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‘Keep the Cream’ — Reconciling Coal Recovery at BMA Goonyella Riverside

S N Johnston[1] and M J Kelleher[2]

ABSTRACT

CREAM is an acronym for coal recovery, evaluation, analysis and management and is a business improvement project at BMA’s Goonyella Riverside mine that is focussed on maximising coal recovered.

In August 2003, Goonyella Riverside was set a challenge to quantify coal loss and dilution and their relationship to cost, revenue and ultimately profit. While the mine was confident in its site forecasts of recovery (and loss), it was clear that the traditional measurement and analysis systems were inadequate to firstly, identify key loss areas and mechanisms and secondly, successfully quantify the benefit of various coal recovery initiatives.

The path that BMA Goonyella Riverside has travelled to maximise coal recovered can be divided into four key steps:

1. Mapping the process – This step involved the development of a coal flow process map for Goonyella Riverside that stepped through each component of the process from the coal reserve to the customer and identified key measurement points for the purposes of reconciliation.
2. Understanding coal loss and identifying opportunities – This step involved conducting two detailed Reserve to Customer projects at the mine site to track a block of coal from the reserve to the customer and to gain a greater understanding of the relationship of dilution, coal loss mechanisms, revenue and costs associated with recovering additional coal.
3. Coal data systems development – Two important coal data systems have been developed and implemented at Goonyella Riverside in the past twelve months, namely Snowden’s Coal Reconcilor and SeamFix. These systems enable coal losses and dilution to be quantified and reconciled back to the initial coal reserve.
4. Implementation of loss reduction initiatives – This step involved the formation of a business improvement project referred to as ‘CREAM’ in August 2004, for the purposes of improving pit coal recovery and maximising business value. To date a series of coal recovery trials have been run in a number of pits at Goonyella Riverside that have yielded significant improvements in business value.

The key to the success of this project has been the discipline to follow a defined process map, management commitment through resourcing and shared key performance indicators, a successful acceptance strategy resulting in holistic ownership and the implementation of sustainable reconciliation systems. Coal loss and dilution are now quantifiable and their relationship to cost, revenue and ultimately profit is well understood. This paper discusses the process that Goonyella Riverside has adopted to maximise coal recovered.

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BACKGROUND

Goonyella Riverside is the largest coking coal producer of nine mines operated by BHP Billiton Mitsubishi Alliance (BMA) in the Bowen Basin. Goonyella Riverside is located 190 km south-west of the Hay Point port facilities and 30 km north of the Moranbah township.

The economic coal seams within the Goonyella Riverside lease area are contained within the Late Permian Moranbah Coal Measures. Three seams are typically mined: the Goonyella Upper, Middle and Lower Seams. All are high quality, medium volatile coking coals and are widely recognised for their superior coking characteristics. The combined Goonyella Riverside leases have open cut reserves in excess of 600 million tonnes. The Goonyella lease has an *in situ* resource of approximately 1.6 billion tonnes.

BMA Goonyella Riverside currently operates a stripping fleet of four electric rope shovels (1 × P&H 2800, 1 × P&H 4100A, 2 × P&H 4100XPBs) and seven draglines (2 × BE1370s, 2 × BE1350s, 2 × Marion 8050-47s and 1 × Marion 8050-12). A simple schematic of the mining operation can be seen in Figure 1.

Goonyella Riverside has the capacity to produce over 13 million tonnes of coking coal product. To achieve this production, 180 million cubic metres of overburden will be moved (including rehandle) to uncover around 18.5 million tonnes of raw coal. It is clear that given the existing strip ratio that any incremental coal recovered from this process will add significant value to the business (a one per cent coal recovery improvement at Goonyella Riverside, equates to 185 000 tonnes of raw coal).

