BENGALLA MINE MODIFICATION 5

SUBMISSIONS REPORT

for Bengalla Mining Company Pty Limited

29 July 2022

DOCUMENT CONTROL

Document Status

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1. INTRODUCTION

1.1 BACKGROUND – APPROVED PROJECT

Bengalla Mining Company Pty Limited (BMC) operates the Bengalla Mine (Bengalla) in the Upper Hunter Valley of NSW. Bengalla is approved by State Significant Development 5170 (SSD-5170) granted under the then Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). SSD-5170 (as modified) authorises the continuation of open cut coal mining and associated activities at Bengalla until 28 February 2039.

SSD-5170 has been modified on four occasions. The conditions of SSD-5170 require the development to be carried out generally in accordance with:

- '*Continuation of Bengalla Mine Environmental Impact Statement'* (Hansen Bailey, 2013) as modified by the '*Continuation of Bengalla Mine Response to Submissions*' (Hansen Bailey, 2014) (collectively referred to as the Bengalla EIS);
- '*Bengalla Mine Development Consent Modification Statement of Environmental Effects*' (Hansen Bailey, 2015a) and Response to Submissions (Hansen Bailey, 2015b) (MOD1 SEE);
- '*Bengalla Mine Development Consent Modification Statement of Environmental Effects*' (Hansen Bailey, 2016a) and Response to Submissions (Hansen Bailey, 2016b) (MOD2 SEE);
- '*Bengalla Mine Development Consent Modification 3 Statement of Environmental Effects'* (Hansen Bailey, 2016a) and Response to Submissions (Hansen Bailey, 2016b) (MOD3 SEE); and
- '*Bengalla Mine Development Consent SSD-5170 Modification 4 Statement of Environmental Effects'* (Hansen Bailey, 2017), Response to Submissions (Hansen Bailey, 2018) and additional information dated July 2018 and November 2018 (MOD4 SEE).

The activities approved by SSD-5170 (as modified) comprise the Bengalla EIS, MOD1 SEE, MOD2 SEE, MOD3 SEE and MOD4 SEE (the Project).

1.2 OVERVIEW OF THE MODIFICATION

BMC is seeking a modification to SSD-5170 under section 4.55(2) of the EP&A Act to facilitate the following activities:

- Operation of a mobile rock crushing facility and ancillary equipment, and the use of that crushed rock at Bengalla;
- Geotechnical investigations in connection with any activities approved under SSD-5170 from time to time;
- Prospecting operations (including exploration drilling) in accordance with BMC's mining leases issued under the *Mining Act 1992* (Mining Act);
- Realignment of the Western Diversion Levee within the approved Disturbance Boundary;
- Enlargement of the ROM coal stockpile located adjacent to the ROM dump hopper from 40 kt to 150 kt approximate maximum capacity;
- Upgrade/widening of an existing haul road (Southern Endwall Road) adjacent to the Southern visual bund, which may require removal of part of the visual bund (to be replaced by an equivalent measure);
- Disposal of tyres in pit; and
- Minor administrative changes to conditions of SSD-5170.

The Modification Application and supporting '*Bengalla Coal Mine Modification 5 to SSD-5170 Modification Report*' (Modification Report) (James Bailey Associates, 2021) was prepared and placed on public exhibition from 13 January 2022 until 28 January 2022. Five submissions were received by the Department of Planning and Environment (DPE) during the public exhibition of the Modification Report. This Submissions Report has been prepared to respond to issues raised during the exhibition period. This Submissions Report has been prepared generally in accordance with DPIE '*State Significant Development Guidelines – Preparing a Submissions Report'* (SSD Submissions Guidelines) (DPIE, July 2021).

The following regulatory authorities made submissions in relation to MOD5:

- Environment Protection Authority (EPA);
- Mining Exploration & Geoscience (MEG);
- DPIE – Water Division (DPIE Water);
- Muswellbrook Shire Council (MSC); and
- NSW Resources Regulator.

Responses to these regulatory submissions are provided **Section 2**. No submissions were received from the local or wider community.

1.3 DOCUMENT PURPOSE

This Submissions Report has been prepared by James Bailey & Associates Pty Limited (JBA) on behalf of BMC to support MOD 5 to SSD-5170 under section 4.55(2) of the EP&A Act. The document responds to the issues raised in submissions during the public exhibition period.

1.4 DOCUMENT STRUCTURE

This Submissions Report is structured as follows:

- **Section 2** provides responses to the issues raised by Government Agencies;
- **Section 3** provides a revised management and monitoring summary;
- **Section 4** outlines referenced materials relevant to this Submissions Report; and
- **Section 5** lists the abbreviations utilised in this Submissions Report.

Contaminated land specialists Engage Environmental Services have provided additional expert advice on the in pit disposal of tyres. The Tyre Disposal Assessment is provided in **Appendix A**. The BMC procedure for disposal of Off the Road (OTR) tyres in pit titled *PRO – 0333 Scrapped tyre in pit dumping*[1] *(BMC Scrapped Tyre Procedure)* is provided in **Appendix B**.

[1] BMC procedures may be discontinued, replaced or updated from time to time.

2. RESPONSES TO REGULATORY SUBMISSIONS

This section responds to the submissions received from regulatory authorities. The matters raised in submissions are summarised in the responses in this section. The original submissions can be found on the NSW Planning Portal website.

2.1 ENVIRONMENTAL PROTECTION AUTHORITY

2.1.1 Mobile Crushing Plant Dust

Issue

The EPA commented that additional detail is required about the proposed dust management measures and water usage requirements for the mobile crushing plant.

Response

The air quality assessment for the Modification was undertaken by Todoroski Air Sciences Pty Limited (TAS). It concluded that the proposed Modification would not result in any discernible additional air quality impacts beyond the existing dust levels at private receptors in the vicinity of Bengalla. Proposed dust controls will be implemented to minimise any potential dust emissions from the mobile crushing plant including:

- Water application via the water cart fleet to trafficked surfaces associated with the mobile crushing facility; and
- Use of water sprays at the mobile crushing facility.

BMC is proposing that the operation of the crushing plant will be modified when available controls are unable to mitigate impacts due to adverse meteorological conditions in accordance with the Bengalla Air Quality Management Plan (AQMP).

The total water usage for dust suppression is not considered to be substantial enough to have any perceptible impact on the site water balance model. It is estimated approximately 15,000 litres/day (5.5 ML/year) will be required to operate the sprays. The water used will be sourced from the mines water management system. The mine holds adequate water licences in all of the relevant Water Sharing Plans for the minor additional water take proposed.

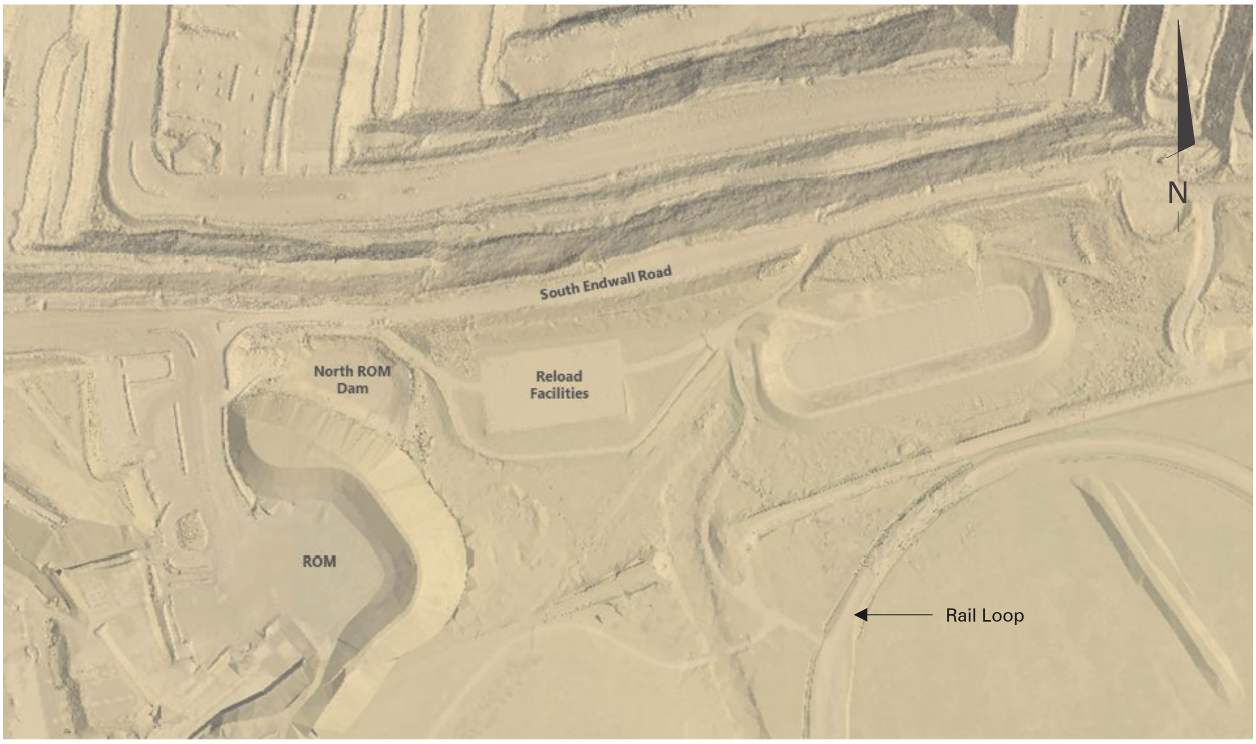
2.1.2 ROM Coal Stockpile

Issue

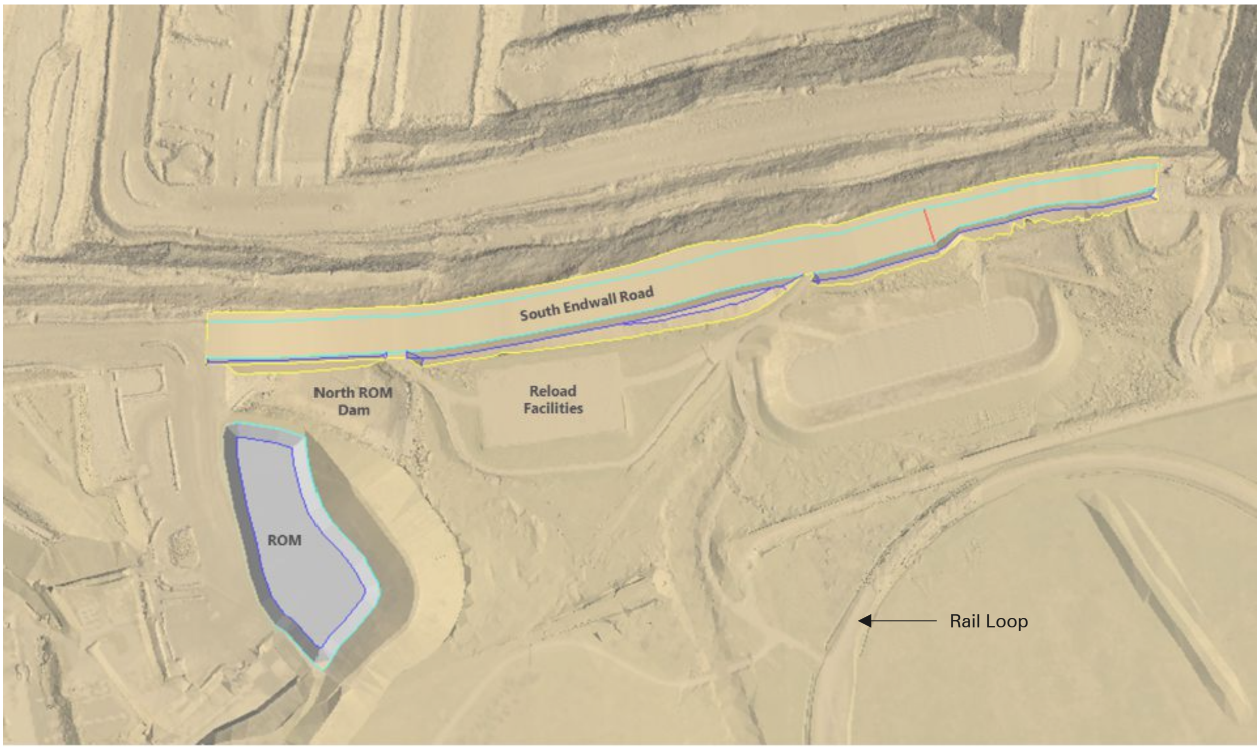
The EPA has requested further clarification of the proposed ROM coal stockpile footprint, surface water and dust mitigation management measures.

Response

The Modification includes the enlargement of the ROM coal stockpile to increase its maximum capacity from 40 kt to 150 kt. The additional capacity will be achieved by increasing the footprint of the stockpile. The height of the stockpile will increase to approximately 10 m and the length will increase to approximately 170 m. This will remove a small part of the Western side of the existing visual bund. The ROM coal stockpile footprint is shown in **Figure 1.**



EXISTING ROM COAL STOCKPILE



PROPOSED ROM COAL STOCKPILE

JBA 2111 - BENGALLA - F 02 ROM COAL STOCKPILE (22/03/2022)

BENGALLA

JAMES BAILEY & ASSOCIATES
Environmental and Planning Consultants

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Mod 5 ROM Pad
Existing and Proposed ROM Coal Stockpile Footprint

FIGURE 1

Operational dust from wind erosion off the ROM coal stockpile extension was modelled by TAS. TAS concluded that the extension to the coal stockpile would be located within the approved disturbance area. As such the area is an exposed area subject to wind erosion regardless of the Modification. The Modification activities are predicted to generate less than one per cent more dust relative to the existing approved activities. Any potential dust emissions can be effectively managed in accordance with the existing controls described in the approved AQMP including:

- Initiation of sprays when adverse meteorological conditions occur in accordance with the AQMP; and
- The water cart fleet will be used for water application to unsealed roads and stockpiles where reasonable and feasible.

The total water usage for dust suppression is not considered to be substantial enough to have any perceptible impact on the site water balance model.

2.1.3 Disposal of Waste Tyres

Issue

The EPA submission requested additional information about the disposal of waste tyres at the Premises.

Response

Contaminated land specialists Engage Environmental Services Pty Limited completed an assessment of the disposal pathway and process, assessed any potential pollution impacts and appropriate controls associated with the in pit disposal of waste OTR tyres. The review of the potential alternatives to in pit disposal of OTR tyres has not identified any reasonable or feasible higher order use for waste OTR tyres produced by the Bengalla mine. The assessment is provided **Appendix A**.

Tyre Stewardship Australia has been formed to implement the national Tyre Product Stewardship Scheme to promote the development of viable markets for end of life tyres. Michelin is the primary supplier of tyres to the Bengalla mine and is a levy contributor to Tyre Stewardship Australia's Tyre Product Stewardship Scheme. In April 2021 Tyre Stewardship Australia was given a grant for $1,086,488.70 to accelerate work on an industry led product stewardship scheme and improve rates of OTR tyre recycling in the mining industry.

The technology for recycling of OTR tyres is still in the development phase. There has been some very early progress on the recycling of OTR tyres within the Queensland coal industry through a proposed end of life tyre facility by Novum Nona Pty Ltd at Biloela. The proposed facility will recycle OTR tyres by a thermal kiln process to recapture oils, gases and carbon products, with remnant steel being recycled as well. BHP and Anglo American will supply used earth moving tyres to the proposed plant (Moffat, C. August 4, 2020, https://www.insidewaste.com.au). There is no known fixed start date for the project to BMC (Anglo American Media Release https://australia.angloamerican.com/media). As the technology is still in the development phase it is not presently known whether the technology will provide a viable option for the recycling of OTR tyres. There are no known current facilities close to Bengalla in NSW for recycling of OTR tyres.

Based on the research that has been undertaken, there are no reasonable or feasible higher order uses for end of life OTR tyres from Bengalla. In terms of the environmental impacts, the conclusions from the environmental assessment are summarised below.

Waste Classification

In accordance with the '*Waste Classification Guidelines – Part 1: Classification of Waste*' (NSW EPA, 2014), waste tyres generated on a mine site are classified as '*Special Waste*'.

Disposal Pathways

The assessment concluded onsite disposal of OTR waste tyres is currently the most 'reasonable and feasible' disposal pathway. Alternative pathways were reviewed including:

- Licenced Landfill –which is not considered appropriate as this has the same overall method/outcome as burying the OTR tyres onsite. However, this method requires additional transportation, handling and cost. It would also require upgrades to existing landfill facilities which would then reach capacity sooner and increase demand for new landfill sites; and

- Recycling – One proposed heavy vehicle tyre recycling facility has secured planning approval in Queensland. As previously summarised, this facility has not yet been constructed and the technology is still in the development phase. Existing tyre recycling facilities, which process light vehicle tyres, do not have the capacity or technology to recycle OTR tyres due to their size.

