Application of the QMRS GAG at Crinum North Mine

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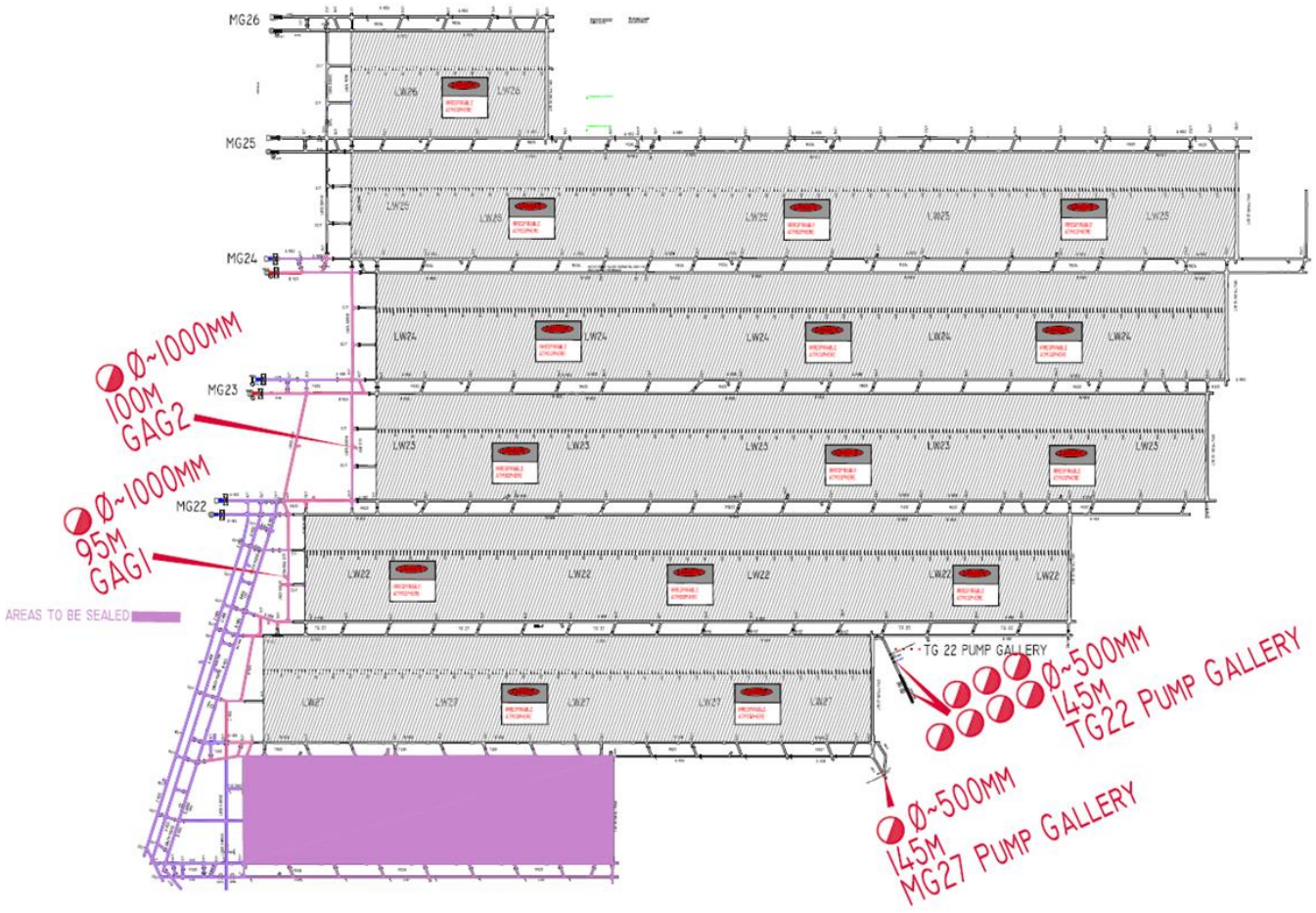
Introduction

