AIR QUALITY MANAGEMENT PLAN

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1. COMMITMENT AND POLICY

1.1 Purpose

ABM Resources NL (ABM) is committed to reducing its impact on the environment and ensuring a safe and healthy working environment for all personnel working at the Twin Bonanza mine site. This Air Quality Management Plan (AQMP) relates directly to Mineral Lease 29822.

The purpose of the AQMP is to provide an effective management system to identify and control potential air quality impacts and to reduce the dust impact generated from operations on ABM staff, external stakeholders and the environment. Additional receptors are limited as there are no settlements within 100km of the site, local populations of native flora and fauna, including bilbies, may be considered a receptor for the purposes of this document.

Emissions from the project are generated primarily from mining activities that result in the movement of waste rock and ore, and subsequent ore processing. The main particulate emission of concern is dust, and to a lesser extent, emissions associated with the vehicles, processing plant and power station operations.

The main impacts on air quality in regards to the Twin Bonanza mine site include:

1. impacts of dust from operations associated with mining
2. vehicle exhaust emissions
3. emissions from power station (gen sets)
4. emissions from processing plant
5. emissions and dust from blasting
6. odours from sewage and landfills

Potential impacts from particle emissions associated with the project are expected to be minimal based on the implementation of a number of mitigation measures, the remote location of the project and the absence of nearby residential facilities will limit any adverse impacts.

1.2 Scope

This AQMP has been created to assist in compliance with the *Work Health and Safety (NUL) Act* 2011 under Division 2 Primary Duty of Care and relevant regulations, and has been requested as part of the Environmental Impact Statement (EIS) by the Northern Territory Environmental Protection Authority (NT EPA). As part of this role the NT EPA is the administrating agency of the Northern Territory's *Waste Management and Pollution Control Act 2009* (the Act). Section 83 of the Act provides for general environmental offences, including that a person must not create an environmental nuisance. Section 4 of the Act defines environmental nuisance as:

An adverse effect on the amenity of an area that:

1. is caused by noise, smoke, dust, fumes or odour
2. unreasonably interferes with or is likely to unreasonably interfere with the enjoyment of the area by persons who occupy a place within the area or are otherwise lawfully in the area.

Additionally, relevant guidelines that ABM will align itself with are outlined below:

1. Leading Practice Sustainable Development (LPSD) - Airborne Contaminants, noise and vibration

2. International Erosion Control Associations (IECA) Best Practice Erosion and Sediment Control Guidelines (BPESC) (Books 1-6).

1.3 Climate

The Tanami region has a typical Northern Australian climate with most rainfall events occurring during a 'wet season' between November and April. The summers are hot with temperatures in excess of 40°C and winters are usually mild although nights are cold with occasional overnight minimum temperatures below 0°C. The closest weather station is located at Rabbit Flat, which is approximately 90km to the east of the Twin Bonanza project. Average annual maximum temperature is 33.6°C; average annual minimum temperature is 16.6°C. The dominant wind direction is from the east (Figure 1), the Wind rose in Figure 1 shows data from Rabbit Flat (Site No: 015666 • Opened Jun 1996 • Still Open • Latitude: -20.1824° • Longitude: 130.0148° • Elevation 340m). Rabbit Flat is the nearest weather station with most accurate weather observations for Twin Bonanza project average annual rainfall is 430.7mm (EcOz Environmental Services, 2012).

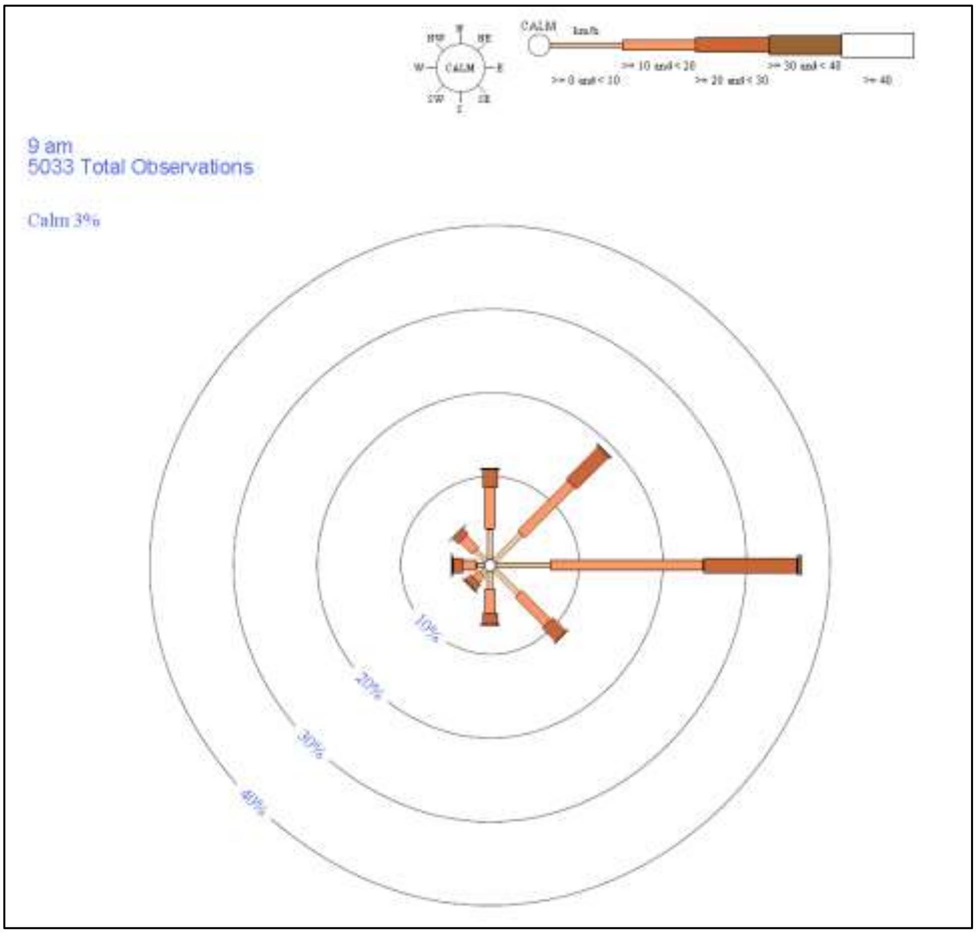

Figure 1. Speed Rose of wind direction versus wind speed in km/h (15 Nov 1996 to 30 Sep 2010) at Rabbit Flat. Rabbit Flat is the nearest weather station with most accurate weather observations for the Twin Bonanza project (National Climate Centre of the Bureau of Meteorology, 2012).

2. LEGISLATIVE & OTHER REQUIREMENTS

The activities of ABM are conducted in accordance with relevant legislation and requirements of statutory authorities.

The NT EPA has determined that the proposed development requires formal assessment under the *NT Environmental Assessment Act 1982*, at the level of an Environmental Impact Statement (EIS). The then Department of Sustainability, Environment, Water, Population and Communities (SEWPaC), under the *Environment Protection and Biodiversity Conservation Act 1999,* also requested the assessment on the basis of the proposed activities to be considered may have a significant impact on the matters pertaining to National Environmental Significance (NES).

As the Northern Territory does not have specific air quality legislation, other criteria have been used to determine the environmental goals of the project with regard to air quality. In selecting these, the following sources (listed in order of priority) have been used:

- National Environment Protection Council (NEPC) - *National Environment Protection Council Act 1994* (Clth)
- National Environment Protection Measure for Ambient Air Quality (the 'Air NEPM');
- New South Wales Department of Environment Climate Change and Water (NSW Department of Environment and Conservation 2005) has standards for dust deposition
- National Standards for Air Quality - Australian Government, Department of the Environment and Heritage, 2005
- Australian state legislation
- other international criteria

2.1 National Environment Protection Council

The NEPC comprises of environment ministers from the Australian Government and each state and territory. It was formed to take a cooperative approach to the management of environmental issues in Australia, established under the *National Environment Protection Council Act 1994* (Commonwealth) and corresponding legislation in the other jurisdictions.