Potential pollution impacts:

The assessment included a review of a relevant environmental study that assessed potential leachates from waste OTR tyres and the impact posed to the surrounding environment. The environmental study concluded that any potential leachate does not pose a risk to groundwater resources and the level of contaminates in any leachate will remain within the relevant drinking water standard concentrations. BMC has implemented a groundwater and surface water quality monitoring program in accordance with the Bengalla Water Management Plan (WMP) which includes a suite of analytes which will assist in identifying any potential contamination from waste OTR tyre disposal.

Compliance with Landfill Standards:

Although the proposed development does not involve development for the purpose of a landfill, it does involve the disposal of mine related waste within the pit. While not strictly applicable, the '*Environmental Guidelines: Solid waste landfills, Second Edition'* (NSW EPA, 2016) (the Guidelines) contain 'best practice' measures that are potentially relevant when disposing of waste in the manner proposed. The minimum standards for landfills set out in the Guidelines require consideration of:

1. Leachate barrier systems;
2. Leachate storage and disposal;
3. Stormwater management;
4. Water quality monitoring;
5. Land gas management and monitoring;
6. Amenity issues;
7. Waste acceptance and security;
8. Covering of waste;
9. Final capping and revegetation;
10. Closure; and
11. Quality assurance.

For the reasons set out in the report at **Appendix A**, there are no significant leachate related environmental issues associated with burying of OTR tyres. The proposed method of disposal does not pose any threat to water quality. As the proposed tyre disposal occurs within the broader mining operation it does not give rise to any other impacts that would have an adverse impact on the environment.

Only OTR tyres from the Bengalla mine will be disposed of at the site with the consequence that there are no 'waste acceptance' or security issues that would otherwise apply to landfills. SSD 5170 already contains a comprehensive regime that regulates noise, air quality, surface and ground water, final landform and rehabilitation. The regime, including the Bengalla procedures that are set out in **Appendix A**, address the Guidelines with the result that the disposal of OTR tyres on site, when considered as a whole, meets both the relevant minimum standards contained in the Guidelines and the "*broad goals for landfills in NSW*".

2.2 MINING, EXPLORATION AND GEOSCIENCE

The submission from MEG did not raise any issues in relation to the Modification.

2.3 DEPARTMENT OF PLANNING AND ENVIRONMENT – WATER

2.3.1 Geotechnical Investigations

Issue

DPIE – Water Division (DPIE – Water) requested further information about the proposed geotechnical investigations.

Response

Geotechnical investigations (such as geotechnical drilling, test pits and surveys) will enable BMC to gather information on the soil and/or subsurface geological properties at approved construction sites. This allows the effective design and construction of the previously approved infrastructure. Prospecting operations include exploration boreholes that may also be cored for geotechnical investigations. The proposed investigations will not result in any additional impacts as all investigations will be undertaken within the existing Project Boundary and will require minimal disturbance. A Ground Disturbance Permit will be completed prior to any disturbance to ensure relevant controls are implemented in accordance with SSD-5170, relevant Mining Leases and the Rehabilitation Management Plan[2].

The DPIE – Water response references phrasing in the Modification 5 Report which states, '*activities that are facilitated by geotechnical investigations have previously been assessed and approved under SSD-5170*'. To clarify, the '*Continuation of Bengalla Mine Environmental Impact Statement*' (Hansen Bailey, 2013) included the assessment and approval of infrastructure and activities required for the continued operation of Bengalla for example the progressive construction of dams for the Water Management System. The construction of an approved dam will require a geotechnical investigation as part of the design process. Modification 5 seeks to ensure geotechnical investigations are approved, for 'completeness', as a part of the process for the construction of already approved activities.

2.3.2 Location of Mobile Crushing Facility

Issue

DPIE – Water Division (DPIE – Water) raised concerns relating to the placement of the mobile rock crushing plant within or near the 3rd order stream mapped as occurring within the Disturbance Boundary.

Response

Dry Creek is the 3rd order ephemeral stream located within the Project Boundary. It flowed generally Southwards through the central portion of Bengalla before entering the Hunter River to the South West of Bengalla Mine.

[2] Rehabilitation Management Plan required under *Mining Act 1992* and *Mining Regulation 2016*.

The approved activities in accordance with SSD-5170, include the diversion of Dry Creek via a dam and pipeline system. The original alignment of Dry Creek within the disturbance boundary is authorised to be mined so there is no requirement to further consider the impact on Dry Creek.

After year 15 (subject to production rates) a permanent realigned Dry Creek will be constructed through established rehabilitation areas when emplacement areas are suitably advanced. The mobile rock crushing plant if required will be placed and operated to enable Dry Creek to convey clean water.

2.3.3 Post Determination Recommendation – Water Take

Recommendation

DPIE – Water Division (DPIE – Water) recommended BMC conduct a review of the available water entitlements to ensure adequate water licences are held to account for potential water take should prospecting or geotechnical activities intercept groundwater.

Response

Water licencing was assessed as part of the *'Continuation of Bengalla Mine Environmental Impact Statement'* (Hansen Bailey, 2013) as modified. To account for the maximum amount of groundwater taken by the Project, BMC holds WAL 41547 for 365 Units/year. Total passive take/ groundwater inflows and the total active pumping is recorded and reported in the Annual Review.

The proposed geotechnical investigations and prospecting operations (including exploration drilling) will be conducted generally in advance of mining to further define the coal deposit and or inform infrastructure design. All prospecting operations will be located within the Project Boundary and relevant mining leases (MLs) for coal held by BMC (currently being ML1397, ML1450, ML1469, ML1729 and ML1796). Should these activities intercept any water, this same resource will be intercepted at a later stage by the progression of open cut mining and as such water take would be included in the original assessment of maximum allocation required. Therefore, the existing water licences are sufficient to account for the maximum amount of groundwater to be taken by the Project including any water taken as a consequence of geotechnical investigations and prospecting operations.

2.4 MUSWELLBROOK SHIRE COUNCIL

2.4.1 Disposal of Waste Tyres

Issue

MSC has recommended BMC consider purchasing OTR tyres from companies that have joined the Voluntary Tyre Product Stewardship Scheme.

Response

BMC has an existing tyre supply contract with Michelin[3]. Michelin is a leader in tyre technology and is also a levy contributor to Tyre Stewardship Australia. BMC will continue to monitor developments in technology or opportunities for recycling that may be applicable to Bengalla OTR tyre recycling.

Disposal of OTR tyres on site will be conducted using environmentally responsible methods in accordance with BMC procedures. The Tyre Disposal Assessment, provided in **Appendix A**, includes a review of the existing BMC procedures and processes for the in pit disposal of tyres. These procedures detail methods for the environmentally responsible disposal of tyres:

- Standard work practices for storage and disposal of OTR tyres;

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[3] Michelin is the current primary tyre supplier to BMC. BMC may change its tyre supplier from time to time.

- Methods implemented to extend OTR tyre life including: regular road maintenance, speed limits, OTR tyre inspection and maintenance, repair of tyres where possible and consideration of other beneficial uses on site as needed (i.e., delineation or bunding);
- Groundwater and surface water quality monitoring program in accordance with the Bengalla WMP. This includes a suite of analytes which will assist in identifying any potential contamination from waste tyre disposal; and
- An OTR tyre tracking register.

The following measures are proposed to be implemented on site after the review of existing procedures:

- Only waste OTR tyres generated at the site will be disposed of at Bengalla mine;
- The existing procedure will be reviewed and, if required, an environmental risk assessment will be included as part of the design process for selecting appropriate OTR tyre disposal areas. The risk assessment will consider potential hazards including:
  - Potential soil contamination, erosion, surface water and groundwater contamination;
  - Proximity to reject or potentially acid forming material; and
  - Final landform stability and depth of cover.
- A OTR tyre tracking register will continue to be maintained. This register will be reviewed to ensure it captures the recommended details including serial number, type/make and quantity, disposal date, surveyed coordinates of the disposal site area (Easting, Northing, RL), and summary description of the disposal area;
- Any temporary OTR tyre stockpile areas will be inspected as required. Environmental hazards will be assessed including evidence of vermin or mosquito breeding, any potential contamination issues, bushfire fuel loads and maintenance of appropriate asset protection zones (vegetation control) to address any potential stockpile fires;
- Monitoring of disposed waste OTR tyres will also be undertaken as a component of rehabilitation monitoring. Rehabilitation monitoring includes an assessment of the final shaped grade and stability of the landform. Prior to topsoil placement BMC will ensure there is no evidence of waste OTR tyre uprising; and
- Waste OTR tyre disposal information about OTR tyres disposed of in pit will be summarised in the Bengalla Annual Review in accordance with BMC procedures.

Disposal of these tyres will be undertaken in accordance with the internal *BMC Scrapped Tyre Procedure* [4].

Issue

On 1 March 2022 Council resolved to make a further submission as follows:

> *"MOTION*
>
> 1. *Council support Bengalla's development application to landfill tyres subject to the following further conditions:*
>
>   a) *The Environmental Protection License is granted on the basis of an annual review having regard to the State's hierarchy of waste: avoidance, reuse. recycling, waste to energy and landfilling.*

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[4] BMC procedures may be discontinued, replaced or updated from time to time.

> b) *Bengalla provide to Council $50,000 to support investigation into potential industry options that might provide a more sustainable and preferable outcome in terms of the NSW waste hierarchy and the local economy.*

2. *Council seek expressions of interest from a suitably qualified industry expert to undertake an investigation into potential options in the event Bengalla agrees to the payment of $50,000.*

3. *That if the Office of Environment and Heritage or Bengalla do not agree to the above conditions, the matter be referred back to Council for further consideration."*

This further MSC submission to the Bengalla Modification 5 Report was provided by email to DPE on the 4 March 2022.

Response

BMC and MSC have consulted regarding the MSC submissions. At an extraordinary MSC meeting dated 14 June 2022 the MSC 'accepts the commitments made by Bengalla by email dated 31 May 2022 and advise DPE that satisfactory arrangements have been made with Council regarding the disposal of off the road (OTR) tyres in pit initially, and off site disposal when technologically feasible and environmentally responsible.'

BMC and MSC have agreed that BMC will enter into an agreement with MSC separate to SSD 5170 Modification 5 for the investigation of tyre disposal options. BMC will consider off site disposal of OTR tyres when technologically feasible, environmentally responsible and commercially viable.

2.4.2 Mobile Rock Crushing Facility

Issue

Section 1.3.1 of the Modification Report states that 'crushed rock may be used for rock lining of drains in rehabilitation'. It is expected that crushed rock used in the rock lining of drains of rehabilitation will accommodate natural erosive processes and be resistant to weathering in the long term.

Response

BMC notes MSC comments. This issue will be addressed in the Rehabilitation Management Plan.

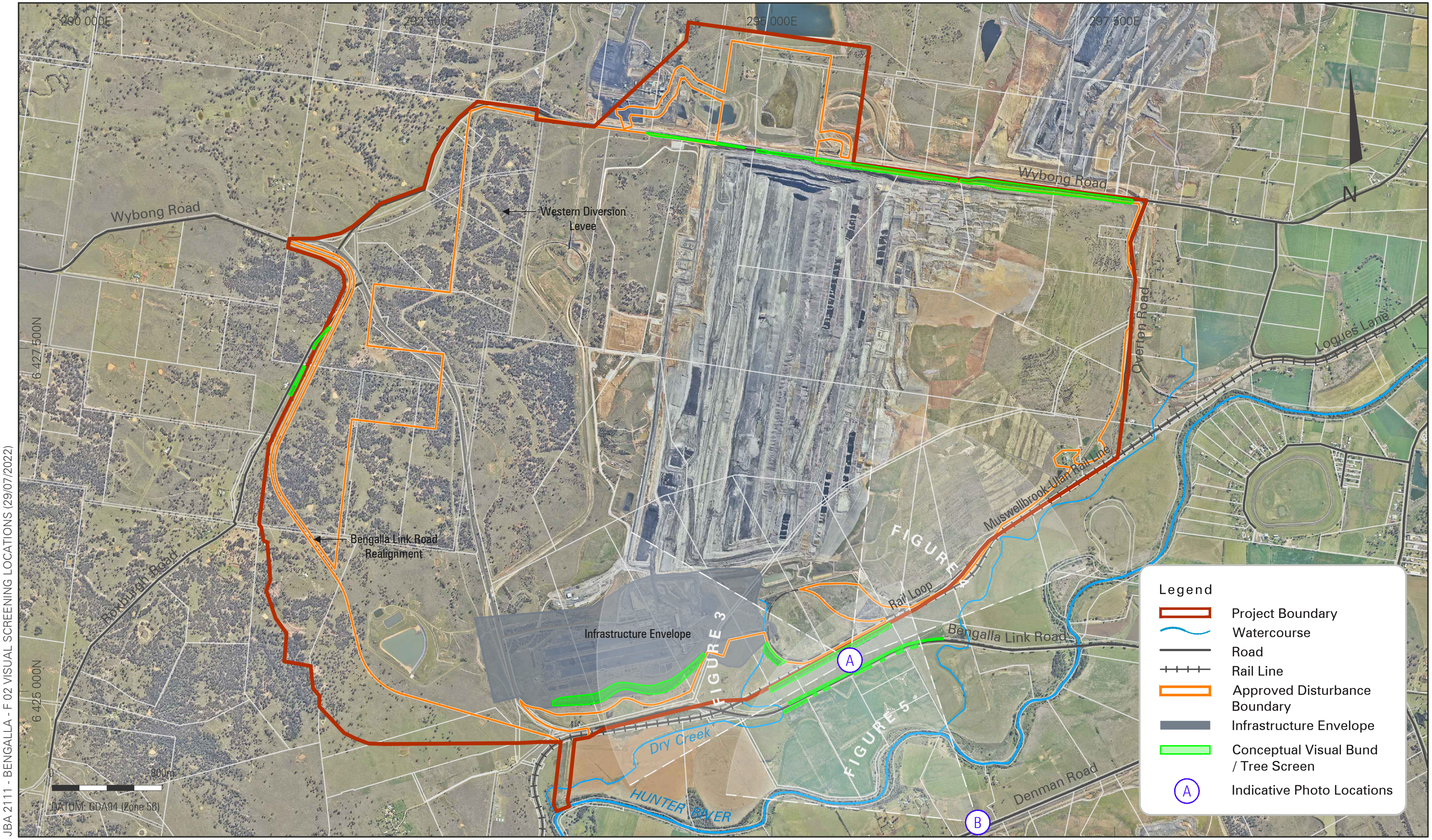
2.4.3 Visual Impact

Issue

MSC has requested photographs from Bengalla Link Road and Denman Road identifying the key approved aspects relevant to the proposed ROM coal stockpiles.

Response

The upgrade of the Southern Endwall Road and enlargement of the ROM coal stockpile will occur within the approved Disturbance Boundary. **Figure 2** illustrates the photograph locations and view points. **Figure 3** to **Figure 5** are annotated photographs from Bengalla Link Road and Denman Road with key approved aspects labelled. This confirms the findings from the Modification Report that the existing visual bund, topography, tree screens and distance will remain adequate to screen views to the ROM coal stockpile from Bengalla Link Road and Denman Road.



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Visual Screening and Photograph Locations

FIGURE 2

Figure 3 Bengalla Link Road – Looking to the North West

Figure 4 Bengalla Link Road – Looking to the North East

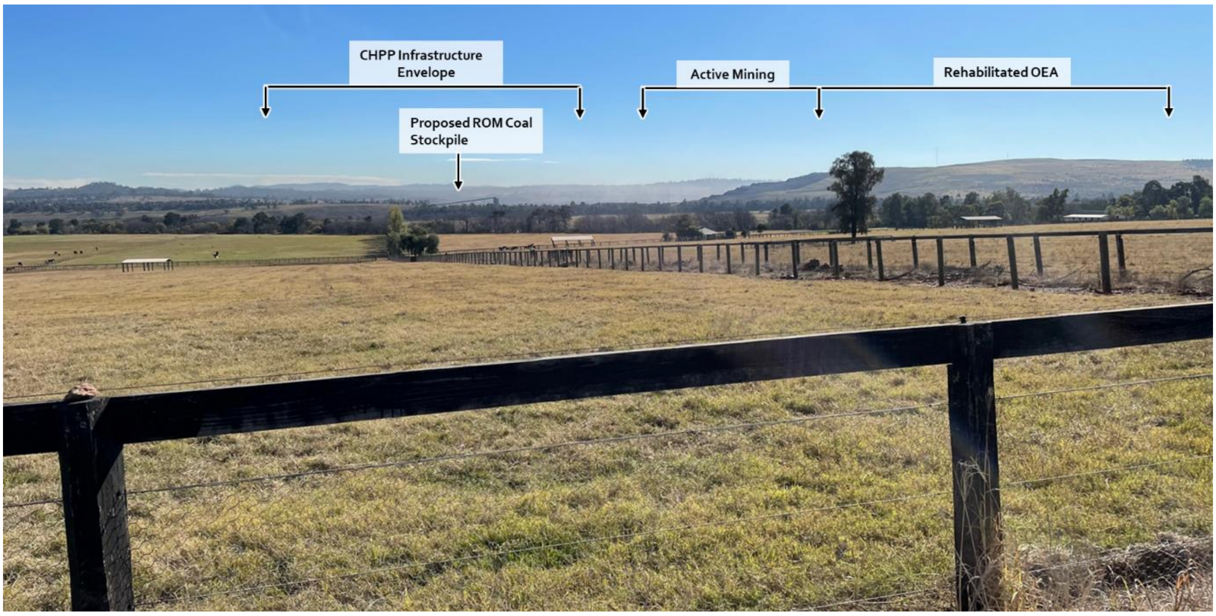


Figure 5 Denman Road from Edinglassie Thoroughbred Stud turnoff – Looking to the North

2.4.4 Tree Screening

Issue

The MSC acknowledges '…*that due to physical constraints within the relevant public road reserves, BMC is seeking amendments to Conditions 40 and 41 of Schedule 3 of SSD-5170 to provide flexibility in relation to the required visual screens. It is also acknowledged that some of the tree plantings have already occurred*.'

