7.15 Effects of the Environment on the Project

7.15.1 Seismic Events

The Tintina Trench is a localized seismogenic zone. The design earthquake selected for the tailings dam corresponds to a return of 10,000 years.

7.15.2 Slides, Avalanches, Floods

The magnitudes of floods for specified return periods (ranging from 1 in 2-year to 1 in 1000-year events) have been identified for drainages of interest as noted in Section 7.4: Surface Water Hydrology. These events are assumed to be entirely from precipitation, whether rain, snowmelt, or a combination of the two. Rain-on-snow events will likely produce the largest floods. Larger floods than the forecast floods are possible, but would likely result from a combination of processes – for instance, a landslide or avalanche in the headwaters of Go Creek could create a temporary blockage of the creek, and the outburst flood created when the blockage failed could potentially be larger than the 1 in 10,000 year flood for upper Go Creek. As outlined in Section 2.8: Tailings Disposal, the design flood of 10,000-year return period is proposed for the tailings dam and closure spillway.

7.15.3 Extreme Weather Events

The magnitude of 1-hour and 24-hour expected rainfall and snowfall for various return periods up to 1 in 10,000 years, and the expected maximum winter snowpack for various return periods, have been estimated and are presented in Section 7.1: Climate. With respect to structures, acceptable risks have been designated based on human exposure, consequences of failure, and expected structure lifespan, and design events have been chosen based on the acceptable risks for the structures, as noted in Section 2.9: Site Water Management and Section 2.11: Transportation.

7.15.4 Forest Fire

Forest fires in the Yukon are typically caused by summer thunderstorms. Forest fires are common; approximately five years ago, a forest fire occurred in the Hawkowl Creek watershed along the proposed mine access road route. The magnitude of a forest fire and response to it will depend upon its location and wind direction. There are no fire fighting support facilities located near the project, but both the camp and industrial complex will be equipped with fire fighting equipment that will each be able to provide 340 m^3/h of firewater. As general site clearing for mine infrastructure along roads corridors, the airstrip, the industrial complex and camp has or will occur, fire fuel will be minimized in the immediate mine site area and the impact of a forest fire on the project is assumed to be controllable.

7.15.5 Climate Change

The climate is constantly changing. Some of these changes are of short-term duration (months to years), while others are long-term (years to decades). Some of these changes are seemingly random, while others are cyclical. However, a new type of change appears to be occurring now. It is long-term and uni-directional leading to a shift in the climatic means - Global Climate Change (GCC). This GCC is a long-term trend (decades to centuries) that, while it includes natural variations, has been triggered by human activity on Earth. The United Nations Intergovernmental Panel on Climate Change (IPCC) has concluded that the global atmosphere is warming, and that observed warming over the past 50 years can be attributed to human activities that release greenhouse gases into the atmosphere (IPCC 1996; 2001).

Climate in the Yukon has changed over the past 100 years, and it is projected to change over the next 100 years. In order to design infrastructure that must accommodate environmental factors such as precipitation and runoff, past climate patterns are normally used to predict future patterns. However it is now clear that the past climate trends will not necessarily predict future climate trends. It is thus important to consider climate change impacts on infrastructure projects.

Designs that do not account for potential changes in the climate may over- or underestimate the effects of climatic variables. The first step in a consideration of climate change is to consider what changes have occurred in the past, and the rate at which they have occurred. The second step is to consider past climate change, and use models to predict future climate change.

7.15.5.1 Observed Annual and Seasonal Temperature Trends

The IPCC has determined that average global temperature increased by 0.6ºC during the 20th century, and that the 1990s were the warmest decade in the last 1,000 years. Globally, the greatest warming occurred in the higher latitudes of the Northern Hemisphere.

Northwestern BC warmed at a rate equivalent to 1.7ºC per century, or about three times the global average (MWLAP 2002), and the Yukon has exhibited a clearly identifiable warming trend of 1.5^{o}C over the past 100 years (Ogden and Johnson 2002). Ogden and Johnson found that this warming has occurred mainly in winter and spring with a very weak trend in the summer and gradually decreasing temperatures in autumn.

Average annual temperature across northern BC and southern Yukon will continue to vary from year to year in response to natural cycles in air and ocean currents. Relatively warm years, however, will almost certainly increase in frequency (MWLAP 2002).

7.15.5.2 Observed Annual and Seasonal Precipitation Trends

The IPCC has concluded that regions of northwestern Canada experienced a gradual increase in annual precipitation of more than 20 percent from 1901 to 1995, or an increase of almost 2 percent per decade. They also found that precipitation is very likely to have increased by 0.5 to 1.0 percent per decade over most mid-latitudes (30ºN to 60ºN) of the continental Northern Hemisphere during the 20th century.

