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Narrabri Mine

Greenhouse Gas Minimisation Plan

Stage 2 Longwall Project

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Narrabri Coal Operations Pty Ltd
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Stage 2 Longwall Project

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EXECUTIVE SUMMARY

Narrabri Coal Operations Pty Ltd (NCOPL) has commissioned SLR Consulting Australia Pty Ltd (SLR Consulting) to perform a revision to the Narrabri North Coal Mine Stage 1 Operations Greenhouse Gas Minimisation Plan (GHGMP). This revision is required for the Stage 2 operations of the Narrabri Mine, as outlined within the Project Approval (PA 08_0144).

As required under the Project Approval, NCOPL are required to implement all reasonable and feasible measures to minimise greenhouse gas (GHG) emissions from the underground mining operations. In addition, a particular focus is required on capturing and/or using these emissions, investigating the feasibility of implementing each option and proposing the measures to be implemented at the site. Further to this, a research program is required to inform the continuous improvement of the GHG minimisation measures on site.

GHG emissions have been calculated for the Narrabri Mine (Stage 2 operations) and are shown to total 410,322 tonnes of CO_2-equivalent (CO_2-e) per annum with 39% associated with pre-drainage gas, 16% with exhaust vent gas, 10% with goaf gas, 33% with emissions associated with electricity consumption and 1% with diesel combustion.

An Energy Savings Action Plan (JCM, 2011) developed for the site includes a range of measures which can be implemented to reduce electricity consumption. A Level 3 Energy Audit is proposed to be performed following Stage 2 commencement which will allow quantification of the impact of implementation of each proposed energy efficiency measure.

Emissions from diesel combustion are not anticipated to represent a major source of GHG emissions however where practicable, use will be made of direct energy supplies rather than using diesel for power generation.

Fugitive emissions of methane and carbon dioxide from the coal seam represent the majority (>66%) of total site emissions. However, challenges in the utilisation of this gas stream result from the characteristics of the gas, in particular the methane and carbon dioxide content. Examination of a range of mitigation measures is presented, with the installation of a Ventilation Air Methane (VAM) oxidation unit identified as being the most feasible at the present time.

NCOPL are currently investigating the operational feasibility of installing VAM oxidation units at the Narrabri Mine, and are also investigating the possibility of utilising goaf and/or pre-drainage gas streams to supplement the VAM gas, potentially resulting in greater GHG abatement.

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1 INTRODUCTION

Project Approval (PA) 05_0102 for the Narrabri Coal Mine (Stage 1) was granted to Narrabri Coal Operations Pty Ltd (NCOPL) by the Minister for Planning on 13 November 2007 and permits the mining and rail transportation of up to 2.5 million tonnes per year (Mtpa) of run-of-mine (ROM) coal for a period of 21 years. Following the receipt of PA 05_0102, ML 1609 was issued in January 2008 and site works on the Pit Top Area commenced in April 2008.

Since commencing Stage 1, continued geological exploration and a range of related technical studies have been completed to evaluate the feasibility of converting the Stage 1 continuous miner operation to a longwall mining operation (Stage 2). PA 08_0144 was granted to NCOPL on 16 July 2010 and relates to the Stage 2 operations.

NCOPL has commissioned SLR Consulting Australia Pty Ltd (SLR Consulting) to perform a revision to the Narrabri North Coal Mine Stage 1 Operations Greenhouse Gas Minimisation Plan (GHGMP). This revision is required for the Stage 2 operations of the Narrabri Mine, as outlined within PA 08_0144.

2 PURPOSE OF THE GREENHOUSE GAS MINIMISATION PLAN

The GHGMP is required to provide NCOPL with options to reduce GHG emissions from the Stage 2 Project and to understand the major sources of emissions. If feasible, NCOPL are required to provide an implementation timeframe for each measure.

2.1 Statutory Requirements

The conditions of PA 08_0144 require the submission of a GHGMP. The specific requirements are reproduced below.

