TARRAWONGA COAL MINE - WASTE TYRE DISPOSAL

MODIFICATION REPORT

FEBRUARY 2021

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1 INTRODUCTION

This Modification Report has been prepared for Tarrawonga Coal Pty Ltd (TCPL) for the Tarrawonga Coal Mine (TCM) Waste Tyre Disposal Modification (the Modification).

1.1 OVERVIEW OF THE APPROVED TARRAWONGA COAL MINE

The TCM is an open cut coal mining operation located approximately 42 kilometres (km) north-northwest of Gunnedah in New South Wales (NSW) (Figure 1).

The TCM is an open cut coal mine which has been in operation since 2006. Run-of-mine (ROM) coal is crushed and screened on-site, and the sized ROM coal is loaded onto on-highway trucks for transport via the Approved ROM Coal Transport Route to the Whitehaven Coal Handling and Preparation Plant (CHPP).

The TCM is owned and operated by TCPL, a wholly owned subsidiary of Whitehaven Coal Limited (Whitehaven).

1.2 APPROVALS HISTORY

Project Approval (PA) 11_0047 (as modified) for the TCM was issued by the NSW Planning Assessment Commission under delegation of the NSW Minister for Planning and Infrastructure pursuant to section 75J of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) in 2013.

The TCM was also granted approval under the *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act) in 2013 (EPBC Act approval 2011/5923).

PA 11_0047 has been modified on eight separate occasions, with the most recent being the Whitehaven Temporary Water Haulage Modification which was approved in June 2020, and allowed for temporary trucking of water sourced via contingency use of an existing bore and associated infrastructure at the Vickery Coal Mine.

TCPL submitted the TCM Life of Mine Modification in May 2020 which proposed a ROM Coal production rate increase, relocation of the ROM coal stockpile and associated infrastructure, and reduction to the open cut extent, amongst other minor modifications. The TCM Life of Mine Modification was at the assessment phase at the time of writing this document.

1.3 OVERVIEW OF THE MODIFICATION

1.3.1 Background

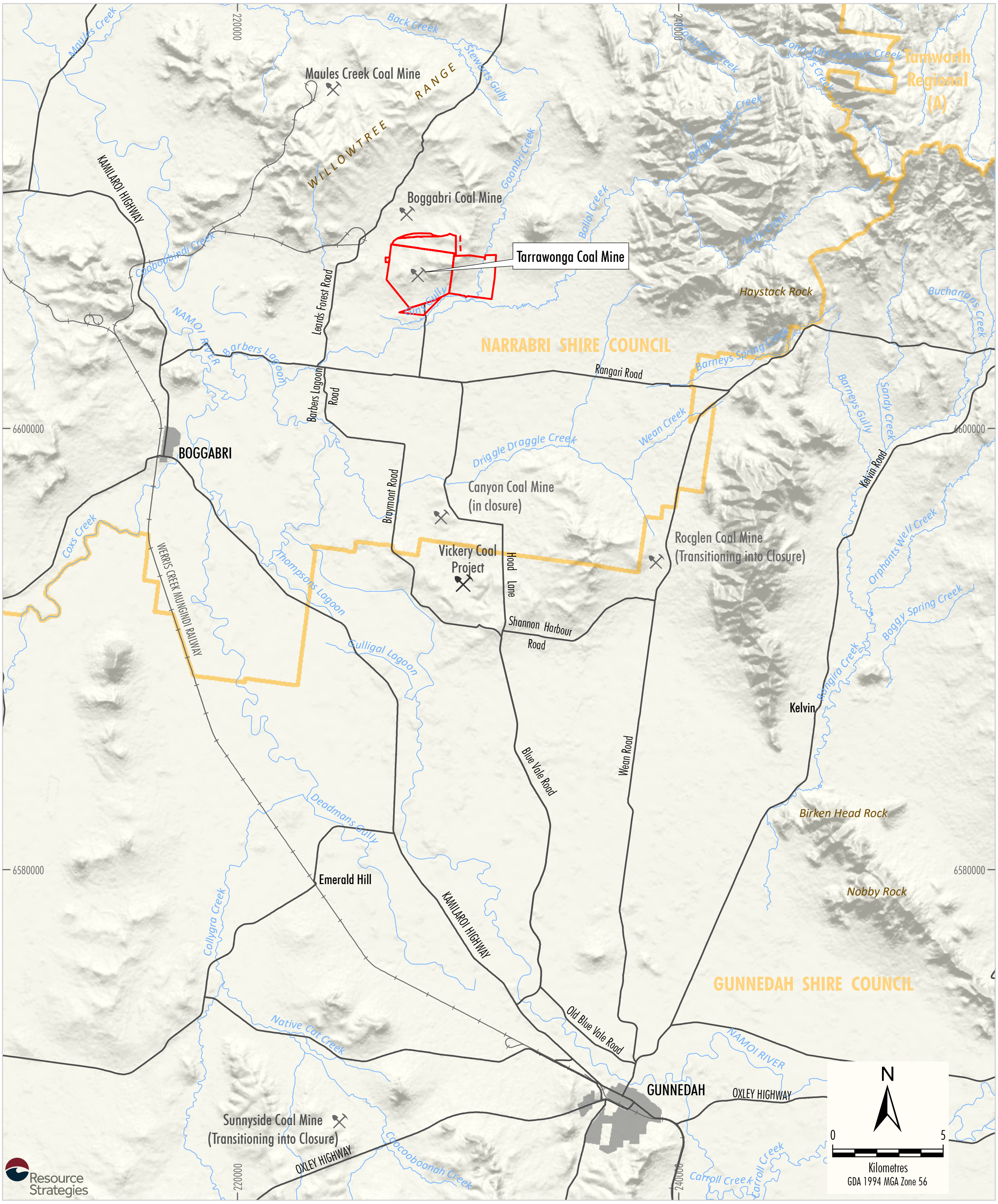
Consistent with the description of waste management within the *Tarrawonga Coal Project Environment Assessment* (TCPL, 2012), used heavy vehicle tyres are proposed to be disposed of in the emplacement areas. Used tyres from mining equipment would continue to be stockpiled on-site prior to disposal within emplacement areas.

It is estimated up to approximately 350 tonnes of waste heavy vehicle tyres from mining equipment would be stockpiled per year of operation and require disposal within overburden emplacements.

Waste tyres which have been stockpiled since the commencement of operations at the TCM would also be required to be disposed within overburden emplacements. Disposal of these tyres would be staggered for the remainder of the mine life to optimise disposal locations and volumes.

A range of measures are implemented at the TCM for the purpose of extending the operational lifespan of mining equipment tyres and minimising disposal rates. These measures include road design, mining equipment speed limits, regular tyre inspection and maintenance, repair of tyres as far as reasonably practicable without impacting safe operation of equipment and consideration of other beneficial use on-site, where practical (e.g. re-use as bunding, for intersection construction etc.).

This Modification Report has been prepared to describe the disposal methodology and environmental management to be applied to the disposal of heavy mining equipment waste tyres.



LEGEND
- Mining Tenement Boundary (ML, CL and AUTH)
- Mining Lease Application Boundary (MLA 1)
- Major Roads
- Railway
- Local Government Boundary

Source: LPMA - Topographic Base (2010); NSW Department of Industry (2018)

WHITEHAVEN COAL

TARRAWONGA COAL MINE

Regional Location

Figure 1

1.3.2 Modification Summary

TCPL is seeking a modification of the TCM Project Approval (PA 11_0047) via section 4.55(1A) of the EP&A Act for the disposal of waste heavy vehicle tyres in the emplacement areas.

TCPL considers that disposal of waste tyres in the emplacement areas would be of minimal environmental impact. Furthermore, TCPL considers that PA 11_0047 as modified would remain substantially the same development as was last modified.

1.4 ASSESSMENT PATHWAY

Environmental Planning and Assessment Act, 1979

TCM was declared to be State Significant Development (SSD) for the purposes of the EP&A Act on 17 August 2018. As such, approval for the proposed Modification has been sought under section 4.55(1A) of the EP&A Act as it is substantially the same development to the existing operations for which consent was originally granted for TCM (PA 11_0047, as modified).

The consent authority is, therefore, required to satisfy itself that any consent as modified would result in the approved TCM remaining substantially the same development approved by the Whitehaven Temporary Water Haulage Modification (being the most recent modification under section 75W of the EP&A Act).

A comparative analysis is provided in Table 1 that outlines the key elements of the approved TCM (as modified) as a basis for comparison against the Modification, including the key environmental assessment outcomes.

Consideration of the key comparatives detailed in the draft guideline *Modifying an Approved Project* (NSW Government, 2017) when considering whether the proposed Modification could be considered to be “substantially the same” is provided in Table 1.

The TCM has demonstrably remained an open cut coal mining operation with only minor changes (such as the rejects disposal, ROM coal haulage and temporary road and water haulage) approved under PA 11_0047 (as modified).

Table 1
Summary Evaluation for “Substantially the Same” Test

Key Comparatives	Tarrawonga Coal Mine (as modified)	Waste Tyre Disposal Modification
Development size, scale and footprint	Conventional open cut mining operation including coal and gravel crushing, screening and loadout infrastructure.	No change.
Intensity including rates of production	3 Mtpa ROM coal.	No change.
Primary, secondary and ancillary use	On-site water management system comprises water management storages and collection drains, runoff diversions, sediment control and open cut dewatering. Existing Mine Facilities Area (comprising a crib hut, offices, hardstand, first aid building, maintenance workshop, toilets, wash bay and light vehicle parking area). Haulage of ROM coal and coal rejects along the Approved Road Transport Route.	No change.
Project life and hours of operation	Project Approval to December 2030. Operating hours are 24 hours per day, seven days per week. ROM coal dispatch hours: ■ 6.00 am to 9.15 pm Monday to Friday; and ■ 7.00 am to 5.15 pm Saturday.	No change.
Extent, duration and severity of impacts	As described in previous environmental assessments and as authorised by PA 11_0047.	No material change.

Based on the information contained in this report the consent authority can be satisfied that the TCM incorporating the Modification would remain "substantially the same" as the development approved by the Whitehaven Temporary Water Haulage Modification.

Furthermore, this Modification Report includes a Statement of Environmental Effects in accordance with clause 115(1)(e) of the NSW *Environmental Planning and Assessment Regulation 2000*. The assessment contained herein concludes that the Modification is of "minimal environmental impact", given that the disposal of waste heavy vehicle tyres would result in only minor impacts due to the change in land use and no additional land disturbance or amenity impacts.

No additional land is required to be included within the PA 11_0047 boundary.

State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007

State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (Mining SEPP) and its relevance to the Modification are described in detail in Attachment 1.

State Environmental Planning Policy No 55 – Remediation of Land

State Environmental Planning Policy No 55 – Remediation of Land (SEPP 55) provides for the management of potential land contamination impacts resulting from a change in land use. As the disposal of waste tyres is limited to previously approved emplacement areas, no significant change in land use would occur.

In addition, no sites are listed in the EPA's Contaminated Land Register within the Modification area. Therefore, SEPP 55 is not considered further for the Modification.

1.5 CONSULTATION FOR THE MODIFICATION

TCPL regularly consults with relevant Government agencies regarding operation of the TCM, including the NSW Environment Protection Authority (EPA). Relevant to disposal of end-of-life mining equipment tyres within the overburden emplacements, correspondence from the EPA (dated October 2019) detailed requirements that would need to be addressed in an environmental assessment. These requirements, and where they are addressed in this EA, are summarised in Table 2.

TCPL also consults with relevant stakeholders (including relevant landholders) regarding activities at and associated with the TCM on an ongoing basis.

Table 2
EPA Waste Tyre Disposal Environment Assessment Requirements

EPA Environmental Assessment Requirement	Section where Addressed
1. *A copy of any environmental impact assessment and planning approval that relates in-pit mine tyre disposal at Tarrawonga Coal Mine.* *If this cannot be supplied, please provide an environmental impact assessment for the activity that includes but is not necessarily limited to:*	This Modification Report
a. the types of tyres to be disposed of onsite;	Sections 2.3 and 2.4
b. proposed locations for disposal of tyres;	
c. the method of disposal;	
d. any and all long-term effects that the disposal will have on mine rehabilitation;	
e. how disposal locations will be monitored; and	
f. how tyres will be tracked and recorded.	
2. *An accurate estimate of the volume of tyres that would be disposed of on-site over the life of the mine.*	Section 2.2
3. *Consideration of alternate option s for disposal including recycling, and justification as to why onsite disposal is the preferred option*	Section 2.1

TCPL has advised the TCM Community Consultative Committee (CCC) of its intent to modify the Project Approval PA 11_0047 to allow disposal of waste tyres in emplacement areas. Further detail of the Modification will be provided at the upcoming CCC meeting in Q2 2021.

