NARRABRI MINE

GREENHOUSE GAS MINIMISATION PLAN

Prepared by:

Title	Name	Signature	Date
Associate	Mike Gale Onward Consulting		28 August 2023
Director	Mark Vile Onward Consulting		28 August 2023

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Acronyms and abbreviations

Acronym	Description
BCS	Biodiversity, Conservation and Science Directorate
CAS	Climate and Science Branch
CH_4	methane
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent (gases/emissions)
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water
DPE	NSW Department of Planning and Environment
EMS	Environmental Management Strategy
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EPA	NSW Environment Protection Authority
ESAP	Energy Savings Action Plan
GHG	greenhouse gas
GHGE	greenhouse gas emissions
GHGMP	Greenhouse Gas Minimisation Plan
IEA	Independent environmental audit
km	kilometre
LW	longwall panel
ML	Mining Lease
mm	millimetre
Mtpa	million tonnes per annum
NCOPL	Narrabri Coal Operations Pty Ltd
ROM	Run of mine
SoC	Statement of Commitments
VAM	Ventilation Air Methane
WHC	Whitehaven Coal Limited

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1. Introduction

1.1 Background

The Narrabri Mine is an existing underground coal mining operation situated in the Gunnedah Coalfield. It is located approximately 25 kilometres (**km**) south-east of Narrabri and approximately 60 km north-west of Gunnedah, within the Narrabri Shire Council Local Government Area in New South Wales (**NSW**). The Narrabri Mine includes an underground coal mine, a coal handling and preparation plant and associated rail siding and surface infrastructure.

The Narrabri Mine is operated by Narrabri Coal Operations Pty Ltd (**NCOPL**), on behalf of the Narrabri Mine Joint Venture, which consists of two Whitehaven Coal Limited (**WHC**) wholly owned subsidiaries, and other joint-venture partners. The underground mine is covered by Mining Lease (**ML**) 1609 which covers an area of 5,298 hectares (**ha**) for the predominant purpose of mining for coal from the Hoskissons Coal Seam.

Stage 1 of the Narrabri Mine was approved in November 2007 under Part 3A of the *Environmental Planning and Assessment Act 1979* (**EP&A Act**). Construction of the mine and supporting infrastructure commenced in 2008, with production using a continuous miner commencing in 2010. Following the approval of the Stage 2 Environmental Assessment (R.W Corkery & Co., 2009) (the **EA**) and the issue of the Stage 2 Project Approval 08_0144 (**Project Approval**) in July 2010, and *Environment Protection and Biodiversity Conservation Act 1999* approval (**2009/5003**) in January 2011, the Narrabri Mine was converted to an 8 million tonnes per annum (**Mtpa**) run of mine (**ROM**) longwall mining operation, which commenced in 2012.

The Project Approval has subsequently been modified on a number of occasions. The environmental assessment for Modification 5 (Resource Strategies, 2015), approved in December 2015, changed the mine geometry by reducing the number of longwall (**LW**) panels from 26 to 20, increased some LW panel widths and increased the production to 11 Mtpa of ROM coal until July 2031.

Modification 7, the most recent modification of the Project Approval, was approved on 23 November 2021. The environmental assessment for Modification 7 (Resource Strategies, 2021) describes the change in mining method within the extent of the previously approved LW 201 and LW 202 and allows for up to 0.7 Mtpa via bord and pillar extraction at pillar reduction panels Cut and Flit (CF) 201 to CF 205. There is no change to the previously approved LW panels LW 203 to LW 209. The bord and pillar mining will occur concurrently with existing LW operations for a period of approximately five years, with the maximum ROM coal production rate remaining within the approved limit of 11 Mtpa.

The Narrabri Mine Stage 2 underground mining layout is shown in Figure 1-1.

Figure 1-1 Underground mining layout

1.2 Purpose and scope

This Greenhouse Gas Minimisation Plan (**GHGMP** or **Plan**) has been developed in accordance with Schedule 4, Condition 32 of the Project Approval and the applicable regulatory framework regarding greenhouse gas emissions (**GHGE**). NCOPL will implement the GHGMP as approved by the Department of Planning and Environment (**DPE**).

This GHGMP forms part of the Narrabri Mine Environmental Management Strategy (**EMS**).

The key elements of the Energy Savings Action Plan (**ESAP**) required in accordance with Schedule 4, Condition 30 of the Project Approval have been integrated into section 6 of this Plan given the link between energy efficiency and GHGE minimisation. The ESAP will therefore not be maintained as a standalone document within the Narrabri Mine EMS.

1.3 Objectives

The objectives of this Plan are to:

- provide details of the relevant statutory requirements, including any relevant approval, licence or lease conditions;
- identify options for minimising GHGE from underground mining operations, focusing on capturing and/or using these emissions;
- investigate the feasibility of implementing each identified option;
- describe the measures that are to be implemented in the short to medium term on site;
- provide detail on the proposed research program with the intent to inform the continuous improvement of the GHGE measures on site; and
- include energy management and monitoring measures to reduce energy use on site.

1.4 Preparation and consultation

In accordance with Schedule 4 Condition 30 and Condition 32[1] of the Project Approval, this Plan has been prepared in consultation with the Climate and Science (**CAS**) Branch of the DPE, the NSW Environment Protection Authority (**EPA**) and the NSW Biodiversity, Conservation and Science Directorate (**BCS**). The draft GHGMP (Revision 2) was provided to CAS[2], the EPA and the BCS on 22 June 2023 for review and comment.

The EPA provided a response letter dated 30 June 2023 specifying that the EPA will not be providing any specific comment on the Plan. The BCS also provided a response letter on 6 July 2023 stating that the BCS have no specific comments to make on the Plan, given that the BCS no longer contain an atmospheric science branch within the Directorate.

Appendix B provides evidence of consultation with the EPA and the BCS.

[1] Schedule 4 Condition 32 and Schedule 4 Condition 30 (ESAP component) of the Project Approval requires the GHGMP to be prepared in consultation with BCS. NCOPL advised DPE in writing on 31 May 2023 that it proposes to submit the GHGMP to the CAS and EPA as the relevant agencies in addition to the BCS. Letter correspondence from the DPE on 13 June 2023 endorsed NCOPL's intention to consult with the Climate and Science (CAS) Branch of the DPE and the EPA as the appropriate agencies in addition to the BCS.

[2] On 29 June 2023, DPE advised that the Department would provide the GHGMP to CAS following submission.

1.5 Access to information

In accordance with Schedule 6 Condition 10 of the Project Approval, the approved GHGMP, audits and reports, and summaries of all relevant monitoring data will be made publicly available on the WHC website. All information will be kept up to date. Note that any printed copies of this GHGMP are uncontrolled.

2. Roles and responsibilities

All NCOPL employees and contractors (and their sub-contractors) are responsible for the environmental performance of their activities and for complying with all legal requirements and obligations. All personnel will be required to comply with the statutory approval requirements of the activities they undertake, and any potential environmental impacts from all activities will be managed in accordance with the relevant strategies, plans and programs.

In accordance with Schedule 6 Condition 1 of the Project Approval, the EMS sets out the roles, responsibilities, authorities and accountabilities of all key personnel involved in the environmental management of operations at the Narrabri Mine, which encompasses the requirements and obligations under this GHGMP.

3. Statutory requirements

3.1 Project approval

This Plan has been developed in accordance with Schedule 4 Condition 32 of the Project Approval. In accordance with Schedule 6 Condition 2(b), Appendix A, Table A-1 provides a summary of the relevant Project Approval conditions relating to GHGE and outlines the section of the GHGMP in which each of these conditions have been addressed.

The Statement of Commitments (**SoCs**) (Appendix 3 to the Project Approval) relating to greenhouse gas are detailed in Appendix A Table A-2, which includes a cross reference to the section of the GHGMP in which each of these commitments have been addressed.

3.2 Mining lease

NCOPL are the holder of ML 1609 issued in January 2008. NCOPL are required to implement all practicable measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation of the development.

4. Greenhouse gas emissions

The average annual GHGE have been forecast for the five-year period FY23 to FY27 (Year 1 to Year 5), covering the extraction of LW 203 to LW 206 and Panel 201 to Panel 202 (bord and pillar extraction). GHGE have been calculated for the following sources:

- consumption of diesel fuel (Scope 1);
- consumption of electricity (Scope 2);
- consumption of LPG (Scope 1);
- fugitive emissions (Scope 1) including:
  - pre-drainage gas;
  - goaf gas; and
  - ventilation exhaust gas.
- emissions from post-mining activities.

4.1 Diesel

Diesel usage for the Narrabri Mine was sourced for FY2022, with a total of 3,839 kilolitres of diesel consumed for the 12-month period for stationary and transport energy purposes (3,739 kilolitres and 100 kilolitres respectively). An emission factor (kilolitres of diesel per tonne of ROM coal) was calculated for each stream and applied to the five-year mining schedule.

The definitions for stationary and transport energy purposes are contained with the *Reporting consumption of liquid fuels guideline* (Clean Energy Regulator, 2017).

Using the emission factors and energy content factors from the February 2023 revision of the 2022 Australian National Greenhouse Account Factors (DCCEEW, 2023), an average annual emission of approximately 16,567 t carbon dioxide equivalent (CO_2-e) is estimated for the stationary energy stream (ranging from 13,480 t CO_2-e to 18,608 t CO_2-e) and approximately 445 t CO_2-e for the transport energy stream (ranging from 362 t CO_2-e to 500 t CO_2-e) for the period.

The annual diesel emissions calculated are shown in Table 4-1 and Table 4-2.

Table 4-1 Annual diesel emissions – stationary energy purposes

Mining year	GHG emissions (t CO_2-e / annum)
Year 1	13,480
Year 2	13,896
Year 3	18,425
Year 4	18,426
Year 5	18,608

Table 4-2 Annual diesel emissions – transport energy purposes

Mining year	GHG emissions (t CO_2-e / annum)
Year 1	362
Year 2	373
Year 3	495
Year 4	495
Year 5	500

4.2 Electricity

Purchased electricity consumption for FY2020–FY2022 was reviewed, with an average of 90 GWh purchased each year. An electricity consumption factor was calculated and applied to the five-year mining schedule.

Using the emission factors and energy content factors within the publication *Australia's emissions projections 2022* (DCCEEW, 2022), an average annual emission of approximately 61,453 t CO_2-e is estimated (ranging from 54,096 t CO_2-e to 73,999 t CO_2-e) for the period.

The annual electricity emissions calculated are shown in Table 4-3.

Table 4-3 Annual electricity emissions

Mining year	GHG emissions (t CO_2-e / annum)
Year 1	73,999
Year 2	63,065
Year 3	58,651
Year 4	57,455
Year 5	54,096

4.3 LPG

LPG usage for Narrabri for FY2019–FY2022 was reviewed, and appears to be constant (i.e. not dependant on production) with an average of 24 tonnes of LPG consumed from stationary sources each year.

Using the emission factors and energy content factors (DCCEEW, 2023), a total annual emission of approximately 31 t CO_2-e is estimated for the period.

The annual LPG emissions calculated are shown in Table 4-4.

Table 4-4 Annual LPG emissions

Mining year	GHG emissions (t CO_2-e / annum)
Year 1	31
Year 2	31
Year 3	31
Year 4	31
Year 5	31

4.4 Fugitive emissions

As part of the development of the GHGMP, NCOPL engaged a suitably qualified specialist to conduct a Gas Emission Review for Longwall 203 to Longwall 206 and Panel 201 to Panel 202 (Palaris 2023) (**gas emission review**). The forecast ROM coal production figures for the five-year period FY23 to FY27 (Year 1 to Year 5) are presented in Table 4-5, representing combined production of coal from development mining, LW 203 to LW 206 extraction and Panel 201 to Panel 202 bord and pillar extraction.

Table 4-5 Forecast ROM coal production relevant to scope of fugitive emissions calculations

Mining year	Total ROM (t / annum)
Year 1	1,827,224
Year 2	6,489,179
Year 3	8,417,498
Year 4	8,566,991
Year 5	6,316,716

Note: Year 1 is lower compared to other years as longwall mining in LW 203 occurs for only a small portion of that year (approximately 570m of LW 203 extracted).

Appendix C provides the gas emissions review, which provides further detail on background data and assumptions used to calculate the emissions for each stream.

4.4.1 Pre-drainage gas

Annual gas capture estimates have been completed using the gas reservoir model and emissions assessment previously developed for the Narrabri Mine, in combination with the five-year mining schedule.

In areas where methane (**CH_4**) composition is greater than 30%, flaring of the captured gas has been assumed. Projected emissions assume the implementation of gas flaring would commence during 2024, allowing for the lead time required for the installation of the flare unit.

Using the emission factors and energy content factors from the *Estimating emissions and energy from coal mining guideline* (Clean Energy Regulator, 2023), an average annual emission of approximately 154,716 t CO_2-e is estimated (ranging from 100,811 t CO_2-e to 200,070 t CO_2-e) for the period.

The annual pre-drainage gas emissions calculated are shown in Table 4-6.

Table 4-6 Annual pre-drainage gas emissions

Mining year	GHG emissions (t CO_2-e / annum)
Year 1	42,246
Year 2	128,203
Year 3	200,070
Year 4	189,780
Year 5	100,811

Note: Year 1 is lower compared to other years as the mining area for LW 203 occurring in that year is short (approximately 570m of LW 203 extracted). As such, this was excluded from the range presented as they do not represent the full year emissions.

4.4.2 Goaf gas

Annual LW emission estimates have been completed using the gas reservoir model and emissions assessment previously developed for the Narrabri Mine, in combination with the five-year mining schedule.

It has been assumed that a post-drainage system is in place with the capture efficiency for each emission zone shown in Appendix C (Figure 2.9).

Using the emission factors and energy content factors (Clean Energy Regulator, 2023), an average annual emission of approximately 52,013 t CO_2-e is estimated (ranging from 20,180 t CO_2-e to 72,256 t CO_2-e) for the period.

The annual goaf gas emissions calculated are shown in Table 4-7.

Table 4-7 Annual goaf gas emissions

Mining year	GHG emissions (t CO_2-e / annum)
Year 1	0
Year 2	20,180
Year 3	52,222
Year 4	72,256
Year 5	63,392

Note: Year 1 mining area is located in a gas emission zone with no requirement for goaf gas capture. As such, this was excluded from the range presented.

4.4.3 Ventilation exhaust gas

An assessment of emissions arising from the extraction of coal was completed to determine the total emissions exhausted by the mine. The following streams were included:

- LW mining emissions;
- development mining rib emissions;
- emissions from sealed mining areas (also referred to as outbye emissions); and
- emissions from bord and pillar mining.

The methodology employed to estimate bord and pillar emissions was the same as for the LW, however, it was assumed that only 30% of the gas would be released during secondary extraction.