The Air NEPM sets national standards for the six key air pollutants to which most Australians are exposed: carbon monoxide, ozone, sulfur dioxide, nitrogen dioxide, lead and particles.

The National Standards for Air Quality are set out below (Australian Government, Department of the Environment and Heritage, 2005);

Table 1. National standards for air quality.

POLLUTANT	CONCENTRATION AND AVERAGING PERIOD
Carbon monoxide	9.0 ppm (parts per million) measured over an eight hour period
Nitrogen dioxide	0.12 ppm averaged over a one hour period
	0.03 ppm averaged over a one year period
Ozone	0.10 ppm of ozone measured over a one hour period
	0.08 ppm of ozone measured over a four hour period
Sulfur dioxide	0.20 ppm averaged over a one hour period
	0.08 ppm averaged over a 24 hour period
	0.02 ppm averaged over a one year period
Lead	0.5 $\mu g/m^3$ (micrograms per cubic metre) averaged over a one year period
Particles as PM_{10}	50 $\mu g/m^3$ averaged over a 24-hour period
Particles as $PM_{2.5}$	Advisory reporting standard: 25 $\mu g/m^3$ over a one day period; 8 $\mu g/m^3$ over a one year period

The *National Greenhouse and Energy Reporting Act 2007* (Division 1 - Part 2 provides a greenhouse gas (GHG) emissions threshold that regulates the corporate responsibility in terms of reporting of GHG for inclusion in the National Greenhouse Gas Account (NGA). The Act specifies that any corporation, which generates more than 50 kilotonnes of GHG as a group has to provide annual report of the emissions to the NGA.

Standards of dust deposition and generation are not specified in the NEPM, however the NSW Department of Environment and Conservation has legislated standards for dust deposition; these have been adopted for the purposes of dust monitoring and mitigation. A value of 4g grams/m_2/month equates to a visible dust layer on outdoor furniture or vegetation. The standard is detailed below.

Table 2. NSW Department of Environment and Conservation 2005 standards for dust deposition

INDICATOR	ENVIRONMENTAL VALUE	OBJECTIVE	PERIOD
Dust Deposition	Nuisance	4 grams/m2/month	Monthly (total)
	Nuisance	2 grams/m2/month	Monthly (increase)

2.2 Consultation

ABM will consult with employees, contractors, and regulatory authorities when a decision is to be made that may affect air quality management at the Twin Bonanza mine site and accommodation facilities. Examples of situations requiring consultation include, but are not limited to:

- changes to surface work environments, work methods, work systems, or equipment which may alter air quality impacts
- a Job Safety Analysis (JSA) is undertaken for a new task
- undertaking, or reviewing risk assessments and implementing controls
- investigating incidents and complaints.

2.3 Employees and contractors

Consultation with employees and contractors under the AQMP may be through the following methods

- reviews of this management plan
- safety and toolbox meetings
- risk Assessments
- incident / accident Investigations

2.4 Regulatory authorities

ABM will communicate on relevant air quality management aspects of the mine's operation within the Mining Management Plan pursuant under section 40 of the *Mining Management Act* 2001 and if required under the EIS assessment.

3. RISK ASSESSMENT

The Twin Bonanza mine site is located in the Tanami Desert. Land within the project area is on Sboriginal freehold land that is used by the Traditional Owners, for traditional purposes. The nearest Traditional Owner's settlement, Balgo, is 120km to the west of the project area. The site is located approximately 625 km north-west of Alice Springs and 267 km south-east of Halls Creek. It is accessed via the Tanami Road from Alice Springs or Halls Creek. An air quality risk assessment has been conducted and the results are outlined below. This risk assessment identified the risks associated with the different aspects of the mine with regards to dust, greenhouse gas emissions and odours impacting on the workforce, flora and fauna.

3.1 Existing air quality

To date no baseline air quality data has been collected for the Twin Bonanza. The ambient air quality surrounding the site will be a function of bushfires and vehicle activity along gravel roads. During the 2014 dry season, a baseline dust study will be completed details of which will in reported in the Mine Management Plan.

3.1.1 Dust

Depositional dust can be generated through the operation of the mine site. Dust can be generated from:

- disturbance of vegetation and topsoil
- areas cleared of vegetation, exacerbating natural erosion
- during construction activities
- drilling and blasting programmes
- excavation and movement of topsoil, waste rock and ore
- vehicle movements along unsealed access and haul roads
- ore processing and movements of mobile equipment in the process area
- closure and rehabilitation activities including contouring of landforms and ripping

Dust emissions from the processing plant will be limited to the stockpiling of ore on the Run of Mine (ROM) pad and loading of the plant as the remainder of the process requires the input of water thus preventing dust.

During dryer periods potential exists for tailings dust to be generated from the tailings dam facility.

3.1.2 Greenhouse gases

Emissions of GHG from the proposed project will be generated primarily from electricity generation and fuel use. In accordance with the *National Greenhouse and Energy Reporting Act 2007* the following greenhouse gases are predicted to be the most prominent:

1. Carbon dioxide (CO2)
2. Methane (CH4)
3. Nitrous Oxide (N2O).
4. Sulfur dioxide (SO_2)

An assessment of the expected GHG emissions from the Twin Bonanza project was undertaken as a requirement of the EIS under the *Environmental Assessment Act* and in-conjunction with the AQMP. Refer to Appendix A for details of the assessment.

Estimates of emissions from the combustion of individual fuel types were performed for each relevant greenhouse gas (in this case, carbon dioxide, methane and nitrous oxide); and separate calculations were carried out for each fuel type and each piece of machinery.

Emissions estimations were then summarised into each of the 5 components of the mine site:

1. construction
2. mine camp operations
3. mine
4. processing plant and ROM pad
5. employee transport
6. vegetation clearing

As the nearest residence is over 100km away, the scale of activity is small creating low levels of emissions further investigations will not occur as the impact is deemed to be low. In addition, during operations no monitoring will be undertaken.

3.1.3 Odours

Potential sources of nuisance odours at the project are the refuelling areas, landfill, sewage system and the concentrated leach. As the facilities that have the potential to produce nuisance odours will be located away from accommodation areas and the concentrated leach area will be fully enclosed the potential nuisance odour risk to onsite receptors is deemed to be low. Based on the low risk no further odorous emissions investigations and monitoring will be implemented.

3.2 Sensitive receptors

There are no communities within 100 km of the Twin Bonanza mine site; therefore sensitive receptors are staff, contractors and visitors to the site as well as local flora and fauna. ABM respects the traditional land use practices of the Aboriginal landowners and through this management plan will aim to reduce the effect that dust, emissions have on their land and odours may have on their activities

Excessive dust will also affect the local vegetation which can ultimately lead to smothering and plant deaths, increasing erosion and decreasing biodiversity in the area. This can have a direct and indirect effect on sensitive fauna which includes the local bilby and mulgara populations which are located adjacent to the mine site within the mineral lease.

The mine site accommodation will be located on the edge of the mine lease. The accommodation is one kilometre away from the processing plant and therefore will be sufficiently distanced from any potential air quality disturbance. The power plant will be located at least 500m from the accommodation and one kilometre from the bilbies, within the northern bounds of the processing plant.

4. RISK MANAGEMENT - OPERATIONAL MANAGEMENT AND MITIGATION

As discussed above, ABM's environmental manager will conduct a baseline dust study during the 2014 dry season and implement ongoing monitoring of air quality in respect to dust. This monitoring will aid in ongoing assessment of air quality around the site. Additionally, complaints regarding air quality will be investigated and action taken if required.