1.6 MODIFICATION REPORT CONTENT

The DPIE has recently launched a new SSD website[1], which contains requirements for modification reports. Accordingly, this Modification Report includes:

- a short description of the approved SSD project and the reasons why the Modification is required (Sections 1.1 and 1.2);
- a description of the proposed Modification (Section 1.3);
- an explanation of the relevant strategic and statutory context (Section 1.4 and Attachment 1);
- a description of the findings of any community engagement (Section 1.5);
- an assessment of the relevant impacts of the Modification (Section 2); and
- an evaluation of the merits of the Modification (Section 3).

[1] URL: https://www.planningportal.nsw.gov.au/major-projects/assessment/state-significant-development/modifications. Accessed February 2021.

2 ENVIRONMENTAL REVIEW

2.1 FEASIBILITY OF WASTE TYRE RECYCLING

The following notes regarding the limited feasibility and viability of recycling waste heavy vehicle tyres have been primarily sourced from material included in Appendix A (ACARP, 2000; Department of Environment and Science; 2014; Tyre Stewardship Australia, 2020):

- On-site disposal of heavy vehicle waste tyres is wide-spread across Australia, including within both mining and agricultural industries.
- Disposal of heavy vehicle tyres in spoil emplacements is acceptable, provided the tyres are placed as deep as possible but not directly on the pit or emplacement floor. Placement should ensure waste tyres do not impede saturated aquifers and do not compromise the stability of the consolidated final landform.
- Currently available recycling technology is predominantly focused around passenger tyres (i.e. not heavy vehicle tyres).
- Recycling facilities do not exist proximal to the TCM and transport of waste heavy vehicle tyres to these facilities is not viable. These recycling facilities are also generally designed on a local council scale for passenger tyres and thus capacity is an issue.
- The perception that whole tyres disposed in landfill "float" upward and may surface overtime is not supported by experimental evidence and is considered unlikely due to the weight and rigidity of heavy vehicle tyres, as well as the depth of disposal.

On this basis, recycling of waste heavy vehicle tyres is not considered to be feasible or viable for the TCM and therefore on-site disposal is the preferred management strategy for this waste stream. TCPL would continue to investigate feasible and reasonable opportunities for recycling waste heavy vehicle tyres from the TCM at a regional location is options become available during the remainder of the mine life.

2.2 VOLUME OF TYRES TO BE DISPOSED

It is estimated up to approximately 350 tonnes of waste heavy vehicle tyres from mining equipment would be stockpiled per year of operation and require disposal within overburden emplacements.

Waste tyres which have been stockpiled since the commencement of operations at the TCM would also be required to be disposed within overburden emplacements. Disposal of these tyres would be staggered for the remainder of the mine life to optimise disposal locations and volumes.

A range of measures are implemented at the TCM for the purpose of extending the operational lifespan of mining equipment tyres and minimising disposal rates. These measures include road design, mining equipment speed limits, regular tyre inspection and maintenance, repair of tyres as far as reasonably practicable without impacting safe operation of equipment and consideration of other beneficial use on-site, where practical (e.g. re-use as bunding, for intersection construction etc.).

2.3 ON-SITE DISPOSAL METHODOLOGY

Scope

TCM will maintain a comprehensive inventory of all waste heavy vehicle tyres buried on-site as well as dump locations within the overburden emplacements. Prior to the selection of an appropriate disposal area for the waste heavy vehicle tyres, TCPL will undertake a preliminary Environmental Risk Assessment which would consider the potential for unacceptable risk of soil; sediment; groundwater or surface water contamination, as well as proximity to coal rejects and potentially acid-forming (PAF) material.

Proposed Methodology

Disposal of waste heavy vehicle tyres will include stockpiling and transport to identified disposal locations within the overburden emplacement areas, as determined by mine progression. The disposal methodology will generally include the following:

- operational personnel will initiate tyre disposal once a stockpile has accumulated that warrants a feasible disposal event;
- completion of a pre-task risk assessment for each waste tyre disposal event, to consider both the location and manner in which the tyres will be disposed, as well as required monitoring;
- relocation of the tyres will be undertaken generally consistent with Whitehaven's internal Mine Tyre Disposal Environmental Procedure (provided in Appendix B for reference);
- tyres will be placed as deep into the overburden emplacement area as is reasonably practical, with a minimum of 20 metres of material to be dumped over all tyre disposal areas;
- tyres will not be disposed of in areas with potential to impede saturated aquifers, compromise the stability of the consolidated final landform or have any long-term effects on rehabilitation;
- tyre dumps will be located more than 15 metres from any coal rejects or PAF material emplacement areas to minimise the potential for spontaneous combustion.

The pre-task risk assessment must consider the following:

- fire hazards and their management;
- safety hazards and their management;
- potential for saturated/perched aquifers to be disturbed or impeded;
- required depth to prevent uprising and ensure stability of the final consolidated landform; and
- proximity to coal rejects, PAF and depth of cover.

Whitehaven's internal Mine Tyre Disposal Environmental Procedure (Appendix B) provides further detail on proposed used heavy vehicle tyre storage and disposal methods, and will be reviewed periodically and amended as required. The method of disposal described in the Procedure includes the loading of waste tyres at the designated storage location onto a flat-bed type truck or equivalent piece of heavy equipment suitable for transporting large heavy equipment tyres, for transportation to and unloading at the final disposal location.

Stockpiling of tyres at the allocated disposal area may be required prior to final coverage and burial.

TCPL will maintain a register documenting all waste tyre disposal. Key information to be included in the register will include:

- serial number;
- type/make and quantity;
- disposal date;
- surveyed co-ordinates of the disposal site area (Eastings, Northings, RL), and
- summary description of the disposal area.

At the completion of each disposal event, the register will be updated by the relevant operational personnel. Waste tyre disposal information would also be reported in the TCM Annual Reviews in accordance with Condition 4, Schedule 5 of the PA 11_0047 and can be reported to the EPA upon request.

2.4 MONITORING

TCPL will monitor on-site stockpiling of waste tyres to identify when a disposal event is required.

Monitoring of disposed waste tyres will assess the final shaped grade and stability of the landform over the disposed waste tyre area prior to topsoil placement to ensure no up-rising of waste tyres has occurred, and that at least 20 metres of emplacement material is over the disposed waste tyre area.

Monitoring of disposed waste tyres will also be undertaken as a component of rehabilitation monitoring, consistent with a Mining Operations Plan (MOP) and other applicable site management plans. The monitoring program includes assessing the final shaped and rehabilitated landform including aspects such as slope stability, erosion and vegetation establishment. Actions in relation to remediation of the rehabilitated landform, if required, are implemented as per controls specified in the MOP.

An existing groundwater quality monitoring program is undertaken in accordance with the TCM Water Management Plan and includes a suite of analytes which will assist in identifying any potential contamination from waste tyre disposal and prompt remediation actions.

3 CONCLUSION

The Modification application seeks approval for disposal of waste heavy vehicle tyres in the emplacement areas, which would be of minimal environmental impact.

Disposal of waste heavy vehicle tyres and associated monitoring would be undertaken in accordance with the methodology described above and in Whitehaven's Mine Tyre Disposal Environmental Procedure (Appendix B).

No additional land disturbance is required for the Modification. The Modification does not propose to change the mining operation or any components of the TCM itself, nor would it alter the Project operational workforce.

The TCM would remain substantially the same development as the development approved by the Whitehaven Temporary Water Haulage Modification (being the most recent modification under section 75W of the EP&A Act).

4 REFERENCES

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

Department of Environment and Science (2014) *Mining Operational Policy – Disposal and storage of scrap tyres at mine sites*.

NSW Government (2017) *Modifying an Approved Project*.

Tyre Stewardship Australia (2020) *Mining Industry – Off the Road Used Tyre Analysis*.

Tarrawonga Coal Pty Ltd (2012) *Tarrawonga Coal Project Environment Assessment.*

ATTACHMENT 1

STATUTORY CONTEXT – MINING SEPP

WATE TYRE DISPOSAL MODIFICATION

STATUTORY CONTEXT – MINING SEPP

Under s 4.55(3) of the *Environmental Planning and Assessment Act 1979* (EP&A Act), the consent authority is required to take into consideration:

1. such of the matters referred to in s 4.15(1) as are of relevance to the development the subject of a modification application under s 4.55(1A); and

2. the reasons given by the consent authority for the grant of the consent that is sought to be modified.

Section 4.15(1) states:

> (1) **Matters for consideration—general**
>
> In determining a development application, a consent authority is to take into consideration such of the following matters as are of relevance to the development the subject of the development application—
>
> (a) the provisions of—
>
> (i) any environmental planning instrument, and
>
> (ii) any proposed instrument that is or has been the subject of public consultation under this Act and that has been notified to the consent authority (unless the Planning Secretary has notified the consent authority that the making of the proposed instrument has been deferred indefinitely or has not been approved), and
>
> (iii) any development control plan, and
>
> (iiia) any planning agreement that has been entered into under section 7.4, or any draft planning agreement that a developer has offered to enter into under section 7.4, and
>
> (iv) the regulations (to the extent that they prescribe matters for the purposes of this paragraph),
>
> (v) (Repealed)
>
> that apply to the land to which the development application relates,
>
> (b) the likely impacts of that development, including environmental impacts on both the natural and built environments, and social and economic impacts in the locality,
>
> (c) the suitability of the site for the development,
>
> (d) any submissions made in accordance with this Act or the regulations,
>
> (e) the public interest.

The *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (**Mining SEPP**) is an environmental planning instrument relevant to the Tarrawonga Coal Mine (TCM) Waste Tyre Disposal Modification (the Modification).

The purpose of this document is to consider the Mining SEPP insofar as it is relevant to the Modification.

Aims of the Mining SEPP

Clause 2 of the Mining SEPP states:

> The aims of this Policy are, in recognition of the importance to New South Wales of mining, petroleum production and extractive industries—
>
> (a) to provide for the proper management and development of mineral, petroleum and extractive material resources for the purpose of promoting the social and economic welfare of the State, and
>
> (b) to facilitate the orderly and economic use and development of land containing mineral, petroleum and extractive material resources, and
>
> (b1) to promote the development of significant mineral resources, and
>
> (c) to establish appropriate planning controls to encourage ecologically sustainable development through the environmental assessment, and sustainable management, of development of mineral, petroleum and extractive material resources, and
>
> (d) to establish a gateway assessment process for certain mining and petroleum (oil and gas) development—
>
> (i) to recognise the importance of agricultural resources, and
> (ii) to ensure protection of strategic agricultural land and water resources, and
> (iii) to ensure a balanced use of land by potentially competing industries, and
> (iv) to provide for the sustainable growth of mining, petroleum and agricultural industries.

Until other feasible recovery options are available, the disposal of waste heavy vehicle tyres within emplacement areas would provide an economically efficient method to dispose waste tyres and allow for continued production and ongoing employment at the TCM.

As such, the Modification would facilitate or be consistent with the aims contained within cl 2(a), (b), (b1) and (c) of the Mining SEPP.

With respect to promoting the social and economic welfare of the State, it is emphasised that:

- Whitehaven is the single largest private sector employer in North West NSW.
- The TCM is a major source of regional employment and investment.
- There are approximately 210 employees and contractors at the TCM.

Part 3 of the Mining SEPP

Part 3 of the Mining SEPP contains numerous matters for consideration with respect to development applications for mining development. Some of these matters are also relevant to modification applications.

For the purpose of the Modification, clauses 12, 13, 14 and 17 within Part 3 are most relevant.

Clause 12 states:

> Before determining an application for consent for development for the purposes of mining, petroleum production or extractive industry, the consent authority must—
>
> (a) consider—
>
> > (i) the existing uses and approved uses of land in the vicinity of the development, and
> >
> > (ii) whether or not the development is likely to have a significant impact on the uses that, in the opinion of the consent authority having regard to land use trends, are likely to be the preferred uses of land in the vicinity of the development, and
> >
> > (iii) any ways in which the development may be incompatible with any of those existing, approved or likely preferred uses, and
>
> (b) evaluate and compare the respective public benefits of the development and the land uses referred to in paragraph (a) (i) and (ii), and
>
> (c) evaluate any measures proposed by the applicant to avoid or minimise any incompatibility, as referred to in paragraph (a) (iii).