Using the emission factors and energy content factors (Clean Energy Regulator, 2023), an average annual emission of approximately 1,181,287 t CO_2-e is estimated (ranging from 975,343 t CO_2-e to 1,334,579 t CO_2-e) for the period.

The annual ventilation gas emissions calculated are shown in Table 4-8.

Table 4-8 Annual ventilation gas emissions

Mining year	GHG emissions (t CO_2-e / annum)
Year 1	835,385
Year 2	1,201,545
Year 3	1,334,579
Year 4	1,213,681
Year 5	975,343

Note: Year 1 is lower compared to other years as the mining area for LW 203 occurring in that year is short (approximately 570m of LW 203 extracted). As such, this was excluded from the range presented as they do not represent the full year emissions.

Outbye emissions estimate

Measured data was assessed for a three-year monitoring period covering the extraction of previous mining areas LW 109, LW 110A and LW 110B. The assessment showed that the assumptions used to estimate GHG emissions from outbye areas (Appendix C) is consistent with the measured data.

Modelled gas concentrations at the upcast shaft

Predicted CH_4 and CO_2 concentrations at the upcast shaft during the mining of Longwall 203–206 have been modelled to range from 0.27% to 0.4% for CH_4 and 0.65% to 0.86% for CO_2. The increase in CH_4 concentration arises from changes to the gas reservoir characteristics of the 200 series panels, with higher CH_4 composition.

The assumptions used to assign gas content and composition to non-coal strata are consistent with measured data assessed for over 400 gas content samples for non-coal strata. Changing the assumption used in the GHG estimates to assign 100% CO_2 to non-coal strata reduces overall GHG emissions by approximately 9% for the LW 203-206 extraction period.

A sensitivity case was modelled assuming virgin gas contents for longwall extraction (i.e. no pre-drainage) to assess the influence on GHG emissions of retaining more seam gas in-situ whilst maintaining the same level of production, which resulted in a reduction of emissions of less than 0.5%. This minor reduction is potentially due to the margin of error of the modelling, meaning that there is likely no difference between the two cases.

Gas retained in coal

Remaining gas content for LW emission models has been assumed to be approximately 3 m^3/t, which is consistent with the values achieved for the 100 series LWs. Verification of this remaining gas content will be obtained once LW 203 commences.

The proposed method includes obtaining coal samples from the LW conveyor belt, placing them in a gas content testing canister (as used for compliance coring). The samples obtained can then be tested as per standard gas content testing procedures. As part of the sample collection, the time taken from when the coal is cut to when the sample is placed in the canister will need to be recorded and a Q1 (lost gas) gas content test completed prior to sending the sample to the laboratory.

4.4.4 Emissions through connective fracturing to surface

A theoretical model was used to ascertain the risk of gas migrating to the surface due to connectivity through fractures. The findings from the theoretical model suggest an effective barrier from the surface to the fractured and caved zones, resulting in a low risk of surface connectivity.

4.5 Post-mining activities

Post-mining activities are defined by the Clean Energy Regulator as ongoing desorption of gas after coal has been mined and it covers the period when the coal sits on the surface in stockpiles, an estimate that is not included in the estimates for gas streams in mine ventilation and gas drainage.

Using the emission factors and energy content factors (Clean Energy Regulator, 2023), an average annual emission of approximately 148,551 t CO_2-e is estimated (ranging from 120,364 t CO_2-e to 173,319 t CO_2-e) for the period. The emission factor to apply is 0.019 t CO2-e post-mining methane emissions per tonne of ROM coal extracted from the mine during the year.

The annual emissions from post-mining activities calculated are shown in Table 4-9.

Table 4-9 Annual emissions from post-mining activities

Mining year	GHG emissions (t CO_2-e / annum)
Year 1	120,364
Year 2	123,500
Year 3	163,400
Year 4	173,319
Year 5	162,173

Note: Year 1 was adjusted to cover the entire year rather than only the forecast period covering the extraction of LW 203 to LW 206 and Panel 201 to Panel 202 (bord and pillar extraction).

Measurement and management of coal stockpile emissions

Fugitive gas emissions from a large coal stockpile are difficult to measure and sample, with collection of data as the main barrier (World Coal, 2013). Whilst some research has been carried out in the field of measuring GHG emissions from coal stockpiles, the information available is limited (Connell, et al., 2012). Current regulations (NGER, 2008) recognise a single method to estimate emissions from post-mining activities (which includes surface stockpiles), therefore, any alternative options that may be investigated for the Narrabri Mine, would not comply with statutory reporting requirements.

A literature review was completed, with a relevant report (IEA, 2013) identifying that limited research has been carried out (available in the public domain) regarding the management of emissions from coal stockpiles. The report concludes that these emissions are difficult to quantify, and it is therefore unfeasible to include a methodology for this purpose.

Stockpile emissions are expected to be low for the Narrabri Mine due to remaining gas contents being at atmospheric pressure, resulting in low desorption of gas, which is in-line with the findings from (Kozinc, et al., 2004), suggesting that coal mine stockpile emissions were negligible.

4.6 Emissions summary

The total emissions for the mine have been calculated to average 1,645,451 t CO_2-e, with an annual average breakdown by source presented in Table 4-10.

Table 4-10 Summary of annual GHG emissions

Emission source	GHG emissions (t CO_2-e / annum)	Proportion of total emissions (%)
Diesel fuel	17,012	1
Electricity	83,543	5
LPG	31	0
Pre-drainage gas	154,716	10
Goaf gas	52,013	3
Ventilation exhaust gas	1,181,287	72
Post-mining emissions	148,551	9

4.7 Emissions reductions performance and targets

Emissions reductions have been achieved through efficiency improvements associated with automation control on diesel generators and the use of variable speed drives on conveyors for demand-driven functionality.

Design and procurement of a pre-drainage gas flare unit during 2024 is estimated to result in emissions reduction of approximately 70,000 t CO_2-e for the five-year mining period once implemented. This represents a reduction of approximately 9.5% in pre-drainage gas emissions and approximately 1% of emissions from all sources.

Future reduction targets will be developed to align with legislated limits on GHGE associated with the Safeguard Mechanism scheme.

5. Options for minimising GHG emissions

NCOPL has commenced work to reduce the GHGE from the operations. Overwhelmingly, the key contributor to emissions at the Narrabri Mine are from fugitive sources. The potential projects to reduce fugitive emissions provide the largest emissions reduction potential, however, due to the high concentrations of CO_2, the abatement measures require specialist, emerging technologies, and are likely to be costly. The Decarbonisation Opportunity Assessment undertaken by Palaris, has recently concluded the following options present as feasible emissions reductions that require further assessment prior to implementation.

5.1 Diesel

Emissions from diesel consumption represent approximately 1% of total GHGE, and as such, it is not anticipated that major GHG reductions will be gained from this source. The following opportunities to reduce diesel consumption will be assessed:

- replacement of diesel generators with solar PV/battery/diesel generators; and
- replacement of diesel generators with mains power;
- review of generator capacity versus requirement;
- automation control on generators to switch on/off when not required; and
- electrification of underground fleet (not currently feasible).

These options will require further analysis to determine the emissions reduction potential and commercial viability. In the short term (<1 year), studies will assess the technical viability of these options, as well as the cost to implement. In the medium term (1-5 years), projects that have secured internal and external approvals will be progressed to the implementation phase.

In line with commitments made in the SoC (Appendix A Table A-2) Narrabri mine will continue to:

- optimise and schedule vehicle operations to minimise vehicle movements;
- maintain engines according to manufacturers' guidelines; and
- minimise vehicle idling time.

5.2 Electricity

Emissions from electricity consumption represent approximately 5% of total GHGE.

Since October 2021, Narrabri mine has offset Scope 2 emissions by utilising a carbon neutral power utility supplier for electricity supply.

The following opportunities to reduce emissions from electricity consumption are currently being assessed further:

- solar PV installation on site;
- utilising the variable speed drives on conveyors for demand-driven functionality that matches LW output; and
- audits of power-intensive systems, such as air compressors, conveyors, and ventilation, to identify energy efficiency opportunities.

These options will require further analysis to determine the emissions reduction potential and commercial viability. In the short term (<1 year), studies will assess the technical viability of these options, as well as the cost to implement. In the medium term (1-5 years), projects that have secured internal and external approvals will be progressed to the implementation phase.

5.3 Coal mine gas

Emissions from fugitive sources represent approximately 94% of total GHGE. The following abatement opportunities are currently being assessed further to reduce the emissions from fugitive sources:

- flaring of pre-drainage gas with a methane content greater than 30% and an oxygen content less than 6%;
- reduce emissions from previously mined areas by investigating the viability of sealing off the northern area once mining has concluded in that area. This will require further analysis to understand the optimal path forward for sealing this area; and
- investigate technologies for separation of CO_2 and CH_4 and potential applications for CO_2 utilisation and/or sequestration.

Figure 5-1 provides a visual representation of the multi-criteria assessment undertaken to prioritise various fugitive emissions abatement opportunities for further investigation based on factors including:

- emissions reduction potential;
- technology readiness and historical usage;
- cost;
- timeframe to implementation; and
- operational risk.

In the short term (<1 year), studies will assess the technical viability of these options, as well as the cost to implement. In the medium term (1-5 years), projects that have secured internal and external approvals will be progressed to the implementation phase.

Technologies being implemented

Decarbonisation Technology	Technology Availability	Historical Usage	Cost	Timeframe	Operational Risk
Flaring of pre-drainage Above 30% CH_4	High	High	High	High	High
Sealing of the Northern LW	High	High	High	High	High

Technologies currently undergoing active review

Decarbonisation Technology	Technology Availability	Historical Usage	Cost	Timeframe	Operational Risk
CH_4 Enrichment + Flaring / Power generation	Medium	Medium	Medium	Medium	Medium
Sequestration	Medium	Low	Medium	Medium	Medium

Technologies under observation for future assessment

Decarbonisation Technology	Technology Availability	Historical Usage	Cost	Timeframe	Operational Risk
Catalytic Conversion Technology	Low	Low	Low	Medium	Medium
VAM Abatement	Low	Low	Low	Low	Low
Direct Air Capture	Medium	Low	Low	Low	Medium

Note: Low, Medium and High ratings indicate the degree of favourability for each criteria type against which the abatement opportunity was assessed. The ratings represent a qualitative evaluation and are to be interpreted as a comparative indicator used to evaluate the relative priority between each of the abatement opportunities assessed. For example, a 'Low' rating applied against cost criteria indicates that cost may be a constraint and has been evaluated as less favourable relative to alternative opportunities.

Figure 5-1 Multi-criteria assessment of fugitive emissions abatement opportunities

Sections 5.3.1 to 5.3.6 provide an overview of abatement measures and technologies that have been assessed by NCOPL to date for the minimisation of Scope 1 fugitive gas emissions through the following reviews:

- *Narrabri Underground Stage 3 Extension Project Abatement Technology Assessment* (Palaris, 2021a); and
- *Narrabri Underground Stage 3 Extension Project GHG Abatement Benchmarking* (Palaris, 2021b).

NCOPL will conduct ongoing monitoring of gas volumes and composition and investigate developments in flaring technology to determine whether flaring of pre-drainage and post-drainage gas is a viable option to reduce GHGE.

5.3.1 Gas pre-drainage options

Management options for underground coal mining pre-drainage will be continually reviewed to increase efficiency and productivity. Options which could be further investigated, tested, and trialled include:

- increase of lead-time for gas pre-drainage via surface to seam drilling, allowing for additional gas to be drained prior to mining and potential for gas capture and mitigation; and
- review gas drainage designs to allow for dewatering of the seam and boreholes increasing pre-drainage efficiency.

5.3.2 Flaring of pre-drainage gas

In relation to flaring of pre-drainage gas with a methane content greater than 30% and an oxygen content less than 6%, options are being explored and assessed to flare pre-drainage gas effectively and safely.

Flaring of pre-drainage gas will feasible when the gas stream from the pre-drainage has a methane content of greater than 30% and an oxygen content of less than 6%. Pre-drainage will only generally take place when the in-situ gas content of the Hoskissons Coal Seam is greater than 3.5 m^3/tonne of coal. As discussed in section 4.4.1, projected emissions assume the implementation of gas flaring would commence during 2024, allowing for the lead time required for the installation of the flare unit. Flares will be enclosed (i.e. the burner head is enclosed with a refractory shell), which will assist to limit potential impacts.

5.3.3 Methane enrichment plants

Gas enrichment commonly uses an amine solution to absorb and separate the carbon dioxide from the mixed methane stream, and therefore diverts more methane into the flaring system by stripping other waste gases.

There is a high level of unknown operational risk associated with gas enrichment plants as there are no known plants which are currently operating in the Australian coal industry.

5.3.4 Low methane concentration power generation

Where the methane content in the pre-drainage gas is high enough (over 25%) the methane can be used for power generation.

Given that the period of time of mining where the gas content is suitable for gas generation (above 25% methane) is short, the costs associated with a power station would not be viable in consideration of the potential payback benefit.

5.3.5 Flaring of low methane concentration goaf gas

The flaring of low methane concentration gas occurs in several industry sectors such as landfill, biogas and oil and gas industries. However, careful consideration must be given to the oxygen levels present when low methane concentrations exist. This is due to the risk of explosion where the gas mixtures become unstable at lower concentrations of methane and higher levels of oxygen, creating an undesirable condition for the operation of a flare.

5.3.6 Ventilation air methane abatement

Ventilation Air Methane (**VAM**) is a GHG abatement measure typically used with low concentrations of methane. VAM greenhouse gas abatement can occur either by flaring or with power generation; however, at ventilation air concentrations of 0.2% - 0.5% CH_4, it is economically and technically more efficient to install VAM without power generation.

At concentrations from 0.5% - 0.8% CH_4, it is economically and technically more efficient to install VAM abatement equipment with energy recovery. Drainage gas support is preferred for energy recovery installations to stabilise input fuel conditions.

Given the wide range of potential VAM methane concentrations, VAM abatement can be designed at full ventilation flow rate (500 m^3/s) or partial ventilation flow rate (125 m^3/s). NCOPL will continue to monitor the methane mix, which is currently below modelled predictions and outside of the VAM operating range.

NCOPL does not consider the VAM abatement measure to be viable given the high capital and operating costs, safety risks, technical challenges of maintaining the Regenerative Thermal Oxidiser's self-sustaining process temperature, and relatively low total abatement.

6. Options for minimising energy use

This section describes the elements of the ESAP required in accordance with Schedule 4, Condition 30 of the Project Approval, including energy management and monitoring measures to reduce energy use at the Narrabri Mine.