Some of the management and mitigation strategies and measures that will be implemented at the Twin Bonanza mine and accommodation camp to reduce dust, greenhouse gas emissions and odour impacts from operations on staff and fauna are discussed below.

4.1 General operations

While there are emissions from the power station and mine vehicles, there are no other industrial or urban developments in the vicinity of the mine and therefore, background concentrations of pollutants such as CO_2, $CH_{4,}$ N_2O, and SO_2 will remain relatively low in comparison to industrialised areas.

To reduce greenhouse gases staff and contractors will:

- maintain equipment including tyres to maximise efficiency and prevent incomplete combustion of hydrocarbons
- source and procure machinery with high fuel efficiencies and combustion technologies including catalytic convertors when practicable
- investigate alternative energy sources (i.e. solar power) where applicable
- purchase fuel produces with a low sulfur content if practicable.

If employees and contractors are working in confined spaces or are undertaking tasks that may generate localised dust, breathing protection equipment will be provided and is to be worn by all personnel while completing the task or within breathing protection areas. Appropriate signage under the Australian Standards will designate these protection areas.

Odour will be mitigated by:

- managing chemicals and hydrocarbons appropriately under the standard AS1940-2004 - The storage and handling of flammable and combustible liquids
- containing putrescible waste and disposing of it in accordance to on site waste management procedures that includes incineration and/or disposal in a landfill
- treating sewage via onsite septic and waste water disposal systems
- ensuring the concentrate leach system is closed to prevent the release of cyanide gases into the environment.

4.2 Dust generation

It is expected that the dust levels at the site will be low to moderate with the exception of during windy dry periods. ABM proposes to mitigate and manage dust generation through the strategies outlined below.

- A conservative and a progressive approach to vegetation clearances will be followed, ensuring a minimum area is clear at any one time and the majority of the area is still vegetated and undistributed.
- Topsoil will be removed during periods when soil moisture and wind conditions limit dust generation where practical.
- Dust generation will be mitigated by regular applications of water by a water cart along haul roads and cleared areas to reduce dust from mine traffic and wind.
- The use of a dust suppressant will be investigated to reduce the water consumption while maintaining dust suppression.
- Dust from blasting will be managed by blasting personnel to ensure fine material produced by drilling is used to stem blast holes and adequate stemming will be used at all times.
- A vegetative cover will be established by progressively ripping and rehabilitating areas no longer required.
- Vehicle speeds will be limited around site.

5. RISK MANAGEMENT – Biodiversity & native fauna

There are no government policies or widely accepted guidelines with regard to air quality criteria for animals; however the effect of air quality on wildlife can be similar to the effects observed in humans. Air quality, particularly dust, can adversely affect wildlife by interfering with communication, breeding activities, cause stress or avoidance reactions and (in the extreme) result in temporary or permanent habitat damage. The implementation of the measures detailed in 5.1 and 5.2 will also manage air quality with respect to biodiversity and native fauna.

6. MONITORING

The following is the planned monitoring to be conducted under this AQMP.

6.1 Dust monitoring

Dust monitoring at the Twin Bonanza mine site and accommodation facilities will comprise dust deposition monitoring points and daily visual monitoring. Dust deposition levels are to be monitored using six dust monitoring sites. Strategically positioned dust gauges mounted on stands will be established based on the prevailing wind with a focus on the processing plant, waste dump, tailings dam, proximal to the main haul road and near the accommodation complex. Deposition dust monitors provide details of dust deposition within a defined time period but cannot be correlated to specific dust events or sources. To be able to monitor dust on a daily basis managers within the process, accommodation and mining area, will observe current dust conditions. Depending on conditions this will facilitate management measures for example, more frequent water application via a water cart.

Dust deposition limits are not specified in the Northern Territory or in the NEPM. For the purposes of the EIS ABM has adopted the NSW Department of Environment and Conservation legislated standards for dust deposition for dust monitoring and mitigation.

Nuisance dust levels are defined as a total of 4 grams/m2/month, and monitoring is recommended over the space of a month. Also an increase of 2 grams/m2/month can be considered a nuisance.

The dust collected in the gauges will in accordance to standard AS/NZS 3580 tested for insoluble solids and ash content. The results of the monitoring program will be used to provide an indication of the effectiveness of the dust control measures being implemented at the mine site. Where the dust limit is exceeded targeted dust management actions are to be implemented.

6.2 Monitoring protocols and compliance

6.2.1 Non-compliances

The project can be considered in non-compliance if dust deposition, is above the specifications outlined in section 3.1. This may occur for two reasons:

1. The dust from machinery is excessive, in which case ABM would not be meeting its commitments.
2. The dust was increased by extreme, non-standard weather effects.

In the case of the latter, further monitoring at a later date is required to determine compliance under "normal" meteorological conditions.

6.2.2 Community / social monitoring

ABM will also monitor its operations by recording and trending complaints over time by entering these in the complaints register and reviewing the nature of complaints on an annual basis. This will assist in determining the environmental aspects of the complaint and requirement for additional controls or management strategies to limit the air quality impacts.

6.3 Record keeping

6.3.1 Dust monitoring

Monitoring results will be kept within ABM's data management system to assist in monitoring compliance with this management plan.

7. INFORMATION & COMMUNICATION

7.1 Internal information and communication

Key avenues for internal communication on environment and community aspects /concerns of operations will be maintained mainly through meetings. Additionally, ABM will implement the following methods of communication with the workforce and employees.

7.1.1 Accident / incident report

In the event monitoring detects deterioration in air quality conditions or an air quality complaint, ABM personnel including contractors are to attempt to stop the source, or control the source of the dust. If they can't control the incident then they are to report the incident to their supervisor and / or the environmental manager or delegated representative.

A record is to be taken as per the "Environmental Incident Report". The environmental manager is to be notified of the incident as soon as possible to assist in determining actions and to inform the mine manager of the environmental incident.

Incidents which may occur that relate to the AQMP include:

- air quality complaints & enquiries
- deterioration of air quality conditions.

7.2 External information and communication

7.2.1 Government departments

ABM will report the monitoring results in the within the Mining Management Plan pursuant under section 40 of the *Mining Management Act* 2001. If the project exceeds substance emission limits as defined by categories 1, 1a, 1b, 2a, 2b or 3 of the National Pollutant Inventory as administered by the Commonwealth Department of Environment, then ABM will report as required. NT WorkSafe (if health and safety related) and the NT EPA will be notified if air quality results in an onsite incident. Reporting will be as soon as practicable after the incident. Workplace Health and Safety NT require an incident notification form to be emailed or faxed as soon as possible.

Contact details for both organisations as follows:

Workplace Health and Safety NT
Fax: 8999 5141
Telephone: 1800 019 115
Incident Notification form: http://www.worksafe.nt.gov.au/Forms/Notifications/FM137.pdf
Email: ntworksafe@nt.gov.au

Environmental Operations
NT Environment Protection Authority
GPO Box 3675
Darwin NT 0801
Email: Environmentops.@nt.gov.au

7.2.2 Community complaints and enquiries

ABM will respond to any community inquiries or complaints received as described in the ABM Incident Report and further management actions will be taken if required.

7.2.3 Responsibilities

The AQMP will be implemented by the ABM environmental manager with the assistance of ABM staff and qualified contractors. It is the responsibility of the ABM environmental manager to maintain, audit and review the monitoring program.

8. AUDIT

The objectives of an audit are to maintain compliance with the AQMP.

8.1 Internal Audits

Internal audits of the ABM AQMP will be conducted annually or as new machinery with potential to exceed allowed air quality levels are introduced to the mine site or accommodation area.

8.2 External Audits

Independent audits of the AQMP shall be conducted as requested by government regulators.

9. REVIEW

Revisions are to be coordinated by the site environmental manager or as directed by the managing director. The objectives of a review are to:

- maintain compliance
- identify opportunities for improvement in the AQMP
- consider community and employee feedback on the AQMP.

