8. Climate Change and Sustainability Assessment

8.1 Introduction

This chapter addresses climate change and sustainability aspects of the Project.

It describes the historical and existing climate, extreme weather events and projected climate change for the Mt Todd project area, and aims to assess changes in projected climate patterns for the region over the proposed life of the mine. This information will be used to select climate parameters for the final design.

This chapter also identifies sustainability initiatives to facilitate reduced construction and operation costs, reduced costs associated with the environmental footprint and minimise potential adverse impacts associated with project development, operation and closure.

Detailed climate change and sustainability assessment is provided in Appendix G and H respectively. The potential impacts and associated mitigation measures identified in this chapter form the basis of the climate change and sustainability component of the project risk assessment undertaken in Chapter 5. The project risk assessment includes consequence, likelihood and residual risk ratings for impact after management measures are implemented.

8.2 Climate Change

8.2.1 Current and Historical Climate for the Mt Todd Region

Rainfall

Rainfall records in the vicinity of the Project were obtained at Katherine Aviation Museum, approximately 55km south-east of the Project where rainfall has been recorded since 1943. To date, the highest annual rainfall was measured in 1998 at 1772.5mm, and the lowest annual rainfall was measured in 1970 at 678.3mm. The average rainfall over this time is 1188.7mm (BOM 2012).

Temperature

The Mt Todd area experiences a tropical savannah climate with distinct Wet and Dry Seasons. Daily temperatures in the Dry Season typically range from 24°C - 36°C, occasionally reaching 39°C. Nights in the Dry Season can be quite cool with temperatures falling to 7°C. During the Wet Season, daily temperatures can range from 27°C - 42°C (BOM 2011).

Relative Humidity

High levels of humidity occur within the project area, with intensity reaching 80 - 100% between October and March. During this time, the region receives spectacular electrical storms along with vigorous lightning displays. Throughout the Dry Season (April – September), humidity levels can range from 50 - 70% (BOM 2011a).

Wind

A wind monitoring station is located at Royal Australian Air Force Tindal, approximately 20km south of the Project. Wind direction and speed are based on recordings made between 1985 and 2004.

At 9am, 30% of wind comes from the south-east, with 15% from the north-west. At 3pm, 32% comes from the east with 25% from the south-east. Wind speeds recorded at both times can reach 30km/h with an average speed of 10 to 20km/h (BOM 2011b).

Temperature Inversions

Temperature inversions are a common feature of the sub-tropical inner Northern Territory climate. Typically, inversions can be created due to the following conditions:

- during clear nights, the ground surface cools by radiating heat, and air in contact with it becomes cooler. The resulting cold dense air sinks and any wind is unable to mix the cold air with the warmer air overhead. The temperature inversion forms with conditions ideal for the formation of frost;
- air settling in the subtropical high pressure belts is compressed and warmed as it subsides. This often results in inversions. These inversions, typically 300 to 3000m above the surface, put a lid on convection and restrict cloud growth. Above the inversion, the air is warm and dry, which is a major reason for the arid weather of the subtropical high pressure belt; and
- after sunrise, radiation from the sun is absorbed by the ground material, but scarcely any is absorbed by the air. Conduction of heat from the ground warms the air in the lowest few centimetres, but not higher up, due to the poor conductive properties of air. If there is no wind this sets up a large vertical temperature difference in the lowest metre or so of the atmosphere.

Extreme Wind and Tropical Cyclones

The Mt Todd project area is susceptible to extreme weather events. Tropical cyclones occur over the Wet Season (October - April) due to low pressure systems forming offshore over warm tropical waters. As the cyclone system moves onshore, wind speeds can reach 270km/h within the storm centre. As a result, significant damage can be caused to property and vegetation caught in the path of such a weather event.

Floods

Some of the heaviest rainfall and worst flooding over northern Australia can occur when a tropical cyclone crosses the coast and moves inland. As the cyclones energy progressively weakens, an exceptional quantity of water will fall.

8.2.2 Methodology

This section discusses the methodology, modelling approach and future climatic predictions for the project area for 2030 and 2070. A climate change adaptation risk assessment was then conducted to assess how alterations to weather patterns have the potential to impact the Project.

Climate change projection data are sourced from those available in the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Australian Major Cities Summaries. The nearest major city to the site is Darwin. The climatic impacts in Darwin will differ slightly from those in the Mt Todd region and a review of historical meteorological data was undertaken to determine similarities or differences of significance.

