_M + K_T S$$

Where the extreme event rainfall (X_T) is equal to the mean rainfall (X_M) plus the frequency factor (K_T) multiplied by the standard deviation (S).

The frequency factor (K_T) is calculated as follows:

$$K_T = \frac{-\sqrt{6}}{\pi}\left(0.5772 + \ln\ln\left(\frac{T}{T-1}\right)\right)$$

Table A.8.2-1 Extreme 24-hr Rainfall Values

Return Period (years)	Frequency Factor	Extreme Event (mm)
2	-0.164	29
5	0.719	35
10	1.305	39
15	1.635	42
20	1.866	43
25	2.044	45
50	2.592	49
100	3.137	53
200	**3.679**	**56**
500	4.395	62
1000	**4.936**	**66**
PMP	**17.973**	**159**

A.8.2.1.4 R252

R252. Discussion of the role of aspect in relation to climate variables at the Project site.

For climate-based studies conducted at both the regional and local area level, the effect of aspect was accounted for within the mean climatic conditions and extreme climatic conditions and their respective standard variations. At the regional level, vegetation, soils, and topography are related to the regional climate and the regional climate is the overriding identifier that sets the bounds for climatic characteristics in that area.

Within the context of the baseline climate study, especially considering the extents of the regional and local study areas, elevation was considered to be the main contributor to any localized climate conditions that could be attributed to slope effect. For this reason, an orographic factor was applied to the data to scale it with respect to elevation.

A.8.2.1.5 R253

R253. Justify the use of only Pelly Ranch in building climate baseline data at the Project site for periods where data are unavailable for the Project location.

The reliability of the long-term synthetic series to represent actual Project site data is measured through the coefficient of determination. The Pelly Ranch regional climate station was selected to build the climate baseline data at the Project set because the coefficient of determination indicated that the long-term synthetic series and regression relationships generated were considered to be statistically reliable; additional data sets were not incorporated because the data was considered to be statistically reliable.

Nine regional climate stations operated by the Meteorological Service of Canada (MSC) are located within 150 km of the Casino mine site, primarily within the Klondike Plateau region. These climate stations are listed in Table 2.1-1 of the Baseline Climate Report (Appendix 8A). The reliability and completeness of the long term data sets and the representativeness of elevation and proximity were taken into consideration in selecting which data set could be used to generate long-term synthetic series for climate indicators for the Project location.

The majority of these climate stations, with the exception of Pelly Ranch, had many years of incomplete data record, for reasons outside the control of this Project and CMC. For example, even though the Casino Creek Climate Station (ID 2100310) is the closest to the Project site and within the general Project area, it has measured data recorded between 1969 and 1995 but has no complete years of record and therefore could not be used. Eight regional climate stations have greater than 20 complete years of record and these stations are all situated in low-elevation settings (between 320 m to 649 m). The Pelly Ranch regional climate station is the closest to the Project site and is an active monitoring station with a reliable long term data set.

A.8.2.1.6 R254

R254. Confirm that on-site meteorological data collection is ongoing. Provide raw and processed data and recalculate precipitation estimates and measures of variability.

In 1993, Hallam Knight Piésold Ltd. (HKPL) installed a climate station near the Casino exploration camp at an elevation of 1,200 m. This climate station was used to measure temperature and precipitation and operated from 1993 to 1995. In 2008, a new Project climate station was established at approximately the same location by RWDI Air Inc. (RWDI). Casino Mining Corporation confirms that this climate station continues to be operational and continues to measure air temperature, rainfall, wind speed and direction, relative humidity, barometric pressure, and snow depth.

Casino Mining Corporation believes that the climate data that has been presented in the Proposal is of sufficient duration and seasonal variation to establish a representative precipitation baseline for the purpose of understanding the potential effects of Project. Climate data that is collected on site will be used in the future to support operational monitoring. For these reasons, CMC believes that providing additional raw and processed data beyond what was provided in the Proposal or recalculating precipitation estimates and variability is not warranted.

