

MINE VENT

2019



Tracer Gas Study of Nano Diesel Particulate Matter (nDPM) Behaviour in Secondary Ventilation Practices

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What is nDPM? nano Diesel Particulate Matter

- Diesel engines generate Ultrafine particles (even Tier3 and Tier4)

not all captured by filtration

- nDPM - Ultrafine particles ($< 80\text{nm}$) behave more like gases

Penetrate deep in the lungs

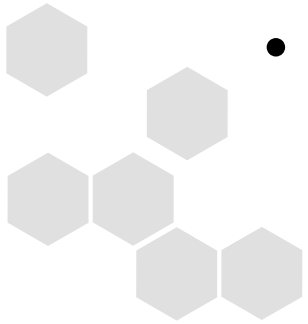
Can use Tracer Gas technology to understand the flow behaviour of Ultrafine particles



Tracer Gas - SF₆

Clearly differentiates between the contribution of different emission sources - No interference

- Reliable and repeatable results
 - Instruments are able to detect very low concentration
 - No cross sensitivity to other sources
- Safe to use



MRIWA Project M495: A Study of nDPM Behaviour and Physico-chemical Changes in Underground Hard Rock Mines of Western Australia.

Funded: DMIRS and MRIWA

Aim

to assess the applicability of tracer gas technology as a tool to study diesel exhaust flow behaviour and source contribution in an underground hard rock mine.



Tracer Gas Study

Use of tracer gas (SF_6) to Study localized air flow and contribution of nDPM from various sources