The MSC '…*does not have any objections of the wording of the inclusion of planting trees where reasonable and feasible 'to Councils written satisfaction (partially covered by a Section 138 permit).'*

MSC has requested an update on the progress of the tree planting program at Bengalla.

Response

BMC has continued to liaise with DPE regarding progress on satisfying Conditions 40 and 41 primarily via the provision of a quarterly report. Currently BMC have been provided an extension of time to 31 December 2022 to satisfy Conditions 40 and 41. BMC have undertaken visual bund construction and plantings that currently partly satisfies Conditions 40 and 41 being:

- Wybong Road: In addition to existing road cuttings on Wybong Road and tree plantings on the mine site adjacent Wybong Road, BMC has constructed a visual bund West of the original Dry Creek commencing in the vicinity where Dry Creek crosses Wybong Road. The visual bund extends West to the East of the Mount Pleasant Operation rail and associated infrastructure area. BMC will have access to this area after 31 October 2022 when Mount Pleasant finalise demolition of their rail and associated infrastructure;
- Roxburgh Road: Tube stock planting adjacent to Roxburgh Road on land owned by the Bengalla Joint Venture (BJV) that have views of Bengalla; and

- Roads South of Bengalla: There are existing tree planting areas on areas of Bengalla Link Road, Denman Road adjacent Mt Arthur Coal Mine and the Muswellbrook Ulan Rail line that provide adequate screening to Bengalla from these locations. Areas of Denman Road further West in the vicinity of the original location of the Edderton Road and Denman Road intersection that have views of Bengalla are subject to a S138 approval process and the issue of a Road Occupancy Licence on acceptable terms to BMC.

Figure 6 Photo of Wybong Road cutting looking generally East to Bengalla

Figure 7 Photo of a Wybong Road cutting and visual bund located on the mine site looking generally East to Bengalla

Figure 8 **Photo of a visual bund located adjacent to Wybong Road on the mine site looking generally West to Bengalla**

Figure 9 **Photo of a visual bund and tree screen located adjacent Wybong Road on the mine site looking generally East to Bengalla**

Figure 10 **Photo of a tree screen located adjacent Roxburgh Road on BJV land looking generally East to Bengalla**

Figure 11 **Photo of a tree screen located adjacent Roxburgh Road on BJV land looking generally East to Bengalla**

2.4.5 Disturbance Boundary

Issue

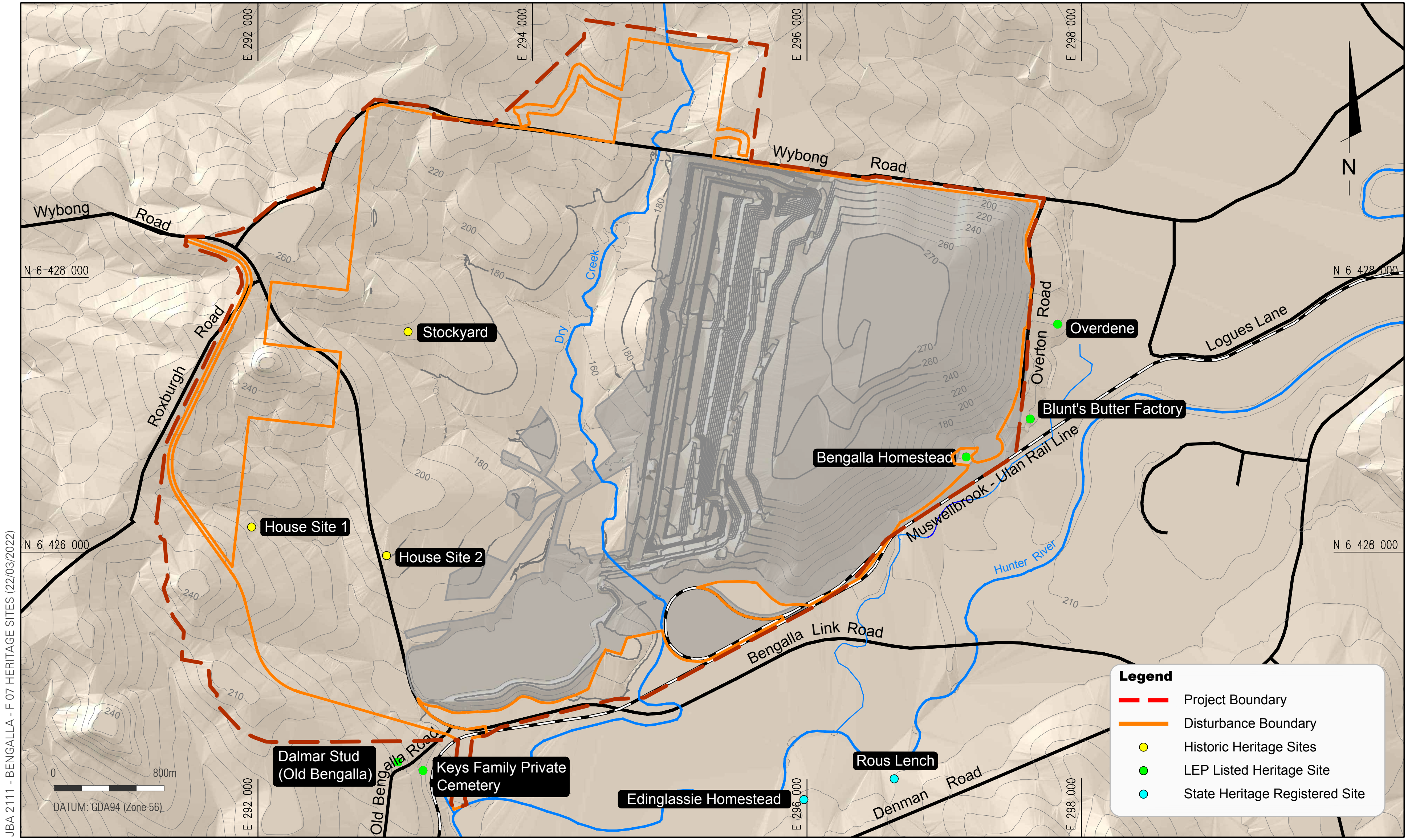
MSC pointed out a discrepancy in the Disturbance Boundary illustrated on *Figure 2* and *Figure 6* of the Modification Report.

Response

An administrative error occurred in the drafting of *Figure 6* in the Modification Report. The Disturbance Boundary illustrated the increased disturbance required for the Continuation of Bengalla Mine approved by SSD-5170. *Figure 6* of the Modification Report has been updated to show the entire approved Disturbance Boundary and is shown in **Figure 12**.

2.5 NSW RESOURCES REGULATOR

The submission from the NSW Resources Regulator did not raise any issues in relation to the Modification. It was noted that the risks associated with the burial of tyres in pit will need to be included in the Rehabilitation Management Plan.



BENGALLA

JAMES BAILEY & ASSOCIATES
Environmental and Planning Consultants

BENGALLA MINE

Historic Heritage Sites

FIGURE 12

3. REVISED MANAGEMENT AND MONITORING SUMMARY

Table 1 *provides a consolidated summary of the additional management and monitoring commitments resulting from this Submissions Report.*

Table 1 Submissions Report Mitigation and Monitoring Commitments

Ref	Commitment	Section
Air Quality		
1.	Operation of the crushing plant will be modified when available controls are unable to mitigate impacts due to adverse meteorological conditions in accordance with the AQMP.	2.1.1
Surface Water & Groundwater		
2.	No further commitments required.	-
Visual		
3.	No further commitments required.	-
Disposal of Waste Tyres		
4.	Only waste OTR tyres generated at the premises will be disposed of at Bengalla.	2.1.3 & 2.4.1
5.	Existing internal OTR tyre disposal procedures will be reviewed and if required an environmental risk assessment will be included in BMC relevant procedures.	2.1.3 & 2.4.1
6.	Tyre tracking register will be reviewed and maintained to ensure relevant tyre disposal detail is recorded.	2.1.3 & 2.4.1
7.	Any temporary tyre stockpile areas will be inspected as required. Environmental hazards will be assessed including evidence of vermin or mosquito breeding, any potential contamination issues, bushfire fuel loads and maintenance of appropriate asset protection zones (vegetation control) with respect to potential stockpile fires.	2.1.3 & 2.4.1
8.	Monitoring of disposed waste OTR tyres will also be undertaken as a component of rehabilitation monitoring. Rehabilitation monitoring includes an assessment of the final shaped grade and stability of the landform. Prior to topsoil placement BMC will ensure there is no evidence of waste OTR tyre uprising.	2.1.3 & 2.4.1
9.	Waste OTR tyre disposal information of tyres disposed in pit will be summarised in accordance with BMC procedures in the Bengalla Annual Review .	2.1.3 & 2.4.1

4. REFERENCES

- Department of Planning, Infrastructure and Environment (2021), *State significant development guide – Preparing a Submissions Report.*
- Department of Planning, Infrastructure and Environment (2021), *State significant development guide – preparing a modification report.*
- Department of Planning, Infrastructure and Environment (2021), *State significant development guide – preparing an environmental impact statement.*
- Hansen Bailey (2013), *Continuation of Bengalla Mine Environmental Impact Statement*.
- Hansen Bailey (2014), *Continuation of Bengalla Mine Response to Submissions*'.
- Hansen Bailey (2015a), *Bengalla Mine Development Consent Modification Statement of Environmental Effects*.
- Hansen Bailey (2015b), *Bengalla Mine Development Consent Modification Response to Submissions*.
- Hansen Bailey (2016a), *Bengalla Mine Development Consent Modification Statement of Environmental Effects.*
- Hansen Bailey (2016b), *Bengalla Mine Development Consent Modification 2 Response to Submissions*.
- Hansen Bailey (2016a), *Bengalla Mine Development Consent Modification 3 Statement of Environmental Effects*.
- Hansen Bailey (2016b), *Bengalla Mine Development Consent Modification 3 Response to Submissions*.
- Hansen Bailey (2017), *Bengalla Mine Development Consent SSD-5170 Modification 4 Statement of Environmental Effects*.
- Hansen Bailey (2018), *Bengalla Mine Development Consent Modification 4 Response to Submissions.*
- Muswellbrook Shire Council (2015), *Land Use Development Strategy*.
- NSW Government (2016), *Hunter Regional Plan 2036.*
- Rural Fire Service (2019), *Planning for Bush Fire Protection*.
- Worley Parsons (2014), *Hunter River Flood Study (Muswellbrook to Denman)*.
- Bengalla Mining Company Pty Limited (2019) *SYS-0025 Tyre Management Plan*
- Bengalla Mining Company Pty Limited *(2021)PRO – 0333 Scrapped tyre in pit dumping.*

5. ABBREVIATIONS

Abbreviation	Meaning
AEP	Average Exceedance Probability
APZ	Asset protection zone
AQMP	Air Quality Management Plan
Bengalla EIS	Environmental impact statement titled '*Continuation of Bengalla Mine, Environmental Impact Statement*' (6 volumes), dated September 2013, as modified by the *Response to Submissions* dated March 2014
BJV	Bengalla Joint Venture
BMC	Bengalla Mining Company Pty Limited
CCC	Community Consultative Committee
CHPP	Coal Handling and Preparation Plant
DPE	Department of Planning and Environment
EP&A Act	*Environmental Planning & Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPA	*Environmental Protection Authority*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPL	Environment Protection Licence
ESD	Ecologically sustainable development
FTE	Fulltime equivalent
HRP	*Hunter Regional Plan 2036 (NSW Government, 2016)*
HVEC	Hunter Valley Energy Coal Pty Ltd
LGA	Local Government Area
LUDS	*Land Use Development Strategy (Muswellbrook Shire Council, 2015)*
MACH	MACH Energy Australia Pty Limited
MIA	Mine infrastructure area
Mining Act	Mining Act 1992
MOP	Mining Operations Plan
Mining SEPP	*State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*
ML	Mining Lease
MOD1 SEE	Statement of Environmental Effects titled '*Bengalla Mine Development Consent Modification Statement of Environmental Effects*' dated August 2015 and prepared by Hansen Bailey, including the *Response to Submissions* document dated October 2015
MOD2 SEE	Statement of Environmental Effects titled '*Bengalla Mine Development Consent Modification Statement of Environmental Effects*' dated April 2016 and prepared by Hansen Bailey, including the *Response to Submissions* document dated June 2016

Abbreviation	Meaning
MOD3 SEE	Statement of Environmental Effects titled '*Bengalla Mine Development Consent Modification 3 Statement of Environmental Effects*' dated September 2016 and prepared by Hansen Bailey, including the Response to Submissions document dated November 2016
MOD4 SEE	Statement of Environmental Effects titled '*Bengalla Mine Development Consent Modification 4 Statement of Environmental Effects*' dated December 2017 and prepared by Hansen Bailey, including the *Response to Submissions document* dated May 2018 and additional information dated July 2018 and November 2018
MOD5	*Bengalla Coal Mine Modification 5 to SSD-5170 Modification Report*' prepared by Hansen Bailey dated November 2021.
MSC	Muswellbrook Shire Council
MSD	Mine subsidence district
Mt	Million tonnes
Mtpa	Million tonnes per annum
Muswellbrook LEP	Muswellbrook Local Environmental Plan 2009
NMP	Noise Management Plan
NPW Act	National Parks and Wildlife Act 1974
OEA	Overburden emplacement area
PBFP	Planning for Bush Fire Protection (NSW Rural Fire Service, 2019)
PMF	Probable Maximum Flood
POEO Act	Protection of the Environment Operations Act 1997
Roads Act	Roads Act 1993
ROM	Run of Mine
SPL	Sound Power Level
The Guidelines	*'Environmental Guidelines: Solid waste landfills, Second Edition'* (NSW EPA, 2016)
The Project	Bengalla Continuation of Mining Project
TSP	Total Suspended Particulate
VPA	Voluntary Planning Agreement
WAL	Water Access Licence
WM Act	Water Management Act 2000
WMP	Water Management Plan

APPENDIX A

TYRE DISPOSAL ASSESSMENT

PROJECT NUMBER – E1234
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Engage Environmental Services

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BENGALLA ROAD
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ABBREVIATIONS

BMC	Bengalla Mine Company Pty Limited
DPE	Department of Planning and Environment
EPA	Environment Protection Authority - NSW
MOD	Modification Report
MSC	Muswellbrook Shire Council
NSW	New South Wales
OTR	Off the Road
ROM	Run of Mine

ENGAGE ENVIRONMENTAL Services

Contents

1.0 INTRODUCTION

Engage Environmental Services Pty Limited was commissioned by James Bailey & Associates Pty Limited to provide a report to Bengalla Mine Company Pty Limited (BMC) in response to Bengalla SSD-5170 Modification 5 response letters from Muswellbrook Shire Council (MSC) and the Environment Protection Agency - NSW (EPA) regarding the disposing of waste Off The Road (OTR) tyres onsite at Bengalla Mine (Bengalla).

2.0 ENVIRONMENTAL REVIEW

2.1 Feasibility of OTR Tyre Recycling

The resource management and recovery sector utilise a hierarchical approach that underpins the Waste Avoidance and Resource Recovery Act 2001. The hierarchy is as follows:

Avoidance – The highest priority is to avoid generating waste and to reduce generation of waste.
Re-Use – Finding a secondary use for the materials without further processing.
Recycling – Finding an alternative use through processing the materials to make the same or different products, keeps materials in the productive economy, benefits the environment by decreasing the need for new materials and waste disposal.
Recovery – This is the recovery of energy from the material.
Disposal – This is the final option of the hierarchy for the material.

General Discussion on the Hierarchy for OTR Tyres

BMC has procedures in place regarding the management of OTR tyres. The procedures are discussed later in this document. BMC wants to achieve the best results from its purchases of OTR tyres, that is, limit down time on trucks to repair OTR tyres or replace OTR tyres. BMC avoids as much as reasonable and feasible generating OTR tyre waste. This has a beneficial outcome for the environment as the maintenance regime extends the life of the OTR tyres as far as practicable and therefore less OTR tyres will be required over the life of Bengalla. By implementing the BMC procedures, that allows for avoidance of some OTR tyre waste.