- Production at Crinum North mine ceased November 2015
- Gregory Crinum (underground) is in care & maintenance
  - Required sealing of all underground areas
- Majority of Crinum North mine unsealed
  - MG25 & MG26 portals and LW25 X-Drive sealed October 2015
  - MG22, MG23 & MG24 portals, South Mains & LW28 remained open for LW28 second workings
  - Some surface to seam boreholes remained open for LW28 second workings
- Crinum North atmosphere benign
  - Seam gas predominantly CO2
  - Methane detected always below 0.1%
  - Sealed goves self-inertise, moving from fuel lean inert to non-combustible without passing through the explosive range
  - All previously sealed areas allowed to self-inertise (including Crinum South & Crinum East)
- LW28 would self-inertise, however approximately 8km (~130,000m^3) of open roadways outbye of LW28 would take considerable time to self-inertise
- QMRS GAG unit utilised to assist underground atmosphere

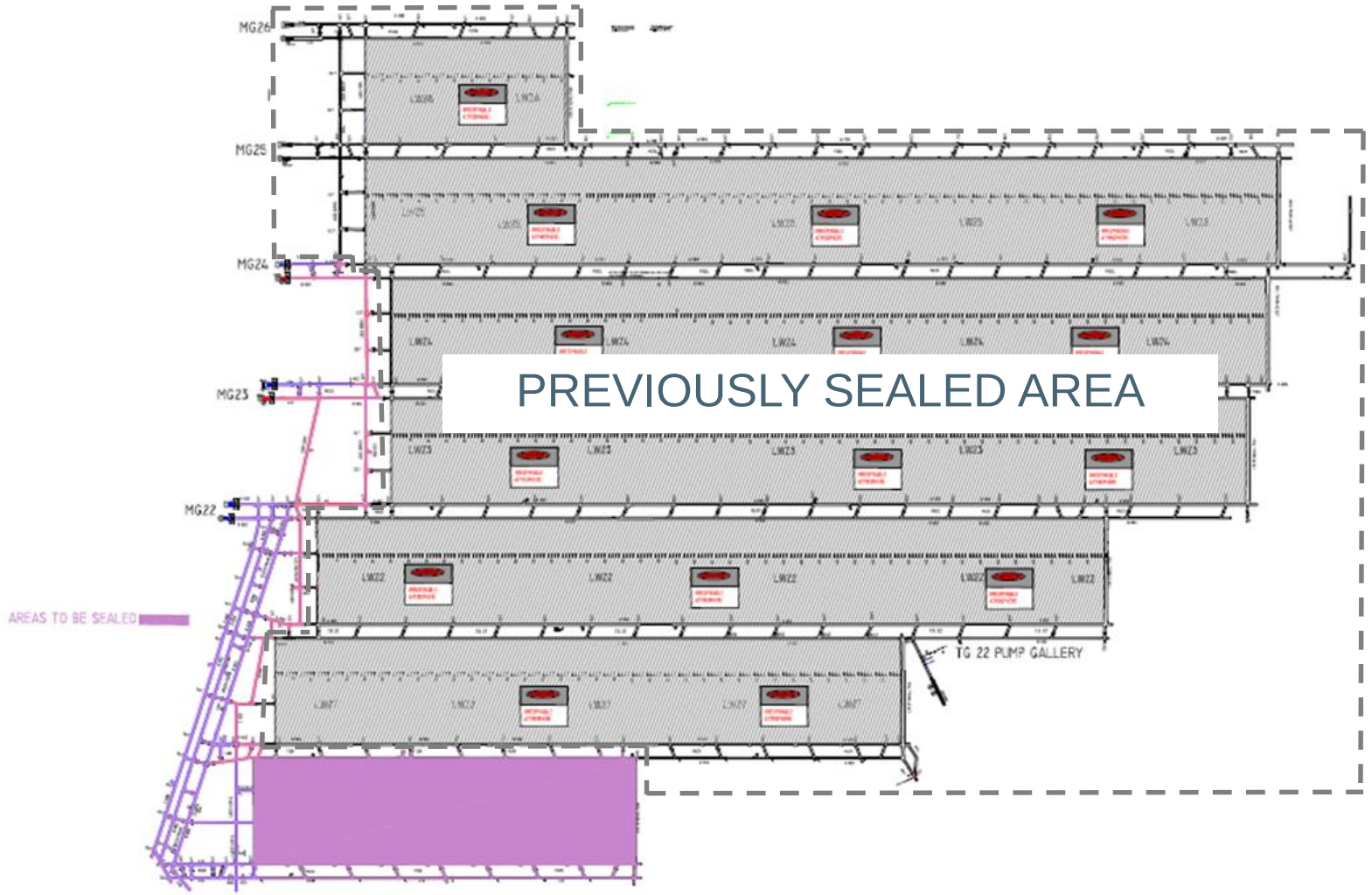
Crinum North Mine



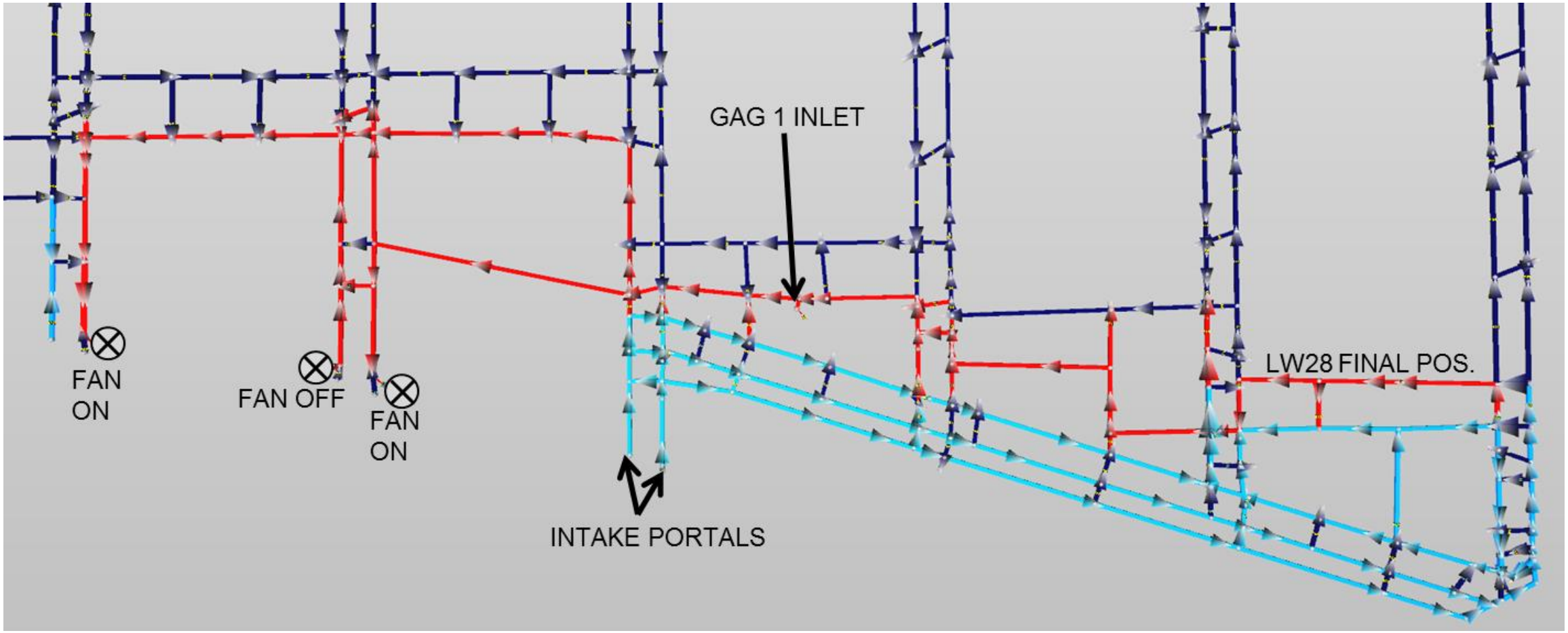
Sealing method

- Longwalls 22, 23, 24, 25, 27 sealed progressively following second workings & allowed to self-inertise
- Northern part of Crinum North sealed following extraction of longwall 26
- Southern sections of Crinum North remained open for second workings in longwall 28, with final mine sealing taking place following second workings of longwall 28
- Type E seals installed at all portals in competent strata as per sealing management plans
- Final stage of sealing involved sealing of all pump boreholes and two GAG inlet boreholes