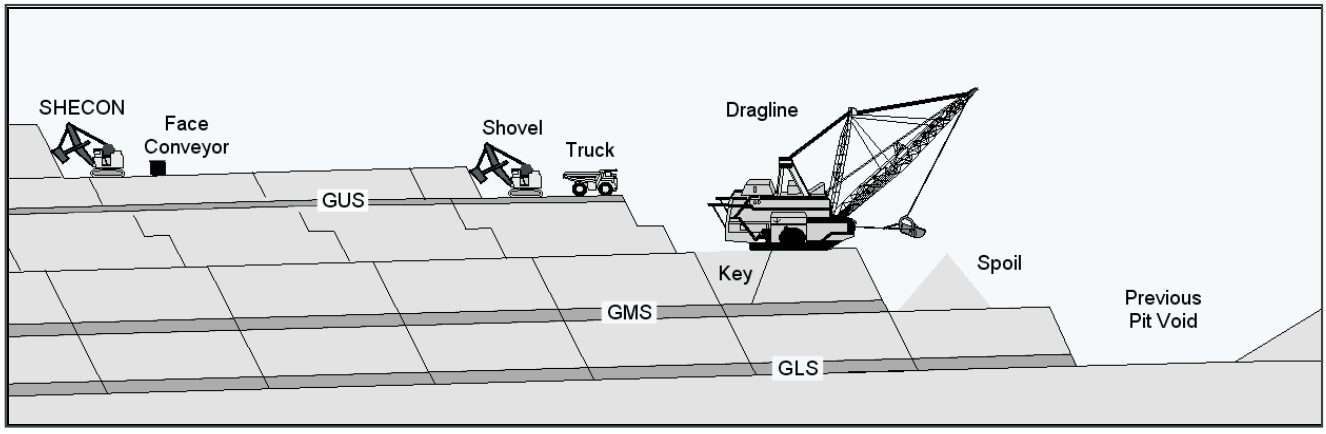

FIG 1 - Goonyella Riverside Mine stripping operations.

THE PATH TO MAXIMUM COAL RECOVERY

Coal damage, loss and dilution are inevitable outcomes of the mining process when utilising large-scale mining equipment. The path that BMA Goonyella Riverside has followed to maximise coal recovered can be divided into four key steps:

1. mapping the process,
2. understanding coal loss and identifying opportunities,
3. coal data systems development, and
4. implementation of loss reduction initiatives.

These four steps highlight Goonyella Riverside's journey through the process of reconciliation and business improvement to ultimately maximise business and shareholder value. Each of these four steps is discussed in greater detail below.

MAPPING THE PROCESS

Development of the BTRAK guide

The Business Improvement and Optimisation group within BMA facilitated a joint corporate/mine site project to map the coal flow process from the reserves to the customer, identifying key measurement points for the purposes of reconciliation. This was later developed into the BMA guidelines for tracking coal referred to as 'BTRAK'. A gap analysis was carried out on the existing measurements and analysis processes and an action plan was created to rectify shortfalls.

UNDERSTANDING COAL LOSS AND IDENTIFYING OPPORTUNITIES

The mine site undertook two Reserve to Customer projects to track a block of coal from the reserve to the customer and to gain a greater understanding of the relationship of dilution, coal loss, revenue and costs associated with recovering additional coal. Direct costs associated with recovering the coal and processing additional dilution as well as indirect costs associated with scheduling constraints and inefficiencies generated by these recovery processes were analysed. By understanding the mechanisms through which coal is lost, continuous improvement initiatives may be developed on-site to maximise coal recovered.

After the completion of the two Reserve to Customer trials, Goonyella Riverside reviewed its site coal assumptions used for forecasting and reserving.

Reserve to Customer (R2C) projects

Reserve to Customer trial 1 – Ramp 13 North Strip 22 Goonyella Lower Seam

In August 2003, the first Reserve to Customer (R2C) project was performed in Ramp 13 North Strip 22 Goonyella Lower Seam to define and demonstrate the engineering and operational requirements to monitor and manage the coal production chain to maximise shareholder value (Reserve to Customer Project, 2004: 4; Scott *et al*, 2004).

The objectives of the mining recovery trial were as follows (Reserve to Customer Project, 2004: 11; Scott *et al*, 2004):

- to compare the quantity and quality of a target block of coal with the parameters defined from exploration;
- to track the coal mined from the target area through the preparation plant to the product coal stockpile;
- to identify the locations and mechanisms of loss and dilution;
- to quantify mining recovery, breaker performance and preparation plant yield;
- to compare the overall recovery of saleable coal with that expected from the reserves;
- to recommend any changes to the current planning, measurement, mining, handling or washing practices that would improve future performance and finally; and
- to identify the resources required for similar analyses to be performed reliably and routinely.