Condition	Requirement	Addressed
Schedule 4 31	The Proponent shall implement all reasonable and feasible measures to minimise the greenhouse gas emissions from the underground mining operations to the satisfaction of the Director-General.	**Section 4**
Schedule 4 32	Prior to carrying out longwall coal mining operations, the Proponent shall submit a Greenhouse Gas Minimisation Plan for the approval of the Director-General. This plan must: a be prepared in consultation with DECCW; b identify options for minimising greenhouse gas emissions from underground mining operations, with a particular focus on capturing and/or using these emissions; c investigate the feasibility of implementing each option; d propose the measures that would be implemented in the short to medium term on site; and e include a research program to inform the continuous improvement of the greenhouse gas minimisation measures on site.	**Section 4** **Section 5** **Section 6**
Schedule 6 2	The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines.	**Whole document**

3 GREENHOUSE GAS EMISSIONS

Scope 1 and Scope 2 GHG emissions for the Stage 2 Project have been calculated for the following sources:

- Consumption of diesel fuel (Scope 1)
- Consumption of electricity (Scope 2)
- Pre-drainage gas (Scope 1)
- Goaf gas (Scope 1)
- Ventilation exhaust gas (Scope 1)

3.1 Diesel Fuel

Diesel usage at the Narrabri Mine has been sourced from the Annual Environmental Management Report (AEMR) for the period 1 April 2010 to 31 March 2011 (AEMR, 2011). The AEMR indicates that during this 12 month period, a total of 1,670,000 litres of diesel was consumed. Data for the period 1 April 2011 to 31 March 2012 indicates a diesel fuel consumption of 2,065,034 litres. As discussed in JCM (2010), the quantity of diesel consumed in 2011/2012 is not expected to differ significantly during the life of the Stage 2 Project. Assuming a fuel energy content of 38.6 GJ/kL and a CO_2-e emission factor of 69.9 kg CO_2-e/GJ (NGA Factors, 2011), a total annual emission of 5,572 t CO_2-e is anticipated.

3.2 Electricity

Electricity consumption for the Stage 2 Narrabri Project has been sourced from the AEMR (2011) and indicates a total electricity usage of 8,828,000 kWh over the reporting period (1 April 2010 to 31 March 2011). Electricity consumption for the period 1 April 2011 to 31 March 2012 indicates a total site electricity consumption of 20,293,027 kWh. This figure does not include longwall extraction and the CHPP at full production. Once full production occurs, electricity consumption is anticipated to increase significantly.

Data sourced from the Narrabri Mine Energy Saving Action Plan (JCM, 2011) indicates an expected total electricity usage of 153,292 MWh per annum during Stage 2 operations. Application of the Scope 2 emission factor of 0.89 kg CO_2-e/kWh (NGA Factors, 2011) yields 136,430 t CO_2-e emissions annually.

3.3 Pre-Drainage Gas

Information on the quantity and composition of pre-drainage gas from the Stage 2 Longwall Project between 1 April 2011 to 31 March 2012 indicates that a total of 51,858,272 m^3 of gas was measured from pre-drainage wells, with 90% of this gas measured as CO_2 and 10% as CH_4. Calculation of monthly average gas flows and concurrent gas composition over the 1 year period allowed the calculation of the total CH_4 and CO_2 gas flow:

- 46,672,445 m^3 CO_2
- 5,185,827 m^3 CH_4

Assuming gas densities of 0.68 kg/m^3 and 1.84 kg/m^3 for CH_4 and CO_2, respectively (at normal temperature and pressure [20°C, 101.3 kPa]), the quantity of CH_4 emitted each year has been calculated to be 3,526 tonnes and for CO_2 85,971 tonnes. Applying a Global Warming Potential value of 21 for methane results in a total annual emission of 160,024 t CO_2-e from the pre-drainage circuit. It is not anticipated that this gas composition or gas flow will change significantly during Stage 2 operations.

3.4 Goaf Gas

Average annual emissions of goaf gas from the Project have been calculated with reference to the GHG Emissions Mitigation Strategy document produced for the Narrabri Project in 2009 (Moreby, 2009). This report provides likely quantities of goaf gas (CO_2 and CH_4) for each year of the production schedule. Based on this data, it is anticipated that an average of 5.9 Mm^3 of CO_2 and 2.2 Mm^3 of CH_4 will be emitted during the Stage 2 operations (maxima of 9.8 Mm^3 of CO_2 and 5 Mm^3 of CH_4) resulting in total average annual emissions of 42,387 t CO_2-e (80,242 t CO_2-e maximum).