Crinum North sealed areas



Ventilation system when longwall at final position



Strategy

- Use GAG 1 inlet – intersecting LW22 X-Drive in underground workings
  - Surface to seam borehole with inlet elbow on surface
  - LW22 X-Drive was return roadway for South Mains during operations
  - Second GAG borehole 300m away (LW23 X-Drive) sealed prior to GAG run
- All ventilation removed from underground immediately prior to GAG starting
  - MG23 A heading fan remained on until GAG about to start
- All portal seals constructed
  - Hatches in MG22 A, MG23 A & MG24 B heading seals
  - Hatches open, with locked gate to allow displacement and venting of atmosphere
- No changes to ventilation system after completion of LW28 production
- Expectation that majority of LW28 goaf would be inert when GAG run
- Hatches to be progressively closed throughout GAG run by mines rescue trained personnel under CABA
  - Gas levels at hatches checked by personnel under CABA with MSA Altair 5x prior to closing hatches
  - Target of 8% O2 at hatch for closing trigger

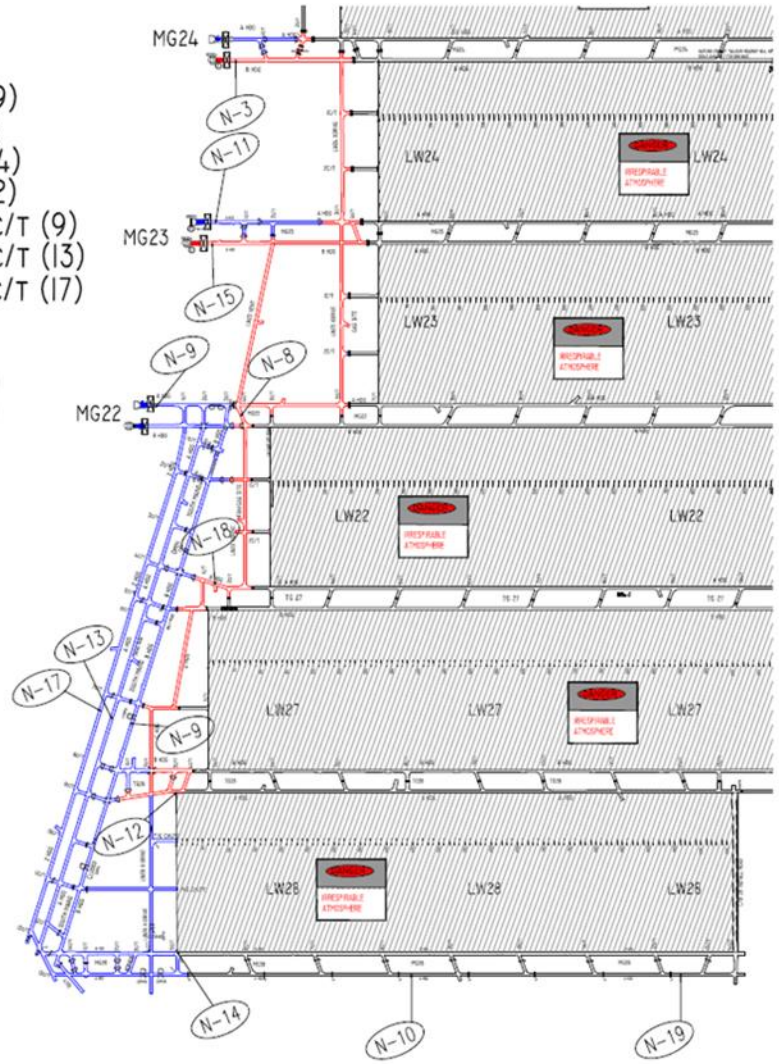
Gas monitoring

Gas monitoring data utilised to determine migration of GAG product throughout mine and trigger closing of hatches

- Tube bundle lines throughout underground in key places
  - LW28 tube bundle as per PHMP
  - Tube bundle lines placed throughout mains to gain understanding of GAG product flow
  - Tube bundle at 4 of 6 portals
  - All tubes relocated away from GAG inlet point prior to construction of seals
  - Tubes not in area to be sealed turned off for duration of GAG operation
- Real-time monitors placed at portals near hatches
  - All other underground Real-time monitors decommissioned as part of demobilisation
  - Portal monitors to provide instant readings to control room whilst GAG running
  - Sensor limitations understood
- Gas levels at hatches checked by hatch closing teams with MSA Altair 5x units

