



# **Review of Management of Used Tyres at Landfill Sites**

**August 2006**

Dr Margaret Matthews  
25 Henley Road,  
Mount Pleasant WA 6153  
S3mmatthews@hotmail.com  
Ph: 08 9315 9075  
Mob: 0402 105 649  
Fax: 08 9315 1005

August 2006

## **Limitations**

This is an external report commissioned by the Department of Environment and Conservation on behalf of the Waste Management Board of WA. The findings and recommendations contained in the report do not necessarily represent the views of the Waste Management Board.

All care has been exercised in undertaking the preparation of this report. Neither the Board nor the Department of Environment and Conservation accept liability for any loss or damage incurred as a result of any use of the information contained in the report.

Sustainable Strategic Solutions (S3) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the Department of Environment and Conservation WA. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Request for Quotation.

The methodology adopted and sources of information used by S3 are outlined in this report. S3 has made no independent verification of this information beyond the agreed scope of works and S3 assumes no responsibility for any inaccuracies or omissions. No indications were found during the investigation that information contained in this report as provided to S3 was false.

The report is based on the research undertaken, data provided by stakeholders and information reviewed at the time of preparation. S3 disclaims responsibility for any changes that may have occurred after this time.

<b>LIMITATIONS.....</b>	<b>2</b>
<b>EXECUTIVE SUMMARY.....</b>	<b>5</b>
<b>1. INTRODUCTION .....</b>	<b>9</b>
<i>THE REQUIRED TASKS .....</i>	<i>9</i>
<i>DELIVERABLES.....</i>	<i>10</i>
<i>PROJECT APPROACH.....</i>	<i>10</i>
<b>2. CONFIRMATION OF THE QUANTITIES, LOCATION AND COMPOSITION/TYPES OF USED TYRES BEING DISPOSED IN LANDFILLS IN WESTERN AUSTRALIA .....</b>	<b>13</b>
<i>USED TYRE GENERATION IN WESTERN AUSTRALIA .....</i>	<i>13</i>
<i>FATE OF END-OF-LIFE TYRES.....</i>	<i>13</i>
<i>SUMMARY.....</i>	<i>18</i>
<b>3. REVIEW OF LANDFILL OPERATIONS DEALING WITH USED TYRES .....</b>	<b>21</b>
<i>SUMMARY.....</i>	<i>26</i>
<b>4. AN OVERVIEW OF POTENTIAL IMPACTS AND RISKS OF TYRE RECEIVAL, HANDLING AND BURIAL .....</b>	<b>27</b>
<i>POTENTIAL ENVIRONMENTAL IMPACTS .....</i>	<i>27</i>
<i>Tyre leachate.....</i>	<i>27</i>
<i>Tyre fires .....</i>	<i>30</i>
<i>Tyres as breeding grounds for vermin.....</i>	<i>32</i>
<i>POTENTIAL ECONOMIC IMPACTS.....</i>	<i>32</i>
<i>Risks Associated with Landowner/ facility owner.....</i>	<i>33</i>
<i>Costs of managing a storage facility .....</i>	<i>33</i>
<i>Costs associated with mitigating site contamination .....</i>	<i>34</i>
<i>Future value of used tyres .....</i>	<i>35</i>
<i>Cost of future disposal if no viable reprocessing option is developed.....</i>	<i>35</i>
<i>Economic benefits of tyre storage.....</i>	<i>36</i>
<i>POTENTIAL SOCIAL IMPACTS .....</i>	<i>36</i>
<i>Social benefits of tyre storage.....</i>	<i>36</i>
<b>5. REVIEW OF BEST PRACTICE IN RELATION TO TYRE DISPOSAL AND RECOVERY OPTIONS IN LANDFILL .....</b>	<b>37</b>
<i>ABOVE GROUND STORAGE.....</i>	<i>39</i>
<i>TYRE MONOFILLS.....</i>	<i>39</i>
<i>RETRIEVAL OF TYRES FROM MONOFILL.....</i>	<i>45</i>
<i>SUMMARY.....</i>	<i>49</i>
<b>6. SPECIFIC RECOMMENDATIONS TO ADDRESS ISSUES THAT WOULD DETRACT FROM THE IMPLEMENTATION OF THE RECOMMENDED GUIDELINE.....</b>	<b>51</b>
<b>APPENDIX A: STAKEHOLDERS CONTACTED DURING THE PREPARATION OF THIS REPORT .....</b>	<b>55</b>
<b>APPENDIX B: A RECOMMENDED DRAFT GUIDELINE FOR USED TYRE DISPOSAL IN LANDFILLS IN WESTERN AUSTRALIA TO ASSIST THE RECOVERY OF TYRES FOR REUSE/REPROCESSING .....</b>	<b>57</b>
<i>INTRODUCTION.....</i>	<i>57</i>
<i>Background.....</i>	<i>57</i>

<i>Objectives of the Guideline</i> .....	58
<i>The Guideline's Audience</i> .....	58
<i>WASTE MANAGEMENT FRAMEWORK</i> .....	58
<i>Waste Management Hierarchy</i> .....	58
<i>Statutory Framework</i> .....	59
<i>Best Practice Framework</i> .....	60
<i>BEST PRACTICE SITING CONSIDERATIONS</i> .....	60
<i>Screening for Potential Monofill Sites</i> .....	61
<i>BEST PRACTICE DESIGN</i> .....	68
<i>Environmental Assessment</i> .....	68
<i>Site Layout</i> .....	69
<i>Liner system</i> .....	70
<i>Sub-base</i> .....	71
<i>Clay Layer</i> .....	71
<i>Construction Quality Assurance</i> .....	72
<i>Water Management</i> .....	74
<i>Air Quality</i> .....	76
<i>Noise</i> .....	77
<i>Traffic Considerations</i> .....	78
<i>Site Security and Fencing</i> .....	78
<i>BEST PRACTICE OPERATION</i> .....	78
<i>Financial Assurance</i> .....	79
<i>Acceptance of Tyres</i> .....	79
<i>Pre-treatment of Tyres</i> .....	80
<i>Placement of tyres in the monofill</i> .....	80
<i>Cover</i> .....	82
<i>Fires</i> .....	82
<i>Contingency Planning</i> .....	83
<i>Management of Chemicals and Fuels</i> .....	84
<i>Disease Vector Control</i> .....	84
<i>Noxious Weed Control</i> .....	84
<i>Performance Monitoring and Reporting</i> .....	84
<i>Aftercare</i> .....	85

## **Executive Summary**

The Western Australian Waste Management Board has recently approved a Used Tyre Strategy for Western Australia. The Strategy identified a number of actions that are required including a review of the process by which used tyres are managed at landfill operations and development of a standard that maximises the opportunities for recovery of tyres either now or in the future.

Existing practices and regulations for the management of used tyres in Western Australia act as a barrier to reuse, recycling, and energy recovery, because disposal options are comparatively cheap and do not reflect the real cost of used tyre disposal.

According to the Strategy a reassessment of how used tyres are disposed at landfill is required. The aim of the landfill should be to manage used tyres in a way that, potentially, will provide for maximum recovery in the future. The establishment of tyre monofills, devising ways to maximise the number of used tyres into a specific area and developing ways to reduce the level of contamination would all assist in making the recovery of landfilled tyres more economical.

The Department of Environment engaged S3 to undertake a review of the existing management of used tyres at landfill sites and to develop minimum recommended guidelines for the receipt, sorting and disposal of used tyres at landfill operations so as to provide an opportunity for maximum (economically viable) recovery of used tyres either now or in the future.

The study involved confirmation of the quantities of tyres and types of tyres being disposed to landfills in Western Australia and the locations of these landfills as well as an examination of the current methods used for disposal of tyres to landfill. The potential risks and impacts of tyre handling and burial were examined along with issues relating to the recovery of tyres from landfills.

A review of best practice models for tyre disposal/storage in landfill and the recovery options was used to develop model draft guidelines for the storage of used tyres in landfill for recovery and reuse or recycling in the future.

This report recommends that the best way to manage tyre landfills so that the tyres can be economically recovered is in monofills, either at current landfill sites or at dedicated tyre facilities.

The Used Tyre Strategy defines a tyre monofill as a temporary long-term storage for used tyres. The Strategy suggests it may be possible to reuse tyres from monofills provided:

- the tyre monofill is designed to have clean linings etc to minimise contamination with cover material;
- the tyres themselves are cut, baled or compacted to remove voids;
- quantities are sufficient to warrant recovery; and
- a cheap & effective method of decontamination or cleaning of tyres is developed.

The overview of potential impacts from the receipt and handling of tyres at landfills identified issues to consider during the design and operation of a tyre monofill including:

- Site selection to prevent/alleviate impacts of –
  - Leaching into groundwater;
  - Flooding;
  - Noise affecting nearby uses;
  - Dust affecting nearby uses;
  - Effects on visual amenity;
  - Impacts on cultural values/land use;
  - Access to major transport routes;
- Minimisation of leachate production by having adequate cover;
- Minimisation of contamination of soil and groundwater at the site and in the surrounding area;
- Fire prevention and minimisation of fire spread;
- Minimisation of vermin and insects breeding;
- Need for regulatory certainty regarding tyre disposal requirements;
- Need for financial assurance to ensure ongoing management of facility;
- Need for caveat/land use overlay on title to record storage site; and
- Requirement for easy retrieval and cleaning of tyres.

It is recommended that whole tyres should be compressed in bales prior to storage. Shredded tyres are more likely to leach contaminants and it is difficult to visualise an easy or economical process of retrieval and cleaning for reprocessing of tyres that have been shredded prior to monofilling.

The baling of tyres prior to burial has several advantages. The tyres are compact and can be stacked in an orderly manner into a monofill cell. The additional cost of baling is offset somewhat by the saving in landfill space as up to three times the number of baled tyres can be buried compared with loose tyres. Baling compresses tyres so that air and water are excluded, minimising the risk of fire and leaching. Dirt is also excluded from the interior of the bale.

The design of tyre monofills in the United States seems to be similar to the requirements of a putrescible waste landfill, with liner systems, leachate collection systems and extensive monitoring. A recent study concluded that a similar system should be developed for New Zealand.

However since the primary purpose of tyre monofills in WA will be storage for later retrieval of used tyres for reprocessing, the systems of shredding and cutting of tyres used elsewhere (and noted in the New Zealand study as likely to prove problematic for later recovery) are not appropriate.

The baling system used by STEG at their Brookton monofill results in ongoing clean storage of used tyres and allows their retrieval for later recycling. In addition it overcomes the need for shredding to save landfill space and excludes air and water and lessens the risk of leaching from exposed metal.

With the lower risk of leaching, leachate collection systems are not recommended, though groundwater monitoring and stormwater management would probably be prudent. Similarly the reduced fire risk achieved through exclusion of oxygen, coupled with a system of fire blanket fills between layers and cells should obviate the need for temperature sensors and monitoring. Standard fire control measures such as fencing, access to fire fighting trucks and availability of water for fire fighting should be required as at any landfill.

Although the risks of financial liability for an abandoned monofill should be lower than for a standard landfill due to the inert nature of tyres and their potential value, the requirement for financial assurances and the addition of caveats to titles should be considered.

The most important issues in mitigating financial risk to operators relate to regulatory certainty, particularly regarding requirements for storage of used tyres in monofills rather than disposal to landfill. This can only be resolved through the consistent application of standards and requirements across the State.

These issues were addressed in the development of a draft Guideline for used tyre disposal in landfills in Western Australia to assist the recovery of tyres for reuse/reprocessing, which forms part of this report.

During the course of this project several issues were raised that could potentially detract from the implementation of the Guideline on monofill storage of used tyres. The issues include:

- Lack of enforcement leading to illegal dumping/stockpiling;
- Lack of infrastructure for baling;
- Need to store tyres above ground until sufficient quantities are generated for baling;
- Extra costs for baling before monofilling; and
- Baling is not feasible for larger tyres.

The following recommendations were developed to address these issues:

**Recommendation 1:** Estimate the proportion of unaccounted for tyres by checking the transport information from the Controlled Waste Tracking System against landfill data and sales data, if not

already available under the licence conditions for tyre retailers. Consider developing a requirement for tyre retailers to demonstrate proper disposal of used tyres.

**Recommendation 2:** Encourage Shires to consolidate their tyre facilities so that one tyre landfill is established for each region. Tyres could be transported loose to this site and baled before monofilling. Consider assisting councils to jointly purchase mobile balers that can be kept in the region but moved between sites and/or based at the common tyre landfill site.

**Recommendation 3:** Allow sites to store up to 5,000 tyres for baling using the stockpile guideline prepared by GHD for the Department.

**Recommendation 4:** Consider funding for the purchase of balers and establishment of above ground storage facilities.

**Recommendation 5:** Mine sites should be required to have tyre management plans that ensure maximum recovery of tyres in the future through monofilling with survey and GIS mapping. At tyre monofills oversize tyres should be compressed through baling where possible or otherwise stacked in a cell to an equivalent height of stacked bales.



## **1. Introduction**

The Western Australian Waste Management Board has recently approved a Used Tyre Strategy for Western Australia<sup>1</sup>. The Strategy identified a number of actions that are required including a review of the process by which used tyres are managed at landfill operations and development of a standard that maximises the opportunities for recovery of tyres either now or in the future.

Existing practices and regulations for the management of used tyres in Western Australia act as a barrier to reuse, recycling, and energy recovery, because disposal options are comparatively cheap and do not reflect the real cost of used tyre disposal.

A reassessment of how used tyres are disposed at landfill is required. The aim of the landfill should be to manage used tyres in a way that, potentially, will provide for maximum recovery in the future. The establishment of tyre monofills, devising ways to maximise the number of used tyres into a specific area and developing ways to reduce the level of contamination, all assist in making the recovery of landfilled tyres more economical.

The Department of Environment required a review of the existing management of used tyres at landfill sites and the development of minimum recommended guidelines for the receipt, sorting and disposal of used tyres at landfill operations so as to provide an opportunity for maximum (economically viable) recovery of used tyres either now or in the future.

The study involved confirmation of the quantities of tyres and types of tyres being disposed to landfills in Western Australia and the locations of these landfills as well as an examination of the current methods used for disposal of tyres to landfill. The potential risks and impacts of tyre handling and burial were examined along with issues relating to the recovery of tyres from landfills.

A review of best practice models for tyre disposal/storage in landfill and the recovery options was used to develop model draft guidelines for the storage of used tyres in landfill for recovery and reuse or recycling in the future.

Sustainable Strategic Solutions (S3) is pleased to submit this report to the Department.

### **The required tasks**

The objective of the project was to develop minimum recommended guidelines for the receipt, sorting and disposal of used tyres at landfill operations so as to provide an opportunity for maximum recovery of used tyres either now or in the future.

The consultancy was required to undertake a number of tasks:

---

<sup>1</sup> Used Tyre Strategy for Western Australia (Draft), Department of Environment WA, November 2005.

