SAFETY & SUSTAINABLE DEVELOPMENT

LEARNING FROM INCIDENTS

INVESTIGATION REPORT

GROSVENOR MINE

Metallurgical Coal

Incident Number: IN.00211941

Classification: ***DNRM HPI***

Incident Title: CH4 Exceedance LW103

Incident Date: 7 November 2019

Report Date: 20 November 2019

CONFIDENTIAL

Learning from Incidents Investigation Report

1 INVESTIGATION TEAM MEMBERS

Name	Role	Designation
Logan Mohr	Tech Services Manager	Sponsor
Hayden Hearne	Ventilation and Gas Superintendent	Investigation Lead / Facilitator
Ray Kostowski	Technical Services Superintendent	Technical / Operational Expert
Stephen Giese	Geology and Geotechnical Superintendent	Technical / Operational Expert
Adam Maggs	ERZ Controller	Technical / Operational Expert

2 KEY WITNESSES

List of Key Witnesses	
Name	**Designation**
Adam Maggs	ERZ Controller

3 METHODOLOGY AND TOOLS USED

An investigation has been conducted in accordance with the Anglo American investigation methodology known as the Learning from Incidents model, supported by various investigative and analytical tools.

The analysis tools used for this investigation are:

Analysis Tool	Attached as Appendix if applicable - Yes/No
Time Series Events Chart	Yes – mandatory tool
Control Analysis	Yes
Behaviour Analysis	No
Change Analysis	Yes
Why Analysis	Yes

4 DESCRIPTION OF INCIDENT

On Thursday the 7th of November during normal production, the shearer on the LW103 face was travelling to the MG (cutting bi-directional) when at roof support #9, a floor blower became active at roof supports #22 and #55 after mining past the area and advancing the face. The tailgate drive sensors at 03:04 went above 2.0% tripping face power. The methane monitor in the TG roadway peaked at 2.73% at 03:08am.

The methane calculated to have released into the mine's general body atmosphere was approximately 1,504m^3 after 2 hours before returning to normal background levels.

4.1 Geotechnical Assessment

Floor fracturing behind/underneath a longwall face has not been studied extensively due to the operational limitations surrounding such research. No specific study has been performed for Grosvenor to date that identifies the extent of potential floor fracturing; as such a literature review has been performed to identify how deep floor fractures can reasonable extend under a longwall retreat scenario.

A paper by Bai & Tu, 2019 titled *A General Review on Longwall Mining-Induced Fractures in Near-Face Regions* discusses this issue in some detail. This paper discussed that field observations indicated that there are two main types of primary floor failure, namely shear failure along bedding planes in the floor which causes horizontal fractures, and the formation of subvertical fractures parallel to the longwall face ahead of the longwall shield supports. Observations also indicated that vertical fractures play a dominating role within the failure zones, with numerical simulations confirming these observations. These vertical fractures are what can act as a conduit for gas/water to flow through from underlying reservoirs.

This paper, which primarily focuses on longwall operations in China, discusses that many operations there work above confined aquifers, hence determining failure scope within the floor is an important factor. An empirical formula was developed to predict the depth of 'water-conducting failure zones' for Chinese operations, however it is proposed that this is applicable as well for Grosvenor to provide indicative values of depth of fracturing that may provide a conduit for gas flow.

This empirical formula is as follows:

$$H_f = 0.303L_x^{0.8}$$

Where:

H_f is the depth of fracturing into the floor that can act as a hydraulic conduit

L_x is the width of the longwall panel.

Using this relationship for Grosvenor, the approximate depth of fracturing is 29m. It is acknowledged that this relationship is an empirical one derived from longwall operations in China, however the database contains cases with a varying range of cover depths (103m to 560m), hence can be used to provide a baseline value.

In addition to this, there are varying models that can be used for the prediction of the degree of gas emissions from overlying and underlying seams in a longwall operation. One such model is the Flugge model, as shown below.

