AshtonCoal
PART OF THE YANCOAL AUSTRALIA GROUP

APPENDIX 8

Assessment of Proposed Reticulated Goaf Gas Drainage and Associated Public Risk

Wells Environmental Services

PacificMGM

Mining and Gas Management Consultants

ABN: 83 095 263 871

ASSESSMENT OF PROPOSED RETICULATED GOAF GAS DRAINAGE AND ASSOCIATED PUBLIC RISK

ASHTON UNDERGROUND MINE

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Table of Contents

Table of Figures

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ABOUT THE AUTHOR

Dr Dennis Black is an experienced Mining Engineer and Manager with over 20 years experience working in a variety of senior technical and operation roles in the QLD and NSW coal industry.

Dennis has a PhD in Mining Engineering and a variety of other qualifications, which include:

- Chartered Professional Engineer – MAusIMM(CP)
- Registered Professional Engineer (RPEQ).
- First and Second Class Mine Manager's Certificate of Competency
- Mine Deputy Certificate of Competency
- Mine Ventilation Officer Certificate of Competency
- Graduate Diploma in Mine Ventilation

Dennis established PacificMGM in 2008 to provide specialist consulting services to the mining and gas industries. In addition to reservoir modelling and gas production forecasting, Dennis also develops total gas management solutions; from gas drainage and capture through to emission reduction and gas utilisation solutions.

1 Introduction and Scope

Increasing gas emissions into the underground mine workings at Ashton Coal Operations Pty Limited (ACOL) led to the introduction of goaf drainage in 2010. Goaf drainage involves extracting gas from the caved zone formed behind the retreating longwall face. Typically a series of vertical boreholes are drilled from the surface to extract gas and control the concentration of gases present in the working areas of the mine at safe levels. Based on the success of the initial program ACOL is seeking to expand the gas drainage system to cover additional underground mine workings based on the operation of a centralised gas drainage plant to improve gas capture efficiency and reduce greenhouse gas emissions.

PacificMGM has been engaged to undertake a preliminary review and assessment of surface gas drainage arrangements proposed to be used at the Ashton underground mine and in particular on Macquarie Generation (MacGen) land (overlying the Ashton underground mine) and in proximity other private land holdings, to consider potential risk to the public resulting from the operation of the proposed gas management program. Two specific considerations are:

1. Safety of people working in close proximity to ACOL gas wells; and
2. The potential for goaf gas to accumulate in areas where MacGen personnel or other neighbouring landowners may be operating.

Detailed identification and assessment of risk associated with the construction and installation of the various components of the overall system are not within the scope of this report and are expected to be covered separately within the overall project and job specific risk management process.

2 Summary

The extraction of gas from the longwall goaf using both the current mobile plant and central plant designs being proposed by ACOL is commonly used within the underground coal mining industry to manage gas emissions. The neighbouring Ravensworth underground mine (RUM) are currently operating a similar goaf drainage plant and are also proposing to construct a central drainage plant and surface pipe network similar to the proposed ACOL installation.

Other industries, such as natural gas, coalbed methane (CBM) and landfill waste management, also utilise a similar arrangement to that being proposed by ACOL which includes the central gas extraction plant connected to individual gas wells via a surface gas pipeline network.

Based on the information provided to PacificMGM and provided ACOL use an effective risk management process to identify risk and implement effective controls, incorporating the learning from experienced operators of similar systems, the risk of methane gas accumulating in the MacGen working area, including Void 5, and on other non-ACOL owned neighbouring land is considered negligible.

A list of recommendations is provided for ACOL consideration in Section 7 of this report.

3 Current Practice – Drainage and Treatment of Coal Seam Gas

ACOL currently utilise a simple, yet effective, mobile surface gas drainage plant that relies on a venturi effect to create suction that draws free gas from the goaf, through a cased 300 mm diameter borehole to the surface. Drained gas is presently exhausted from the top of a vent stack at a height of approximately 4.5 metres where it dilutes well below explosive limits and is dispersed into the general atmosphere.

Each mobile surface goaf drainage installation is contained within a 15 m x 20 m perimeter fence, as shown in Figure 1.