NCOPL has commenced work to reduce energy use from the operations. The following opportunities will be assessed to reduce energy consumption:

- regularly maintain plant and equipment to minimise fuel/electricity consumption and associated emissions;
- selection of plant and equipment that are energy efficient;
- training relevant mine personnel on continuous improvement strategies regarding efficient use of plant and equipment, including maintaining equipment to retain high levels of energy efficiency;
- potential upgrades to ROM and product coal handling systems, which may result in reduced dozer utilisation;
- replacement of diesel generators with solar PV/battery/diesel generators;
- sourcing electricity generated by renewable or carbon neutral energy sources;
- solar PV installation on site;
- utilising the variable speed drives on conveyors for demand-driven functionality that matches LW output; and
- audits of power-intensive systems, such as air compressors, conveyors, and ventilation, to identify energy efficiency opportunities.

These options will require further analysis to determine the energy use reduction potential and commercial viability. In the short term (<1 year), studies will assess the technical viability of these options, as well as the cost to implement. In the medium term (1-5 years), projects that have secured internal and external approvals will be progressed to the implementation phase.

The following monitoring program will be implemented to assess the effectiveness of measures to reduce energy use on site:

- conduct an energy audit in accordance with *AS/NZS 3598:2014 Energy Audits* every five years to provide a detailed analysis of energy usage, savings opportunities and the cost to achieving identified savings;
- management review of the energy audit outcomes to determine objectives and management actions; and
- develop an energy efficiency implementation plan.

7. Research program

NCOPL will prepare and implement a research program and allocate funds towards the implementation of the program. The research program will be targeted at genuine research to investigate GHG abatement technologies and methods, including the improvement of abatement of direct Scope 1 GHGE by:

- enrichment of methane content in gas streams to be burnt by flaring (i.e. by stripping methane from waste streams);
- flaring or power generation of gas with low methane content (less than 30% methane);
- capture of carbon dioxide for beneficial re-use or sequestration; and
- other identified potential abatement options.

Table 7-1 provides an overview of the projects forming part of the current NCOPL research program regarding greenhouse gas minimisation.

Table 7-1 Current research study projects

Project	Description
Narrabri Northern Area fugitive reduction study	This study aims to provide guidance on the recommended method of sealing LW panels to reduce VAM contribution from existing LW panel goaf seals. The study will involve: • initial characterisation including review of existing ventilation modelling, planned ventilation changes, ventilation audits, goaf sealing and management practices and gas monitoring data; • establish current baseline VAM contribution from seals and forecast expected make post-sealing based on conceptual remediation options; • develop approach for post-sealing monitoring to improve confidence in validation of abatement improvements; • review and select options for further detailed study; • review post-sealing data against modelled options to confirm validity of baseline assumptions and assess identified options to quantify expected abatement benefit; and • development, modelling and assessment of options to evaluate each method and risk assess the selected preferred method.
Carbon capture, utilisation and storage	This study will involve: • review of publicly available drilling information from exploration wells on site and adjacent to the site; • review regional geology and stratigraphy and define potential geosequestration reservoirs that may be available for CO_2 storage (including coal seams, sandstone reservoirs and other formations) • develop a simplistic, broad regional model of the reservoirs to enable prediction of depths to potential targets; • assess coal seam reservoir potential based on gas composition and permeability of coal seams at depth; and • identify structural or other features which may influence release of CO_2 from target reservoirs.

Project	Description
Site CO_2 sequestration	This concept level study aims to investigate the feasibility of CO_2 sequestration in deep undersaturated coal seams. The study will involve: • assessment of gas reservoir suitability; • review of geological conditions, petrophysical properties and rock mechanics relevant to CO_2 sequestration; • determination of drilling and exploration requirements, including assessment of conceptual dual use exploration/injection ready hole design; • estimation of potential gas storage rates; and • conceptual description of a small-scale pilot program (using pre-drainage gas) and evaluation of horizontal well construction opportunities.

Research and analysis of existing and emerging emission reduction technologies for Scope 1 emissions is actively undertaken at a Whitehaven Coal Group level. One example of these emerging technologies is a process owned by Hydrobe Pty Limited (Hydrobe), in which Whitehaven Coal is a significant investor. Hydrobe has a world-patented process to run industrial emissions through chambers of specially selected microbial algae and bacteria that turn CO_2 into saleable products including fertiliser, green hydrogen and syngas. Whitehaven Coal is considering the application of this technology to mine sites and to end users of Whitehaven Coal's products. The difference in the Hydrobe approach to decarbonisation is that the company's patented biological process converts CO_2 without generating new CO_2. That is, Hydrobe's energy requirements are generated from biological reactions.

NCOPL have developed a decarbonisation pathway to identify other GHGE abatement measures for all fugitive emissions. This is a three-phased approach which has been developed to ensure that all abatement opportunities are identified and screened, with financial and technical analysis applied to prioritise the pathway, in order to implement the most appropriate and feasible abatement measure/s. The decarbonisation pathway will apply to the broader Narrabri Mine in accordance with Schedule 4 Condition 32(e) of the Project Approval and is summarised below:

- **Phase 1: Mapping the Carbon Footprint:**
  - The first step is to map an operation's carbon footprint. Emission sources are categorised into four emission types (fugitive, mobile combustion, stationary combustion, and process) to develop a comprehensive emissions profile.
- **Phase 2: Identifying Abatement Opportunities**
  - The second phase is to identify the abatement opportunities available to NCOPL with recommendations as to which technologies are most suited to take forward to prioritisation.
  - This is through identifying and reviewing all significant abatement opportunities that can reduce Scope 1 and Scope 2 emissions and evaluating these opportunities using an assessment framework.
  - Opportunities with viable emissions reduction potential are taken through to phase 3.
- **Phase 3: Pathway Prioritisation**
  - Prioritisation is done via a Marginal Abatement Cost Curve to quantify the emissions reduction potential of abatement opportunities
  - This phase will detail the potential abatement options for NCOPL and will include estimates of associated costs (CAPEX and OPEX), and recommendations for a forward pathway.

8. Contingency plan

It is considered unlikely that operation of the mine will result in any unpredicted or unforeseen impacts regarding GHGE.

Under the Safeguard Mechanism scheme, NCOPL has a requirement to report on and reduce its annual emissions. In the event of an unforeseen change in the emissions produced by the Narrabri Mine, NCOPL will be required to reduce of offset the emissions produced.

9. Incidents and non-compliance

9.1 Incident notification

An incident is defined under the Project Approval as *a set of circumstances that causes or threatens to cause material harm, and/or breaches or exceeds the limits of performance measures/criteria*. Material harm to the environment is defined under the Project Approval as *involving actual or potential harm to the health or safety of human beings or to the environment that is not trivial.* This definition excludes "harm" that is authorised under the Project Approval or any other statutory approval (e.g., the Environmental Protection License [**EPL**]).

In the event of any exceedance of the performance criteria, NCOPL will advise the Secretary and any other relevant agencies as soon as practicable after becoming aware of the incident, in accordance with Schedule 6 Condition 4. Within 7 days of the event, NCOPL will also provide the Secretary and any relevant agencies a detailed report which will:

- describe the date, time and nature of the exceedance/incident;
- identify the cause (or likely cause) of the exceedance/incident;
- describe what action has been taken to date; and
- describe the proposed measures to address the exceedance/incident.

Notifications to the NSW Environment Protection Authority will be made by contacting the Environment Line on 131 555 and written details of the notification will be provided within 7 days of the date on which the incident occurred.

Incident reporting and emergency response is further described in NCOPLs EMS.

9.2 Non-compliance

In accordance with Schedule 6 Condition 2, where a non-compliance with a statutory requirement/s or an exceedance of the relevant criteria or performance measures has occurred, NCOPL will, at the earliest opportunity, take all reasonable and feasible steps to ensure that the exceedance ceases and does not recur. Once this has been achieved, all reasonable and feasible options for remediation (where relevant) will be considered.

In accordance with Schedule 6 Condition 4, within seven days of becoming aware of a non-compliance, NCOPL will notify DPE of the non-compliance[3]. The notification will be made in writing via the Major Projects website and identify the development (including the development application number and name), set out the condition or requirement that the development is non-compliant with, why it does not comply and the reasons for the non-compliance (if known) and what actions have been, or will be, undertaken to address the non-compliance.

NCOPL will implement any reasonable remediation measures as directed by the Secretary, to the satisfaction of the Secretary.

[3] A non-compliance which has been notified as an incident under section 9.1 does not need to also be notified as a non-compliance under section 9.2.

10. Reporting, evaluation and review

10.1 Annual Review

In accordance with Schedule 6 Condition 6, NCOPL will review the performance of its GHGE for the previous calendar year and report the relevant results within the Annual Review, to the satisfaction of the Secretary. The Annual Review will at minimum provide information regarding the effectiveness of the management measures to prevent, and if prevention is not reasonable and feasible, to minimise any impact to the environment.

Further, the Annual Review requires a number of items to be reviewed or assessed. In summary these are:

- monitoring results and complaints;
- non-compliances and incidents;
- compliance with performance measures;
- discrepancies between predicted and actual impacts; and
- measures to be implemented to improve environmental performance.

The Annual Review may also make recommendations for any additions, changes, or improvements to NCOPLs environmental management procedures.

The Annual Review will be made available on the WHC website.

10.2 Independent environmental audits

Prior to 13 September 2010, and every 3 years thereafter, unless the Secretary directs otherwise, NCOPL will commission and pay the full cost of an Independent Environmental Audit (**IEA**) of the development (Stages 1 and 2), to be conducted in accordance with the requirements of Schedule 6 Condition 7.

The audit team will be led by a suitably qualified auditor and the IEA will be conducted by suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Secretary.

10.3 Management plan review and evaluation

As required by Schedule 6 Condition 3 of the Project Approval, NCOPL will review, and if necessary, revise this Plan, within three months of any of the following:

- submission of an IEA (as required by Schedule 6 Condition 7);
- submission of an Incident Report (as required by Schedule 6 Condition 4);
- submission of an Annual Review (as required by Schedule 6 Condition 6); and
- any modification to the conditions of the Project Approval (unless the conditions require otherwise).

This is to ensure that the strategies, plans and programs are updated on a regular basis, and incorporate any recommended measures to improve the environmental performance of the Narrabri Mine operations.

Schedule 6 Condition 3 further states that if the review determines that this GHGMP requires revision, then this will be completed to the satisfaction of the Secretary. A dedicated review register will be maintained which will provide the details of the review of all relevant strategies, plans and programs that need to be reviewed as

required under Schedule 6 Condition 3 of the Project Approval. The revision status of this GHGMP is indicated in section 14.

10.4 Improvement measures

Project Approval Schedule 6 Condition 2(f) requires this Plan to include a program to investigate and implement ways to improve the environmental performance of the development over time. Improvement measures may be investigated through review of the following:

- monitoring data, and any assessment of trends;
- audit outcomes, including audits of the water management measures; and
- incident reports, including any community complaints.

Reasonable and feasible improvement measures will be implemented and documented as a management measure in a revision to the Plan as described in section 10.3.

In accordance with Schedule 6 Condition 2(g) a protocol for periodic review of this Plan has been addressed under section 10.3.

11. Complaints management

Any complaints received in relation to GHG will be managed in accordance with the complaints management protocol as follows:

- publicly advertised telephone complaints line, 1800WHAVEN, will be in place to receive complaints.
- each complaint received will be recorded in a Complaints Register, which will include the following details:
  - date and time of complaint;
  - method by which a complaint was made;
  - personal details the complainant wishes to provide or, if no such details are provided, a note to that effect;
  - nature of the incident that led to the complaint;
  - action taken by NCOPL in relation to the complaint (i.e., any required remedial actions), including any follow-up contact with the complainant; and
  - if no action was taken, the reason why no action was taken.
- the Environmental Superintendent will be responsible for ensuring that an initial response is provided within 24 hours of receipt of a complaint (except in the event of complaints recorded when the mine is not operational or outside of usual business hours).
- once the identified measures are undertaken, the Environmental Superintendent will sign off on the relevant complaint within the Complaints Register.
- if necessary, follow-up monitoring will take place to confirm the source of the complaint is adequately mitigated.
- a summary of the complaints will be maintained by NCOPL and made available to the Community Consultative Committee, the complainant (on request) and on the WHC website. A summary of complaints received every 12 months will be provided in the Annual Review.

In the event that any complainant considers that NCOPL has not adequately addressed their concerns, the NCOPL representative will convene additional meetings with the complainant. If the complainant believes the matter remains unresolved, and no further agreement can be reached as to additional measures to be undertaken, then they may refer the matter to DPE.

12. References

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Clean Energy Regulator, Australian Government (July 2023). *Estimating emissions and energy from coal mining guideline.*

Clean Energy Regulator, Australian Government (August 2017). *Reporting consumption of liquid fuels guideline.*

Connell, L., Lu, M., Chen, Z. & Chen , D. (2012). *Estimation Of The Residual Gas Content In Mined Coal And Coal Waste - ACARP Report C20004*, s.l.: ACARP.

Department of Climate Change, Energy, the Environment and Water (February 2023). *Australian National Greenhouse Accounts Factors.*

Department of Climate Change, Energy, the Environment and Water (December 2022). *Australia's emissions projections 2022.*

IEA (2013). *Gaseous Emissions from Coal Stockpiles*, s.l.: International Energy Agency - Clean Coal Centre.

Kozinc, J., Zupancic-Kralj, L. & Zapusek, A. (2004). *Evaluation of gas emissions from coal stockpile*. Chemosphere, 55(8), pp. 1121-1126.

Palaris Australia Pty Ltd (May 2021) *Narrabri Underground Mine Stage 3 Extension Project Abatement Technology Assessment*. Prepared for Narrabri Coal Operations Pty Ltd.

Palaris Australia Pty Ltd (October 2021) *Narrabri Underground Mine Stage 3 Extension Project GHG Abatement Benchmarking*. Prepared for Narrabri Coal Operations Pty Ltd.

Palaris Australia Pty Ltd (May 2023) Gas Emission Review for Longwall 203 to Longwall 206 and Panel 201 to Panel 202. Prepared for Narrabri Coal Operations Pty Ltd.