Re-use of the OTR tyres is limited, there can be some use on site such as in bunding, intersection or directional barriers, these uses would be temporary and are tracked through the tyre management system. Previously there has been no higher order uses for the heavy vehicle waste tyres. The OTR tyres are large and dangerous to manoeuvre and re-use as bund wall or retaining walls is not seen as appropriate. Further, the tyres can be a combustion hazard if a fire or bushfire is too close.

Recycling and recovery of energy from the OTR tyres, if feasible and available, can be undertaken, through the recovery of metal, oils and a granular or shredded rubber which can be used in various products from roadway pavements to playground surfaces is an appropriate outcome for the re-use of OTR tyres. This is, however, currently unavailable within NSW.

Disposal Pathways Options

Apart from the on-site disposal option another disposal pathway would be to send the OTR tyres to a Licensed Landfill for disposal. This is only slightly different to retaining the OTR tyres onsite and burying them. The difference being that there is more transporting, logistics, and upgrades of landfills that may be required, landfills would reach their capacity sooner and therefore additional landfills would be required if offsite disposal of OTR tyres was to be utilised. This option is not reasonable or feasible.

There is a proposed recycling and energy recovery facility in Queensland. The proposed facility, if it is built, will likely accept OTR tyres from nearby mine sites. The distance to the proposed facility is over 11 hrs driving time from Bengalla. This option is not currently reasonable or feasible to BMC.

There are passenger tyre and light commercial tyre recycling facilities in NSW, but they are not able to accept the OTR tyres. That is the OTR tyres are too big for their facilities.

The onsite disposal in pit is currently the most reasonable and feasible disposal method of OTR tyres for Bengalla subject to appropriate environmental controls being in place.

Onsite Disposal Pollution Consideration

A report was produced in 2000 by Australian Coal Association Research Program (ACARP, 2000) titled Management of Waste Tyres in the Mining Industry (Report), the following is an extract from this report regarding the pollution potential in groundwater from buried tyres. A full version of this report has been attached as an Appendix.

> *Tyre manufacturing companies are very reluctant to provide information about the ingredients of tyre manufacture. Several studies, however, have investigated the composition of tyres. Tyres are manufactured from natural or synthetic rubber, carbon black, sulfur, zinc stearate, a variety of antioxidants and other additives (Masterton & Slowinski, 1977). The vulcanisation reaction involved in tyre manufacture combines natural rubber with sulfur under heat. Styrene-butadiene rubber (SBR) is made by copolymerising 75% Butadiene and 25% Styrene and is the most important synthetic rubber used by the tyre industry (Edil, 1989). An analysis of tyres by the US EPA (1995) outlines the compounds used in the manufacture of tyres. It is important to note that this analysis is of passenger tyre manufacture but it can be assumed that OTR tyres are manufactured from similar components but will contain higher proportions of more valuable natural rubber (Brewer, 1997). It should also be noted that each tyre design often has a different composition. The list of the major chemicals used in rubber compounding (US EPA, 1995) is included as appendix 1 of this review. The biodegradation of tyres has been estimated to take 50-80 years (Baglioni et al, 1994). Studies of tyre leachate suggest that shredded or whole tyres do not pose a risk to ground water. In an analysis of tyre leachate, Park et al (1989) concluded that shredded tyres do not release any significant amounts of priority pollutants. In a comparison of*

leachate from shredded and whole tyres, Burnell and McOmber (1997) found iron, zinc and sulfur were released and were in higher concentrations in leachate from shredded tyres but were well below drinking water standard concentrations.

There are a series of practical measures outlined in BMC procedures below which BMC has employed and currently employs to prevent or minimise pollution from the placement of OTR tyres in pit.

2.2 Existing BMC Procedure Extracts

Bengalla Mine Tyre Management Plan

The SYS-0025 Bengalla Mine Tyre Management Plan[1] (SYS-0025) is the overarching document to guide tyre management practices and processes used at Bengalla. The SYS-0025 provides detail on the following items listed in the purpose section:

1. Training & Competency
2. Tyre & Rim/Wheel Handling Tools & Equipment
3. Tyre Storage & Handling
4. Tyre Selection
5. Operation & Maintenance of Tyres
6. Operation & Maintenance of Rims and Wheels
7. Tyre Pressure Maintenance
8. Storage & Disposal of Scrap Tyres
9. Tyre Fires & Potential Tyre Explosions
10. Managing the Use of Second Hand Tyres
11. Tyre Protection Chains & Traction Chains

The relevant extracts to this report from SYS-0025 are reproduced below in italics:

"7.2.1 Tyre Storage

Tyres are stacked to maximise storage space and minimise the possibility of unplanned movement. However, when stacking large tyre assemblies, consideration must be taken towards potential structural integrity damage at the base of the stack. The maximum stacking height of tyres depend on the tyre profile and can be viewed in Table 1 below.

[1] BMC procedures may be discontinued, replaced or updated from time to time.

Table 1: tyre Stacking Height

Tyre Size	Tyre Stack Height
23.5R25	4
2700R49	4
29.5R29	4
29.5R25	4
35/65R33	3
45/65R45	2
875/65R29	3
50/90R57	3
37.25R35	3
60/80R57	2
40/00R57	3
53/80R63	3

Light vehicle tyres should be stored in an upright position, in designated storage racks according to type. Tyre and rim assemblies should be stored on a level, well compacted surface.

Category B & C tyres shall be stored at a maximum pressure of 30 psi.

OTR tyre storage areas are well drained to minimise pooling of water around the tyre stacks. They are also risk assessed to ensure all combustible materials are removed and bush fire risks are managed.

9.2 Tyre Repairs

Tyres requiring repair are identified through tyre inspections. Inspections are carried out by tyre maintenance personnel during the weekly tyre pressure and inspection check process.

Mining technicians also inspect tyres during their pre-operational inspection. If a defect is found, an inspection is requested via dispatch and conducted or appointed by a maintenance technician or tyre fitter.
When inspecting tyres, caution shall be applied equally when tyre assemblies and equipment are either loaded or unloaded.

Tyres requiring repair are included in the weekly tyre change schedule and the site maintenance plan.

9.9 Tyre Management Practices

The following controls are employed to ensure tyres operate safely and to maximise performance;

- *Corner Speed Monitoring – Corner speed monitoring prevents excessive mechanical and thermal stress (belt edge separation failures) from excessive corner speeds.*
- *Road Maintenance – Roads are maintained to minimise the formation of "soft spots" and the resultant dynamic loading of tyres, spillage, associated cut damage, negative super elevation and associated tyre stress.*
- *Road Design- Roads are designed to comply with BMC's road design standard.*
- *Pit Reports – Pit reports are conducted to identify surfaces where there are: poor road conditions, potential points of contact with structures, and constrictions in the road due to centre islands.*
- *Road Condition Monitoring- Workers are able to assess road conditions in loading areas through the use of cameras on excavators.*
- *All tyre management practice should be annually reviewed to ensure that tyres are operating at the specific design parameters applicable for their use.*

9.10 Tyre Damage/End of Life Standards

Tyres that are removed for end of life reasons are placed into BMC's tyre inspection area. Once it is inspected by the Tyre OEM [Original Equipment Manufacturer] *representative, it is moved to the scrap area or sent to repair if possible. Once a tyre is placed in the scrap area it will not be accessed again until it is disposed of in a nominated disposal area.*

11 Storage and Disposal of Scrap Tyres

Tyres scrapped on site shall be stored and disposed within the environmental constraints of BMC's development consent conditions.

11.1 Scrap Tyre Process

Tyre fitters will remove tyres for inspection when the tyre no longer meets the BMC tyre standard or if the tyre has been identified for repair. The inspection will determine if the tyre can be repaired or scrapped based on the safety and/or viability of the repair. If a tyre is deemed as "scrap", it is marked accordingly and moved to a temporary scrap stockpile area.

11.2 Scrap Tyre Storage

Scrap tyres are stored on site at the nominated tyre storage area. They are stored in accordance with site storage standards to minimise accumulation of water, eliminate any fall or toppling risks and minimise the potential risk of a roll-away.

Due to the intricate mine sequencing of the BMC pit, there is only one opportunity every mining strip to bury tyres at the bottom of the pit. Therefore, tyres will need to be adequately stored until then.

Additional fire precautions should be taken when storing tyres awaiting disposal, including removing grass or other materials that present a fire hazard to the scrap tyre storage area. Vehicle access shall be maintained for the perimeter of the stockpile to aid any firefighting or access requirements.

Stacking of scrap tyres shall be against an earth barrier or boundary fence where no work activity is present behind the stack. The necessary controls for this area consist of setting up a TWA [Tyre Work Area] *for stacking and a moving RWZ* [Restricted Work Zones].

11.3 Tyre Disposal Process

The BMC tyre supervisor is responsible for the tracking of all heavy earthmoving tyres purchased by BMC. Tracking of tyres shall involve recording:

- *The serial number of the purchased tyre*
- *Equipment allocation code of that tyre*
- *Purchase date of that tyre*
- *Final disposal date and GPS* [Global Positioning System] *location for that tyre*

The superintendent of mine production and BMC tyre coordinator are responsible for identifying suitable dump locations for scrapped tyres within in-pit spoil areas.

At no time shall tyres be buried:

- *Within 10 metres of known coarse rejected material as spontaneous combustion may result.*
- *In active operational areas.*

A minimum capping depth of 20 meters of inert overburden material shall be placed between the uppermost tyres to the final rehabilitated surface level. Tyres shall be neatly stacked horizontally in the bottom of the cut at a maximum height of three (3) meters.

Where practicable, scrapped tyres may also be used for road markers and other delineation purposes. These tyres will be identified in the tyre tracking database as "Road Delineation" until the time when the tyre is disposed, and the final disposal location is updated with the GPS coordinates.

The mine surveyor is responsible for determining the exact location of any tyre disposal area via GPS coordinates and providing a scan of the nominated disposal area, post disposal. Mine surveyors are also responsible for recording and making available survey plans, highlighting the location of such tyre dumps and the number of scrapped tyres portioned to each area.

The GPS co-ordinates will be entered into the tyre tracking database and must be finalised that the tyre disposal runs are completed.

The quantity buried must be communicated to the geologist and environmental teams on site for tracking and inclusion into annual disposal figures for site.

All tyres deemed to be fit for disposal shall be accompanied by a tyre scrap report.

11.4 Alternate Options for Scrap Tyres

BMC continues to liaise with industry experts and government agencies with the aspiration of recycling and waste minimisation practices. At the present time, no technological solution exists for the recycling or recovery of earthmoving tyres. As such, BMC currently disposes of waste tyres back into the mining operation awaiting industry development.

Sale of disposed rubber or donation of tyres for use off-site is prohibited as environment tracking does not allow for an undetermined final location.

14 Responsibilities - Role - Tyre Coordinator

The Tyre Coordinator is responsible for:

- *Forecasting future tyre and rim stockpile requirements on a quarterly basis*
- *Overseeing tyre and rim record keeping and maintain tyre tracking database*
- *Auditing and provide operational TKPH* [Tonnes Kilometres Per Hour] *updates and most suitable tyre selection for the operation*
- *Technical cost, usage and performance reporting*
- *Stocktake and auditing on tyre stocks on a six monthly basis*
- *Ensuring training updates and refreshers as well as tyre procedures and information are up to date for all production and maintenance related systems"*

PRO-0333 Scrapped tyre in pit dumping

The Bengalla internal procedure *PRO-0333 Scrapped tyre in pit dumping*[2] outlines the process for disposing scrapped tyres at Bengalla.

The relevant extracts to this report from PRO-0333 are reproduced below in italics:

> *"The Short-term Planning Superintendent identifies a suitable disposal location for scrapped tyres in-pit including laydown areas for offloading according to:*
>
> - *Geotechnical considerations:*
>   - *Scrapped tyres shall be placed at the toe of the existing low wall (pit floor) or at the toe of the preceding dump.*
>   - *Scrapped tyres are not to be buried under a high-risk dump (>30m tip height off a highwall) or into water.*
>   - *Scrapped tyres are not to be buried within 10 metres (or 2 lifts) to where the dragline will disturb the scrapped tyres or an area of intended rehandle.*
>   - *Scrapped tyres buried on pit floor shall be emplaced south of block 20.*
> - *Spontaneous combustion / Acid Rock Drainage:*
>   - *A capping depth of approximately 20 metres of inert overburden material shall be placed from the scrapped tyres to the rehabilitated surface.*
>   - *Scrapped tyres are not to be buried within 10 metres (or 2 lifts) of reject material, carbonaceous material, dyke material or Wynn overburden material (Archerfield Sandstone).*
>   - *Scrapped tyres are not to be buried within 10 metres (or 2 lifts) of any known spontaneous combustion or area showing evidence of heating.*
>
> *Scrapped tyres are to be neatly stacked generally horizontally up to 3 tyres high and 3 rows deep per work instruction issued by Tyre Supervisor.*
>
> *Where practicable, scrapped tyres may also be used for road markers and other delineation purposes at Bengalla prior to disposal.*
>
> *The Mine Surveyor marks (or similar) the selected tyre disposal area and provides suitable survey plans of the tyre disposal area.*
>
> *The Tyre Supervisor records the number of scrapped tyres in each tyre disposal area and relevant details of the scrapped tyres."*

[2] BMC procedures may be discontinued, replaced or updated from time to time.

2.3 NSW Waste Classification Guidelines

The OTR waste tyres are classified as special waste under The *NSW EPA's Waste Classification Guidelines* (NSW EPA, 2019). Subject to some potential improvements identified below, the above procedures are consistent with industry practice and manage the environmental risks identified in the ACARP report.

The Disposal Regime and the NSW EPA *Environmental Guidelines: Solid Waste Landfills (second edition 2016).*

The proposed development does not involve development for the purpose of a landfill, it does involve the disposal of mine related waste within the pit. While not strictly applicable, the Environmental Guidelines: Solid waste landfills, Second Edition (NSW EPA, 2016) (Guidelines) contain 'best practice' measures that are potentially relevant when disposing of waste in the manner proposed. The minimum standards for landfills set out in the Guidelines require consideration of:

1. Leachate barrier systems;
2. Leachate storage and disposal;
3. Stormwater management;
4. Water quality monitoring;
5. Land gas management and monitoring;
6. Amenity issues;
7. Waste acceptance and security;
8. Covering of waste;
9. Final capping and revegetation;
10. Closure; and
11. Quality assurance.

3.0 ENVIRONMENTAL ASSESSMENT

As set out in the ACARP article referred to above, there are no significant leachate related environmental issues associated with burying tyres and the proposed method of disposal does not pose a threat to water quality. Because the proposed tyre disposal occurs within the broader mining operation it does not give rise to any other impacts that would have an adverse impact on the environment.

Only OTR tyres from Bengalla will be disposed of at the site with the consequence that there are no 'waste acceptance' or security issues that would otherwise apply to landfills. SSD 5170 already contains a comprehensive regime that regulates noise, air quality, surface and ground water, final landform and rehabilitation.

The regime proposed, including the procedures that are set out above, address where relevant, the Guidelines with the result that the proposal, when considered as a whole, meets both the relevant minimum standards contained in the Guidelines and the broad goals for landfills in NSW being:

- Landfills should be sited, designed, constructed and operated to cause minimum impacts to the environment, human health and amenity
- The waste mass should be stabilised, the site progressively rehabilitated, and the land returned to productive use as soon as practicable.
- Wherever feasible, resources should be extracted from the waste and beneficially reused.
- Adequate data and other information should be available about any impacts from the site, and remedial strategies should be put in place when necessary.
- All stakeholders should have confidence that appropriately qualified and experienced personnel are involved in the planning, design and construction of landfills to high standards.

4.0 RECOMMENDED IMPROVEMENTS TO BMC DOCUMENTATION

The MOD 5 response letter from MSC highlights several items for consideration which may be included into the existing OTR tyre procedures. Many of these items are addressed in the current BMC procedures – see above. Below are items that BMC consider require addressing separately.

MSC recommends a range of measures regarding the disposal of the OTR tyres:

1. '*A limitation be imposed on the number of, and origin of tyres that can be stockpiled and disposed of at the premises in any one year.*'

   Response

   MSC requested a limitation be imposed on the number of, and origin of tyres that can be stockpiled and disposed of at the premises in any one year. A numerical limit would be very difficult to manage in practice. Rather than imposing a numerical limit BMC will use all reasonable and feasible measures to minimise the number of tyres stockpiled and disposed of at the site relevant to operational requirements and market supply.

2. '*Only waste tyres generated at the premises may be disposed of on the subject site*.'

   Response

   BMC has not sort approval to accept OTR tyres from other mine sites or facilities.

3. '*Tyres should be placed as deep as possible, but not directly on the pit or emplacement floor. Any associated placement activities should ensure that waste tyres do not impede saturated aquifers or compromise that stability of the consolidated final landform*.'

   Response

   The ACARP Report found '*The biodegradation of tyres has been estimated to take 50-80 years (Baglioni et al, 1994). Studies of tyre leachate suggest that shredded or whole tyres do not pose a risk to ground water.*'

   BMC will implement the practice described in PRO-0333 Scrapped tyre in pit dumping procedure being, in part, '*Scrapped tyres shall be placed at the toe of the existing low wall (pit floor) or at the toe of the proceeding dump*.' Further placement of OTR tyres on the pit floor will not impede an aquifer or the stability of the final landform.