- Confirm the quantities, location and composition/types of used tyres being disposed in landfills in Western Australia
- Review the landfill operations dealing with used tyres;
- Provide an overview of potential impacts and risks of tyre receipt, handling and burial, and associated issues (leachate, tyre fires, economic or financial risks associated with recovering buried tyres, etc) focussing on Western Australian conditions;
- Review best practice in relation to tyre disposal and recovery options in landfill;
- Develop a model draft standard or guidelines for used tyre disposal in landfills in Western Australia that will assist the recovery of those tyres for reuse/reprocessing either now or in the future;
- Identify and detail all relevant stakeholders that are contacted regarding this consultancy including regional and local governments, mining, landfill operators, tyre recycling and transport companies, etc.; and
- Make specific recommendations to address any pertinent aspects that would detract from the implementation of the recommended standard or guideline.

### **Deliverables**

The deliverables of this project are a consolidated report and possible presentation to the Waste Management Board that provides:

- Documented account of the methodology used in the study;
- Documented account of the organisations/businesses contacted in the analysis, including regional and local governments, mining, landfill operators, tyre recycling and transport companies, etc.;
- Documented findings of each assessment conducted against criteria listed in the scope of works;
- References; and
- Draft guideline/standard for the receipt, handling and disposal of used tyres in landfill so as to provide an opportunity for the maximum (economic viable) recovery of used tyres for reuse/reprocessing.

### **Project approach**

The project was approached in the following stages:

1. Project initiation;

An inception meeting was held with the Department of Environment soon after beginning the project. The purpose of the inception meeting was to:

- Confirm the objectives and deliverables for the project
- Clarify project management and reporting arrangements, and
- Collect available information held by the Department to support the project.

2. Confirmation of the quantities, location and composition/types of used tyres being disposed in landfills in Western Australia;

This stage of the work required a more in-depth examination of the locations of landfills in the State which are receiving used tyres, including those for which information has been obtained through the recent survey of local governments. The Triple Bottom Line analysis conducted by S3 found that only a few landfills receive tyres from the metropolitan area of Perth, the major sites being the ones operated by J.W. Cross and Sons at Stanley Road Australind and the STEG site at Canns Road Bedforddale/Brookton. The data being generated by the recording of the destinations of used tyres under the Controlled Waste Regulations was also useful in confirming the sites and quantities and types of tyres being disposed to landfill.

3. Review of landfill operations dealing with used tyres;

In addition to the sites at Australind and Brookton there are several major regional sites receiving tyres for landfill, including the Humpty Doo facility in the mid west region. Australind, Brookton and Humpty Doo are tyre monofills, though until recently the STEG site has been the only one baling tyres prior to landfill. The survey of local governments provided a great deal of information regarding the location and types of tyres at landfill sites throughout the State as well as revealing the existence of several above ground stockpiles. The data for the most significant of these sites was confirmed through discussion with local governments and regional offices of the Department.

4. An overview of potential impacts and risks of tyre receipt, handling and burial, and associated issues (leachate, tyre fires, economic or financial risks associated with recovering buried tyres, etc) focussing on Western Australian conditions;

Discussions with the operators of the landfills at Australind and Brookton were useful in providing information about issues around the receipt, handling and management of tyres at landfills only receiving tyres. A review of the literature as well as discussion with landfill operators and Departmental officers was used to develop an overview.

5. Review of best practice in relation to tyre disposal and recovery options in landfill;

There is considerable information available from other Australian jurisdictions and from overseas regarding best practice disposal of used tyres. There is less information about storage of tyres in

monofills and the recovery of used tyres from landfill for reprocessing. The review considered the advantages or otherwise of baling before monofilling as well as social and economic issues.

6. Develop a model draft standard or guideline for used tyre disposal in landfills in Western Australia that will assist the recovery of those tyres for reuse/reprocessing either now or in the future;

The review of best practice was used to develop a draft guideline for the storage of tyres in monofills. This draft guideline takes into consideration Western Australian conditions including the need for landfill storage in remote locations and the facilities available in those locations.

7. Specific recommendations to address any pertinent aspects that would detract from the implementation of the recommended standard or guideline.

During the course of the project issues were raised that may be perceived as barriers to the implementation of best practice landfill storage/disposal of tyres for later recovery. These issues are highlighted with recommendations to address them. A full list of recommendations arising from the findings of the project is provided in the Executive Summary as well as in the body of the report.

## 2. Confirmation of the quantities, location and composition/types of used tyres being disposed in landfills in Western Australia

### Used tyre generation in Western Australia

The equivalent of approximately 1.8 million passenger vehicle tyres are sold in Western Australia each year. This equates to about 18,000 tonnes of rubber. It is anticipated that the equivalent amount of used tyres is disposed in Western Australia each year<sup>2</sup>. Western Australia is also one of the largest consumers of oversize or off-the-road (OTR) tyres used in the mining and agricultural industries. In 2002 the OTR import figure for WA was 17,043 tonnes<sup>3</sup>, and given the current resources boom this figure is now likely to be much higher.

Approximately 73% of the tyres are generated in the Perth Metropolitan area, 11% in regional areas (Bunbury, Busselton, Geraldton, Northam, Albany, Kalgoorlie-Boulder, Esperance, Port Hedland, Roebourne and Broome) and the remaining 16% generated in country areas. As a large proportion of tyres generated in the country areas are from the mining and agricultural industries the percentage of EPU would be greater than 16%<sup>4</sup>.

### Fate of end-of-life tyres

For tyres generated in the Perth metropolitan area, it has been estimated that, on a mass basis, approximately 34% are landfilled, approximately 28% are retreaded or used for material recovery, with 1% exported (nominal value) and the remaining 37% are used for acceptable or approved end uses or dumped illegally<sup>5</sup>.

The number of tyres that are reused or recycled in regional and country areas is considerably less. Until recently there has been no reliable data available on used tyre management in country areas.

The data being generated by the recording of the destinations of used tyres under the *Environmental Protection (Controlled Waste) Regulations 2004* was examined to confirm the sites and quantities and types of tyres being disposed to landfill. Nine sites are recorded as receiving tyres from carriers licensed under the Regulations; however the system is unable to generate data on tyre volumes for five of these sites<sup>6</sup>.

---

<sup>2</sup> Used Tyre Strategy for Western Australia (Draft), Department of Environment WA, November 2005.

<sup>3</sup> Economics of Tyre Recycling, ARRB Transport Research Ltd, June 2004.

<sup>4</sup> Economics of Tyre Recycling, ARRB Transport Research Ltd, June 2004.

<sup>5</sup> Economics of Tyre Recycling, ARRB Transport Research Ltd, June 2004

<sup>6</sup> Controlled Waste Branch, Department of Environment.

Table 1: Data from the Controlled Waste Tracking System

Company/Shire	Tyres received (kg) 01/06/05-01/06/06	Tyres received (numbers) 01/06/05-01/06/06	Tyres received (EPU)* 01/06/05-01/06/06
Australind Sand Supplies/JW Cross & Sons	1,031,703	547**	108,600
Hamersley Iron, Tom Price	0	0	0
Reclaim Industries Ltd	2,408,510	157,385	253,527
Shire of Broome, Refuse site	1,050	150**	110
Totals	3,441,263	158,082	362,238
Totals to landfill	1,032,753	697**	108,710

\*EPU is calculated by dividing the weight in kg by 9.5 kg (1EPU)

\*\* These figures may actually be the number of loads of tyres rather than the number of tyres.

Unfortunately it is difficult to have confidence in the data from the Controlled Waste Tracking System (CWTS) at this stage as several of the figures seem to vary widely from those expected. For example in 2005 it was reported that the J.W. Cross and Sons site at Stanley Road Australind was receiving large quantities of oversize tyres from OTR Tyre Repair and Sales (approximately 7 tonnes per day) from Perth, in addition to operating their own bin pick up service in the South West, providing approximately another 4,000 tonnes per annum<sup>7</sup>.

Figures provided in compliance with the requirements of the Landfill Levy<sup>8</sup> show that the JW Cross site received 2,493 tonnes of tyres from the metropolitan region for the 8 months from 1 July 2005 to 1 March 2006. Extrapolated over a full year this would mean approximately 3,739 tonnes of tyres from the metropolitan region were landfilled at Stanley Road. Tyres from outside the metropolitan region are in addition to this figure, so it is likely the Stanley Road site receives at least 7,739 tonnes (814,631 EPU) per year.

Similarly the figure provided for the Shire of Broome (150 loads or tyres/1,050 kg) is much lower than that provided by the Shire itself: 5,000 tyres /year or 85,500 kg (see below).

As Reclaim Industries recycles tyres, sending those that cannot be recycled to the STEG landfill, the Reclaim figures are not included in the total landfill figures. Unfortunately the controlled waste tracking system cannot generate data on the number of tyres being received at the STEG landfill.

Data on the volumes of tyres received by STEG was provided by Peter Bertei.

<sup>7</sup> Rick Cross, JW Cross & Sons, Personal communication, cited in Triple Bottom Line Analysis of the Used Tyre Industry, Sustainable Strategic Solutions for the Department of Environment WA, July, 2005.

<sup>8</sup> Alan Hessey, Department of Environment and Conservation, Personal communication.

Table 2: Volumes of tyres received by metropolitan landfills

Company	Tyres received (kg) 01/06/05-01/06/06	Tyres received (numbers) 01/06/05-01/06/06	Tyres received (EPU) 01/06/05-01/06/06
STEG	4,786,000 (4,786 bales each about 1 tonne)	Approx 502,530 (approx 105 car tyres/tonne)	Approx 503,789
JW Cross	7,739,000	ND	814,631
RCG Quinns	127,000	ND	13,368
Totals to metropolitan landfill	12,652,000	503,077 ++	Approx 1,331,789

++ There is no valid method to calculate the numbers of tyres received by JW Cross or RCG Quinns. The CWTS gives a figure of 547, obviously incorrect, but the other source (Landfill levy) supplies only tonnage of tyres. Neither system provides information on the types of tyres received.

STEG receives baled tyres from Tyre Waste WA who bale tyres collected from retailers as well as the non-recycled tyres they collect from Reclaim Industries and from Tyre Recyclers WA (who also delivers bales to the Cross site at Australind).

Assuming the CWTS data for Reclaim Industries is accurate it is possible to calculate the volume of tyres reprocessed by Reclaim Industries by deducting the volumes of passenger and other tyres sent to STEG<sup>9</sup>. Approximately 103,644 tyres or 984,618 kgs were sent for monofilling at STEG, leaving 53,741 truck tyres (2,552,697 kg) to be recycled.

Data provided by Reclaim Industries for the six months from January to June 2006 confirms this estimate is close. The numbers of tyres received for processing at Reclaim increased from January 2006 when Rick Cross decided to no longer accept truck tyres<sup>10</sup>. For the six months from January 34,199 truck tyres (1,624,452 kg) were received. The numbers received in the preceding six months would have been slightly lower.

Small volumes of tyres are received by other metropolitan landfills: RCG Quinns received 85 tonnes over 8 months (approximately 127 tonnes over a full year), while Red Hill and Hopkinson Road also received tyres but sent them on to STEG<sup>11</sup>.

Discussions were also held with the managers of the major regional landfills receiving used tyres, identified during the recent survey of local governments and other authorities to determine the

<sup>9</sup> Records supplied by Peter Bertei, STEG.

<sup>10</sup> Chris Forrester, Reclaim Industries, Personal communication.

<sup>11</sup> Alan Hessey, Department of Environment and Conservation, Personal communication; Peter Bertei, STEG, Personal communication.

extent and location of stockpiles<sup>12</sup>. The survey was undertaken to identify stockpiles of tyres across the State and incidentally covered landfill sites. The survey did not ask how many tyres are received at the landfill site or how many are buried; only the quantities stockpiled, therefore the survey data is a starting point but in most cases will not be clearly related to the actual quantities of tyres being landfilled.

Landfill operators were asked to confirm the quantities and types of tyres being received at their landfill. In several cases it was very difficult to obtain assistance from the local government manager who referred to the fact that regional offices of the Department of Environment are supplied with this information annually as part of the licence conditions. It would be a useful exercise for the Waste Management Branch to obtain this data from the regional offices for each licensed landfill each year so that it can be centrally available.

Table 3: Tyres received at regional/rural landfills

Local Government	Site	Quantity at site (survey of local governments 2005)	Quantity confirmed*	Types (survey of local governments 2005)	Types confirmed
Albany <sup>13</sup>	Vancouver Waste Services Mindijup Road	No data	4,651/year (1/2/05 – 31/1/06) 83,447 kg 8,784 EPU	No data	67% car, 18% light truck, 14.5% truck, 0.25% tractor tyres, 0.17% oversize
Broome <sup>14</sup>	Buckley's Road	1.14 tonnes, 120 EPU	5,000/year 85,500 kg 9,000 EPU	70% passenger, 30% truck	40% 4WD, 40% car, 20% truck
Busselton <sup>15</sup>	Rendezvous Road, Busselton Transfer Station sent to JW Cross	0.921 tonnes, 97 EPU	Approximately 585/year 8,407 kg 885 EPU	70% passenger, 7% truck, 3% oversize	90% light vehicle, 10% heavy vehicle
	Vidler Road,	0.817 tonnes, 86	Approximately	62% passenger,	80% light

<sup>12</sup> Data from a survey of local Governments in WA, Department of Environment 2005.

<sup>13</sup> Alana Thorpe, South Coast Office, Department of Environment, Personal communication.

<sup>14</sup> Danielle Rippin, Environmental Health Officer, Shire of Broome, Personal communication.

<sup>15</sup> Kylie Rowe, Contract Officer, Shire of Busselton, Personal communication.



*Review of Management of Used Tyres at Landfill Sites*

	Dunsborough Transfer Station sent to JW Cross	EPU	525/year 8,977 kg 945 EPU	17% truck, 21% oversize	vehicle, 20% heavy vehicle
Dundas <sup>16</sup>	Refuse Site, Shire of Dundas	19.99 tonnes, 2105 EPU	Unknown, perhaps 30m <sup>3</sup> approx 550/year 32,651 kg 3,437 EPU	30% passenger, 50% truck, 20% oversize	55% passenger, 35% truck, 10% oversize
Geraldton <sup>17</sup>	Humpty Doo site (Shire does not accept tyres)	No data for landfill site	16,383 (2005) 187,634 kg 19,751 EPU	No data for landfill site	95% passenger tyres, 5% truck tyres
Kalgoorlie- Boulder <sup>18</sup>	Yarri Road Refuse Facility	23.75 tonnes, up to 2500 EPU	11,542 (2005) 306,935 kg 32,309 EPU	35% passenger, 35% truck, 20% oversize	33% car tyres, 29% light truck tyres, 33% truck tyres, 4% miscellaneous
Karratha <sup>19</sup>	7 Mile Road	3.325 tonnes, 350 EPU	(1/7/05 – 1/7/06) 409,000 kg 43,052 EPU	30% passenger, 30% truck, 40% oversize	No breakdown available therefore no estimate of tyre numbers
Port Hedland <sup>20</sup>	North Circular Road, South Hedland	852 tonnes, 89,684 EPU	10,000/annum, forecast to rise in 2006 to 18,000- 20,000/annum 164,255 kg 17,290 EPU	20% passenger, 30% truck, 50% oversize	65% passenger, 14% truck, 21% oversize
Total rural landfill			48,126 tyres +		

<sup>16</sup> Peter Bennett, Shire of Dundas, Personal communication.

<sup>17</sup> Nanette Schapel, Midwest Region, DoE, Personal communication.

<sup>18</sup> Adam Rayner, NRM Officer, Department of Water, Kalgoorlie, Personal communication.