10. REFERENCES

Australian Government, Department of the Environment and Heritage 2005 *National standards for criteria air pollutants in Australia. Air quality fact sheet.* Available from: <http://www.environment.gov.au/atmosphere/airquality/publications/standards.html>**.** [20 August 2013].

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NSW Department of Environment and Conservation 2005, Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. Available from: <http://www.environment.nsw.gov.au/resources/air/ammodelling05361.pdf>. [20 August 2013].

10.1.1 Legislation

- *Work Health and Safety (NUL) Act 2011* (NT) under Division 2 Primary Duty of Care
- *Waste Management and Pollution Control Act 1998* (NT)

10.1.2 Codes of practice and guidance material

- Leading Practice Sustainable Development (LPSD) - Airborne Contaminants, noise and vibration
- Leading Practice Sustainable Development (LPSD) - Biodiversity Management
- International Erosion Control Associations (IECA) Best Practice Erosion and Sediment Control Guidelines (BPESC) (Books 1-6).

11. CONTROL AND REVISION HISTORY

11.1 Document information

PROPERTY	VALUE
Approved by	General Manager
Document Owner	Environmental Manager
Effective Date	11/10/2013
Keywords	See definitions

11.2 Revisions

VERSION	DATE REVIEWED	REVIEW	NATURE OF THE AMENDMENT
1	08/08/13	Rebecca Richards	Initial Issue
2	10/10/13	Justin Robins	Review
3			
4			

11.3 Read by

	NAME	DATE	SIGNED
1	R. Richards	08/08/2013	
2			
3			
4			

APPENDIX A – Memo: Greenhouse gas emissions estimations for Twin Bonanza project 1.

MEMORANDUM

Date: 01/10/2013

Author: Rebecca Richards

TITLE: Greenhouse gas emissions estimations for Twin Bonanza project 1

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1. INTRODUCTION

An assessment of the predicted greenhouse gas (GHG) emissions from the Twin Bonanza project was undertaken as a requirement of the Environmental Impact Statement (EIS) under the *Environmental Assessment Act,* and in-conjunction with the Air Quality Management Plan (AQMP).

This GHG emissions estimation relates directly to Mineral Lease 29822, and the proposed Twin Bonanza 1 project (the project).

Emissions from the project are generated primarily from mining activities that result in the movement of waste rock and ore, and subsequent ore processing. The main particulate emission of concern is dust, and to a lesser extent, emissions associated with the vehicles, processing plant and power station operations. Dust will not be addressed in this memo.

2. AIM / OBJECTIVES

The aim of emissions modelling is to model the emissions from predicted sources on the mine site, these sources include:

1. vehicle exhaust emissions
2. emissions from power station (gen sets)
3. emissions from processing plant
4. emissions from infrastructure
5. emissions from clearing of vegetation and vegetation decay

The principle GHG generated by the combustion of fossil fuels for energy is carbon dioxide. The quantity of gas produced depends on the carbon content of the fuel and the degree to which the fuel is fully combusted (Department of Climate Change and Energy Efficiency 2012a); the oxidation factor generally ranges from 98% and 99.5%. Small quantities of methane and nitrous oxide are also produced, depending on the actual combustion conditions.

Primary fuel sources on site include:

1. ultra low sulfur diesel
2. aviation fuel (Avgas)

Legislation

The *National Greenhouse and Energy Reporting Act 2007* (Division 1 - Part 2) provides a GHG emissions threshold that regulates the corporate responsibility in terms of reporting of GHG for inclusion in the National Greenhouse Gas Account (NGA).

The Act specifies that any corporation which generates more than 50 kilotonnes of GHG as a group has to provide an annual report of the emissions to the NGA.

3. METHODOLOGY

Estimates of emissions from the combustion of individual fuel types were performed for each relevant GHG (in this case, carbon dioxide, methane and nitrous oxide). Refer to sections 3.1 and 3.2. Separate calculations were carried out for each fuel type and each piece of machinery.

Emissions estimations were then summarised into each of the 6 components of the mine site:

1. construction
2. mine camp operations
3. mine
4. processing plant and ROM pad
5. employee transport
6. vegetation clearing

Annual emissions results were then multiplied by 3 (years) to account for the projected span of the project life.

3.1 Vehicle and machinery emissions

The following methodology was used.

<u>Establishing inventory of emission sources</u>

1. All potential emission sources and relevant fuels were tabulated (Table 1). Fuel Consumption per hour was estimated based on Vehicle / Machinery performance manuals (Caterpillar Inc. 2012; Caterpillar Inc. 1998; Komatsu Ltd. 2009; Handel Aviation 2008)(Table 2).

2. Operating hours were estimated based on projected duration of machinery operation per year (Table 2).

Table 3. Summary of Emission sources for the Twin Bonanza Project.

MINE SITE COMPONENT	EMISSION SOURCE	DETAILS	QUANTITY	FUEL TYPE
Construction	Dozer	Caterpillar D9T Dozer	1	Diesel
	Excavator	Komatsu PC1800 Excavator - Fuel Consumption estimated based on Komatsu PC2000-8 Hydraulic Excavator	1	Diesel
	Water cart	Caterpillar 8 wheel water cart - Fuel Consumption estimated based on CAT 777D Flat floor haul truck.	1	Diesel
	Light vehicles	Toyota Landcruiser	2	Diesel
	Compaction rollers	Fuel consumption estimated based on Caterpillar CB434D XW (double drum).	1	Diesel
	Haul trucks	Komatsu haulage dump truck HD785-5	1	Diesel
	Front end loaders	Fuel consumption estimated based on CAT 990 Series II	1	Diesel
Mine camp operations / power generation	Power (including camp, RO plant, processing plant, office and workshop, ancillary equipment (i.e. 5 x lighting plants).	(4 x 1MWA Diesel gensets - two full time, one half time, one for servicing and breakdowns).	4	Diesel
	Generator - Wilsons Bore	30 kVA Genset - powers bore pump	1	Diesel
	Generator - Corsair Bore	28 kVA Genset - powers bore pump	1	Diesel
Mine	Excavators	Hitachi EX1200-6	2.00	Diesel
	Haul trucks	Hitachi B50D	4.00	Diesel
	Dozer	Caterpillar D9T Dozer	1.00	Diesel
	Grader	Caterpillar 14H Grader	1.00	Diesel
	Water cart	Fuel consumption estimated based on Hitachi B50D	1.00	Diesel
	Drill rig	PowerROC T30: Tophammer drill rig	1.00	Diesel
	Service truck	Toyota service truck - Fuel consumption estimated based on Toyota Landcruiser	1.00	Diesel
	Light vehicles	Toyota Landcruiser	8.00	Diesel
	Front end loaders	Fuel consumption estimated based on CAT 990 Series II	1.00	Diesel
Processing plant & ROM pad	Loader	estimated based on CAT 938H Medium wheel loader	1	Diesel
Employee transport	Aircraft	Metro	1	AvGas
	Bus	Toyota coaster bus (21 seats)	1	Diesel

Table 4. Summary of fuel consumption and duration Twin Bonanza Project.