This method of gas extraction is similar to the methods and equipment used in other mining areas, such as the Illawarra and Central Queensland, which use relocatable goaf drainage plant.

Figure 1: Typical goaf drainage surface equipment layout compound

4 Proposed Gas Drainage and Emissions Reduction Strategy

Based on the demonstrated success of the goaf drainage program to date, ACOL intends to continue goaf drainage and are planning to implement a more effective gas drainage solution involving the construction of a centralised gas drainage plant and gas flaring facility. ACOL's plan is to sequentially install gas wells and connect these to a surface pipe network used to reticulate the extracted goaf from each gas well to the central gas drainage plant. The sequence and timing of installing and extracting gas from each gas well being governed by the mine production schedule.

From the central drainage plant the gas will be directed to the flaring facility where the methane component in the drainage gas will be combusted to significantly reduce the global warming potential (GWP) of the gas mix.

In the period until the new gas drainage plant has been installed and commissioned ACOL propose to continue to use the existing mobile goaf drainage arrangements, as required, to support safe and efficient longwall mine operations. Where necessary, the mobile drainage plant may be required to extract gas from certain future goaf wells, primarily where connection to the centralised gas drainage network is unable to be achieved.

The general arrangement of the proposed ACOL surface gas drainage and emissions reduction system, which may by necessity include the periodic use of the mobile gas plant at certain locations, is illustrated in Figure 2.

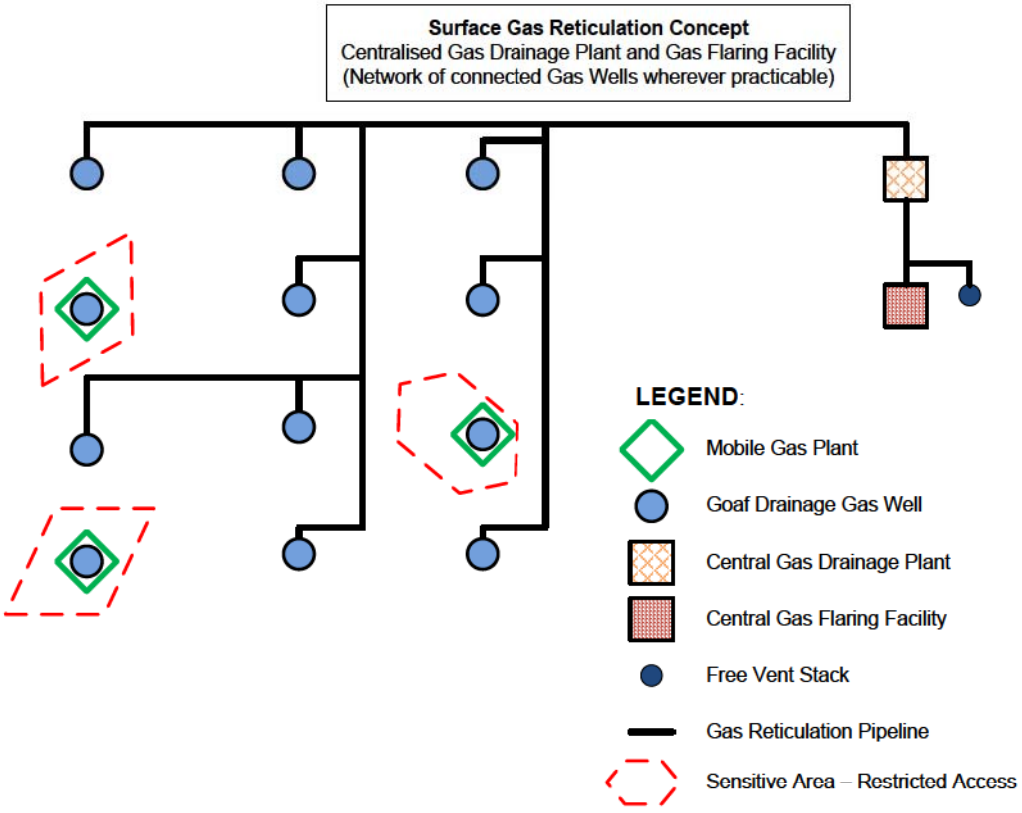

Figure 2: Indicative general arrangement of the proposed ACOL surface gas drainage system