<sup>19</sup> Craig Fitzgerald, Shire of Roebourne, Personal communication.

<sup>20</sup> Darryal Eastwell, Manager Environmental Health, Town of Port Hedland, Personal communication.

			Karratha, 1,269,422 kg 133,623 EPU		
--	--	--	--	--	--

\*Tonnes/EPU has been estimated based on the numbers and types of tyres, using the conversion factors provided in the Used Tyre Strategy<sup>21</sup>. The estimation of tonnes and EPU for tractor tyres has used the conversion figures provided for small tractor tyres, for "earthmoving" and "oversize" tyres the figures for medium earthmoving tyres have been used. 4WD tyres have been treated as car tyres. "Heavy" vehicles were treated as trucks, "light" vehicles as cars, "miscellaneous" as trucks. The figures for Dundas have been derived based on the volume provided and the numbers of tyres collected at Busselton and Dunsborough in similar volumes and using the breakdown of tyre types provided by Dundas shire.

Tyres handled by the Shire of Busselton are collected by JW Cross & Sons for landfilling at the Australind site, so are not included in the total figure for rural landfills. These data have many weaknesses, including the fact that not all rural landfills were surveyed, only those appearing to receive the highest volume of tyres.

In the mid west region the Department of Environment has worked with the shires and with tyre retailers to develop alternative solutions<sup>22</sup> to the Shire landfill. One option is the Humpty Doo facility, a tyre monofill. Two sites in the area also have licences to receive tyres for quarry rehabilitation: Sangarra Plains and Constantine.

Mine sites were not surveyed, however most mine sites in WA dispose of their oversize tyres on-site<sup>23</sup> and there are several other known sites that take oversize tyres, for example Rod Howe (Circle Track Productions) at the Northam Speedway is licensed as an inert landfill to receive tyres. Some of the tyres are used to build embankments for the Speedway but most are buried. The site receives 50 - 60 of the very large haul pack tyres per month from mine sites. The companies pay \$200-400/tyre for disposal at the site<sup>24</sup>.

## Summary

Unfortunately it is still not possible to obtain definitive figures for tyre disposal to landfill, particularly for country landfills. It was hoped that the controlled waste tracking system would assist greatly but it appears that there are still issues with the system. Most notably it cannot provide information for one of the largest tyre landfills in the State; the STEG monofill.

<sup>21</sup> Used Tyre Strategy for Western Australia (Draft), Department of Environment WA, November 2005.

<sup>22</sup> Nanette Schapel, Midwest Region, DoE, Personal communication.

<sup>23</sup> Triple Bottom Line Analysis of the Used Tyre Industry, Sustainable Strategic Solutions for the Department of Environment WA, July, 2005.

<sup>24</sup> Mike Allen, Department of Environment, Personal communication.

If we assume conservatively that 18,000 tonnes of used passenger tyres and another 18,000 tonnes of used oversize tyres are generated annually in Western Australia it can be seen that large volumes of tyres are not accounted for by the landfills surveyed.

A rough calculation based on the figures obtained for rural landfills and the figure for metropolitan landfill (also likely to be an underestimate due to uncertainty regarding the figure for the JW Cross site) shows that around 38% of the 36,000 tonnes total estimated mass of tyres generated per annum in Western Australia is being disposed of to the landfills surveyed.

Table 4: Summary of tyre landfill data

Landfill	Tyres received (kg)	Tyres received (numbers)	Tyres received (EPU)
Metropolitan	12,652,000	503,077 ++	1,331,789
Rural	1,269,422	48,126 + Karratha	133,623
<b>Total</b>	<b>13,921,422</b>	<b>551,203 + Karratha</b>	<b>1,465,412</b>

This figure is slightly higher than the 34% previously estimated<sup>25</sup>. The high proportion of oversize tyres used in WA and disposed of mostly on mine sites and agricultural properties is likely to increase the proportion accounted for to at least 40%.

Another 7% (approximately 2,552,697 kg) of tyres is reprocessed by Reclaim Industries.

A large proportion of the tyres sold in WA is unaccounted for in these estimates. The TJ Waters report<sup>26</sup> estimated that 38% of used tyres in the metropolitan Perth area (on a mass basis) or approximately 10,000 tonne are unaccounted for each year<sup>27</sup>.

If 73% of the 1.8 million used passenger tyres generated in WA each year are in the Perth metropolitan region, an estimate of the unaccounted for tyres can be made using the figures obtained from the landfill levy and derived for this study. A rough calculation suggests almost 66% of the 13,140 tonnes of passenger tyres in the metropolitan region are accounted for by the landfill levy figures.

The tyres recycled by Reclaim are not included as they do not handle passenger tyres. Quite a high proportion of the tyres from the metropolitan region received by JW Cross will not be

<sup>25</sup> Economics of Tyre Recycling, ARRB Transport Research Ltd, June 2004

<sup>26</sup> Technical Report: Management of Used Tyres in Western Australia, TJ Waters Environmental 2003.

<sup>27</sup> Lillias Bovell, Department of Environment, Personal communication.

passenger tyres, however almost all of the tyres received by STEG are passenger tyres. Some of the tyres received by STEG are from outside the metropolitan region.

Table 5: Fate of used tyres from the metropolitan region

Destination	Company	Tyres received (kg)	Percentage Metropolitan Tyres
Landfill	RCG Quinns	127,000	0.96
	STEG	4,786,000	36.42
	JW Cross	3,739,000	28.45
Total		8,652,000	65.8

### 3. Review of landfill operations dealing with used tyres

Tyres are classified as an inert waste under the Environmental Protection Act. The *Environmental Protection Regulations 1987 Part 6 Tyres* determines standards for the storage and disposal of tyres including the Tyre Landfill Exclusion Zone (TLEZ). The Act requires that batches of whole or shredded tyres are covered by at least 500mm of soil and specifies the size of batches that must be separated by at least 100mm of soil. Licensing conditions imposed on landfill operators controls the management of tyres at landfill sites and are administered through regional offices throughout the state.

The two landfills receiving large volumes of used tyres from the metropolitan region (as well as from surrounding country areas) region both bury tyres in monofills. The STEG monofill only receives tyres; the JW Cross landfill is an inert landfill but has dedicated areas for tyres and other rubber.

At the STEG landfill tyres are pressed into bales of 1 tonne at the depot or using a mobile press. The bales are then arranged in landfill cells each containing 1015 bales with a weight of 1015 tonnes<sup>28</sup>.



Baled tyres ready for storage in the STEG monofill, photograph supplied by Paul Turner, GHD.

The cells are buried up to 4 layers deep with a 0.5m minimum clean fill fire blanket between each set of layers. The top layer is dressed with at least 0.8m top soil to encourage plant growth. The

---

<sup>28</sup> Peter Bertei, STEG, Personal communication.

very tight baling means significant exclusion of air to reduce fire risk. As there is clay beneath the monofill water is retained, further reducing the fire risk and minimising any prospect of leaching.



Bale tyres placed in the monofill, photograph provided by Paul Turner, GHD.



Photograph provided by Alan Hessey showing the tyre landfill operation at STEG.

Tyre cells are plotted and logged by GPS before burial to facilitate future recovery. The available storage area is about 100 acres, providing potential storage for 2.5 million tonnes of tyres.



The JW Cross landfill accepts baled tyres and loose tyres. The tyres are either buried or stacked above ground in a “mound” type landfill then surrounded and covered by fill. As this landfill receives both loose and baled tyres, baled tyres are often used to build a “cell” which is filled with loose tyres. Large oversize tyres are stacked and the centre of the stack also filled with loose tyres. Sometimes large stacked oversize tyres are used to form the wall of the cell.



Photographs provided by Alan Hessey showing the tyre landfill operation at the JW Cross landfill.

Many of the regional landfills accepting tyres bury tyres with other waste. Some require shredding prior to burial. These practices were surveyed for the landfills receiving significant volumes of tyres.

The managers of major regional landfills receiving tyres were asked to describe how tyres are landfilled, for example whole, shredded, loose or baled. They were also asked to describe any problems the landfills experience in receiving and storing tyres until they can be landfilled.

Table 6: Management of tyres at regional/rural landfills

Local Government	Site	Method of landfill	Issues
Albany <sup>29</sup>	Vancouver Waste Mindijup Road (Shire does not accept tyres)	Buried whole in dedicated trenches	Only receiving 1-2% of tyres generated in region
Broome <sup>30</sup>	Buckley's Road	Used to reinforce the face of the landfill. Encourage shredding through cheaper disposal rate	Whole tyres create voids, take up too much space
Busselton <sup>31</sup>	Rendezvous Road, Busselton; Vidler Road, Dunsborough	Tyres are stockpiled in a separate section at the waste facility until enough to fill a 10m <sup>3</sup> bin, then transported off-site for landfilling at the Cross site	No issues for the facilities, fees are charged per tyre: \$5/light vehicles, \$10 heavy vehicles
Dundas <sup>32</sup>	Refuse site, Shire of Dundas	Tyres are buried whole in landfill	No accurate figures on tyre volumes (unmanned tip); tyres are difficult to bury; people set tyres alight; dumping from other towns to avoid charges at other tips
Geraldton <sup>33</sup>	Humpty Doo site	Tyres are buried whole & no other wastes are accepted.	High price charged by private landfill is a deterrent.
Kalgoorlie-Boulder <sup>34</sup>	Yarri Road Refuse Facility	Tyres are shredded a few times a year and buried	

<sup>29</sup> Martin Shuttleworth, Vancouver Waste Services, Personal communication.

<sup>30</sup> Danielle Rippin, Environmental Health Officer, Shire of Broome, Personal communication.

<sup>31</sup> Kylie Rowe, Contract Officer, Shire of Busselton, Personal communication.

<sup>32</sup> Peter Bennett, Shire of Dundas, Personal communication.

<sup>33</sup> Nanette Schapel, Midwest Region, DoE, Personal communication.



		with other waste	
Karratha <sup>35</sup>	7 Mile Road	Tyres are separately landfilled whole in a trench 60m long x 8m wide x 3m deep. Location is recorded on electronic & hard copy plans of site	
Port Hedland <sup>36</sup>	North Circular Road, South Hedland	Burial of whole tyres	Very large number of tyres including large road train tyres, causing problems due to licence requirements for stockpiling only 100 tyres at a time, rapid use of landfill space.

The operator of the Vancouver Waste site expressed extreme concern regarding the fate of used tyres in the region. In Albany alone there are at least 15,000 cars and seven tyre retailers, yet the facility receives only 3,000 car tyres per year. The facility is a dedicated tyre landfill. Vancouver Waste provides a bin to each retail premise and collects tyres but the bins are frequently empty. The bins are not in locked areas and retailers complain that members of the public use the bins to dump their tyres, however it is more frequently the case that the tyres disappear from the bins before collection. Retailers complain that the charge of \$2 per car tyre is too high. Only one of the retailers appears to be properly disposing of its tyres. The Controlled Waste Tracking System does not seem to be in operation in the region. Tyres from Denmark are reportedly sent to Albany but Vancouver Waste does not receive them.

The TJ Waters study<sup>37</sup> noted that only 10,000 of the 40,000 tyres sent to Albany each year are returned to Perth. It is unlikely that many tyres are currently returning to Perth and since only 4,600 per year are accounted for it appears at least 35,000 tyres are being used for "tree guards and bunding" probably on private properties. This issue warrants enforcement attention.

A business in Broome is considering the shredding of tyres on a commercial basis. If this occurs the shire operated landfill will stockpile tyres so they can be shredded.

<sup>34</sup> Adam Rayner, NRM Officer, Department of Water, Kalgoorlie, Personal communication.

<sup>35</sup> Jon Jones, Shire of Roebourne, Personal communication.

<sup>36</sup> Darryal Eastwell, Manager Environmental Health, Town of Port Hedland, Personal communication.

<sup>37</sup> Technical Report: Management of Used Tyres in Western Australia, TJ Waters Environmental 2003.

The Town of Port Hedland is experiencing major difficulties with the disposal of tyres. Already receiving approximately 10,000 tyres per annum, the resource boom has seen a significant increase in road train traffic to local mine sites, leading to a forecast doubling in the number of these tyres requiring disposal. The site currently has a Department of Environment licence allowing for the stockpiling of 100 tyres until burial, a major limitation when a company recently delivered 900 tyres in one day.

There are no contractors in the area able to assist with recycling, shredding, baling or cutting, all of which would make the issues more manageable. The biggest problem is the pressure this volume of tyres places on the existing landfill space. The Town would be keen to participate in establishing a regional tyre facility.

### **Summary**

Country landfills experience a range of problems with accepting tyres. These problems include the displacement of other wastes in the landfill due to the space they take up, whole tyres “floating” in the landfill leading to instability, difficulties in meeting licence conditions for daily cover and the risk of fires. Some landfills have attempted to overcome these problems through requiring or encouraging tyre shredding, and while this does assist the management of tyres in the landfill it prevents any future recovery of the resources in the tyres. Other sites are avoiding the problems caused by tyres in mixed landfills by using cells dedicated to tyre monofill.

There are already several tyre monofills, including Australind, Brookton, Humpty Doo and the Vancouver Waste site at Albany. Tyres are baled before monofilling at Brookton and the Australind site accepts a mixture of baled and loose tyres.

Tyre monofills within a landfill operation can be considered as a temporary long-term storage for used tyres. How used tyres are stored in landfills impacts on the potential reuse applications that are available for those tyres.

## **4. An overview of potential impacts and risks of tyre receival, handling and burial**

Discussions with the managers of landfills receiving tyres were useful in providing information about issues around the receival, handling and management of tyres. Assuming a shift away from landfill disposal to the concept of storage of tyres in monofills, which seems to be required if the Government is to achieve the aim of future recovery of used tyres, the potential impacts of storing tyres in monofills were examined.

A review of the literature, particularly from overseas where tyre monofills are well established, was undertaken to develop a broader overview of these issues and of the economic or financial risks associated with recovering buried tyres, etc focussing on Western Australian conditions.

### **Potential environmental impacts**

The most commonly reported potential environmental impacts associated with tyre storage<sup>38</sup> were:

- compounds leaching from the tyres and contaminating soil, groundwater and surface water;
- tyre fires causing the release of pyrolytic oils and other compounds into the soil and groundwater and smoke, coupled with contaminated runoff of water used to extinguish the fire;
- tyre piles may become breeding grounds for insects, particularly mosquitoes, rodents and other animals.

### **Tyre leachate**

A great deal of research has been undertaken to determine whether or not tyres “leach” contaminants into the environment. The issue has been confused by the comparison of different types of tests.

The NSW Extended Producer Responsibility Priority Statement lists chemicals leaching from dumped tyres as one of the reasons for listing tyres as a priority waste product. “Data is currently limited on the toxicity of tyre leachate to terrestrial organisms. However preliminary studies indicate that leachate from tyres may, under certain circumstances, be toxic to aquatic organisms. Leachate

---

<sup>38</sup> End-of-Life Tyre Management: Storage Options Final Report for the Ministry for the Environment (New Zealand), MWH New Zealand, July 2004.

from tyre pieces and crumbs appears to be more toxic than leachate from whole tyres, but only whole tyres are likely to be used in the aquatic environment<sup>39</sup>.