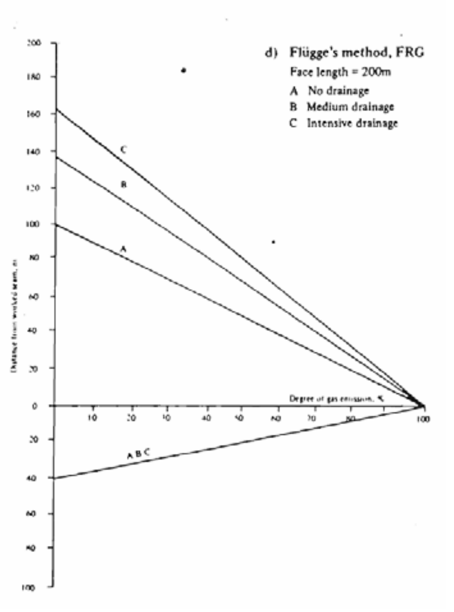


Figure 1 - Flugge Model for Predicting Gas Emission Degrees

This model suggests that the deepest below the floor that a seam may emit emissions from is 40m. This is in a similar range to the value derived from the empirical model by Bai & Tu for estimating floor fracturing creating a hydraulic conduit for gas to flow from underlying seams. As such it can be concluded that seams up to 40m below the seam floor should be considered for potential to emit gas into the LW working area/goaf. In the zone for this LFI, this would include the GML and the Harrow Creek Lower Measures (see Appendix: Stratigraphy).

It is important to note that geological structures can create localized anomalous conditions that may lead to a zone of fracturing that can act as a conduit for gas emissions, or the fault plane itself can act as a conduit. The figure below shows the LW face at the time of the incident and highlights the major structure in the area.