In areas where the mobile gas plant is required to be used in preference to gas well connection to the surface pipe network, ACOL may consider the use of relocatable enclosed flare units to aid in reducing fugitive gas emissions (tCO_2-e) released from the Ashton complex. An example of relocatable enclosed flares, which may be used to combust the methane rich goaf gas to produce carbon dioxide and water vapour, is shown in Figure 3. The addition of a relocatable flare(s) to the mobile gas drainage plant surface installation will increase the footprint of the plant and the impact of such an increase would need to be considered and appropriately managed.

Figure 3: Example of relocatable enclosed flares treating drained goaf gas

Figure 4 shows an indicative layout of the proposed pipeline connecting the gas wells above each longwall panel to the central gas drainage plant located in the north eastern corner of the network.

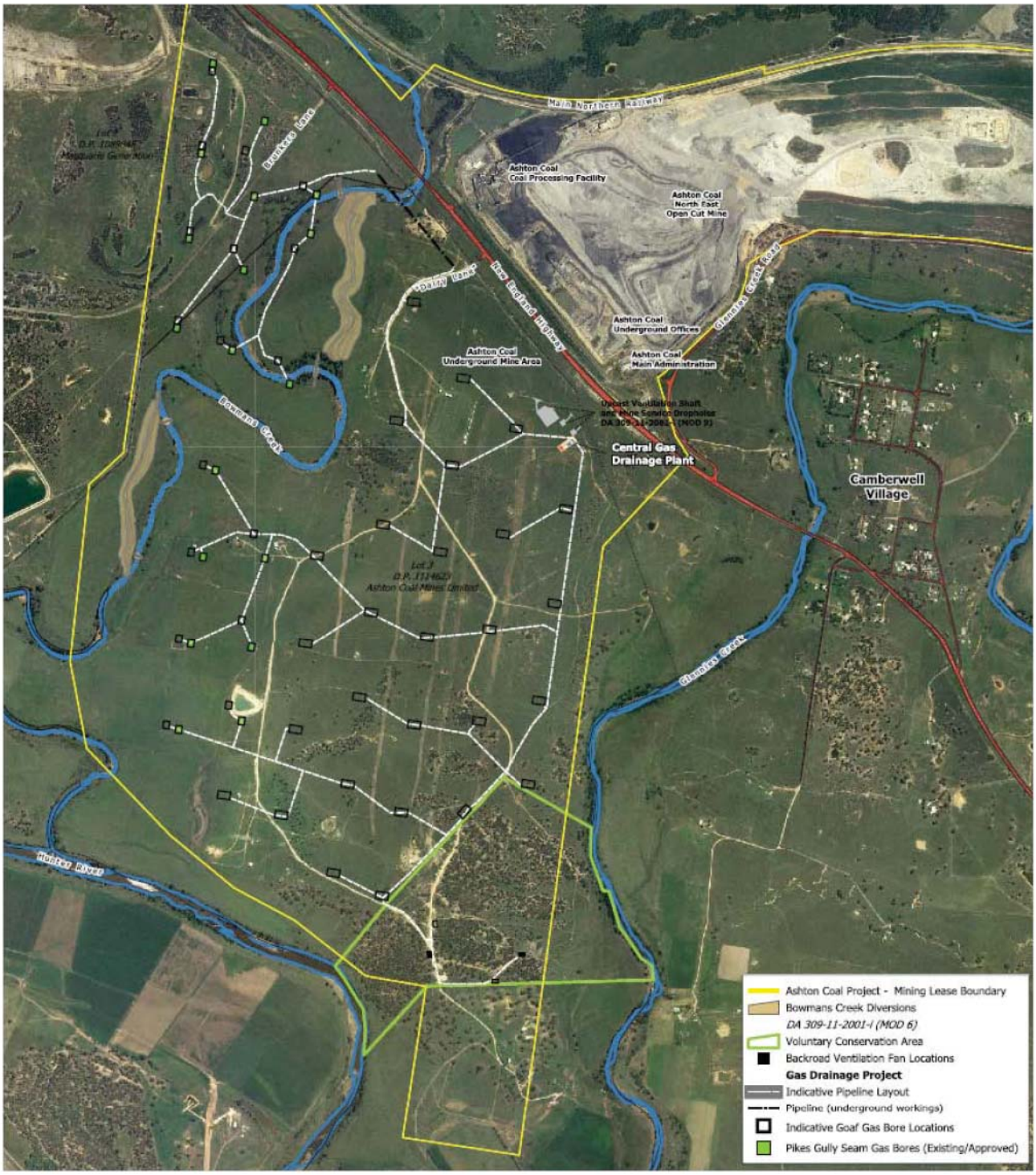

Figure 4: Indicative layout of proposed surface gas reticulation pipeline

The indicative layout of the proposed ACOL gas wells and surface gas reticulation pipeline on MacGen land (Lot 2, D.P.1089848) is shown in greater detail on Figure 5.