A.8.2.1.7 R255

R255. Clarification regarding the climate variables that have been utilized as part of project safety and design as well as an explanation for why those climate variables have been chosen.

Assuming that the question is primarily directed towards the TMF, the Project sought to ensure safety through mitigation by engineering design. Mitigation by engineering design is simply ensuring that risks are mitigated by incorporating factors of safety into the design basis that protect against foreseeable risks. This process relied on the completion of a dam hazard classification in conformance with the Canadian Dam Associations "Dam Safety Guidelines" (2007). Under the CDA a HIGH consequence dam classification was assigned to the TMF. Subsequent to this classification, CMC voluntarily chose to adopt the EXTREME dam consequence classification to incorporate an additional factor of safety to the design.

Based on the EXTREME dam classification assigned to the TMF, an appropriate IDF is an event equal to the Probable Maximum Flood (PMF). In this case, the inflow design flood is an extreme indicator rather than an average indicator. The CDA Guidelines require that an EXTREME dam classification be designed for a probabilistically derived event (defined as the Earthquake Design Ground Motion) having an annual exceedance probability (AEP) of 1/10,000. Consequently, the maximum design earthquake (MDE) selected for the TMF is the 1 in 10,000 year earthquake. Again this is an extreme indicator as opposed to an average indicator.

If the query was intended to extend beyond the TMF other water retaining structures, all building structures are anticipated to be designed and constructed to meet provincial and federal standards such as the Canadian Standards Association (CSA) Building Code that consider the effects of climate in order to ensure structural stability and safety.

A.8.2.1.8 R256

R256. Clarification regarding the values used when considering climate change projections and their interactions with the project.

Casino Mining Corporation assumes that this request for information by the Executive Committee is related to the approach taken in the Baseline Climate Report (Appendix 8A) to calculate evaporation and evapotranspiration. YG's comments that "Department of Environment considers Thornthwaite rather rudimentary as it only considers one variable: air temperature. The simplicity of this approach is often seen as its main advantage; however more detailed methods exist" (YOR 2014-0002-252-1). YG further states that "a more robust methodology using air temperature, relative humidity, wind speed, and solar radiation are available and should be employed to develop estimates of evaporation and evapotranspiration" (YOR 2014-0002-252-1).

There are no site specific or regional evaporation or evapotranspiration data available for the Project area, so estimates of mean monthly potential evapotranspiration (PET) for the Project area were generated comparing two commonly applied empirical relationships, those developed by Hargreaves (Maidment 1993) and Thornthwaite (Thornthwaite 1948).

Hargreaves Equation

The Hargreaves equation uses mean, minimum and maximum daily temperature values, as well as site latitude, to estimate PET. For the Project site, only minimum and maximum daily temperature values are available for the 2008-2009 dataset, and therefore the 1993-1994 data were not applicable. The Hargreaves equation is as follows:

$$PET = 0.0023\left(T_{mean} + 17.8\right)\left(T_{\max} - T_{\min}\right)^{0.5} R_a$$

Where:

- *PET* = potential evapotranspiration rate (mm/day)
- R_a = water equivalent of extraterrestrial solar radiation (mm/day)
- T_{mean} = mean daily temperature (°C)
- T_{max} = maximum daily temperature (°C)
- T_{min} = minimum daily temperature (°C)

And:

$$R_a = \frac{24(60)}{\pi} G_{sc} d_r \left[\omega_s \sin(\varphi)\sin(\delta) + \cos(\varphi)\cos(\delta)\sin(\omega_s)\right]$$

Where:

- *Ra* = extraterrestrial radiation (MJ m^{-2} day^{-1})
- G_{sc} = solar constant = 0.0820 (MJ m^{-2} min^{-1})
- d_r = inverse relative distance Earth-Sun (rad)
- δ = solar decimation (rad)
- ω_s = sunset hour angle (rad)
- φ = latitude (rad)

This equation produces negative results for temperatures below -17.8 °C and any such values were removed from the estimated dataset. It was also assumed that days with a maximum daily temperature value below zero have zero PET. The 2009 temperature records were slightly warmer than the long-term synthetic temperature record; hence, the 2009 annual value of 403 mm may slightly overestimate the long-term average evapotranspiration.