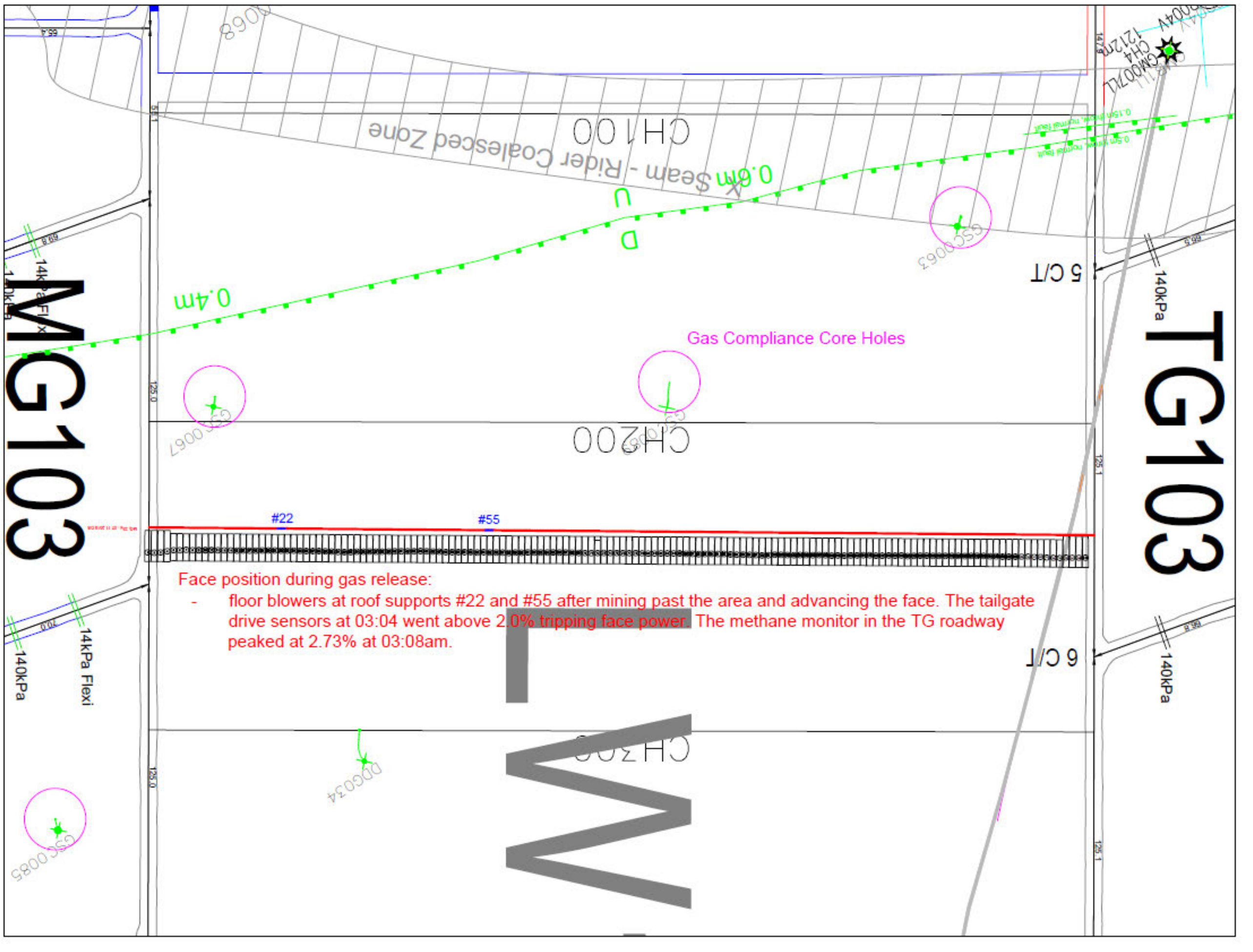


Figure 2 – Geological Conditions During Event

This section shows that the face was not affected by any geological discontinuities at the time of the event, with the only major structure within the area located approximately 80m outbye in the maingate at the time of the event. This information suggests the this event was not caused by a localized geological structure.

In addition to this, the diagram above also shows gas compliance holes within the area of the event, however none of these holes took samples of the underlying seams below the GM.

5 CRITICAL CONTROL FAILURE

(List any identified critical control failures that contributed to this event)

What / which critical controls failed? (List CT number)	Nil

6 EVENT FACTORS

Review data from LFI Tools and record into the identified **factors** below. This data is required for the Enablon summary.

Individual Factors	Nil individual factors identified
Workplace Factors	LTA pre-drainage program in lower seam(s)
Organisational Factors	Gas make (SGE) greater than expected in excess of system capacity (Floor release) Less than adequate methane pre-drainage / recovery / dilution

7 FINDINGS AND CONCLUSIONS

Through the LFI Investigation process, the following were found to have contributed to the unwanted event:

- The floor blowers located at #22 and #55 roof support released approximately 1,504m^3 after 2 hours.
- Mining past the area stimulated the release of gas into the mine atmosphere from a reservoir from beneath the target mining seam.
- The release of gas was substantial enough to trip power to the face and exceed 2.5% in the tailgate return.
- Underlying seams up to 40m below the GM seam should be considered for the potential to emit gas into the longwall working section

8 PREVENTATIVE ACTIONS / RECOMMENDATIONS

The following key actions were identified to prevent recurrence and have been assigned as detailed below in Enablon.

Task Description	Hierarchy of Control	Task Assignee	Due Date	Task ID
Trial of GML holes underway in LW105 to target immediate Gas Reservoir in floor horizon.	Engineering	Hayden Hearne	05/02/2020	TS.01166665
Conduct a detailed investigation to try and identify the source of the methane	Administration	Hayden Hearne	05/02/2020	TS.01166669

9 TEST FOR EFFECTIVENESS

Post Implementation Action Plan

Test of effectiveness is to be done to ensure that the above actions to prevent recurrence have worked as intended. (Nominally scheduled 3,6 or 12 months after completion of preventative action plan)

Enablon Task No.	Action Description	Responsible Person	Due Date	Completed Date
TS.01166671	Review effectiveness of action close out from Incident INC.00211941	Logan Mohr	08/05/2020	

10 INVESTIGATION REPORT SIGN –OFF

The Incident Investigation Team submits this report as a true reflection of the information gathered. To maximize the preventive potential of the investigation report, the findings, conclusions and learning's of the report should be distributed as appropriate.

Acceptance of Final Report for Management Sign Off

Department Superintendent		
Name Hayden Hearne	Signature [redacted]	Date 5 12 19

MEM/EEM Sign Off (if applicable)

Electrical Engineering Manager or Mechanical Engineering Manager (tick)		
Name	Signature	Date

Management Sign Off

Department Manager		
Name	Signat[redacted]	Date
Logan Mohr		5/12/19
SHE Manager		
Name	Signature	Date
KATE BACHMANN SHE MANAGER	[redacted]	5 12 19
Underground Mine Manager		
Name	Sig[redacted]	Date
Walter Michaels		5/12/2019
General Manager		
Name	Signature	Date
Robert Nieuwenhuis	[redacted]	6/12/19.
Head of Operations		
Nam[redacted]	Signature	Date
	G Britton	10/12/19