Standards Australia (2014). *Australian Standard / New Zealand Standard 3598:2014 Energy Audits.*

World Coal (2013). *Gaseous emissions from coal stockpiles*. [Online] Available at: https://www.worldcoal.com/coal/25022013/gaseous_emissions_from_coal_stockpiles-193/

13. Glossary

Term	Definition
Annual Review	The review required by Condition 6 of Schedule 6
Department	The NSW Department of Planning and Environment (DPE)
Environment	Includes all aspects of the surroundings of humans, whether affecting any human as an individual or in his or her social groupings
Feasible	Feasible relates to engineering considerations and what is practical to build
Goaf	The mined-out area into which the immediate roof strata breaks
Incident	A set of circumstances that causes or threatens to cause material harm to the environment, and/or breaches or exceeds the limits of performance measures/criteria in the Project Approval
Material harm	Harm to the environment is material if it involves actual or potential harm to the health or safety of human beings or ecosystems that is not trivial
Minimise	Implement all reasonable and feasible mitigation measures to reduce the impacts of the Narrabri Mine
Mining operations	The extraction, processing and transportation of coal on the site, including the formation of mine access drifts and associated surface infrastructure such as gas and water drainage facilities.
Mitigation	Activities associated with reducing the impacts of the development
Narrabri Mine	The development approved under Project Approval 05_0102 and Project Approval 08_0144
Non-compliance	An occurrence, set of circumstances or development that is a breach of the conditions of the statutory approvals
Plan	Greenhouse Gas Minimisation Plan
Reasonable	Reasonable relates to the application of judgement in arriving at a decision, taking into account: mitigation benefits, cost of mitigation versus benefits provided, community views and the nature and extent of potential improvements.
Second workings	Extraction of coal from longwall panels, mini-wall panels or pillar extraction
Secretary	Planning Secretary under the EP&A Act, or nominee
Stage 2	Narrabri Mine Stage 2 approved under PA 08_0144
Statement of Commitments	The Proponent's revised commitments in Appendix 3, dated May 2010

14. Review history

Revision	Comments	Author	Authorised by	Date
0	Initial document	M Doyle	S Pegg	June 2012
1	Revision following Annual Review submission	S Farrar	D Ellwood	June 2017
2	Revision following Decarbonisation Opportunity Assessment	M Gale	S Rily	June 2023
2B	Approved by the Department of Planning and Environment 21 December 2023	M Gale	S Rily	August 2023

Appendix A Compliance conditions relevant to this Plan

Table A-1 Project Approval conditions relevant to this Plan

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
Schedule 2, Condition 1	The Proponent shall implement all practicable measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation of the project.	Section 5 Section 6
Schedule 2, Condition 2	The Proponent shall carry out the project generally in accordance with the: (a) EA; and (b) conditions of this approval.	Section 3 Appendix A
Schedule 2, Condition 11	With the approval of the Secretary, the Proponent may submit any management plan or monitoring program required by this approval on a progressive basis. ***Note**: The conditions of this approval require certain strategies, plans, and programs to be prepared for the project. They also require these documents to be reviewed and audited on a regular basis to ensure they remain effective. However, in some instances, it will not be necessary or practicable to prepare these documents for the whole project at any one time, particularly as these documents are intended to be dynamic and improved over time. Consequently, the documents may be prepared and implemented on a progressive basis, subject to the conditions of this approval. In doing this however, the Proponent will need to demonstrate that it has suitable documents in place to manage the existing operations of the project.*	No staging of the GHGMP proposed
Schedule 4, Condition 7	The Proponent shall:	
	(a) implement all reasonable and feasible measures to minimise the:	Section 5 Section 6 Section 7 Refer to the Air Quality Management Plan
	• odour, fume and dust emissions of the project; and	
	• release of greenhouse gas emissions from the project;	
	(b) operate a comprehensive air quality management system that uses a combination of predictive meteorological forecasting and real-time air quality monitoring data to guide the day to day planning of operations and the implementation of both proactive and reactive air quality mitigation measures to ensure compliance with the relevant conditions of this approval;	Refer to the Air Quality Management Plan
	(c) minimise any visible air pollution; and	
	(d) minimise the air quality impacts of the project during adverse meteorological conditions and extraordinary events (see note d to Tables 4-6 above).	
	to the satisfaction of the Secretary.	

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
Schedule 4, Condition 30	The Proponent shall revise the Energy Savings Action Plan for the Stage 1 project to encompass all proposed mine activities and potential impacts associated with energy management for the site (Stages 1 and 2) and subsequently implement this revised version of the Energy Savings Action Plan to the satisfaction of the Secretary. This plan must:	Section 6
	(a) be prepared in consultation with BCS;	Section 1.4
	(b) be prepared in accordance with the *Guidelines for Energy Savings Action Plans (DEUS, 2005)*, or its latest version;	Section 6 No latest version available for guidance
	(c) be submitted to the Secretary for approval prior to 30 June 2011; and	Not applicable to the revision of this GHGMP
	(d) include a program to monitor the effectiveness of measures to reduce energy use on site.	Section 6
Schedule 4, Condition 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 secretary.	Section 5 Section 7
Schedule 4 Condition 32	Prior to carrying out longwall coal mining operations, the proponent shall submit a Greenhouse Gas Minimisation Plan for the approval of the Secretary. This plan must:	
	(a) be prepared in consultation with BCS;	Section 1.4
	(b) identify options for minimising greenhouse gas emissions from underground mining operations, with a particular focus on capturing and/or using these emissions;	Section 5 Section 7
	(c) investigate the feasibility of implementing each option;	Section 5 Section 7
	(d) propose the measures that would be implemented in the short to medium term on site; and	Section 5
	(e) include a research program to inform the continuous improvement of the greenhouse gas minimisation measures on site.	Section 7
Schedule 6, Condition 2	The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
	a) detailed baseline data;	Section 4
	b) a description of:	
	• the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Section 3 Appendix A
	• any relevant limits or performance measures/criteria;	Section 3.1

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
	• the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures	
	c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria:	Section 5 Section 6 Section 7
	d) a program to monitor and report on the:	
	• impacts and environmental performance of the project;	Section 6 Section 7 Section 10.1
	• effectiveness of any management measures (see (c) above);	
	e) a contingency plan to manage any unpredicted impacts and their consequences;	Section 8
	f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Section 10.4
	g) a protocol for managing and reporting any:	
	• incidents;	Section 9.1
	• complaints;	Section 11
	• non-compliances with statutory requirements; and	Section 9.2
	• exceedances of the impact assessment criteria and/or performance criteria; and	Section 8
	h) a protocol for periodic review of the plan.	Section 10.3
Schedule 6 Condition 3	Within 3 months of the submission of an:	Section 10.3
	a) audit under condition 7 of Schedule 6;	
	b) incident report under condition 4 of Schedule 6; and	
	c) annual review under condition 5 of Schedule 6; and	
	d) any modification to the conditions of this approval (unless the conditions require otherwise),	
	the Proponent shall review, and if necessary revise, the strategies, plans, and programs required under this approval to the satisfaction of the Secretary.	
Schedule 6 Condition 4	The Proponent shall notify the Secretary in writing via the Major Projects website and any other relevant agencies of any incident associated with the project as soon as practicable after the Proponent becomes aware of the incident. Within 7 days of the date of the incident, the Proponent shall provide the Secretary and any relevant agencies with a detailed report on the incident.	Section 9.1
Schedule 6 Condition 5	The Proponent shall provide regular reporting on the environmental performance of the project on its website, in accordance with the reporting arrangements in any plans or programs approved under the conditions of this approval, and to the satisfaction of the Secretary.	Section 10.1

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
Schedule 6 Condition 6	By the end of March each year, the Proponent must submit a review of the environmental performance of the project for the previous calendar year to the satisfaction of the Secretary.	
Schedule 6 Condition 7	Prior to 13 September 2010, and every 3 years thereafter, unless the Secretary directs otherwise, the Proponent shall commission and pay the full cost of an Independent Environmental Audit of the project (Stages 1 and 2).	Section 10.2
Schedule 6 Condition 10	The Proponent shall: (a) make copies of the following publicly available on its website: • the documents referred to in Condition 2 of Schedule 2; • all current statutory approvals for the project; • all approved strategies, plans and programs required under the conditions of this approval; • a comprehensive summary of the monitoring results of the project, reported in accordance with the specifications in any conditions of this approval, or any approved plans and programs; • a complaints register, updated on a monthly basis; • minutes of CCC meetings; • the annual reviews of the project; • any independent environmental audit of the project, and the Proponent's response to the recommendations in any audit; • any other matter required by the Secretary; and	Section 1.5 Section 10.1 Section 10.2 Section 11
	(b) keep this information up-to-date, to the satisfaction of the Secretary.	

Table A-2 Statement of Commitments – greenhouse gas

SoC	Commitment	Reference
11.18	Optimise and schedule vehicle operations to minimise vehicle movements.	Section 5.1
11.19	Maintain engines according to manufacturers' guidelines and keep tyres at optimum pressure.	
11.20	Minimise vehicle idling time.	
11.21	Prepare an updated Energy Savings Action Plan (ESAP).	Section 6

Appendix B Consultation records

DOC23/552303-1

30 June 2023

Shane Rily
Environmental Superintendent
Narrabri Coal Operations
Whitehaven Coal
10 Kurrajong Road
BAAN BAA NSW 2390
Email: SRily@whitehavencoal.com.au

Response to the draft Greenhouse Gas Minimisation Plan

Dear Mr Rily,

Thank you for consulting the NSW Environment Protection Authority (EPA) on the draft Greenhouse Gas Minimisation Plan prior to being submitted for approval to the Department of Planning and Environment.

The EPA encourages the development of Environmental Management Plans and Programs to ensure that licensees have determined how they will meet their statutory obligations and environmental objectives as specified by any Project Approval (or other statutory approval) and/or the conditions of an environment protection licence. However, the EPA does not review these plans and programs (unless in circumstances deemed necessary) as the role of the EPA is to set conditions, or criteria, for environmental protection and management and not to be directly involved in the development of strategies to comply with such conditions or criteria.

In this instance, the EPA will not be providing any specific comment on the management plans. As a management tool, such plans and programs should assist Narrabri Coal Operations in meeting their commitment to statutory compliance and wider environmental management and where appropriate should be integrated with other management plans.

The EPA has recently released a Climate Change Policy and Action Plan 2023-26. The Policy and Action Plan outlines the EPA's regulatory approach and set of actions to address climate change in NSW, within the EPA regulatory remit. The Climate Change policy and Action Plan can be found on the EPA website at: www.epa.nsw.gov.au/your-environment/climate-change/policy-and-action-plan.

If you have any questions about this request, please contact Daniel Stokes on 02 4908 6804 or via email at info@epa.nsw.gov.au.

Yours sincerely

LINDSAY FULLOON
Manager Regulatory Operations
Regulatory Operations Regional West

Department of Planning and Environment

Our ref:DOC23/600081

Shane Rily
Environmental Superintendent
Narrabri Coal Operations
SRily@whitehavencoal.com.au

Dear Shane

Narrabri Underground Mine Stage 2 Project – Greenhouse Gas Minimisation Plan

Thank you for your e-mail dated 23 June 2023 to the Biodiversity, Conservation and Science Directorate (BCS) of the Department of Planning and Environment (DPE) inviting comments on the Narrabri Underground Mine Stage 2 Project – Greenhouse Gas Minimisation Plan.

BCS have no specific comments to make on this plan, given we no longer contain an atmospheric science branch within our Directorate. We support your intention to consult with the Climate and Science (CAS) Branch of the DPE and the Environmental Protection Authority (EPA) as the appropriate agencies in this circumstance.

If you have any questions about this advice, please do not hesitate to contact me, A/ Principal Project Manager, via ben.ellis@environment.nsw.gov.au or (02) 8275 1838.

Yours sincerely

Ben Ellis

A/ Principal Project Manager Planning North West

Biodiversity, Conservation and Science Directorate

6 July 2023

Department of Planning and Environment

Our ref: MP08_0144-PA-53

Mr Shane Rily
Environmental Superintendent
Narrabri Coal Operations Pty Ltd

21/12/2023

Subject: Narrabri Coal Mine – Stage 2 Greenhouse Gas Minimisation Plan

Dear Mr Riley

I refer to the Greenhouse Gas Minimisation Plan (GHGMP) submitted in accordance with Condition 32, Schedule 4 of the consent for the Narrabri Coal Mine – Stage 2 (MP08_0144-PA-53). I also acknowledge your response to the Department's review comments and request for additional information.

I note the Greenhouse Gas Minimisation Plan has been prepared in consultation with the Independent Expert Advisory Panel (the panel) and the Department's Net Zero Emissions Modelling (NZEM) team and contains the information required by the conditions of consent.

Accordingly, as nominee of the Planning Secretary, I approve the Greenhouse Gas Minimisation Plan (revision 2B, dated 28 August 2023).

The Department also notes the panels advice (attached) with regard to future GHGMP's that are required, and as such, should continue to reflect substantive improvements in detailing how greenhouse gas emissions are assessed and in reporting on the implementation and impact of measures to minimise greenhouse gas emissions.

You are reminded that if there are any inconsistencies between the Greenhouse Gas Minimisation Plan and the conditions of consent, the conditions prevail.

Please ensure you make the document publicly available on the project website at the earliest convenience.

If you wish to discuss the matter further, please contact Brittany Golding on 02 9995 5742.

Yours sincerely

Stephen O'Donoghue
Director
Resource Assessments
As nominee of the Planning Secretary

Appendix C Gas Emission Review

Report

Gas Emission Review for Longwall 203 to Longwall 206 and Panel 201 to Panel 202

Client	Whitehaven Coal Limited (Corporate)
Site	Narrabri Mine
Date	7 Jun 2023
Doc No.	WHC6640-01

IMPORTANT NOTICE

The Client

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VERSION MANAGEMENT

Process	Name	Date	Version
Author	E Yurakov, F Palominos	18 May 23	1
Peer Review By	J Pala	19 May 23	2
Draft Issued To	M Gale	29 May 23	4
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EXECUTIVE SUMMARY

An initial assessment of greenhouse gas (GHG) emissions for Longwall 203 to 206 was completed by Palaris in November 2022 (WHC6420-02, 2022).

The gas reservoir characterisation has been updated since the creation of WHC6420-02, resulting in updated emission models and GHG emission forecast (WHC6500-02, 2023).