MINE SITE COMPONENT	EMISSION SOURCE	QUANTITY	FUEL TYPE	FUEL CONSUMPTION PER UNIT (L/HR)	DURATION TOTAL (HR/YEAR)	CONSUMPTION TOTAL (KL/YEAR)
Construction	Dozer	1	Diesel	53.70	600	32.22
	Excavator	1	Diesel	79.50	600	47.70
	Water cart	1	Diesel	53.00	600	31.80
	Light vehicles	2	Diesel	10.30	1200	12.36
	Compaction rollers	1	Diesel	11.40	600	6.84
	Haul trucks	1	Diesel	78.90	600	47.34
	Front end loaders	1	Diesel	18.00	600	10.80
Mine camp operations / power generation	Power	4	Diesel	183.33	26280.00	1606.00
	Generator - Wilsons Bore	1	Diesel	4.17	4380.00	18.25
	Generator - Corsair Bore	1	Diesel	3.33	4380.00	14.59
Mine	Excavators	2	Diesel	79.50	11680.00	928.56
	Haul trucks	4	Diesel	26.00	23360.00	607.36
	Dozer	1	Diesel	53.70	876.00	47.04
	Grader	1	Diesel	28.00	876.00	24.53
	Water cart	1	Diesel	26.00	2920.00	75.92
	Drill rig	1	Diesel	25.00	2920.00	73.00
	Service truck	1	Diesel	10.30	1752	18.05
	Light vehicles	8	Diesel	10.30	7008	72.18
	Front end loaders	1	Diesel	18.00	2920	52.56
Processing plant & ROM pad	Loader	1	Diesel	15.00	6424	96.36
Employee transport	Aircraft - metro	1	AvGas	414.2	439.4	182.00
	Bus	1	Diesel	12.00	584	7.01

<u>Assessment of energy emissions</u>

The NGA factors (Department of Climate Change and Energy Efficiency 2012a) were then used to estimate the CO_2 annual emissions (CO_2-eTonnes) for each emission source, energy content factor (GJ/t) and emission factors (kg CO_2-e/GJ) for CO_2, CH_4 and N_2O (Table 3).

Emission factors vary for stationary energy emissions and transport energy, as fuels used for transport purposes produce slightly different methane and nitrous oxide emissions than if the same fuels were used for stationary energy purposes (Table 3). The emission factors for transport purposes only apply to those vehicles that are registered for road use (in line with NGA recommendations) all other vehicles apply stationary energy factors for individual fuel types). The relative global warming potential of the GHGs is considered by expressing the factors as a carbon dioxide equivalent (CO_2-e).

Table 5. Fuel combustion emission factors - liquid fuels and certain petroleum based products for stationary energy purposes. Source: National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Schedule 1). Notes: All emission factors incorporate relevant oxidation factors (sourced from the DCCEE's National Inventory Report).

FUEL TYPE	EMISSION SOURCE	ENERGY CONTENT (GJ/KL)	EMISSION FACTOR KG CO2-E/GJ (RELEVANT OXIDATION FACTORS INCORPORATED)			EQUIPMENT TYPE
			CO_2	CH_4	N_2O	
Diesel	Stationary	38.60	69.20	0.1	0.2	All heavy vehicles, power generators and stationary plant equipment
Diesel	Transport	38.60	69.20	0.2	0.5	Light vehicles only, including service truck and Bus
AvGas	Transport	33.10	66.30	0.04	0.7	Aircraft

The following formula (Department of Climate Change and Energy Efficiency 2012a) was used to estimate GHG emissions from the stationary combustion of each type of liquid fuel listed in Table 3.

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1\,000}$$

where:

Eij is the emissions of gas type (j), (carbon dioxide, methane or nitrous oxide, from fuel type (i) (CO_2-e tonnes)

Qi is the quantity of fuel type (i) (kilolitres) combusted for stationary energy purposes

ECi is the energy content factor of fuel type (i) (gigajoules per kilolitre) for stationary energy purposes

If ***Qi*** is measured in gigajoules, then ***ECi*** is 1.

EFijoxec is the emission factor for each gas type (j) (which includes the effect of an oxidation factor) for fuel type (i) (kilograms CO_2-e per gigajoule)

The following formula was used to estimate GHG emissions (Department of Climate Change and Energy Efficiency 2012a) from the combustion of each type of fuel listed in Table 3 used for transport energy purposes.

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1\,000}$$

where:

Eij is the emissions of gas type (j), carbon dioxide, methane or nitrous oxide, from fuel type (i) (CO2-e tonnes)

Qi is the quantity of fuel type (i) (kilolitres or gigajoules) combusted for transport energy purposes

ECi is the energy content factor of fuel type (i) (gigajoules per kilolitre or per cubic metre) used for transport energy purposes — see Table 3

If ***Qi*** is measured in gigajoules, then ***ECi*** is 1

EFijoxec is the emission factor for each gas type (j) (which includes the effect of an oxidation factor) for fuel type (i) (kilograms CO_2-e per gigajoule) used for transport energy purposes — see Table 3

3.2 Vegetation emissions

The calculation of the GHG emissions from the vegetation due to land clearing was conducted with the Full Carbon Accounting Model (FullCAM). The FullCAM program (Department of Climate Change and Energy Efficiency 2012d) is the model used to construct Australia's national GHG emissions account for the land sector.

FullCAM deals with both the biological and management processes which affect carbon pools and the transfers between pools in forest and agricultural systems. The exchanges of carbon, loss and uptake between the terrestrial biological system and the atmosphere are accounted for in the full/closed cycle mass balance model which includes all biomass, litter and soil pools.

The removal of vegetation via land clearing for the purposes of mining will contribute carbon dioxide and other GHGs to the atmosphere. Once rehabilitation commences post mining, the regeneration of vegetation over these areas will provide an important carbon sink, reversing the process and providing removal of carbon dioxide from the atmosphere.

The following assumptions have been made:

1. The removal of vegetation will be complete and maintained over the course of the 3 year mine life.
2. The cleared area will be 300 ha (current figure is conservatively overestimated).
3. The re-vegetation will be fully completed post mining, reversing the initial vegetation clearance; however reestablishment of the vegetation will take longer than the initial clearing and will vary depending on the mine use and post mining landform.

Simulating GHG emissions using the FullCAM model

The Australian Government Department of Climate Change's National Carbon Accounting System (NCAS) FullCAM tool was used to estimate GHG emissions from land clearing at the Twin Bonanza Project.

FullCAM is a carbon ecosystem model that calculates GHG emissions and removals in both forest and agricultural lands using a mass balance approach to carbon cycling. As the most significant emissions and removals of GHGs in the land sector occur with transitions between forest and agricultural land use, the model fully integrates agricultural and forestry modelling.

A single layer forestry plot was used, for the purposes of the deforestation at the Twin Bonanza site as the vegetation on site is predominately native and not agricultural. The co-ordinates for site, -20.114 26 degrees N and 129.937 26 degrees East, were input and data, including soil type, vegetation characteristics and mass for that specific area, were downloaded from the DCC server computer.

The initial tree species specified was "Acacia open woodland", the most representative category relevant to the vegetation at Twin Bonanza. No further species were selected and modelled.

ABM specified the cleared area (modelled plot area) to be 300 ha and masses are measured in tonnes per hectare so results are presented as mass per unit area.

Events were input to simulate the range of activities proposed to be undertaken at Twin Bonanza during the life of the mine (Table 4). Initial vegetation clearance was assumed to start during April 2014, with annual maintenance through windrow clearing and assumed burning as the result of bushfires (10 % of the cleared area and only if necessary) assumed to occur annually every June thereafter.

Table 6. Simulated events input for the FullCAM model at Twin Bonanza.

EVENT	DATE	% FOREST AFFECTED
Native vegetation	2014 / 01	
Clearing	2014/04	100 – assumes no regrowth (days 20)
Windrows burnt / firebreaks	2014 / 07 2015 / 07 2016 / 07	10% area, 90 leaf regrowth (10 days)
Rehabilitation	2017 /09	
Native vegetation	2017 / 09	

Revegetation was not modelled in the FullCAM programme as it is difficult to predict how long the vegetation will take to regenerate back to its original state; however research on carbon sequestration within rehabilitated landscapes has highlighted that rehabilitation reverses the carbon loss by sequestering carbon through vegetation regrowth back towards original levels (Su et al 2010, West & Mohan 2002). The tailings dams and other artificial landforms will revegetate back to their original state more slowly.