MWH New Zealand undertook a review of reported leachate testing of tyres, both in the laboratory and in landfills<sup>40</sup>. In the laboratory tyre leachate is often generated by inundating a tyre sample (plug, shred, chip, or crumb) with water. The New Zealand report<sup>41</sup> concluded that the following general observations can be made about the tyre leachate generated in the laboratory:

- it may be toxic to some fish species (eg rainbow trout but not minnow), bacteria, invertebrates and green algae;
- levels of aluminium and manganese are likely to be elevated, especially where steel is exposed;
- levels of mercury and lead may be elevated; however most studies reported negligible levels;
- levels of zinc and organic compounds are likely to be dependent on individual circumstances as a wide range of levels have been reported in the studies reviewed;
- levels of other substances are likely to be below United States Drinking Water Standards; and
- levels of leachate compounds (metals and organic compounds) are likely to increase with time of inundation, increase proportionally with amount of tyre and decrease proportionally with size of tyre exposed to inundation.

The same authors reviewed field trials in which tyre leachate is generated by water percolating through the tyre sample (whole tyre, shred or chip) and made the following general observations:

- levels of manganese and iron are likely to be elevated in groundwater, especially when steel is exposed;
- levels of aluminium, zinc and organic compounds may be elevated in groundwater; however the majority of studies reported negligible levels;
- levels of cadmium and lead may be elevated in soil; however no studies reviewed reported elevated levels in groundwater;

---

<sup>39</sup> A Review of the Toxicity of Tyre Leachate in the Environment with an Assessment of the Necessity for Further Research and Recommendations for Further Research, Environment Protection Authority, Sydney, November 2001, unpublished, cited in Report on the Extended Producer Responsibility Consultation Program, Department of Environment and Conservation, NSW, March 2004.

<sup>40</sup> End-of-Life Tyre Management: Storage Options Final Report for the Ministry for the Environment (New Zealand), MWH New Zealand, July 2004.

<sup>41</sup> End-of-Life Tyre Management: Storage Options Final Report for the Ministry for the Environment (New Zealand), MWH New Zealand, July 2004.

- levels of other substances measured are likely to be below United States Drinking Water Standards; and
- levels of leachate compounds in groundwater are likely to decrease down gradient of the tyre site.

The potential environmental impacts of tyre leachate are contamination of soil, surface water and groundwater on the site and surrounding area. MWH<sup>42</sup> listed several factors that may affect the rate of leaching and/or the concentration of tyre leachate compounds in soil, surface water and groundwater:

- *tyre size*: leaching from whole tyres is likely to be slower than leaching from tyre chips or shreds – this is because of the differences in the surface area to volume ratio;
- *amount of exposed steel*: if steel is exposed, say in tyre chips, there is likely to be faster leaching of manganese and iron than from whole tyres where the steel is not exposed;
- *chemical environment*: leaching of metals is likely to be more rapid under acidic conditions while leaching of organic compounds is likely to be more rapid under basic conditions;
- *permeability of soil*: leaching is likely to be faster when soils are permeable;
- *distance to groundwater table*: the greater the vertical distance to the groundwater table, the less likely the contamination of groundwater;
- *distance from tyre storage site*: the further the downstream distance from the tyre storage site, the lower the contaminant concentration in the soil and groundwater;
- *contact time with water*: the longer the tyres are in contact with water, the greater the risk of groundwater contamination;
- *vertical water flow through soil*: the greater the water flow through the soil (eg, from rainfall), the greater the dilution of contaminants;
- *horizontal groundwater flow*: the greater the groundwater flow, the greater the spread of the contaminant plume;
- *leached compounds at site*: levels of manganese and iron are likely to be elevated in groundwater when steel is exposed. Levels of aluminium, zinc and organic compounds

---

<sup>42</sup> End-of-Life Tyre Management: Storage Options Final Report for the Ministry for the Environment (New Zealand), MWH New Zealand, July 2004.

may be elevated in groundwater. Levels of zinc, cadmium and lead may be elevated in soil.

Later work by some of the same researchers reviewed by MHW<sup>43</sup> found that the dilution of tyre leachate to levels comparable to the flow rate of streams where fish and other vulnerable aquatic organisms are found showed that at these levels tyre leachate is not lethal. It has also been established that the rate of leaching slows considerably and the lethality to fish of water containing tyre leachate drops significantly over time.

Making the case for the use of whole baled tyres in civil engineering projects one author<sup>44</sup> concludes that it is nearly impossible to make tyre water that kills fish outside the lab when tyres are used in this way. First, if there is no water then there will be no leaching. Many tyre derived products are dry most of the time or all of the time so they will not leach. Second, if there is too much water, the concentration of the pollutants will be undetectable. Third, over the long term (more than six months) there are no significant leachates even with exactly the correct volume of water.

The conclusion seems to be that leaching from whole tyres is negligible compared with leaching from tyre shred or chips. Properly constructed landfill storage of whole tyres should therefore not present problems in this regard. Measures to address any concerns regarding the possibility of tyre leachate are discussed in Chapter 5, the Review of Best Practice and provided in the draft Guideline at Appendix B.

### Tyre fires

Tyres are very difficult to ignite<sup>45</sup>, however once they are burning tyre fires are very difficult to extinguish. A wide variety of decomposition products are generated during scrap tyre fires<sup>46</sup>. The decomposition products include

- ash (typically containing carbon, zinc oxide, titanium dioxide, silicon dioxides, etc);
- sulphur compounds (carbon disulfide, sulphur dioxide, hydrogen sulphide);

<sup>43</sup> Abernethy, S.G., B.P. Montemayor and J.W. Penders, 1996, The Aquatic Toxicity of Scrap Automobile Tyres, *Report prepared for: Waste Reduction Branch, Ontario Ministry of Environment and Energy*, PIBS 3509E.; Nelson, S.M., G. Mueller, D.C. Hemphill, 1994, Identification of Tire Leachate Toxicants and a Risk Assessment of Water Quality Effects Using Tire Reefs in Canals, *Bulletin of Environmental Contamination and Toxicology*, 52:574-581.

<sup>44</sup> Leachate from Tyres – Exploring the Myths, Eric Claus, Claus Environmental Engineering

<sup>45</sup> Basel Convention Technical Guidelines on the Identification and Management of Used Tyres, Basel Convention on the control of transboundary movements on hazardous wastes and their disposal. Document No. 10, Basel Convention Working Group, 1999.

<sup>46</sup> International Association of Fire Chiefs (IAFC), Scrap Tyre Management Council (STMC) and National Fire Protection Association (NFPA) (2000) *"The Prevention and Management of Scrap Tire Fires"*, cited in End-of-Life Tyre Management: Storage Options Final Report for the Ministry for the Environment (New Zealand), MWH New Zealand, July 2004.

- polynuclear aromatic hydrocarbons (such as benzo(a)pyrene, chrysene, benzo(a)anthracene, etc) are usually detected in oil runoff;
- aromatic, naphthenic and paraffinic oils;
- oxides of carbon and nitrogen;
- particulates; and
- various light-end aromatic hydrocarbons (such as toluene, xylene, benzene, etc).

The extent to which each of these and other combustion products are generated depends on the circumstances of each fire<sup>47</sup>.

Uncontrolled tyre fires usually have major environmental impacts, which include<sup>48</sup>:

- *air pollution*: black smoke and other substances such as volatile organic compounds, dioxins and polycyclic aromatic hydrocarbons are released into the atmosphere
- *water pollution*: the intense heat allows pyrolysis of the rubber to occur, resulting in an oily decomposition product which is manifested as an oil runoff. This runoff can be carried by water, if water is used to put out the fire. Other combustion residues (such as zinc, cadmium and lead) can also be carried by fire water off the site
- *soil pollution*: residues that remain on the site after the fire can cause two types of pollution; these are immediate pollution by liquid decomposition products penetrating soil, and gradual pollution from leaching of ash and unburned residues following rainfall or other water entry.

The costs associated with fighting and cleanup of tyre fires depends upon the size and location of the tyre stockpile. A tyre fire at Salisbury in Queensland in 1992 is estimated to have cost the fire brigade \$750,000 to extinguish and clean up the site. A similar fire at Bindoon, Western Australia in 1990 is estimated to have cost the WA EPA \$600,000 to clean-up a contaminated watercourse<sup>49</sup>. There are also potential health impacts from tyre fires. A fire at a retail tyre outlet in Sydney in 2002 caused the hospitalisation of people from surrounding areas due to respiratory concerns<sup>50</sup>.

Fires can also occur within landfills providing there is enough oxygen for combustion.

---

<sup>47</sup> Waste Tyres, Understanding the challenge, Goodyear Tyre and Rubber Company, Akron, Ohio, USA 1990, cited in Best practice environmental management of waste tyres: Storage, transport, reuse, reprocessing and disposal Department of Primary Industries, Water and Environment, February 2002.

<sup>48</sup> *Basel Convention Technical Guidelines on the Identification and Management of Used Tyres*, Basel Convention on the control of transboundary movements on hazardous wastes and their disposal. Document No. 10, 1999, cited in End-of-Life Tyre Management: Storage Options Final Report for the Ministry for the Environment (New Zealand), MWH New Zealand, July 2004

<sup>49</sup> Best practice environmental management of waste tyres: Storage, transport, reuse, reprocessing and disposal, Department of Primary Industries, Water and Environment (Tasmania), February 2002.

<sup>50</sup> Report on the Extended Producer Responsibility Consultation Program, Department of Environment and Conservation, NSW, March 2004.

Measures to prevent tyre fires in landfill storage facilities are discussed in Chapter 5, the Review of Best Practice and provided in the draft Guideline at Appendix B.

#### **Tyres as breeding grounds for vermin**

Dumped or stored tyres can provide habitat for weeds and pest animals. Water in dumped tyres can be a suitable environment for breeding mosquitoes, which are a nuisance and a health hazard, being vectors for diseases such as Ross River Virus, Dengue Fever and also Malaria<sup>51</sup>.

Measures to control weeds and vermin at tyre storage facilities are discussed in Chapter 5, the Review of Best Practice and provided in the draft Guideline at Appendix B.

#### **Potential economic impacts**

The disposal of tyres in mixed waste landfills can cause solid waste management problems<sup>52</sup>. Whole tyres consume large amounts of space and contain voids, which allow the movement of gases and liquids. Buried whole tyres have been reported to rise back to the surface and to destabilise compacted landfills. Most states in Australia have restrictions or bans in place controlling waste tyre disposal in landfills.

The storage of tyres in monofills should avoid the problems encountered in mixed landfills. The space required to store tyres in landfill can be dramatically reduced by baling tyres prior to storage.

There are a number of potential economic impacts and financial risks associated with the long term storage of tyres in monofills.

The potential financial risks or areas of financial sensitivity associated with tyre storage include<sup>53</sup>:

- risks associated with the landowner and storage facility owner;
- costs of managing the facility, including meeting any regulatory requirements, insurances, site aftercare;
- costs associated with mitigating site contamination;
- future value of end-of-life tyres; and
- cost of future disposal if a viable reprocessing option is not developed.

---

<sup>51</sup> Best practice environmental management of waste tyres: Storage, transport, reuse, reprocessing and disposal, Department of Primary Industries, Water and Environment (Tasmania), February 2002.

<sup>52</sup> Report on the Extended Producer Responsibility Consultation Program, Department of Environment and Conservation, NSW, March 2004.

<sup>53</sup> End-of-Life Tyre Management: Storage Options Final Report for the Ministry for the Environment (New Zealand), MWH New Zealand, July 2004.



#### Risks Associated with Landowner/ facility owner

The risks to be considered in this category include:

- the landowner/facility owner may abandon the land, creating a large liability associated with the cost of either cleaning up the site or continuing to operate the site;
- the landowner/facility owner may not have sufficient funds to cover future costs associated with the site, again creating a potentially large liability associated with the costs of either cleaning up the site or continuing to operate the site;
- the landowner/facility owner may sell the land without informing the new owner that tyres are/were stored on the land. If the new landowner is unaware of the situation, they may not have sufficient funds to cover the costs associated with the site, for example to cover clean up costs.

If the owner does abandon the site or becomes unable to cover the future costs associated with the site, sufficient funding should be available either to continue to manage the site or to dispose of the tyres in an environmentally sound manner and reinstate the site. This is also true if a new owner is unable to meet the costs associated with the site. Measures to ensure this funding is available are discussed in Chapter 5, the Review of Best Practice and provided in the draft Guideline at Appendix B.

Potential buyers can be alerted to the existence of a tyres storage facility through a caveat on the land title or a planning overlay. The Department of Environment and Conservation may also serve an Environmental Protection Notice on the site to ensure ongoing management of the site and place the site on the Contaminated Sites Register to ensure that all potential future stakeholders are aware of the ongoing management requirements of the site.

The potential sources of revenue for a private tyre storage facility are gate fees collected when tyres are received at the facility and income received when tyres are later sold to a reprocessing facility.

#### Costs of managing a storage facility

Factors that may affect the financial situation of a storage facility include<sup>54</sup>:

- collection and transport costs;
- regulatory requirements, which could address environment protection measures, environmental monitoring measures, operational control measures, and financial risk mitigation measures;

---

<sup>54</sup> End-of-Life Tyre Management: Storage Options Final Report for the Ministry for the Environment (New Zealand), MWH New Zealand, July 2004.

- change in credit rating of facility operator;
- change in economic climate, eg, land rental increases (for leased sites), cost of borrowing increases, cost of insurance increases, cost of bonds increases, etc;
- underestimation of time before a reprocessing facility will be established;
- reprocessing facility is not established and the owner must pay for disposal of stored tyres;
- overestimation of tyre volumes or gate fees received at the facility, for example if there are no legal requirements to dispose of tyres at a specific type of storage facility; and
- unexpected remediation requirements.

The most obvious economic impacts relate to the costs of establishing and managing tyre monofills and the subsequent cost of “disposing” of tyres to the facility. It is doubtful that most rural landfills are charging at a level that would cover the cost of monofill cell construction, particularly if baling prior to monofilling was also required. Of course the costs of receiving and storing tyres may be recovered in the near future when demand for tyres for recycling increases. In the short term however, increased charges for tyre management are likely to impact on tyre collectors and retailers and eventually consumers. This extra cost is likely to be absorbed without difficulty so long as the same requirements for tyre storage are imposed on all operators and there is a level playing field. A requirement that all used tyres sent to landfill are to be stored in monofills will overcome uncertainty regarding competition with other landfills.

Certainty regarding regulatory requirements can be provided through licensing conditions based on the draft Guideline at Appendix B. Financial assurances to ensure ongoing management or remediation of the site are discussed in Chapter 5, the Review of Best Practice.

#### Costs associated with mitigating site contamination

Tyre storage sites can become contaminated through slow leaching, for example of heavy metals or through flooding of the site. This contamination may result in groundwater or stormwater contamination leading to financial liability for monitoring and clean-up. These risks have been discussed and measures to avoid them are provided in the draft Guideline.

Tyre fires can lead to large discharges of contaminants to air, water and soil. There are generally large costs associated with tyre fires, including:

- costs associated with fire fighting, which are usually large because tyre fires can take weeks or years to extinguish;
- costs associated with onsite and offsite environmental clean-up, which tend to be large because of the severe environmental damage caused directly by the fire and smoke plume fallout and indirectly by the water runoff from fire fighting;

- financial losses associated with losing the tyre stores; and
- costs associated with litigation regarding for example, health and safety matters, and property damage.