The main changes identified for the gas reservoir include:

- Larger area of higher virgin gas contents (>5.5 m^3/t) identified for Longwall 203-205 and Panel 201-202 (cut and flit (C&F) panels)
- Increased methane (CH_4) composition for Longwall 203-204 of up to 40% CH_4 (compared to 25% previously)
- Larger area with potential for flaring of gas (where CH_4 composition >30%)

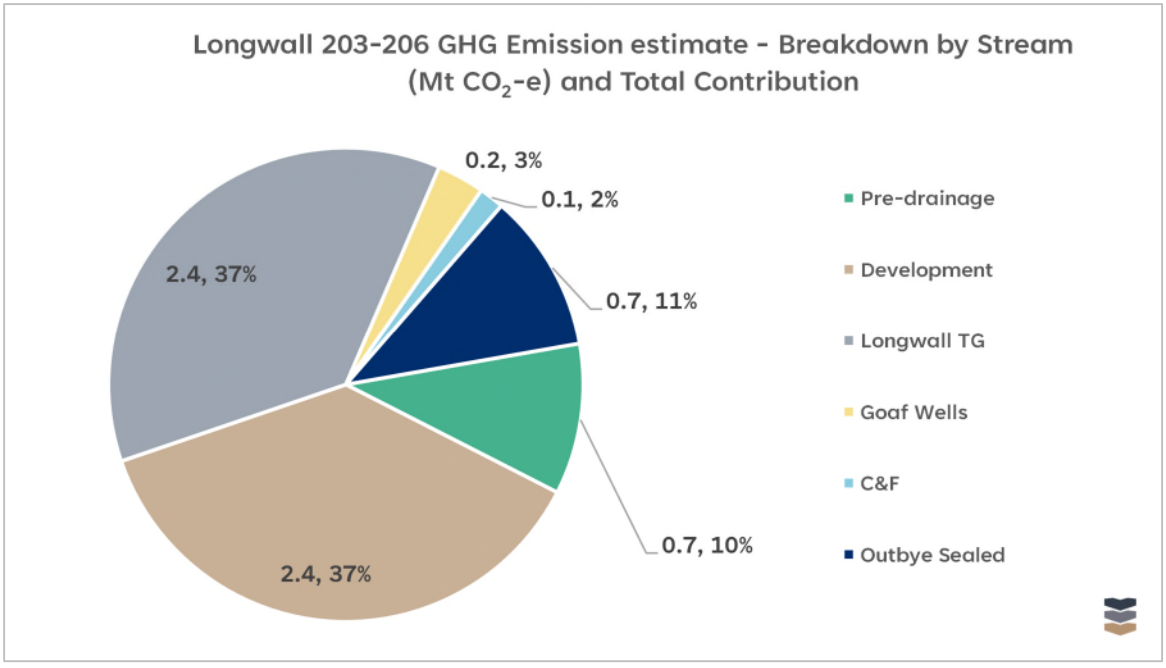
The gas emissions review for Longwall 203-206 has been updated to incorporate:

- The changes to the reservoir model characterisation and emission models under WHC6500-02
- Inclusion of C&F mining gas emission stream, associated with Panel 201-202
- An updated mining schedule ("230127a4 Narrabri Spry - MASTER ES") as used in WHC6500-02

These changes to the gas reservoir characteristics result in GHG emissions ~40% higher compared to the ones presented in WHC6420-02.

Total emissions are estimated to be ~6.4 Mt CO_2-e, with an average of ~1.29 Mt CO_2-e per financial year. The main contributors include:

- Development stream (~37%)
- Longwall tailgate stream (~37%)
- Outbye sealed areas stream (~11%)



1 GAS RESERVOIR SUMMARY

1.1 Seam Thickness

HSK seam thickness ranges from 6 m to 9 m, with most of Longwall 203-206 and Panel 201-202 (the study area) being between 6-8 m (Figure 1.1).

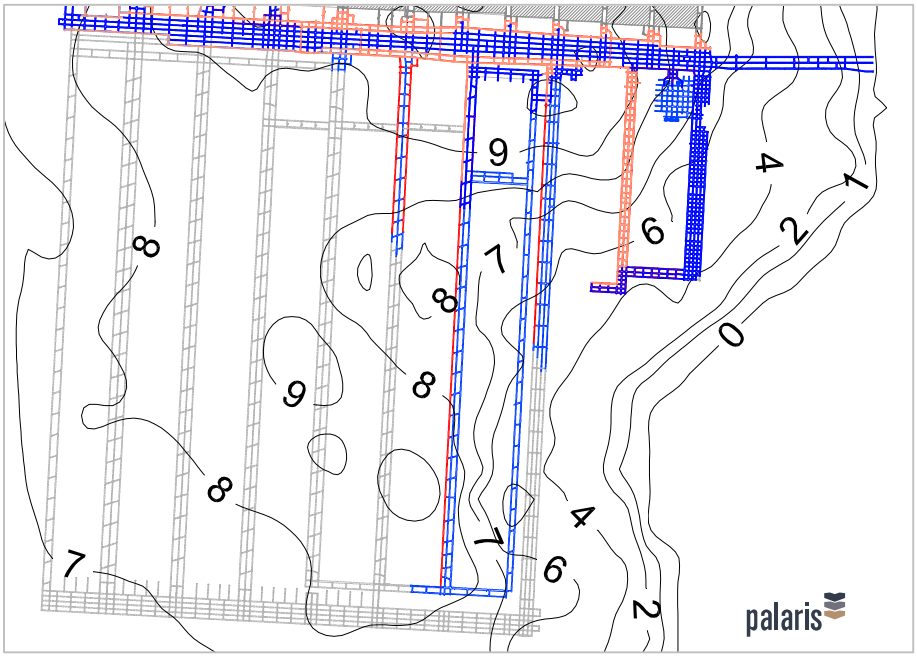


Figure 1.1 HSK Seam Thickness

1.2 Seam Ash

HSK seam ash varies from 10% to 30% for the 200 series, typically between 15% and 25% for the study area (Figure 1.2).

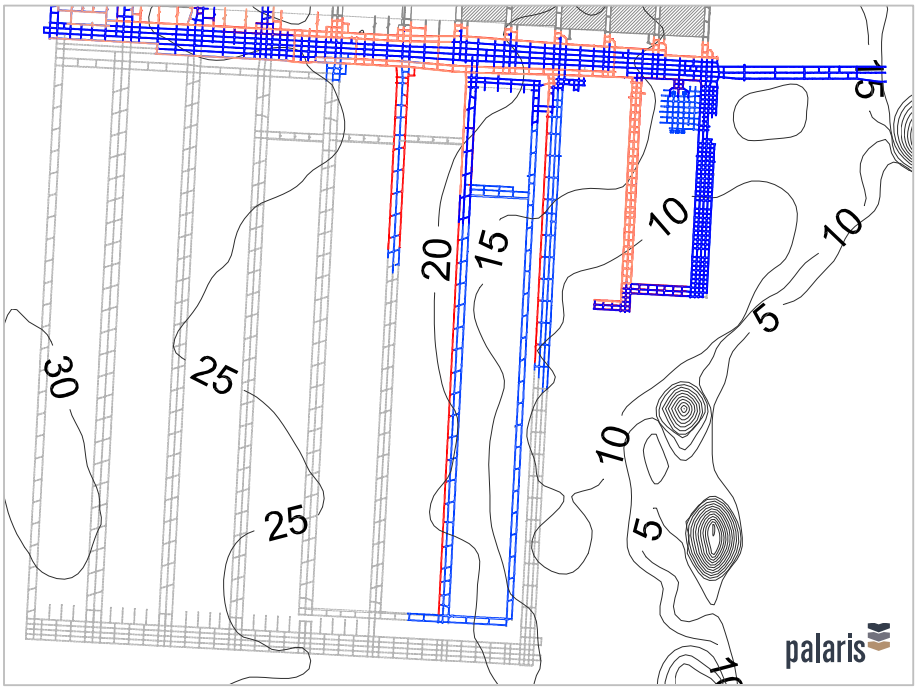


Figure 1.2 HSK Seam Ash

1.3 Gas Content

On a seam ash basis, the gas content ranges from 4 m^3/t to 8 m^3/t for the 200 series panels. The highest gas contents (>5.5 m^3/t) are in the north-east section, around the C&F panels and the outbye half of Longwalls 203-205, with gas content reducing to the south-west (Figure 1.3).

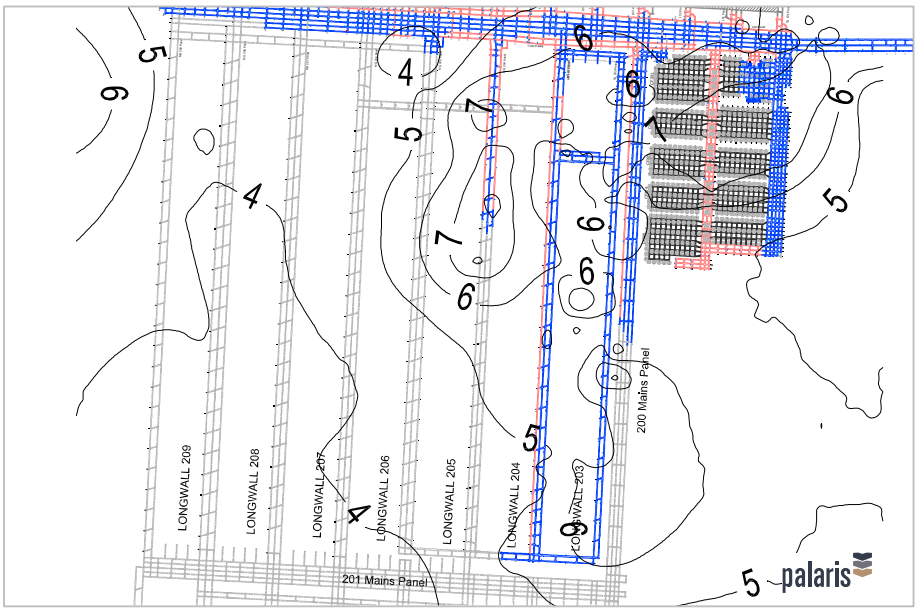


Figure 1.3 HSK Seam Virgin Gas Content (at seam ash)

1.4 Gas Composition

Seam gas composition for the 200 series panels is in the range of 10%-40% CH_4.

The typical CH_4 gas composition for the southern longwalls is different to that experienced in the 100 series panels, which was <10-15% CH_4.

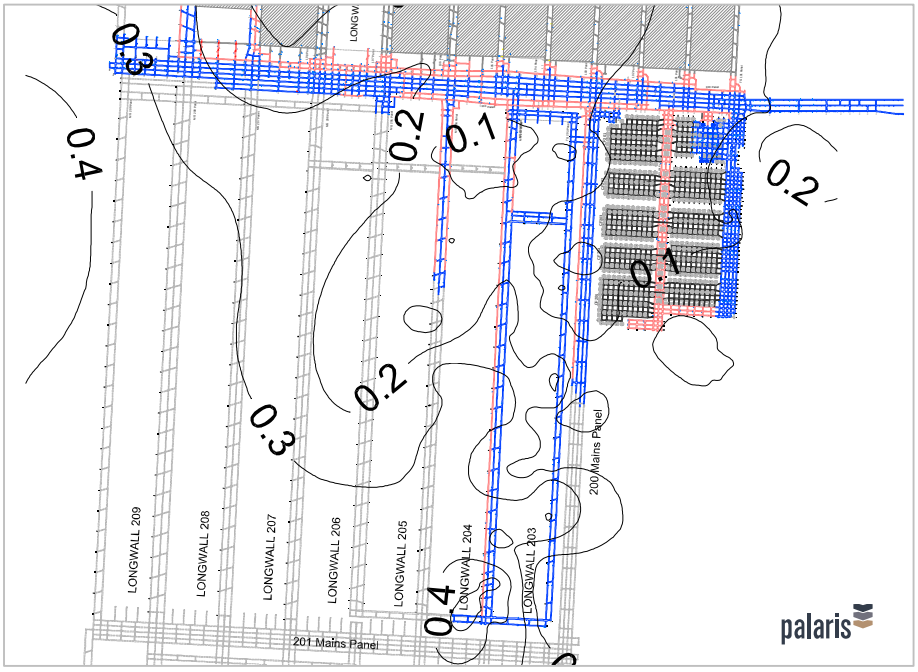


Figure 1.4 HSK Seam Gas Composition ($CH_4/(CH_4+CO_2)$)

2 GAS EMISSIONS

Narrabri Mine has commissioned a forecast for greenhouse gas (GHG) emissions produced from mining of the Hoskissons (HSK) Seam for the study area.

An updated mine schedule ("230127a4 Narrabri Spry - MASTER ES") has been used to determine the extent of the workings encompassed by the study area, which cover the period from ~FY23-FY27 (Figure 2.1).

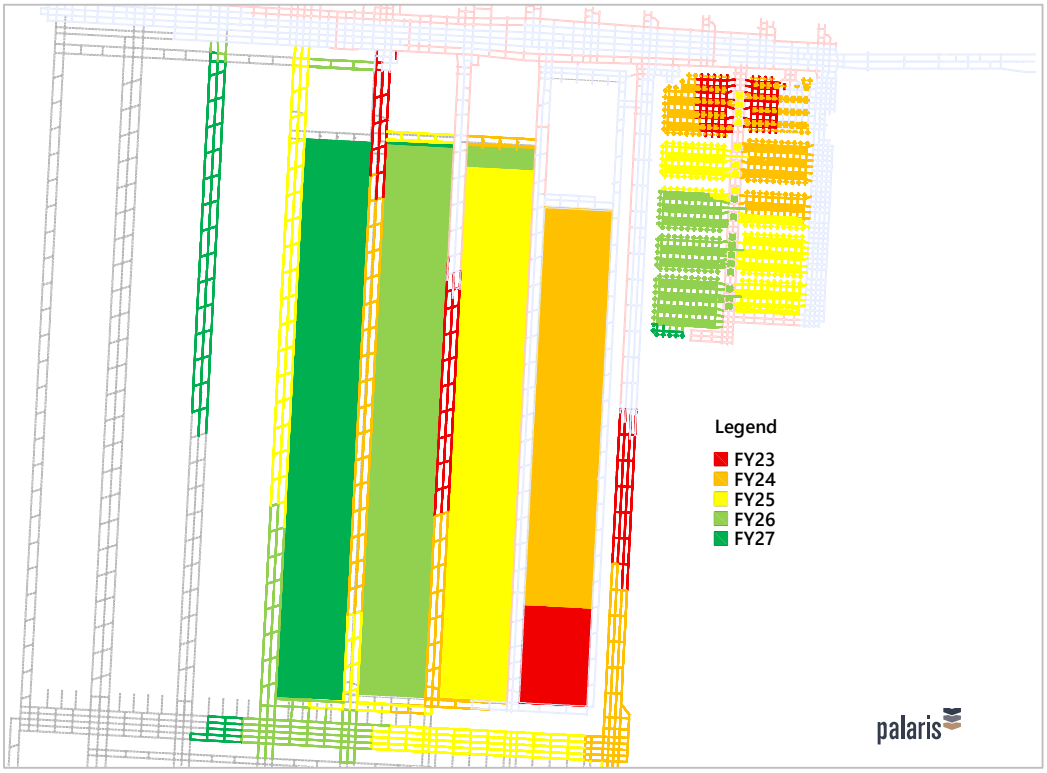


Figure 2.1 Longwall 203-206 Study Area

The extent of the calculations excludes emissions from the 100 series panels and from post mining activities. The emissions have not been updated to capture findings completed since May 2023. The streams used for the emissions calculations are as follows:

- Gas pre-drainage stream
- Development mining stream
- Longwall mining stream
- C&F mining stream
- Outbye sealed areas stream

Since the development of WHC6420-02, the gas reservoir characterisation and emission models have been updated to reflect newly available data for the Hoskissons (HSK) Seam obtained as part of the compliance coring program around the study area, with an additional ~130 cores taken and added to the gas database (WHC6500-02, 2023).

The updated models were used in conjunction with the mine schedule noted above to calculate the emissions for each stream.