Historical rehabilitation (ripping and natural re-seeding) of drill pads and tracks from exploration activities at the Twin Bonanza project have proven that the native woodlands and grasses establish a good ground cover within a year and in less than 4 years the original disturbance is no longer noticeable as having been significantly disturbed (Figure 1). Fully established trees will take longer, however there are limited numbers of trees that will be disturbed in the clearing process.

Figure 2. Rehabilitated Drill Holes at Twin Bonanza with well established vegetation.

4. RESULTS

4.1 Vehicle and machinery emissions

The results of the emissions estimations are detailed below in Table 5.

The following assumptions were made for the calculation of the results in table 5:

1. Fuel consumption was based on estimated load rates – the highest load rate perceived for the vehicle was adopted to conservatively overestimate consumption.
    a. Vehicle age, maintenance and driver factors were not taken into account.
2. Mine site machinery and vehicles are assumed to run for 80% of the year (292 days) to account for breakdowns, mine shutdown due to extreme conditions (i.e. poor weather) etc..
3. Power generation is assumed to run for 100% of the year, 24 hours per day.
4. Aircraft are assumed to operate for 7% of the year – approximately 1 flight per week (which is estimated 8hr return trip from Broome).

Table 7. GHG emissions results for all phases of Twin Bonanza mine site.

Mine site component	Emission source	Quantity	Fuel type	Consumption total (KL/Year)	Duration total (Hr/year)	Annual Emissions (CO_2-eTonnes)			Project Total (3 years) Emissions (CO_2-eTonnes)		
						CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Construction	Dozer	1	Diesel	32.22	600	86.06	0.12	0.25	258.19	0.37	0.75
	Excavator	1	Diesel	47.70	600	127.41	0.18	0.37	382.24	0.55	1.10
	Water cart	1	Diesel	31.80	600	84.94	0.12	0.25	254.82	0.37	0.74
	Light vehicles	2	Diesel	12.36	1200	33.02	0.10	0.24	99.05	0.29	0.72
	Compaction rollers	1	Diesel	6.84	600	18.27	0.03	0.05	54.81	0.08	0.16
	Haul trucks	1	Diesel	47.34	600	126.45	0.18	0.37	379.35	0.55	1.10
	Front end loaders	1	Diesel	10.80	600	28.85	0.04	0.08	86.54	0.13	0.25
Mine camp operations / power generation	Power	4	Diesel	1606.00	26280	4289.82	6.20	12.40	12869.46	18.60	37.19
	Generator - Wilsons Bore	1	Diesel	18.25	4380	48.75	0.07	0.14	146.26	0.21	0.42
	Generator - Corsair Bore	1	Diesel	14.59	4380	38.96	0.06	0.11	116.88	0.17	0.34
Mine	Excavators	2	Diesel	928.56	11680	2480.30	3.58	7.17	7440.89	10.75	21.51
	Haul trucks	4	Diesel	607.36	23360	1622.33	2.34	4.69	4866.99	7.03	14.07
	Dozer	1	Diesel	47.04	876	125.65	0.18	0.36	376.96	0.54	1.09
	Grader	1	Diesel	24.53	876	65.52	0.09	0.19	196.55	0.28	0.57
	Water cart	1	Diesel	75.92	2920	202.79	0.29	0.59	608.37	0.88	1.76
	Drill rig	1	Diesel	73.00	2920	194.99	0.28	0.56	584.98	0.85	1.69
	Service truck	1	Diesel	18.05	1752	48.20	0.14	0.35	144.61	0.42	1.04
	Light vehicles	8	Diesel	72.18	7008	192.81	0.56	1.39	578.42	1.67	4.18
	Front end loaders	1	Diesel	52.56	2920	140.39	0.20	0.41	421.18	0.61	1.22
Processing plant & ROM pad	Loader	1	Diesel	96.36	6424	257.39	0.37	0.74	772.17	1.12	2.23
Employee transport	Aircraft - metro	1	AvGas	182.00	439	399.4	0.24	4.22	1198.24	0.72	12.65
	Bus	1	Diesel	7.01	584	18.72	0.05	0.14	56.16	0.16	0.41

Construction

A summary of the CO_2, C_4H and N_2O emissions for the construction of the tailings dam is presented in Table 6. The construction period is estimated for less than one year; therefore the results are reported in annual emissions (CO_2-eTonnes).

Table 8. Fuel Consumption and annual GHG emissions for the construction of the tailings dam.

EMISSION SOURCE	QUANTITY	CONSUMPTION TOTAL (KL/YEAR)	DURATION TOTAL (HR/YEAR)	ANNUAL EMISSIONS (CO_2-ETONNES)		
				CO_2	CH_4	N_2O
Dozer	1	32.22	600	86.06	0.12	0.25
Excavator	1	47.7		127.41	0.18	0.37
Water cart	1	31.8		84.94	0.12	0.25
Light vehicles	2	12.36	1200	33.02	0.1	0.24
Compaction rollers	1	6.84	600	18.27	0.03	0.05
Haul trucks	1	47.34		126.45	0.18	0.37
Front end loaders	1	10.8		28.85	0.04	0.08
Total (tonnes/construction period)				**505**	**0.77**	**1.61**

Mine camp operations and power generation

A summary of the CO_2, C_4H and N_2O emissions for the generation of power for the entire mine site; including the camp, processing plant, office and workshop and ancillary equipment (i.e. 5 x lighting plants- Allight) (Table 7).

Table 9. Fuel consumption and annual GHG emissions for the mine camp operations and power generation.

EMISSION SOURCE	QUANTITY	CONSUMPTION TOTAL (KL/YEAR)	DURATION TOTAL (HR/YEAR)	ANNUAL EMISSIONS (CO_2-ETONNES)		
				CO_2	CH_4	N_2O
Power	4	1606	26280	4289.82	6.20	12.40
Generator - Wilsons Bore	1	18.25	4380	48.75	0.07	0.14
Generator - Corsair Bore	1	14.59	4380	38.96	0.06	0.11
Total (tonnes/annum)				**4377.53**	**6.33**	**12.65**

The total emissions (CO_2, C_4H and N_2O) for the generation of power for the entire mine site for the project period (3 years); are presented in Table 8.

Table 10. Fuel consumption and GHG emissions for the mine camp operations and power generation for the life of the mine.

EMISSION SOURCE	QUANTITY	CONSUMPTION TOTAL (KL/YEAR)	DURATION TOTAL (HR/YEAR)	PROJECT TOTAL (3 YEARS) EMISSIONS (CO_2-ETONNES)		
				CO_2	CH_4	N_2O
Power	4	1606	26280	12869.46	18.60	37.19
Generator - Wilsons Bore	1	18.25	4380	146.26	0.21	0.42
Generator - Corsair Bore	1	14.59	4380	116.88	0.17	0.34
Total (tonnes/project period)				**13132.60**	**18.98**	**37.95**

Mine operations

The GHG emissions calculated per annum for the mine operations (excluding power and ancillary equipment) are presented in Table 9.

Table 11. Fuel consumption and annual GHG emissions for the mine.

EMISSION SOURCE	QUANTITY	CONSUMPTION TOTAL (KL/YEAR)	DURATION TOTAL (HR/YEAR)	ANNUAL EMISSIONS (CO_2-ETONNES)		
				CO_2	CH_4	N_2O
Excavators	2	928.56	11680	2480.30	3.58	7.17
Haul trucks	4	607.36	23360	1622.33	2.34	4.69
Dozer	1	47.04	876	125.65	0.18	0.36
Grader	1	24.53	876	65.52	0.09	0.19
Water cart	1	75.92	2920	202.79	0.29	0.59
Drill rig	1	73.00	2920	194.99	0.28	0.56
Service truck	1	18.05	1752	48.20	0.14	0.35
Light vehicles	8	72.18	7008	192.81	0.56	1.39
Front end loaders	1	52.56	2920	140.39	0.20	0.41
Total (tonnes/annum)				**5072.98**	**7.68**	**15.71**

The total emissions (CO_2, C_4H and N_2O) for the mine for the project period (3 years); are presented in Table 10.

