Broadmeadow Mine Diesel Particulate Reduction Program

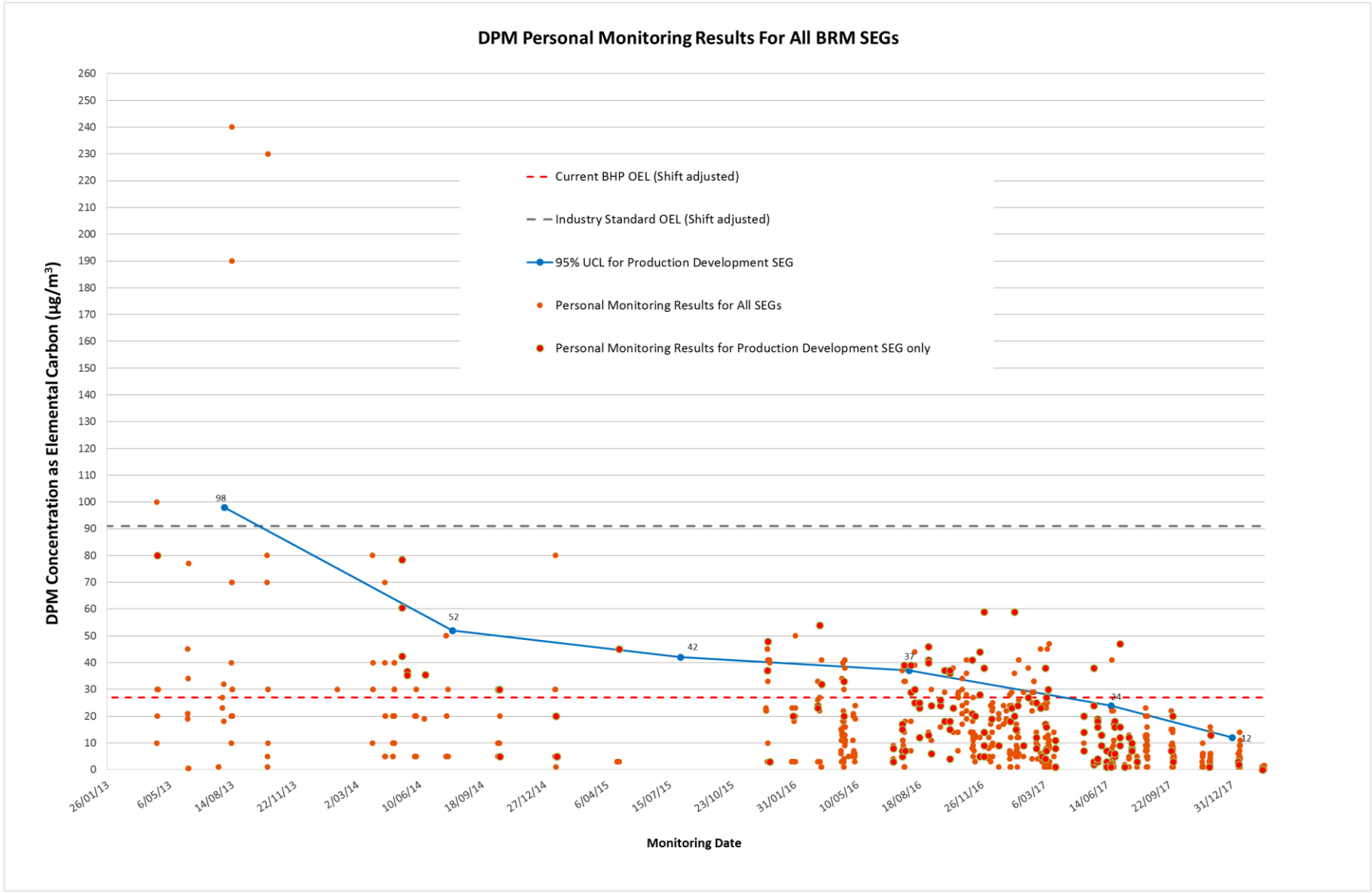
BMA Broadmeadow Mine

The Challenge

There are a number of epidemiological studies that demonstrate an association between exposure to diesel particulate matter (DPM) emission and lung cancer (Hoffman et al 2006). The International Agency for Research on Cancer (IARC) has declared diesel exhaust to be carcinogenic to humans.

BHP engaged the Institute of Occupational Medicine to conduct a review of the published literature (IOM 2015) and provide an update on the potential occupational exposure risk to DPM. IOM used dose response relationships derived from the literature to estimate the relative risk of lung cancer from occupational exposure to DPM. Based on these risk estimates and in the absence of any statutory limit specified for DPM, BHP MAU introduced a requirement for all operations to manage DPM exposures to no higher than an occupational exposure limit (OEL) of 30µg/m3 by Nov 2016, develop a 5-yr project pipeline to deliver the lowest diesel exhaust exposure that is technically feasible and to investigate the technical feasibility of achieving an OEL of 10µg/m3 in underground operations. The OELs set by BHP are significantly lower than the recommended Industry standard limits of 100 µg/m3, and this reflects a genuine commitment to protect the long term health and wellbeing of its employees.