After the coal had been uncovered in the trial area, thorough surveys were performed to accurately quantify the coal lost during the dragline uncovery and coal mining phases. During this exercise, cores were taken from 25 in-pit drill holes. The cores did not contain coal lost from the top of the seam in the overburden removal process and thus the full seam data was recreated using other core information. The quantity and quality of the *in situ* coal was then compared to the reserve model where it was found that the two estimates of the *in situ* tonnage agreed within one percent.

From the Ramp 13 North Strip 22 Goonyella Lower Seam trial it was found that the total loss could be distributed between four key areas: low wall coal wedge, top of coal edge, top of seam and floor of seam. Table 1 outlines the distribution of total coal loss from this trial.

TABLE 1

Distribution of total loss in the Ramp 13 North Strip 22 Goonyella Lower Seam trial.

Loss area	Percentage of total loss
Low wall coal wedge	27.42%
Top of coal edge	6.45%
Top of seam	48.39%
Floor of seam	17.74%

It should be noted that only 45 per cent of total loss takes place in the mining process with the remainder lost during the overburden removal processes. The total actual losses were found to be consistent with forecast actual loss; however, other key coal assumptions required further analysis.

Figures 2, 3 and 4, highlight the various types of coal losses that were analysed and measured during the Ramp 13 North Strip 22 Goonyella Lower Seam trial.

Reserve to Customer trial 2 – Ramp 10 North Strip 24 Goonyella Middle Seam

In February 2004, the second Reserve to Customer trial was performed in Ramp 10 North Strip 24 Goonyella Lower Seam for the purpose of confirming the key findings deduced from the first Reserve to Customer trial, to demonstrate that coal can be recovered using coal recovery initiatives and to further develop pit loss measurement techniques.

Similar to the first Reserve to Customer trial, extensive survey and geological control were crucial in successfully quantifying coal lost from the top of coal, low wall edge and floor as well as dilution due to the various mining processes from drill and blast through to eventual coal mining.

Due to an increased focus on coal recovery during the second Reserve to Customer project, it was apparent that there was significantly less damage to the top of coal and the low wall edge in comparison to the first Reserve to Customer project. In this trial, an excavator was utilised to expose the low wall edge of coal (an excavator dug low wall trench), which provided extremely favourable results and warranted further assessment. An important finding from this trial process was that the cost of utilising an excavator to dig the low wall trench is extremely cheap in comparison to the economic value obtained from the additional coal recovered.

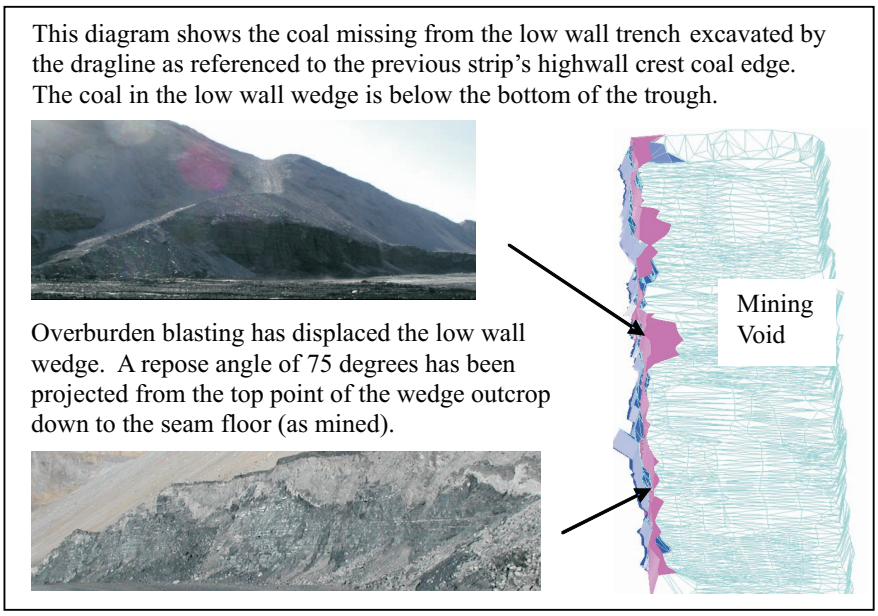

FIG 2 - Low wall coal loss during the Ramp 13 North Strip 22 Goonyella Lower Seam trial.