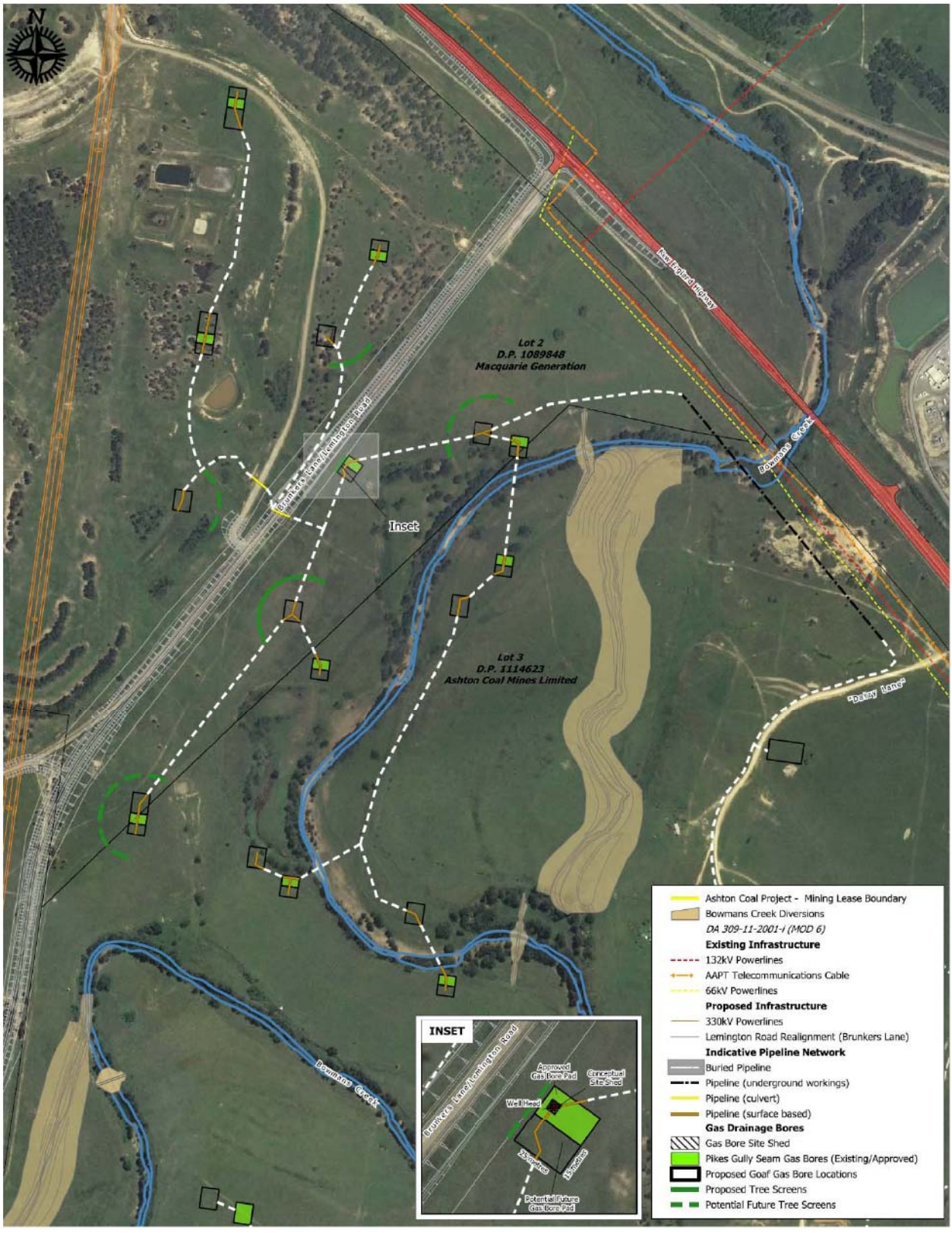

Figure 5: Indicative layout of proposed gas wells and surface gas reticulation pipeline on MacGen land

Examples of the major components of the system such as the centralised gas drainage plant, enclosed flares and individual gas well connection to the surface pipe network, as installed at other mine sites, are shown in Figure 6, Figure 7 and Figure 8, respectively.

Figure 6: Central gas drainage plant installation

Figure 7: Enclosed flare installation

Figure 8: Gas well connection to a gas reticulation pipe network

5 Assessment of the Mobile Drainage Plant Arrangement

Figure 9 provides an example of the monitoring software used by ACOL to continuously monitor and track the performance of the mobile gas plant. In addition to monitoring gas plant performance parameters such as pressure, temperature and flow of gas through the mobile gas plant, the composition of the goaf gas being discharged through the exhaust stack is also monitored.

Several additional safety features installed in the mobile gas plant include:

a. Methane gas sensor (Yard CH_4) installed within the enclosure that monitors any increase in the concentration of methane present within the enclosure. In the unlikely event of an accumulation of methane an alarm will be raised at the control room when the gas concentration reaches approximately 20% of the lower explosive limit.
b. Main actuator valve (AV1004) is a compressed air actuated safety shut-off valve that automatically closes to effectively seal the gas well following a loss of compressed air from the plant safety circuit. Once the main actuator valve closes all gas flow from the goaf through the gas well will cease. In response to an event that causes the main actuator valve to close an alarm will be raised in the control room.

Secure fencing is erected and maintained around each mobile gas plant site to restrict unauthorised access, which is considered an effective and appropriate control. Secure fencing shall be installed around all future mobile gas plant installations.