The methodology and assumptions employed for the calculations of each stream are described in the relevant section.

2.1 Gas Pre-drainage Stream

Pre-drainage of the HSK Seam is planned to occur in areas where the virgin gas content is greater than 3.5 m^3/t (Figure 2.2). The gas is assumed to drain to an estimated remaining gas content of 3.5 m^3/t, which reflects the actual results achieved in the 100 series longwalls.

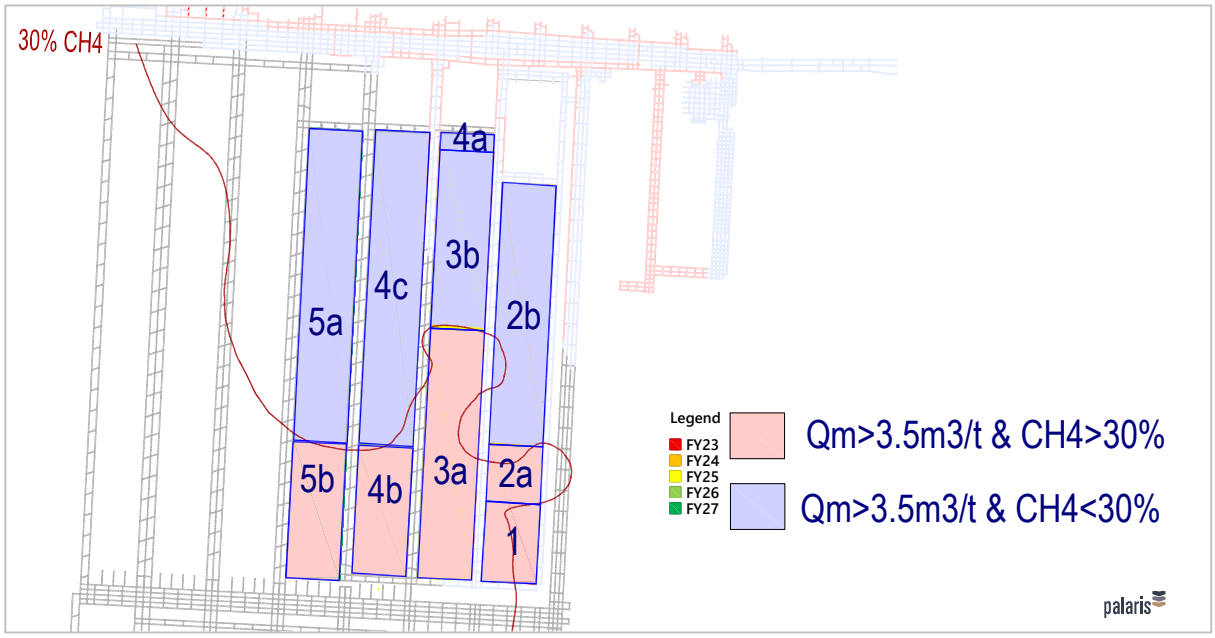


Figure 2.2 Longwall 203-206 Pre-drainage Sub-Zones

Gas pre-drainage is currently planned to occur for the longwall panel only, from the maingate side of the block, resulting in no gas drainage effect for the development panel (Figure 2.3).

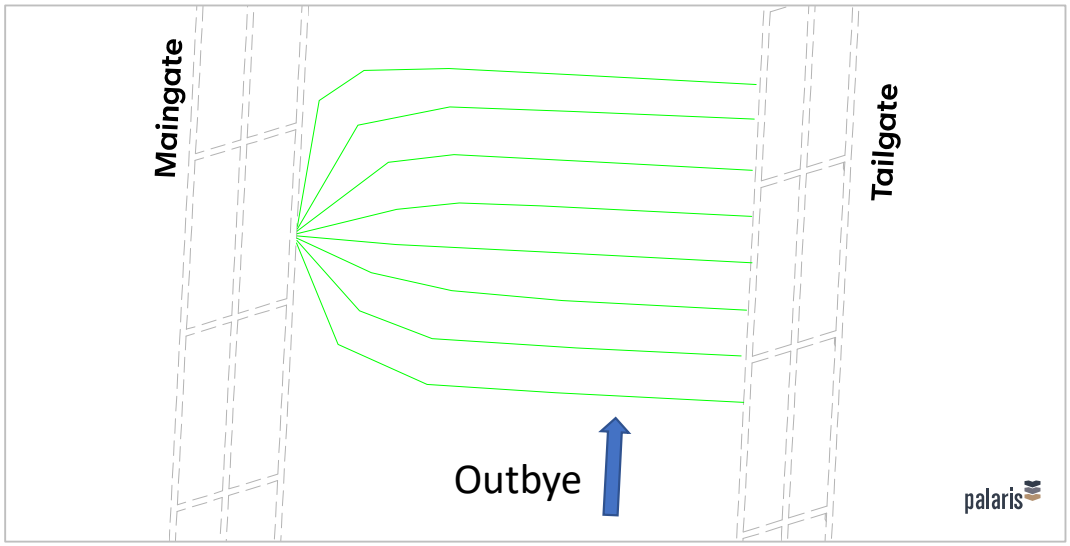


Figure 2.3 Longwall 203-206 Proposed Inseam Drilling Strategy

Pre-drainage gas volumes were estimated using a mass balance of the gas in place, assuming that gas would be flared where the HSK Seam gas composition is greater than 30% CH_4, using the gas composition isopachs derived from gas content testing (Figure 2.4).

Gas flaring has been assumed to commence from the 1st of April 2024, allowing for the lead time required for the installation of the flare unit, which is proposed to be completed Q1 calendar year 2024.

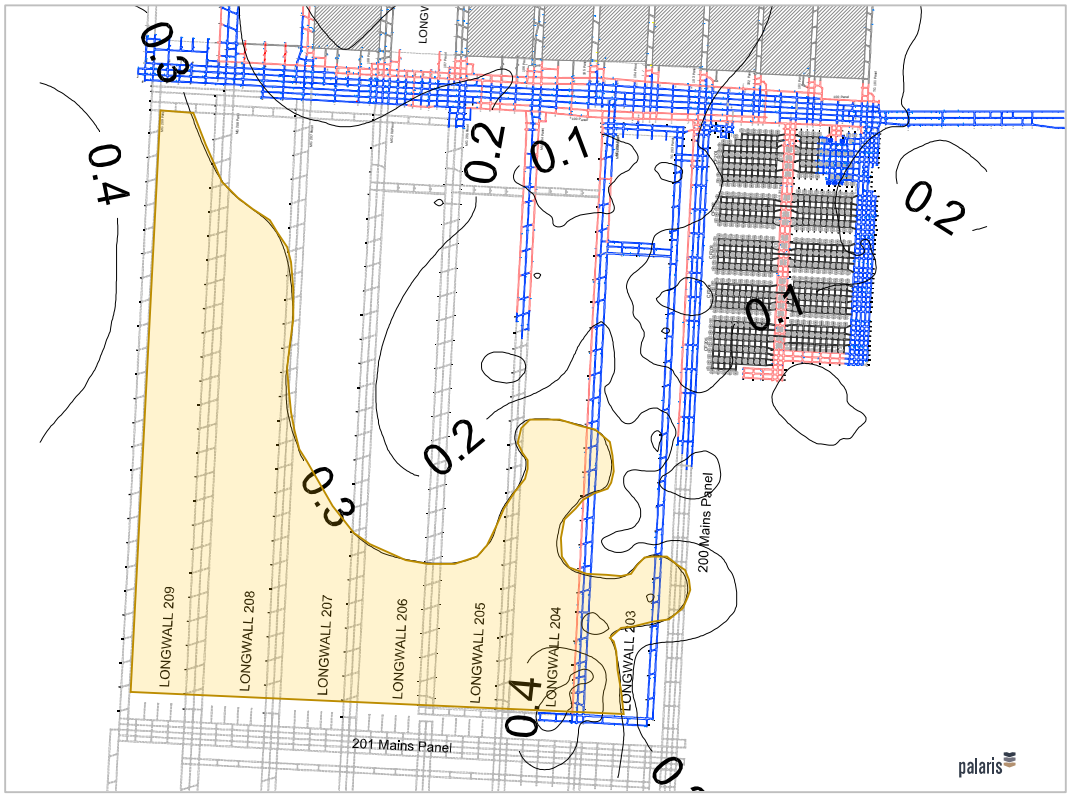


Figure 2.4 Area Exhibiting Favourable Flaring Conditions

The methodology employed for the calculations and reference material used is outlined in Table 2.1.

Table 2.1 Gas Pre-drainage GHG Estimate Methodology

Step	Description	Reference Documentation
1	Identify the locations across the study area where: ▪ Gas pre-drainage will occur (>3.5 m^3/t) ▪ The pre-drainage gas can be flared (composition >30% CH_4)	▪ WHC6500-02
2	Overlay the longwall mining locations (by financial year) on the HSK Seam gas content and composition contouring to establish FY pre-drainage sub-zones (Figure 2.2) delineated by: ▪ Longwall location ▪ Gas Composition (<30% or >30% CH_4)	▪ WHC6500-02 ▪ Mine Schedule "230127a4 Narrabri Spry - MASTER ES"
3	For each pre-drainage sub-zone, estimate the average gas content, composition, seam thickness and ash	▪ WHC6500-02
4	Calculate the area of each pre-drainage sub zone	N/A

Step	Description	Reference Documentation
5	Calculate the volume of gas above 3.5 m^3/t for each pre-drainage sub zone (volume of pre-drainage gas)	N/A
6	Synthesise the data to calculate the volume of pre-drainage gas, flared and unflared for each FY	N/A
7	For each financial year: ▪ Calculate the fugitive emissions (t CO_2-e) from the vented gas pre-drainage ▪ Calculate the emissions (t CO_2-e) from the flared gas pre-drainage ▪ Calculate the total emissions from gas pre-drainage	▪ Section 3.6 - Method 4, National Greenhouse and Energy Reporting (Measurement) Determination 2008 ▪ Section 3.15 - Method 2, National Greenhouse and Energy Reporting (Measurement) Determination 2008 ▪ GWP of CH_4 - 28
8	Calculate a "no-flaring" case to calculate the abatement of GHG emissions (t CO_2-e) resulting from flaring	▪ Section 3.6 - Method 4, National Greenhouse and Energy Reporting (Measurement) Determination 2008 ▪ Section 3.15 - Method 2, National Greenhouse and Energy Reporting (Measurement) Determination 2008 ▪ GWP of CH_4 - 28

The volumes of gas and GHG emissions resulting from gas pre-drainage are summarised by financial year in Table 2.2.

Table 2.2 Gas Pre-drainage GHG Emission Estimate

LW Mining FY	Gas Drainage Reporting FY	Pre-drainage Zone #	Flared						Unflared						'Base Case (Flared)' Total Pre-drainage GHG emission (t CO_2-e)	'No Flaring Case' Assume all unflared Total Pre-drainage GHG emission (for comparison) (t CO_2-e)
			Total Pre-drainage Gas (m^3)	Pre-drainage Gas CH_4 (m^3)	Pre-drainage CO_2 Gas (m^3)	Pre-drainage Gas CH_4 Composition (%)	Pre-drainage GHG CH_4 (t CO_2-e)	Pre-drainage GHG CO_2 (t CO_2-e)	Total Pre-drainage Gas (m^3)	Pre-drainage Gas CH_4 (m^3)	Pre-drainage CO_2 Gas (m^3)	Pre-drainage Gas CH_4 Composition (%)	Pre-drainage GHG CH_4 (t CO_2-e)	Pre-drainage GHG CO_2 (t CO_2-e)		
2023	2022	1							5,889,859	1,825,856	4,064,003	31	34,683	7,563	42,246	42,246
2024	2023	2a, 2b							22,779,208	5,008,168	17,771,040	22	95,131	33,072	128,203	128,203
2025	2024	3a, 3b	3,790,570	1,326,699	2,463,870	35	2,420	4,585	31,154,271	7,936,611	23,217,660	25	150,758	43,208	200,970	223,752
2026	2025	4a, 4b, 4c	4,835,336	1,692,368	3,142,968	35	3,087	5,849	34,736,652	6,781,721	27,954,931	20	128,820	52,024	189,780	218,840
2027	2026	5a, 5b	3,469,128	1,179,504	2,289,625	34	2,151	4,261	17,851,986	3,570,397	14,281,589	20	67,820	26,578	100,811	121,064
Total															**662,010**	**734,105**

2.2 Development Mining Stream

Rib emission models were developed using SIMEDWin, a gas reservoir simulator which employs the Extended Langmuir isotherm to model multi-component gas flow. At initial stage of desorption, CH_4 is desorbed faster than carbon dioxide (CO_2), resulting in increased CH_4 composition in gas flow compared to the total CH_4 ratio.

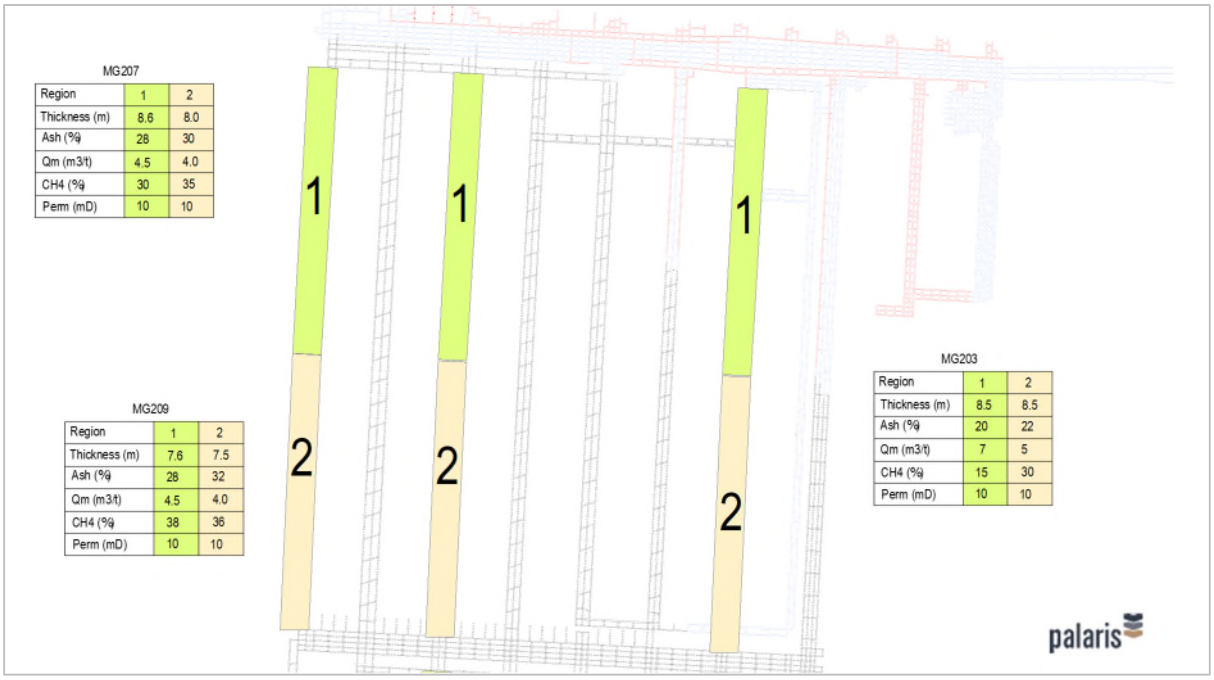


Figure 2.5 Rib Emission Models - 200 Series Panels - Virgin Seam Conditions

A permeability of 10 millidarcy (mD) has been used for all rib emission models, which is the average value of all in-situ permeability tests completed across the study area.