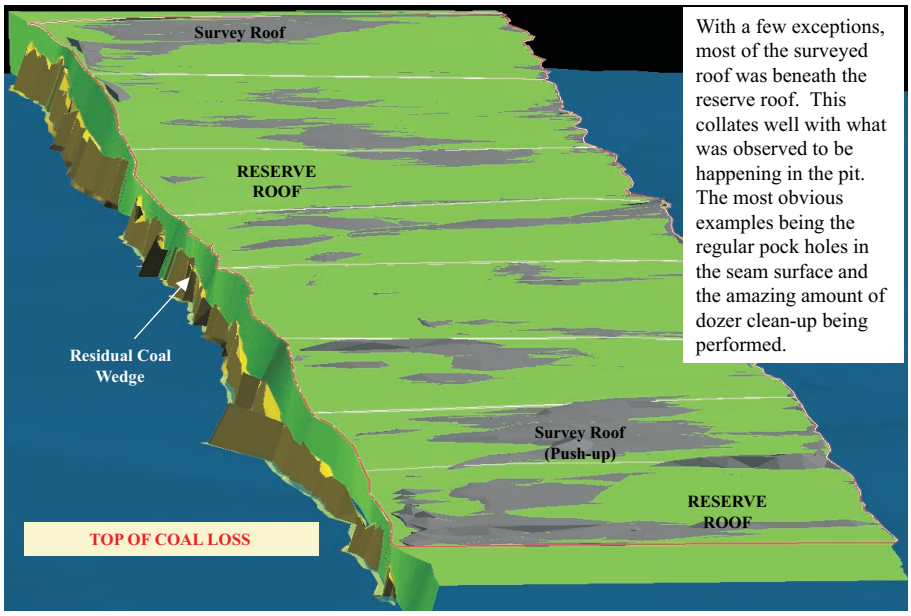

FIG 3 - Top of coal loss during the Ramp 13 North Strip 22 Goonyella Lower Seam trial.

Conclusions from the Reserve to Customer trials

The key findings and results from the two Reserve to Customer trials were as follows:

1. That coal can be tracked on a block-by-block basis from Reserve to Customer.
2. That the existing data and information gathering systems were under-utilised.
3. That a change in loss calculation philosophy was required. This involved a move from the traditional calculation (reserve minus mined void equals loss) to the direct analysis of loss itself.
4. That additional coal can be recovered at minimal cost by the implementation of coal recovery initiatives.
5. The *in situ* reserves and forecast saleable coal were within one per cent of actual.
6. For the purposes of reconciliation, coal data systems development was required to reduce engineering and surveying requirements.
7. A review of the Goonyella Riverside key coal assumptions for forecasting and reserving was required.
8. The development of a sustainable and an ongoing pit recovery project would be required to implement coal recovery initiatives to maximise business value.

Review of site coal assumptions

Based on the key findings from the two Reserve to Customer projects, the business improvement and optimisation group at Goonyella Riverside facilitated a review of the site coal assumptions for forecasting and reserving. The inconsistencies between short-term and long-term forecasting were resolved and the findings were implemented immediately.