BMA Broadmeadow mine is an underground coal mine located in the central Queensland and uses Longwall processing to extract the coal to the surface. The management team and workforce at Broadmeadow have met the challenge of reducing DPM exposures to as low as reasonably achievable by embarking on a journey of continually challenging and extending the boundaries of what has been previously considered best practice. The combined effort of the entire workforce being engaged on this journey, has culminated in the ongoing reduction of personal DPM exposures to below 25 µg/m3 (UCL-95%) for every Similar Exposure Group (SEG), by Feb 2018.


DPM Personal Monitoring Results For All BRM SEGs
DPM Concentration as Elemental Carbon (µg/m³)
Monitoring Date
Current BHP OEL (Shift adjusted)
Industry Standard OEL (Shift adjusted)
95% UCL for Production Development SEG
Personal Monitoring Results for All SEGs
Personal Monitoring Results for Production Development SEG only
98
52
42
37
24
12
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
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26/01/13
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14/08/13
22/11/13
2/03/14
10/06/14
18/09/14
27/12/14
6/04/15
15/07/15
23/10/15
31/01/16
10/05/16
18/08/16
26/11/16
6/03/17
14/06/17
22/09/17
31/12/17

The Solution

The DPM exposure reduction performance has been the result of multiple interventions which have been introduced over several years 2013-2018. The net result of where we are today is due to the combined contribution from multiple controls:

In summary:

1. Introduction of Exhaust Particulate Filters (2013). Application and Selection of filters was optimised 2014-2016.

2. Optimising Ventilation through Introduction of Diesel TAG Boards (2013), Improved TAG Board application/ effectiveness (2017/18) and increased Ventilation Efficiency (2017/18) Diesel TAG Boards.

3. Introduction of Emission Based Maintenance on Diesel Machines (In-house emission standards and scheduled engine emission testing, engine tuning, scrubber maintenance optimised from 2015)

4. Introduction of Low-Sulphur Fuel (BP Ultimate) (Sep-Nov 2016)

5. Introduction of low DPM emission (supercharged HINO) engine package to replace targeted high DPM emission machine types on LHD Loaders (2017-2018) – HINO engines installed on all LHD loaders deployed to Development districts by Mar 2018.

6. DPM Awareness training provided to all CMWs – at Induction course and follow-up periodic onsite training, including site specific information. Awareness training reinforces Diesel machine operating practices to minimise DPM emissions and compliance to wear RPE and

7. Personal respiratory protection equipment (RPE) – Designated mandatory RPE areas allocated to all production areas where SEG exposures exceed OELs. Minimum standard P2 half face respirators worn in all designated RPE areas. Mandatory respirator Fit Testing conducted for all CMWs to ensure individual provided with suitable face-piece selection.

8. Future controls under investigation include electrification of personnel carriers and/or engine substitution consistent with HINO installation of LHD Loaders.

9. Hygiene exposure monitoring and assessment has provided the primary system for Identifying those priority SEGs exposed above the OEL and provides the mechanism for how our DPM performance and success is measured. Personal exposure sampling is conducted at 1-2 monthly intervals and a sufficient number of samples collected from each SEG to ensure statistically valid analysis can be completed at quarterly intervals for the priority SEGs and on an annual basis for all other SEGs.

Personal DPM Monitoring

Personal DPM Monitoring

For the purpose of developing an exposure profile, workers were grouped into similar exposure groups (SEGs) according to the tasks they performed and areas they worked. For groups with risk of exposure to DPM, exposure data was gathered through personal monitoring for elemental carbon using NIOSH method 5040.

The sampling system includes a DPM cassette on which the sample is collected and a pump for drawing the air through the cassette. The DPM cassette is placed inside of a sampling head and connected to the pump unit by flexible tubing . The sampling head is then placed within the 30cm breathing zone and measure exposure for a period that is representative of the worker's activities. The samples collected are then sent to laboratory for analysis.

The results received for each SEG is statistically analysed according to BHP Billiton's Our Requirement Health (previously GLD.011 Health) to define the exposure risk profile.

The sampling head should be within the 30cm breathing zone to measure exposure accurately

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- The results of individual personal exposure samples are reviewed (and scrutinised) at the monthly DPM Committee Meeting and Managers Meeting.

- Single sample exceedances above the OEL are formerly investigated according to standard incident investigation procedures, to identify contributing factors and root causes and to identify and implement further DPM exposure reduction opportunities.