The potential for tyre fires can be greatly reduced through the application of measures discussed in the Best Practice Review and included in the draft Guideline.

#### Future value of used tyres

The future value of used tyres is dependent on several factors including the impact of the proposed national Product Stewardship scheme for tyres which will help to determine market demand for the resource.

In Western Australia the future value will also depend upon the establishment (or continuation) of viable reprocessing facilities and the development of markets for reprocessed rubber and other tyre derived products.

Other factors to be considered<sup>55</sup> for each storage facility include:

- the cost of retrieving tyres from storage (which will be dependent on the method of storage);
- the cost of transporting stored tyres to the reprocessing facility (which will be independent of storage method but dependent on the location of the storage site); and
- the cost of cleaning tyres if contaminated with dirt.

The best methods of storage for easy retrieval and low contamination are discussed in the Review of Best Practice.

#### Cost of future disposal if no viable reprocessing option is developed

This area of financial risk applies to the above ground storage of tyres. If monofills are established under licence as a subset of inert landfills and have been operated according to the Guideline there is no reason why the tyres stored should need to be moved to a disposal facility in the future, even if no viable options for their use are developed.

The financial risks remaining in this situation are a need for some ongoing monitoring of the stability of the monofill (not likely to be onerous) and the loss of potential income from resale of the tyres as well as issues concerning possible other uses of the site.

---

<sup>55</sup> End-of-Life Tyre Management: Storage Options Final Report for the Ministry for the Environment (New Zealand), MWH New Zealand, July 2004.

### Economic benefits of tyre storage

There are likely to be considerable economic benefits in the long term from the improved management of used tyres as a resource for the future. These benefits should include business and employment opportunities for Western Australians, perhaps in regional and rural areas and the freeing of other resources which are replaced with tyre derived products. Ending the practice of burying tyres in mixed landfill will also benefit rural landfills, freeing up landfill space and resolving the management problems caused by whole tyres floating in landfills.

### Potential social impacts

The major potential social impact of tyre storage is the potential health risk posed by insects and vermin breeding in tyre piles. These issues are not important when considering below ground storage, except for a possible interim stockpile stage until tyres can be buried or baled for burial. The Guideline for stockpiling of tyres<sup>56</sup> recently developed for the Department of Environment should consider these issues.

All landfills have the potential to impact on visual and other aspects of amenity, through increased noise and dust created by trucks and earthmoving equipment and storage of tyres prior to monofilling. There are also potential impacts on land use and cultural values that need to be considered when planning for monofills.

All of these impacts need to be considered in siting and operating the monofill and are addressed in the Guideline at Appendix B.

The occupational health and safety issues of managing tyre storage facilities are in some ways different from the issues involved in other tyres of landfill, particularly in the degree of handling of tyres for baling and it may be necessary to ensure that safe manual handling practices are understood and enforced.

### Social benefits of tyre storage

There should be a range of social benefits accruing from the proper management of used tyres including alleviating problems for disposal for country landfills, preventing illegal dumping and providing possible business or community development opportunities for small communities<sup>57</sup>. These issues should be examined as part of planning for centralised storage locations. In the longer term the recovery of used tyres as a resource will also provide social benefits in terms of employment and business opportunities as well as resource conservation.

---

<sup>56</sup> Recovery of Tyres in Remote Locations, GHD for the Department of Environment WA, July 2006.

<sup>57</sup> Triple Bottom Line Analysis of the Used Tyre Industry, Sustainable Strategic Solutions for the Department of Environment WA, July, 2005.

## **5. Review of best practice in relation to tyre disposal and recovery options in landfill**

The WA Government Used Tyre Strategy<sup>58</sup> aims to maximise the opportunities for the recovery of tyres (and the resources embodied in those tyres) either now or in the future. The Strategy states that current used tyre management practices act as a barrier to reuse, recycling, and energy recovery options because, under existing Western Australian practices and regulations, these disposal options are comparatively cheap and do not reflect the real cost of used tyre disposal.

The aim of tyre landfills should be to manage tyres so that they can be economically recovered. The first step would be the isolation of tyres from other wastes, that is in monofills, either at current landfill sites or at dedicated tyre facilities. Consideration of how to protect tyres from contamination by soil, which may add to the cost of recovery and of maximising the numbers of tyres in a specific monofill are also important in eventual economic recovery of used tyres.

The Used Tyre Strategy defines a tyre monofill as a temporary long-term storage for used tyres. The Strategy notes that no tyre monofills have been identified as being “mined” to date, however the absence of examples may be more a reflection on the policy of banning of landfilling of tyres by other jurisdictions rather than an assessment of the economics of recovery.

The Strategy suggests it may be possible to reuse tyres from monofills provided:

- the tyre monofill is designed to have clean linings etc to minimise contamination with cover material;
- the tyres themselves are cut, baled or compacted to remove voids;
- quantities are sufficient to warrant recovery; and
- a cheap & effective method of decontamination or cleaning of tyres is developed.

There has been very little recovery of tyres from landfill for recycling to date and few landfill facilities have been designed as storage facilities to enable this recovery. While there is considerable information available from other Australian jurisdictions and from overseas regarding best practice disposal and storage of used tyres, there is little information available on the below ground storage of tyres intended for later recovery. For example, the Tasmanian Department of Primary Industries, Water and Environment has produced a Best Practice Guideline<sup>59</sup> for the management of waste tyres that requires that:

---

<sup>58</sup> Used Tyre Strategy for Western Australia (Draft), Department of Environment WA, November 2005.

<sup>59</sup> Best practice environmental management of waste tyres: Storage, transport, reuse, reprocessing and disposal Department of Primary Industries, Water and Environment (Tasmania), February 2002.

(i) All waste tyres from passenger cars, light trucks, and trucks are cut or shredded, including separation of the tyre tread and the side-walls, to reduce the tyre volume by at least 50%, before burial in landfill.

(ii) Whole waste tyres from vehicles, other than passenger cars, light trucks and trucks providing each tyre is placed in the waste depot in a manner that removes at least 90% of the void within the tyre, such as filling of the void with soil or refuse.

In Victoria and in the wider metropolitan area of NSW there is also a requirement to shred tyres before landfilling to overcome problems at landfills caused by loose tyres. The requirement to shred tyres is an extra cost to the tyre collector<sup>60</sup>.

Other States, such as Queensland limit the quantities of used tyres that may be disposed of whole at any one landfill site each year<sup>61</sup>. For new (from 2004) development applications the number of whole tyres disposed of annually at any one facility is limited to 10,000 EPU. The Queensland EPA policy states that this is the national and international best practice policy position. Tyres disposed to landfill must be covered regularly to limit the potential for fire and mosquito breeding events.

Most used tyres generated in Western Australia are disposed of to landfill. This includes the tyres generated in the metropolitan region, where a Tyre Landfill Exclusion Zone (TLEZ) seems to have been totally ineffective in encouraging the diversion of tyres from landfill due to the number of exemptions granted to allow metropolitan landfills to receive tyres and the availability of landfill outside the TLEZ<sup>62</sup>.

There is no requirement for shredding prior to landfilling though some councils refuse to accept whole tyres at their landfills.

The disposal of tyres is regulated under the Environment Protection Act *Environmental Protection Regulations 1987 Part 6 Tyres*:

"tyres may be disposed of by burial under a final soil cover of not less than 500 mm —

(a) in batches separated from each other by at least 100 mm of soil and each consisting of not more than 40 cubic metres of tyres reduced to pieces; (2 cubic metres = 100 used tyres, so 40 = 2,000)

(b) in batches separated from each other by at least 100 mm of soil and each consisting of not more than 1 000 whole tyres; or

---

<sup>60</sup> Economics of Tyre Recycling, ARRB Transport Research Ltd, June 2004.

<sup>61</sup> Limitation on the disposal of whole tyres at new landfills Operational policy Environmental Protection Agency (Queensland), August 2004.

<sup>62</sup> Triple Bottom Line Analysis of the Used Tyre Industry, Sustainable Strategic Solutions for the Department of Environment WA, July, 2005.

(c) in the case of tyres in any volume or number in a dump existing on 4 December 1992, at the location of that dump, in accordance with such conditions as are imposed by the Chief Executive Officer in respect of that burial for the purpose of ensuring that drainage, safety, soil erosion and soil stability at, and in the vicinity of, the site of that burial are adequately controlled.”

As in other States of Australia and other countries, including the US and the UK, there is a system in place to track the movement of used tyres to disposal or recycling facilities. The Controlled Waste Tracking System in WA has only been extended to used tyres in the last year.

### **Above ground storage**

It is likely that there will be the need to store tyres above ground for some period prior to monofilling. The Department of Environment has recently commissioned a study to produce guidelines to cover this storage<sup>63</sup>.

Factors that need to be considered for above ground storage of tyres to be monofilled for future recovery include<sup>64</sup>:

- fire prevention and minimisation of fire spread, for example by using minimum distances between piles;
- minimise leachate production, eg by covering tyre pile;
- minimise leachate contamination into soil and groundwater, eg, by having a compacted clay surface; and
- minimise vermin and insects breeding.

Another issue to consider is the need to keep tyres as clean as possible; this might be achieved through covering tyre piles and/or storing the tyres on a compacted or gravel surface.

There are several best practice guidelines available for the above ground storage of tyres, for example from the UK<sup>65</sup>.

### **Tyre monofills**

As noted in the Used Tyre Strategy there is little technical information that specifically addresses the design and operation of tyre monofills. This lack of information has been confirmed by others including MWH in their report for the New Zealand Ministry for the Environment<sup>66</sup>.

---

<sup>63</sup> Recovery of Tyres in Remote Locations, GHD for the Department of Environment WA, July 2006.

<sup>64</sup> End-of-Life Tyre Management: Storage Options Final Report for the Ministry for the Environment (New Zealand), MWH New Zealand, July 2004.

<sup>65</sup> UK Waste Tyre Management Best Practice: Handling of Post-Consumer Tyres – Collection & Storage, The Waste & Resources Action Programme [www.wrap.org.uk](http://www.wrap.org.uk), May 2006.

<sup>66</sup> End-of-Life Tyre Management: Storage Options Final Report for the Ministry for the Environment (New Zealand), MWH New Zealand, July 2004.

MWH did find some information in current waste management regulations contained in the California Code of Regulations (administered by the California Integrated Waste Management Board, CIWMB)<sup>67</sup> and in the Ohio Administrative Rules<sup>68</sup> (administered by the Ohio Environmental Protection Agency). This information suggests tyre monofills are constructed and operated as sanitary landfills with a liner and leachate collection system.

There is also a Basel Convention guideline on the management of used tyres<sup>69</sup>.

There are many examples of guidelines for the construction of landfills for inert and putrescible waste. The Department of Environment has recently produced a new draft Best Practice Environmental Management Guideline for Siting, Design, Operation and Rehabilitation of Landfills (Class III) which is based on the Guideline used by the EPA Victoria<sup>70</sup>.

The overview of potential impacts from the receipt and handling of tyres at landfills identified issues to consider during the design and operation of a tyre monofill including:

- Site selection to prevent/alleviate impacts of –
  - Leaching into groundwater;
  - Flooding;
  - Noise affecting nearby uses;
  - Dust affecting nearby uses;
  - Effects on visual amenity;
  - Impacts on cultural values/land use;
  - Access to major transport routes;
- Minimisation of leachate production by having adequate cover;
- Minimisation of contamination of soil and groundwater at the site and in the surrounding area;
- Fire prevention and minimisation of fire spread;
- Minimisation of vermin and insects breeding;
- Need for regulatory certainty regarding tyre disposal requirements;
- Need for financial assurance to ensure ongoing management of facility;
- Need for caveat/land use overlay on title to record storage site; and

---

<sup>67</sup> Waste Tire Monofill Proposed Regulatory Requirements. California Integrated Waste Management Board, October, 2003.

<sup>68</sup> Ohio Administrative Code, [www.epa.state.oh.us](http://www.epa.state.oh.us)

<sup>69</sup> Basel Convention Technical Guidelines on the Identification and Management of Used Tyres, Basel Convention on the control of transboundary movements on hazardous wastes and their disposal. Document No. 10, Basel Convention Working Group, 1999.

<sup>70</sup> Margaret Redfern, Licensing Policy Unit, Department of Environment, Personal communication.



- Requirement for easy retrieval and cleaning of tyres.

The requirements of the CIWMB, the Ohio Rules and the Basel Convention were compared for information regarding each of the aspects identified. Although not directly relevant for inert waste such as tyres the draft Best Practice Environmental Management Guideline for Siting, Design, Operation and Rehabilitation of Landfills (WA) was included. The methods used by the STEG monofill were also included for comparison as they are being currently used by a tyre monofill in WA.

Table 7: Comparison of regulatory requirements for tyre monofills

Criteria	Basel Convention <sup>71</sup>	CIWMB	Ohio EPA <sup>72</sup>	BPEM Guideline	STEG <sup>73</sup>
Siting	Not on wetlands, floodplains, ravines, canyons, steep grade	Not in areas subject to floods in 100 year period Seismic design criteria	Road grade specified to control erosion, dust Survey marks to measure stability	Consider: Community needs, buffer distances, groundwater, surface water, flora & fauna, geology, infrastructure, cultural issues Method of fill to minimise dust, control measures, noise control	
Minimise leachate production		No fire damaged tyres Limits on steel exposure in shred, sampling & records required	Cap system to minimise infiltration	No acid sulfate soil to be used as fill or cover	Baling with press compresses tyres, excluding water
Minimise contamination of soil & groundwater	Flat site with concrete /hard clay surface to capture run off	Stormwater control & diversion; Fire water runoff containment Construction Quality Assurance required	Recompacted soil liner, constructed using at least 4 lifts, max permeability specified, soil particle size & compaction specified Membrane liner not used due to heat from burning pyrolytic oils in fire Leachate collection system Stormwater management for 25 year storm event	Best site has clay attenuation layer Sub-base & clay liner Stormwater management, groundwater monitoring Cap gradient to minimise run-off Construction Quality Assurance required	

<sup>71</sup> Most of this information is sourced from Guidelines For the Prevention and Management of Scrap Tyre Fires (International Security and Fire Department Access - The Scrap Tyre Management Council).

<sup>72</sup> Ohio Administrative Code, Rule 3745-27-72 Scrap tire monofill facility construction; Rule 3745-27-73 Final closure of a scrap tire monofill facility; Rule 3745-27-15 Financial assurance for solid waste facility or scrap tire transporter final closure; Rule 3745-27-75 Operational criteria for a scrap tire monofill facility, [www.epa.state.oh.us/rules.htm](http://www.epa.state.oh.us/rules.htm)

<sup>73</sup> STEG Tyre Storage Systems, STEG submission to Minister for Environment and Waste Management Board, December 2005.