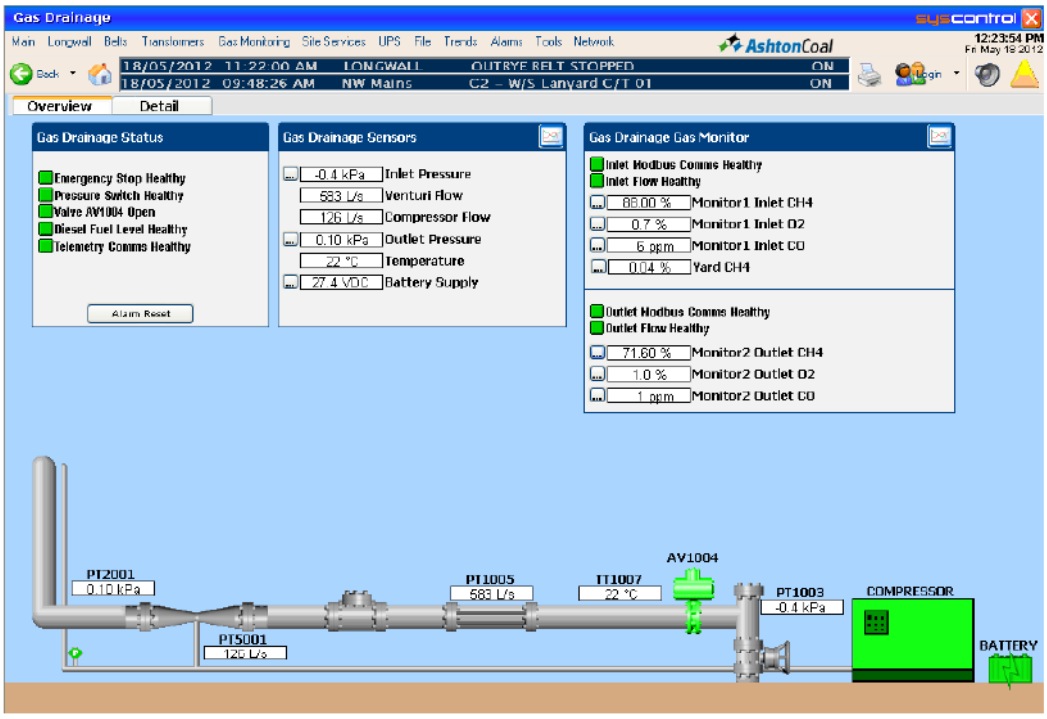

Figure 9: Screen shot of Mobile Gas Plant condition monitoring

In the example shown in Figure 8, the mobile drainage plant is discharging a mixture of goaf gas and compressed air at a rate exceeding 700 L/s through a 300mm diameter exhaust stack which equates to a discharge greater than 10 m/s which will aid the dispersion of the gas into the atmosphere. The dispersal and dilution of the goaf gas will be further aided by the fact that methane (CH_4), which is lighter than air (specific gravity of 0.55), is the major component of the goaf gas mix and will tend to rise into the atmosphere following discharge from the exhaust stack

and be diluted through contact with the surrounding air mass and be swept away from the site by the prevailing breeze. Therefore the risk of goaf gas accumulating near ground level within or in areas surrounding the mobile gas drainage plant enclosure is extremely unlikely.

Site experience and exploration data from future longwall panels indicates methane will continue to be the dominant component of the goaf gas mix. However ongoing sampling and analysis of the composition of goaf gas is recommended to identify any change in the composition of the goaf gas mix in future mining areas. Although unlikely, an increase in the carbon dioxide (CO_2) concentration (specific gravity of 1.53), may result in an increased risk of the discharged gas accumulating near ground level. Should such a change occur, the location of each gas plant installation along with the suitability of the gas discharge arrangement would need to be reviewed to ensure effective dilution of the discharged gas.

6 Assessment of the Central Drainage Plant Arrangement

The proposed central gas drainage plant will utilise a series of liquid ring pumps to create a vacuum within the surface gas reticulation pipeline (typically in the order of –40kPa gauge) that will effectively suck gas from the underlying goaf areas, through the gas well boreholes and pipe network, to the drainage plant.

The diameter of the pipe installed throughout the network must be of sufficient size to ensure that suction is applied to each and every gas well connection. In addition to providing increased gas extraction capacity an added benefit of maintaining suction throughout the surface pipe network is the minimal risk of gas being discharged from the pipeline in the event of the pipeline being damaged by machine interaction or a malicious act.