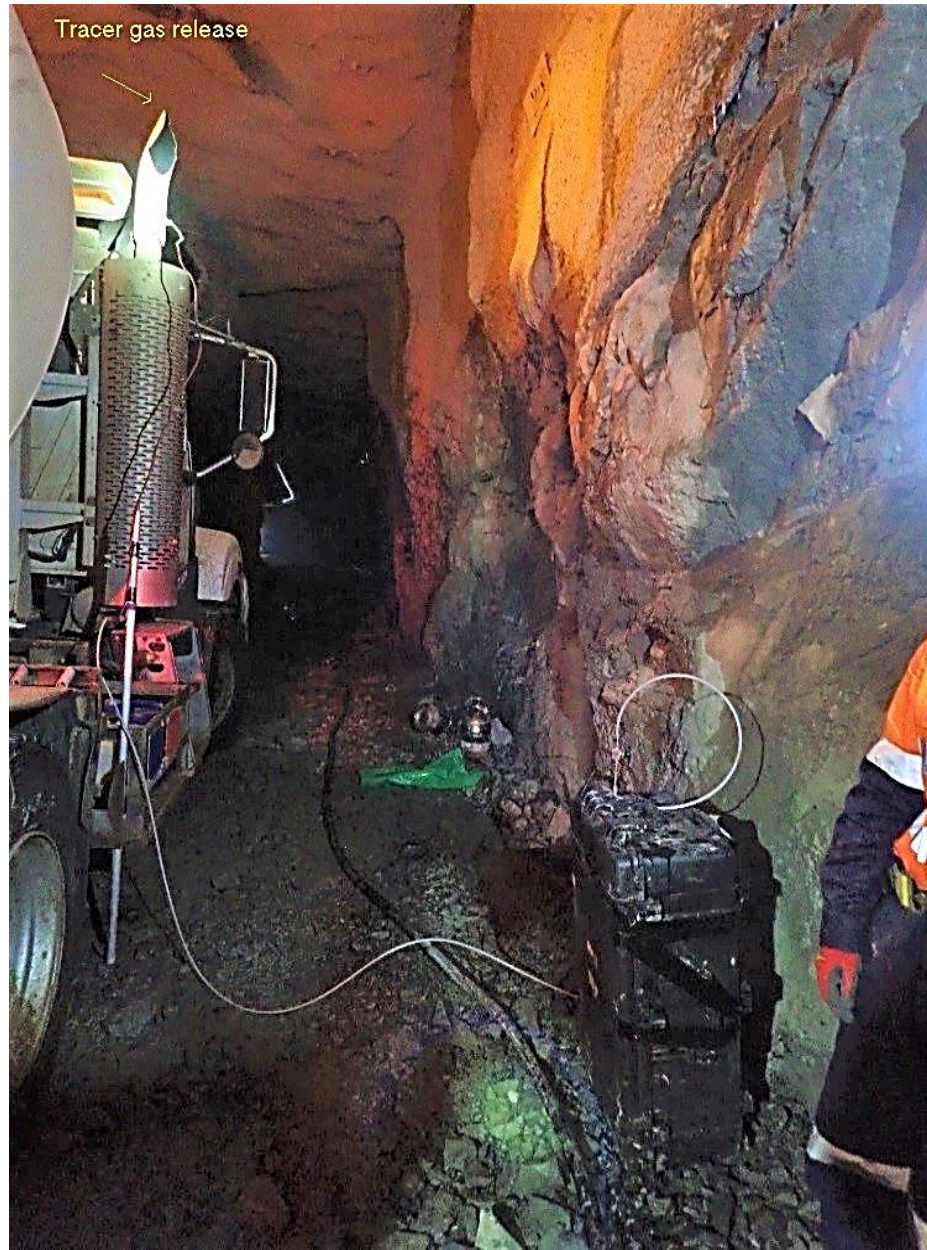
Development Heading - Astro 1900

- Charge-up
- Bogger
- Hydro-scaling, Spraymec
- Shotcreting
 - Spraymech; and
 - Agi-truck
- Truck
- Traverse study
- WATU WSX Portal interaction

Ventilation Conditions

Activity at Heading	Size of drive	Rated kW	Required airflow	Measured airflow	Condition by visual inspection
Hydro-scaling	5.5 m x 6.0 m	90 kW	4.5 m ³ /s	30 m ³ /s	Very good
Shotcreting	5.5 m x 6.0 m	346 kW [90 +256 kW]	17.3 m ³ /s	31 m ³ /s	Good
Charging	5.5 m x 6.0 m	110 kW	5.5 m ³ /s	29 m ³ /s	Good
Bogging	5.5 m x 6.0 m	305 kW	15.25 m ³ /s	28 m ³ /s	Good

nDPM Study – Agi-truck





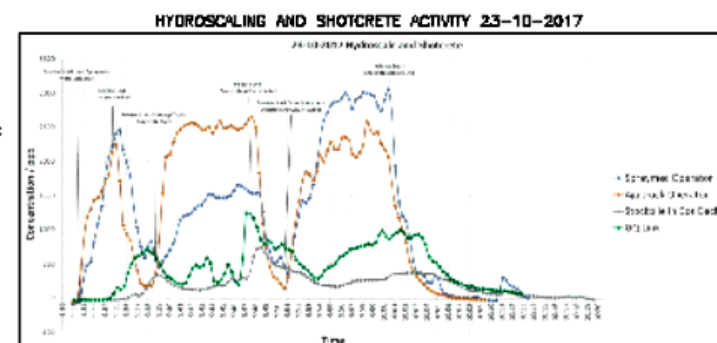
ASTRO 1900 HEADING
±40m/s

STOCKPILE

GQ 1895
LINK

GQ DECLINE









COS DECLINE.



NOTES:

1. 1.

LEGEND:

- | | |
|---|----------------------------|
|  | OPEN DUCT |
|  | CHOKED DUCT |
|  | TRUCK ROUTE |
| AS | AIR SAMPLING |
| M | MIRAN |
|  | TEMPORARY COOLER |
|  | REGULATOR |
| III | S/C WALL |
|  | GEC |
| # | BRATICE |
|  | AUTOMATED BLIND |
| [| ACTIVE DEVELOPMENT END |
| [| INACTIVE DEVELOPMENT END |
|) (| AIR CROSSING |
|  | TRUCK LOADING BAY (T.L.B.) |

**DRAFT
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INFORMATION**

DATE	HEADING ACTIVITY
16/10/2017	HYPERD SCALING
20/10/2017	SHOOTING
21/10/2017	BOCCY
22/10/2017	CHANGE-UP
23/10/2017	SHOOTING & 4-WHEEL SCALING
24/10/2017	SHOOT

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AND OTHER.		