Tube bundle monitoring

TUBE BUNDLE LOCATIONS:
MG28 A HDG 12-13C/T (19)
MG28 A HDG 8-9C/T (10)
MG28 B HDG 5C/T INT (14)
TG28 A HDG 5C/T INT (12)
SOUTH MAINS B HDG 7-8C/T (9)
SOUTH MAINS A HDG 7-8C/T (13)
SOUTH MAINS Z HDG 7-8C/T (17)
TG27 A HDG 1-2C/T (18)
MG22 A HDG 0-1C/T (9)
MG22 A-B HDG 4C/T (8)
MG23 B HDG 0-1C/T (15)
MG23 A HDG 0-1C/T (11)
MG24 B HDG 0-1C/T (3)



Site management

Risk assessment carried out to identify and control hazards on-site associated with use of the GAG

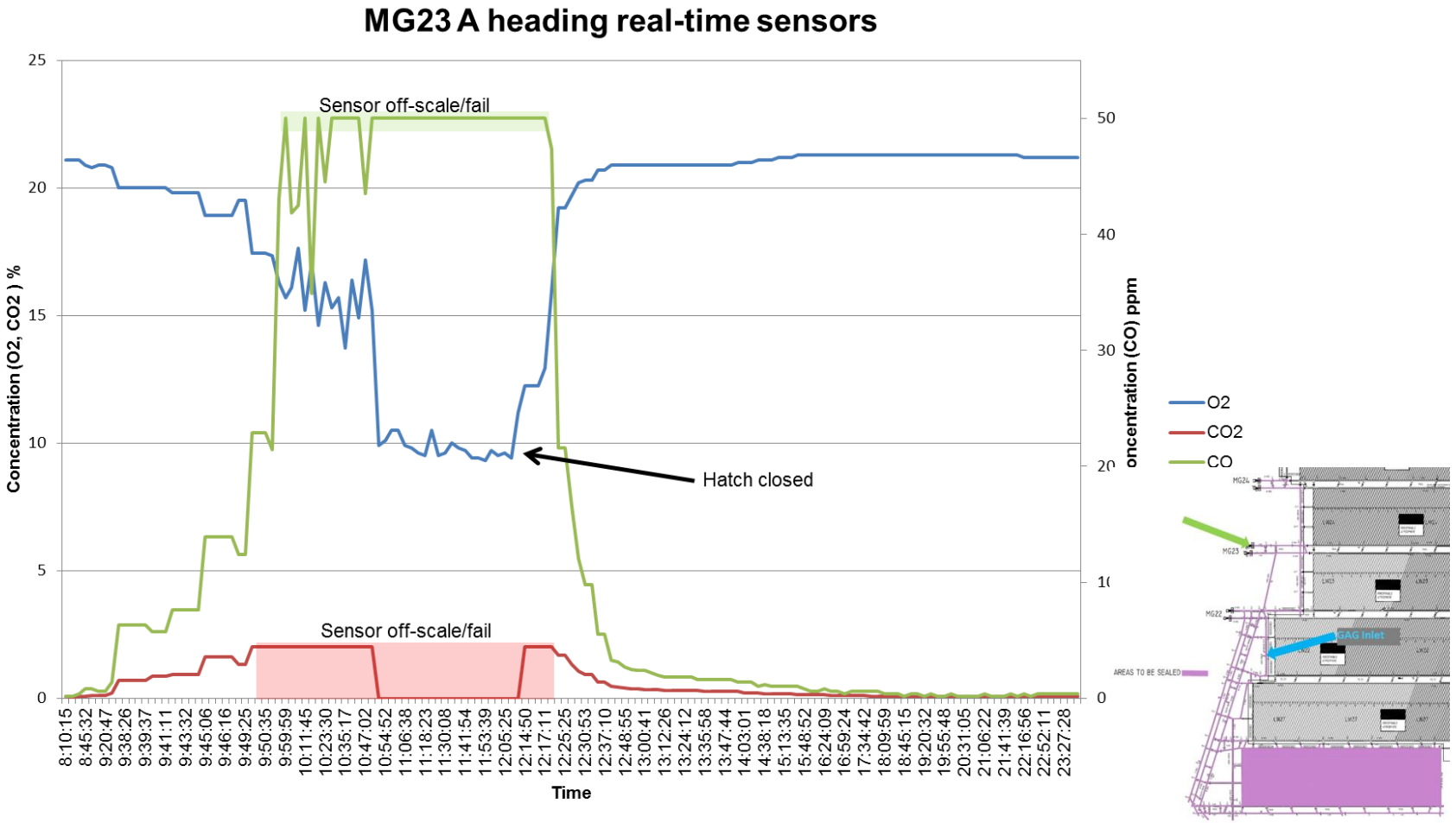
- Controls in place:
  - Limited work and personnel on-site for GAG run day
    - GAG docking area & GAG unit under QMRS control
    - Mines rescue trained personnel in trench only
    - Personnel not involved in GAG operations required permission to leave administration area
    - Site personnel briefed of activities
  - Sentries in place at entrances to Crinum North trench
  - Exclusion zone around GAG unit
  - No-road barricades & signage at portals
  - Hatches chained back
  - Mines rescue trained personnel to don CABA at car park prior to entering portals
  - Radio and phone communications between control room, QMRS, GAG coordinator, hatch team
  - Compressed air available at portals to clear GAG product after hatches closed
  - Sentries in place until portals confirmed clear of irrespirable atmosphere
  - Run sheet used to control activities throughout day