The existing and approved land use in the vicinity of the TCM (i.e. the Modification area) is predominately the use of land for the purposes of mining. It is not expected that the likely preferred use of land in this area will materially change in the foreseeable future.

The disposal of waste heavy vehicle tyres within emplacement areas is not considered to have any significant impact on, or be incompatible with, this existing land use.

Further, the disposal of waste tyres would be undertaken in accordance with a prescribed methodology, including selection of an appropriate disposal area, to avoid or minimise any incompatibility with existing and likely preferred land uses at the TCM.

Clause 13 states:

> (1) This clause applies to an application for consent for development on land that is, immediately before the application is determined—
>
> > (a) in the vicinity of an existing mine, petroleum production facility or extractive industry, or
> >
> > (b) identified on a map (being a map that is approved and signed by the Minister and copies of which are deposited in the head office of the Department and publicly available on the Department's website) as being the location of State or regionally significant resources of minerals, petroleum or extractive materials, or
> >
> > Note. At the commencement of this Policy, no land was identified as referred to in paragraph (b).
> >
> > (c) identified by an environmental planning instrument as being the location of significant resources of minerals, petroleum or extractive materials.
> >
> > Note. Sydney Regional Environmental Plan No 9—Extractive Industry (No 2—1995) is an example of an environmental planning instrument that identifies land as containing significant deposits of extractive materials.
>
> (2) Before determining an application to which this clause applies, the consent authority must—
>
> > (a) consider—
> >
> > > (i) the existing uses and approved uses of land in the vicinity of the development, and

(ii) whether or not the development is likely to have a significant impact on current or future extraction or recovery of minerals, petroleum or extractive materials (including by limiting access to, or impeding assessment of, those resources), and

(iii) any ways in which the development may be incompatible with any of those existing or approved uses or that current or future extraction or recovery, and

(b) evaluate and compare the respective public benefits of the development and the uses, extraction and recovery referred to in paragraph (a) (i) and (ii), and

(c) evaluate any measures proposed by the applicant to avoid or minimise any incompatibility, as referred to in paragraph (a) (iii).

The disposal of waste tyres within emplacement areas is not considered to be incompatible with any current or future extraction or recovery of minerals.

The Modification will facilitate the continued current and future extraction of the valuable coal resource at the TCM and thereby contribute to the considerable public benefits delivered by the TCM.

Clause 14 states:

(1) Before granting consent for development for the purposes of mining, petroleum production or extractive industry, the consent authority must consider whether or not the consent should be issued subject to conditions aimed at ensuring that the development is undertaken in an environmentally responsible manner, including conditions to ensure the following—

(a) that impacts on significant water resources, including surface and groundwater resources, are avoided, or are minimised to the greatest extent practicable,

(b) that impacts on threatened species and biodiversity, are avoided, or are minimised to the greatest extent practicable,

(c) that greenhouse gas emissions are minimised to the greatest extent practicable.

(2) Without limiting subclause (1), in determining a development application for development for the purposes of mining, petroleum production or extractive industry, the consent authority must consider an assessment of the greenhouse gas emissions (including downstream emissions) of the development, and must do so having regard to any applicable State or national policies, programs or guidelines concerning greenhouse gas emissions.

(3) Without limiting subclause (1), in determining a development application for development for the purposes of mining, the consent authority must consider any certification by the Chief Executive of the Office of Environment and Heritage or the Director-General of the Department of Primary Industries that measures to mitigate or offset the biodiversity impact of the proposed development will be adequate.

With respect to clause 14(1), it is noted that the SSD Consent for the TCM already contains a suite of conditions aimed at ensuring that the TCM is undertaken in an environmentally responsible manner. In particular, the Modification is consistent with condition 60 of Schedule 3 of the SSD Consent, which requires TCPL to ensure that the waste generated by the Project is appropriately stored, handled and disposed of.

Further, the disposal of waste tyres will be undertaken in an environmentally responsible manner. For example:

1. Only tyres at the end of their operational lifespan would be disposed.
2. Waste tyre disposal would be undertaken in accordance with Whitehaven's internal Mine Tyre Disposal Environmental Procedure.
3. An Environmental Risk Assessment would be undertaken to identify potential soil, sediment, groundwater or surface water contamination risks, proximity to coal rejects and potentially acid-forming material, fire and safety hazards and required disposal depths for stability of the final landform.
4. TCPL would maintain a register of the number, type, and location of tyre disposal sites.
5. Monitoring of tyre disposal locations would be undertaken up until topsoil application on the landform, as well as a component of rehabilitation monitoring.

Clause 17 states:

(1) Before granting consent for development for the purposes of mining, petroleum production or extractive industry, the consent authority must consider whether or not the consent should be issued subject to conditions aimed at ensuring the rehabilitation of land that will be affected by the development.

(2) In particular, the consent authority must consider whether conditions of the consent should—

(a) require the preparation of a plan that identifies the proposed end use and landform of the land once rehabilitated, or

(b) require waste generated by the development or the rehabilitation to be dealt with appropriately, or

(c) require any soil contaminated as a result of the development to be remediated in accordance with relevant guidelines (including guidelines under clause 3 of Schedule 6 to the Act and the Contaminated Land Management Act 1997), or

(d) require steps to be taken to ensure that the state of the land, while being rehabilitated and at the completion of the rehabilitation, does not jeopardize public safety.

Disposal of waste tyres within the emplacement would not have any effect on planned rehabilitation of the final landform for the TCM.

As described above, the Environmental Risk Assessment and ongoing monitoring of disposal locations through emplacement construction and rehabilitation would ensure that disposal of waste tyres would not impact the proposed land use for the TCM final landform.

APPENDIX A

SUPPORTING INFORMATION ON WASTE TYRE DISPOSAL

Operational policy

Mining

Disposal and storage of scrap tyres at mine sites

Operational policies provide a framework for consistent application and interpretation of legislation by the Department of Environment and Science. Operational policies will not be applied inflexibly to all circumstances. Individual circumstances may require an alternative application of policy. This policy concerns mining activities as defined under s. 110 of the Environmental Protection Act 1994*.*

1 Policy issue

Best practice environmental management for scrap tyres generated by mining activities follows a waste management strategy according to the following hierarchy in decreasing order of preference and desirability: avoidance, recycling, waste-to-energy, and disposal. Adoption and implementation of this hierarchy reflects the economic cost of handling and transporting large mine tyres in Queensland and the considerable energy and material resource embedded in the tyres.

2 Determination

For new applications, environmental authority conditions for scrap tyre management on mine sites should adhere to the following waste management strategies in decreasing order of preference and desirability:[1]

2.1 Avoidance

When negotiating purchase agreements with new tyre suppliers, seek take-back clauses to maximise freight backloading opportunities.

2.2 Recycling

Explore opportunities to recycle scrap tyres on-site and locally through use in impact-absorbing surfaces, bitumen and road construction, pastoral and agricultural use, and civil engineering applications.

2.3 Waste-to-energy

Use existing opportunities in Queensland to recover the intrinsic energy value through waste-to-energy options.

2.4 Disposal

(a) Tyres stored awaiting disposal—or transport for take-back and, recycling, or waste-to-energy options – should be stockpiled in volumes less than 3m in height and 200 square metres in area. Additional fire precautions should be taken, including removal of grass and other materials within a 10m radius of the scrap tyre store. Tyres should be stored in a manner that prevents water retention and minimises mosquito breeding events. Options may include holing side-walls, covering with tarpaulins, spraying with a non-persistent insecticide, or reducing the stockpile during rain events.

[1] Information contained in the guideline 'Application requirements for activities with waste impacts' (available from www.qld.gov.au using ESR/2015/1836 as a search term) should also be considered.

(b) Disposing of scrap tyres in underground stopes is acceptable provided this practice does not cause an unacceptable fire risk or compromise mine safety.

(c) Disposing of scrap tyres in spoil emplacements is acceptable, provided tyres are placed as deep in the spoil as possible but not directly on the pit floor. Placement should ensure scrap tyres do not impede saturated aquifers and do not compromise the stability of the consolidated landform.

(d) Disposing of scrap tyres (and other wastes) on mine sites is a notifiable activity under Schedule 3 of the *Environmental Protection Act 1994*, and the locations of the disposal sites need to be recorded on the Environmental Management Register.

3 Other issues to consider

Scrap tyre management issues that arise under ERA 16 (extractive and screening activities) should also follow this operational policy when establishing conditions for new environmental authority applications.

Approved:

5 December 2014

Enquiries:

Permit and Licence Management

Ph. 1300 130 372 (select option 4)

Ph:13 QGOV (13 74 68)

Fax. (07) 3330 5875

Email: palm@des.qld.gov.au

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ACARP

Australian Coal Association Research Program

FINAL REPORT

Management of Waste Tyres in the Mining Industry

C8037

July 2000

ACARP

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

[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.

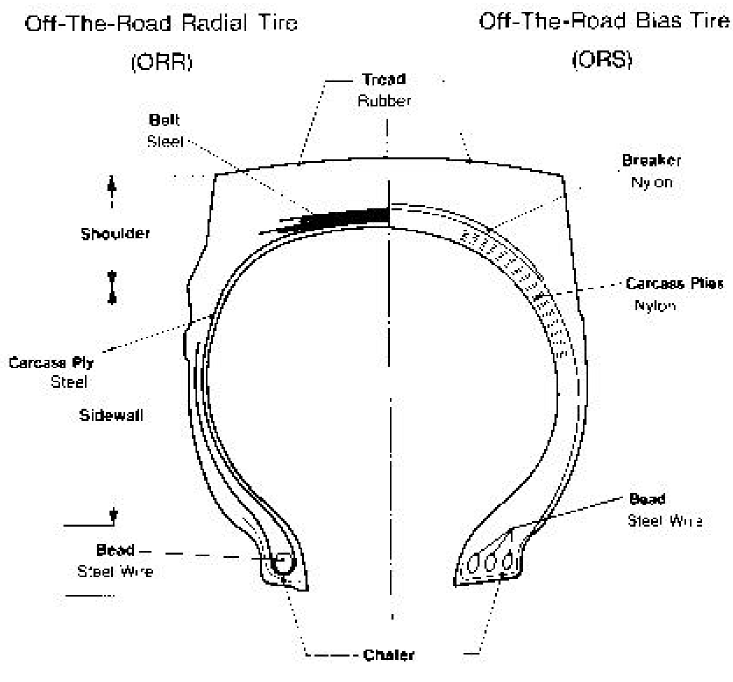

Figure 4.0.1 OTR Tyre Construction (Source: Bridgestone OTR technical data)

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.

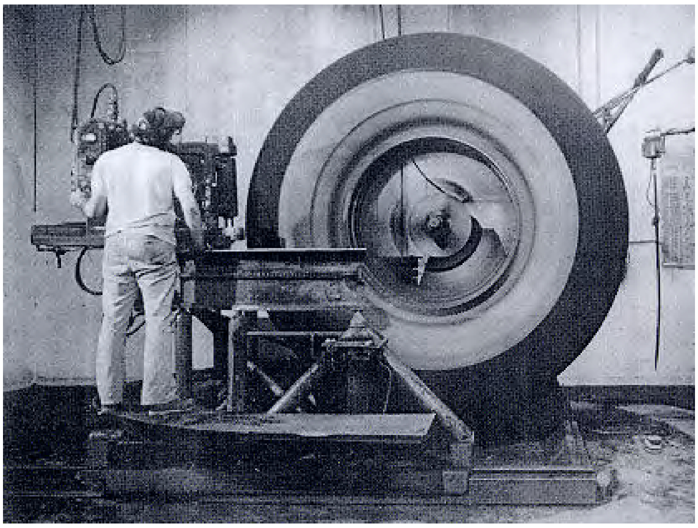

Figure 4.2.2. A large OTR Tyre Buffer

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).

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[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.