- Statistical analysis is conducted on the sampling results to calculate the 95% Upper Confidence Interval (UCL-95%) for all SEGs at 6-monthly and 12-monthly intervals to assess and update the DPM exposure profile, to track and review trends and monitor performance against our DPM exposure reduction plans.

- As we reduce exposures to below 10 µg/m3, we will be approaching the detection limit of the internationally accepted sampling method (NIOSH 5040) and more innovative sampling and analysis techniques will be required in order to maintain accurate exposure risk assessment.

- In addition the Broadmeadow Hygiene Team in collaboration with an international BHP working group, has commenced using real time DPM samplers in order to improve our understanding of DPM exposure scenarios and to verify the effectiveness of existing and proposed DPM controls. The real time sampling technique was successfully used in Aug 17 to measure the workplace DPM concentrations in air while operating a LHD Loader and compare the difference between the existing engine type and the proposed replacement HINO engine package. The results of this testing confirmed the significant reduction in DPM exposure achievable by carrying out the engine replacement at trial, prior to proceeding with the replacement of an entire loader fleet.

Recognising the wealth of knowledge and experience of the workforce it was decided to create a DPM exposure reduction committee. Sponsored by the Maintenance manager was a sign of management commitment and participation by ERZ controllers, Union representatives, SSHRs, ventilation officers, statutory officials, contractors and other interested CMWs ensured efficient use of the available expertise. The DPM exposure reduction committee was established chaired by the Development Diesel Superintendent.

The DPM committee developed a roadmap that detailed a unique multi-disciplined approach consisting of:

- workforce education aimed at buy in and commitment
- mine design review aimed at aligning ventilation strategies to support for DPM emission reduction
- Hygiene monitoring aimed at determining which and how effective controls worked.
- External technical resource engagement aimed at identifying what technology would be beneficial on this journey to eliminate DPM emission reduction

The DPM committee had regular meetings during which progress and effectiveness were discussed and where needed adjustments to the roadmap/ project plan were agreed upon.

The team realized that:

- Continue with current fleet of loaders, Broadmeadow Mine unable to achieve BHP DPM targets. High ongoing DPM filter costs and exposure of CMW to DPM.
- Electric Personnel Transporters: Continue with diesel fleet, high DPM filter costs and exposure of CMW to DPM

The technology solutions that the team landed on were;

- A capital project for upgrading all loaders with dry scrubber Hino engine packages. The Hino engine posed a challenge of having to meet the Broadmeadow Mine safety and operating requirements.
- Replacement of all diesel powered personnel transporters to Electric powered Personnel transporters which were in a prototype phase and yet had to be designed and commissioned.

Fuels & additives

BP Ultimate

In July 2016 BRM undertook gas tests on an alternative fuel, BP Ultimate Diesel. BP Ultimate Diesel is an advanced diesel fuel specially formulated with additives that clean and protect the engine's components. BP Ultimate ensures best combustion performance can be achieved over all working conditions. The increased combustion performance results in less fuel being used.

BP Ultimate Diesel was introduced at BRM on 1 Sept 2016

Emulsified Diesel

Trials have been conducted on the use of an emulsion additive to the diesel. Surface trials produced a DPM reduction of approximately 60%.

While this was a positive result the test fuel contained ethanol meaning the flash point would compromise the fuel and would not be certified for underground use. The test fuel also calcified the fuel tank of the machine and eroded an injector seat completely.

No further investigations are planned.