An assessment of the regional variability of climate impacts was performed to identify a weather station meeting the following criteria:

1. Located near the project site.
2. Projected climate changes for the weather station are included in the CSIRO Technical Report (CSIRO 2007).
3. Representativeness of the selected weather station to the mine site.

Katherine Aviation Museum is the closest long-term weather station to Mt Todd and its climate data can be used for comparison and variability assessment. A comparison of the main climatic variables between Darwin and Katherine identified only minor differences (Table 1, Appendix G). The variation between these two sites is considered acceptable for this level of climate risk assessment.

In the study of climate change, emission projections and predicted climatic change are compared to a historical baseline. This historical baseline was obtained from publicly available data including:

- Bureau of Meteorology, Darwin Airport weather station (site number 014015) humidity record, based on the average at 9am and 3pm, years 1941 – 2012; and
- Bureau of Meteorology, Katherine Aviation Museum weather station (site number 014903) humidity record, based on the average at 9am and 3pm, years 1946 - 2011.

Projected climate conditions and scenarios were obtained from:

- Global Climate Models, consisting of an ensemble of 23 models expressing mathematically the known processes that dictate the behaviour of the atmosphere and the ocean (CSIRO 2007);
- CSIRO's Climate Change in Australia Technical Report 2007 (Appendix B City Summaries, Years 2030 and 2070, CSIRO 2007). CSIRO's projected climate changes for Darwin include:
  - annual mean temperature (^{o}C);
  - number of days at or above 35^{o}C;
  - tropical cyclones (frequency and intensity);
  - annual relative humidity (%);
  - annual rainfall (%);
  - annual potential evaporation (%);
  - annual wind speed (%); and
  - annual solar radiation (%).
- Intergovernmental Panel on Climate Change, Special Report on Emissions Scenarios that described a family of six greenhouse gas emission scenarios to condition global climate models (IPCC 2000).

The Mt Todd study used the A1B (medium) and A1FI (high) emissions scenarios for the target evaluation dates of 2030 and 2070 (IPCC 2000). This provides a mid-point scenario on a shorter time horizon and a more extreme scenario on a longer-term time horizon to accommodate an upper level of risk.

A1FI previously represented a worst-case scenario emissions projection. Recent observations of emissions make the A1FI scenario the most plausible compared to other scenarios, thus making this the 'business as usual' case (US Department of Energy, Oak Ridge National Laboratory 2012).

8.2.3 Climate Projections

Temperature

Generally, the annual average mean temperature in Darwin is expected to increase by 0.7^{o}C to 1.4^{o}C, and by 2.3°C to 4.4°C in 2070. The modelling suggests a small annual mean temperature increase would also apply for the Mt Todd region. In applying the projected increase in temperature, it is expected that the annual average mean temperature in the region will increase slightly by 2030 (Table 8-1).

Table 8-1 Projected Average Annual Mean Temperature Change

Emissions Scenario, Year	Katherine Baseline (°C)	Change from Baseline Temperature (°C)	Katherine Max Projected Mean Temperature (°C)
A1B, 2030	34	1.0 (0.7, 1.4)	35.0 (34.7, 35.4)
A1FI, 2070	34	3.2 (2.3, 4.4)	37.2 (36.3, 38.4)

*Values in brackets correspond with the 10th and 90th percentile results

Extreme Temperature

The CSIRO study estimates that the incidence of extreme temperatures (often taken to be above 35°C) will increase under both A1B and A1F1 scenarios (Table 8-2). However, without a specific analysis of modelled data for the Mt Todd region, the Darwin data is only presented as a reference because it would be inappropriate to treat this statistic in any site-relative sense. Under the A1B scenario, the frequency of temperatures >35°C in Darwin is projected to exceed 28 days by 2030 and to exceed 141 days under the A1F1 scenario for 2070.

Table 8-2 Projected Average Duration of Extreme Temperatures

Emissions Scenario, Year	Duration of T>35°C (days/year)
Baseline	151
Baseline Darwin	11
A1B, 2030 (Darwin)	28 (28, 69)
A1FI, 2070 (Darwin)	141 (141, 308)

*Values in brackets correspond with the 10th and 90th percentile results

Rainfall

The CSIRO study provides projected changes in annual mean precipitation (mm/yr) for the years 2030 and 2070. The projected changes were applied to the historical daily-sampled precipitation record recorded at Katherine (Table 8-3).