Virgin gas content conditions have been assumed for all cases.

The methodology employed for the calculations and reference material used is outlined in Table 2.3.

Table 2.3 Development GHG Estimate Methodology

Step	Description	Reference Documentation
1	Calculate the average advance rate for each gateroad	▪ Mine Schedule "230127a4 Narrabri Spry - MASTER ES"
2	Setup development rib emissions models for the HSK Seam to reflect: ▪ Virgin gas content conditions (from isopachs) ▪ Permeability of 10 mD	▪ WHC6500-02 ▪ Mine Schedule "230127a4 Narrabri Spry - MASTER ES"
3	For each FY identify: ▪ Development panel(s) being mined (Figure 2.1) ▪ Mid-point distance of the FY from the start of the gateroad	▪ Mine Schedule "230127a4 Narrabri Spry - MASTER ES"
4	Calculate the average rib emission for each FY for each development panel being mined using the mid-point distance in (3) and the rib emission models in (2)	N/A

Step	Description	Reference Documentation
5	Identify gateroads that are standing from the completion of development to the start of longwall mining	▪ Mine Schedule "230127a4 Narrabri Spry - MASTER ES"
6	Calculate the standing gateroads duration and apply an emission per FY based on the rib emission modelling in (2)	N/A
7	Synthesise the data to calculate the total volumes of gas (CH_4 and CO_2) for each FY	N/A
8	Calculate the GHG emissions (t CO_2-e) from the extraction of coal (development) using Method 4 from NGERS (2008)	▪ Section 3.6 - Method 4, National Greenhouse and Energy Reporting (Measurement) Determination 2008 ▪ GWP of CH_4 - 28

The volumes of gas and GHG emissions resulting from development mining are summarised by financial year in Table 2.4.

Table 2.4 Development GHG Emission Estimate

Development Mining FY	Panel	Total Development Emission (l/s)	Total Development CH_4 Emission (l/s)	Total Development CO_2 Emission (l/s)	Total Development Emission (m^3)	Total Development CH_4 Emission (m^3)	Total Development CO_2 Emission (m^3)	Development CH_4 Composition (%)	Total Development GHG (t CO_2-e)	Development GHG CH_4 (t CO_2-e)	Development GHG CO_2 (t CO_2-e)
2023	MH200, MG204, MH205, MG203, TG203	2,427	854	1,573	76,536,058	26,944,358	49,591,699	35	604,104	511,813	92,290
2024	MH200, MG204, MG205, MG204	2,428	960	1,468	76,576,320	30,272,832	46,303,488	40	661,209	575,038	86,171
2025	MG205, MG206, MH201, MG205	1,813	823	990	57,190,320	25,964,496	31,225,824	45	551,312	493,201	58,111
2026	MG206, MH201, MG206	999	548	452	31,509,648	17,268,422	14,241,226	55	354,520	328,017	26,503
2027	MG207, MH201	671	342	329	21,160,656	10,785,312	10,375,344	51	224,178	204,869	19,309
Total									**2,395,323**	**2,112,939**	**282,384**

2.3 Longwall Mining Stream

Gas reservoir information to inform all longwall emission zones and resulting emission rates (Figure 2.6) was obtained from the isopachs derived from gas content testing.

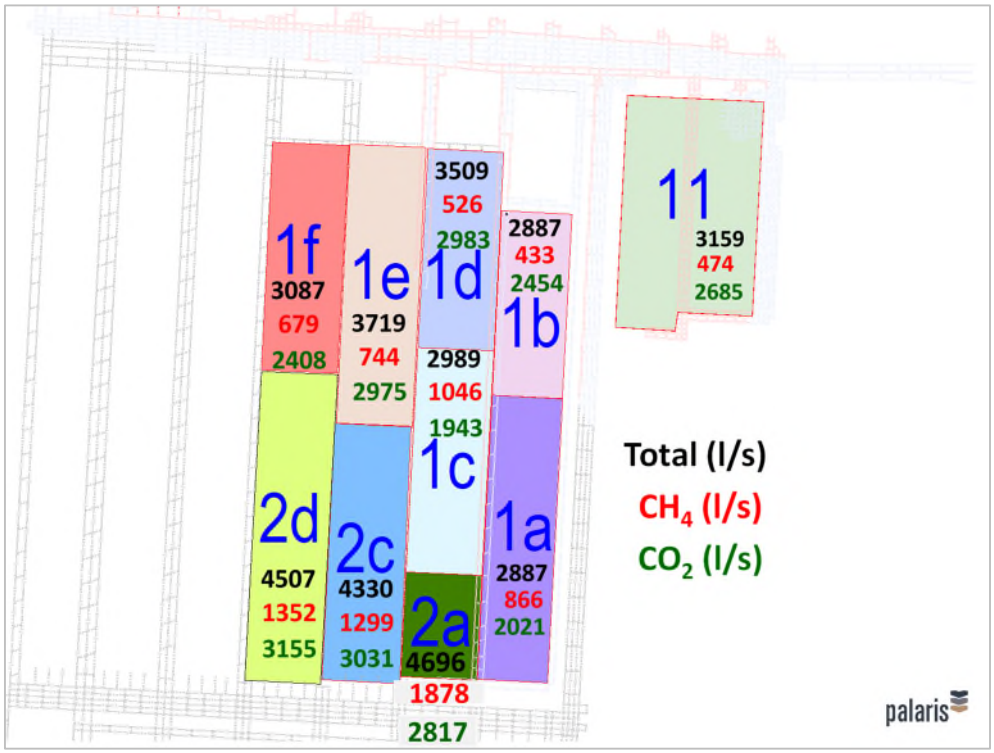


Figure 2.6 Modelled LW Weekly Average Gas Emission Rates at 164 ktpw - Drained Seam Conditions

Specific gas emission (SGE) curves were derived for each longwall emission zone as per Figure 2.7.

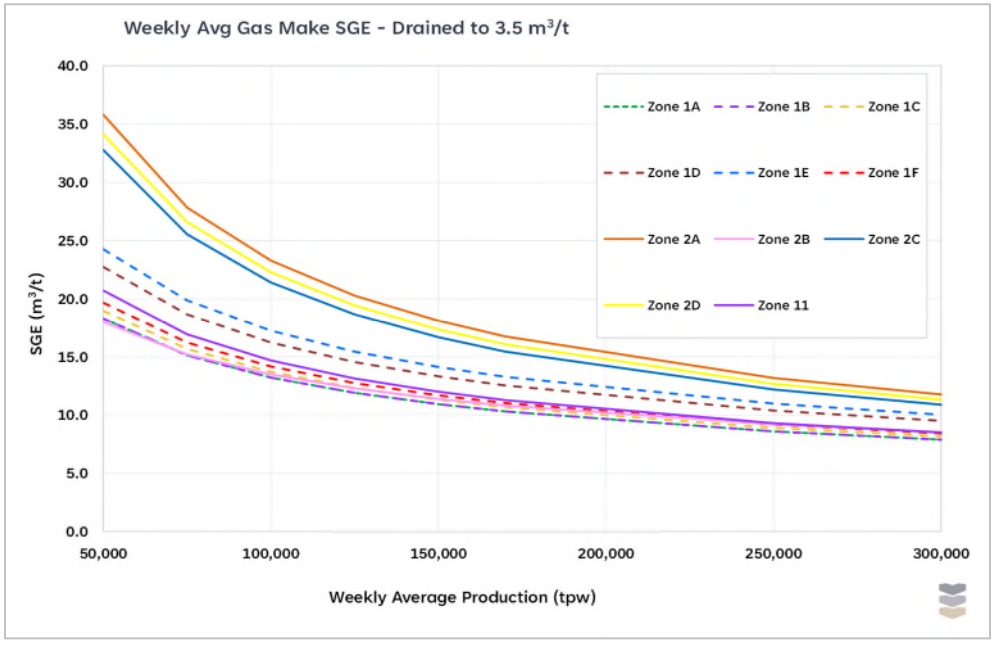


Figure 2.7 Modelled Longwall Gas Make Curves - Drained Seam Conditions, Mixed Gas

Weekly average production rates for each longwall panel were derived from the mining schedule (Table 2.5), which were applied to the longwall emission models.

Table 2.5 Longwall Weekly Production Rate

Longwall (In order of extraction)	Production rate (tpw)
LW203	119,442
LW204	154,407
LW205	170,417
LW206	169,774

In this estimate, longwall emissions have been separated into tailgate emissions, reporting to the ventilation stream and goaf drainage emissions, reporting to the goaf drainage system.

The methodology employed for the calculations and reference material used is outlined in Table 2.6.

Table 2.6 Development GHG Estimate Methodology

Step	Description	Reference Documentation
1	Update longwall emission models for the HSK Seam pre-drained to 3.5 m^3/t (@ seam ash)	▪ WHC6500-02
2	Obtain the specific gas emission (SGE) curves and goaf gas composition from the longwall emission models	▪ WHC6500-02
3	Combine the mining schedule with the longwall emission zones derived in the gas reservoir characterisation to determine the retreat distance in each zone each year (Figure 2.8)	▪ Mine Schedule “230127a4 Narrabri Spry - MASTER ES” ▪ WHC6500-02
4	Calculate the volume of gas for each longwall gas emission sub zone	N/A
5	Synthesise the gas volume data using a weighted average from the lengths of each longwall emission sub zone and the length of each longwall FY location	N/A
6	Determine the portion of gas reporting to the goaf drainage stream based on the calculated post-drainage capture efficiency (PDCE) requirements for each emission zone (Figure 2.9)	▪ WHC6500-02
7	Calculate the GHG emissions (t CO_2-e) from the extraction of coal (longwall) using Method 4 from NGERS (2008)	▪ Section 3.6 - Method 4, National Greenhouse and Energy Reporting (Measurement) Determination 2008 ▪ GWP of CH_4 - 28

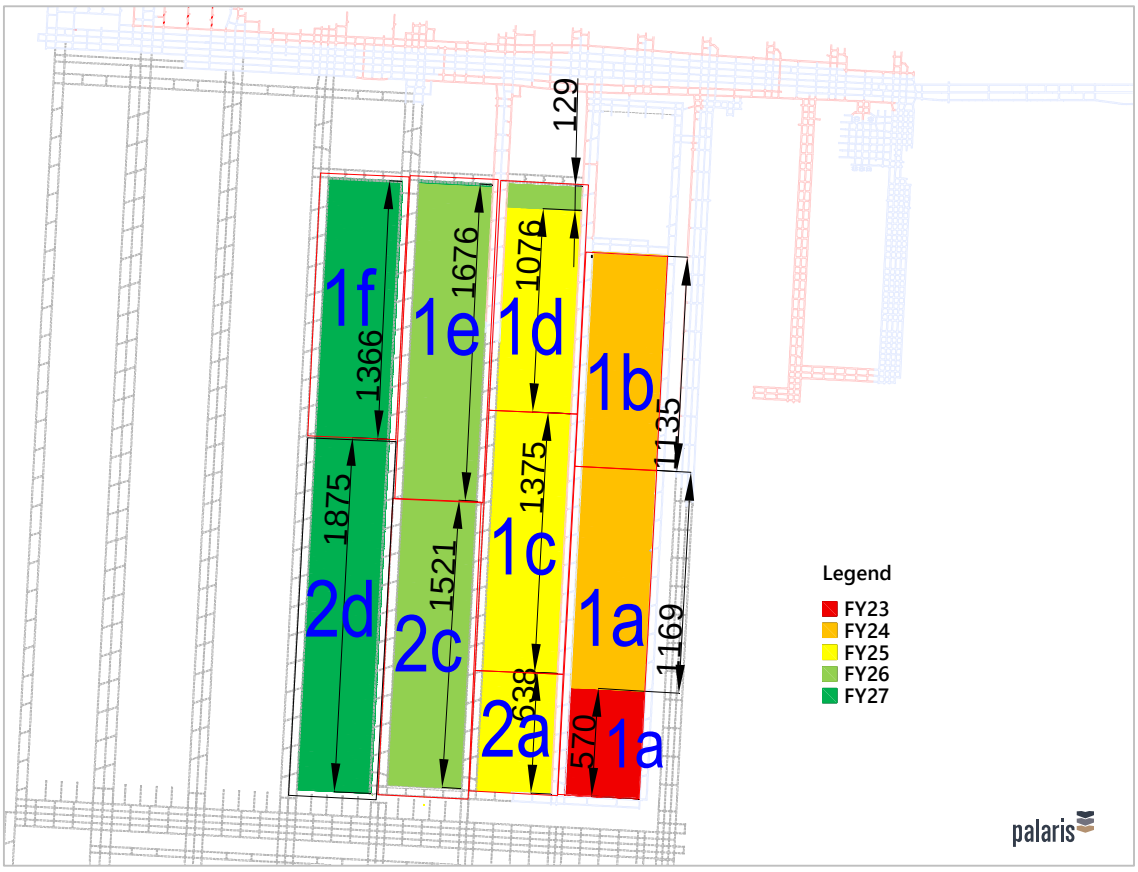


Figure 2.8 Longwall Yearly Retreat by Gas Emission Zone

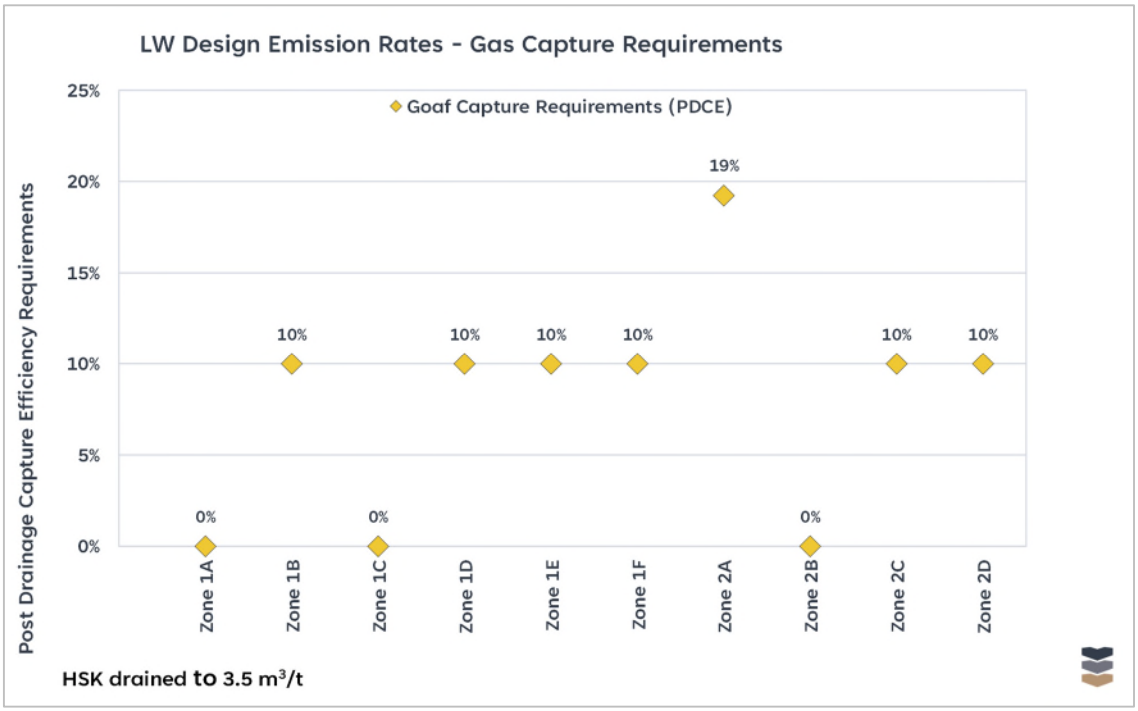


Figure 2.9 Longwall PDCE requirement by Zone - Weekly Average Emissions

The volumes of gas and GHG emissions resulting from longwall mining are summarised by financial year in Table 2.7 and Table 2.8.