The data record for northern BC is incomplete or of insufficient length to determine whether or not precipitation in this region has changed. In the Yukon there has been a clear trend to increasing precipitation by decade (McCoy and Burn, 2001). McCoy and Burn found that over the past seventy years the proportion of annual precipitation falling as snow increased while the proportion falling as rain decreases.

7.15.5.3 Predicted Annual and Seasonal Temperature Trends.

The IPCC predicts the north will continue to warm at rates considerably greater than the global average. Climate models project that over the next century, temperatures could rise by 2 to 6°C in Yukon, with the most probable rise in the range of 3 to 5°C (IPCC 2001; CICS 2005). In BC, climate models predict warming at the rate of 1ºC to 4ºC per century (MWLAP 2002).

Projections from climate models consistently show increases in temperatures year-round for the Yukon over the next century. Winters are projected to warm more than summers, with winter warming being greater at higher latitudes. Also, because of the moderating effect of the Beaufort Sea, summers are projected to warm more in the south and central Yukon than in the North. (Ogden and Johnson 2002)

7.15.5.4 Predicted Annual and Seasonal Precipitation Trends

Global precipitation projections are considered to be more uncertain than for temperature change. Estimates vary widely, but all models suggest increased winter precipitation in northwestern North America, and most climate models forecast greater increases in precipitation with increasing latitude (WLAP 2001). For the southeast Yukon, models predict an increase of 15-20% in annual precipitation by 2080 (CICS 2005), which is consistent with the 2% per decade increase seen in the period 1901-1995. Predicted seasonal precipitation increases are as follows: winter-0-10%, spring 10-20%, summer 10-25% and fall 10-15%.

7.15.5.5 Effects of Climate Change on the Project

Applying the above broad climate trends to measured climate attributes provides an estimate of what climate may be like by 2100 at the project area. Estimates beyond 2100 are presently not realistic due to limitations of existing climate models.

As noted above, temperature is expected to increase by an average of 2-6°C over the next century, with the most probable temperature increase in the 3-5°C. This increase is seasonally dependent, with a greater increase in temperatures expected in winter and spring than in summer and fall. Precipitation is expected to increase by an increment of 0.25 to 0.75 mm/day over the next century. This is an average annual increase of 90 to 275 mm. Note that mean annual precipitation at the project site is presently approximately 550mm, or 1.5 mm/day, so the magnitude of the increase in precipitation over the next century is in the range 16% to 50%.

The effects of this precipitation increase can be understood by comparing them to the current range of natural variability at the site. If the increase in precipitation over the next century is at the lower end of the expected increase (0.25 mm/day), then in 100 years the average annual precipitation will be approximately 640mm, equal to the current 5-year wet year. If the increase in precipitation is at the upper (0.75mm/day) end of the expected range, then the average annual precipitation in 100 years will be 810mm, equivalent to the current 200-year wet year.

Over the 10 to 20 year active lifespan of the mine, the climate can be expected to change, but the magnitude change will likely be within the existing range of natural variability. Any change can be expected to manifest as a tendency towards the warmer and wetter portions of that natural variability range. Beyond the active lifespan of the mine, measurable change in temperature and precipitation, and thus hydrology, should be expected. Due to warmer temperatures, the snowpack will develop later in the season, but at the elevation of the minesite, the overall amount of snowfall will increase due to increased winter precipitation. However, warmer temperatures will also cause an earlier onset of spring melt.

The snow water equivalent of the snowpack will not increase to the same degree as the snowfall, because warmer temperatures mean that some of the extra snow that falls will melt rather than accumulate. Because of the earlier onset of melt and slight increase in snow water equivalent, summer baseflow should increase (due to the greater snowpack depth), and the peak flow of the snowmelt hydrograph should diminish (because the melt will begin earlier, and thus take place over a longer period). Evaporation will increase slightly as a result of the warmer winter and spring temperatures.

Overall summer precipitation is modeled to increase only slightly. However, it is expected that the magnitude and frequency of intense precipitation will increase. This means that for a given return period, the magnitude of the event will be larger than the event predicted from past climate data. Conversely, for a given magnitude, the return period will diminish. In other words, the 200-year storm will have a greater magnitude than is presently predicted, or more than one presently predicted “200 year” storm will occur per 200 years. Peak flow resulting from intense precipitation events will also increase. This effect will be somewhat further augmented by higher summer baseflow. However, the relative contribution of higher baseflow to the overall magnitude of the peak flows will be small for the project area, because base flow only contributes a small fraction of the volume of a peak flow. Influences of climate change have been incorporated into project design, specifically the tailings facility, through the incorporation of the 10,000- year flood event.