GAG run

- Set up completed Monday 7 & Tuesday 8 December
- Test run Tuesday 8 December
- GAG started 8.30am Wednesday 9 December
- Ran for 11 hours

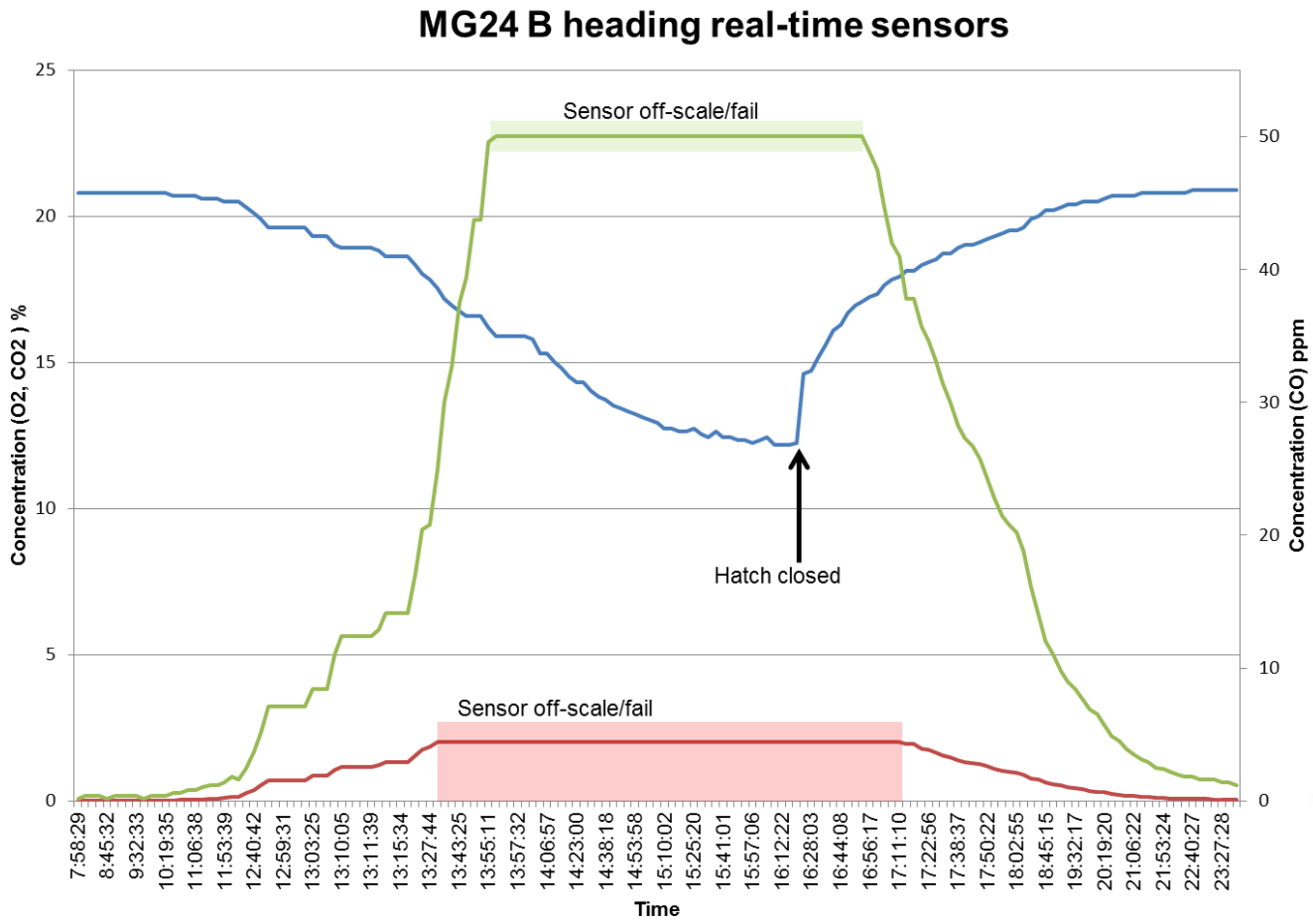
GAG run

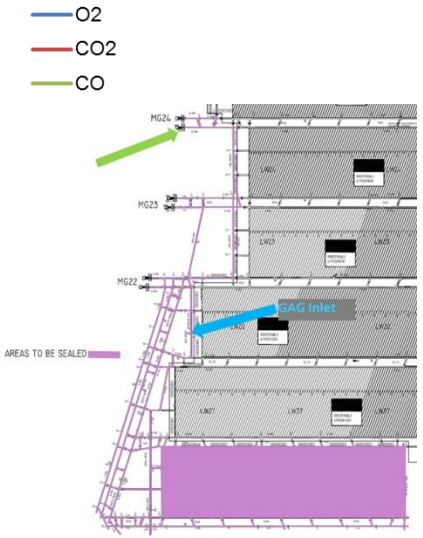
- GAG product first detected at either end of LW22 X-Drive by tube bundle system at around 9.15am
- First signs of GAG product then detected at MG23 A heading hatch at around 9.35am
- Gas concentration at MG23 A heading hatch reached 10% O2 at 10.50am