Table 8-3 Projected Average Annual Change in Mean Rainfall

Emissions Scenario, Year	Katherine Baseline (mm/yr)	Change from Baseline Rainfall (%)	Projected Average Annual Mean Rainfall (mm/yr)
A1B, 2030	1,143	0.0 (-7.0, -6.0)	1,143 (1,136, 1,137)
A1FI, 2070	1,143	-1.0 (-21.0, -20.0)	1,142 (1,122, 1,123)

*Values in brackets correspond with the 10th and 90th percentile results

Although the average annual mean figures are relatively constant over the 20 and 50-year return periods, there is a wide degree of variability between the 10th and 90th percentile results. This is an indication that there may be a greater occurrence of extreme dry and wet periods.

Notwithstanding the above projection for little change in future climates, rainfall statistics for the region indicate a period of increased rainfall since 1988 relative to the longer-term baseline annual mean (1941-2012). The shift in mean annual rainfall since 1988 at Darwin is of the order of 4% and at Katherine 3%.

These shifts are representative of the range of variability on inter-decadal timescales that can occur in such statistics and, in association with consideration of extreme rainfall events and the potential for increases in the likelihood of flash flooding, should form the basis of sensitivity analyses of the design for expanded mine operations.

Potential Evaporation

Annual potential evaporation changes were estimated by CSIRO for the years 2030 and 2070. Annual potential evaporation is projected to increase by 3% in 2030 and 10% in 2070 (Table 8-4).

Table 8-4 Projected Average Change in Potential Evaporation

Emissions Scenario, Year	Katherine Baseline (mm/yr)	% Change in Potential Evaporation	Projected Potential Evaporation (mm/yr)
A1B, 2030	2,400	3 (2, 5)	2,472
A1FI, 2070	2,400	10 (7, 15)	2,424

*Values in brackets correspond with the 10th and 90th percentile results

Wind Speed

The CSIRO study projected changes in annual average mean wind speed (m/s) for the years 2030 and 2070. The projected changes were applied to the historical daily wind speed record at Katherine (Table 8-5). The forecast change in wind speed is unlikely to provide any major impact to the Mt Todd site.

Table 8-5 Projected Annual Average Change in Mean Wind Speed

Emissions Scenario, Year	Katherine Baseline (km/h)	Change from Baseline Wind Speed (%)	Projected Average Annual Mean Wind Speed (km/h)
A1B, 2030	6.8	1.0 (-1.0, 2.0)	7.8 (5.5, 8.8)
A1FI, 2070	6.8	2.0 (-4.0, 7.0)	8.8 (2.8, 13.8)

*Values in brackets correspond with the 10th and 90th percentile results

Relative Humidity

Changes in annual relative humidity were projected by CSIRO for 2030 and 2070. The projected changes were applied to the historical daily humidity records for data recorded from at Katherine. Average humidity is projected to decrease by 0.5% by 2030 and 1.5% by 2070 (Table 8-6).

Table 8-6 Projected Annual Average Change in Relative Humidity

Emissions Scenario, Year	Katherine Baseline (%)	Change from Baseline Humidity (%)	Projected Average Annual Humidity (%)
A1B, 2030	52	-0.5 (-1.0, 0.0)	51.5 (53.0, 52.0)
A1FI, 2070	52	-1.5 (-3.2, 0.1)	50.5 (48.8, 52.1)

*Values in brackets correspond with the 10th and 90th percentile results

Solar Radiation

Changes in annual solar radiation were projected by CSIRO for 2030 and 2070. Average solar radiation is projected to stay the same by 2030 and increase by 0.1% by 2070 (Table 8-7).

Table 8-7 Projected Average Annual Change in Solar Radiation

Emissions Scenario, Year	Katherine Baseline (Kw/m^2)	% Change in Annual Solar Radiation
A1B, 2030	6.3	0.0 (-1.1, 1.3)
A1FI, 2070	6.3	0.1 (-3.6, 4.3)

*Values in brackets correspond with the 10th and 90th percentile results

Tropical Cyclones

The CSIRO study projected broad regional trends in tropical cyclone activity; it did not provide a pattern for the Darwin area specifically. For the Northern Territory, the study indicates that there is likely to be an increase in the proportion of the tropical cyclones in the more intense categories, but a possible decrease in the total number of cyclones. The study also found that the location of cyclones is not likely to change over time.