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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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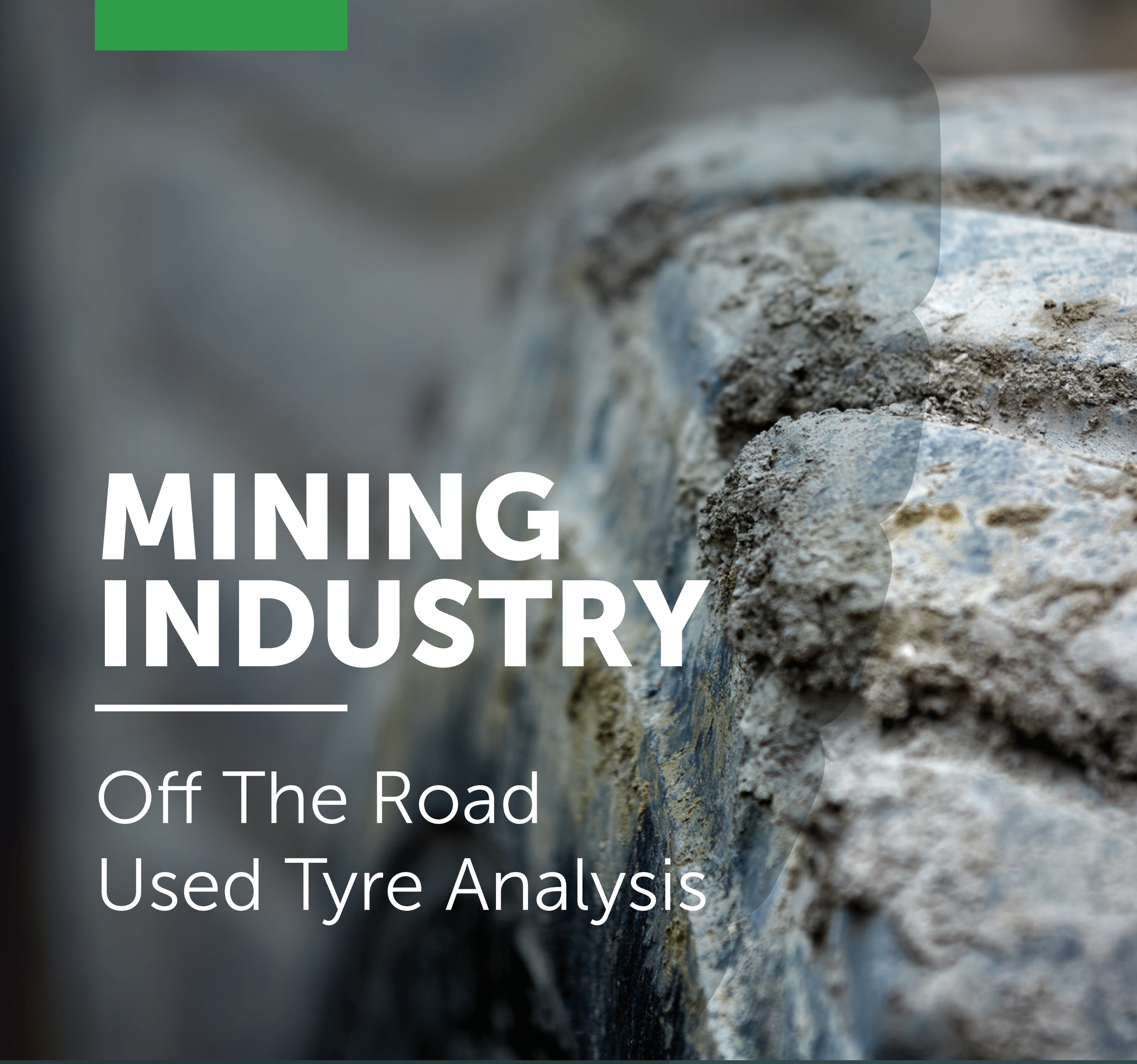


MINING INDUSTRY

Off The Road Used Tyre Analysis

FINAL REPORT

January 2020

Prepared for Tyre Stewardship Australia
by Randell Environmental Consulting
in association with Brock Baker
Environmental Consulting

TyreStewardship AUSTRALIA

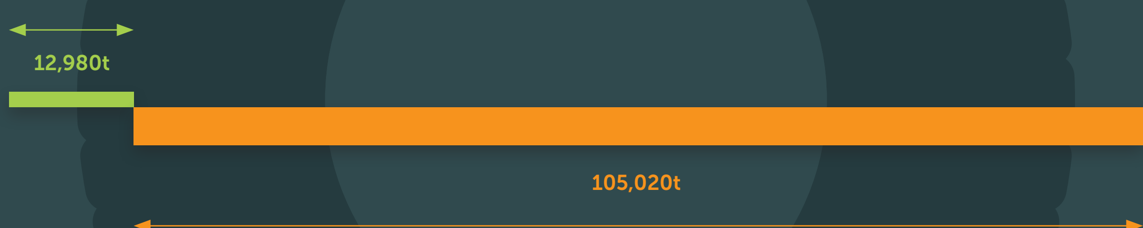
Contents

Introduction

In 2019, Tyre Stewardship Australia engaged Randell Environmental Consulting in association with Brock Baker Environmental Consulting to complete an analysis of the consumption and fate of mining industry Off-The-Road tyres

This analysis followed the completion of the report commissioned by Tyre Stewardship Australia titled ***End-Of-Life Tyres Supply Chain and Fate Analysis*** *(REC 2019)* by Randell Environmental Consulting

REC 2019 identified the need to better understand OTR tyre consumption and fate given the estimated **recovery rate in 2018/19 was just 11%**



The remaining 89% were not recovered (with 81% assumed to be disposed onsite at mining, farming or similar sites)

Basde on 118,000 tonnes of used OTR tyres in 2018/19.

Outline

Section 1 of this report begins by providing a detailed profile of all OTRs in Australia

- The profile includes analysis of OTR types and the industry sectors that generated the estimated 118,000 tonnes of used OTR tyres in 2018/19
- This section also provides analysis of the fate of all types of OTR tyres (i.e. what happens to the used OTR tyres)

Section 2 onwards, provides focused analysis of the mining portion of the used OTR tonnages

The 'deep-dive' into mining includes:

- A profile of the mining industry across Australia, including mine types
- Mapping of the mining industry sites and current used tyre processing sites, that enables analysis of travel times to used tyre processing facilities for different areas of Australia
- The historical and current management and fate of used mining tyres[2]
- Analysis of the technical feasibility of used mining tyre repair, re-treading, recycling or energy recovery
- A discussion of international best practice for used mining tyre management
- Analysis of the financials of used mining tyre recovery versus the current management practices
- Analysis of options to improve the recovery rates of used mining tyres

Project Scope

This report is intended to provide the foundation for further engagement with the mining sector

Much of the analysis is preliminary and intended to provide an understanding of the core issues.

The report does not provide 'the answers' to improved used mining tyre recovery, however, it will enable more informed discussions.

Scope 1

OTR tyre consumption and used tyre generation

- Detailed Material Flow Analysis (MFA) for OTR tyres that will detail OTR consumption, use, used tyre generation and fate by OTR tyre type
- Profile OTR tyre consumption and used tyre generation by industry sector (i.e. mining, agriculture, civil construction, other)

Scope 2

Mining industry sector analysis

- Provide a profile of the mining industry across Australia including mine types to enable analysis of the management of used tyres (based on mine type)
- Provide mapping of the mining industry sites to enable assessment of travel times to used tyre processing facilities for different areas of Australia
- Targeted consultation with state and territory regulators, a few mining companies, and used tyre recycling industry to confirm the historical and current management and fate of used mining tyres

Scope 3

Used mining tyres recovery analysis

- Analyse the technical feasibility of used mining tyre re-treading, recycling or energy recovery
- Analyse the financials of used mining tyre re-use, recycling or energy recovery, compared with current management practices
- Literature review of international best practice for used mining tyre management

Scope 4

Preliminary options analysis to improve recovery of used mining tyre

- Provide analysis of options to improve the recovered rates of used mining tyres
- The options analysis to include discussion of system wide reforms (product stewardship options) and, where appropriate, specific infrastructure investments that need to be implemented to enable used mining tyre recovery
- This options analysis is intended to provide the foundation for further engagement with the mining sector

Off-the-road tyre consumption, used tyre generation and fate

This section provides the detailed Material Flow Analysis (MFA) for all OTR tyres imported into Australia, including OTR tyre consumption, used OTR tyre generation and fate by tyre type and generating industry sector.

OTR tyre consumption

1.1

To profile OTR tyre consumption, OTR imports (both loose and fitment) were categorised by tyre type and then allocated to the assumed industry sector (that uses the OTRs). Table 1 provides the OTR tyre categories and related industry sectors derived for the project analysis.

Table 1. OTR tyre categories and industry sector allocations

OTR tyre category	Industry
Tractor (note 1)	Agriculture
Aircraft	Aviation
Grader, Bobcat and tractor	Construction
Solid and Fork lift	Manufacturing & trade
Earth mover	Mining

Note 1: Tractor small and large were split between Agriculture (80%) and construction (20%)

Table 2 provides the estimated OTR consumption by industry sector from 2014 till 2019 and the five-year average, in tonnes.

Table 2. OTR tyre consumption by industry sector 2014-2019 and five-year average (tonnes)

Industry	2014	2015	2016	2017	2018	2019	5-Yr. Ave.
Agriculture	46,300	38,800	36,100	39,000	37,300	33,800	37,000
Aviation[3]	2,200	2,800	2,200	4,500	3,500	3,700	3,400
Construction	14,100	10,600	10,400	10,400	9,300	8,500	9,800
Manufacturing & trade	36,700	55,700	21,700	2,400	8,600	2,900	18,200
Mining	62,200	44,600	58,500	67,600	80,800	76,900	65,700
Total	**161,500**	**152,400**	**128,800**	**123,900**	**139,600**	**125,800**	**134,100**

Over the past five years Australia has consumed an average of around 134,000 tonnes of OTR tyres.

On a tonnage basis, the mining and agriculture sectors have dominated consumption over the past 5 years, representing around 75% of the tonnages of OTR tyre consumption.

Figure 1 includes the 2018-19 OTR consumption by industry sector, in tonnes. It shows mining OTRs made-up 61%, followed by agriculture at 27% and construction, manufacturing and trade at around 10% and aviation tyres which made-up about 3%.

Figure 1. **2018-19 OTR consumption by industry sector (tonnes)**

Mining 61% Agriculture 27% Construction 7% Manufacturing & Trade 2% Aviation 3%

3. Aviation tyre tonnages are likely to be an over-estimate as a single weight of 100 kgs per new tyre has been applied to all aviation tyre imports (as they are all under one import code) and that weight is too high for smaller aviation tyres.

Used OTR tyre generation

1.2

Following OTR tyre consumption and use, used OTR tyres are generated. The tonnages of used OTR generation relate to the consumption tonnages from the previous years. The tonnages of used tyres are lower than new tyre consumption from previous years due to tyre wear and the weight difference between a new and used tyre.

Table 3 provides the estimated used OTR generation by industry sector from 2014 till 2019 and the five-year average, in tonnes.

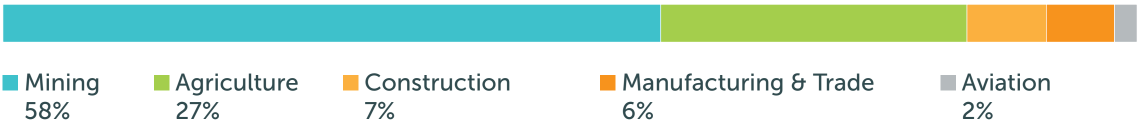
Table 3. **OTR used tyre generation by industry sector 2014-2019 and five-year average (tonnes)**

Industry	2014	2015	2016	2017	2018	2019	5-Yr. Ave.
Agriculture	38,300	39,000	32,700	30,400	32,900	31,400	33,300
Aviation	1,800	1,900	2,300	1,900	3,800	3,000	2,600
Construction	11,700	11,900	9,000	8,800	8,800	7,900	9,200
Manufacturing & trade	30,300	30,900	46,900	18,300	2,000	7,300	21,100
Mining	51,500	52,400	37,500	49,200	56,900	68,000	52,800
Total	133,600	136,000	128,400	108,500	104,400	117,600	119,000

Over the past five years an average of around 120,000 tonnes of OTR tyres have been generated.

Figure 2 includes the 2018-19 used OTR generation by industry sector, in tonnes. It shows mining OTRs made-up 58%, followed by agriculture 27% and construction, manufacturing and trade at around 13% and aviation tyres were presented about 2%.

Figure 2.
2018-19 used OTR by industry sector (tonnes)



Used OTR tyre fates

1.3

This section provides analysis of the fate (i.e. what happens to the used tyres) for Australia's used OTR tyres. The fate categories are based on those adopted in *REC 2019*, as listed below. All fate categories apart from 'export overseas for processing' refer to local on-shore fates.