Fire prevention	<p>Ban smoking/open air burning</p> <p>Chain link fence around perimeter at least 3m high, on-site security when open, Gates &amp; roads must allow fire vehicle access</p> <p>Water supply</p> <p>Layers to 2.5m thick, separated by layer 0.3m earth, hard core</p> <p>Compaction</p> <p>Cover daily</p>	<p>Tyres must be "altered" for compaction but fines &amp; small fragment fraction is controlled to minimise fires; Altering includes baling. Sampling &amp; records required compaction of top layer</p> <p>Cells 6m deep, 1,161 m<sup>2</sup>, 2 feet between cells</p> <p>Limits on organic matter in fill (&lt;5%)</p> <p>Only 2 cells open at any time</p> <p>Cover daily</p> <p>Temperature sensors between vertical cells, records required</p> <p>Stockpile of cover required</p> <p>Fire safety training of staff</p> <p>Fire Prevention, Control &amp; Mitigation plan</p>	<p>Burning tyres to be separated &amp; immediately extinguished</p> <p>Cover weekly</p>	<p>Wire mesh fence around perimeter at least 2 m high</p> <p>Cover each day 0.3m</p> <p>No ignition sources, water supply, firebreaks</p>	<p>Baling with press removes oxygen</p> <p>Cells with up to 4 layers, min 0.5m fill fire blanket between each 2 layers</p> <p>2m clean fill firewall between stacks of layers</p>
Minimise vermin & insects			Cover weekly	<p>Compaction of wastes (not specifically tyres)</p> <p>Cover each day 0.3m</p> <p>Noxious weed control</p>	Baling with press prevents breeding
Regulatory certainty: tyre disposal requirements					
Financial assurance to ensure ongoing management		<p>Post closure management</p> <p>Financial assurance required</p>	<p>Post closure management 15 years</p> <p>Financial assurance required for scrap tire storage facilities</p>	<p>Post closure management</p> <p>Financial assurance required</p>	

Caveat/land use overlay on title to record site			Requirement to record on title deed use as scrap tire facility, location, volumes, types, depth etc	Caveat/land use overlay on title to record site	GPS monitoring & logging of site
Easy retrieval & cleaning of tyres		Mining requires approved site-specific excavation & material management plan	Only tires > 24 inch may be placed in cell whole		Baled tyres easy to retrieve & transport Minimal soil& water entry to bale = minimal contamination

It is interesting to note the emphasis on fire control in the CIWMB Regulations. Many of these requirements are due to the decision to shred tyres for compaction to exclude air and save space. The report used by the CIWMB as technical background<sup>74</sup> for the prescriptive standards in the Waste Tire Monofill Regulations notes that shredded tyres are vulnerable to landfill fires, stating that several shredded tires fills have been reported to combust but the mechanism that causes the internal heating that leads to combustion is not presently well understood. One best practice Guideline for storage of used tyres<sup>75</sup> states that stored shredded tyres with metal content should be continually monitored for heat build up due to oxidation of the metal which generates enough heat to start fires.

Shredded tyres are also more likely to leach contaminants. It is difficult to visualise an easy or economical process of retrieval and cleaning for reprocessing of tyres that have been shredded prior to monofilling.

The baling of tyres prior to burial has several advantages. The tyres are compact and can be stacked in an orderly manner into a monofill cell. The additional cost of baling is offset somewhat by the saving in landfill space as up to three times the number of baled tyres can be buried compared with loose tyres<sup>76</sup>. Baling compresses tyres so that air and water are excluded, minimising the risk of fire and leaching. Dirt is also excluded from the interior of the bale.

### **Retrieval of tyres from monofill**

As there are no reports in the literature of tyres being recovered from monofills (or other landfills) for reprocessing, it was decided to retrieve bales from a cell at the STEG monofill and open them to determine the levels of preservation and contamination. The trial was undertaken in January 2006, with the assistance of STEG and in the presence of Departmental officers and consultants involved with developing advice to the Board and the Department on used tyre management.

The tyres had been compressed and buried in bales for about 3 years. A front-end loader was used to scrape the soil away from the edge of the cell, exposing the wall of bales. A bale was then lifted out of the cell. There was obviously some clay and sand on the outside of the bale. Photographs of the retrieval process have been kindly provided by Paul Turner from GHD.

---

<sup>74</sup> Technical Considerations for Scrap Tire Monofills by Geosyntec Consultants, Inc., April 25, 1998,

<sup>75</sup> UK Waste Tyre Management Best Practice: Handling of Post-Consumer Tyres – Collection & Storage, The Waste & Resources Action Programme [www.wrap.org.uk](http://www.wrap.org.uk), May 2006.

<sup>76</sup> Triple Bottom Line Analysis of the Used Tyre Industry, Sustainable Strategic Solutions for the Department of Environment WA, July, 2005.



The steel bands holding the tyres in the bale were intact and in good condition. When the bands were cut with wire cutters the tyres were released from the pressure but they did not spring apart suddenly, rather they slowly began to expand and to resume their original shape.







Each individual tyre within the bale was quite clean and dry, with only the tyres on the outside edges of the bale showing some surface dirt and moisture. It would appear that the tyres are not contaminated to any extent and certainly not to the extent that would make reprocessing difficult.

The trial also showed that bales could be retrieved and transported whole to a reprocessing facility, representing a potentially large saving in transport costs.

A reasonable proportion of the tyres landfilled in WA has been monofilled and at the STEG site almost all have been baled prior to burial. At the JW Cross and Sons site some tyres are baled but others are buried loose. The space saved by baling means there is effectively unlimited storage available at the STEG monofill alone for the total estimated mass of tyres generated per annum in Western Australia.

As an interim measure until market demand increases, a requirement that tyres must only be stored baled in a monofill could be considered. This could possibly also be applied to country landfills.

The most economical method would be to wait until a stockpile of several thousand tyres has accumulated at a Council site or at several neighbouring sites, and then have the tyres baled by a mobile baler. The mobile baler owned by the current operator can handle 2,500 tyres per day, i.e. producing 25 bales per day<sup>77</sup>.

When baled, 1,000 tyres can be stored in a landfill cell 2m deep x 10m long x 5m wide, easily dug with a front end loader. Councils or Regional Councils could establish small tyre monofills. Alternatively tyre storage facilities could be privately managed.

---

<sup>77</sup> David Gooch, Tyre Waste WA, Personal communication.



While the current landfill fees for baled and unbaled tyres are almost identical it is obvious that baling reduces the amount of land needed considerably. This may or may not be a deciding factor when establishing rural and remote storage facilities. The extra cost of baling can be offset by both lower land costs and cheaper costs for eventual transport to Perth and perhaps by cheaper recovery costs.

The only estimates for the cost of extracting tyres from landfills are derived for cleaning up illegal dumps of used tyres<sup>78</sup>. The cost of extracting tyres from the ground was given at \$0.10 per tyre and cleaning for shredding \$0.15 per tyre. There would also be transport and handling costs of approximately \$0.20 per tyre. These costs were estimated for cleaning up a large dump (over 100,000 tyres) of loose tyres, where there would be significant economies of scale. The recovery trials undertaken at STEG in early 2006 indicated that very little cleaning would be required for baled tyres.

Baling is not currently practicable for oversize tyres, although a baler has been redesigned to compress tyres up to 2.5 m<sup>79</sup>. Tyres this size can be compressed to one-third of their original size (1 tyre/bale) and there is a possibility of further redesigning balers to manage larger tyres and compress them further. Since none of the regulatory guidelines surveyed require baling the issue has not been considered. The Ohio EPA allows large tyres to be buried whole at the face of the cell.

David Gooch has also undertaken trials to cut oversize tyres into 10-12 pieces using jigsaws, a labour intensive process. The cut pieces are then compressed into a bale with the exposed steel in the centre<sup>80</sup>. However as it has been shown that shredded and cut tyres are more likely to leach contaminants into the environment due to the exposed steel, the best option is probably burial of whole tyres, perhaps in a dedicated monofill cell.

## **Summary**

The design of tyre monofills in the United States seems to be similar to the requirements of a putrescible waste landfill, with liner systems, leachate collection systems and extensive monitoring. The MWH study<sup>81</sup> concluded that a similar system should be developed for New Zealand. If tyres were to be shredded to landfill in WA these standards should be adopted.

However since the primary purpose of tyre monofills in WA will be storage for later retrieval of used tyres for reprocessing, the systems of shredding and cutting of tyres used elsewhere (and noted in the New Zealand study as likely to prove problematic for later recovery) are not appropriate.

---

<sup>78</sup> A National Approach to Waste Tyres, prepared for Environment Australia by Atech Group, 2001.

<sup>79</sup> David Gooch, Tyre Waste WA, Personal communication.

<sup>80</sup> David Gooch, Tyre Waste WA, Personal communication.

<sup>81</sup> End-of-Life Tyre Management: Storage Options Final Report for the Ministry for the Environment (New Zealand), MWH New Zealand, July 2004.

The baling system used by STEG results in ongoing clean storage of used tyres and allows their retrieval for later recycling. In addition it overcomes the need for shredding to save landfill space and excludes air and water and lessens the risk of leaching from exposed metal.

With the lower risk of leaching, leachate collection systems are not recommended, though groundwater monitoring and stormwater management would probably be prudent. Some tyre monofills have been required to conduct groundwater monitoring in the past in WA but this has been discontinued<sup>82</sup>. Similarly the reduced fire risk achieved through exclusion of oxygen, coupled with a system of fire blanket fills between layers and cells should obviate the need for temperature sensors and monitoring. Standard fire control measures such as fencing, access to fire fighting trucks and availability of water for fire fighting should be required as at any landfill.

Although the risks of financial liability for an abandoned monofill should be lower than for a standard landfill due to the inert nature of tyres and their potential value, the requirement for financial assurances and the addition of caveats to titles should be considered.

The most important issues in mitigating financial risk to operators relate to regulatory certainty, particularly regarding requirements for storage of used tyres in monofills rather than disposal to landfill. This can only be resolved through the consistent application of standards and requirements across the State.

---

<sup>82</sup> For example the Vancouver Waste Services site at Albany, Karen Goobourne, DoE, Personal communication.

## **6. Specific recommendations to address issues that would detract from the implementation of the recommended guideline**

During the course of this project several issues were raised that could potentially detract from the implementation of the Guideline on monofill storage of used tyres (at Appendix B). The issues include:

- Lack of enforcement leading to illegal dumping/stockpiling;
- Lack of infrastructure for baling;
- Need to store tyres above ground until sufficient quantities are generated for baling;
- Extra costs for baling before monofilling; and
- Baling is not feasible for larger tyres.

Perhaps the most important of these is the issue of enforcement. In spite of the classification of used tyres as a controlled waste and the requirement for their transport to be tracked through the Controlled Waste Tracking System, large quantities of tyres are unaccounted for, particularly in the south-west of the State. These tyres are being illegally dumped or stockpiled and it is likely that requiring more expensive storage will only exacerbate this problem unless steps are taken to enforce proper management. The Controlled Waste Tracking System does not seem to have been implemented in Albany.

**Recommendation 1:** Estimate the proportion of unaccounted for tyres by checking the transport information from the Controlled Waste Tracking System against landfill data and sales data, if not already available under the licence conditions for tyre retailers. Consider developing a requirement for tyre retailers to demonstrate proper disposal of used tyres.

The recent survey of local governments<sup>83</sup> established that there are numerous used tyre stockpiles around the State. There are also many small landfills receiving small quantities of tyres in numbers too low to justify the establishment of dedicated tyre monofills or the purchase of a baler. Rationalising the number of storage sites would greatly assist with the management of used tyres and would facilitate recovery of the resource in the future. A previous report<sup>84</sup> identified criteria for determining the optimal sites for storage nodes:

---

<sup>83</sup> Survey of local Governments in WA, Department of Environment 2005.

<sup>84</sup> Triple Bottom Line Analysis of the Used Tyre Industry, Sustainable Strategic Solutions for the Department of Environment WA, July, 2005.

- Sufficient generation of used tyres in a defined catchment area;
- Proximity to major transport routes; and
- Availability of appropriate sites and management.

In addition to existing monofills (all privately operated), thirteen Shire landfills were identified as possible storage locations. There is also a need to establish at least one or two facilities between Derby and the Kununurra region and a site at Meekatharra or Mt Magnet.

Except for two businesses based in Perth there are no tyre balers in the State. Mobile balers are able to visit sites within reasonable proximity to Perth; however more remote regions require their own equipment, which might be shared between neighbouring Councils or travel between sites in a region. A mobile baler can be purchased for \$100,000<sup>85</sup>.

**Recommendation 2:** Encourage Shires to consolidate their tyre facilities so that one tyre landfill is established for each region. Tyres could be transported loose to this site and baled before monofilling. Consider assisting councils to jointly purchase mobile balers that can be kept in the region but moved between sites and/or based at the common tyre landfill site.

A previous study<sup>86</sup> found that once demand for rubber for recycling increases it will be economically viable to transport used tyres by road or rail from as far north as Broome to Perth for recycling and from north of Broome to Darwin, perhaps for export. It is not however economically viable to transport tyres to Perth for storage.

The preferred method of storage is as bales in a tyre monofill however it often takes a period of time for sufficient tyres to accumulate at any one rural location to justify a visit by a mobile baler. Tyre Waste WA has a mobile baler and has travelled to some rural landfills to bale tyres; however they have found it is uneconomical to return baled tyres to the STEG monofill at current prices and would like to investigate the option of baling for burial at local Shire landfill sites, perhaps in a small monofill cell. Councils are willing to pay \$1-2/tyre which will cover the costs of taking the baler to regional centres such as Quairading and Albany and even Esperance and but will not cover the costs of transport back to the STEG landfill at Brookton. Baling, with travel and handling costs is about \$1.10/car tyre, \$2.50 for 4-wheel drive and small truck tyres and \$8.50 for larger truck tyres. The mobile baler can handle 2,500 tyres per day, ie producing 25 bales per day<sup>87</sup>. The baler can not handle very large OTR tyres, although balers are currently being redesigned to handle tyres up to 2.5m in diameter.

---

<sup>85</sup> David Gooch, Tyre Waste WA, Personal communication.

<sup>86</sup> Triple Bottom Line Analysis of the Used Tyre Industry, Sustainable Strategic Solutions for the Department of Environment WA, July, 2005.

<sup>87</sup> David Gooch, Tyre Waste WA, Personal communication.

Councils are currently able to store only 100 tyres without additional licence conditions; however the Department is currently investigating the possibility of removing this restriction<sup>88</sup>.

Assuming tyres will be accumulated for storage above ground it will be necessary for the sites to have some form of managed storage to ensure there is minimal fire risk and risk of vermin breeding. Ideally the storage conditions would also minimise contamination of the tyres with dirt, for example by providing cover.

**Recommendation 3:** Allow sites to store up to 5,000 tyres for baling using the stockpile guideline prepared by GHD<sup>89</sup> for the Department.

Requirements to bale tyres and store them in a monofill will raise the price of used tyre management. This cost will be passed on to consumers where possible, however there is a risk that illegal dumping will increase (see Recommendation 1 above). Some assistance could be provided to Councils to establish above ground storage facilities (for tyres awaiting baling) and purchase balers. There has been a rebate available to Councils from the Resource Recovery Rebate Scheme (RRRS) for diverting used tyres from landfill although it is rarely claimed<sup>90</sup>. With the proposed changes to the RRRS rebate the Waste Management Board might consider diverting some strategic funds for this purpose.

**Recommendation 4:** Consider funding for the purchase of balers and establishment of above ground storage facilities.

There is currently no recycling of rubber from earthmoving tyres in Australia. The large percentage of steel in these tyres (up to 50%) and the large size makes shredding difficult<sup>91</sup>. There are currently no balers or shredders in Australia capable of handling large oversize tyres. In the future baling of oversize tyres may become practical and trials are currently underway showing it is possible to compress tyres up to 2.5m into a bale one third of their original size<sup>92</sup>.