3.5 Ventilation Exhaust Gas

Emissions of ventilation exhaust gas have been calculated with reference to the data presented in **Table 1**.

Table 1 Ventilation Parameters

Parameter	Value	Comment
Ventilation quantity	320 m^3/s	Average ventilation quantity anticipated
CO_2 concentration in exhaust gas	0.2%	CO_2 concentration
CH_4 concentration in exhaust gas	0.02%	CH_4 concentration

Source: S. Boatwright, Ventilation and Gas Drainage Officer, Narrabri Mine

Based on the figures in **Table 1**, the annual quantity of gas flow through the ventilation shaft would be 10,092 Mm^3 each year, 2 Mm^3 of which would be CH_4 and 20 Mm^3 of which would be CO_2. Assuming gas densities of 0.68 kg/m^3 and 1.84 kg/m^3 for CH_4 and CO_2, respectively (at normal temperature and pressure [20°C, 101.3 kPa]), the quantity of CH_4 emitted each year would be 1,372 tonnes and for CO_2 would be 37,177 tonnes. Applying a GWP value of 21 for methane results in a total annual emission of 65,999 t CO_2-e from the ventilation circuit.

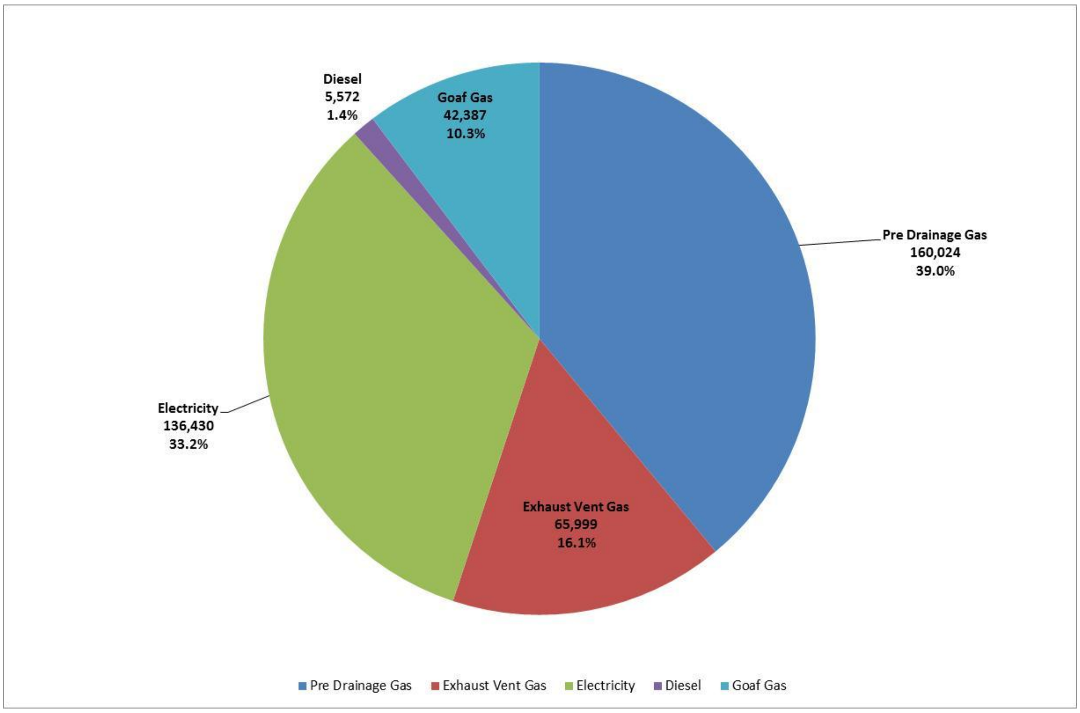
3.6 Emissions Summary

A summary of GHG emissions anticipated for the Stage 2 operations is presented in **Table 2** and **Figure 1**

Table 2 Summary of Annual GHG Emissions – Narrabri Mine Stage 2 Operations

Emission Source	GHG Emission (t CO_2-e/annum)
Diesel fuel	5,572
Electricity	136,340
Pre-Drainage Gas	160,024
Goaf Gas	42,387
Ventilation Exhaust Gas	65,999
Total	**410,322**

Figure 1 Summary of Annual GHG Emissions – Narrabri Mine Stage 2 Operations



4 OPTIONS FOR MINIMISING GHG EMISSIONS

4.1 Diesel

Considering the total GHG emissions associated with diesel use are calculated to be less than 1.5% of total GHG emissions, it is not anticipated that major GHG savings will be made from this source. Diesel is consumed in surface and underground mobile plant as well as remote isolated surface installations for power generation. Where practicable, use will be made of direct supply from the power grid resulting in improved energy conversion efficiency.