Thornthwaite Equation

The Thornthwaite equation only requires mean monthly temperature as an input. This equation assumes that no PET occurs when the mean monthly temperature is below zero degrees Celsius. The mean monthly temperature values from the historical datasets recorded in 1993-1995 and 2008-2009 were used to estimate the monthly and annual PET values.

$$ET_0 = \begin{cases} 0, T < 0 \deg C \\ 16\left(\frac{10T_i}{I}\right)^a, 0 \le T \le 26.5 \deg C \\ -415.85 + 32.24T_i - 0.43T_i^2, T \ge 26.5 \deg C \end{cases}$$

Where:

- PET_0 = Potential evapotranspiration (mm/month)
- T_i = Mean monthly temperature (°C)
- *I* = Heat index, sum of 12 monthly index values (*i*)
- *i* = Monthly heat index
- *a* = Empirically derived exponent, which is a function of I

And:

$$i = \left(\frac{T}{5}\right)^{1.514}$$

$$a = 6.75*10^{-7} I^3 - 7.71*10^{-5} I^2 + 1.79*10^{-2} I + 0.49$$

The PET estimates based on the Thornthwaite equation are lower than those provided by the Hargreaves equation, and are more in line with the regional estimates for this area of 200-300 mm based on the annual lake evaporation isolines from the Hydrological Altas of Canada produced by NRC. Accordingly, the Thornthwaite equation was selected for estimating long-term PET for the Project.

At the request of the Executive Committee, PET was re-calculated using the Penman-Montieth combination equation, which requires inputs of air temperature, relative humidity, barometric pressure, wind speed and solar radiation. The results of this re-calculation and description of how it has been incorporated into the Project is presented in the response to R258.

A.8.2.1.9 R257

R257. Additional information on wind speed/direction sensor position and height.

The instrumentation types and models installed at the Casino Climate Station are:

- Campbell Scientific CR800 Data Logger
- RM Young 05103 Wind Monitor
- Texas Electronics TE525 Tipping Bucket Rain Gauge
- RM Young 61205V Barometric Pressure Sensor
- Campbell Scientific HC-S3 Temperature and Relative Humidity Probe
- Campbell Scientific SR50A Sonic Range Snow Depth Sensor

The dominant wind direction at the Project is northerly, followed by southwesterly, as presented in the Proposal (Appendix 8A and Appendix 8B). The wind speed sensor, or anemometer, is positioned on a tower at a height of 10 m above the ground surface.

A.8.2.1.10 R258

R258. Develop a more robust estimate of evaporation and evapotranspiration using air temperature, relative humidity, wind speed and solar radiation.

PET was re-calculated using the Penman-Montieth combination equation, which requires inputs of air temperature, relative humidity, barometric pressure, wind speed and solar radiation. The data record used for this calculation is the same record that was used in Appendix 8A (Baseline Climate Report). Solar radiation is not measured at the Casino climate station, so it was estimated using calculations related to the latitude of the Project, albedo of the surface, and actual hours of sunshine. Albedo was estimated to be 0.15 for the TMF pond and Open Pit lake, while sunshine hours were assumed equivalent to those reported for Whitehorse by Environment Canada. Calculated PET for the period of May through October was summed to derive the mean annual PET estimate, in order to account for frozen conditions of the water bodies in November through April. The resultant annual potential evapotranspiration is 415 mm. It should be noted that there is a reasonable amount of uncertainty associated with this value, due to the numerous estimates and approximations required to apply the Penman-Montieth equation.