11 APPENDIX: SEQUENCE OF EVENTS

Date	Time	Event or Condition
06/11/2019	20:00	Start of Night Shift (communications and travel)
	21:40	Production
7/11/2019	12:20 – 12:30	Production Delay – Removed structure
	12:30-02:00	Production
	02:00-02:10	TG Inspection
	02:10-02:15	Production
	02:15-02:20	Delay: BSL Pilot Fault
	02:20-03:00	Production
	03:04	Production stoppage due to tailgate drive sensor >2.0% CH_4 – Lost Face Power
7/11/2019	03:08	EVENT: CH_4 >2.5% in Tailgate Return Outbye CH Sensor Peaks at 2.73%
7/11/2019	Post Incident	ERZ Controller informed UM, UM informed UMM
		A floor blower was found at #22 and #55 Roof Support
		Setup Venturis @ #22 Roof Support
	04:07	Power restored to face

12 APPENDIX: CONTROL ANALYSIS

From the description of what happened and the sequence of events, what were the absent or failed controls?

Consider:

- What would have prevented the incident?
- What would have decreased the severity of the incident?

Unwanted Event: Methane in excess of 2.5%				
Hazard: Elevated methane				
Absent of Failed control and support systems	**How did they perform?**	**Why did they fail or were absent?**	**Outcome of failed or absent controls and support systems.**	**Site critical control Yes or No?**
Gas Pre-drainage Process	Failed	Isolated region of gas relieving into mine atmosphere after induced stresses	Methane reported to general body atmosphere greater than acceptable limits from adjacent seam/strata	No

APPENDIX: CHANGE ANALYSIS

Change is anything which alters the planned operating process or system. The Change Analysis technique identifies how new risks which were a direct result of change in the work environment were managed prior to the incident occurring.

Basic Methodology: -

- Describe the situation before the change was made
- Describe situation at the time incident occurred
- Conduct a gap analysis by comparing steps 1 & 2
- Identify the impact of the gap

Normal Practice	Situation or practice at the time of the incident	Gap (difference)	Impact of Difference
Pre-drainage system	Pre-drainage of GM and P Seam	Floor Blowers connecting to reservoir below GM Seam	General body concentrations of CH4 exceeding 2.0% at Tailgate drive and 2.5% in tailgate roadway
Mine ventilation system	Normal operation	Increased gas make – Floor blower	General body concentrations of CH4 exceeding 2.5% in tailgate roadway

13 APPENDIX: WHY TREE ANALYSIS

The Event

CH4 Greater Than 2.5% in Tailgate Return

Gas Drainage and Ventilation System LTA

Floor blower uncovered by production

Floor blower released methane under pressure

Gas released greater than dilution capacity of system

Ventilation and Gas Management System unable to accommodate sudden spikes in general body concentration

14 APPENDIX: INCIDENT REPORT

Enablon ID No. 211941

ONRM HPI

Hazard & Incident Report Form 31388

AngloAmerican

To be completed by reporting person with assistance from Supervisor (for Surface incidents) or ERZ Controller (for UG incidents)

ALL Sections of this form are mandatory unless marked.

Title of Hazard / Incident:	Gas Exceedance In tailgate from Blowers		
Date occurred:	7 / 11 / 19	**Time:**	3-05 (am) / pm

Classification: Hazard ☑ Safety ☐ Material Losses / Damage / Business Interruption ☐ Legal / Regulatory ☑ Environment ☐ Social / Community ☐ Impact on Reputation ☐ Health Illness ☐ Workplace Exposure ☐

Department: Outbye ☐ Development ☐ Longwall ☑ Compliance ☐ Tech Services ☐ Seamgas ☐ SHE ☐ Business Improvement ☐ Human Resources ☐ Commercial / Supply Chain ☐ Maintenance / Engineering ☐ Other

Specific Location:	TG Roadway & Longwall face.		
Reported By: *Include ID #*	Adam Meggs		
Key Person(s) Involved: *Include ID #*	Adam Meggs		
Others Involved: *Include ID #* (e.g. Witnesses)	—		
Equipment Involved:	TG RTW Sensor.	**ERZC / Supervisor:** *Include ID #*	Adam Meggs
Crew:	A	**Contractor Group:**	—
Shift Length:	12	**Hours into Shift:** 8	**Consecutive days worked:** 6

Incident Description: Whilst cutting into Maingate Power Dropped of On Inspection found 2 Blowers @ 22# & 55# which Cause an increase in gas on face & spike TG RTW Sensor 2.789% CH4

Diagram (Attach additional notes if required):

Immediate Direct Cause:	Blowers in Coal	**Mechanism:**	Gas
Immediate Corrective Actions Taken:	Investigated, Reported & Setup Venturies @ 22#		