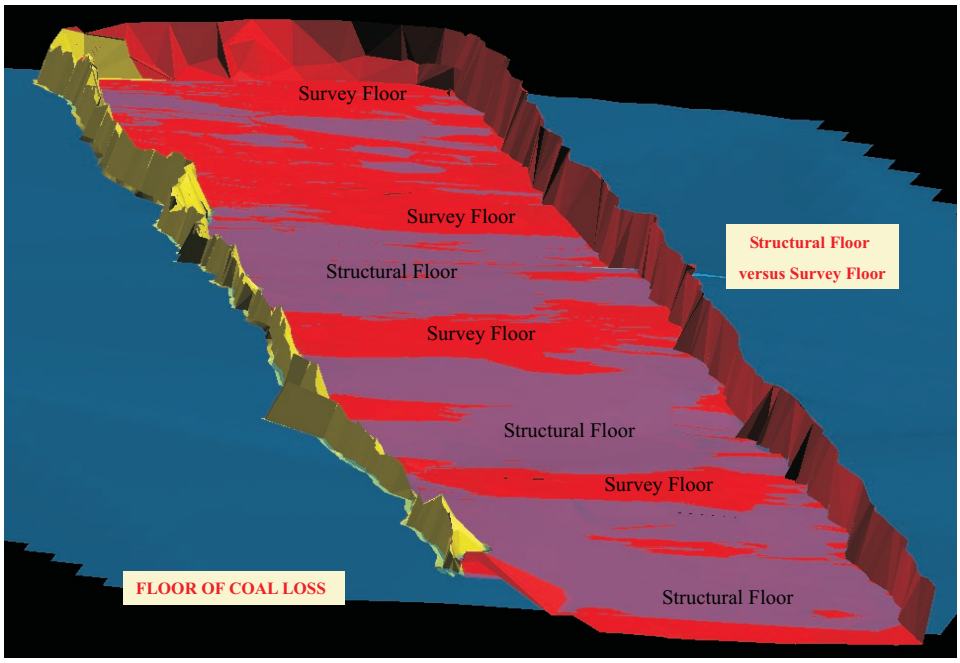

FIG 4 - Floor of coal loss during the Ramp 13 North Strip 22 Goonyella Lower Seam trial.

COAL DATA SYSTEMS DEVELOPMENT

An integrated coal data management system is essential to efficiently and effectively reconcile coal processes. During the past twelve months, two important coal data systems have been developed and implemented at Goonyella Riverside they were Snowden's Coal Reconcilor and SeamFix. The key goal of the implementation of these systems was to allow sustainable reconciliation with a minimal increase in engineering and surveying resources.

Snowden's Coal Reconcilor

In April 2004, Goonyella Riverside commenced a trial using Snowden's Coal Reconcilor for the purposes of integrating all site coal data to enable tracking and reconciliation of coal from the reserve model to the product stockpile.

Snowden's Coal Reconcilor is an Internet based software program that directly imports coal mining haulage data from the on-site fleet management system (FMS), reserving information from the XPAC mine model and preparation plant data from the mine information system. It allows input from survey, coal, dragline and prestrip planners on updated coal parameters and further input from coal geologists. The Internet based format of Snowden's Coal Reconcilor is extremely user friendly and allows the identification of coal losses and targeting of continuous improvement initiatives to maximise coal recovered. The most significant hurdle in the implementation of this software was the modifications required to existing coal data systems and the roll out of consistent nomenclature. This trial will be concluded in March 2005.

SeamFix

During the two Reserve to Customer trials, the surveyors at Goonyella Riverside were required to perform an unsustainable level of daily surveys due to the level of accurate measurement required for the purposes of reconciliation. It was concluded from the Reserve to Customer projects, that the traditional measurement of the mined void for the purposes of reconciliation added little value as the error in the mined void calculation was often found to be greater than the loss to be reported. In response to the development of a new loss measurement philosophy, the chief surveyor at Goonyella Riverside (Damien Vella) designed a graphics based survey software tool called 'SeamFix'.

SeamFix exploits the very regular and consistent seam structure along the strike as measured in exposed high-walls to interpolate the strike undulation string between surveyed high-walls for any position on the dip. This string is then indexed up or down to visually fit the actual surveyed roof and floor that reveals structural undulations along the dip. This indexing is at the discretion of the experienced pit surveyor who has made the measurements and is familiar with the existing geology and pit conditions.

The structural roof grade model is reconstructed using the available survey data and observations of pit conditions and photographs. The top of coal roof survey is used to vertically index the interpolated strike lines where the seam is not damaged. An interactive graphical interface provides the means to make these adjustments to the grade model with a high level of confidence by providing an instantaneous visualisation in both profile and section views at any place in the pit.