In the unlikely event of the pipeline being damaged, the suction within the pipeline would draw air into the pipeline and an increase in oxygen (O_2) would be detected at the central gas drainage plant. Gas monitoring sensors installed in the gas pipeline and linked to the programmable logic controller (PLC) at the central drainage plant control and monitoring room would detect the rise in O_2 concentration and an alarm would be raised at the mine control room. Should the O_2 concentration exceed a pre-determined limit the safety system would cause the drainage plant to trip on a high O_2 alarm. This would trigger an investigation to determine the cause of the increase in O_2 concentration.

In response to the gas drainage plant tripping due to high O_2, or in response to any event that results in a stoppage at the gas drainage plant, actuated valves should be installed at each well head to close and effectively isolate the gas well from the surface pipe network, thereby preventing gas from exiting the gas wells and entering the pipeline.

The design of the gas reticulation network associated with the central drainage plant is such that under normal operating conditions no gas will be released from, or in close proximity, to the individual gas wells. All of the drained gas will, under normal conditions, be directed to the central flare facility where the methane gas will be burnt and converted to CO_2 and water vapour. In extenuating circumstances, such as (a) a surge in gas production that exceeds the capacity of the flare, or (b) maintenance being performed on one or more flares that reduces gas flaring capacity, the excess gas may be directed to the free vent stack located adjacent to the central gas plant where it will be discharged to atmosphere. In such situations, in order to reduce fugitive gas emissions, ACOL may choose to temporarily reduce the total gas extraction rate, either by (a)

reducing the capacity of the drainage plant, and / or (b) reducing the number of gas wells within the network from which gas is being extracted.