Casings & seconds	Refers to used tyres that are **re-treaded** for reuse. It does not include OTR mining tyres that are repaired due to a sidewall puncture, for example.
Civil engineering	Refers to the use of used tyres in the construction of retaining walls or similar.
Crumb, granules and buffings	Refers to the highly processed rubber products that are made from used tyres for a wide range of uses from improving the performance of asphalt in road construction to tile adhesives.
Pyrolysis	Refers to the heating of tyres in the absence of oxygen to decompose and separate various organic components to generate end products including char, oil, syngas and steel.
Kilns/boilers/ furnaces	Refers to used tyres that are used as a fuel supplement in cement kilns or similar industrial facilities.
Stockpiles (>40 t, 5,000 EPU)	Refers to more than 40 tonnes of used tyres (5,000 equivalent passenger units, EPU) stockpiled for more than 12 months that are untreated and unprocessed to product specification. Stockpiles refer to large, typically illegal, piles of used tyres as opposed to dispersed dumping of tyres in small quantities, or onsite disposal of used tyres at mine sites or similar.
Landfill	Refers to used tyres sent to a legal landfilling site that is permitted by state or territory environmental regulators.
Onsite disposal (mining, other OTR)	Refers to the onsite disposal of OTR tyres (only) within a mining void or onsite on farms or similar.
Dumping dispersed	Refers to small incidental dumps, of several tyres, across Australia
Exported for processing	Refers to the used tyres that are not managed in Australia and are exported for re-treading and reuse, recycling or energy recovery.

Consultation with state and territory regulators and the used tyre recycling industry has been completed to enable analysis of the historical and current management and fate of used OTR tyres.

Table 4 and **Table 5** include the estimated proportions of each OTR tyre category sent to each of the local or export fates, listed above, as a percentage of total used OTR generation detailed in Table 3. Each of the fate category allocations are discussed below.

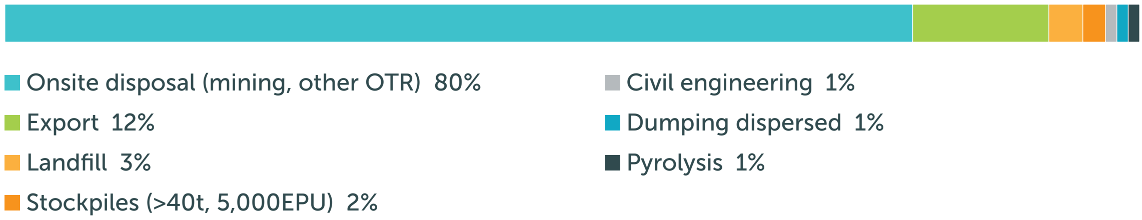
Table 4. Used OTR tyres assumed local and export fate proportions by tyre category, 2018-19 (%)

Fate	Agriculture	Aviation	Construction	Manufacturing & trade	Mining
Casings & seconds (re-treading)	–	–	–	–	–
Civil engineering	1%	–	1%	1%	1%
Crumb, granules & buffings	–	–	1%	1%	–
Pyrolysis	–	–	–	–	1%
Kilns/boilers/furnaces	–	–	–	–	–
Stockpiles (>40 t, 5,000 EPU)	2%	–	2%	2%	2%
Landfill	4%	4%	4%	4%	3%
Onsite disposal (mining, other OTR)	90%	10%	10%	10%	93%
Dumping dispersed	3%	3%	3%	3%	–
Export for processing	–	83%	79%	79%	–
Total	**100%**	**100%**	**100%**	**100%**	**100%**

Table 5. Used OTR tyres assumed local and export fate proportions by tyre category, 2018-19 (tonnes)

Fate	Agriculture	Aviation	Construction	Manufacturing & trade	Mining	Total	%
Casings & seconds (re-treading)	-	-	-	-	-	-	0%
Civil engineering	300	-	100	100	700	**1,200**	1%
Crumb, granules & buffings	-	-	100	100	-	**200**	0%
Pyrolysis	-	-	-	-	700	**700**	1%
Kilns/boilers/furnaces	-	-	-	-	-	-	0%
Stockpiles (>40 t, 5,000 EPU)	600	-	200	100	1,400	**2,300**	2%
Landfill	1,300	100	300	300	2,000	**4,000**	3%
Onsite disposal (mining, other OTR)	28,300	300	800	700	63,300	**93,400**	79%
Dumping dispersed	900	100	200	200	-	**1,400**	1%
Export for processing	-	2,500	6,200	5,700	-	**14,400**	12%
Total	**31,400**	**3,000**	**7,900**	**7,200**	**68,100**	**118,000**	**100%**

Figure 3.
Used OTR tyres assumed local and export fate proportions, 2018-19 (%)



Onsite disposal (mining, other OTR) – 80%

Stakeholder consultation found that onsite disposal was the main fate for used OTR tyres in Australia, particularly for the mining and agricultural sectors, that generated about 85% of the used OTR tonnage in 2018-19. An estimated total of 93,400 tonnes of used OTRs were disposed onsite in Australia in 2018-19. Across Australia mining sites have been allowed to dispose used OTR tyres into mining voids, see Section 3.2 for further discussion.

Replacement agricultural OTRs are typically fitted on-farm by the tyre retailer. Industry commented that the cost of back loading and disposing of agricultural OTRs (around $120 per used OTR tyre) means that most used agricultural OTRs stay on-farm and are stored, repurposed or dumped on-farm in erosion gullies or similar.

Export for processing overseas – 12%

An estimated 14,400 tonnes of used OTR tyres were exported overseas for processing in 2018-19. Around 2,500 tonnes of aviation tyres were exported. Large aviation tyres would be re-treaded and refurbished and returned to Australia for continued use. Other smaller used aviation OTR tyres, that cannot be re-treaded, would be exported as shredded tyre derived fuel or baled. The remaining, around 12,000 tonnes, of OTR exports would likely be used OTR tyres from the construction and manufacturing and trade sectors that have been sectioned into manageable sized pieces for export.

Landfill – 3%

Most jurisdictions do not allow landfilling of any whole tyres and landfill operators typically would not want to accept large used OTR tyres for landfilling as they are very poor use of airspace and difficult to handle/compact. Landfilling of shredded OTRs is also unlikely given the high costs of shredding an OTR and the additional cost of landfilling gate fees. Some more remote, unmanned or less tightly controlled landfills would have used OTR tyres disposed onsite. A total of 4,000 tonnes of used OTR tyres were estimated to have been sent to these more remote, less controlled landfills in Australia in 2018-19.

Stockpiles _ 2%

Industry consultation found that stockpiling, that excludes onsite disposal, of OTRs in large, typically illegal stockpiles was not common in 2018-19. An estimated total of around 2,300 tonnes of used OTRs were disposed into stockpiles in Australia in 2018-19.

Civil engineering – 1%

Industry consultation found that the use of used OTRs in civil construction is not a significant fate for used OTRs. A total of 1,200 tonnes of used agriculture, construction, manufacturing and trade and mining OTRs were estimated to be used in civil engineering in Australia in 2018-19.

Dispersed dumping – 1%

The mapping and drive-time analysis of all Australian landfills and transfer stations, presented REC 2019, shows that 97% of Australians live within a 30-minute drive of a landfill or transfer station. The remaining 3% of the population are assumed to have no used tyre drop-off service in their area (due to being very remote) and are not likely to drive more than 30 mins to access a disposal point, and therefore the used tyres are likely to be dumped in diffuse small dumping events. For used OTR tyres where onsite disposal is allowed (i.e. mining OTRs) diffuse dumping is unlikely to occur and the used tyres would be kept onsite. Based on the method outlined above, an estimated total of 1,400 tonnes of used OTRs were illegally dumped across Australia in 2018-19.

Pyrolysis – 1%

TSA participants recovered a small amount, around 700 tonnes, of used OTR tyres via pyrolysis in Australia in 2018-19.

Crumb, granules and buffing – >1%

TSA participants processed a very small amount, around 200 tonnes, of used OTRs in Australia in 2018-19.

Cement kilns, industrial boilers or furnaces – 0%

No used tyres of any kind were sent to cement kilns, industrial boilers or furnaces in Australia in 2018-19.

Casing and seconds (re-treading) – 0%

Industry consultation found that re-treading of used OTR is not practiced in Australia, currently, except for aviation OTRs. Larger aviation OTRs (greater than 15 inch in diameter) are commonly re-treaded up to six or seven times once a set number of landings have been completed, to extend the life of the tyre. Australia exports all large aviation OTRs for re- treading off-shore to specialist facilities that provide complete refurbishment of the tyres before sending tyres back for continued use, see tonnages reported under 'export for processing overseas' below.

Key finding:

This report's more detailed used OTR tyre category and fate analysis came to essentially the same conclusion as *REC 2019*, **with an estimated 84% of used OTR tyre tonnages not recovered and 80% being disposed onsite at mining sites, farms or similar.**

Mining industry sector analysis

This section provides a profile of the mining industry across Australia including mine types, mapping of mining sites and used tyre processing facilities for different areas of Australia.

Australian mining sector profile

2.1

Geoscience Australia's OZMIN database (last updated Feb 2015) provides useful information about the profile of mining sites in Australia. Table 6 provides a summary of the number of operational mines in Australia by mine type and jurisdiction. Mining industry consultation has also informed the type of mining voids that are used for each mine type in Australia.

Table 6. Australian mining sites by mine type and by state

Mine type	NSW	NT	QLD	SA	TAS	VIC	WA	Total	%	Void type and % split[4]
Coal	61		52	1	4	5	2	125	31%	Open cut
Gold	10	7	5	2	2	7	74	107	26%	Open cut and underground 50/50
Other	6	4	6	6	6	2	15	45	11%	Rare earth mines mostly open cut 70/30
Iron ore	1	1	1	2	1		38	44	11%	Open cut
Copper	6	2	10	3			6	27	7%	Mostly underground 80/20
Nickel							23	23	6%	Mostly underground 70/30
Zinc	4	1	6	1	3			15	4%	Mostly underground 70/30
Bauxite		1	2				3	6	1%	Open cut
Opal	2			3				5	1%	Underground
Lead	1		1				2	4	1%	Mostly underground 70/30
Uranium		1		2				3	1%	Underground
Total	91	17	83	20	16	14	163	404		

Some 400 mines were operational in Australia in 2015. Coal mines, mostly in NSW and Qld, make up around 30% of mining sites in Australia. Gold mines, mostly in WA, make-up around 26%. Rare earth, iron ore, copper, nickel and zinc make up around 40%.

[4] *Source: mining industry consultation, pers. comm.*

By the number of sites, most of the mines in Australia are open pit mines, that would utilise large ridged and articulated haul truck tyres.

Whilst there will be significant amount of smaller mining OTRs used in underground mining, the above analysis illustrates the need for any used mining tyre recovery program to be able to cater for large bulk haul truck tyres, which will be the main tyre type/tonnages that would require processing.

Used mining OTR tyre disposal practices 2.2

This section analyses the historical and current used mining tyre disposal practices in Australia. The analysis is based on consultation with the key mining jurisdictions WA, Qld, NSW and NT environmental protection agencies and some industry consultation.

Western Australia 2.2.1

In WA used mining tyres are permitted to be disposed onsite in designated areas that are defined in the mining site environmental licence. WA licenses typically contain requirements for used mining tyre storage and onsite burial.