Given the amount and quality of rubber and steel available in OTR tyres, strong demand is likely to emerge for these tyres for recycling.

---

<sup>88</sup> Margaret Redfern, Department of Environment Licensing Branch, Personal communication.

<sup>89</sup> Ronan Cullen, GHD Pty Ltd, Personal communication.

<sup>90</sup> Triple Bottom Line Analysis of the Used Tyre Industry, Sustainable Strategic Solutions for the Department of Environment WA, July, 2005.

<sup>91</sup> Issues and Options for the Management of Waste Tyres in the Australian Mining Industry, Sustainable Strategic Solutions for the Minerals Council of Australia, June 2006.

<sup>92</sup> David Gooch, Tyre Waste WA, Personal communication.

While some mining companies have developed Environmental Guidelines to manage the disposal of used tyres, for example requiring the surveying and recording of the site of burial of tyres, this is not required by regulation. Under the Environmental Protection Regulations 1987 “tyres may be disposed of by burial under a 500 mm layer of soil in batches separated by 100mm of soil”. Mine sites in WA have no license conditions relating to tyre disposal and there is no requirement to bury tyres separately from other inert waste. Most tyres are buried on site.

There are different regulatory requirements for the management of tyres on mine sites around the country, which could be used as models for WA. The Queensland EPA has a policy statement relating to the disposal and storage of tyres at mine sites which limits the size of stockpiles and provides guidance as to acceptable disposal methods on site. Disposing of scrap tyres and other wastes on mine sites is a notifiable activity under schedule 2 of the Environment Protection Act 1994, and the locations of the disposal site(s) need to be recorded on the Environmental Management Register<sup>93</sup>.

The Ohio EPA<sup>94</sup> allows the disposal of off-the-road construction and mining equipment tyres, that have a bead width of at least fourteen inches and a rim or wheel diameter of a least twentyfour inches, at an off-road construction or mining site. The owner of the scrap tires has to be the owner or lessee of the off-road construction or mining site where the scrap tyres are to be or were disposed and totally bury the scrap tyres in that portion of the off-road construction or mining site least likely to be disturbed by future construction or mining. Only tyres from the equipment operated by the owner or lessee may be accepted as acceptance of other tyres would create an unlicensed landfill.

**Recommendation 5:** Mine sites should be required to have tyre management plans that ensure maximum recovery of tyres in the future through monofilling with survey and GIS mapping. At tyre monofills oversize tyres should be compressed through baling where possible or otherwise stacked in a cell to an equivalent height of stacked bales.

---

<sup>93</sup> Disposal and storage of scrap tyres at mine sites, Operational Policy EPA Queensland.

<sup>94</sup> Ohio Administrative Code Section 3734.86, Rule 3745-27-60, [www.state.oh.us](http://www.state.oh.us)

## Appendix A: Stakeholders contacted during the preparation of this report

Stakeholder	Contact details
Vic Andrich Waste Management Branch Department of Environment	08 6364 7008 vic.andrich@environment.wa.gov.au
Peter Bennett Manager of Work Shire of Dundas	9039 1205 peterb@dundas.wa.gov.au
Peter Bertei STEG	0418 923389
Lillias Bovell Controlled Waste Branch Department of Environment	9222 7147
Ronan Cullen GHD Pty Ltd	6222 8222 ronan.cullen@ghd.com.au
Darryal Eastwell Manager Environment and Health Services Port Hedland	0427 110533
David Gooch Tyre Waste WA	9459 2468
Karen Goodbourne/ Alana Thorpe Albany District Office Department of Environment	9842 5760
Alan Hessey Inspector / Compliance Officer Landfill Levy Waste Management Branch Department of Environment and Conservation	0407 944932 6364 7021 <a href="mailto:alan.hessey@dec.wa.gov.au">alan.hessey@dec.wa.gov.au</a>
Jon Jones/ Craig Fitzgerald Shire of Roebourne	0408 906040 <a href="mailto:jon.jones@roebourne.wa.gov.au">jon.jones@roebourne.wa.gov.au</a>
Margaret Redfern Licensing Policy Unit Department of Environment	6364 6994 <a href="mailto:margaret.redfern@environment.wa.gov.au">margaret.redfern@environment.wa.gov.au</a>
Adam Rayner Natural Resource Management Officer Kalgoorlie Department of Water	9026 2222 <a href="mailto:adam.rayner@water.wa.gov.au">adam.rayner@water.wa.gov.au</a>
Danielle Rippin Environmental Health Officer Shire of Broome	08 9191 3443 <a href="mailto:danielle.rippin@broome.wa.gov.au">danielle.rippin@broome.wa.gov.au</a>
Kylie Rowe	9781 0359

Contract Officer Shire of Busselton	kylier@busselton.wa.gov.au
Nanette Schapel Midwest Region DoE	9964 5978 nanette.schapel@environment.wa.gov.au
Martin Shuttleworth Vancouver Waste Services	9842 9666



## **Appendix B: A recommended draft guideline for used tyre disposal in landfills in Western Australia to assist the recovery of tyres for reuse/reprocessing**

### **Introduction**

#### **Background**

Most used tyres in Western Australia are disposed of to landfill. The Waste Management Board's Used Tyre Strategy for Western Australia aims to facilitate the development of a sustainable used tyre recycling industry for the State, providing a viable alternative to disposal of used tyres. There is growing demand for used tyres as a resource for recycled rubber, for use in construction projects and as a fuel source. A national Product Stewardship scheme for tyres, to be launched in 2007, is likely to accelerate the growth of this demand.

Until demand meets supply however there is still a need to manage the 1.8 million tyres replaced in WA each year. A major impediment to improving the management of used tyres in Western Australia is the availability of inexpensive landfill and stockpiling options. Stockpiling of used tyres defers disposal and has the potential to place an unfunded burden on future landholders and government. Inexpensive disposal of used tyres, particularly whole tyres, to landfill amounts to the loss of a reusable resource.

Current used tyre management practices act as a barrier to reuse, recycling, and energy recovery options because, under existing Western Australian practices and regulations, these disposal options are comparatively cheap and do not reflect the real cost of used tyre disposal.

The aim of the landfill should be to manage used tyres in a way that, potentially, will provide for maximum recovery in the future. The establishment of tyre monofills, maximising the number of used tyres stored in a specific area and with measures to reduce the level of contamination will assist the economical recovery of landfilled tyres.

This Guideline is a source document for best practice management for tyre monofills, with the aim of achieving maximum possible recovery of used tyres in the future and providing safe, environmentally sound storage in the interim. As the aim of this guideline is to maximise the probability of recovery of the used tyres in the future, economic and social issues as well as environmental issues are considered. The Guideline also takes into consideration the need for landfill storage in remote locations and the facilities available in those locations.

The Guideline is based on the Best Practice Environmental Management Guideline for Siting, Design, Operation and Rehabilitation of Landfills produced by the Department of Environment and Conservation and draws on a review of best practice regarding tyre disposal and recovery options

in landfill. It provides a framework of management objectives, required outcomes and suggested measures that may be used to achieve or surpass the objectives.

#### Objectives of the Guideline

This guideline aims to provide existing and future operators of tyre landfills, planning authorities and regulating bodies with:

- information on the potential impact of tyre landfills on the environment and how this is to be assessed;
- a clear statement of environmental, social and economic performance objectives; and
- information on how to avoid or minimize adverse environmental, social and economic impacts, to assist them to meet the objectives.

This guideline is intended to be a default position for tyre landfill siting, design and operation. Existing landfill operators should, as far as possible, implement the relevant best practice measures.

#### The Guideline's Audience

The target audience for this guideline is:

- Regional Waste Management Councils, particularly in the screening and ranking of potential tyre storage sites;
- Planning authorities, particularly in the preservation of planning attributes, such as buffer distances, of designated future sites;
- Landfill operators in all elements of the guideline, but particularly in the design, operation and aftercare of tyre landfills;
- The broader community so that a wider understanding can be reached of the valuable resource represented by used tyres and the need to conserve this resource for the future;
- Regulators, understanding what the expected standards are and to give some guidance to how to achieve these standards.

#### **Waste management framework**

##### Waste Management Hierarchy

When making decisions regarding the management of all wastes, including municipal and industrial wastes, the following hierarchy must be followed at all times:

- (a) avoid;

- (b) minimise;
- (c) recycle;
- (d) treat;
- (e) dispose.

This hierarchy is expressed in the Waste Management Board's Strategic Direction document and cuts across all aspects of waste management, regardless of source.

When a generator has exhausted all possibilities for waste avoidance and reduction, then the alternatives for reuse, recycling and reclamation should be investigated. If there is no possibility of transporting tyres to a recycling facility in the short to medium term, storage in landfill to enable future recycling or reuse can be undertaken. This landfill storage should not be considered a means of final disposal.

#### Statutory Framework

All landfill operations must comply with the *Environment Protection Act 1986* (EP Act), its Regulations and relevant Environmental Protection Policies.

The following types of landfills are defined in the Environment Protection Regulations 1997 and are subject to the works approval provisions of the EP Act:

- Category 63 (Class I) – inert landfills
- Category 64 (Class II, III) – putrescible landfills
- Category 65 (Class IV) – secure landfills
- Category 66 (Class V) – intractable landfill

Tyres are classified as an inert waste and dedicated tyre monofills would be Class I landfills, however many rural landfills are licensed as Class II or III landfills due to the majority of the waste received being putrescible. These landfills may have one section dedicated to tyre monofill.

It is suggested that tyre monofills be classified as a sub-section of inert (Class I) landfills.

A works approval must be obtained before a landfill can be constructed or significantly modified. Operating Class I, II and III landfills are also subject to licensing. The licence conditions set the performance objectives of the operating landfill, define operating parameters and commonly require monitoring to check on environmental performance. The legislation that is particularly relevant is described below.

## Environmental Protection Act 1986

The principle legislative vehicle for pollution control in Western Australia is the *Environmental Protection (EP) Act 1986*.

The EP Act regulates the discharge or emission of waste to water, land or air by a system of works approvals and licences. The acceptable environmental quality standards and conditions for discharging waste and identification of beneficial uses of the environment are specified in relevant Environment Protection Policies (EPPs).

## Environment Protection Policies

EPPs set out policies of the Government to manage the environment. These policies establish the environmental quality that must be attained and maintained to protect designated beneficial uses (i.e. amenity, health, ecosystem protection). Policies typically set quantitative, ambient, environmental (e.g. air, water, soil) objectives, and specify measures that must be implemented to minimise the risk of activities causing the policy's ambient standards to be exceeded.

Activities that result in environmental quality objectives being exceeded or cause pollution may be subject to enforcement action.

## Best Practice Framework

This document is intended to provide guidance for how landfill operators can meet the environment protection objectives of the regulatory framework. This is achieved by establishing a hierarchy of objectives, required outcomes and suggested measures for each section of the document. The objectives and required outcomes must be achieved. The suggested measures are suggestions for how to achieve the objectives and required outcomes.

## Best practice siting considerations

The primary environmental control on a landfill is appropriate siting. A preliminary investigation of all possible sites should be conducted to identify sites with the best potential to be developed for tyre storage in landfill.

The objective of this section is to establish the means and criteria for identifying and ranking those sites that are the most appropriate for future landfills. These sites require the fewest engineering and management controls to meet all relevant environmental, social and economic objectives.

An investigation of the sites that have the best potential for a tyre monofill is conducted in two steps:

- a broad approach to identify all potential sites for new facilities from a broader group of all possible sites; and
- ranking of the potential sites in terms of their preference for use as a monofill.

The investigation is will result in a ranking of preferred sites within and adjacent to the area to be served by the monofill. This ranking should be used in the development of planning strategies for the region, and the development of new monofills should be in accordance with this ranking.

#### Screening for Potential Monofill Sites

Screening for potential monofill sites starts with a list of all possible sites. As a minimum, this should include all extractive industry sites and existing landfill sites in the region, but may also include undeveloped sites, which may be suitable for trench-and-fill landfills (see section on monofill type).

The hierarchy of aspects to be considered when screening for potential landfill sites is:

1. Community needs
2. Landfill type
3. Buffer distances
4. Groundwater
5. Surface water
6. Flora and fauna
7. Infrastructure
8. Geology
9. Land ownership
10. Aboriginal and heritage issues

These are discussed in detail below.

Once a list of potential landfill sites has been derived from a list of all possible landfill sites, this list should be ranked to indicate the preferred order of development of potential sites as landfills.

#### Community Needs

Full community engagement is expected for any project that may impact upon the community.

Generally, local government is responsible for providing a framework for the orderly development of waste management facilities for both the public and private sectors, and ensuring that a reliable system of waste management, including tyre monofill space, is maintained within a region. A monofill should not be located where it is not needed for the storage of a community's used tyres.

It is important to liaise with the community very early in the planning stage, as this enables early identification of the issues that are important to the local community and environment. These issues have an impact on the siting, design and operation of the monofill. Liaison unlocks the significant amount of local knowledge contained by the community, enabling insights into how better environmental outcomes may be achieved. The visual impact of the operation is often one of the key aspects that a community expects to be addressed. The clever use of natural screening to reduce the visual intrusiveness of storage operations is one way of ensuring that the monofill fits in with the general community. This should be considered at a very early stage, and particular care should be used to construct bunds for visual screening, noise barriers and landscaping. This is particularly important for rural sites where tyres will often need to be stored above ground for some time until sufficient numbers are available for baling.

Best practice measures for community consultation include:

- recognising that local knowledge may provide useful insights leading to better environmental outcomes
- being readily contactable and flexible in dealing with community concerns
- listening to all community concerns and ensuring a considered response is provided to all concerns raised.

Further information on successful consultative programs can be obtained from DEC's Interim Industry Guide to Community Involvement document.

### Monofill type

When screening for potential monofill sites, consider the type of monofill to be developed.

The four basic types of **landfills** and the hierarchy of their preference for use is:

- area method where an existing hole such as a former quarry is filled;
- trench-and-fill method where a hole is dug and back filled with waste using the excavated material as cover;
- mound method where most of the landfill is located above the natural ground level; and
- valley or change of topography fill method where a natural depression is filled.

For tyre monofills trench-and-fill is the preferred method because it enables the operator to determine exactly how the cells are to be configured on the ground, for the best possible design of the monofill.

The area method does not offer the usual outcome for landfill of rehabilitating an existing hole, as the tyres are to be retrieved in the future. The mound method is not appropriate for tyre monofills due to the requirements for stability and fire management.

Valley fill landfills require complex engineering solutions as they have inherent environmental problems such as unstable slopes, water infiltration and potential leachate seepage.

#### Buffer Distances

An adequate separation (buffer) distance should be maintained between the monofill and sensitive land uses to protect sensitive land uses from any impacts resulting from normal and upset monofill operating conditions, such as offensive odours, noise, insects and dust. Sensitive land uses include houses, schools, hospitals, airports and market gardens.

Buffer areas are not an alternative to providing appropriate management practices, but provide for contingencies that may arise with typical management practices. Where this buffer is not available, management practices need to be significantly improved to provide the same level of protection to sensitive land uses. While buffers have traditionally been used to protect residential amenity, the buffer for a landfill may also protect different segments of the environment such as watercourses (for example in the event of a tyre fire).