BBE CONSULTING
AUSTRALASIA

**MINE VENTILATION
AND REFRIGERATION
SPECIALISTS**

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DPM RESEARCH

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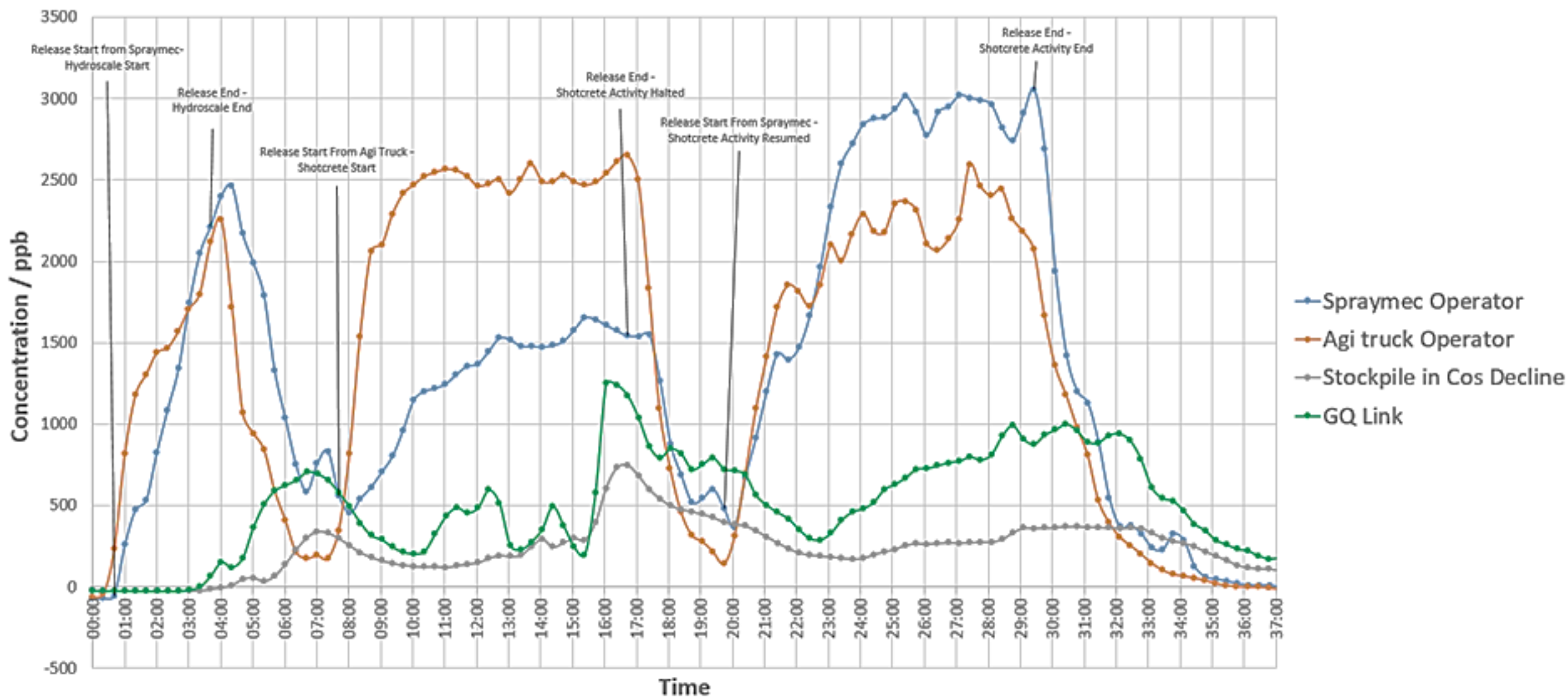
WHEELER 2002

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nDPM Study – Shotcrete



23-10-2017 Hydroscale and Shotcrete





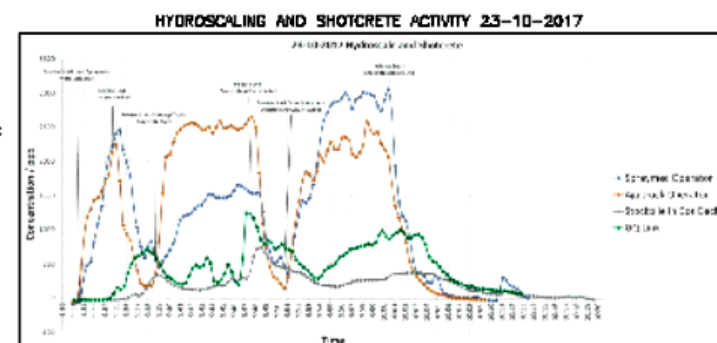
ASTRO 1900 HEADING
±40m/s

STOCKPILE

GQ 1895
LINK

GQ DECLINE














COS DECLINE.