4.2 Electricity

GHG emissions associated with the use of electricity result in approximately 33% of the total site GHG emissions. This offers significant opportunity to reduce emissions. In August 2011, the Narrabri Mine Energy Savings Action Plan (ESAP) was updated by JCM Solutions on behalf of Narrabri Mine (JCM, 2011). This ESAP resulted in a range of energy saving solutions being identified which included:

- Car park lighting switch to solar;
- Ventilation fans fitted with VVVF drives to allow speeds to match actual process demands; and,
- Improving the efficiency of energy consumption during coal cutting with development of continuous miners by optimising the cutting pick length.

Additionally, a number of proposed energy savings opportunities were identified:

- Use of energy efficient lighting;
- Installation of sky lights and PV cells in workshops;
- Use of instantaneous hot water systems in bath houses;
- Undertake a Level 3 energy audit;
- Placing all conveyors on VVVF drives except small ones underground – for softer start;
- Use of VVVF drives on all pumps;
- Convene Site Energy Management Committee meetings every 6 months to analyse site energy use and identify areas for savings;
- Conduct audits on:
  - Compressed air;
  - Ventilation system;
  - Water – pumping and what goes in;
  - Hydraulic bypass and leaks on Longwall face;
  - Gas drainage system
- Establish energy KPI's for each operational area over time;
- Optimisation of ventilation power consumption through control of the number of fans in use and their respective rotation speeds; and,
- Establish an Energy Savings Suggestion scheme to capture all staff suggestions for efficiency improvements.

Until the site is operating at approximately 5 to 6 Mtpa, it is difficult to set the baseline energy benchmark or even to accurately quantify the true magnitude of the improvement projects already implemented. The conduct of the Level 3 Energy Audit of the mine would be a major milestone in establishing both the benchmark position for energy consumption, additional detailed improvement opportunities and measurement methodologies to capture the quantitative impact of each energy efficiency project undertaken in the future.

4.3 Coal Mine Methane

Emissions associated with coal mine methane (CMM) are anticipated to contribute to approximately 66% of total site GHG emissions. Although the pre-drainage, goaf and ventilation exhaust streams have different characteristics, a number of measures are available to reduce GHG emissions associated with CMM. These measures are highly dependent on gas flows, gas concentrations and reservoir lifetimes.

A summary of the CMM characteristics associated with the Narrabri Stage 2 operations are provided in **Table 3**.

Table 3 Characteristics of CMM – Narrabri Stage 2 Operations

CMM Emission Source	Characteristics	Comments
Pre-drainage Gas	Flow: 5,928 m^3/hr average	8,549 m^3/hr maximum 4,232 m^3/hr minimum
	CH_4: 10% average	47.8% maximum 0.6% minimum
	CO_2: 90% average	99.4% maximum 22.5% minimum
Goaf Gas	Flow: 913.2 m^3/hr	1,381.3 m^3/hr maximum 319.6 m^3/hr minimum
	CH_4: 27% assumed average	
	CO_2: 73% assumed average	
Ventilation Exhaust Gas	Flow: 1,152,000 m^3/hr average	
	CH_4: 0.3% potential	0.02% currently
	CO_2: 0.9% worst case	0.2% currently

Note: Only flow of CH_4 and CO_2 known for goaf gas.

At the present time, the reservoir characteristics and potential lifetimes of gas availability are not fully understood. The information provided in **Table 3** is the current situation which may change over time.

Section 4.3.1, **Section 4.3.2** and **Section 4.3.3** examine the emissions associated with pre-drainage gas, goaf gas and ventilation exhaust gas respectively and assess the potential options which exist for GHG abatement, based on current technical feasibility. Each feasible option is assessed for its cost effectiveness in **Section 5**.