Table 12. Fuel consumption and GHG emissions for the mine during the life of the mine.

EMISSION SOURCE	QUANTITY	CONSUMPTION TOTAL (KL/YEAR)	DURATION TOTAL (HR/YEAR)	PROJECT TOTAL (3 YEARS) EMISSIONS (CO_2-ETONNES)		
				CO_2	CH_4	N_2O
Excavators	2	928.56	11680	7440.89	10.75	21.51
Haul trucks	4	1843.10	23360	4866.99	7.03	14.07
Dozer	1	47.04	876	376.96	0.54	1.09
Grader	1	24.53	876	196.55	0.28	0.57
Water cart	1	154.76	2920	608.37	0.88	1.76
Drill rig	1	73.00	2920	584.98	0.85	1.69
Service truck	1	18.05	1752	144.61	0.42	1.04
Light vehicles	8	72.18	7008	578.42	1.67	4.18
Front end loaders	1	52.56	2920	421.18	0.61	1.22
Total (tonnes/project period)				**15218.95**	**23.04**	**47.12**

Processing plant and ROM pad

The GHG emissions calculated per annum for the processing plant and ROM pad (excluding power and ancillary equipment) are presented in Table 11.

Table 13. Fuel consumption and annual GHG emissions for the processing plant and ROM pad

EMISSION SOURCE	QUANTITY	CONSUMPTION TOTAL (KL/YEAR)	DURATION TOTAL (HR/YEAR)	ANNUAL EMISSIONS (CO_2-ETONNES)		
				CO_2	CH_4	N_2O
Loader	1	96.36	6424	257.39	0.37	0.74
Total (tonnes/annum)				**257.39**	**0.37**	**0.74**

The total emissions (CO_2, C_4H and N_2O) for the processing plant and ROM pad for the project period (3 years); are presented in Table 12.

Table 14. Fuel consumption and GHG emissions for the processing plant and ROM pad during the life of the mine.

EMISSION SOURCE	QUANTITY	CONSUMPTION TOTAL (KL/YEAR)	DURATION TOTAL (HR/YEAR)	PROJECT TOTAL (3 YEARS) EMISSIONS (CO_2-ETONNES)		
				CO_2	CH_4	N_2O
Loader	1	96.36	6424	772.17	1.12	2.23
Total (tonnes/project period)				**772.17**	**1.12**	**2.23**

Employee transport

The GHG emissions calculated per annum for the employee transport are presented in Table 13. The Fairchild Metro 23 has been modelled in these calculations to account for the potential upgrade of the airstrip and the regular flights of larger aircraft to and from the site.

Table 15. Fuel consumption and annual GHG emissions for the employee transport.

EMISSION SOURCE	QUANTITY	CONSUMPTION TOTAL (KL/YEAR)	DURATION TOTAL (HR/YEAR)	ANNUAL EMISSIONS (CO_2-ETONNES)		
				CO_2	CH_4	N_2O
Aircraft	1	182.00	439	399.40	0.24	4.22
Bus	1	7.01	584	18.72	0.05	0.14
Total (tonnes/annum)				**87.90**	**0.10**	**0.87**

The Total Emissions (CO_2, C_4H and N_2O) for the employee transport for the project period (3 years); are presented in Table 14.

Table 16. Fuel Consumption and GHG emissions for the Employee transport during the life of the mine.

EMISSION SOURCE	QUANTITY	CONSUMPTION TOTAL (KL/YEAR)	DURATION TOTAL (HR/YEAR)	PROJECT TOTAL (3 YEARS) EMISSIONS (CO_2-ETONNES)		
				CO_2	CH_4	N_2O
Aircraft	1	182.00	439	1198.21	0.72	12.56
Bus	1	7.01	584	56.16	0.16	0.41
Total (tonnes/project period)				**263.70**	**0.29**	**2.60**

TOTAL EMISSIONS

The total fuel consumption and GHG emissions for the operation of the Twin Bonanza project are presented in Table 15. The total emissions for the first year include additional fuel consumption associated with the construction of the tailings dam.

The annual GHG emissions from the operation of the Twin Bonanza project will not exceed the 50 kilotonnes threshold specified in the *National Greenhouse and Energy Reporting Act 2007.* ABM will therefore not be required to report greenhouse gas emissions to the NGA. If it is calculated at any stage the Twin Bonanza project exceeds the corporate group threshold specified in the *National Greenhouse and Energy Reporting Act*, ABM will report to the national NGA.

Table 17. Twin Bonanza total fuel consumption and GHG emissions.

Source	Consumption total (KL/Year)	Annual Emissions (CO₂-eTonnes)			Combined Total CO₂-eTonnes
		CO_2	CH_4	N_2O	
Construction subtotal	189.06	505.00	0.77	1.61	507.38
Mine camp operations / power generation & bores subtotal	1638.84	4377.53	6.33	12.65	4396.51
Mine subtotal	1899.20	5072.98	7.68	15.71	5096.37
Processing plant & ROM pad subtotal	96.36	257.39	0.37	0.74	258.50
Employee Transport subtotal	189.01	418.12	0.30	4.35	422.77
TOTAL EMISSIONS - Breakdown					
First year (including construction)	4012.46	10631.03	15.45	35.06	10681.53
Second Year	3823.40	10126.03	14.68	33.45	10174.15
Third Year	3823.40	10126.03	14.68	33.45	10174.15
FULL PROJECT (3 years)	**11659.27**	**30883.08**	**44.80**	**101.97**	**31029.84**

Vegetation emissions

CO_2 emissions

The total GHG emissions for the land clearance at the Twin Bonanza project are presented in Figure 1 and Table 16.

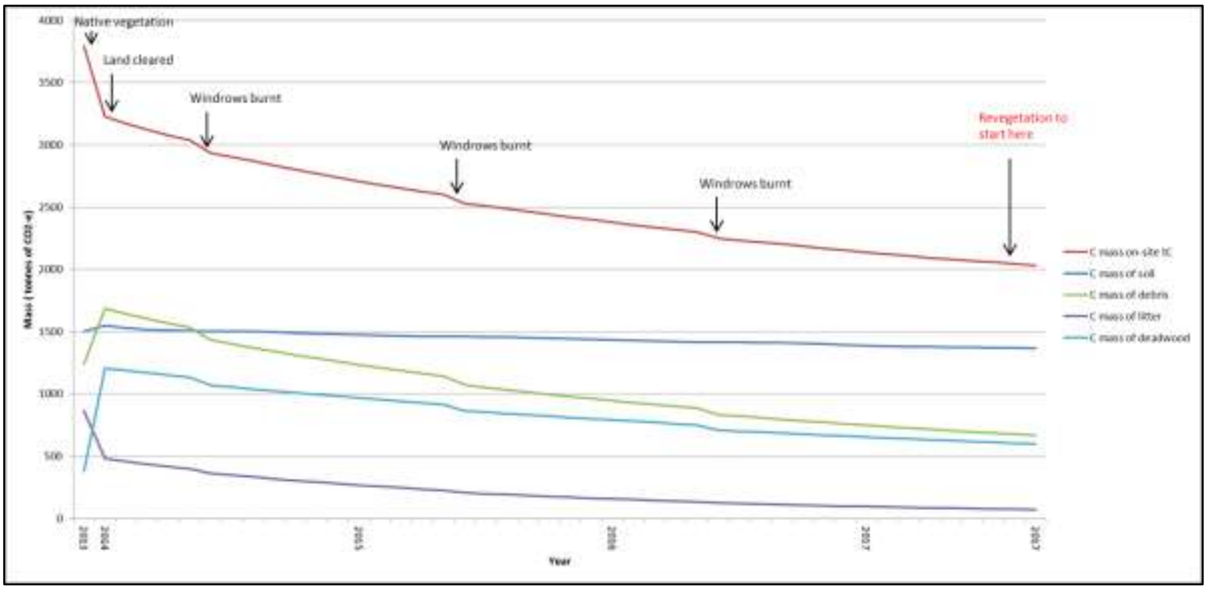

Figure 3. NCAS FullCAM output from plot simulation showing loss of carbon through time after clearing and burning. Key events used in the event queue for the FullCAM simulation during the clearing native vegetation for the mine site are shown (Table 4).The total mass of carbon per hectare is shown (in tCO_2-e) by the red line, and broken down into carbon stored in the soil, debris, litter and deadwood.