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24/10/2017	SHOOT

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EXPENSE	DATE	AMT
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GENERAL CO.		
CPA/PAUL CO.		
RENTAL CO.		
CLIFF CO.		
ONE CO.		
AND OTHER		

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DPM RESEARCH

457

WINE: 2002

Tracer Gas Study - Outcomes

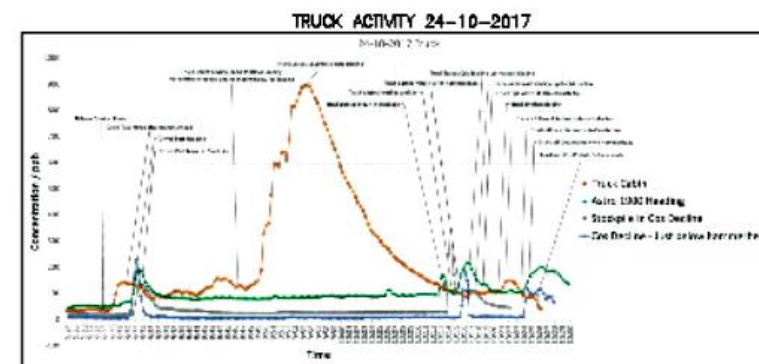
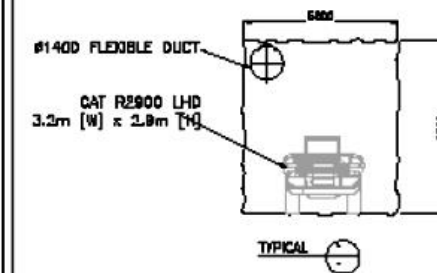
During shotcreting, the Agi truck operator experienced approximately the same exposure of SF₆ from the Agi truck and spraymech exhaust. In contrast, the spraymech operator received almost twice the exposure from the spraymech exhaust than from the Agi truck exhaust. The Agi operator in this instance was at greater risk.

Hence, because the spraymech is the more significant contributor of exhaust to the operators it is recommended that a focus on improving systems around the spraymech will give the greatest initial return on investment.
















nDPM Study – Truck





NOTES:

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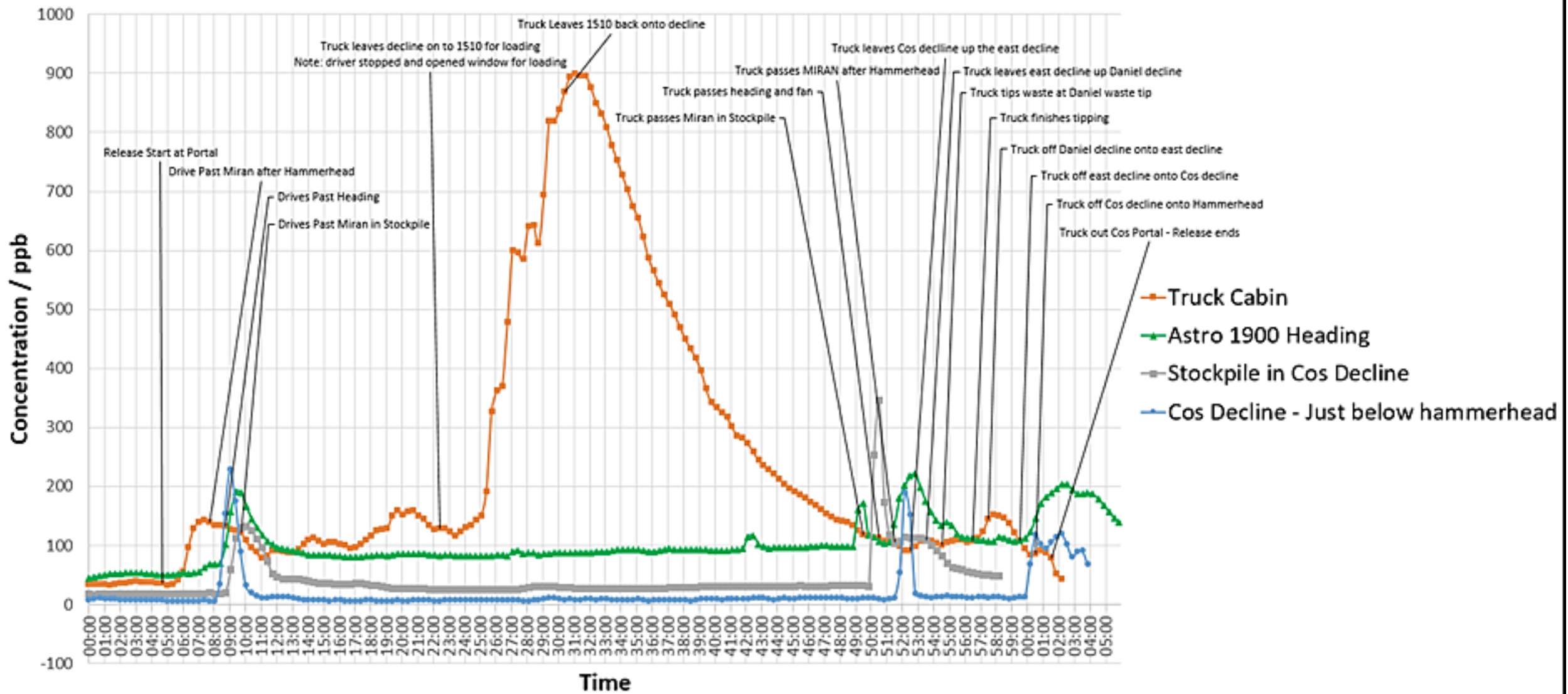
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DATE	HEADING ACTIVITY
19/10/2017	HINDO SKOLING
20/10/2017	SHUTCRETE
21/10/2017	BORDER
22/10/2017	CHARGE-UP
23/10/2017	SHUTCRETE & HINDO SKOLING
24/10/2017	SHUTCRETE

DPN RESEARCH		DATE		BY		CHK		APP		DATE		BY		CHK		APP		DATE	
DPN No.	REFERENCE DRAWINGS	REV	DATE	REASON DESCRIPTION				BY	CHK	APP	DATE	REASON DESCRIPTION				BY	CHK	APP	DATE

24-10-2017 Truck



Tracer Gas Study - Truck

The SF6 results from the **truck** study suggest that the enclosed airconditioned cabin is very effective in managing exposure levels. However, the level of SF6 exposure to the truck driver increases significantly when a window is opened (a 9 fold increase). Once the window is closed the clearance time is very slow. Thus, the opening of the window not only results in increased levels but also results in prolonged exposure to higher levels once the SF6 is inside the cabin. The benefits of ensuring the cabin remains isolated is clear and some administrative control needs to be considered.

A recommendation from this study is that the truck driver should keep the window closed while stationary during loading. However, if the truck driver needs to open the window to communicate with the loader driver it is best that the window is left open while driving away for a certain amount of time to ensure faster clearance of exhaust from the cabin.