8.2.4 Potential Climate Change Impacts on the Project

Changes in climatic conditions and water availability over the design life have the potential to impact the Project's structures, processes, supply chain logistics and lifecycle maintenance costs. Structures and processes are influenced by ambient air temperatures, precipitation, wind speeds and water availability. In addition, maintaining water balance is essential for mining and ore processing activities, necessitating the provision of appropriate resources to cope with periodic drought and/or flood conditions.

Possible climate-related impacts on the Mt Todd system include:

- increased expansion and contraction of built structures from increased temperature variability;
- evaporation and / or extreme flood events may affect the efficiency of wetlands;
- capacity and efficiency of dams and ponds may be affected by high rates of evaporation and/or extreme flood events; and
- potential increased risk of flooding or inundation of pits / dams / retention ponds.

Potential climate risks and implications for the project site are summarised in Table 8-8.

Table 8-8 Summary of Potential Climate Risks and Implications for the Mt Todd Project

Climate Parameter	Project Components Most Likely Affected	Implications for the Site
Ambient air temperature	◗ Administration and plant site buildings ◗ Power and gas supply ◗ Critical structures	Increase in the number of extreme heat days may have a minor impact on the Project.
Extreme precipitation / flash floods / tropical cyclones	◗ Anaerobic treatment wetlands ◗ Clay borrow area ◗ Critical structures ◗ Decant and polishing ponds ◗ Low grade ore stockpiles ◗ Mine pit ◗ Raw water dam ◗ Retention ponds ◗ Roads ◗ Services ◗ Tailings storage facilities ◗ Waste rock dump ◗ Water treatment plant	The mean annual rainfall is not projected to change for the 2030 and 2070 scenarios. Precipitation extremes may increase, thus accentuating the risk of flash floods. The incidence of tropical cyclones will likely stay the same or decrease, however the intensity of cyclonic events may increase. The project catchment is characterised by perennial flows which recharge groundwater levels.

Climate Parameter	Project Components Most Likely Affected	Implications for the Site
Evaporation	◗ Anaerobic treatment wetlands ◗ Decant and polishing ponds ◗ Raw water dam ◗ Retention ponds ◗ Services ◗ Tailings storage facilities ◗ Water treatment plant	Projected changes in evaporation rates are not considered significant for the water requirements for the site. Therefore this risk is not considered significant.
Wind speed	◗ Administration and plant site buildings ◗ Critical structures ◗ Low grade ore stockpiles ◗ Roads ◗ Waste rock dump	Projected increase in mean wind speed is relatively insignificant and is thus unlikely to have any considerable impact on the Project.
Humidity	◗ Administration and plant site buildings ◗ Power and gas supply	Impacts of humidity changes are unlikely to have any significant impact on the project site.

8.2.5 Management Measures

Adaptive measures for facilities and infrastructure potentially impacted as a result of climate change are presented in Table 8-9. These measures have been incorporated as project commitments.

Table 8-9 Adaptive Management Options

Climate Parameter	Potential Adaptation Options
Ambient air temperature	◗ Consider appropriate temperature ranges in selection of plant and equipment. ◗ Undertake adequate preventative maintenance of plant, pumps, generators etc. as part of standard procedures. ◗ Monitor plant and equipment on days of extreme weather conditions. ◗ Appropriate design of structures and materials selection. ◗ Consider appropriate temperature suitability of stored chemicals and explosives.
Extreme precipitation / flash floods / tropical cyclones	◗ Ensure site drainage is sufficient to manage potential extremes in rainfall events. ◗ Appropriate bunding of watercourse redirection and overflow collection areas will be provided as appropriate / necessary. ◗ For recycled plant process water, ensure that the design considers both dry and wet periods. Provisions will be considered for adequate supply reserves. For example, tailings thickening agents may be considered during dry periods. ◗ Ponds will be sized appropriately including overflow capacity. ◗ Open pit slopes will be walled and designed to withstand appropriate flood volumes.
Extreme wet and dry periods and evaporation	◗ Increase height of the raw water dam to increase water availability and security

Based on the results of the study, special consideration will be given to the risks of flash flooding. In particular, the following aspects of the design will be reviewed:

- the design flood level criteria for the mine and design outcomes, especially with regard to roads, stockpiles, ponds, open pits, water treatment and storage facilities; and
- resilience of the overall site water balance to wet and dry periods.

8.3 Sustainability

8.3.1 Methodology

The methodology applied to undertake the sustainability assessment incorporated a detailed review of the following documents:

- Notice of Intent; and
- Project documents and technical studies provided by Vista Gold including the Pre-feasibility Study.