PET was assumed to equal lake evaporation in the water balance to model evaporation from the TMF and Open Pit lakes. Other methods of estimating lake evaporation in the region, including pan evaporation measurements in Alaska and scaling of the Atlas of Canada values by the underestimation factor derived for the Lupin research site in Northwest Territories, suggest that lake evaporation at the Project should be in the range of 350 mm to 400 mm. All of the above estimates are considerably greater than the previously calculated 300 mm, and therefore the evapotranspiration estimate in the water balance was updated to an average annual value of 390 mm as an estimated value in the upper range between 300 mm and 400 mm, which is considered appropriate considering the available information. The results of the updated water balance model are provided in Appendix A.7A.

A.8.3 CLIMATE CHANGE REPORT

A.8.3.1.1 R259

R259. A discussion on how variability and uncertainty associated with the impacts of climate change was considered in Project safety and design and how those impacts will be mitigated, particularly with respect to permafrost thaw and hydrological changes.

Predicted possible general increases in temperature and precipitation, as a result of global climate change, have been considered both directly and indirectly in the planning and design of the Project. Appendix 20A of the Proposal (Climate Change Report) indicates that temperatures are predicted to increase in the order of 1°C to 4°C over the next 40 to 50 years, that annual precipitation is predicted to increase in the order of 5% to 25%, and that greater atmospheric energy associated with the higher temperatures may lead to greater climatic variability, including a greater frequency and severity of extreme events.

Three key ways that the effects of these potential future changes in climate were taken into consideration in the Project design are:

- Peak design flow estimates;
- Sizing and staging of the TMF; and
- Permafrost melt susceptibility of foundation conditions.

The potential for an increase in the frequency and severity of rainfall events, snowmelt and corresponding peak flows was directly considered by applying an uplift factor of 15% to all peak design flow estimates, as stated in Appendix 7B, Hydrology Report.

The effects of variability and potential changes in hydroclimatic conditions on the sizing and staging of the TMF were considered by incorporating adaptability into the designs and operating plans for the mine. For example, tailings storage facility embankments are constructed in stages and tailings slurry and pond levels are continuously monitored, such that if conditions prove to be wetter than expected due to climate change or climate variability, appropriate adjustments can be made to the dam stage construction schedule. Furthermore, since the mine is currently expected to operate in a water deficit, the mine plan includes the ability to extract make-up water from the Yukon River. The water extraction system is currently sized with a capacity well in excess of the expected deficit, such that the make-up system has substantial contingency in place in the event that evaporation losses associated with predicted increases in temperature exceed gains from predicted increases in precipitation. Any needs to increase the make-up water extraction are not likely to have a significant effect on flows in the Yukon River, since the maximum capacity of the make-up water system is equal to less than 1% of the lowest ever recorded flow in the Yukon River. Conversely, if conditions prove to be wetter than expected, the volume of water pumped from the Yukon River can be reduced to compensate for additional water in the TMF.

Warmer temperatures could substantially alter the permafrost conditions in the Casino Project area, most notably affecting the extent of the seasonally thawed permafrost layer (active layer) and thereby altering the foundation conditions of civil infrastructure works, including buildings, roads, railways, airstrips, and pipelines. The most basic risk is the loss of mechanical strength and eventual thaw settlement or subsidence, as well as increased frost heaving potential. Accordingly, the foundation conditions for most of the major project infrastructure elements were assessed for permafrost melt susceptibility, and then appropriate measures were incorporated into the respective foundation designs. For instance, the foundation designs for the plant site, the heap leach pads and the tailings embankment all entail the excavation of overburden material to bedrock, such that all permafrost susceptible soils will be removed. A similar approach is also likely to be employed for road design but will be confirmed in detailed design. In support of future refinement in the Project design and future construction activities, ground temperature data is currently being collected at a number of locations across the mine site using thermistor strings and data loggers that were installed in vertical drillholes. Continued monitoring in the operations phase will allow for identification of real-time changes in permafrost conditions that may be connected with climate change. The need for additional mitigations for permafrost degradation will be assessed in detailed design taking into account on-going ground temperature data currently being collected or proposed to be collected.