For example, the Newcrest Telfer Gold Mine licence, page 15, requires the following for storage:

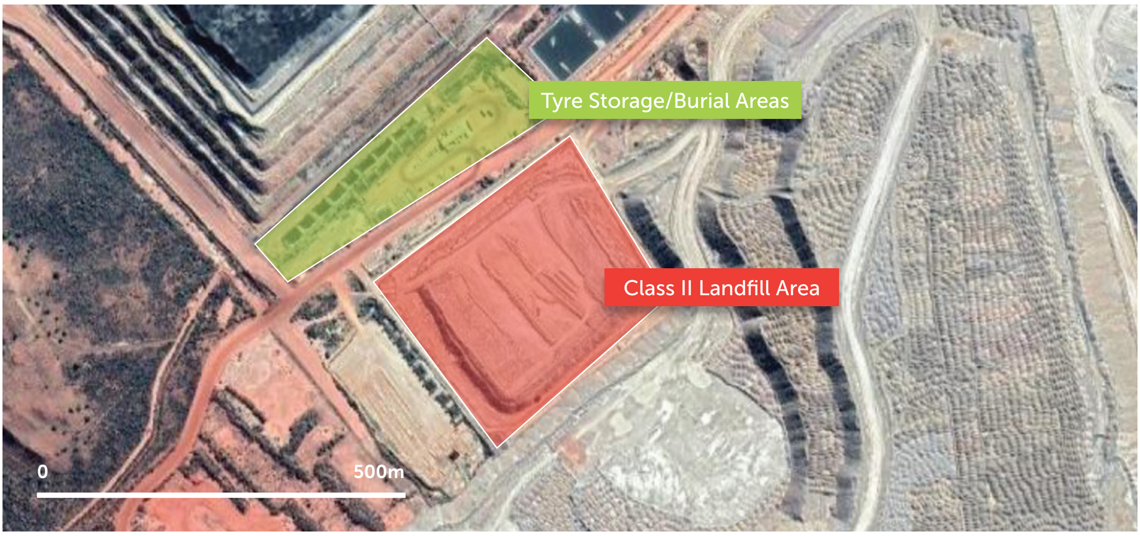
- Storage of tyres shall only take place within the tyre storage/burial areas shown on the Landfill Area Map in Schedule 1 (Figure 3).
- Not more than 30,000 used tyres shall be stored at the premises at any onetime;
- Used tyre stacks shall not exceed 1000 tyres per stack and 5 m in height; and
- Used tyre stacks are to be stored no less than 4 m from any other tyre stacks

The licence also specifies the onsite burial requirements for used mining tyres as follows:

- Burial of tyres shall only take place within the tyre burial areas shown on the Landfill Area Map in Schedule 1 (Figure 3 and Figure 4).
- Tyres shall only be land filled:
  a. in batches separated from each other by at least 100mm of soil and each consisting of not more than 40 cubic metres of tyres reduced to pieces;or
  b. in batches separated from each other by at least 100mm of soil and each consisting of not more than 1000 whole tyres.
- Cell locations where tyres are to be buried will be surveyed and the latitude and longitude recorded.

Figure 4 shows the 'landfill map area' referred to above, extracted from page 23 of the licence. Large storages of used tyres can be seen in separated piles awaiting burial.

Figure 4 **Example of permitted mining tyre storage and burial area at Telfer Gold Mine in WA.**



WA government are currently reviewing the practice of used mining tyre onsite disposal and the current licence allowances with a view to improve recovery rates of used mining tyres.

Queensland

2.2.2

In Qld used mining tyres are permitted to be stored and disposed onsite with no limits on quantities or location. The recently approved Adani Carmichael Coal Mine licence (EPML01470513) includes only the following requirement for used tyre disposal, see page 9:

- Scrap tyres are authorised to be stored awaiting disposal or disposed on the mining lease in a manner that minimises environmental harm. A record must be kept of the number and location of tyres disposed.

The Qld Department of Environment and Science have also published ***Operational policy, Mining, Disposal and storage of scrap tyres at mine sites*** (DES 2014). This policy states that new mining approvals should apply the 'waste hierarchy' in the management of used mining tyres by:

2.1 Avoidance

When negotiating purchase agreements with new tyre suppliers, seek take-back clauses to maximise freight backloading opportunities.

2.2 Recycling

Explore opportunities to recycle scrap tyres on-site and locally through use in impact-absorbing surfaces, bitumen and road construction, pastoral and agricultural use, and civil engineering applications.

2.3 Waste-to-energy

Use existing opportunities in Queensland to recover the intrinsic energy value through waste-to-energy options.

2.4 Disposal

a. *Tyres stored awaiting disposal—or transport for take-back and, recycling, or waste-to-energy options – should be stockpiled in volumes less than 3m in height and 200 square metres in area. Additional fire precautions should be taken, including removal of grass and other materials within a 10m radius of the scrap tyre store. Tyres should be stored in a manner that prevents water retention and minimises mosquito breeding events. Options may include holing side-walls, covering with tarpaulins, spraying with a non-persistent insecticide, or reducing the stockpile during rain events.*

b. *Disposing of scrap tyres in underground stopes is acceptable provided this practice does not cause an unacceptable fire risk or compromise mine safety.*

c. *Disposing of scrap tyres in spoil emplacements is acceptable, provided tyres are placed as deep in the spoil as possible but not directly on the pit floor. Placement should ensure scrap tyres do not impede saturated aquifers and do not compromise the stability of the consolidated land form.*

d. *Disposing of scrap tyres (and other wastes) on mine sites is a notifiable activity under Schedule 3 of the Environmental Protection Act 1994, and the locations of the disposal sites need to be recorded on the Environmental Management Register.*

Qld Department of Environment and Science noted that there has been discussions held at senior level of Government with the Minerals Council of Australia flagging the Department's expectation for the current management practices for used mining tyres to change as new processing options come online and that the Department would consider banning onsite used tyre disposal if industry do not pursue an alternative to onsite disposal.

New South Wales

2.2.3

Consultation with NSW EPA staff found that mining tyres are allowed by EPA to be stored and disposed onsite with no limits on quantities or location.

A review of mining licences such as the Mt Arthur Coal mine licence, one of NSW largest coal mines, found no reference to used tyres and no reference to onsite burial requirements.

EPA noted that if a farmer in NSW was to bury waste tyres on their farm it would be an offence. NSW EPA is likely to review the status of mining tyre onsite disposal in its annual review of regulations.

Northern Territory

2.2.4

Consultation with NT EPA and NT Department of mining staff found that mining tyres are allowed by EPA to be stored and disposed onsite with no limits on quantities or location. NT staff noted that licences in NT do not specify onsite burial requirements.

NT EPA would like to see the tyres recovered but, due to remote locations, on-site burial has always been seen as the only option.

Key findings:

- Any used mining tyre recovery program needs to be able to cater for large bulk haul truck tyres, which will be the main tyre type/ tonnages that would require processing.
- All jurisdiction consulted allow onsite disposal.
- WA is the only jurisdiction consulted with requirements for used mining tyre storage and disposal included in the mine licence (i.e. that are required)
- QLD, NSW, WA are all reviewing the current practice of allowing onsite disposal and Qld government have raised this issue with Minerals Council of Australia
- Historically onsite disposal has been allowed due to there being no alternatives. As this changes, mining companies should expect the allowance of onsite disposal to cease.

Section 3

Mining sites and used tyre processing locations

This section provides analysis of mining site and used tyre processing locations around Australia and analysis of average travel distances.

Figure 6. **Examples of lower and upper end of processing investment costs.**

Photos by Tyrecycle and Pearl Global

Figure 7, overleaf, illustrates the location of Australian mining and used tyre processing locations. It also includes the 500 km distance 'circle' from each used tyre processor. The green shading for the 500 km distance circle also illustrates the density of processing sites in each 500 km area.

Important! Only a few of Australia's used tyre processors are currently able to receive large mining OTR tyres. **So Figure 7, is simply illustrating the current network of used tyre processing sites that could take used mining OTRs in future and most of these sites would require investment to be able to process large mining OTRs.** The extent of the investment would depend on the level of mining tyre processing to be done onsite. Investments could range from as little as $100,000 for excavator shears to simply section the tyres to allow enable transport or shipping for further processing in Australia or off-shore, through to multi-million-dollar investments to build full OTR tyre processing plants such as those recently established by Pearl Global in Queensland (see example photo above right).

Figure 7. Australian mine sites and current used tyre reprocessors (most without mining OTR capability)

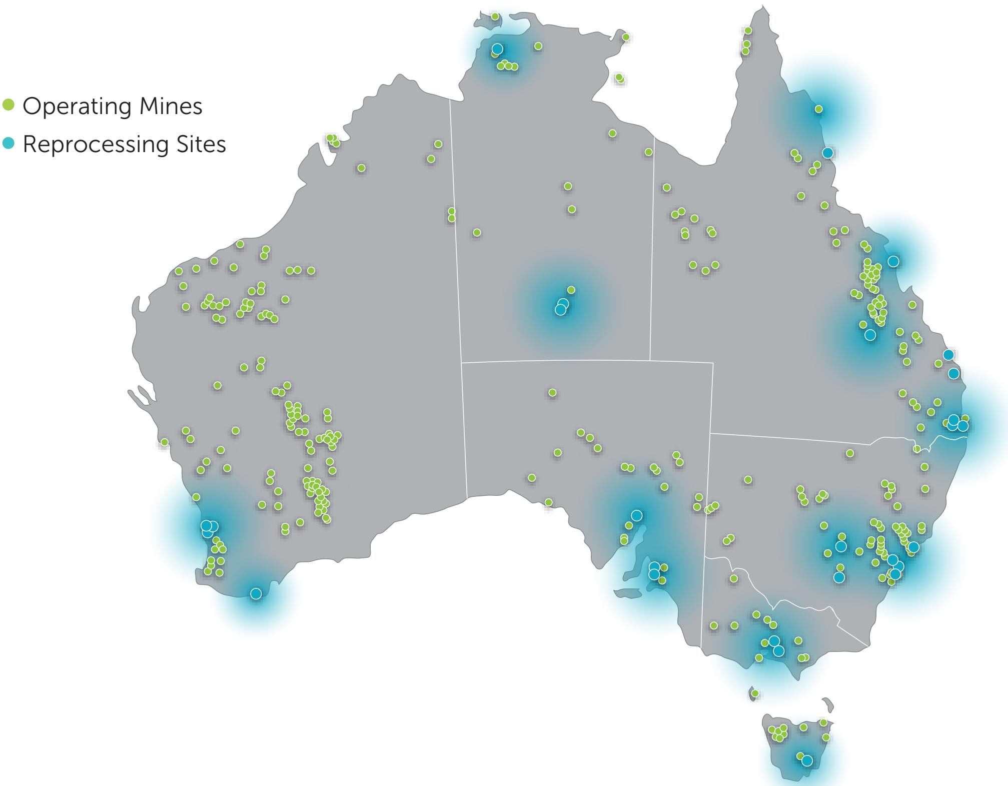


Table 7 provides the results of analysis for the distances between used tyre processors and mining sites.

Table 7. Distance between mines and used tyre processors by jurisdiction (kilometres)

Distance (kilometres)	NSW	NT	QLD	SA	TAS	VIC	WA
Average distance between mines and processors	183	442	449	327	268	168	832
Closest mine to a processor	7	53	21	49	62	56	101
Furthest mine to a processor	731	1,208	1,244	582	406	422	1,713

Vic, NSW and Tas have similar average distances of around 200 kms between mining and processing sites. Qld and NT both have average distances of around 400 kms. WA has by far the longest average distance of around 800 kms.

Table 8 provides the results of analysis for the proportions of mining sites within distance ranges to used tyre processors by jurisdiction and nationally.

Table 8. Proportions of mining sites within distance ranges to used tyre processors by jurisdiction (%)

Distance from nearest processor	NSW	NT	QLD	SA	TAS	VIC	WA	Australia
Within 500 km	98%	53%	73%	73%	100%	100%	13%	**57%**
Between 500 km and 1,000 km	2%	40%	12%	27%	0%	0%	62%	**30%**
Greater than 1,000 km	0%	7%	15%	0%	0%	0%	24%	**13%**

Key findings:

- Nationally, 57% of sites are within 500 kms of the used tyre processor, 30% are between 500 and 1,000 kms and 13% are more than 1,000 kms away from a processor.
  WA, Qld and NT all have sites that are more than 1,000 kms from a processor site, but WA has by far the largest proportion with 24% of the mines more than 1,000 kms from a processor.

- Only a few of Australia's used tyre processors are currently able to process large used mining tyres. Most used tyre processors in Australia would require investment to be able to process large used mining tyres.

  The extent of the investment would depend on the level of mining tyre processing to be done onsite. Investments could range from as little as $100,000 for excavator shears to simply section the tyres to allow enable transport or shipping for further processing in Australia or off-shore, through to multi-million-dollar investments to build complete mining tyre processing plants.

Section 4

Used mining tyre recovery analysis

This section provides analysis of the technical feasibility of large used mining tyre repair, re-treading, recycling or energy recovery.

Used mining tyre repair 4.1

Repairing of partly worn, but damaged, mining tyres is common in Australia. For example, Bridgestone Mining Solutions Australia (BMSA) have six mining OTR repair service centres located around Australia, as detailed here. Due to the cost of new mining tyres (around $40-50,000 for a large mining tyre) there is a strong financial driver to repair mining tyres where significant tread remains. Apart from repair, mine operators also put chains around worn tyres to get more life out of the tyre before disposal.

Used mining tyre re-treading 4.2

Industry consultation found that re-treading of mining OTRs is currently not happening in Australia and is unlikely to in future. Industry noted that there has been attempts to re-tread mining tyres in the past that have failed. This main cause of failure was wear/damage to the casing making the re-treaded tyre less reliable. The adhesive bond between the casing and the re-tread was not typically the cause of failure.