Refer to attached Grosvenor Risk Matrix for below:

Actual Consequence: Not Applicable for Hazards	**Insignificant** (first aid case, damage <0.01% annual revenue etc)	**(Minor)** (medical treatment, damage 0.01-0.1% annual revenue)	**Moderate** (lost time injury, damage 0.1-1.0% annual revenue)	**High** (permanent disability/ fatality, Anglo HPI)	**Major** (numerous permanent disabilities/ fatalities, Anglo HPI)
Potential Consequence:	**Insignificant** (first aid case, damage <0.01% annual revenue etc)	**(Minor)** (medical treatment, damage 0.01-0.1% annual revenue)	**Moderate** (lost time injury, damage 0.1-1.0% annual revenue)	**High** (permanent disability/ fatality, Anglo HPI)	**Major** (numerous permanent disabilities/ fatalities, Anglo HPI)
Has the hazard, defect or incident been effectively controlled on shift?				YES ☑	NO ☐

If not, why not?

GM0180 3B PRINT

Enablon ID No.

Hazard & Incident Report Form

AngloAmerican

		Timeline	
Peoples Behaviours:	—		
		2.00	Cutting
		3.05	Loss of Power
Environment:	Gas Exceedance.	3.15	Inspected found
			Blower 22ft & 55ft
		320	Reported.
Equipment:	Sensors,		
Procedures:	Legislative HPI		

Additional Actions to prevent reoccurrence: (ERZ Controller/ Supervisor to complete)

Action Description	By Whom	Action Due (date)	Enablon ID #
~~Setup Venturies~~	~~Deputy~~	—	—
COMPLETE LFI	H.HEARNE		TS.01146930
			TS.01146932
			TS.01146933
Is a Banner Alert required to be issued? Yes ✓ No ☐ If yes, which Banner Alert: Green ☐ Orange ☐ Red ☐	H Hearne		TS.01146934
			TS.01146935

Incident Sign Off:

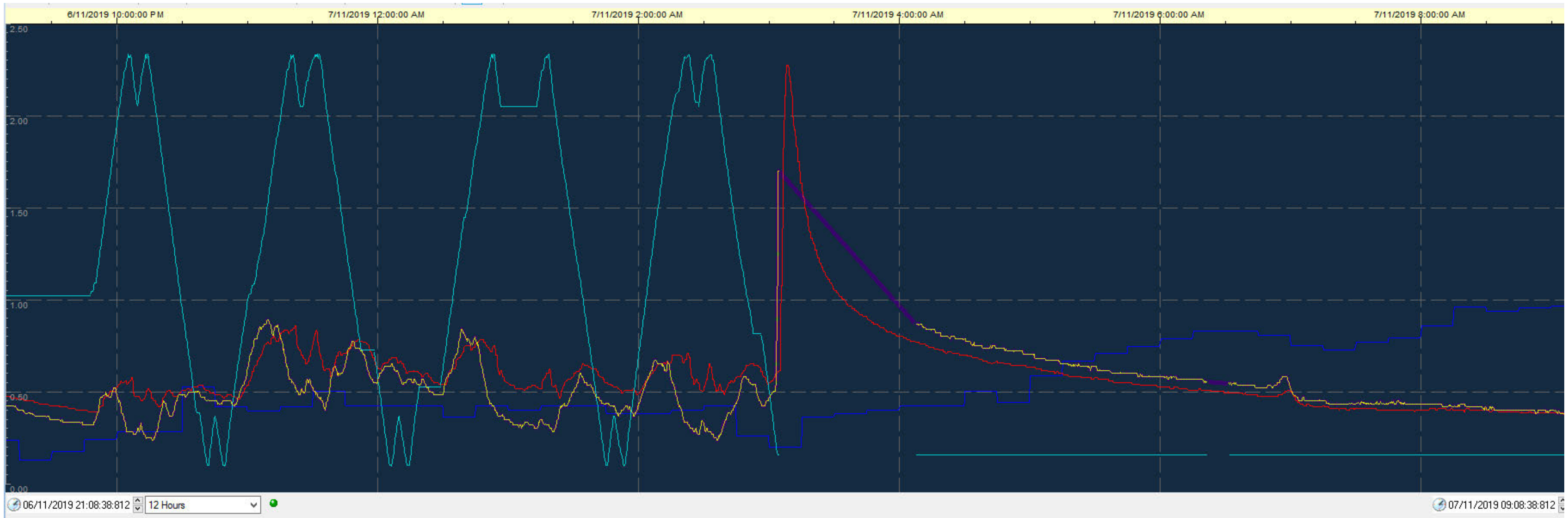
Person Reporting:	Date: 7/11/19	Supervisor (for Surface incidents) ERZ Controller (for UG incidents)	Date: 7/11/19
Name: Adam Maggs		Name: Adam Maggs	
Signature: [redacted]		Signature: [redacted]	