A.8.3.1.2 R260

R260. In planning the design and construction of the mine, a greater range of potential change should be considered (and not just the mean). For example, if the range of precipitation change is projected to be between 5 and 25 percent, design considerations should not be limited to a mean (15 percent) but should address the potential maximum (25 percent). Please clarify what values were used when considering climate change projections and their interactions with the Project.

The climate at any particular location in the world is never constant, regardless of whether or not climate change, as defined by the Intergovernmental Panel on Climate Change (IPCC), is occurring, and consequently the engineering design of a mine must always consider the variability of climate and the potential magnitude of climatic and associated hydrologic extremes. The uncertainty of hydroclimatic conditions, with respect to water supply and water management, is typically considered in a Project design process through the use of factors of safety and by incorporating adaptability into the designs and operating plans for a mine. Consequently, mine structures are inherently well-suited to accommodate possible effects due to climate change. Nonetheless, in order to account for the potential climate change related increases in the variability and magnitude of hydroclimatic events, efforts are made to quantify those changes, such as described in the Climate Change report provided in Appendix 20A of the Proposal, and design factors of safety and stochastic modelling parameters are modified accordingly. For example, the peak design flow procedure for the Casino Project includes a climate change adjustment of +15%, and although this value is somewhat arbitrarily selected, it is consistent with professional practice guidelines (APEGBC 2012) and with general practices as determined through attendance at various climate change symposiums and discussions with industry experts.

In addition to water management related issues, climate change has implications for the design, operation and maintenance of civil infrastructure (Hinkel et al. 2003; Instanes 2003). Warmer temperatures could substantially alter the permafrost conditions in the Casino Project area, most notably affecting the extent of the seasonally thawed permafrost layer (active layer) and thereby altering the foundation conditions of civil infrastructure works, including buildings, roads, railways, airstrips, and pipelines. The most basic risk is the loss of mechanical strength and eventual thaw settlement or subsidence, as well as increased frost heaving potential. These factors must be considered in the design of all civil infrastructure for the Casino Project.

As the Project proceeds, CMC will rely on a planned and systematic process for continuously improving environmental management practices associated with climate change by observing actual outcomes (i.e., adaptive management). CMC will implement mitigation measures over the life of a project to address unanticipated effects resulting from climate change.

A.8.3.1.3 R261

R261. Clarification on the calculations related to the projected rate of increase of flow, including details on how historical trends for Big Creek have been taken into consideration in the projection as well as how the potential maximum increase has been addressed.

It is CMC's opinion that the peak flow values are appropriately estimated. Trends in the Big Creek flood record were not linearly extrapolated to predict future flood magnitude. Historical trends for Big Creek have been taken into consideration but not used in the projection, because the trendline indicating a 2 m^3/s per year increase in flow for Big Creek is not statistically significant, even at a 0.1 level of significance. Big Creek is considered not to be strongly representative of future peak flow trends.

The Climate Change Report (Appendix 20A) observed that the trend of increasing peak flows in Big Creek was largely influenced by the two highest flows in the record; the two noted historic flows had a disproportionate influence on the observed increasing flow trend. If these two points were removed from the 29 point dataset, the trendline would indicate a much reduced rate of increase of 0.36 m^3/s per year. The Climate Change Report highlighted the fact that the dataset is relatively short and therefore subject to being disproportionately influenced by one or two points (in sampling error).

Trendlines in data should be viewed with appropriate caution because they are very sensitive to the period of data selected for the analysis. For instance, an evaluation of the most recent 11 years of data (2001-2011), which might be argued is more reflective of future conditions than the full set containing earlier data by virtue of having occurred more recently, the trendline actually indicates a decrease in flow (0.1 m^3/s per year). On the other hand, if the time period is extended back to 1993, the trendline indicates a very dramatic increase in flow (6.3 m^3/s per year).

Despite the above observations, the historical trends in the Big Creek flood record were incorporated into the flood frequency analysis. The peak flow estimates presented in the Casino Hydrology Report (Appendix 7B) are based on the frequency analyses of historical annual peak flow series derived from long-term synthetic flow series generated for each of the streamflow gauging stations in the project area. The synthetic flow series were generated through correlations of the site gauging station data with concurrent data for Big Creek, and then those correlation equations were applied to the long-term flow series for Big Creek. Accordingly, the historical annual peak flow series for each of the site gauging stations directly incorporates the historic trends in the Big Creek dataset.