However, in contrast to this view, Kal Tyre promote a global mining tyre re-treading business that has been operating for over 45 years, here. Kal Tyre re-tread over 10,000 OTR tyres annually in the UK, West Africa, Canada, Chile and Mexico.

Used mining tyre recycling 4.3

Recycling of used large mining tyres by processing the tyres into crumbed rubber and steel is not currently happening in Australia, however, it is technically feasible and there are international examples such as those discussed below.

ELDAN recycling installed a mining tyre recycling plant in at the OK Tedi Mining Limited copper mine in Papua New Guinea. For this plant the mining tyres are pre-cut, and have the bead removed, by a heavy-duty demolition shear into pieces which fit the in-feed of the shredder, which is designed to process mining tyres. The tyre sections are processed into tyre shreds, and free steel wire is liberated and removed from the shreds by a powerful magnet. The tyre shreds are then further processed in a granulation and separation plant. Depending on the customer specific requirements a high-quality rubber granulate and clean steel wire can be produced.

Companies such as Eco Green Equipment are marketing processing equipment purpose built to recycle large used mining OTR tyres, as demonstrated here. This equipment is purpose built to cut the remaining rubber from the three outer sites of the tyre and then remove the steel bead from the mining OTR before sectioning and shredding the casing for rubber and steel recovery.

Tyrecycle are the main company in Australia that are currently marketing the recycling of mining tyres into rubber and steel, as shown here. However, it is understood that all mining OTR processing is occurring at overseas facilities, with only primary size reduction happening onshore.

The recycling of used mining tyres is an energy intensive process that requires multiple stages of size reduction which adds to the processing costs.

Used mining tyre recovery via pyrolysis 4.4

There are several pyrolysis plants that are either built, commissioning, under construction or in the planning stages of establishing in Australia with the intention of targeting used mining tyres as one of the primary feedstocks.

The Pearl Global facility in Stapylton, Qld has recently completed commissioning, is operational and is receiving large mining tyres. The processing units can be housed in a 40-foot ISO frame so it is portable and scalable and can be located in proximity to tyre generating sites.

The stated time to replicate the facility is 16 weeks. With six processing units operating at one site, 18,000 tonnes of tyres could be processed per annum. The processing units require the tyre to be shredded down to two-inch feedstock before processing.

Southern Oil is considering a pyrolysis facility designed to be able to process whole large used mining tyres or baled tyres and will provide oil that can be further refined.

Tytec Recycling is a collaboration between Tytec Group and Green Distillation Technologies Corporation (GDTC) and is planning to build a pyrolysis system for whole used mining tyres processing also to be located in Qld. They anticipate the plant to be operational by mid-2021.

Sister company, Tytec Logistics, currently specialise in delivering new OTR tyres to mining sites in purpose-built trailers, that maximise payload, and service large portions of the mining industry, including remote sites. Tytec Recycling recognise the significant backloading opportunity for used tyres using the same transports, see photos below.

Photos by Tytec

Used mining tyres are also being processed in pyrolysis plants overseas at plants such as the Titan Tyre Recycling Facility in Canada, that started operating in 2016.

Canadian company Kal Tyre are set to open their first major mining tyre pyrolysis facility in Chile, South America to service the vast copper mines. The plant will have two kilns and capacity to process 7,500 tonnes of rubber. Two kilns will enable 24/7 operation of the plant. Similar to the Pearl Global proposition, the Kal Tyre units are to be built close to mine sites and be scalable and relatively easy to replicate.

Used mining tyre energy recovery (TDF) 4.5

The shredding of mining tyres for use as a fuel supplement, or tyre derived fuel (TDF), in industrial kilns is also technically feasible. Tyrecycle is the main company in Australia that is currently marketing the collection of mining tyres to produce TDF, as shown here.

The process for TDF production is the same as the first stages of recycling (i.e. de-beading, tyre sectioning and shredding). Once the material is shredded to the appropriate size, it is exported to kilns located in Asia and used to supplement coal, mostly in cement kiln firing. As noted in Section 1.3, no used tyres are sent to the cement kilns in Australia, that operate in NSW, SA, Qld and Tas.

Key findings:

- The repair of large mining tyres that are partly worn and damaged is a well-established industry in Australia, currently.
- Re-treading of fully worn large mining tyres is not happening in Australia currently and some do not think re-treading is a viable option for large mining tyres. However, companies such as Kal Tyre have an international network of mining tyre re-treading sites.
- The recycling of used large mining tyres into crumbed rubber and steel is technically feasible, however, energy intensive and currently the only reported recycling is by Tyrecycle who cut the tyres into manageable sections and export the tyres for recycling overseas where overhead costs are lower.
- It is technically feasible to produce a TDF from large used mining tyres, however, in Australia this is understood not to be happening in significant tonnages due to the energy intensive processes required to shred large mining tyres for export as TDF.
- Recovery of large used mining tyres by pyrolysis is technically feasible and several pyrolysis plants are either built, commissioning, under construction or are in the planning stages of establishing in Australia with the intention of targeting used mining tyres as one of the primary feedstocks.
- Historically, large used mining tyres have been allowed by regulators to be disposed of into mining voids. With the development of onshore options for recovery by pyrolysis and several providers tyring to establish onshore operations to target large used mining tyres, it is an appropriate time for regulators to review if this practice should be allowed to continue.

Used mining tyre best practice management

This section provides results of the literature review of international best practice for used mining tyre management.

Whilst there are several examples of what could be termed 'best practice' mining tyre **recovery**, that have been discussed above, the literature review found little information on best practice used mining tyre management (i.e. examples of mining tyre governance and resulting recovery rates).

Literature such as ***Investigating global best practice waste tyre management***, L. O'Keefe, 2016, available here, provide detailed review of global approaches to used tyre management. However, the focus of such studies is, understandably, on passenger and truck tyres with limited discussion of mining tyre management best practice.

The review found that onsite disposal of used large mining tyres is wide spread, globally.

The ELDAN recycling system installed at the OK Tedi Mining Limited copper mine in Papua New Guinea, discussed in Section 4.3, provides an example of an onsite solution for large used mining tyres. However, it is unclear how successful the onsite recycling plant has been and what ongoing markets have been established for recycled products.

An example that is worth noting is new legislation in Chile, that includes a ban on the onsite disposal of mining tyres onsite. The *Extended Product Liability and Recycling Promotion* legislation was passed in 2016. The regulation will come into force with the 'supreme decrees' that will establish collection and valorisation goals for each priority product (including tyres). **For used mining tyres, the legislation states that by 2026, 100 per cent of collection and recovery must be achieved.**

The legislation differentiates tyre recycling goals according to their size, above and under 57 inches, projecting that larger mining tyres should be completely reused in 2026, while those less than 57 inches, should attain a 98 per cent recycling rate by 2028. Source: Tyre and Rubber Recycling, New Chilean Plan for Mining Tyres, Jan 2019.

Key findings:

- The review found that onsite disposal of used large mining tyres is wide spread, globally.
- Chile has implemented legislation that requires 100 per cent recovery of mining tyres by 2026. The implementation of this legislation has been key to enabling Kal Tyre to invest in, develop and build their new mining tyre pyrolysis facility.
- While mining companies are allowed to stockpile or dispose of used mining tyres onsite, which they can do at effectively no cost, the recovery of mining tyres is unlikely to be wide spread.

Used mining tyre recovery financials

This section provides analysis of the financials of large used mining tyre recycling or energy recovery compared with current management.

Stakeholder consultation found that onsite disposal was the fate of almost all used large mining tyres in Australia. Whilst there would be some handling involved in shifting and burying the used tyres, this is all assumed to be within normal site operations. There would be no external costs associated with onsite mining tyre disposal. The costs for onsite disposal are therefore assumed to be zero.

The tyre recovery industry has been consulted to inform the analysis below.

The financials presented below are for large used mining tyres with an assumed weight of three tonnes. There are some heavier mining tyres (up to 4.5 tonne) and some lighter. As discussed in Section 2, large bulk haul truck tyres will be the main tyre type/tonnages that would require processing and these are assumed to have an average weight of three tonnes.

Table 9 Estimated cost range for collection of used large mining tyres for offsite processing (total costs to the waste generator) ($/tyre)

Mine site	Lower		Upper		Comments
	$/unit	$/tonne	$/unit	$/tonne	
Regional	$1,000	$333	$1,800	$600	Collection costs vary by distance travelled. 'Regional' collections typically allow for up to 500 kms from processor.
Remote	$1,400	$467	$2,300	$767	Collection costs vary by distance travelled. 'Remote' collections typically allow for up to 1,000 kms from processor.

Table 9 provides the estimated cost range for the collection of used large mining tyres for the off-site processing from regional mines (up to 500 kms from processing site) and remote mines (up to 1,000 kms from processing site).

Mining companies located in regional areas could expect to pay from $1,000 to $1,800 per three tonne used mining tyre (collection and processing costs). Mining companies located in remote areas could expect to pay from $1,400 to $2,300 per three tonne used mining tyre (collection and processing costs).

Assuming an average new tyre cost of $45,000, these costs present 2-4% of a new tyre cost in regional area and 3-5% of a new tyre cost in remote areas.

Table 10 provides the estimated processing cost ranges for a tonne of used large mining tyres. It shows processing costs are highest for recycling back into crumbed rubber, followed by pyrolysis and then energy recovery (via shredding and TDF export). Whilst processing costs are higher for recycling and pyrolysis, it is important to note that these processes will generate revenue from recycled products.

Table 10 Estimated processing cost ranges for used large mining tyre ($/tonne, excluding freight)

Process	Lower	Upper	Comments
	$/tonne	$/tonne	
Recycling (crumbed rubber - onshore)	$600	$800	Assumes an additional $200/tonne to process large mining tyres for de-beading and extra size reduction costs. Crumbing costs are typically $400 -$600 per tonne.
Recovery via pyrolysis (oil, syngas, act. carbon - onshore)	$300	$500	Costs are for whole mining tyres processing.
Energy recovery (tyre derived fuel - exported)	$285	$300	Assumes an additional $200/tonne to process large mining tyres for de-beading and extra size reduction costs. Typical costs for TDF exports are around $85 to $100.

Where mining tyre recovery facilities are located very close to mining sites, the collection costs in Table 9 would decrease (due to reduced transport costs) and would be closer to the processing cost ranges listed in Table 10.

Key findings:

- Mining companies located in regional areas could expect to pay from $1,000 to $1,800 per three tonne used mining tyre (collection and processing costs). Mining companies located in remote areas could expect to pay from $1,400 to $2,300 per three tonne used mining tyre (collection and processing costs).

- Assuming an average new tyre cost of $45,000, these costs present 2-4% of a new tyre cost in regional area and 3-5% of a new tyre cost in remote areas.

- For remote sites, where mining tyre recovery facilities are located very close to mining sites, the costs to the mining company could reduce significantly (due to reduced transport costs).

Improving recovery of used mining tyres

Considering the analysis that is presented in the sections above, the items below discuss a range of ways to improve the recovery of used mining tyres in Australia. This discussion does not provide 'the answer,' however, it will aid in further engagement with the mining sector.

Mining tyre importers become members of the current Tyre Stewardship Scheme(TSS) 7.1

If mining tyre importers were to join the current TSS, around $100 dollars (per large mining tyre imported and sold into Australia) would be collected, or 0.2% of the sale price for a $45,000 mining tyre.

As the analysis in Section 6 illustrates, the costs to recover large used mining tyres is estimated to be 10-23 times more than the TSS fees that would be collected.

Membership of the scheme would fund TSA to provide support to mining tyre manufacturers, importers and mining companies to:

- Build upon research such as that included in this report to development an industry strategy for mining tyre recovery
- Investigate and identify areas of the country with needs for additional recovery infrastructure, to support industry to make funding applications to Governments (for example)
- Support market development for products derived from used mining tyre recovery.

Co-regulatory or mandatory product stewardship to fund recovery 7.2

The Australia *Product Stewardship Act* is currently under review. It is possible that used mining tyres could be included under a **co-regulatory or mandatory product stewardship** scheme under this review. There are numerous possibilities as to how this could unfold.

If used mining tyres are included under a co-regulatory or mandatory scheme, the key outcome would be the payment of part or all of the recovery costs for used mining tyres (by tyre manufacturers/importers). This would likely see a significant increase in used tyre recovery infrastructure capacity and capability around Australia.