4.3.1 Pre-Drainage Gas

Emissions of GHG associated with pre-drainage gas represent approximately 39% of total site emissions. Considering the relatively large proportion of methane within the gas stream (average of 10% and maximum of 48%) when compared to the ventilation gas stream (<0.3%), this offers some options to utilise the gas for on-site combustion applications or use of the gas regenerative thermal oxidation (RTO), refer **Section 4.3.3**.

Flaring of CMM is an abatement option that may be attractive if its utilisation for power generation is not feasible. Ideally, each utilisation plant should be equipped with a flaring facility in case of a breakdown or when scheduled maintenance requires that the plant be temporarily shut down, and during the early mine development stage when methane production has not yet reached commercially viable levels. This action will minimise methane emissions into the atmosphere and thereby protect the environment whenever utilisation is not available.

The coal industry and mine regulatory authorities in some countries have opposed flaring at mines over concerns that the flame could propagate back down through the drainage system into the mine, causing an explosion. At the very least, safe flaring requires rigorous design incorporating flame and detonation arrestors, seals, sensors, and other safety devices. CMM flares have operated successfully in a number of countries including Australia, China, and the United Kingdom. Conceptually, the safety risk is no different from that of a CMM boiler, a well-established application.

Flares may be either open “candlestick” flares or enclosed (ground) flares. Enclosed flares may cost substantially more than open flares, but the destruction efficiency will consistently be greater. In “perfect conditions,” the efficiencies are almost equal and can approach 98% to 99%, but the efficiency of open flares fall dramatically when wind and other factors are introduced (University of Alberta, 2004). The UNFCCC Clean Development Mechanism (CDM) Executive Board, for example, has established default values of 90% for enclosed flares and 50% for open flares (UNFCCC CDM Executive Board, 2009). Actual efficiencies can be measured and used for enclosed flares. A final consideration is that enclosed flares have greater aesthetic appeal as the flame is not visible and combustion pollutants can be better managed (United Nations, 2010).

For the Narrabri Mine, it is not considered that flaring of gas is a suitable GHG abatement option given that the high CO_2 concentrations within the gas stream may not support ignition of the flare. A more suitable option would be the use of Regenerative Thermal Oxidation, discussed in **Section 4.3.3**.

4.3.2 Goaf Gas

Emissions of goaf gas are calculated to result in approximately 42,000 t CO_2-e per annum, a contribution of 10% to the total site emissions. Based on information supplied by Moreby (2009), a total annual emission of CH_4 is anticipated to be between 0.9 Mm^3 and 5 Mm^3 per annum.

An average methane concentration of <23% is considered to be a low methane gas stream and as is the case with pre-drainage gas, concentrations mixed with large volumes of CO_2 are expected to be too low to support ignition.

As for pre-drainage gas, this goaf gas is likely to be suitable for free venting with a low probability of sustaining any ignition. Options for mitigation of methane release would be limited to some form of VAM technology that oxidises the methane to carbon dioxide and water but is not capable of producing any viable energy source.

A second option is to upgrade the gas quality. Systems to upgrade gas quality can be expensive. Prior to installing such a system, great care should be taken to assess the options and weigh the costs and benefits against the CMM project objectives. If gas upgrading is the desired approach, the simplest solution is to blend lower-quality goaf gas with high-quality, pre-mine drainage to achieve an optimal mix. The other option is to rid the mine gas of contaminants (oxygen, nitrogen, carbon dioxide, and carbon monoxide, but also hydrogen sulphide), using one of three basic technologies: 1) pressure swing adsorption (PSA); 2) molecular sieve adsorption (MSA), a variant of PSA; and 3) cryogenic separation (United Nations, 2010).

- Pressure Swing Adsorption: In most PSA nitrogen rejection systems, wide-pore carbon molecular sieves preferentially adsorb methane during each pressurization cycle. The process recycles methane-rich gas so that the methane proportion increases with each cycle. PSA recovers up to 95% of available methane and may operate on a continuous basis with minimal on-site attention.

- Molecular Sieve Adsorption: MSA employs a PSA process with an adjustable molecular sieve. It allows the pore size to be adjusted to 0.1 angstrom. The process becomes uneconomical with an inert gas content of more than 35% and is unlikely to be suitable for the Narrabri Mine.
- Cryogenic Separation: The cryogenic process - a standard, economic solution for upgrading below specification gas from natural gas fields - uses a series of heat exchangers to liquefy the high pressure feed gas stream. Cryogenic plants have the highest methane recovery rate of any of the purification technologies with about 98%, but are very expensive and thus more appropriate for large-scale projects.