4. '*Temporary tyre stockpile areas should be subject to ongoing and robust monitoring and management program to ensure that stored tyres do not provide an environment that promotes harbourage of vermin or encourages mosquito breeding. Appropriate mitigation and management measures should be put in place in respect of potential stockpile fires*.'

   Response

   Any temporary tyre stockpile areas will be inspected as required. Environmental hazards will be assessed including evidence of vermin or mosquito breeding, any potential contamination issues; bushfire fuel loads and maintenance of appropriate asset protection zones (vegetation control) with respect to potential stockpile fires.

5. '*Monitoring of disposed waste tyres should occur as part of establishment of the final landform for rehabilitation. Monitoring should assess the final shaped grade and stability prior to topsoil placement to ensure no up-rising of waste tyres has occurred, and that at least twenty metres of emplacement material is over the deposited waste area.*'

   Response

   Monitoring of disposed OTR tyres will be undertaken as a component of rehabilitation monitoring. Rehabilitation monitoring includes an assessment of the final shaped grade and stability of the landform. Prior to topsoil placement BMC will ensure there is no evidence of waste tyre uprising.

6. A preliminary Environmental Risk Assessment (RA) be undertaken prior to the selection of an appropriate disposal area for the waste heavy vehicle tyres. '*The RA is to consider the potential unacceptable risk of soil; sediment; groundwater or surface water contamination, as well as proximity to coal rejects and potentially acid forming material*.'

   Response

   BMC will review its procedures and develop a risk assessment regarding management of and emplacement of OTR tyres. If the review determines that an RA is required, an RA will be included in existing procedure(s) where appropriate.

7. *Waste tyre disposal information should be reported in the Bengalla Mine Annual Review. Additionally, the following information should be clarified:*
   - *The quantity of tyres currently stockpiled and historically buried at the mine (where applicable).*
   - *How existing stockpiles will be managed e.g. disposal of these tyres should be staggered to optimise disposal locations and volumes.*

   Response

   Information on OTR tyres disposed in pit will be summarised according to BMC procedures in the Bengalla Annual Review.

8. *The existing groundwater monitoring program should assist in identifying any potential contamination form waste tyre disposal and prompt remediation actions.*

   Response

   BMC conducts a groundwater and surface water quality monitoring program in accordance with the Bengalla Water Management Plan. This includes a suite of analytes which will assist in identifying any potential contamination from OTR tyre disposal.

5.0 CONCLUSION

BMC has procedures for the disposal of the OTR tyres including serial number registration, site selection, stockpiling, care and maintenance, inspections, moving and placement, survey of disposal area, covering with soil and sign off.

There are no higher order uses for the used OTR tyres at Bengalla. While the technology to recycle and recover waste is still being developed, there may be advancements within this sector in the near future. At present, the disposal of OTR tyres in pit is the most reasonable and feasible tyre disposal option for BMC and provided it is carried out the with the appropriate controls discussed in this report, disposal of tyres in pit can be carried out in an environmentally acceptable way.

REFERENCES

Australian Coal Association Research Program (ACARP, 2000), Management of Waste Tyres in the Mining Industry

Anglo American Media Release 2021, *Anglo American shifts towards circular economy future*, https://australia.angloamerican.com/media.

Moffat, C. August 2020, *BHP and Novum Energy to tackle mining truck tyre recycling* https://www.insidewaste.com.au

NSW Department of Planning, Industry and Environment (DPIE) has developed a Waste and Sustainable Materials Strategy 2041 (June 2021)

NSW EPA 2016, Environmental Guidelines: Solid Waste Landfills (second edition 2016).

NSW EPA 2019, Waste Classification Guidelines.

NSW Waste Avoidance and Resource Recovery Act 2001.

SYS-0025 Bengalla Mine Tyre Management Plan, BMC Internal Procedure Document.

PRO-0333 Scrapped tyre in pit dumping, BMC Internal Procedure Document.

ATTACHMENT A

ACARP 2000 Management of Waste Tyres in the Mining Industry

Management of Waste Tyres in the Mining Industry

FINAL REPORT

Australian Coal Association Research Program
Project No. C8037

M.H Corbett
Centre for Mined Land Rehabilitation

THE UNIVERSITY OF QUEENSLAND

ACARP
Australian Coal Association Research Program

CMLR

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CONTENTS

EXECUTIVE SUMMARY

The disposal of large off-the-road (OTR) tyres generated by the mining industry has generally been by landfill or a stockpile in a registered waste area on-site. Their size, construction and invariably remote location make them very difficult and expensive to handle and process. This Australian Coal Association Research Program (ACARP) project aims to identify opportunities to *Reduce, Reuse and Recycle* scrap mine tyres and to identify cost-effective alternatives for managing waste OTR tyres at remote mining operations.

Tyre recycling technology and literature is focussed on passenger tyres. The legislative impetus overseas and in Australia to ban whole tyres to landfill is more likely to be designed to conserve urban landfill space and to promote recycling rather than to prevent contamination or because tyres tend to 'float' in landfill. The technological and economic limitations in processing OTR tyres currently restrict any alternative uses to those that use whole or sectioned tyres or steel-containing shreds.

While in the context of Best Available Technology, the use of Tyre Derived Fuel (TDF) in cement kilns appears the most appropriate alternative, the high energy and cost input required to process, transport and 'dispose' OTR tyres suggests that this option is more appropriate for the utilisation of passenger tyres.

On-going dialogue with the mining industries and regulatory organisations has constituted a considerable component of this project and is difficult to detail in a report such as this. However, the input of this industry-funded research in policy development is evident in both the Scrap Tyre Task Force Strategy as well as the Queensland Environmental Protection Agency's (QEPA) Draft Operational Policy (ERA21) directing disposal and storage of scrap tyres on mine sites under the *Environmental Protection Regulation 1998.*

This project has demonstrated that recycling or reuse is extremely difficult to apply efficiently in relation to OTR tyres on remote mine sites. This conclusion is reflected to some extent in recent legislative developments indicating that the disposal option, although not preferable, is acceptable. Our findings do concur with those of the QEPA in that, while potentially the highest consumer cost option, the *Extended Producer Responsibility Principle* would result in the greatest likelihood that scrap OTR

management would move up the waste management hierarchy, probably through recycling. Failing the successful instigation of this process, the most appropriate scrap OTR management option will be site specific and depend largely on the proximity of the site to facilities that can process and utilise the waste. For remote sites, whole tyre on-site burial at depth according to the relevant policy directions is currently the next best option. A significant step forward has been made in that previously, uncertainty of the legislative and environmental issues associated with scrap OTR tyres meant that the worst option, that is perpetual above ground stockpiling, was invariably adopted.

1.0 Introduction

A tyre is engineered and constructed with durability in mind. When a tyre wears out, it remains a virtually indestructible parcel of rubber, chemicals, fabric and steel. At the end of it's service life, an estimated 80% of it's original resources remained trapped in the tyre (Duffy, 1996). In the United States, largely as a result of legislation banning the disposal of whole tyres to landfill, over 70% of the estimated 253 million scrap tyres generated annually are utilised in some form of energy reclamation, recycled rubber manufacture or civil engineering application (Blumenthal, 1997a). In Australia, approximately 10 million tyres expire annually, their most probable destination is currently in landfill, either in shredded or whole form (Anon., 1997). Legislative change in Australia banning tyres to landfill is stimulating the development of retreading, reprocessing and energy reclamation technology (Mills 1993).

From the outset of this report, it is important to differentiate between passenger[1] and large off-the-road (OTR) tyres[2]. OTR tyres are larger, will typically have a higher proportion of natural rubber and may contain steel beads measuring up to 100mm in diameter (Brewer, 1997). The disposal of OTR tyres generated by the mining industry has generally been in landfill or a stockpile in a registered waste area on-site. Their size, construction and invariably remote location make them very difficult and expensive to handle (Carter, 1996). Also, OTR tyre piles are not visible to the public and thus, there is a dearth of information and opportunity with respect to their reuse options.

The vast majority of the literature and developing tyre-recycling technology is focused on passenger tyres. Passenger tyres are much smaller and typically stockpiled in large numbers in populated areas, so they are easier and cheaper to access, transport, handle and process. However, the higher proportions of natural rubber found in OTR tyres is much more valuable than the synthetic rubber used in passenger tyres (Brewer 1997). The economics of rubber reclamation, the legislative trend banning tyres in landfill and

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[1] Passenger vehicle and light truck tyres

[2] Tyres which are larger than 1400X24, but which can be up to 3.5 metres in diameter and weighing over 2 tonnes. Hereafter refered to simply as OTR tyres.

the opportunity to reduce waste and recycle valuable resources could stimulate the recycling of OTR tyres.

This report details work completed for the Australian Coal Association Research Program (ACARP) project C8037, 'Management of Waste Tyres in the Mining Industry'. The project aims to identify opportunities to 'Reduce, Reuse and Recycle' waste tyres employing best available technology and to deliver a cost effective alternative for managing waste OTR tyres at remote mining operations.

The report is divided into two sections, which represent two distinct phases in the project. The first section presents a review of the literature, current industry practise, developing technology and regulatory policy and makes recommendations on which the second phase of the project was based. Section two analyses the various options identified, in terms of practicality and cost, as well as presenting a summary of more recent policy developments, which have largely coincided with this project.

SECTION 1 – State of the art and identification of options

2.0 How does the mining industry currently manage expired OTR tyres?

Although the mining industry accounts for less than 1% of all scrap tyres, the typically large size of scrap tyres generated by the industry accounts for 15% of scrap tyre weight (Carter 1996). Some 20,000 OTR tyres, as well as an additional 3500 giant earthmover tyres[3] are replaced annually in Queensland mines alone (Weinzel, *pers. comm.*; Managing Director: Link Recycling Technology). Currently, the uses for such tyres are very limited. Companies with the technology to process them in Australia are non-existent and the cost to transport them for destruction are prohibitively high[4]. Most significantly, legislation in both Queensland and N.S.W currently allows for mine tyres to be disposed to landfill. A preliminary survey of coal mines in the Bowen Basin in Queensland and the Hunter Valley in N.S.W suggests that, apart from a few limited alternative end uses, such as feed troughs for farmers or road safety barriers on site, scrap tyres are either stockpiled in numbers allowable under the regulations or are monofilled[5]. In some cases, the tyres are quartered[6] to reduce their volume and also to prevent the risk of tyres 'floating'[7] in the landfill. Some mining operations are shallow filling tyres to allow the option for recovery at a later date, should the technology become available too economically process them. In all cases, stockpiling or monofilling of scrap tyres was a decision driven by cost and regulation. Stockpiles at mining operations surveyed contained between 50 to 750 tyres, with the rates of addition to the stockpiles ranging from 60 to 300+ tyres annually. BHP Coal mines alone generated 937 scrap OTR tyres in the 97-98 financial year (Anon, 1998).

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[3] Tyre >1.5 tonnes
[4] Approximately 24cents/tyre/km for transportation and $300/tyre for high temperature incineration.
[5] A single waste type, or homogenous, landfill
[6] Cut into four pieces using hydraulic, backhoe-mounted shears.
[7] Refer to section 3.3

3.0 Problems associated with the stockpiling and landfilling of tyres

3.1 A Wasted Resource

The average tread depth remaining on a scrapped OTR tyres on a BHP Coal mine can be as high as 45% (Anon, 1998). A $30,000 giant earthmover tyre may be scrapped with 97% tread, or over 1 tonne of tread rubber remaining (Anon, 1998). The average scrap OTR tyre may have as much as 0.7 cubic metres of high quality natural rubber remaining in the tread area alone. An additional 0.5 cubic metre of rubber and 200 kilograms of steel may be present in the sidewall and bead. Based on these figures[8], it is estimated that 16,200 cubic metres of high quality rubber and 2700 tonnes of steel are buried or dumped each year in Queensland alone.

Queensland Environmental Protection (Waste Management) Policy (1997) encourages management of wastes in accord with the waste management practices hierarchy. However, the policy does state that 'the use of a practice not in accord with the order of the hierarchy is acceptable where it can be established that less environmental harm will result from the use of that practice than any other practice'.

Figure 3.1.1 Waste Management Hierarchy.

The hierarchy sets out the management practices that should be employed in the order of most preferred to least preferred.

[8] Authors calculations based on Michelin specifications for an 'average' OTR tyre size

3.2 Potential for Contamination

When considering management options for scrap tyres and the relative advantages and disadvantages of current and proposed disposal (or reuse) options, the first step should be to assess tyres' chemical composition and their potential toxicity/leachability in landfill or stockpiles.

Tyre manufacturing companies are very reluctant to provide information about the ingredients of tyre manufacture. Several studies, however, have investigated the composition of tyres. Tyres are manufactured from natural or synthetic rubber, carbon black, sulfur, zinc stearate, a variety of antioxidants and other additives (Masterton & Slowinski, 1977). The vulcanisation reaction involved in tyre manufacture combines natural rubber with sulfur under heat. Styrene-butadiene rubber (SBR) is made by copolymerising 75% Butadiene and 25% Styrene and is the most important synthetic rubber used by the tyre industry (Edil, 1989). An analysis of tyres by the US EPA (1995) outlines the compounds used in the manufacture of tyres. It is important to note that this analysis is of passenger tyre manufacture but it can be assumed that OTR tyres are manufactured from similar components but will contain higher proportions of more valuable natural rubber (Brewer, 1997). It should also be noted that each tyre design often has a different composition. The list of the major chemicals used in rubber compounding (US EPA, 1995) is included as appendix 1 of this review.

The biodegradation of tyres has been estimated to take 50-80 years (Baglioni et al, 1994). Studies of tyre leachate suggest that shredded or whole tyres do not pose a risk to ground water. In an analysis of tyre leachate, Park et al (1989) concluded that shredded tyres do not release any significant amounts of priority pollutants. In a comparison of leachate from shredded and whole tyres, Burnell and McOmber (1997) found iron[9], zinc and sulfur[10] were released and were in higher concentrations in leachate from shredded tyres but were well below drinking water standard concentrations. An assessment of leachate from waste rubber products using the US EPA (1990) Toxicity Characterisation Leaching Procedure (TCLP), which assesses the

[9] Resulting from the oxidisation of reinforcing steel beads
[10] Released through an ion exchange process.
[11] 205kg/m^3 for rubber compared to 1344kg/m^3 for glass (EPA, 1990)

leaching potential of over 40 different volatile and semi- volatile organics and metals, showed that none of TCLP regulatory levels were exceeded. In areas retaining water, continued leaching can increase concentrations of barium, iron, manganese and zinc (Getz & Teachey, 1992).

3.3 Landfill Volume and Stability

There is a common perception that whole tyres disposed to landfill 'float' upward and may surface over time. There are numerous theories as to the reason for this 'floating' but this review has been unable to identify any case study or experimental evidence of this phenomenon. The often vague explanations of the 'floating' theory relate to passenger tyres and include; (1) methane gas generated in municipal landfills captured in whole tyres causing them to rise, (2) air trapped in tyres causing them to rise in saturated landfill, (3) partially compressed tyres flexing in landfill and rising to the surface and (4) tyres vibrating to the surface as heavy machinery travels over the surface. The US EPA (1995) states that "when buried, tyres tend to work their way back to the surface as casings compressed by the dirt slowly spring back into shape and "float" the tire upward". The rigid nature of large OTR tyres, their weight, the depth at which they are generally monofilled and the nature of the overlying material, however, may preclude any threat of 'floating'.

The deposition of whole tyres in landfill is a very inefficient use of landfill space. Tyres are 85% air space (Weinzel, *pers. comm.*) and so have a very low landfill density[11]. Tyres disposed in landfill can prevent satisfactory compaction (Levitzke, 1996). The legislation governing disposal of tyres to landfill is most likely aimed at preserving urban landfill space although this is generally not a concern for mining operations. A common misconception, however, is that shallow monofilling of tyres will allow for recovery at a later date, should the technology to reprocess them become available. Most existing tyre processing technology requires a clean tyre so in reality, the economics of tyre recycling are so marginal that the additional cost of recovery and cleaning the tyres is most likely to prevent any recycling of buried tyres (Brewer, 1997).

3.4 Health Risks

There is a wealth of literature discussing the public health and the environmental risks associated with the open stockpiling of tyres (Webb, 1996; Vickers, 1996; Lemieux and Ryan, 1993; Dorer, 1978). The two major risks associated with an open stockpiling of tyres are:

(1) The potential to provide a breeding ground for mosquitoes and vermin which provide a vector for disease and
(2) The potential fire hazard causing extreme radiant heat, toxic gas emissions and water and soil contamination.

Aedes aegytpi and *Aedes notoscriptus* are two species of mosquito that are known to transmit disease, namely Dengue Fever and Ross River Virus respectively. These mosquitoes are present in Queensland and breed readily in water collected in waste tyres (Webb, 1996). The Public Health Act (1937) and the Mosquito Prevention and Destruction Regulations (1982) directs the prevention and destruction of mosquito breeding grounds. The required treatment of each tyre in a stockpile with a suitable larvicide every 5-7 days, however, is impractical and the treatment poses health risks to personnel in itself.