Ban on onsite disposal of mining tyres in all jurisdictions 7.3

Following Chile's lead, jurisdictions around Australia could implement a ban on the onsite disposal of used mining tyres. A lead time of at least several years (Chile gave a 10-year lead time) would allow time for the establishment of the required recovery infrastructure around the country. All states and territories should implement the ban to ensure used tyres are not simple shifted to a mine in another jurisdiction. A will structured national ban for onsite disposal would provide the used tyre recovery industry with the feedstock security that has been lacking historically.

Establishing a network of used tyre processing sites in close proximity to new mining tyre distribution locations 7.4

Transport costs are a significant part of mining tyre recovery costs, especially while used mining tyre processing facilities are not available as a network of sites across the country.

Backloading of used tyres when delivering new tyres may be the best means of reducing transport costs. However, if there is no used tyre processing facility in proximity of the new mining tyre distribution locations, significant additional freight costs would still be incurred.

Establishing a network of used tyre processing sites in close proximity to significant mining areas

7.5

Another approach to reducing transport, and overall recovery costs, could involve establishing a network of used mining tyre processing facilities in close proximity to significant mining areas with a significant tonnage of used mining tyres.

These facilities could be setup to provide full processing of mining tyres, as is proposed by the Pearl Global and Kal Tyre technologies or be a far more basic facility that is set-up to section the tyres and load them for efficient transport to Australian or export markets (Tyrecycle's current model).

Tyre retailers lease mining tyres rather than sell them

7.6

Mining tyre importers/retailers could set-up contracts with miners that include leasing of the tyres rather than purchasing. This would allow for drop-off and pick-up of mining tyres at the same time and build the used tyre processing costs into the leasing fees. This would also allow the mining company to resolve tyre supply, pick-up and processing costs within one contact. It would also provide the mining company with assurance that the used tyre is sent to an appropriate facility for processing.

Develop on-shore energy recovery markets for TDF

7.7

Australia currently exports significant tonnages of shredded used tyres as TDF to Japan and Korea. Currently, no Australian used tyres are sent to local industrial kilns/boilers/furnaces as a fuel (i.e. brown coal) supplement.

There has been very little incentive for Australian coal fired kilns/boilers/furnaces operators to install the required infrastructure to utilise TDF as Australia has access to huge reserves of cheap coal.

Used mining tyres could be processed into TDF and used to offset coal use in future, as pressure increases for the reduction of coal fired energy production.

Glossary of terms / abbreviations

Term / abbreviations	Description
TSA	Tyre Stewardship Australia
BBEC	Brock Baker Environmental Consulting
REC	Randell Environmental Consulting
Material flow analysis (MFA)	MFA is an analytical method to quantify flows and stocks of materials in a well-defined system. MFA is used to study material flows across different industrial sectors. When combined with an assessment of the costs associated with material flows this business-oriented application of MFA is called *material flow cost accounting*. MFA is an important tool in establishing a circular economy.
Stockpile	The following definition of used tyre stockpile was adopted for the report analysis: 1. More than 40 tonnes (5,000 EPUs) in storage onsite 2. More than 12 months storage 3. Untreated, unprocessed to product specification.
Casings	The rigid, inner of a tyre upon which a tread is placed. Typically, tyres good enough for re-tread or resale as seconds are referred to as casings.
Civil engineering	Engineering discipline that deals with the built environment, including works like roads, bridges, canals, dams, and buildings.
Crumb rubber	A highly-refined rubber product, typically less than 1mm in diameter, made from recycled tyres.
Domestic recycling	Activities that occur to recycle or reprocess waste tyres within Australia.
Dispersal to the open environment	The dispersal of rubber from in-use tyres to the open environment (land, waterways, etc.) due to wear of the tyre tread.
Used tyre fates	What happens to Australian used tyres when they reach the end of their useful life (either in Australian or overseas) including re-use, recycling, energy recovery, and disposal fates.
Used tyres	A tyre that is deemed no longer capable of performing the function for which it was originally made.
Energy recovery	The use of used tyres in a thermal process to recover energy for electricity generation or industrial process.
Equivalent passenger units (EPUs)	A standard measure, based on the typical weight of a standard passenger tyre (9.5 kgs).
In-use	Tyres that are in demand for the purpose for which they were originally made.
Off-the-road (OTR) tyre	Tyres for mining sites and heavy industry applications.
Recovery	Broadly refers to used tyres that are collected and either reused, recycled or recovered for embodied energy (energy recovery) either in Australia, or overseas.
Recycling	Process to recover constituent materials from end-of-life tyres and use those materials to manufacture other products either in Australia or overseas.
Resource recovery	Refers to used tyres that are collected and either reused recycled or recovered for embodied energy (energy recovery) either in Australia or overseas.
Re-treading	The preparation of used tyres for reuse by replacing the outer tread.
Reuse	The use of tyres for the purpose for which they were originally made, including use of re-treaded tyres and second-hand tyres.
Rubber granule	A refined rubber product, typically 2mm – 15mm, made from recycled tyres.
tpa	Tonnes per annum
Tyre Derived Fuel (TDF)	Shredded tyres prepared to a specification for use in energy recovery.
Tyre Stewardship Australia (TSA)	The not-for-profit organisation established to deliver the National Tyre Product Stewardship Scheme.
Tyre-derived aggregate (TDA)	Shredded tyres prepared to a specification for use as aggregate in civil engineering applications.
Tyre-derived products (TDPs)	Any product produced from rubber, steel, textiles or other material recovery from the recovery of used tyres.

About TSA

Tyre Stewardship Australia (TSA) was established in 2014 to implement the national Tyre Product Stewardship Scheme (the Scheme) which aims to promote the development of viable markets for end of life tyres. The Scheme's objectives are to:

- increase resource recovery and recycling and minimise the environmental, health and safety impacts of end of life tyres generated in Australia; and
- develop Australia's tyre recycling industry and markets for tyre derived products.

TSA accredits participants, including tyre retailers, manufacturers, recyclers and collectors, who are committed to supporting the objectives of the Scheme. TSA also invests in market development initiatives including research and development, and commercialisation, of new productive uses for end of life tyres.

TSA's work helps to drive the transformation of a waste product into a useful commodity, creating new industries and employment opportunities while also reducing the environmental harm caused by the illegal dumping of old tyres. TSA envisions a circular economy for tyres, where resources from end of life tyres are used and reused, such as through recycling, recovery and/or repurposing, ultimately boosting new industries and eliminating tyres from the waste stream.

TSA's Purpose, Vision and Mission

TSA's purpose is to drive sustainable outcomes for end of life tyres.

TSA's vision is to create a circular economy for end-of-life tyres which contributes to a sustainable society.

TSA's mission is to collaboratively ensure the sustainable management, recycling and productive use of end of life tyres.

TSA aims to build awareness and facilitate the commercialisation of better opportunities provided by end of life tyres, provide accreditation and stimulate innovation, in order to advance circular economy principles within the sector.

Mining Industry Off-The-Road Used Tyre Analysis

Tyre Stewardship Australia

Authors

Paul Randell, Brock Baker

Reviewers

Paul Randell

Report Disclaimer

This report has been prepared for Tyre Stewardship Australia in accordance with the terms and conditions of appointment dated 04/11/2019. Randell Environmental Consulting Pty Ltd (ABN 38 326 653 151) cannot accept any responsibility for any use of or reliance on the contents of this report by any third party.

TyreStewardship AUSTRALIA

2/59 Keele Street, Collingwood, VIC 3066
Email: info@tyrestewardship.org.au

getonboard@tyrestewardship.org.au

TSA V1:0320

APPENDIX B

WHITEHAVEN MINE TYRE DISPOSAL ENVIRONMENTAL PROCEDURE

MINE TYRE DISPOSAL PROCEDURE

Approval	Position	Signed	Date
Document Owner:			
Authorised by:			

1. DEFINITION

1.1. The reference to waste mining tyre within this Procedure refers to all waste tyres from heavy mining equipment that are generated on-site and unable to continue to be used safely on heavy equipment. These tyres are to be disposed of within the emplacement area and exclude reference to light vehicle / passenger vehicle tyres.

2. PURPOSE

2.1 The purpose of this Procedure is to ensure potential impacts associated with waste tyre disposal on site are managed, monitored and effective control mechanisms implemented.

3. SCOPE

3.1 To provide a standard work practice for the disposal of waste tyres and guidance on the identification and environmental management of risks associated with the disposal of waste tyres. This procedure details how applicable Whitehaven Coal sites will manage and dispose of waste mining tyres generated on site to address environmental requirements in accordance with applicable legislation.

3.2 This is an internal Whitehaven Coal procedure that will be reviewed periodically and amended from time to time, as required.

4. STORAGE

4.1 Heavy vehicle waste tyres will be stored at a designated storage area/s prior to disposal. The site specific logistics and storage of tyres will be managed on an individual site basis to ensure an appropriate site-specific location is selected. The location will consider appropriate distance from ignition sources and ensuring appropriate access for facilitating disposal events.

5. DISPOSAL PREPARATION AND METHOD

5.1 The Maintenance Department (or relevant operational team) will facilitate, in coordination with relevant operational personnel, the disposal of tyres in the operational area as required when adequate numbers of tyres are accumulated to warrant a disposal event.

5.2 Preparation for a disposal event will include identifying relevant hazards (refer Section 6) and controls for the defined area of disposal.

5.3 The generation and disposal of heavy equipment tyres is managed as far as practicable by implementing a number of measures to extend tyre life including:

- Road design, construction and maintenance;
- Implementation of speed limits;
- Tyre inspection and maintenance;

- Repairing tyres in so far as is reasonably practicable without impacting the safe operation of equipment; and
- Where determined as feasible at an operation, waste tyres may be reused for safety bunds, intersection delineation or temporary stabilisation of areas.

5.4 The method of disposal will generally include loading of waste tyres, at the site-specific storage location/s, onto a flat-bed type truck or equivalent piece of heavy equipment suitable for transporting large heavy equipment tyres.

The loaded truck will be guided by a light vehicle escort to the pre-determined designated disposal area to ensure the correct disposal location of the waste tyres within the operational area. Tyres will be unloaded and placed at the disposal location prior to encapsulation and coverage by overburden material.

5.5 Instances where individual or a small number of waste mining tyres require disposal (ie an equipment maintenance event in the pit, or other related unplanned or planned tyre changing occurrence), the disposal register will be updated accordingly, together with ensuring disposal at the pre-determined disposal location.

5.6 The relevant site safety procedures will apply to a disposal event and a pre-task risk assessment completed to assess hazards and controls relevant to the activity. Disposal controls will also be implemented to ensure locations, disposed tyre details, and location prior to coverage is recorded.

6. HAZARD AND ASSESSMENT

6.1 Disposal of waste tyres in the operation will consider potential safety hazards such as proximity of active dumping, slope and geotechnical stability, weather conditions and relevant site operational conditions.

6.2 A safety risk assessment will be undertaken as noted in section 5.6.

6.3 Environmental assessment of identified disposal areas will consider key aspects as described in the Environmental Assessment, including:

- Ensuring there is at least 20 metres of material available to enable compliant coverage of waste tyre disposal areas.
- Identifying whether potential to impede any saturated aquifers, or compromise the stability of the consolidated final landform or have any long-term effects on rehabilitation;
- Considering presence of any PAF material or coal rejects to ensure the emplacement is not within 15 metres proximity to the disposal area to mitigate risk of spontaneous combustion;

7. WASTE TYRE TRACKING

7.1 A register will document all heavy equipment tyres disposed and buried. Key information to be included in the register will include:

- Serial number of disposed tyres.
- Type/make and quantity.
- Disposal date.
- Surveyed co-ordinates of the disposal site area (Eastings, Northings, RL); and
- Summarised description of the disposal area.

At the completion of each disposal event, the register will be updated by the relevant operational personnel.

8. MONITORING AND REPORTING

8.1 Monitoring of stockpiled tonnage of waste heavy vehicle tyres from mining equipment will occur to identify when a disposal event is required, and ensure any applicable maximum annual disposal limits are complied with.

8.2 Monitoring of disposed waste tyres will occur as part of establishment of the final landform for rehabilitation. Monitoring will 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 disposed waste tyre area. Rehabilitation monitoring required under respective Mining Operation Plan's and applicable site management plans will assess slope stability and identification of any effects related to historical waste tyre disposal.

8.2 The reporting of relevant information within the waste tyre tracking register of the disposal of waste tyres from inception of this Procedure will be supplied, where required, to relevant agencies.