- Hatch closing team investigated to confirm gas concentrations
- After some time of no major change in oxygen levels, MG23 A heading hatch was closed at around midday



GAG run

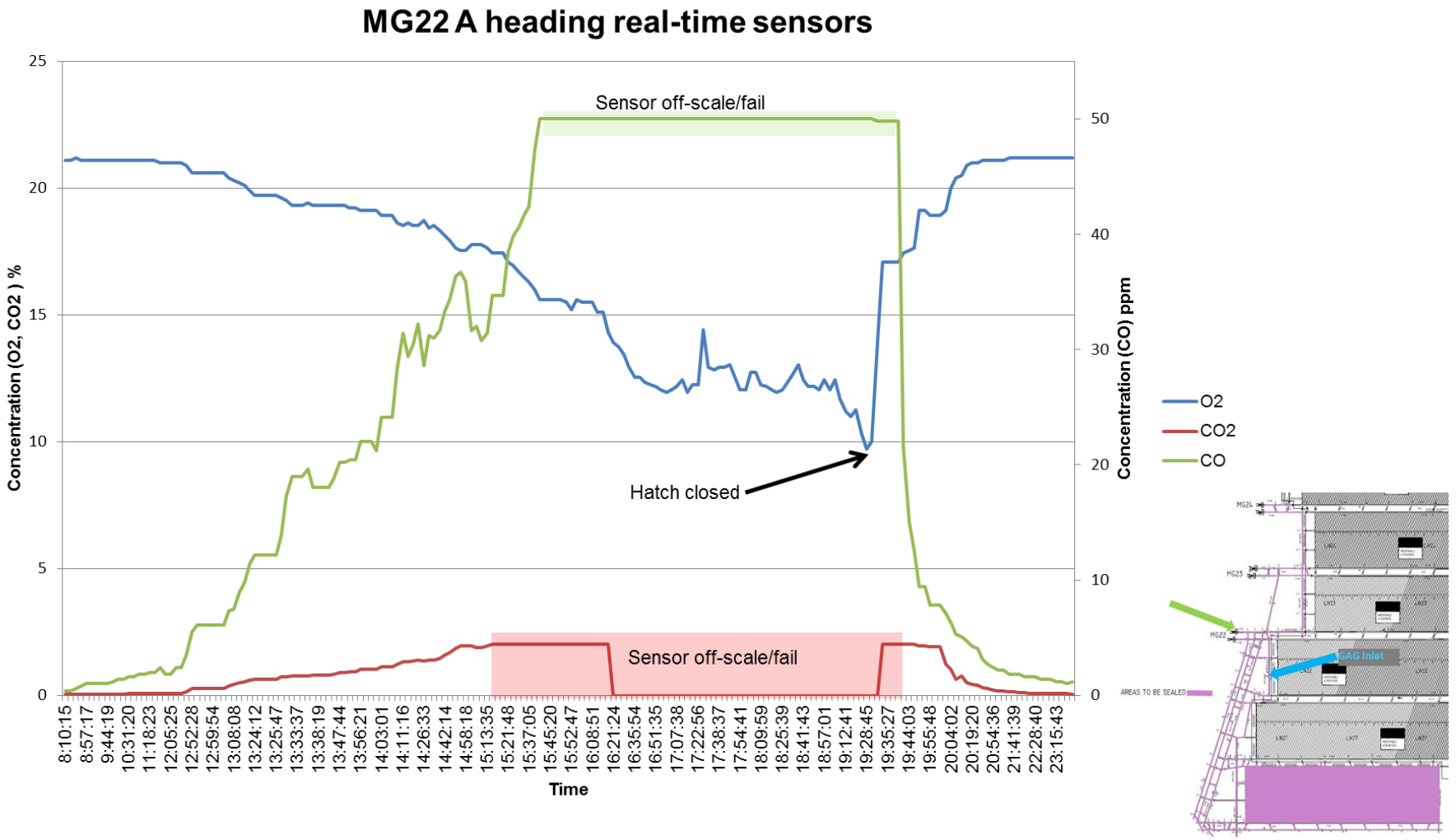
- First sign of GAG product at MG24 was around 10.20am by the real-time sensors
- The tube bundle system started picking up product around 10.45am
- MG24 B heading hatch closed around 4.30pm at an oxygen level of around 12%