Key sustainability issues identified during the review process were evaluated and benchmarked against the following sources:

- the Australian Green Infrastructure Council (AGIC) tool was utilised as a reference and basis to align the sustainability initiatives;
- a Guide to Leading Practice Sustainable Development in Mining (DRET 2011);
- existing sustainability criteria and objectives (Corporate, Territory, Industry or Local);
- technical specialists (mine engineers with extensive operational experience) were consulted to review risks and relevance of sustainability initiatives and indicators; and
- Ecologically Sustainable Development in the Northern Territory.

8.3.2 Sustainability Principles

The International Council of Mining and Minerals (ICMM 2001) developed ten key principles of sustainability to measure performance. The ten principles generally align with the themes outlined in the AGIC rating tool, with the sustainability framework specific to the Project prepared on this basis.

1. Implement and maintain ethical business practices and sound systems of corporate governance.
2. Integrate sustainable development considerations within the corporate decision-making process.
3. Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by the activities.
4. Implement risk management strategies based on valid data and sound science.
5. Seek continual improvement in health and safety performance.
6. Seek continual improvement of environmental performance.
7. Contribute to conservation and biodiversity and integrated approaches to land use planning.
8. Facilitate and encourage responsible product design, use, re-use, recycling and disposal of products.
9. Contribute to the social, economic and institutional development of the communities in which we operate.
10. Implement effective and transparent engagement, communication and independently verified reporting arrangements with stakeholders.

8.3.3 Sustainability Hierarchy

To facilitate the implementation of sustainability into the Project (design and construction), a sustainability hierarchy was established. This includes identification of:

- sustainability initiative / principles;
- objectives;
- indicators / targets; and
- roles and responsibilities.

8.3.4 Management Measures: A Sustainability Framework

The sustainability framework presented in Table 8-10 outlines sustainability initiatives and associated indicators and targets in order to demonstrate how objectives are achieved. Suggested actions will be implemented where practicable. The project phase, during which each recommended respective initiative will be implemented, has been provided, as well as the party responsible for each initiative. Risks and associated mitigation measures dealt with in other chapters of the Draft EIS also contribute to the overall sustainability of the Project. For example, measures to reduce greenhouse gas emissions, effectively manage hazardous materials, minimise pollution, prevent harmful discharges to the environment, protect heritage values and improve community development all contribute to enhancing the social, economic and environmental performance of the Project.

Table 8-10 Sustainability Framework

Theme	Sustainability Initiative	Objective	Suggested Actions / Targets	Project Phase to be Implemented
Management	Environmental management	To adopt a formal environmental management system based on established guidelines.	◗ Implement a system to effectively monitor, measure and report on environmental management. This may include: – Key Result Areas; – Key Performance Indicators; and – An Environmental Management System (EMS). ◗ An environmental management monitoring and reporting schedule will be established, with reports made available to the project team through each project phase. ◗ Educate Vista Gold personnel and contractors and other individuals on-site to make them aware of EMS procedures and work within the system.	Design, Construction and Operation
	Purchase and procurement	To consider type, volume, sourcing and application of materials, services and resources to achieve sustainable outcomes.	◗ Where practicable incorporate sustainability criteria and requirements into tender documents such as material specifications (i.e. establish preferential priority to products which are locally sourced / contain recycled materials / are low in volatile organic compounds / etc.). ◗ Communicate procedures to ensure Contractors are aware of any requirements that have been incorporated into tender documents ◗ Review key contractors based on past performance and / or audit during contract delivery.	Design, Construction and Operation
	Project sustainability	To adopt and improve identified sustainability initiatives throughout the project life, including sustainability reporting and monitoring.	◗ Identify appropriate and achievable sustainability goals for the Project and reflect outcomes of subsequent monitoring and reporting annually.	Construction and Operation
Economic Performance	Economic life	To consider ongoing operational, maintenance, closure and replacement costs in the project design.	◗ Consider whole of life costing in the design. ◗ Consider resilience of equipment to reduce long –term costs. ◗ Undertake mine planning to achieve efficient recovery, processing and resource use.	Design
	Due diligence	To undertake a systematic approach to assessing risks and opportunities.	◗ Apply risk management systems to provide early identification and corrective action to avoid project / mine failure. ◗ Create a culture for site construction and operation of risk awareness and risk management.	Design, Construction and Operation