Finally, application of the 15% factor was done as a climate change contingency measure in accordance with recommendations by the Association of Professional Engineers and Geoscientists of BC (APEGBC 2012). The magnitude of this factor is not directly related to the predicted 5%-25% increase in annual precipitation presented in the Climate Change Report (Appendix 20A), as there is only a general relationship between the magnitude of extreme precipitation events and annual total precipitation (i.e. higher total annual precipitation generally corresponds to higher extreme events), rather than a direct linear correlation as suggested by the comments by Executive Committee in ARR Section 6.0 that appears to interpolate the 15% value being an average of the 5%-25% range.

A.8.4 AIR QUALITY MODELLING

A.8.4.1 Model Inputs

A.8.4.1.1 R262

R262. The CALPUT and CALMET input files such that a recreation of the model is possible.

Casino Mining Corporation is providing supporting data for the CALPUFF and CALMET models in the form of a detailed emissions inventory for the construction and operation phase Project activities with potential emissions sources (Appendix A.8A Emissions Inventory for Construction and Operations). Casino Mining Corporation anticipates that the additional information provided will be sufficient for the Executive Committee to better understand the air quality modelling inputs selected for the Proposal and that recreating the air quality dispersion model is not warranted.

A.8.4.1.2 R263

R263. Details on the specifications of ambient air monitoring and meteorological equipment.

Baseline dustfall monitoring was conducted during the summers of 2010, 2011, and 2013 using dustfall collection canisters suspended 1.5 m off the ground. Real-time dustfall monitoring was undertaken during May 2013 and June 2013 using a DustTrak DRX Aerosol Monitor. The DustTrak DRX was used to simultaneously measure size-segregated mass fraction concentrations corresponding to PM_1, $PM_{2.5}$, PM_4, PM_{10} and Total PM size fractions. Passive sampling of NO_2 and SO_2 was conducted from July 31, 2013 to September 1, 2013 at two mine site stations using an all-season Maxxam Laboratory Passive Air Sampling System (PASS).

Meteorological equipment consists of the following instrumentation types and models installed at the Casino Climate Station:

- Campbell Scientific CR800 Data Logger
- RM Young 05103 Wind Monitor
- Texas Electronics TE525 Tipping Bucket Rain Gauge
- RM Young 61205V Barometric Pressure Sensor
- Campbell Scientific HC-S3 Temperature and Relative Humidity Probe
- Campbell Scientific SR50A Sonic Range Snow Depth Sensor

A.8.4.1.3 R264

R264. An analysis of wind directions compared to other regional sites.

Casino Mining Corporation assumes that this request for information is related to the appropriateness of the dominant wind direction that was selected as an input into the air quality model. The air quality model assumed that the dominant wind direction at the Project site climate station is northerly, followed by southwesterly winds. In comparison, the predominant wind directions at the Minto Mine site are S to SE and N to NW (Capstone Mining Corp. 2013).

A.8.4.1.4 R265

R265. A detailed emission inventory for construction and operational activities.

A detailed emissions inventory for the proposed construction and operations phase activities is provided in Appendix A.8A Emissions Inventory for Construction and Operations.

A.8.4.2 Mitigations

A.8.4.2.1 R266

R266. Clarification if mitigations, such as ultra-low sulphur fuel, proposed for air quality were reflected in model parameters. If not, results of the air quality model with the mitigations reflected in model parameters.

Ultra-low sulphur fuel and all other mitigation measures identified in Table 8.4-7 in Section 8 of the Proposal were represented as model parameters in the air quality model completed for the Project.

A.8.4.2.2 R267

R267. If predicted air quality, after mitigations, results in exceedances, provide mitigations for identified exceedances.