Verification Sign Off:

Undermanager	Name: A KRUSE	Signature: [redacted]	Date: 7/11/19
Superintendent/ Manager	Name: H.HEARNE	Signature: [redacted]	Date: 7/11/19
Entered into Enablon by (Name): J.Cooney		Signature: [redacted]	Date: 8/11/19

15 APPENDIX: EVENT CITECT TREND

12 Hour Period

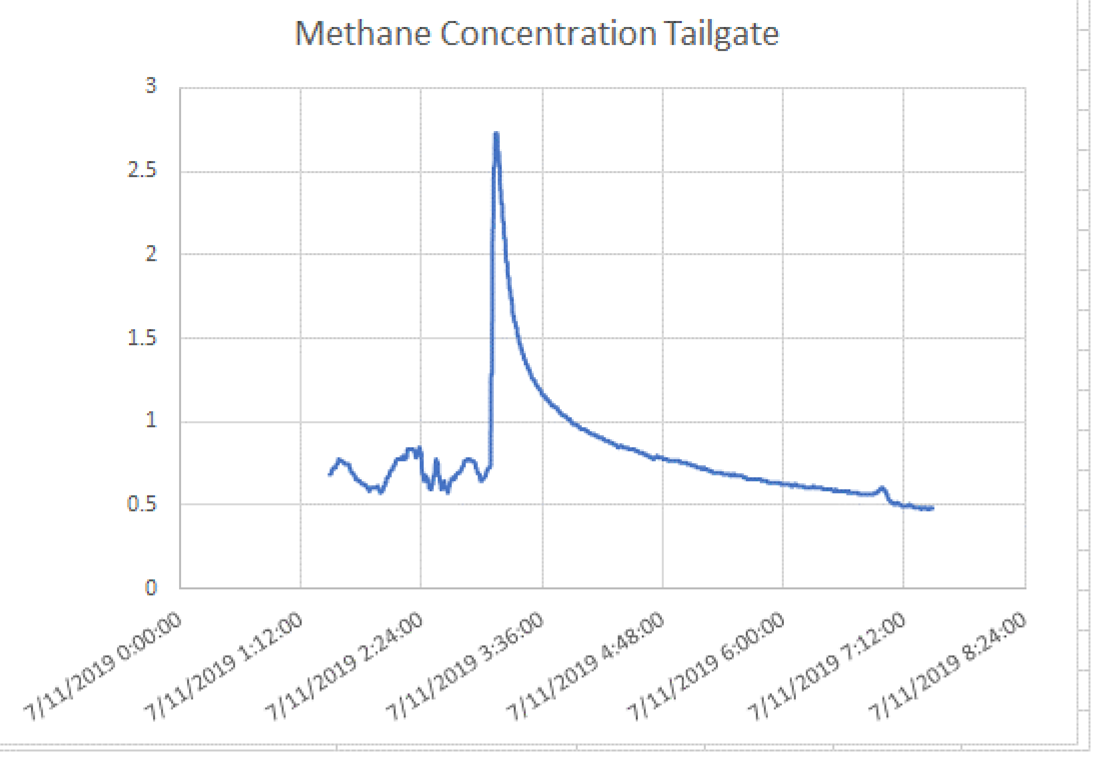


Object Tree	Maximum	Average	Current Value	Cursor	Cursor Time
Pressure (hPa)	988.85	987.08		986.52	7/11/2019 2:10:01 AM
Longwall Shearer CH4 Sensor A	1.38	0.07		0.23	7/11/2019 2:10:01 AM
Longwall Shearer CH4 Sensor B	0.76	0.12		0.34	7/11/2019 2:10:01 AM
Shearer External Feedback - High CH4	-	0		n/a	7/11/2019 2:10:01 AM
Longwall TG CH4 Sensor A	1.70	0.58		0.65	7/11/2019 2:10:01 AM
Longwall TG CH4 Sensor B	1.61	0.56		0.64	7/11/2019 2:10:01 AM
Shr Speed	14	2		11	7/11/2019 2:10:01 AM
Machine Speed	0.0	0.0		n/a	7/11/2019 2:10:01 AM
LOC 68 Methane (CH4)	2.73	0.72		0.78	7/11/2019 2:10:01 AM
LOC 70 Methane (CH4)	-	-		n/a	7/11/2019 2:10:01 AM
Shr Meters From MG Auto	298.8	91.5		204.9	7/11/2019 2:10:01 AM