A typical tyre stockpile fire will burn for days, weeks or even months (Vickers, 1996). Incomplete combustion of tyres in a stockpile fire results in an extremely hazardous emission of gases and particles which present a serious health risk upon inhalation (Webb, 1996). Intense radiant heat inhibits fire fighting efforts and the resulting toxic slurry will have a significant impact on soil, groundwater and waterways (Webb, 1996).

3.5 Legislative Constraints

In 1992, overseas experiences with tyre disposal prompted the Australia New Zealand Environment Conservation Council (ANZECC), made up of state and federal environment ministers, to ban whole tyres to landfill and to introduce a disposal levy (Mills, 1993). This initiative, slowly being implemented around Australia, is largely designed to conserve landfill space in urban centres, where 10 million passenger tyres may be disposed of annually (Anon., 1997). The Queensland Environmental Protection (Interim Waste) Regulation 1996 makes no differentiation between passenger and OTR tyres, which may be landfilled currently, while the N.S.W Waste Minimisation and Management Regulation 1996 only covers the disposal of tyres less than 1.2 metres diameter. The NSW EPA has indicated OTR tyres may be buried on-site after removal of the bead and cutting the sidewall and tread into <250mm sections. The Queensland EPA has recently established a Scrap Tyre Task Force to produce a strategy for scrap tyre management for the state. Their strategy is due December 1999. Currently, tyres are a regulated waste in both states and are subject to the relevant licensing and limitations. In Queensland, a mine depositing more than 10% tyres by weight in a general waste area on site must be a licensed facility. The Queensland Waste Management Legislation Public Consultation Document (Department of Environment, 1997) states that;

'The disposal of whole tyres to landfill is banned from a date to be declared. Such ban may be declared for a specific region or region or may apply to the whole state ...'

While it is likely that this ban is designed to preserve urban landfill space, it is unclear if the proposed change will be applicable to remote mine sites. In 1995, after tyres were banned from landfill in South Australia, Western Mining Corporation received dispensation from the legislation after it was shown that the technology did not exist in Australia to otherwise process large OTR tyres.

4.0 Alternative Disposal/Reuse option.

The traditional tyre swing or cleverly carved white painted tyre swan are no longer the only alternative use for a scrap tyres. In the United States, the three major markets for scrap tyres[12] are (1) Tyre Derived Fuel (TDF) for cement and brick kilns and power stations, (2) civil engineering applications and (3) recycled rubber products (Blumenthal, 1997a). It should be noted that, in terms of the Waste Management Hierarchy, the most appropriate option is 'AVOID'. This could be achieved through strategies designed to maximize tyre life or through retreading. Retreading OTR tyres

[12] The number of scrap passenger tyres having markets has increased from 11% in 1990 to 75% in 1996

is also becoming more popular in the United States (Brodsky, 1998). Before critical analyses of these reuse options for scrap tyres is attempted, it is essential to understand the construction of an OTR tyre and the particular problems they pose in reprocessing due to their size, durability and typically remote location.

A tyre is made up of a rubber tread, steel belts or nylon breakers (depending on a radial or bias ply construction), a sidewall and a steel wire bead. A Bias tyre is manufactured with multiple nylon carcass plies running diagonally from bead to bead. A radial tyre is manufactured with a single ply of high strength steel cord running at right angles to the bead. The bead of a tyre may be a package of a number of steel cords or a single large diameter cord. The characteristics of an OTR tyre differ dramatically according to the type of vehicle to which it is fitted and the type of function it performs, however they are all designed to resist cutting, tearing, heat and wear.

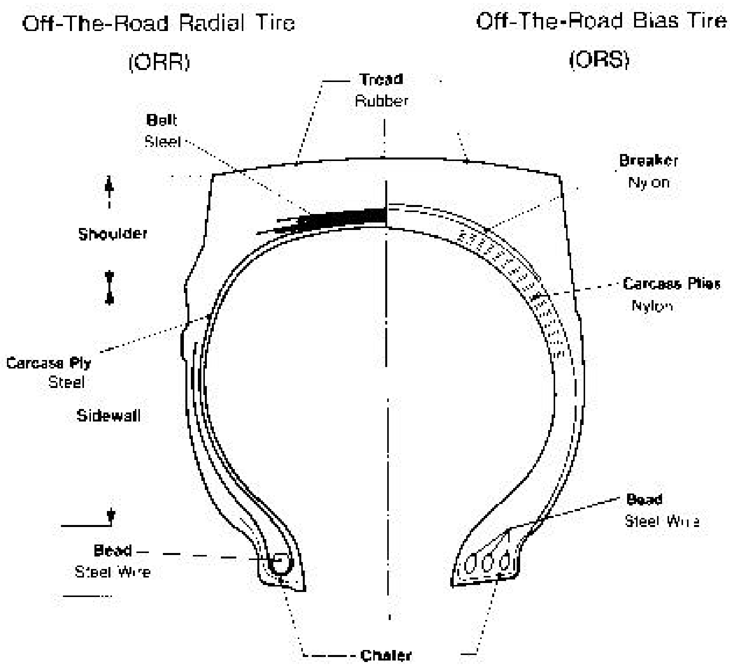

Figure 4.0.1 OTR Tyre Construction (Source: Bridgestone OTR technical data)

4.1 Retreading

While there are no facilities for retreading OTR tyres in Australia, viable retreading occurs in both the United States and Europe (Cummins, *pers. comm.*; Chairman: Independent Retreaders Division, Australian Tyre Dealers and Retreaders Association) In terms of the Waste Management Hierarchy (set out in section 3.1), retreading is the most acceptable option for expired tyres which are suitable for retreading. The American Tire Retread Information Bureau claims that a US$28,000 giant loader tyre can be retreaded for US$18,000 and will provide wear at least equal to the original tyre (Brodsky, 1998). The feasibility of OTR retreading is currently being investigated in Australia (Cummins, *pers. comm.*) and may provide a cost-effective alternative to tyre disposal. It is likely, however, that retreading will be restricted to smaller (<1400X25) OTR tyres.

4.2 Volume Reduction

While shredding, grinding or granulating scrap tyres is not a management option in itself (other than volume reduction in landfill which is a requirement in some states of Australia and most of the United States) it is regarded as a pre-requisite for many processing routes. As already discussed, up to 85% of a tyre's volume is air space, representing an enormous waste of landfill, storage and transportation space. The high cost associated with the transportation of OTR tyres from mine sites may be reduced substantially by shredding scrap tyres on site. The problems associated with the volume reduction of scrap tyres have been summarised (Sive, 1996) as;

- Separation of the components into rubber, fibre and steel.
- Production of components in a form which is suited to a specified market, which has a significant market value and which can be varied in accordance with market demand.
- Handling, transport and processing costs

Additional problems associated with processing OTR tyres include the availability, mobility and durability of equipment and the lack of markets for OTR tyre components.

Four primary techniques for the volume reduction processing of scrap tyres may be considered (Sive, 1996)

- **Shredding** which produces tyre chips by mechanical cutters**.**
- **Grinding** which forces tyre chips between two rollers, as in a cracker mill.
- **Granulation** utilises shearing and chopping; and
- **Impaction** relies on a two stage process of cryogenic cooling and then shattering using a hammermill.

There are typically three stages in producing crumb rubber (Getz & Teachey, 1992). In the first stage, whole tyres are reduced to 50-200mm size chips by a slow speed shear shredder. In the second stage, the pieces are further reduced to smaller than 10mm pieces by cracking and grinding and screening processes. The final stage, producing a final product 99.5% free of steel and fabric, utilises a series of grinders, aspirators and powerful magnets. Alternately, tyres can be cryogenically frozen using liquid nitrogen and smashed in a mill. The cryogenic method liberates almost all steel and fibre from the rubber (Klingensmith & Barnwal, 1998). Rubber particle size and the degree of steel and fabric remaining in the final product are inversely proportional to cost of processing (Blumenthal, 1997a).

A prospective tyre processor should first determine what their end uses are and the size requirement of the market they are targeting (Bruenig, 1994). The existing markets for scrap OTR tyres, however, are extremely limited. While summaries of tyre processing equipment designed to process passenger tyres are numerous (Klingensmith & Baranwal; 1998; Bruening, 1994; Klingensmith, 1991; Sive 1996), this review identified only two mobile machines capable of processing OTR tyres.

The Diamond-Z™ 1463-T has twin 800 horsepower Caterpillar engines, is fully mobile and is capable of reducing 3300mm diameter tyres to 50mm chunks. Bridgestone/Firestone's OTR division mobilises one of these shredders to mines across the western United States, reducing stockpiles of OTR tyres to 50-200mm chunks which are then transported to plants utilising tyre derived fuel (TDF) or landfill. The cost of one of these shredders is approximately US$750,000 ex Idaho (Sept. 1998 estimate). The second machine is a custom built shredder operated by Northern Tyre Salvage in Townsville.

Figure 4.2.1 The Diamond-Z 1463-T mobile shredder

Almost all recycled rubber products utilise a steel and fabric-free rubber crumb. The high price of liquid nitrogen, the wear on machinery caused by the heavy steel beading and the cost and lack of mobility of the plants are factors which currently preclude the economic recovery of pure rubber crumb from OTR tyres. There is potential, however, to reclaim pure rubber relatively simply and inexpensively through a process known as 'buffing'[13]. If this method was to be adapted to reclaim rubber from large OTR tyres, the sidewall rubber could also be buffed, with the potential to produce hundreds of kilograms of high quality, steel-free natural rubber from just one tyre. This method of rubber reclamation, however, does leave a carcass of steel and rubber and so it may be that a combination of processing methods must be employed, depending on the intended

[13] To prepare a tyre for retreading, rubber is first removed from the tread area (the tyre is buffed). The tyre is mounted on an expandable chuck and spun while a cutting tool is passed across the surface of the tread (in the fashion of a lathe) producing a good uniform surface for retreading and a quantity of high-quality rubber compound free of steel or fabric reinforcement. On average, about 10kg of these buffings are produced from a light truck tyre as it is prepared for retreading (Sive, 1996).

end uses of various components of the tyre. An Italian firm manufacture buffing machines which are capable of processing tyres up to 3000mm in diameter.

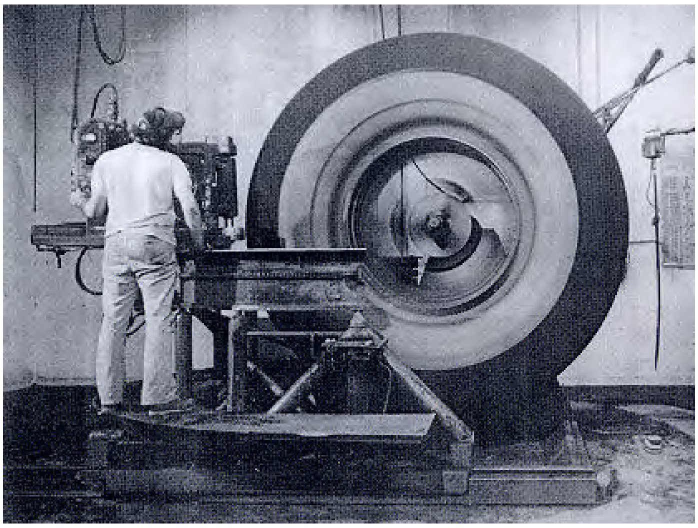

Figure 4.2.2. A large OTR Tyre Buffer

4.3 Waste to Energy/Resource Reclamation

The number of scrap tyres being utilised as a fuel source has increased steadily[14] in both the United States and Australia. Tyre derived fuel (TDF) is by far the most common alternative end use for scrap tyres.

4.3.1 Tyre Derived Fuel (TDF)

In 1996 in the United States, 152 million of the 202 million reused scrap tyres were subject to energy recovery (Blumenthal, 1997a). Electric utilities, pulp and paper mills and cement and brick kilns have all utilised shredded or whole passenger tyres as a fuel source (Farrell, 1996). In Australia, Blue Circle Southern Cement in Geelong, Victoria burn almost all that States' scrap tyres[15] which totals approximately 2 million tyres. This comprises 27% of the plants total fuel consumption (Woods, *pers. comm.*; Business development manager, Queensland Cement Limited).

[14] In the United States, 75% of all scrap passenger tyres are used as fuel (Blumenthal,1997), while 20% of all scrap passenger tyres are used as fuel in Australia (Woods, *pers. comm*)
[15] tyre sizes up to 1200x20
[16] Ironstone, lime and silica are fired between 1450 C and 2000 C to produce cement 'clinkers'

The cement industry discovered that the addition of tyre chips to their kiln actually increased the energy value of coal and that the steel beading and belt material within a tyre could serve as a replacement for iron oxide[16]. Studies have shown that the high temperature combustion in kilns can preclude products of incomplete combustion (black smoke and odours) and that TDF can have lower emissions than conventional fossil fuels (Palmer, 1996; Carter, 1996). Getz and Teachey (1992) state that TDF can emit less sulfur dioxide and nitrogen oxide than most types of coal on a net energy output basis but depending on the combustion system, can result in a net increase in particulate emissions. Initial results from a recent trial conducted at Queensland Cement Ltd.'s Gladstone kiln, firing 60,000 passenger tyres in one week, suggests that NO_x gas emissions were 20% lower than coal and that other emissions were comparable or lower (Woods, pers. comm.). Carter (1996) states that tyres have a high calorific value, contain less than 1% moisture, generate low amounts of ash and have been demonstrated to lower emissions. He further states that 'it is not unreasonable to assume that virtually every cement kiln in the western United States will be using TDF within the next five years'. One hundred and fifty kilns globally currently utilise TDF (Woods, *pers. comm*).

The availability of passenger tyres in large numbers close to plants that can utilise TDF and the relative ease of handling smaller tyres has precluded the use of OTR tyres. This review failed to identify any cases of whole or shredded OTR tyres being used as TDF. However, a new cement kiln at Gladstone will be capable of utilising 50,000 tonnes of TDF annually (about 25% of its coal consumption) (Woods, *pers. comm.*). The kiln will be able to utilise a 100-200mm clean cut section of tyre. For this option to be viable, shredding would have to be carried out on-site (mobile) to reduce transport costs. Disposal costs charged by the plant (if any) would also have to be assessed[17]. The advantage of this option for scrap tyre management is that no component separation is required after the tyres are shredded (ie the steel may be left bound in the rubber) and that the shreds can be transported with coal from the mine to the plant, provided the customer is willing to accept the additive. The abundance of OTR tyres in concentrated mining areas may also make contracting with a waste manager to shred and transport tyres economical. The limitations are that TDF cannot be used in conjunction with pulverised coal (unless a separate fuel feeding mechanism exists) and is limited to use with low sulfur coal[18] (Carter, 1996).

Another form of TDF which should be considered is the use of shredded rubber as a bulking agent/fuel source in the mine blasting process[19]. Rio-Tinto Zinc have developed and patented a product called ANRUB™ which is a rubber crumb designed to partially replace diesel as a fuel source and act as a bulking agent in the blasting process. Currently however, the process utilises crumb rubber obtained from passenger tyres and so while providing potential savings in diesel and ammonium nitrate consumption, this process does not attempt to solve the scrap OTR tyre problem. The use of rubber in the blasting process is reported to facilitate a ‘soft’, more controllable blast (Kirsch, pers. comm.; Environmental Officer, BHP Coal, Norwich Park mine.). An advantage of using rubber shred, as opposed to sawdust, as a bulking agent is that is can act as a waterproofer. The requirement for rubber used in this process is that the rubber be free of any steel reinforcement. The only economical way to obtain this from OTR tyres may be through buffing the rubber from the tread area of the tyre.

4.3.2 Pyrolysis

Pyrolysis involves the breaking down of scrap tyres to their constituent components, principally softening oil, carbon black, fuel oil, steel and hydrocarbon gas using the controlled application of heat in an oxygen-free atmosphere (Mills, 1993). Carbon black has a wide range of uses in the manufacture of belts, hoses, plastics, inks and toners but by far the greatest user is the tyre industry. Extender or softening oil is used in the plastics and rubber manufacturing industry, again predominantly in tyres. The steel can be sold as scrap and the hydrocarbon gas is used as fuel for the pyrolysis process (Glazebrook, 1996). The literature suggests that the economics of pyrolysis are marginal (Mills, 1993; Powell, 1997) and that the use of the technique is declining in the United States (Farrell, 1996). It is therefore unlikely to able to be applied to the recovery of resources from OTR tyres.

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[17] Disposal costs charged by TDF users to tyre disposers globally range from 0-$70/tonne, the average being $25/tonne (Woods, 1998). Blue Circle Southern Cement in Victoria make no charge to disposers but require clean tyres to be delivered to the plant

[18] TDF contains 1.2% to 1.5% sulphur.

[19] a controlled explosion created with a mixture of ammonium nitrate and diesel

4.4 Civil Engineering Applications

About 12 million scrap passenger tyres, or 8% of all tyres scrapped annually in the United States are utilised in civil engineering applications (Farrell, 1996). Included is a summary of uses for scrap tyres in civil engineering applications and comments on their potential applicability to the mining industry.