Information provided in USEPA (2008) indicates that currently, gas containing 50% CH_4 is considered to be the low end of the range for economically viable gas upgrading. Given the CH_4 content of the goaf and pre-drainage gas streams (average 23% and 12.9% respectively) it is not cost-effective to consider CMM upgrading options at the present time.

As is the case with pre-drainage gas, a more likely option would be to use the gas as supplement to the exhaust ventilation air as a means of stabilising methane purity in the exhaust air supply. This ventilation air could then be used in a VAM oxidation unit (refer **Section 4.3.3**).

4.3.3 Ventilation Exhaust Gas

Seam gas emissions contribute the large majority of the overall GHG emissions for the project (66% of total), with ventilation air methane (VAM) the third largest emission source. Appropriately, this report investigates methodologies for treating VAM for mine ventilation emissions as a possible scenario.

In general, the low concentration of methane in VAM (and goaf and pre-drainage gas) presents a major challenge for utilisation and mitigation (Moreby, 2010). In recent years, technologies have been developed that can destroy very low concentration methane in mine ventilation air by thermal oxidation. The primary purpose of these technologies is the reduction of GHG emissions. Some of these technologies may be combined with a heat recovery system for use at the mine or district heating, or to run steam turbines for power generation.

The two oxidation technologies available in the market are Regenerative Thermal Oxidisers (RTO), also known as Thermal Flow Reversal Reactors (TFRR), and the Regenerative Catalytic Oxidisers (RCO), also known by the term Catalytic Flow Reversal Reactor (CFRR). Both use a flow reversal process to maintain the reactor core temperature and differ only in the RCO's use of a catalyst in the oxidation process. Prior to VAM application, these technologies have seen widespread use for pollution control in commercial and manufacturing operations, specifically to oxidise volatile organics, odours, and other air pollutants. Commercial-scale VAM RTOs have been installed and demonstrated for methane mitigation in mines in Australia, China, and the United States. VAM energy recovery has been successfully demonstrated in Australia, using VAM as combustion air in IC engines, and using RTOs to convert VAM to electricity at a mine mouth power plant. A VAM RCO has been proven at full-scale demonstration in a test unit.

Current VAM technologies are generally not able to process methane concentrations below 0.2% without use of additional fuel, but research efforts are underway to lower the concentration threshold because VAM concentrations at many mines worldwide fall below 0.2%. Operations that use VAM to generate power may need to optimise the inflow concentrations and increase the VAM concentration inlet to the oxidation device. One method that has been employed is enriching (spiking) the gas with methane from other sources such as goaf or pre-drainage gas. If enrichment is being considered, the use of low-quality drained gas (<30%) should not be used due to the explosion hazard. Use of higher concentration gas (> 30%) could divert gas from lower-cost CMM power generation.

It is necessary to ensure that the RTOs/RCOs and the infrastructure necessary to transport the mine return air to the reactors do not create additional back pressure on the mine fan, minimise parasitic power consumption to the extent practicable, and contain methane analysers and other safety equipment (e.g., flame arrestors, bypass systems) (United Nations, 2010).

4.3.4 Summary

A summary of the potential usage and abatement options for the CMM gas streams at the Narrabri Stage 2 Project are provided in **Table 4**.

Table 4 Summary of CMM Abatement and Usage Options, Narrabri Stage 2 Project

CMM Stream	Options	Comments	Feasible
Pre-Drainage Gas /Goaf Gas	Natural Gas Pipeline	CH_4 <40% to 85% and inconsistent	✘
	On-Site Combustion	CH_4 <40% to 85% and inconsistent	✘
	Flaring	Option for low CH_4 (<40%) gas although high CO_2 concentrations may not sustain ignition	✘
	Upgrade Gas Quality	CH_4 <50% economically infeasible (USEPA, 2008)	✘
	Enrichment of other CMM Streams	If gas stream is >30% CH_4 can be used to enrich VAM air for oxidation	✓
Ventilation Air	Oxidation or Power Generation	Potential low CH_4 concentrations in VAM may be enriched, but only with >30% CH_4	✓

Based on the summary provided in **Table 4**, the economic viability VAM oxidation is considered further in **Section 5**.