Shr Meters From MG Manual	298.7	98.1		Gated	7/11/2019 2:10:01 AM

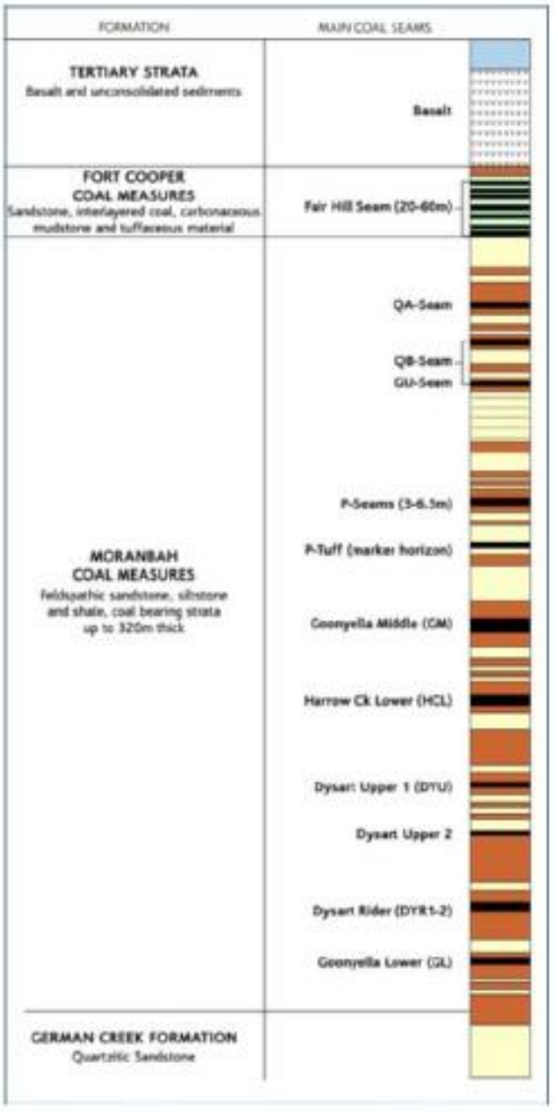
16 APPENDIX: GAS MAKE CALCULATION

Baseline CH4 before event	0.73

Tailgate CH4	
Start of Event	7/11/2019 3:04
End of Event	7/11/2019 5:08
Peak CH4 through fan (%)	2.73
Total CH4 Released (m3)	1,504



17 APPENDIX: STRATIGRAPHY



Seam	Depth (m)			Thickness (m)			Proximity to GM seam (m)
	Min	Max	Avg	Min	Max	Avg	
FH	30	330	200	0.00	50.00	45.00	160
QA	30	380	230	0.20	4.60	2.00	140
QB	30	375	260	0.20	4.25	2.50	120
GU	50	415	275	1.00	2.50	1.75	100
GR	65	455	320	1.50	2.00	2.00	60
PLI	65	465	320	3.25	4.25	4.00	57
PL1	65	465	320	1.50	2.00	1.50	57
PL2	72	470	325	0.30	1.20	1.00	55
GMR	75	500	360	0.30	0.70	0.50	30
GM	90	510	375	3.80	6.20	5.00	-
GML	100	530	400	0.00	1.00	0.20	5
HL1	130	560	410	0.30	1.20	0.50	20
HL2	132	562	415	0.30	1.70	0.60	30
HL3	135	565	420	0.30	1.70	0.60	35
DYU1	140	575	425	0.30	2.20	0.75	50
DYU2	145	580	440	0.10	1.80	0.80	55
DYU3	148	590	450	0.30	1.70	1.00	60
DYR1	165	600	455	0.90	1.30	1.00	70
DYR2	180	605	460	0.30	1.30	0.70	75
GL	190	625	475	3.00	4.00	3.50	95