A number of predicted air quality concentrations are anticipated to exceed the Yukon Ambient Air Quality Standards and/or Canadian Air Quality Objectives after mitigation has been applied. These exceedances are restricted to the private area surrounding the mine site and Freegold Road Extension. In all cases the residual effects were assessed to be Not Significant. The mitigation that has been proposed is considered to be consistent with industry standards and already includes the practical and achievable mitigation measures that are available to the Project.

The Air Emissions Regulations including the Yukon Ambient Air Quality Standards drafted under Yukon's Environment Act do not appear to be applicable to a mine operation. The air quality standards that do apply for the mine site and Freegold Road Extension will be those identified in the Yukon *Occupational Health and Safety Act (2002)*.

A.8.4.3 Exceedances

A.8.4.3.1 R268

R268. The raster data generated from the CALPUFF model in a standard GIS format.

The raster data generated from the CALPUFF model are available in DXF or SHP files for GIS. Casino Mining Corporation is asking for further clarification as to why these files need to be provided for the purpose of a completeness determination as the data are already represented in a standard GIS image output format in Figures 8.4-1 to 8.4-28 of the Proposal.

A.8.4.3.2 R269

R269. A description of predicted exceedances including concentrations and predicted frequency.

The predicted air quality standard and guideline exceedances during construction are summarized in Table 8.4-3 of the Proposal, the concentrations are represented on Figure 8.4-1 to Figure 8.4-14 in Section 8 of the Proposal and the predicted frequency are identified in Table 8.4-9.

The predicted air quality standard and guideline exceedances during construction are summarized in Table 8.4-4 of the Proposal, the concentrations are represented on Figure 8.4-15 to Figure 8.4-28 in Section 8 of the Proposal and the predicted frequency are identified in Table 8.4-9.

In construction and operations, the predicted frequency in Table 8.4-9 are presented as ‘occurs occasionally or less than 1% of the time’ (infrequent) or ‘occurs regularly’ (frequent).

A.8.5 DUST AND DUSTFALL

A.8.5.1.1 R270

R270. Details on the compositions of dust generated by the mine and how this is expected to compare with the proposal’s baseline data.

The baseline dust levels are those that arise naturally from relatively undisturbed landforms. In the construction period the majority of dust will be generated directly by pioneering activities related to mine construction and subsequent aeolian transport of fine particles created as a result of these activities. In general, the chemical composition of the construction-related dust would likely resemble the baseline dust, as the majority of it would be sourced from the same surficial material, with the exception of the dust that is generated through combustion.

During operations, the majority of dust will be generated directly by consumption of LNG at the power plant and aeolian transport of fine particles created through processing such as tailings fines and cyclone sand fines. The chemical composition of the operational dust would be less likely to resemble the baseline dust, as the majority of it would be sourced from consumption of LNG at the power plant and material associated with the ore body that is extracted and processed.

A.8.5.1.2 R271

R271. Details on volumes of water required for dust management and clarification if this water was accounted for in overall water use requirements.

Water required for dust management has not been incorporated into the water balance model prepared for the mine. The volume required for dust suppression is negligible within the context of the mine site water balance. The dust suppression water requirement will be included in the total water requirement applied for under the water use licence under the *Waters Act* and will be sourced from either the fresh water storage pond or the Yukon River water pipeline.

A.8.6 AIR QUALITY MANAGEMENT PLAN

A.8.6.1.1 R272

R272. Update to Table 22.3-2 to include a conclusive list of proposed mitigation measures for potential project effects on air quality.

Table 22.3-2 is included in the Conceptual Environmental Management Plans (Section 22) of the Proposal. Being conceptual, the table presents a summary of the air quality related residual effects, including a summary of the proposed mitigation measures identified in Section 8 of the Proposal. For that reason, the reviewer can rely on Table 8.4-3 and Table 8.4-4 to present the conclusive lists of proposed mitigation measures for potential project effects on air quality, which will be incorporated into the Environmental Management Plans submitted for application for a Quartz Mine Licence and Type A Water Use Licence.