4.4.1 Asphalt/rubber road construction

The main use for crumbed rubber is in road construction and paving applications (Getz & Teachey, 1992). In 1991, regulators in the United States legislated for the use of recycled material in federally funded highways which lead to a rapid expansion of the production of rubber modified asphalt (RMA), which consumes 41% of the total ground rubber produced (Blumenthal, 1997b). Asphalt rubber crack sealant, asphalt rubber seal coating, asphalt rubber stress absorbing membrane inter-layers, asphalt rubber concrete and rubber modified asphalt rubber concrete are all products which utilise waste tyres. Rubberised asphalt can cost between two and four times more than conventional concrete (due largely to the high cost of tyre processing) but can significantly improve road life, lower maintenance, increase crack and chip resistance, increase passenger comfort and improve antiskid properties (Mills, 1993). Road making has the potential to consume very large numbers of processed scrap tyres. The availability of rubber 'buffings' from the retread industry[20] and the extra costs associated with producing a steel-free rubber crumb from OTR tyres will limit the applicability of this option to the mining industry. Steel-free tread rubber buffed from tyres and used in road building or repair on-site may be viable.

4.4.2 Sewage sludge composting

The use of tyre chips has been investigated as a bulking agent in sewage sludge composting with and as a substitute for wood chips. After each composting cycle tyre chips are removed from the compost and reused while wood chips decompose after about three composting cycles, representing a significant saving to treatment facilities

[20] Australia is the largest retreader of any OECD nation

(Getz & Teachey, 1992). Tyre chips have also been used in municipal waste disposal facilities. Farrell (1996) further discusses the advantages of the reusability and longevity of rubber as a bulking agent in the composting process.

4.4.3 Oil and heavy metal absorbent

Surface modified rubber[21] will absorb up to three times its weight in crude oil within minutes of being applied to an oil spill. If left for more than a day, the rubber will absorb up to 8 times its weight in oil (Getz & Teachey, 1992). After it is used, the oil can be extracted from the rubber or the chips used as a fuel. Studies have also demonstrated the potential for tyre rubber in the absorption of heavy metals and the mitigation of volatile organic compounds (Park et al, 1997; Meng et al, 1998; Mead et al, 1997). Rowley et al (1984) demonstrated that shredded tyre rubber will absorb cadmium, mercury and lead using a mechanism involving the ion exchange of zinc[22]. This option may have potential applicability to the mining industry in that the final use for reprocessed tyres could be largely on-site. Surface modification technology is still developing. However, unmodified shredded rubber is used in the absorption of heavy metals.

4.4.4 Drainage Layers/Soil Amendments

Both tyre chips and half tyres have been shown to be effective replacements for stone as a drainfield aggregates in septic systems (Burnell & McComber, 1997) sewage treatment plants and landfill cells (Getz & Teachey, 1982). Research also indicates the addition of rubber particles to soil can dramatically reduce soil compaction and improve drainage (Riggle, 1995). A patented soil amendment process in the United States known as Rebound™[23] is gaining popularity for use on sports fields, golf courses and other high traffic areas. This process utilises steel-free fine crumb rubber and so the economics of production favour passenger tyres. Tyre chips used as drainfield aggregate, however, can be larger and can contain steel and so this may be an option for shredded OTR tyres.

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[21] An emerging technology improving the reuse potential of rubber crumb involving the treatment of rubber particles with chlorine gas (Smith et al, 1995), discussed further in section 4.5.
[22] zinc can comprise 5% of a tyre (Doss et al, 1995)
[23] Rebound™ incorporates crumb rubber and compost in a ratio of approximately 1:5.

4.4.5 Artificial Reefs

Tyres can be strapped together or set in concrete and placed offshore to act as an artificial reef or breakwaters. Construction of artificial reefs offshore using tyres has become less popular after overseas experience has shown fish tend to avoid rather than colonise them and that tyres have repeatedly broken free under the action of tides and waves (Mills, 1993). Collins et al (1995) concluded that while tyre surfaces are colonised by algae, coral and shellfish, poor deployment in the United States led to tyres washing ashore after storms, resulting in the banning of their use in marine applications. It could be argued that this option merely transfers waste from land to sea. Unless a barrier reef surrounding our continent is a management aim, the construction of rubber reefs may not be a sustainable reuse (disposal) option for scrap tyres.

4.4.6 Landscape Stabilisation

Stabilisation of gullies, slopes and banks using tyres has been practised in Australia for many years (Mills, 1993). Tyres can be stacked whole or halved and tied and covered with soil to promote vegetation and prevent erosion. MacGregor and Provencher (1993) discuss the use of truck tyres in portable road building mats. Sidewalls of tyres are fastened together and the 3.2 x 6.2m mats installed on forest construction roads to provide traction. They estimate the cost of production and installation as US$40,000/km but consider the longevity of the mats offsets the high initial cost. These options may have practical applications in minesite safety and mine rehabilitation.

4.4.7 Lightweight Fill

Whole or shredded scrap tyres have been used as clean, lightweight fill for road embankments and road bed support. Scrap passenger tyres can be processed to appropriate specification for less than $60/tonne- approximately the cost of soil and substantially less than some other fill materials (Blumenthal, 1997b). Processing of OTR tyres will be more expensive but this cost may be offset by the saving in transportation costs (of tyre offsite and fill onsite). Processed scrap tyres have been demonstrated to have similar or equal performance of other fill material (Blumenthal, 1997b). During 1994 and 1995 , this application grew rapidly in the United States until two incidences, where thick layers (9 and 15 metres) of rough tyre shreds were overlaid with highly organic cover, resulting in oil discharge and fire (Powell, 1997). Some 75 similar projects were completed successfully and it was believed that the organic matter laid over the 'burning fills' resulted in the excess heat build up (Blumenthal, 1997b). In response to the negative publicity generated by the two fires, the United States Scrap Tyre Management Council (STMC) submitted "Design guidelines to minimise internal heating of tire shred fills" to the Federal Highway Administration which recommended the depth of scrap tyres in fill applications to be less than 3 metres (Blumenthal, 1997b).

4.4.8 Marine fenders, traffic control and feed troughs

Used as fender on docks or tugs, traffic control or safety barriers (along highwalls) and split and used by local pastoralists as feed troughs is probably the most common current alternative use for OTR tyres in Australia. While all these options are useful and inventive, they are not able to consume large volumes of scrap tyres.

4.5 Recycled rubber products

The third major market for scrap tyres is for feedstock to be used in recycled rubber products. These products fall into two categories; (1) Those that are manufactured from crumb rubber[24] and (2) those manufactured by punching or stamping rubber from whole tyres. Recycled crumb rubber to be used in the manufacture of new rubber products may have to undergo some particle surface modification[25] or devulcanization[26] to enable the particle to bond effectively. Without surface modification or devulcanization, crumb rubber can be mixed with resins and glue for some uses but the bonding is physical rather than chemical or molecular and so these products tend to have lower performance specifications (Riggle, 1995). The refinement of

[24] Which may either be a bi-product of the retreading industry or whole tyres extensively and expensively processed to produce steel and fibre free rubber crumbs ranging in size from 6mm down to 0.5mm (Riggle, 1995)

[25] The process of surface modification involves exposure of the particle surface to reactive gases to modify the outer few molecular layers, enabling them to bond with materials like polyurethane, latex and other polymers (Riggle, 1995).

[26] Vulcanisation is a high energy process which facilitates the formation of strong, complex chemical bonds between sulphur and carbon molecules (Sive, 1996). Devulcanization involves the breaking of these sulphur bonds chemically or even microbiologically and allows for the recycled, devulcanized crumb rubber to be chemically bonded with other rubber particles and substances

devulcanization and surface modification processes should see an expansion of crumb rubber markets (Blumenthal, 1997a). The high impact attenuation level of rubber makes it especially ideal for the manufacture of protective surfaces for a wide range of applications (Blumenthal, 1997a).

Because of the expense and difficulty associated with producing steel and fibre free crumbed rubber from OTR tyres, the application of the manufacture of recycled rubber products is unlikely to be suitable to the mining industry. Again, however, the most likely economic method of producing steel and fibre free crumb rubber from large OTR tyres must be by buffing the tyre. A summary of recycled rubber products has been included as Appendix 2 of this review.

5.0 CONCLUSIONS/RECOMMENDATIONS (SECTION 1)

- Tyre recycling technology and literature is focussed on passenger tyres.

- The legislative impetus overseas and in Australia to ban whole tyres to landfill is more likely to be designed to conserve urban landfill space and to promote recycling rather than to prevent contamination or because tyres tend to ‘float’ in landfill.

- Technological and economic limitations currently restrict any alternative uses for mine tyres are to those that use whole or sectioned tyres or steel-containing shreds.

- The most appropriate alternative use is likely to be as TDF. Experience in the United States, which leads the world in the reuse or scrap tyres, supports this.

- If a use is identified onsite or a market develops for high quality, steel free, natural rubber shred, then either the purchase or the construction of a machine capable of buffing the tread rubber from the tyres may be viable.

- The viability and cost of tyre shredding and transport should be investigated on a cost benefit basis, with current management practices.

SECTION 2 – Investigating the options and recent policy developments

Section two analyses various options identified, in terms of practicality and cost and presents a summary of more recent policy developments.

6.0 Investigation of the options

The options that were compared, in terms of practicality, cost and relative benefits, were;

- Extended Producer Responsibility Principle
- Transport off-site and shredded
- On-site storage/burial (sectioned)
- On-site burial (whole)

The outcomes of these trials are presented in the following sections.

6.1 The Extended Producer Responsibility Principle

It is appropriate, given the interest shown by both industry and the QEPA in this approach, to give consideration here to the '*extended producer responsibility principle*' in managing tyres. That is, mining companies negotiating take-back clauses in purchasing agreements with tyre suppliers. Essentially, this implies the tyre is leased and that the responsibility of the waste lies with the producer or supplier. This principle is adopted by most passenger tyre suppliers and adds about 2% to the cost of the tyre. Given the increased freight costs and difficulty of handling and processing, we can assume a higher levy would apply to mine tyres. Table 6.1.1 outlines the cost, advantages and disadvantages of this option

Table 6.1.1. Summary of the 'Extended Producer Responsibility Principle' option

COST / TYRE	≊2-5% of purchase price ($100-$1000)
ADVANTAGES	Greatest likelihood of manufacturer being able to develop the technology/markets to recycle the waste
	Freight costs reduced through backloading after delivery of new tyres to remote sites
	Removes the problem from the mine site
DISADVANTAGES	Transferral of responsibility rather than an 'AVOID' solution of the problem
	On-going mine inputs in maintenance and handling of stockpiles, loading trucks etc.
	Potentially highest cost option

6.2 Shredding (for use as TDF)

Stage one of this project identified the use of TDF in cement kilns as the most appropriate alternative. While passenger tyres are can be fed into QCL's Gladstone kiln whole, large OTR tyres must first be shredded into a 100-200mm clean cut chunk. The aim of this trial was to contrast firstly, the transport logistics and costs of whole or shredded tyres, and secondly the cost of shredding.

Initially, it was hoped that we would mobilise a Diamond-Z shredder and conduct a large scale, on-site trial, however, the mobilisation and shredding cost was prohibitive given our research budget. Another site issue that became apparent was the need for access by shredders to a water source for cooling cutting surfaces. Thus, if the tyres were not stockpiled near a water source, a water truck would present an additional cost to the process. Additionally, earthworks would be needed to bund an area for the retention and reuse of cooling water. Preliminary investigation of on-site shredding suggests that mobilisation costs (of the shredder, conveyor, loader, shears and escort vehicles, 700 kilometres) of approximately $5000 would apply. This fee is additional to shredding and transport costs. Similarly, correspondence with transport contractors revealed problems associated with transport of shredded tyres. The need for a truck to be on stand-by while tyres are shredded (stockpiling shred on the ground could result in contamination unacceptable to the cement kiln) and special handling requirements (walking platform, or tipping truck, excavators etc) would likely offset the transport cost saving from the resultant decreased volume. It was then decided to transport a small sample of whole large tyres to the two shredders capable of handling them. The first shredder is operated by Northern Tyre Salvage (NTS) in Townsville and the second by Blink's Chop and Chip (BC&C) in Brisbane. The two shredders are very different in that the custom-built plant of NTS shreds at very low RPM but relies on very high torque, while the Diamond-Z tub grinder of BC&C uses high revolution cutting blades. The Diamond-Z shredder would consume approximately 30 litres of diesel/tyre while the custom built model consumes approximately 10 litres/tyre. The tyres that were transported to Blink's Chop and Chip were never shredded. This was probably due to the shredder being tied up with core work of shredding urban refuse and forest waste and highlights the limited capacity for this contractor to currently process the volume of tyres generated on mine sites.

Whole tyre transport costs were calculated and are presented in Table 6.2.1 along with the cost, advantages and disadvantages of whole tyre transport for shredding and use as TDF option. It was found that OTR tyres had to be quartered before shredding, using excavator-mounted hydraulic shears (similar to those used in the Ok Tedi trial), which added about $60/tyre to the original shredding cost estimates. The cost estimates presented here are conservative in that they are *exclusive* of any transport/handling costs of shred to a kiln or of any likely charged applied by the kiln operator to receive the 'waste'.

Table 6.2.1. Summary of the shredding (TDF) option

COST / TYRE	≅$370+* ($0.24/tyre/km transport + ≅$150-250/tyre shredding)
ADVANTAGES	More preferred option under QEPA's waste management hierarchy
	Recovers energy embedded in waste
DISADVANTAGES	Intensive energy usage (diesel) to shred and transport OTR tyres may offset benefit of energy recovery
	High cost

*Based on 700km whole tyre transport, e*xclusive* of shred transport and disposal costs charged by QCL which are unclear.

Figure 6.2.1 Quartered OTR tyre handling at Northern Tyre Salvage **(photo Matt Corbett)**

Figure 6.2.2 Feeding tyre sections into the shredder (NTS) **(photo Matt Corbett)**

Figure 6.2.3 2300 RPM are reduced to 2 RPM through a series of gearboxes, producing high torque for shredding (NTS) **(photo Matt Corbett)**

Figure 6.2.4 Shredded OTR tyres (NTS) **(photo Matt Corbett)**

Figure 6.2.5 Northern Tyre Salvages' mobile custom shredder **(photo Matt Corbett)**

6.3 On-site storage and burial (sectioned)

Given the health risks outlined in section 3.4, it is desirable that stockpiling of tyres on-site be minimised. However, some stockpiling will be unavoidable, whether it is while waiting for an appropriate landfill destination on-site or for processing and/or transportation off-site. In order that stored tyres not retain water and to facilitate handling and disposal into landfill cells, a trial was conducted to assess the practicality and cost of storage and burial of sectioned tyres.

A scrap metal contractor used 'hydraulic jaws' fitted to a PC300 excavator to cut tyres (up to 3metres diameter) into 300-400mm chunks that were subsequently disposed of in landfill cells on-site. Table 6.3.1 outlines the cost, advantages and disadvantages of this option

Table 6.2.1. Summary of the on-site sectioned storage and burial option

COST / TYRE	≅$175*
ADVANTAGES	Easily carried out on-site
	Relatively low-cost
	Reduced health risks of stockpile
DISADVANTAGES	Least preferred option in waste management hierarchy = disposal

- ≅$145 cutting cost, ≅$30 disposal cost (transport/labour, adjusted for Australian labour rate)

Figure 6.2.1 Hydraulic shears sectioning tyres (photo Gary Moffat)

Figure 6.2.2 Sectioned tyres awaiting landfill (photo Gary Moffat)

6.4 On-site burial (whole)

The findings of stage 1 with respect to the (lack of) potential for buried tyres to contaminate or float in landfill and the uncertainty of scrap OTR policy direction led us to seek to quantify the cost of the status quo option. A trial was conducted to assess the practicality and cost of emplacement of tyres for burial on the floor of a disused pit.

Fifty tyres were stacked on a low-loader using a tyre handler and hauled approximately 5 kilometres for burial. The procedure took two personnel approximately six hours to complete. Burial depth was approximately 65 metres. Table 6.4.1 outlines the cost, advantages and disadvantages of this option.

Table 6.4.1 Summary of the on-site burial (whole) option

COST / TYRE	≅$30*
ADVANTAGES	Easily carried out on-site
	Lowest cost
	Quickly eliminates stockpiles
	Low energy input
	Tyres are unlikely to affect landform stability or pose a risk to ground water
DISADVANTAGES	Least preferred option in waste management hierarchy = disposal
	Tyres must still be stockpiled while awaiting burial.

- Includes labour and equipment operators

Figure 6.4.1 Whole tyres in disused pit floor **(photo Bernie Kirsch)**

Figure 6.4.2 Whole tyres in disused pit floor **(photo Bernie Kirsch)**

7.0 Recent policy development

As stated earlier, this project has largely coincided with the development by the QEPA of a strategy, and the formulation of policy, directing the management of scrap OTR tyres on mine sites. On-going dialogue with both the mining industry and the QEPA ensured that the outcomes of this research project were given due consideration in the policy development process. Thus, this project represents an example of research acting as an interface between industry and its regulators, and of providing a sound factual basis on which to make policy decisions. Recent developments (post-stage one of this project) in policy relating to the disposal and storage of scrap OTR tyres at mine sites are summarised in this section.