Table 2.7 Longwall Tailgate GHG Emission Estimate

Longwall Mining FY	Longwall	Weighted Average Longwall Production (kt/wk)	Longwall Gas Zone Number	Weighted Average Longwall Emission (l/s)	Longwall TG Total Gas (m^3)	Longwall TG CH_4 (m^3)	Longwall TG CO_2 (m^3)	Longwall CH_4 Composition (%)	Total Longwall TG GHG (t CO_2-e)	Longwall TG GHG CH_4 (t CO_2-e)	Longwall TG GHG CO_2 (t CO_2-e)
2023	LW203	119	1a	2,402	14,525,979	4,357,794	10,168,185	30	101,700	82,777	18,923
2024	LW203	119	1a, 1b	2,402	67,757,776	15,307,098	52,450,678	23	388,372	290,761	97,611
2025	LW204	154	2a, 1c	3,374	94,616,224	27,511,180	67,105,044	29	647,463	522,580	124,882
2026	LW205, LW204	170	2c, 1e, 1d	4,000	107,682,697	26,257,564	81,425,133	24	650,300	498,768	151,532
2027	LW206	170	2d, 1f,	3,901	89,033,760	23,627,235	65,406,524	27	570,526	448,804	121,722
Total									**2,358,361**	**1,843,691**	**514,670**

Table 2.8 Goaf Drainage GHG Emission Estimate

Longwall Mining FY	Longwall	Goaf Wells Total Gas (m^3)	Goaf Wells CH_4 (m^3)	Goaf Wells CO_2 (m^3)	Total Goaf Wells GHG (t CO_2-e)	Goaf Wells GHG CH_4 (t CO_2-e)	Goaf Wells GHG CO2 (t CO_2-e)
2023	LW203	0	0	0	0	0	0
2024	LW203	3,520,726	795,364	2,725,362	20,180	15,108	5,072
2025	LW204	7,631,336	2,218,933	5,412,403	52,222	42,149	10,072
2026	LW205, LW204	11,964,744	2,917,507	9,047,237	72,256	55,419	16,837
2027	LW206	9,892,640	2,625,248	7,267,392	63,392	49,867	13,525
Total					**208,049**	**162,543**	**45,506**

2.4 Cut and Flit Mining Stream

Longwall 201 and 202 have been replaced with C&F panels (Figure 2.10). The methodology employed to estimate emissions was the same as for the longwall, however, it was assumed that only 30% of the gas would be released during secondary extraction.

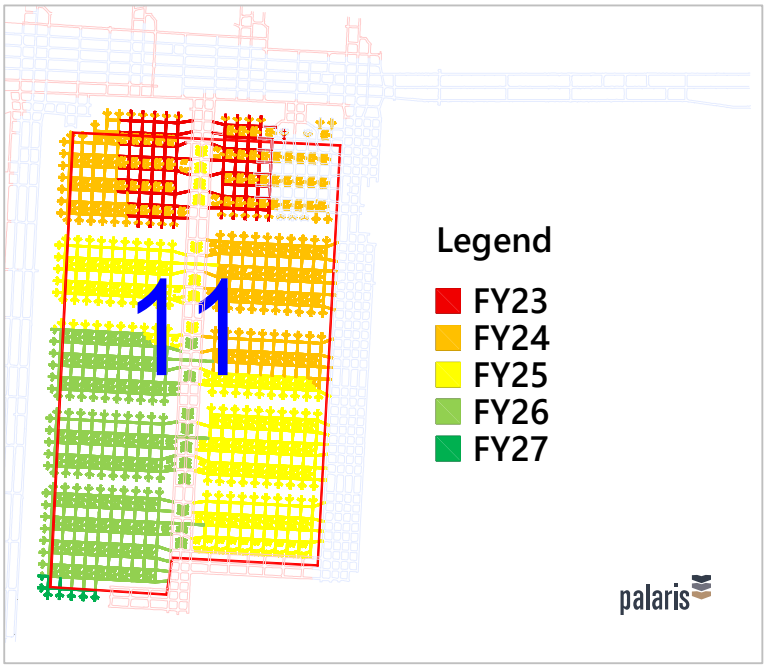


Figure 2.10 C&F Panels Yearly Extraction and Gas Zone

An average weekly production of ~10,000 tpw was used to estimate the degree of emissions.

C&F emissions are estimated to be 0.1 Mt CO_2-e, averaging ~0.03 Mt CO_2-e per financial year and account for ~2% the total fugitive emissions for the study area.

The volumes of gas and GHG emissions resulting from C&F extraction are summarised by financial year in Table 2.9.

Table 2.9 Cut and Flit GHG Emission Estimate

C&F Extraction FY	Panel	Weighted Average Production (kt/wk)	Longwall Gas Zone Number	Weighted Average C&F Emission (l/s)	C&F Total Gas (m^3)	C&F CH_4 (m^3)	C&F CO_2 (m^3)	C&F CH_4 Composition (%)	Total C&F GHG (t CO_2-e)	C&F GHG CH_4 (t CO_2-e)	C&F GHG CO_2 (t CO_2-e)
2023	CF201, CF201	11	11	238	2,162,148	324,322	1,837,825	15	9,581	6,161	3,420
2024	CF201, CF202	10	11	229	7,213,602	1,082,040	6,131,561	15	31,964	20,554	11,411
2025	CF202, CF203, CF204, CF205	11	11	241	7,597,507	1,139,626	6,457,881	15	33,666	21,647	12,018
2026	CF203, CF204, CF205	11	11	243	7,659,542	1,148,931	6,510,611	15	33,940	21,824	12,116

2.5 Outbye Sealed Areas Stream

The GHG emissions for outbye sealed areas historically, has not been measured or assessed for the 100 series panels to ascertain a baseline to which future projections can be applied.

Across other underground mines in NSW, outbye sealed areas emissions can represent up to 50% of the total GHG estimate, being a function of the age of the mine, extent of sealed areas and the way emissions from the sealed environments are managed.

Given the relative simplicity of the Narrabri Mine Plan, few overlying/underlying coal seams across most of the mining area and seam gas composition in the 100 series panels being predominately CO_2, it is unlikely that GHG emissions from outbye sealed areas will be in the order of 50%, rather more likely to be in the range of ~10-30% of the total GHG estimate.

In consideration of the changes in CH_4 composition across the 200 series panels and the increase in longwall GHG emissions across the western panels, 25% of the longwall GHG emissions has been assumed for the outbye sealed areas GHG emission contribution.

The resulting GHG emissions are presented in Table 2.10.

Table 2.10 Outbye Sealed Areas GHG Emission Estimate

Longwall Mining FY	Longwall	Outbye Longwall GHG (t CO_2-e)
2023	LW203	120,000
2024	LW203	120,000
2025	LW204	102,138
2026	LW205, LW204	174,921
2027	LW206	180,639
Total		**697,698**

2.6 Total GHG Emissions

Combining all streams, the total emissions for the extraction of Longwall 203-206 are estimated to be ~6.4 Mt CO_2-e, with an average of ~ 1.27 Mt CO_2-e per financial year (Figure 2.11).

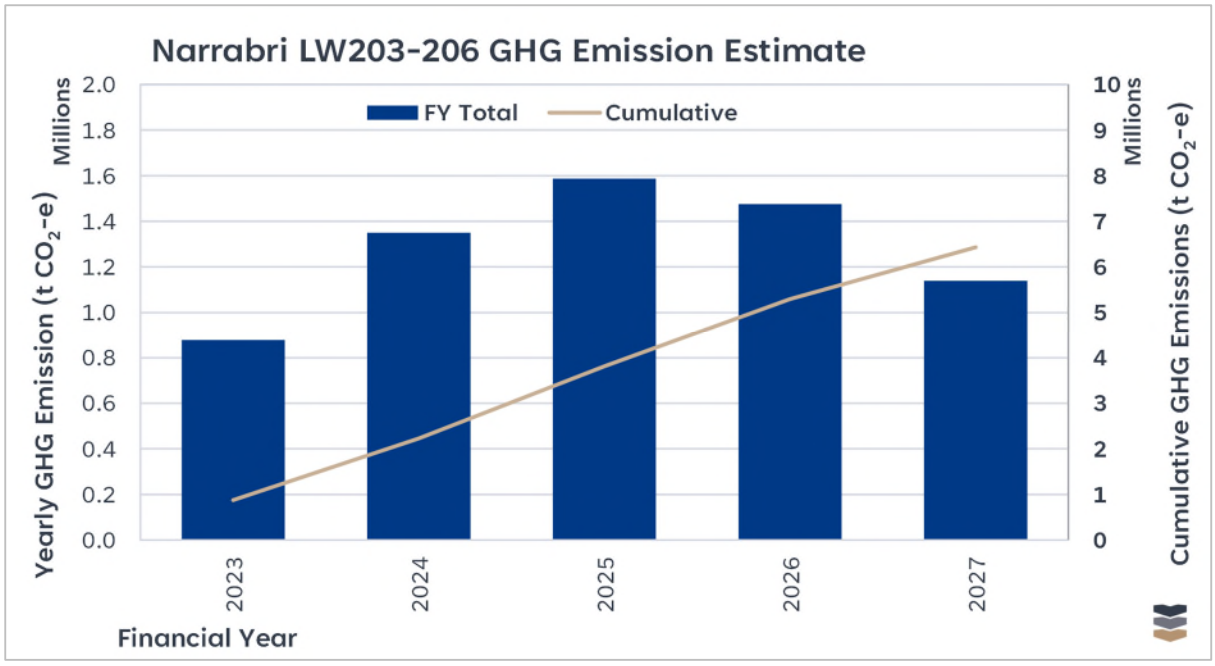


Figure 2.11 Longwall 203-206 GHG Emission Estimate

The highest contributor is development mining (~2.4 Mt CO_2-e), followed by longwall mining (~2.36 Mt CO_2-e) and outbye sealed areas (0.7 Mt CO_2-e). The yearly contribution by stream is shown in Figure 2.12.

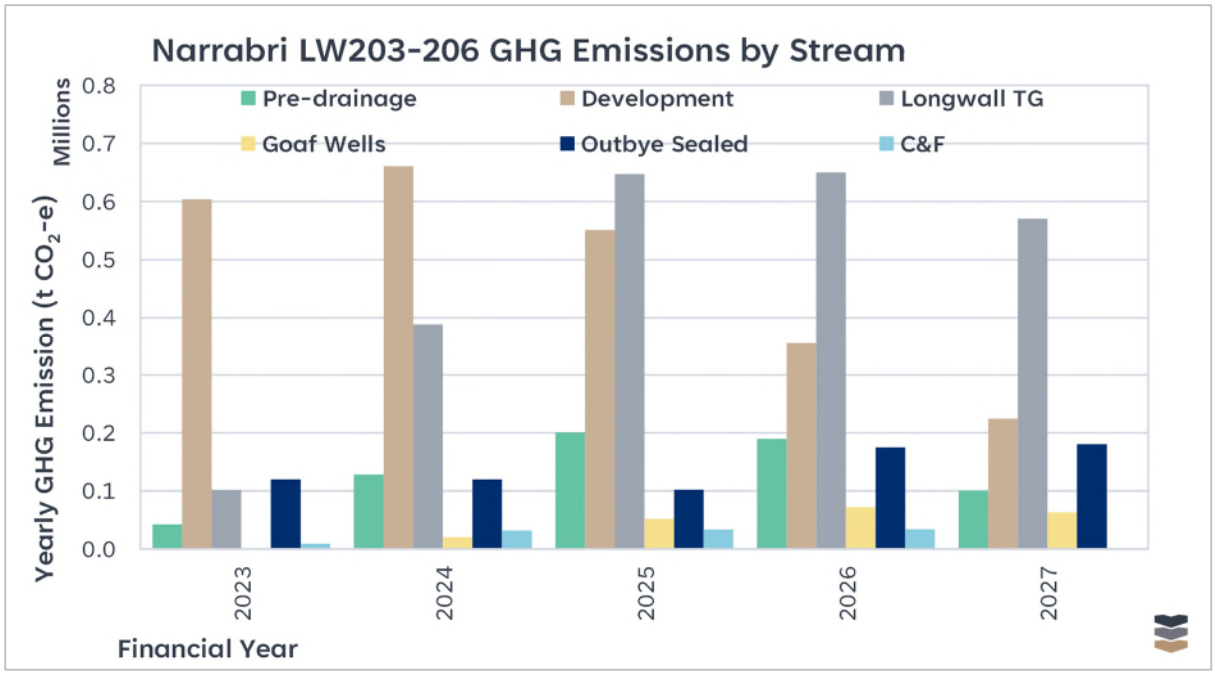


Figure 2.12 Longwall 203-206 GHG Emission Estimate by Stream

3 REFERENCES

WHC6420-02. (2022). *Narrabri South Gas Extraction Review - Gas Emission Review for Longwall 203 to Longwall 206 08Nov22 (Presentation)*. Wollongong, NSW: Palaris.

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