Shunted coal blocks, residual wedges and other abnormal features are measured by digitising in section view on slices taken at suitable distance increments along the pit. Surface comparison and volumetrics are performed on a one by one metre grid with output in standard CSV and Excel formats.

SeamFix is a computational component in a heuristic surveying methodology developed to meet reconciliation requirements. This program provides the means of rebuilding the most probable structural roof using the natural undulation along the strike and the surveyed top of coal surface. SeamFix was primarily designed to assist in calculating losses from coal seams where the successful use of the program is dependent on the user's surveying skills and a thorough knowledge of existing pit conditions. Figures 5 and 6 highlight SeamFix's ability (in cross-section and long-section) to reconstruct the most probable grade control surfaces based on the surveyed seam structure and the defined block seam thickness.

This software program has allowed the surveyors at Goonyella Riverside to appropriately model top of coal, low wall and low wall shunting, floor and dilution losses as well as reconcile a pit within a relatively short period of time. With the implementation of SeamFix, the surveyors at Goonyella Riverside now have a set process to assist and enable mine-site coal reconciliation.

SeamFix applies the well proven and readily understood calculation method of cross-sectioning. The algorithms that dynamically present sections for viewing on the screen are the same used for volumetrics. What you see is what you get.

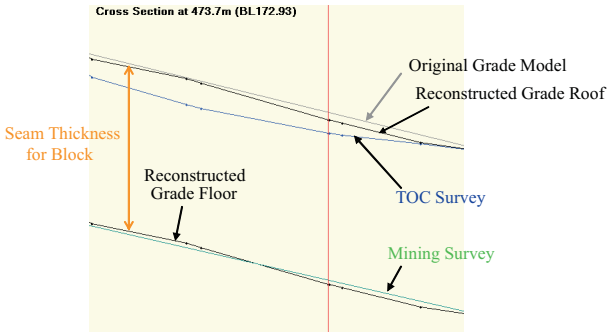

FIG 5 - SeamFix data view in cross-section.

The structural roof grade model is reconstructed using all available survey data and observations of pit conditions and photographs. The top of coal survey is used to vertically index the interpolated strike-lines where the seam is not damaged.

SeamFix provides the means to make these adjustments to the grade model with a high level of confidence by providing an instantaneous visualisation of all structural and surveyed surfaces at any place in the pit.

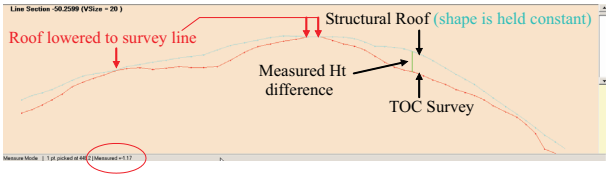

FIG 6 - SeamFix data view in long-section.

IMPLEMENTATION OF COAL RECOVERY INITIATIVES

Project CREAM

Introduction

CREAM is an acronym for coal recovery, evaluation, analysis and management and is an operating excellence project at BMA's Goonyella Riverside mine that is focussed on maximising coal recovered. In line with BMA's Health, Safety, Environment and Community (HSEC) objective of 'Zero Harm' this goal has been incorporated into the vision of CREAM which is '100 per cent coal recovery safely'.

The project is a team-based approach to maximising coal recovered and requires that all functions of the mining operations and technical services departments (that is, drill and blast, prestrip, draglines and coal mining) work together to develop separate coal recovery initiatives to maximise business value.

Process development

In August 2004, a CREAM project team was formulated for the purposes of measuring and managing coal reconciliation, improving pit coal recovery and maximising business value.

Once the team and the team charter were developed, the aims of the CREAM project were derived as follows: to maximise business value, to change the current mine site culture from a dirt driven culture to a 'Keep the CREAM' culture, to accurately measure coal loss (through the use of reconciliation software to minimise the use of surveying and engineering resources) and finally to decrease the amount of contract prestrip on site. The decrease in the amount of on-site contract prestrip was advertised to operators as it is currently visually evident on-site and it was reiterated to them that by mining more coal there is less demand for expensive, future contract prestrip.