7.1 The Scrap Tyre Task Force Strategy

In early 1999, in response to requests from many sectors of the Queensland tyre industry (including consumers, producers & distributors and recyclers), the QEPA formed the

Scrap Tyre Task Force (STTF) to produce a strategy to manage the waste tyre problem. While focussing on the tyre industry as a whole, the strategy does make the important separation between passenger and OTR tyres and does give special consideration to the management of the latter in remote locations.

While seeking to promote management of waste tyres according to the Waste Management Hierarchy, the strategy recognises the limitations posed by the nature of OTR tyres and the remoteness of many of the sites where they are stored. It does however tend to underestimate the component costs (diesel, transport and processing) of the waste-to-energy option. The key actions it recommended with respect to mine tyres can be summarised as;

- Develop standard operating criteria guiding the options for disposal of tyres at mine sites, in conjunction with the Queensland Mining Council;
- Undertake a cost/benefit analysis on the current reuse, recycling, waste-to-energy, and disposal options available for OTR tyres on mine sites;
- Investigate the use of a mobile shredder to process OTR tyres on-site;
- Explore markets for rubber recycled from OTR tyres;
- Encourage mining companies to seek return clauses in purchase agreements in line with the *Extended Producer Responsibility Principle* ; and
- Develop transport processes to centralised facilities for OTR tyres.

(Queensland Environmental Protection Agency, 1999)

Many of these actions have been completed by this project.

7.2 Draft operational policy EPREG.ERA 21

An outcome of both the STTF strategy and the ongoing dialogue between industry and the QEPA has been the formulation of a Draft Operational Policy (ERA21) under the *Environmental Protection Regulation 1998, Schedule 1*, directing the disposal and storage of scrap tyres at mine sites (Queensland Environmental Protection Agency, 2000). The draft policy determines that;

For new applications, licence conditions for scrap tyre management on mine sites should adhere to the following principles in decreasing order of effort and acceptability:

- *Avoidance*. When negotiating purchase agreements with new tyre suppliers, seek take-back clauses to maximise freight backloading opportunities.
- *Recycling*. Explore opportunities to recycle scrap tyres on-site and locally through use in impact absorbing surfaces, bitumen and road construction, farm and agricultural use, and civil engineering applications.
- *Waste-to-Energy*. Utilise existing opportunities in Queensland to recover embedded energy through waste-to-energy options.
- *Disposal*.

(a) Tyres stored waiting disposal should be stockpiled in volumes less than 3m in height and $200m^2$ in area. Additional fire precautions should be taken including removal of grass and other materials within a 10m radius of the scrap tyre store. Side-walls should be removed to prevent water retention and mosquito breeding.

(b) Scrap tyres disposed of in underground stopes is acceptable provided this practice does not constitute a fire hazard or compromise mine safety.

(c) Scrap tyres disposed of in spoil emplacements is acceptable provided the tyres are not placed on the pit floor but still placed as deep in the spoil as possible. This practice will ensure scrap tyres are not placed in saturated aquifers while not compromising the stability of the consolidated landform.

(d) Disposing of scrap tyres on mine sites may be regarded as a notifiable activity under Schedule 3 of the Environmental Protection Act and the locations of the disposal sites need to be recorded on the Environmental Management Register.

Perhaps the most important implication of this draft policy to the consideration of management options, is the indication that, while a non-preferred option, on-site burial will be allowable under the *Environmental Protection Regulation 1998*.

8.0 Conclusions

While this project set out with the aim of identifying opportunities to 'reduce, reuse, recycle', it has been shown that this philosophy is extremely difficult to apply efficiently in relation to OTR tyres on remote mine sites. This conclusion is not arrived at lightly and has evolved over the life of the project though a number of realisations. Firstly, realisation of the relatively benign nature of tyres in landfill. Secondly at the lack of technology to recycle OTR tyres and the high energy input and cost required to process and transport them for waste-to-energy and finally, recent legislative developments indicating that the disposal option is acceptable, albeit non-preferable. Our findings do concur with the QEPA in that, while potentially the highest consumer cost option, the *Extended Producer Responsibility Principle* should be implemented. This would result in the greatest likelihood that scrap OTR management would move up the waste management hierarchy in that tyre manufacturers are the sector of the industry most likely to have the infrastructure, knowledge and economic incentives to develop recycling options. Failing the successful instigation of this process, the most appropriate scrap OTR management option will be site specific and depend largely on the proximity of the site to facilities that can process and utilise the waste. For remote sites, whole tyre on-site burial at depth according to the relevant policy directions is currently the next best option. A significant step forward has been made in that previously, uncertainty of the legislative and environmental issues associated with scrap OTR tyres meant that the worst option, that is perpetual above ground stockpiling, was invariably adopted.

BIBLIOGRAPHY

Anon. (1997) Burning Rubber. *Choice* Feb 1997.

Anon (1998) Total Tyre Control BHP Coal tyre loss report. Klinge & Co Pty Ltd. Brisbane, Queensland.

Baglioni A, De-Angelis S, Bernasconi M & Prandoni F (1994) The scrap tire[27] as a building material. In: *Sustainable construction: Proceedings of the First International Conference of Sustainable Construction*, Tampa, Florida 1994.

Blumenthal M (1997a) Scrap Tire Market Analysis. *Biocycle* V38 N2 pp70-72

Blumenthal M (1997b) Growing markets for scrap tires. *Biocycle* V38 N10 pp 53-55.

Bridgestone (1996) Technical Data. Off-The-Road-Tyres. Bridgestone Corporation Off-The-Road tire sales department. Tokyo, Japan.

Brewer J (1997) OTR Tires...Scrap Tires' Market Niche: Presentation at the ITRA World Tire Conference Program. Held April,1997, Kentucky USA.

Brodsky H (1998) Retreading provides monster savings for monster tires. American Tire Retread Information Bureau (TRIB) news release. www.arib.com.

Bruening J.C (1994) Tire equipment education. *Recycling Today*, June 1994.

Burnell B.N & McOmber G (1997) Used Tires as a Substitute for Drainfield Aggregate. In: M.S. Bedinger (Ed) *Site Characterization and Design of On-Site Septic Systems*. American Society for Testing and Materials.

Carter R (1996) When Rubber Tires Leave the Road. *Coal* March 1996.

Collins K.J, Jensen A.C & Albert S (1995) A review of waste tyre utilization in the marine environment. *Chemical Ecology* V10 No3-4, pp 205-216

Department of Environment (1997) Waste management legislation – public consultation document. Department of Environment, State of Queensland.

Duffy M (1996) Waste Tyre Solutions. In*: Waste Tyre Conference '96. The Full Cycle of Responsibility*. Held in Brisbane June 1996.

Dorer R.E (1978) Mosquitoes, Fish and Old Tires. *Mosquito News* 38(3) pp418-420.

Doss G.J, Elfving D.C, Lisk D.J (1995) Zinc in foliage downwind from a tire-burning power plant. *Chemosphere* 31:3 pp2901-3

Edil T.B (1989) Waste Characterization or Tire Chips. Letter to Mr. Niemi, University of Wisconsin-Madison dept. of Civil and Environmental Engineering.

[27] tire is the American spelling.

Farrel M (1996) Good year for tire recovery. *Biocycle* V37 N3 pp35-37.

Getz N & Teachey M.F (1992) Options in scrap tire management. *Waste Age*, October 1992.

Glazebrook C (1996) Tyre disposal technologies - Tyre Pyrolysis. In: *Waste Tyre Conference '96. The Full Cycle of Responsibility*. Held in Brisbane June 1996.

Klingensmith B (1991) Recycling, production and use of reprocesses rubbers. *Rubber World* 203/6 pp 16-21

Klingensmith B & Baranwal K (1998) Recycling of rubber: An Overveiw. *Rubber World* June 1998. pp41-46

Lemieux P.M & Ryan J.V (1993) Characterization of air pollutants emmitted from a simulated scrap tire fire. *Air and Waste* V43 August 1993 pp1106-1115.

Levitzke V (1996) Waste tyre management in South Australia. In: *Waste Tyre Conference '96. The Full Cycle of Responsibility*. Held in Brisbane June 1996.

Macgregor D.T & Provencher Y (1993) *Recycling used truck tyres into road building mats*. Field note: Roads and Bridges Forest Engineering Research Institute of Canada No.33, 2pp.

Masterton W.L & Slowinski E.J (1977) *Chemical Principals, 4th ed*. W.B Saunders Co. Philadelphia. pp612-616.

Mead E, McCash R & Shawn R (1997) Innovative leachate management: options and answers. *Waste Age*. V28 may pp258-60.

Meng X, Hua Z & Dermatas D (1998) Immobilization of mercury (II) in contaminated soil with used tire rubber. *Journal of Hazardous Materials*. V57 Jan. pp231-241.

Mills S (1993) Recycling of Tyres to Start in Ernest. *Engineers Australia* 22 January 1993.

Palmer G (1996) Scrap Tyres: Energy recovery in cement kilns. In: *Waste Tyre Conference '96. The Full Cycle of Responsibility*. Held in Brisbane June 1996.

Park L.K, Holsen T.M, Bontoux L, Jenkins D and Selleck R.E. (1989) *Permeation of Plastic Pipe by Organic Chemicals*. Univ. of California, Berkeley, Sanitary Engineering and Environmental Health Research Laboratory, Report No. 89-1.

Park J.K, Kim J.Y, Madsen C.D and Edil T.B (1997) Retardation of volatile organic compound movement by a soil-bentonite slurry cutoff wall amended with ground tires. *Water Environmental Research* V69 N5 Jul-Aug pp 1022-1031.

Powell J (1997) Signs of a maturing industry: the recent growth in scrap tire recovery. *Resource Recovery* March 1997 pp18-27.

Queensland Environmental Protection Agency (2000) Operational Policy (ERA21), *Environmental Protection Regulation 1998, Schedule 1.* Draft for comment. April, 2000

Queensland Environmental Protection Agency (1999) A strategy for managing waste tyres in Queensland - DRAFT. Produced by the Scrap Tyre Task Force, October 1999.

Riggle D (1995) A finer grind for rubber recyclers. *BioCycle* 36(3) pp42-54

Roweley A.G, Husband F.M & Cunningham A.B (1984) Mechanisms of metal absorption from aqueous solutions by waste tire rubber. *Water Research* 18(8) pp981-984.

Sive A (1996) Tyre shredding as a tyre disposal technology. In: *Waste Tyre Conference '96. The Full Cycle of Responsibility*. Held in Brisbane June 1996.

Smith F.G, Daniels E.J & Teotia A.P.S (1995) Testing and evaluating commercial applications of new surface treated rubber technology utilizing waste tires. *Resources, Conservation and Recycling*. V15 N2 Nov. pp133-144.

U.S EPA (1990) *Characterization of municipal solid waste in the United States*: 1990 update report No EPA/530-SW-042, 103pp.

U.S EPA (1995) *Profile of the Rubber and Plastics Industry*. EPA Office of Compliance Sector Notebook Project. Office of Compliance, Washington DC.

Webb M (1996) Health and environmental risks associated with open stockpiling of tyres. In: *Waste Tyre Conference '96. The Full Cycle of Responsibility*. Held in Brisbane June 1996.

Vickers O (1996) Health and safety issues- the fire service perspective. In: *Waste Tyre Conference '96. The Full Cycle of Responsibility*. Held in Brisbane June 1996

Appendix 1: List of the major chemicals used in rubber compounding (US EPA, 1995)

- Processing Aids - zinc compounds
- Accelerators - zinc compounds
- Activators - nickel compounds, hydroquinone, phenol, alphanaphthylamine and p-phenylenediamine
- Age restorers - selenium compounds, zinc compounds and lead compounds
- Initiator - benzoyl peroxide
- Accelerator Activators - zinc compounds, lead compounds and ammonia
- Plasticizers - dibutyl phthalate, dioctylphthalate and bis(2-ethylhexyladipate)
- Miscellaneous ingredients - including titanium dioxide, cadmium compounds, organic dyes, sulphur compounds and antimony compounds.

Also, as part of the rubber component of tyres (natural or synthetic) a tyre contains high proportions of carbon and oil. In addition to the rubber, a tyre contains steel (approx. 12% but up to 22%) and nylon (approx. 3%) depending on the type of tyre (Blumenthal, 1997a).

Appendix 2: Applications of Recycled Crumb Rubber (from Sive, 1996)

Road and Rail

- Acoustic barriers
- Portable traffic control devices
- Rail crossings, sleeper and buffers
- Ripple strips and speed bumps
- Roadside safety railings

Construction and Industrial

- Adhesive sealants
- Anti-static computer mats
- Carpet underlay
- Plastic Compounds
- Compression moulding compounds
- Conveyor belts
- Flexible foam
- Foundation material
- Industrial flooring and paths
- Membrane protection
- Mounting pads and shock absorber
- Playground surfacing
- Pond liners
- Recycling bins
- Rollers
- Runways
- Shoe soles

Appendix 2: Applications of Recycled Crumb Rubber (from Sive, 1996) (continued...)

- Solid tyres
- Spray-proofing, insulation and waterproofing

Automotive

- Adhesive and anti-corrosive sealants
- Brake and clutch linings
- Bumpers
- Door and window seals
- Filler in new tyre manufacture
- floor mats, mud flaps and protection strips
- Gaskets
- Tray liners
- Sprayable sealant
- Tyre retreads

Marine

- Anti-fouling and anti-corrosive paints
- Floating docks
- Non-slip flooring
- Wharf fender strips

Sporting

- Equestrian surfaces
- Impact absorbing flooring

Appendix 2: Applications of Recycled Crumb Rubber (from Sive, 1996) (continued...)

- Athletic tracks surface
- Tennis court surfaces

Rural and landscaping

- Agricultural pipes and drains
- Animal bedding
- Irrigation hose
- Fencing
- sprayable wear linings in silos and tanks

Bulk Products and Mining

- Erosion control mats
- Filter for landfill leachate ponds
- Wet weather road mats
- Perma-mulches
- Oil spill absorbent.

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APPENDIX B

BMC PRO-0333 SCRAPPED TYRE IN PIT DUMPING

1. PURPOSE

To outline the process for disposing scrapped tyres at Bengalla Mine.

2. ACTIONS

The Short-term Planning Superintendent identifies a suitable disposal location for scrapped tyres in-pit including laydown areas for offloading according to:

- Geotechnical considerations:
  - Scrapped tyres shall be placed at the toe of the existing low wall (pit floor) or at the toe of the preceding dump.
  - Scrapped tyres are not to be buried under a high-risk dump (>30m tip height off a highwall) or into water.
  - Scrapped tyres are not to be buried within 10 metres (or 2 lifts) to where the dragline will disturb the scrapped tyres or an area of intended rehandle.
  - Scrapped tyres buried on pit floor shall be emplaced south of block 20.
- Spontaneous combustion / Acid Rock Drainage:
  - A capping depth of approximately 20 metres of inert overburden material shall be placed from the scrapped tyres to the rehabilitated surface.
  - Scrapped tyres are not to be buried within 10 metres (or 2 lifts) of reject material, carbonaceous material, dyke material or Wynn overburden material (Archerfield Sandstone).
  - Scrapped tyres are not to be buried within 10 metres (or 2 lifts) of any known spontaneous combustion or area showing evidence of heating.

Scrapped tyres are to be neatly stacked generally horizontally up to 3 tyres high and 3 rows deep per work instruction issued by Tyre Supervisor.

Where practicable scrapped tyres may also be used for road markers and other delineation purposes at Bengalla prior to disposal.

The Mine Surveyor marks (or similar) the selected tyre disposal area and provides suitable survey plans of the tyre disposal area.

The Tyre Supervisor records the number of scrapped tyres in each tyre disposal area and relevant details of the scrapped tyres.

3. ROLES AND RESPONSIBILITIES

Role	Responsibility
The tyre supervisor	Tracks heavy earthmoving tyres purchased by Bengalla Mining Company Pty Ltd (BMC). Tracking of tyres involves recording the serial number of the purchased tyre, equipment allocation code of that tyre, purchase date of that tyre, final disposal date for that tyre.
Short Term Planning Superintendent	Identifies a suitable disposal location for scrapped tyres in-pit

4. REFERENCES

Reference
Work Health and Safety Act 2011
Work Health and Safety Regulation 2011
Work Health and Safety (Mines and Petroleum Sites) Act 2013
Work Health and Safety (Mines and Petroleum Sites) Regulation 2014
Protection of the Environment Operations Act 1997
Protection of the Environment Operations (General) Regulation 2009
Protection of the Environment Operations (Waste) Regulation 2014
Environmental Planning and Assessment Act 1979
Environmental Planning and Assessment Regulation 2000
Mining Act 1992

5. DEFINITIONS

Term	Definition
N/A	

6. DOCUMENT CONTROL AND REVISION STATUS

Version	Revision Update	Date
8	-	18/06/21