nDPM Study – Charge-up



nDPM Study – Charge-up



nDPM Study – Bogger



nDPM Study – Bogger

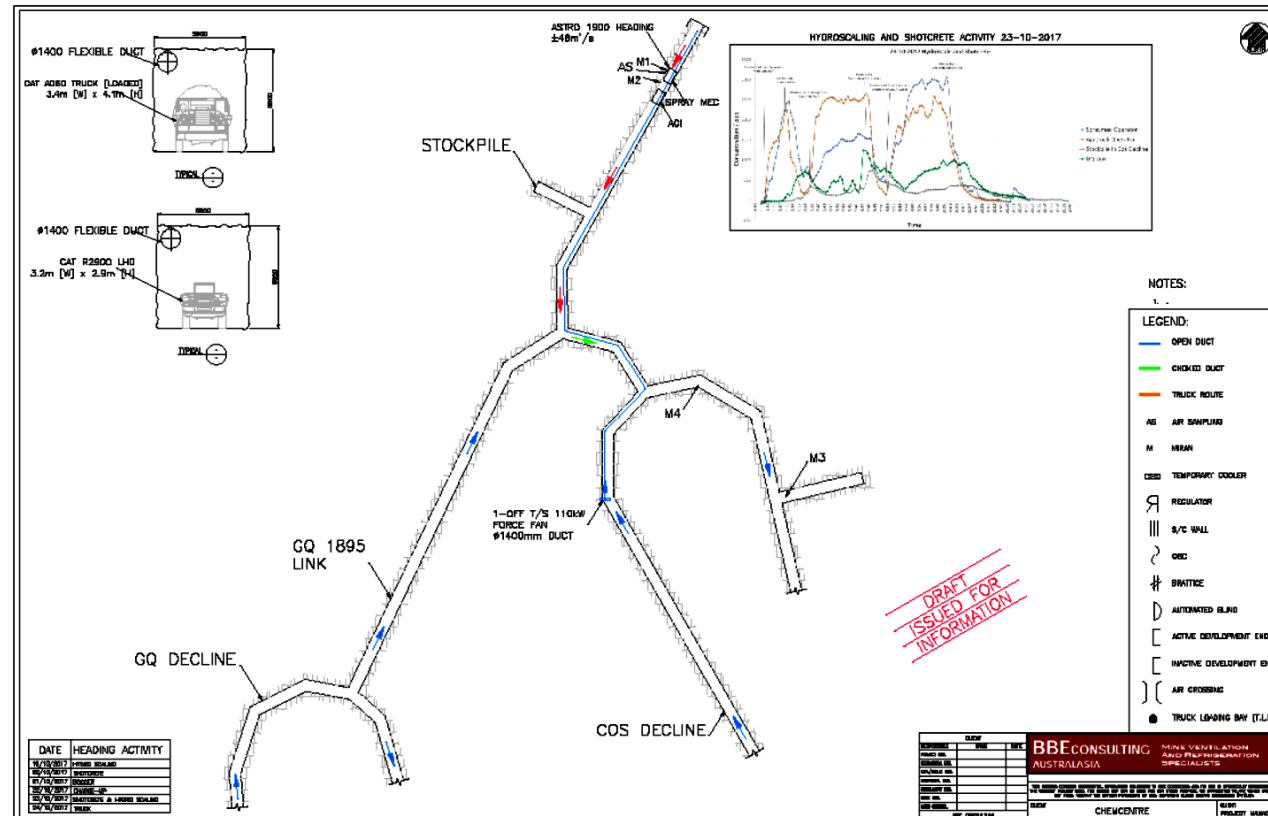


Tracer Gas Study - Outcomes

The tracer gas study of a number of underground mining activities, such as charging, bogging, hydro-scaling, shotcreting and truck driving, demonstrated that during those activities there were consistently **higher SF6 concentrations measured during the hydro-scaling and shotcreting activities.**



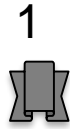
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Traverse Exercise