ACOL should consider developing trigger action response plans (TARPS), to form part of the overall Gas Drainage Management Plan, that list specific actions and responsibilities in response to changes in gas concentration and operating conditions at the (a) central gas drainage plant, (b) within the gas reticulation pipe network, (c) at each gas well site, and (d) the central flare facility. The PLC installed at the gas plant monitoring and control room should be configured to effect immediate action in response to specified triggers, and raise an alert/alarm to initiate a physical inspection by the responsible person.

In addition to gas sensors installed to monitor the composition of gas being extracted through the drainage system, gas sensors shall also be installed at the central gas plant, and in close proximity to the central flare facility and the free vent stack, to monitor and detect the presence of any abnormal methane gas accumulation in the area where the equipment is installed and where personnel can access.

With the exception of the gas pipeline, the majority of which will be buried, the gas wells, gas plant, flare facility and free vent stack should be securely located and appropriately signed to prevent unauthorised access (i.e. by fencing or similar).

The route of the gas pipeline shall be clearly marked to reduce the risk of damage by future work activity in the area and appropriate protection shall be provided where vehicles and other machinery are required to cross the pipeline. ACOL should undertake a risk based assessment to identify any requirement for additional controls that may be considered necessary to protect the pipe in areas where burial is not practical or feasible.

The proposed gas reticulation pipeline (Figure 4) crosses multiple longwall panels and the pipeline will be subjected to the effects of subsidence as the ground moves in response to longwall coal extraction. In addition to complying with applicable Australian and Petroleum Industry Standards relating to gas pipelines it is recommended that ACOL review the proposed layout of the pipeline to ensure the design and installation is adequate to withstand the predicted subsidence and progressive ground movement resulting from multi-seam longwall coal extraction.

7 Summary and Recommendations

The extraction of gas from the longwall goaf using both the current mobile plant and central plant designs being proposed by ACOL is commonly used within the underground coal mining industry to manage gas emissions. Based on the information provided to PacificMGM and provided ACOL use an effective risk management process to identify risk and implement effective controls, incorporating the learnings from experienced operators of similar systems, the risk of methane gas accumulating in the MacGen working area (including Void 5) or on other non-ACOL owned neighbouring land is considered negligible.

The following recommendations are made for ACOL consideration:

- Where possible, gas wells should be connected to the surface gas reticulation pipeline in preference to the mobile gas plant. Connection to the pipeline effectively eliminates any release of goaf gas near the MacGen Void 5 working area or on other neighbouring land.
- Lightning protection should be installed adjacent to each gas well.

- Consider implementing a program of routine air sampling near the MacGen working areas and other non-ACOL owned land to measure the concentration of methane present whilst ever operating mobile gas plant on MacGen land or in close proximity to neighbouring properties.
- Consider installing actuated safety shut-off valves at the well heads of all gas wells connected to the pipeline.
- Consider installing gas sensors to monitor gas composition within the pipe network, which would include the detection of oxygen (O_2) that may indicate a leak in the system.
- Consider installing additional gas detectors to monitor the working areas at the central gas plant, and at the central flare facility and the free vent stack.
- Consider developing trigger action response plans (TARPS) to address changes in gas concentration and operating conditions at (a) the central gas drainage plant, (b) within the gas reticulation pipe network, (c) at each gas well site, and (d) the central flare facility.
- Consider programming the PLC installed at the gas plant monitoring and control room to effect immediate action in response to specified triggers and raise an alert/alarm to initiate a physical inspection by the responsible person.
- In addition to the gas reticulation pipeline being designed and installed to both Australian and Petroleum Industry Standards, the impact and potentially damaging effects of the pipeline crossing longwall panels and being subjected to ground movement during subsidence should be considered.