GAG run

- MG22 was last hatch to be closed
- Product first detected at around 11.40am by real-time sensors
- Tube bundle started to pick up GAG product around 10.30am
- Hatch was closed at 7.30pm after GAG had started shut down
- Hatch was unable to be closed prior to due backpressure on GAG unit reaching maximum with all hatches closed
- 8% oxygen was not able to be reached at any hatch during the GAG run
- GAG output running at ~4.5% O_2



Results of GAG run

Overall reduced oxygen levels throughout Crinum North Mine

- Did not achieve below 8% oxygen on run day throughout underground areas of Crinum North, however oxygen levels were significantly reduced

Gas monitoring continued via tube bundle until the 15 of December

- Most locations below 8% oxygen on 15 December
- Exceptions were at portals, expected that these were influenced by barometric pressure changes & suspected leaking tube
- Seals inspected after GAG run to check integrity – no concerns

GAG was run longer than expected

- Run for 11 hours
- GAG product did not simply displace existing underground atmosphere

Carbon monoxide and carbon dioxide levels at all monitoring locations depleted after GAG run

Run appeared to assist reducing oxygen levels in northern part of mine which had been previously sealed in October 2015

An increase in carbon monoxide levels inbye in LW28 also indicated that some GAG product did migrate through the LW28 goaf

Conclusions

Successfully assisted the underground inertisation of Crinum North Mine

- Accelerated the inertisation from months to days
- Enabled whole mine to be classified as stable and inert, including a previously sealed area which had not yet been declared stable and inert

Successful use of a borehole as a GAG injection point

- Small diameter borehole central to the mine workings utilised
- Inlet elbow minimised leakage at the docking point
- Operation of the GAG well away from portal entries

Real time gas monitors recovered quickly

- Whilst real time gas monitors may have gone off scale during the operation of the GAG, the monitors recovered quickly when fresh air was returned to the area

GAG unit provided sufficient ventilation for the task

- No additional ventilation devices were required
- GAG produced sufficient ventilation from the injection point through the workings to the portal hatches

Recommendations for further work

Modelling and reconciliation of the use of the GAG to enable better predictions to be made in planned and emergency situations

Consideration of placement of GAG docking stations or injection locations for effectiveness

- Locations central to mine workings or placed around areas of elevated risk such as active longwalls

Installation of sensors on the collar of GAG inlets to allow for flow approximation during use of the GAG

Improvements to GAG docking stations to minimise leakage

- In particular where backpressure relief valves are installed

Investigate the use of the GAG as an inertisation tool in combination with other inertisation methods to shorten inertisation time

Test the effect of the GAG exhaust against fill products which may be used in emergency sealings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