To assure alignment and direction during the regular Project CREAM meetings, the team developed a process roadmap through which the project would be taken from the beginning through to project completion.

The steps involved in the CREAM process map were as follows:

1. The development of a diverse team – the CREAM team consisted of both mine operations and technical services personnel from operators through to managers.
2. The development of a Project CREAM charter – the team charter highlights the problem statement, project goals, definition and milestones, the team members and project sponsors.
3. A root cause analysis – this process allows the team to identify the root causes of problems that exist within the mining process.
4. Solutions generation phase – this process involved the brainstorming and development of coal recovery initiatives based directly from the findings deduced from the root cause analysis.
5. A payoff matrix – by plotting the solutions generated graphically (ease of implementation versus impact on coal recovery), those initiatives that were the easiest to implement and had the greatest impact on coal recovery were initially implemented.
6. A stakeholder analysis – as a team a stakeholder analysis was undertaken to identify the communications target, so as to ensure project success.
7. The development of an acceptance strategy – this phase involved extensive communication to mining operations and technical services personnel so as to obtain buy-in and support to the project.
8. Presentations of CREAM coal recovery initiatives and findings to mining operations and technical services personnel.
9. Implementation of CREAM coal recovery initiatives.
10. Reconciliation – this process involves the reconciliation of CREAM coal recovery initiatives utilising coal reconciliation software (Snowden's Coal Reconcilor and SeamFix) and survey control.
11. Feedback on the results and findings to the mining operations and technical services personnel was made.

Root cause analysis

By referencing the conclusions deduced from the Reserve to Customer trials the areas of high coal loss were analysed and the primary mechanisms were identified.

Coal loss was divided into the four keys areas identified in the Reserve to Customer projects; low wall coal wedge, top of coal edge, top of seam and floor of seam. These areas were further divided into loss mechanism groups and a root cause analysis

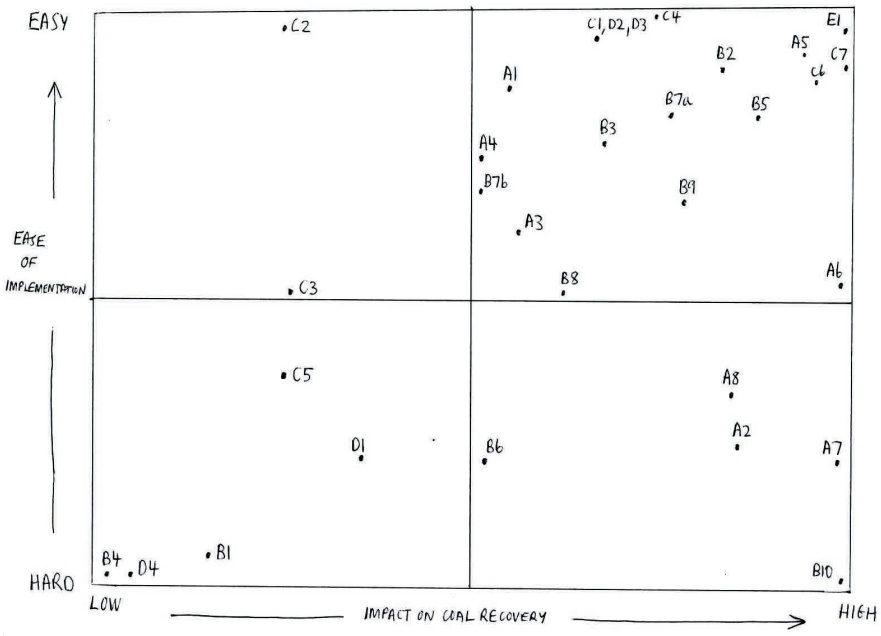

FIG 7 - Payoff matrix from the detailed solutions analysis.

was conducted on each area. Loss processes were tracked back to their fundamental causes. Through this process, several root causes not previously identified were clearly impacting coal recovered. These included planning processes such as geological model updates for overburden drill planning, ultimately causing test holes to coal and subsequently top of coal damage.

This analysis was vital in the team's understanding of the different mechanisms by which coal is lost and from this process the team was able to move into the next phase, solutions generation.