Spraymec
operator
position

Miran1



2

3

4

6.5m

Miran2



13.5m

Miran3



18.5m

Miran4

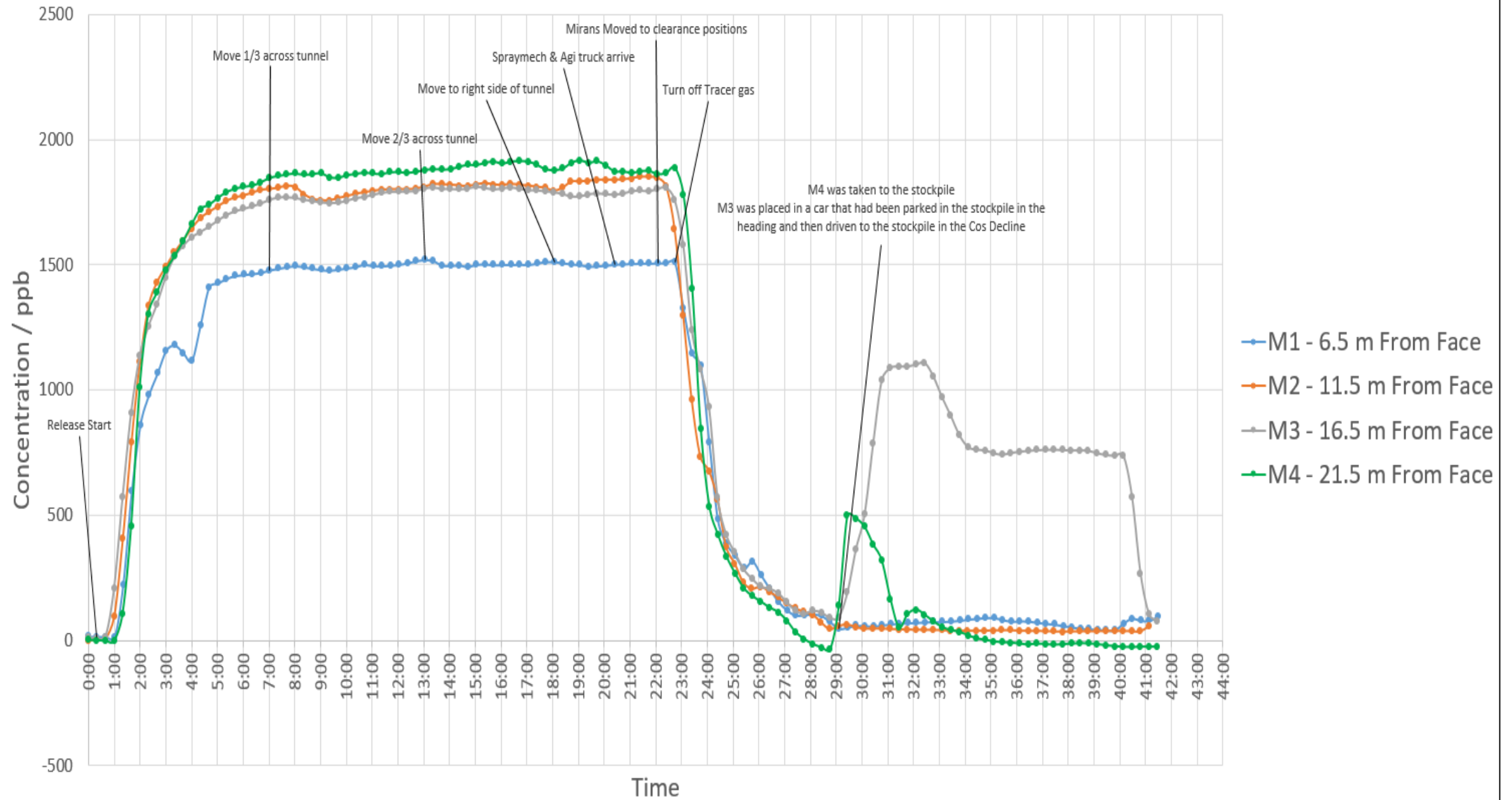


23.5m

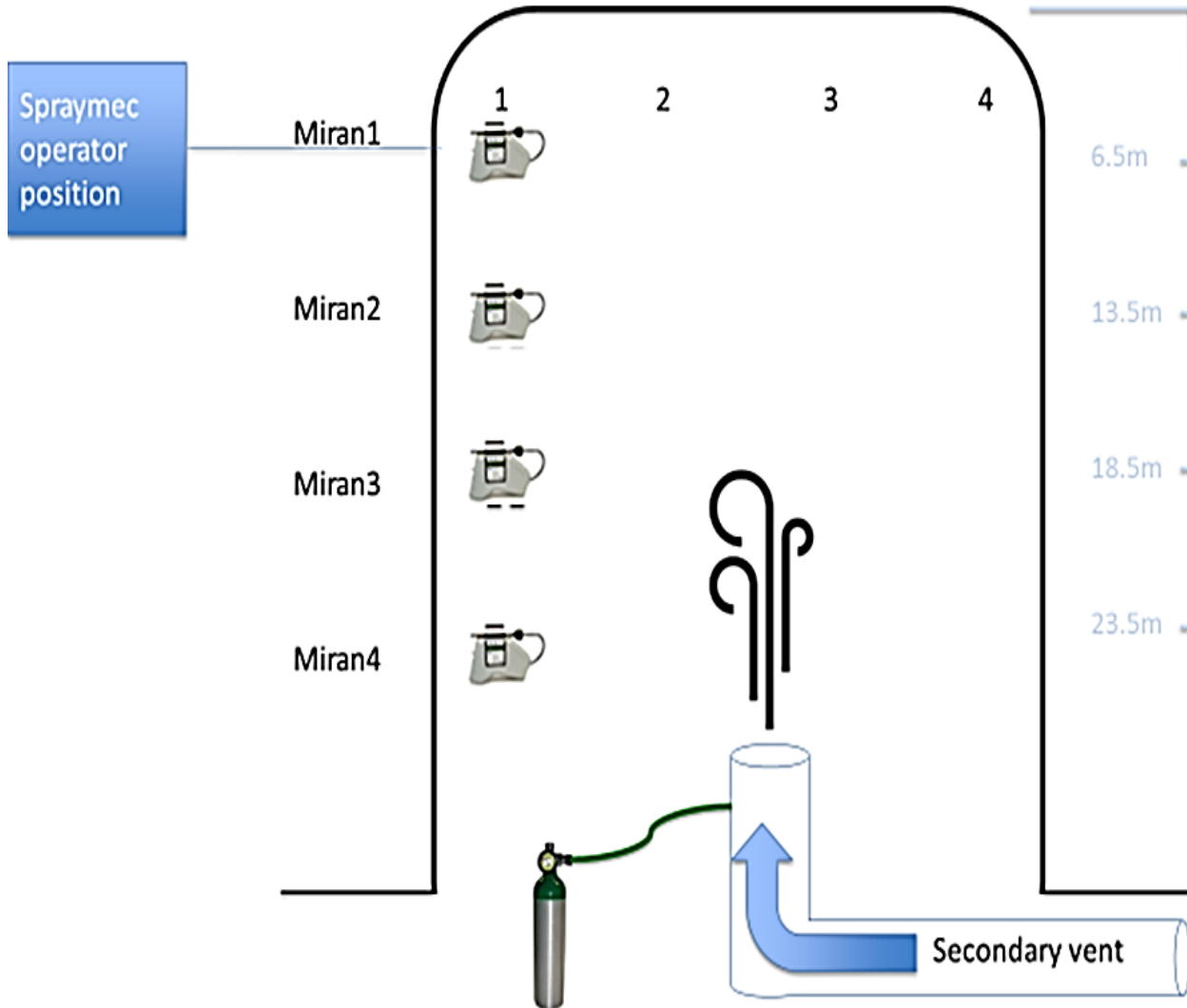


Secondary vent

23-10-2017 Traverse Exercise



Tracer Gas Study - Traverse Exercise



A **traverse exercise** performed in a well ventilated development heading demonstrated that there was little horizontal stratification across the heading despite the vent bag being near the right hand side of the heading wall. However, there was a very rapid drop-off in ventilation flow between 13.5m from the face and 6.5m from the face which means that areas much closer to the face will probably have far less effective ventilation.

Summary

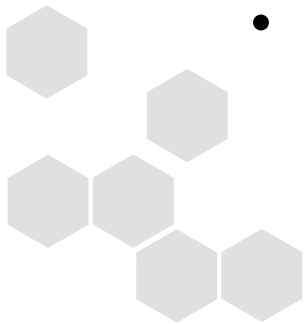
Tracer gas (SF_6) technology was applied successfully to better understand and inform the following:

- SF_6 flow behaviour as a surrogate for diesel exhaust and relative source contribution to exposure of nearby equipment operators;*
- The dispersal of gaseous and ultrafine particulate emissions from diesel exhaust, i.e. particularly nDPM, and the dilution efficiency of the mine ventilation with particular focus on the auxiliary ventilation at the face of a development heading;*
- The impact of ventilation practises on the exposure levels; and*
- The potential impact of nano-diesel particulate matter (nDPM) on air quality.*



Tracer Gas Study – Recommendations for Future Work

- Controlled experimental set-ups with different secondary ventilation configurations should be considered to allow comparative studies that will enable ventilation optimisation.
- It would be possible to correlate SF₆ tracer gas measurements with dispersal of nanoparticles if particle characterisation data is available from the sites studied using tracer gas. This would require particle analysers to be co-located with the tracer gas detectors.
- It is recommended that future research on nDPM in underground mines includes both tracer gas study and particle characterisation at the same location.



Acknowledgments

- **DMIRS and MRIWA**
- **Anglo Gold Ashanti/SDGM & Barminto - On site staff**
- BBE Consulting Australasia - Leon van den Berg
& Katie Manns
- ChemCentre in-kind contribution
- Sandvik, Perth





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Sandvik Visit – Truck



Questions?



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