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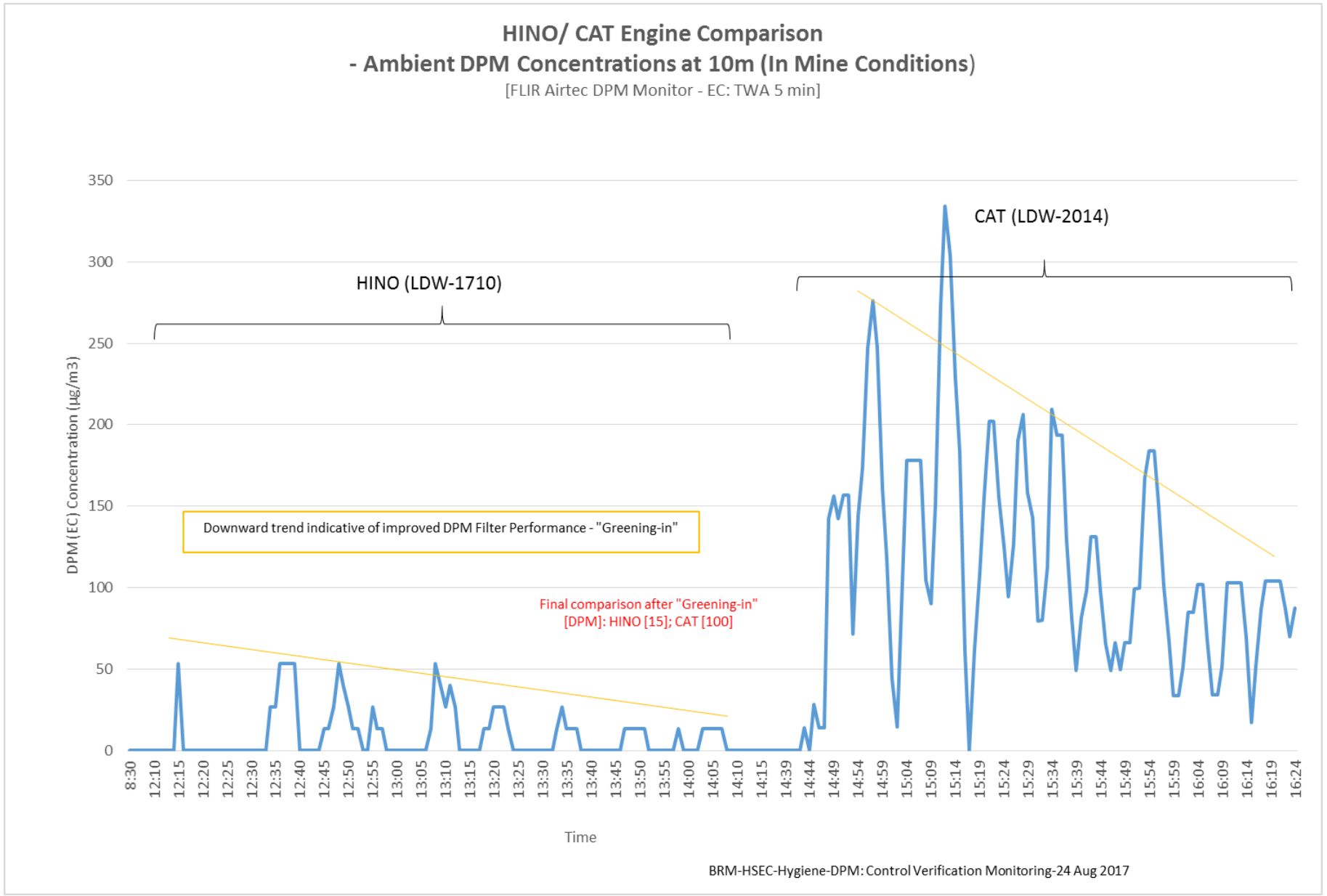
HINO/ CAT Engine Comparison
- Ambient DPM Concentrations at 10m (In Mine Conditions)
[FLIR Airtec DPM Monitor - EC: TWA 5 min]
HINO (LDW-1710)
CAT (LDW-2014)
Downward trend indicative of improved DPM Filter Performance - "Greening-in"
Final comparison after "Greening-in"
[DPM]: HINO [15]; CAT [100]
DPM (EC) Concentration (µg/m3)
Time
BRM-HSEC-Hygiene-DPM: Control Verification Monitoring-24 Aug 2017

Next steps

- Explored with EPEC engine packages using DPM regeneration Technology
- Memorandum of Understanding being created to use current contracts to develop a prototype engine package using proven DPM reduction technology
- Implement minimal modifications to existing fleet to accept new engine package. Full implementation expected by June 2019
- Expectation of 0 SEG exposed above OEL on completion of Personnel Transporter re-power

Benefits/ Effects

Through a holistic collaboration of CMWs, OEMs, Hygienists, subject matter exerts, etc. who by thinking out of the box the BRM team have identified, designed and implemented engineering controls to address DPM emissions. The result is the innovative use of special filters, engine types, maintenance routines and improved CMWs awareness, placing BRM is on track to be completely DPM emission free. BRM is on track to achieve the higher levels on the hierarchy of risk control when it comes to DPM exposure risk.

Current exposures are less than 30 uG/M^3 .And the project is on target to have a sustainable operation with less than 10uG/M3 DPM exposure. This may sound like a hygiene utopia, but the team at Broadmeadow is aiming to completely eliminate DPM emissions while maintaining and improving their production rates.

Transferability

Because the team used a project approach the roadmap and project chart can easily be adjusted to suit other mines. The trial data and the operational information of the technology used can easily be transferred to other mines. The fact that the project can be observed in action at BRM it will make it a lot easier for other mines that would like to go down this path.

Team Members;

Michael Thomas – Maintenance Manager

Toby Everson – Development Diesel Maintenance Superintendent

Daniel Hookham – Engineering Superintendent MEM

Paul Wyatt – Engineering Superintendent EEM

Andrew Bettridge – Mobile Maintenance Coordinator

Andrew Batterson – Specialist Hygiene

Dennis Brunings – Superintendent Health

Peter Baker – Superintendent Ventilation