5 COSTS AND BENEFITS OF CMM ABATEMENT AND UTILISATION

Implementation of GHG abatement and minimisation infrastructure is usually associated with significant costs. However, the Australian Government's introduction of the Clean Energy Future Legislative Package will introduce, on July 1 2012 a carbon price, which aims to create an incentive for businesses across the economy to cut GHG emissions by investing in clean technology and finding more efficient ways of operating. It is hoped to ensure that GHG emissions are reduced at the lowest price to the economy.

A fixed price of $23 per tonne of CO_2-e will be applied from 1 July 2012 for a period of three years. From 1 July 2015, the carbon price will be set by the market. This assessment assumes a constant carbon price of $23/tonne.

The following section includes an assessment of costs and benefits associated with the introduction of VAM oxidation.

5.1 Ventilation Air Methane Oxidation

As previously noted in **Table 3**, the ventilation exhaust gas at Narrabri Mine has a CH_4 content of 0.02% at the present time. It has been noted by the Narrabri Coal Ventilation and Gas Drainage Officer that the potential exists for this to increase to approximately 0.3% during Stage 2 operations. As discussed in **Section 4.3.3**, current VAM technologies are generally not able to process methane concentrations below 0.2%. Detailed design of VAM oxidation systems would require a CH_4 concentration in VAM to be set, below which the VAM would either shut-down, or air enriched with pre-drainage or goaf gas.

Detailed information on the capital and operational costs associated with the purchase of VAM oxidation units is scarce, although VAM projects are reported to deliver positive rates of return at carbon prices as low as US$5 to US$10 per t CO_2-e. Given an Australian carbon price of AU$23 per tonne, a VAM Project may be economically feasible for the Narrabri Mine. Additional information indicates that VAM oxidation units cost approximately US$20 to $US30 per scfm (1.7 Nm^3/hr). For the Narrabri Mine with VAM exhausting at 1,620,000 m^3/hr (approximately 1,031,000 scfm at 0°C), costs of a VAM oxidation process to treat all VAM would be in the order of US$30.9M.

The liability under the Clean Energy Future legislation relating to VAM has been calculated to be AU$1.5M per year (65,999 t CO_2-e (**Section 3.5**) x AU$23/t CO_2-e). Payback on a VAM system would therefore be approximately 20 years assuming a 97% destruction efficiency.

Should pre-drainage gas or goaf gas be used to enrich the ventilation air stream, and be passed through the VAM unit, additional GHG abatement, and costs under the Clean Energy Future legislation would be realised. However, it is unclear at the current time as to the quantity of methane likely to be passed through the VAM oxidation unit from pre-drainage or goaf gas. Assuming a 20% make-up of VAM with pre-drainage and goaf gas (10% of each gas stream), a further 7,557 t CO_2-e of emissions would be avoided with a saving of $173,000 associated with the Clean Energy Future legislation.

Small scale capability proving plant could be installed in the first instance, to avoid risks associated with major infrastructure construction. Grants could be sought from the NSW Coal Innovation Council, such as those granted to Centennial Coal Mandalong to install a trial VAM-RAB demonstration unit, with the aim of installing up to 12 units. VAM is to be enriched with pre-drainage gas to maintain CH_4 at concentrations which can be accepted by the VAM–RAB units.

6 RESEARCH PROGRAM

Given the Clean Energy Future legislation starting date of 1 July 2012, NCOPL are currently in discussions with technology providers to determine the operational feasibility of installation of VAM oxidation units at the Narrabri Mine. Further to this, discussions with technology providers are also ongoing relating to the use of pre-drainage and/or goaf gas to be used as make-up gas for the VAM units in periods of low methane VAM air exhaust.

NCOPL are also currently examining options to use pure CO_2 gas as infill to goaf areas at the termination of longwall mining. This investigation is currently in early stages.

NCOPL continue to update all management plans (including the ESAP and this GHGMP) on a bi-annual basis and therefore as technology becomes more mature and information on the actual gas compositions during Stage 2 operations becomes available, this plan will be updated. In the interim, examination of GHG abatement measures will continue to be investigated and reported within the AEMR each year.

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8 CLOSURE

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

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