The typical output simulation for the Twin Bonanza clearing is shown in Figure 1, where clearing shows a large loss of carbon from the initial native vegetation, followed by a slow decline over the life of the mine. Annual clearing (windrows and burning) are highlighted by sharp drops in the on-site carbon.

As discussed previously, the revegetation is not modelled with FullCAM, but based on field observations is excepted to return to a moderately revegetated state within 3-4 years and a fully vegetated state within ~10 years, depending on final land use.

To determine emissions in tonnes-of-carbon-lost per hectare (tC ha^{-1}), total onsite carbon mass (tC/ha) in October 2017 was subtracted from initial onsite C mass (tC/ha) in 2013 (prior to clearing). Results were later converted from tonnes of carbon per hectare (tC ha^{-1}) to carbon equivalent emissions (CO_2-e t ha^{-1}) by multiplying by 3.667.

The total carbon mass of plants on site prior to clearing is estimated at 1049.27 tonnes of carbon (based on assumptions and parameters in section 3.2).

The estimated total emissions in tonnes of carbon lost per hectare totals 21.50(tC ha^{-1}).

Table 18. Estimated CO2 emissions from land clearing.

DATE			C MASS (tC)						C MASS ON-SITE (tC/ HA)	ON SITE CO_2-e MASS (CO_2-e t ha^{-1})
YEAR	MONTH	DAY	ON-SITE	PLANTS	DEBRIS	LITTER	DEADWOOD	SOIL		
2013	12	31	3791.27	1049.27	1242	864	378	1500	12.64	46.34
2014	1	31	3227.04	0	1682.39	477.51	1204.88	1544.65	10.76	39.45
	3	2	3169.35	0	1642.36	456.2	1186.16	1526.99	10.56	38.74
	4	2	3119.31	0	1603.86	435.92	1167.94	1515.45	10.40	38.13
	5	2	3075.33	0	1566.83	416.61	1150.21	1508.5	10.25	37.59
	6	2	3036.12	0	1531.19	398.23	1132.95	1504.94	10.12	37.11
	7	2	2934.62	0	1431.3	361.89	1069.4	1503.32	9.78	35.87
	8	1	2901.61	0	1399.78	346.28	1053.5	1501.82	9.67	35.47
	9	1	2868.63	0	1369.41	331.4	1038.01	1499.22	9.56	35.06
	10	1	2835.09	0	1340.14	317.21	1022.92	1494.95	9.45	34.65
	11	1	2801.59	0	1311.9	303.69	1008.21	1489.69	9.34	34.24
	12	1	2768.74	0	1284.67	290.79	993.88	1484.07	9.23	33.84
	12	31	2736.99	0	1258.38	278.49	979.89	1478.61	9.12	33.46
2015	1	31	2706.43	0	1233.01	266.76	966.25	1473.42	9.02	33.08
	3	2	2677.21	0	1208.51	255.57	952.94	1468.71	8.92	32.72
	4	2	2649.33	0	1184.83	244.88	939.95	1464.49	8.83	32.38
	5	2	2623.22	0	1161.96	234.69	927.27	1461.26	8.74	32.06
	6	2	2599.12	0	1139.84	224.96	914.88	1459.28	8.66	31.77
	7	2	2529.04	0	1070.85	207.19	863.65	1458.19	8.43	30.91
	8	1	2508.04	0	1051.01	198.8	852.21	1457.03	8.36	30.66
	9	1	2486.75	0	1031.81	190.78	841.03	1454.94	8.29	30.40
	10	1	2464.64	0	1013.22	183.11	830.1	1451.43	8.22	30.13
	11	1	2442.09	0	995.2	175.78	819.42	1446.88	8.14	29.85
	12	1	2419.55	0	977.75	168.77	808.98	1441.79	8.07	29.57

DATE			C MASS (tC)						C MASS ON-SITE (tC/ HA)	ON SITE CO_2-e MASS (CO_2-e t ha^{-1})
YEAR	MONTH	DAY	ON-SITE	PLANTS	DEBRIS	LITTER	DEADWOOD	SOIL		
	12	31	2397.46	0	960.83	162.07	798.76	1436.63	7.99	29.30
2016	1	31	2376	0	944.42	155.66	788.76	1431.57	7.92	29.04
	3	2	2355.36	0	928.51	149.53	778.98	1426.85	7.85	28.79
	4	2	2335.61	0	913.06	143.66	769.4	1422.55	7.79	28.55
	5	2	2317.18	0	898.07	138.05	760.02	1419.12	7.72	28.32
	6	2	2300.31	0	883.51	132.67	750.84	1416.8	7.67	28.12
	7	2	2247.97	0	832.67	123.71	708.95	1415.3	7.49	27.48
	8	1	2233.24	0	819.45	119	700.44	1413.8	7.44	27.30
	9	1	2218.11	0	806.59	114.49	692.1	1411.52	7.39	27.11
	10	1	2202.11	0	794.09	110.16	683.93	1408.02	7.34	26.92
	11	1	2185.53	0	781.93	106.01	675.92	1403.6	7.29	26.71
	12	1	2168.78	0	770.09	102.03	668.06	1398.68	7.23	26.51
	12	31	2152.24	0	758.57	98.22	660.35	1393.67	7.17	26.31
2017	1	31	2136.1	0	747.35	94.56	652.79	1388.75	7.12	26.11
	3	2	2120.55	0	736.42	91.05	645.37	1384.13	7.07	25.92
	4	2	2105.65	0	725.77	87.69	638.08	1379.89	7.02	25.74
	5	2	2091.82	0	715.38	84.46	630.93	1376.44	6.97	25.57
	6	2	2079.27	0	705.26	81.36	623.9	1374.01	6.93	25.42
	7	2	2067.73	0	695.38	78.38	617	1372.34	6.89	25.27
	8	1	2056.5	0	685.75	75.53	610.22	1370.75	6.86	25.14
	9	1	2044.82	0	676.34	72.78	603.55	1368.48	6.82	24.99
	10	1	2032.29	0	667.15	70.15	597	1365.13	6.77	24.84

The estimated GHG emissions from the annual windrow clearing and burning (which covers 10% of the total cleared area) are estimated in table 17.

Table 19. GHG emissions for the annual windrow clearing and burning.

	GHG EMITTED DUE TO FIRE		
Proxy date	C mass	CH_4	N_2O
	tC	tCO_2-e	tCO_2-e
02/07/2014	65.63	9.92	2.71
02/07/2015	47.63	7.2	1.97
02/07/2016	36.72	5.55	1.51
Total (tonnes/project period)	**149.98**	**22.67**	**6.19**

CONCLUSION / RECOMMENDATIONS

Based on the calculations and modelling, of the carbon dioxide equivalents produced from the combustion of fossil fuels and vegetation clearing at the Twin Bonanza project, the annual GHG emissions from the operation of the Twin Bonanza project will not exceed the 50 kilotonnes corporate group threshold specified in the *National Greenhouse and Energy Reporting Act*. Therefore reporting of GHG emissions to the NGA is not required. If at any stage the Twin Bonanza project exceeds the threshold specified in the *National Greenhouse and Energy Reporting Act*, ABM will report GHG emissions.

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