Solutions generation

During the solutions generation phase, the team undertook brainstorming sessions to determine specific coal recovery initiatives that focussed on the individual findings deduced from the root cause analysis. All ideas and solutions were welcomed and considered during this process where 'out of the box' thinking was encouraged. Numerous solutions for lowwall, lowwall trench and top of coal were generated from this process. In all, thirty lowwall and lowwall trench and thirty-five top of coal recovery solutions were formulated.

Development of payoff matrix

After the solutions generation phase, a payoff matrix was developed where the ease of implementation of coal recovery initiatives versus their impact on coal recovery was plotted. The team identified those initiatives that were the easiest to implement and had the greatest impact on coal recovery. These initiatives were then prioritised for further analysis. As can be seen in Figure 7, the various solutions generated from the CREAM project were plotted to develop a payoff matrix.

Acceptance strategy

The acceptance strategy phase is the most important phase of the entire project. If buy-in from operators and site personnel is not obtained, the project will fail. The team's acceptance strategy initially began with a series of marketing campaigns to spark operator interest, which involved the development of 'CREAM?' posters that were pinned to the noticeboards in the crew start-up areas. Utilising these posters raised many questions and queries from operators about the project. This was a successful means of obtaining initial buy-in and support from operators.

The next phase of the acceptance strategy was tailored presentations to the mining operations and technical services work groups and crews. These presentations set out to answer questions generated by the previous marketing campaign. The presentations were simple and informative and highlighted what each individual operator could do to maximise coal recovered. The adoption of feedback and ideas generated from these meetings was vital in obtaining project acceptance from operators.

During the acceptance strategy phase, 'pit custodians' were appointed for the CREAM project. Pit custodians included drill and blast, dragline, contract prestrip, coal mining engineers and supervisors. Pit custodians were asked to discuss coal recovery in their daily contact with operators and work groups along with their usual safety and production messages. Regularly talking about coal with operators highlights the mine's focus and commitment to its vision of '100 per cent coal recovery safely'. This has been an effective tool in changing the culture from that of a dirt driven culture to a 'Keep the CREAM' culture.

Management support towards coal reconciliation has been vital in the success of this project to date. Recently, management at Goonyella Riverside developed shared key performance indicators between all stakeholders in mining operations and technical services for coal recovery improvements. This has further aligned all parties to maximise coal recovered.

From the acceptance strategy, it was decided to implement a newsletter on a weekly basis, which would be used as a simple communication tool to mining operations and technical services. The CREAM newsletter highlighted the following: areas around the mine site that required scavenging, feedback on coal damage and loss, feedback from the weekly CREAM meetings, data analysed from the mine-site reconciliation systems, safety messages and alerts to coal mining crews.

Implementation of Project CREAM trials

The initiative implementation phase will be an ongoing process. Short-term and initial gains were significant however fine-tuning and selection of the best initiatives will take considerable time. It was clear that different solutions were suited to different geology, equipment, technique, schedule constraints and conditions. With so many coal recovery initiatives identified, the challenge was to find the best solution for the identified variables. Solutions were targeted based on these variables and a series of trials were scheduled. Recovery performance was analysed using the recently implemented data systems and a cost/benefit analysis undertaken to benchmark these solutions against other coal recovery solutions. Some solutions that were easy to implement in most existing applications were implemented immediately. An example of this was a review of the top of coal cleanup procedure.

CONCLUSION

Over the past two years, Goonyella Riverside has added significant value to its business through the calculated implementation of coal recovery initiatives. From the defined process of reconciliation, the mine is now in a position to benchmark the performance of specific initiatives or combinations of initiatives in differing conditions to maximise net present value. Key to the success of this project has been the discipline to follow the process map, management commitment through resourcing and shared key performance indicators, a successful acceptance strategy resulting in holistic ownership and the implementation of sustainable reconciliation systems. Significant benefits from optimal coal recovery can be returned to the business as profit through either reduced stripping or additional coal production depending on the current market environment. The 'Keep the CREAM' culture at Goonyella Riverside gives all employees the satisfaction of contributing to optimal, quantifiable coal recovery.

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