The EPA recommends (EPA Guidance for the Assessment of Environmental Factors Draft Guidance Statement No. 3, Separation Distances Between Industrial and Sensitive Land Uses) a minimum buffer distance of 150 metres from an inert landfill to protect the environment and to prevent any amenity reduction in sensitive areas. Buffer distances are measured from the activities capable of causing a nuisance to the nearest sensitive land use. This buffer of 150 metres will protect sensitive land uses from the possible effects of a tyre monofill facility.

Land within buffer areas may be used for purposes that are not adversely affected by the facility. It is preferred that this land is owned or at least under the control of the monofill operator. This is not to imply that the monofill owner must own the buffer but to make the point that an adequate buffer is required to protect amenity.

#### Groundwater

A review of possible impacts of used tyre storage in monofills has established that groundwater pollution by leachate is unlikely, however as this type of pollution is very difficult to remediate, monofills should be sited in areas where impacts on beneficial uses of groundwater are minimised. In particular, monofills should not be located:

- in areas of potable groundwater,
- groundwater recharge areas
- areas identified by the DEC as a Groundwater Supply Area; or

- below the regional watertable.

The Department of Water administers a groundwater database containing information on boreholes throughout Western Australia. This database contains information on the location of boreholes, water levels and some chemical analysis information on groundwater quality. The data can be used to estimate the depth to and quality of groundwater, its general flow direction and utilisation. These estimates must be verified by local field testing.

Where the most appropriate site for a monofill is in a hole that extends below the watertable, the base of the monofill should be raised to above the watertable using a sub-base material that will attenuate contaminants. The sub-base material between the base of the liner and the watertable (that is, in the unsaturated zone) should be made of a natural or imported fine-grade soil with a cation exchange capacity of about 10 mEq/100g. This cation exchange capacity allows the sub-base to remove some contaminants from leachate seeping through the base of the liner, and further minimises the risk of groundwater pollution from the monofill.

The most preferred site for a monofill is one that reduces the risk of groundwater pollution by providing a natural unsaturated attenuation layer beneath the liner for contaminants that may leach through the liner. This means that sites with naturally attenuating soils, such as sites in clayey areas, are preferred to those that do not have such soils, such as sites in sandy areas.

The Best Practice Environmental Management Guideline for Siting, Design, Operation and Rehabilitation of Landfills requires a minimum of 1 metre separation of inert Class I wastes from the watertable.

### Surface Waters

Leachate can be toxic to aquatic organisms. It must be managed so that it cannot escape to surface waters. Accordingly, monofills should not occur in:

- wetlands protected under Ramsar and JAMBA/CAMBA treaties;
- marine and coastal reserves;
- water supply catchments;
- land liable to flooding if determined to be so liable by the responsible drainage authority; and
- within 100 metres of surface waters.

There are 12 Ramsar wetlands in Western Australia. These are

- Ord River Floodplain



- Lakes Argyle and Kununurra
- Roebuck Bay
- Eighty-Mile Beach
- Forrestdale and Thompson Lakes
- Peel-Yalgorup System
- Lake Toolibin
- Vasse-Wonnerup System
- Lakes Warden System
- Beecher Point Wetlands
- Lake Gore
- Muir-Byenup System

The JAMBA and CAMBA treaties (Japan Australia Migratory Bird Agreement and the China Australia Migratory Bird Agreement) protect migratory birds, not particular wetlands. Any proposal near a wetland or river may need assessment to determine if birds protected under this agreement are nearby.

Maps for the Revised Draft Environmental Protection (Swan Coastal Plain Wetlands) Policy and Regulations 2004 can be found at the EPA website.

Monofills should not be located in a 1-in-a-100 year floodplain (where there is a one per cent chance in any year that the site will flood) unless it can be demonstrated that the facility will be protected from flooding and erosion by flood waters.

A solid inert landfill may be located within 100 metres of surface waters if an assessment demonstrates there is no interaction between groundwater and the adjacent surface-waterbody that would potentially transport contaminants to the surface water body. It must also demonstrate that protective measures can ensure no transfer of waste or contamination to surface waters. Similar conditions should apply to tyre monofills.

#### Flora and Fauna Protection

The development of monofills may impact on the flora and fauna of the local area. The potential impacts on flora and fauna are:

- clearing of vegetation;
- loss of habitat and displacement of fauna;
- loss of biodiversity by impacts on rare or endangered flora and fauna;

- potential for spreading plant diseases and noxious weeds;
- creation of new habitats for scavenger and predatory species;
- erosion; and
- alteration of water courses.

Particular areas where monofills should not occur are:

- critical habitats of taxa and communities of flora and fauna; and
- areas where monofills are likely to have a significant impact on threatened species and ecological communities as identified in the Environment Protection and Biodiversity Conservation Act 1999, except with the approval of the Commonwealth Environment Minister.

The *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* provide relevant information.

A survey of the site and collection of comprehensive baseline environmental data are essential to assess potential impacts from proposed monofill operations. The nature and extent of this data should be site-specific, taking into account the size of the proposed operation and the risks posed to adjacent sensitive areas.

#### Infrastructure

Local infrastructure must be able to sustain the operation of a monofill. As a monofill requires the transportation of used tyres, the capacity of the road network to cope safely with increased traffic and minimum of disturbance to the local community, should be examined. The preferred transportation route should minimise the transport of tyres through residential and other sensitive areas. This may influence the placement of the entrance to the monofill.

A transportation study may reveal the need for additional road infrastructure, such as freeway interchanges, turning lanes or signals.

The availability of services such as reticulated water, sewerage and power will influence the facilities provided for staff at the facility. Water storage for fire-fighting will be necessary for sites where tyres are stored above ground prior to baling and for facilities only receiving already baled tyres.

#### Geological Setting

Monofills should be constructed in areas where the land is stable, as the tyres may require long-term storage. The long-term integrity of the monofill cap and liner system must be assured.

Earthquakes could impact the stability. While Australia is considered a seismically stable continent, it does not mean that no large-scale earthquakes will occur, only that they are infrequent. Avoiding sites within 100 metres of a fault line displaced in the Holocene period will provide a reasonable degree of assurance of the long-term protection of the monofill from an earthquake. Maps that show the location of fault lines throughout Western Australia are available.

The geotechnical stability of the ground on which the monofill will be placed must be assessed. This land should be capable of supporting the monofill, with or without engineering assistance. The assessment should cover the site embankments and slopes. It must be demonstrated that the ground will not collapse if there has been subsurface mining.

Karst regions are generally inappropriate for landfills or monofills. Any proposed monofill to be located in a karst region, with sinkholes, caves and possibly large water springs, will require very detailed investigation of the stability of the area. The containment of leachate is difficult to assure.

The mineralogy of the area in which the monofill is to be built must be considered. The shrink/swell characteristics of the monofill substrate should be assessed to minimise the potential for differential movement of the liner resulting from changes in the moisture content of the substrate.

Local material may be suitable for liner construction.

#### Land Ownership

Land ownership will influence the siting of monofills. A landfill may not be established on State land, without the written consent of the Minister responsible for the relevant Act under which the land is managed.

#### Aboriginal and heritage issues

Under the *Commonwealth Native Title Act 1993*, the Department of Land Administration should be contacted to determine if the project is subject to a native title claim.

Section 5 of the *Western Australian Aboriginal Heritage Act 1972* identifies what constitutes an Aboriginal Site. More information on Aboriginal Sites should be obtained from the Department of Aboriginal Affairs. A register of sites can be found at [www.dia.gov.au](http://www.dia.gov.au).

The Heritage Council is the WA advisory body on heritage matters and focuses on places, buildings and sites. It was set up under the *Heritage of Western Australia Act 1990* [www.heritage.wa.gov.au](http://www.heritage.wa.gov.au).

## **Best practice design**

Once a monofill has been sited, it must be designed to ensure that it is able to protect the environment. This section sets out the objectives and required outcomes of each element of a monofill design, as well as providing suggested measures for achieving these.

The design of a monofill facility will be influenced by the existing natural environment, adjacent land uses, available infrastructure, and the need to safely store used tyres above ground prior to baling. It must be based on a thorough understanding of the existing environment and address all of the site-specific circumstances of each site.

## **Environmental Assessment**

An environmental assessment of the site is required to gain a thorough understanding of the existing environment to develop a sound landfill design. This assessment must examine the impact of the monofill on the air, groundwater, surface water and noise environments, and should be based on at least two to three years of data. This data may need to be constructed through a combination of recent, targeted data sets with existing, less targeted sets.

If, following an environmental assessment, the site is identified as unsuitable for a monofill, then the proposal should not proceed any further.

An environmental assessment should contain:

- Meteorological data, including monthly rainfall, monthly evaporation, seasonal wind strength and direction;
- Hydrogeological assessment, including:
  - local and regional geology;
  - spatial distribution of groundwater (local and regional if the watertable is artificially depressed);
  - depth to groundwater (current and after any rebound if the watertable is artificially depressed) and watertable elevation (mAHD);
  - groundwater gradient and flow direction;
  - description of groundwater interaction with local surface waters;
  - aquifer physical properties:
    - permeability;
    - aquifer thickness;
    - saturated thickness; and

- porosity
  - aquifer chemical properties:
    - mineralogy; and
    - cation exchange and sorption capacity;
  - groundwater quality (local and regional if aquifer is likely to have been impacted on by previous activities);
  - beneficial uses of groundwater to be protected;
  - groundwater use in the surrounding area;
  - predicted extent and degree of impacts on groundwater quality during and after the landfill operation;
  - verification that beneficial uses are not adversely impacted at the site, or at the boundary of an attenuation zone if one is designated by the DEC;
- Water Management, including:
    - water balance for the site and estimated volume of leachate to be generated;
    - leachate collection, storage facilities, treatment and disposal;
    - stormwater diversion banks and/or cut-off drains and storage dams;
    - fire-fighting equipment and water supply; and
  - Dust control, including:
    - availability of cover material onsite.

### Site Layout

The monofill and associated facilities should be designed to:

- minimise potential environmental impacts;
- minimise health and safety risks for operators and carriers;
- encourage retrieval and recycling of tyres; and
- make the most efficient use of resources onsite.

Best practice is to fill the site as a series of independent cells. Each cell should take less than two years to fill, and then be immediately rehabilitated. In the case of trench-and-fill landfills, each trench should be sized to ensure that it is filled within two years. Larger excavations for trench-and-

fill landfills must be filled on a cellular basis. In the case of a large area fill landfill, this means establishing independent cells.

Where an area fill or large trench-and-fill excavation is to be filled as a series of cells, prudent location of these cells may help to:

- stabilise a batter or embankment;
- screen the landfill operation from view;
- reduce groundwater flow into the site;
- shed clean stormwater into the stormwater system;
- reduce the need to relocate facilities such as above-ground storage areas;
- minimise the need to constantly construct roads within the site; and
- avoid active monofilling near areas being developed for residential purposes.

A transfer station with drop-off areas should be provided so that tyre carriers and members of the public have no need to unload vehicles at the tipping area. This minimises safety risks to the public and less supervision of the tipping area is required. Storage areas and room for baling equipment will need to be provided. The storage area may be located off site if tyres are baled off-site before transport to the monofill.

The gradient of internal haul roads, the external road network and availability of services will influence the positioning of the storage area, baling facilities, site office, weighbridge, gatehouse, staff facilities, and plant maintenance or storage area.

Best practice for a Class III and Class I landfill is to have a gatehouse at the entrance to the site or at a point that cannot be bypassed when travelling to the landfill. The gatehouse is the first line of active measures to vet the incoming loads and divert loose tyres to the storage and baling areas

A weighbridge is commonly installed at major landfill sites to facilitate accurate record keeping for the purposes of invoicing clients, landfill levy documentation and monitoring waste disposal rates. Weighbridges may also be useful at tyre monofills for similar reasons.

### Liner system

The primary function of a landfill liner system is to protect groundwater from impacts of leachate. The landfill liner slows the vertical seepage of leachate. The liner may also attenuate contaminants in leachate seeping through the liner to the point where the leachate that makes contact with the aquifer beneath the landfill has minimal detrimental impact on groundwater. Another function of the liner is to retard the infiltration of groundwater.

The design objective of the liner is to protect the beneficial uses of all groundwater, including that directly beneath the landfill.

Liners comprise up to five components:

- sub-base;
- clay layer;
- geomembrane and protection layer;
- drainage layer/leachate collection system;
- geotextile.

For an inert material such as whole tyres a liner consisting of the sub-base and a clay layer are sufficient. There is no need for a leachate collection system, though monitoring of groundwater should be undertaken to confirm there is no pollution of this resource.

#### Sub-base

The integrity of the monofill is fundamentally reliant upon the integrity of the sub-base that lies beneath. The sub-base must be well-consolidated, with minimal settlement, to supply a firm platform for the compaction of the clay layer. The sub-base should also offer the capacity to attenuate any contaminants seeping through the liner.

Where the sub-base is undisturbed material (rock or soil) at the base of a quarry, it is likely to be well-consolidated. Where the sub-base has been installed prior to the clay layer, it needs to be installed in such a manner that it is geotechnically stable. One method of providing this stability is to install and compact the sub-base in thin layers.

If solid inert waste is used as sub-base, it should be limited to crushed and compacted hard waste (rock, bricks and concrete with no timber, plastic or steel). This will ensure that the sub-base is sufficiently stiff to build a clay base on.

All plans for the construction of a sub-base must be verified and approved by a geotechnical engineer. To provide assurance of the quality of construction of the sub-base, construction of the sub-base must be included in the Construction Quality Assurance (CQA) plan (see section below), verifying that it is fit for its intended purpose.

#### Clay Layer

The ability of clay to retard water movement and absorb exchangeable cations makes it a suitable natural material for a low-permeability liner. To meet the performance standards of the whole liner, the clay component needs to be at least one metre thick, with a hydraulic conductivity of less than  $1 \times 10^{-9}$  m/s using both fresh water and 50,000 ppm NaCl solution. Australian Standard AS 1289.6.7.1 – 1999 gives details on how hydraulic conductivity testing should be performed.

Some of the properties of the soil measured to determine its suitability as a low-permeability liner are particle size distribution, plasticity (described by the soil plasticity index) and cation exchange capacity (CEC).

The potential for desiccation and subsequent cracking of the low permeability layer must be addressed. Montmorillonite clays are high-plasticity clays and can form good liners; however, they are susceptible to desiccation and subsequent cracking during the liner construction and until tyres are placed over them.

Clay liners are constructed in series of lifts compacted to the specifications detailed in a CQA plan prepared by the monofill designer (see section below). To achieve bonding between each lift, the thickness of each lift must permit the compaction equipment, typically a sheepfoot roller, to penetrate the top lift and knead the previous lift. To improve bonding, scarification of the previous lift may also be required. Bonding is required to overcome the effects of the imperfections within individual lifts.

A further factor is the thickness of the liner and the number of lifts used, with a greater number of lifts and greater total thickness minimising the probability that preferential flowpaths will align. Best practice for minimising the probability that preferential flowpaths align and thus minimise the hydraulic conductivity of the liner, is to bond each successive lift with the preceding lift, construct the liner at least one metre thick, and use a minimum of four to six lifts.

During the installation of the clay liner, continual testing needs to be conducted to ensure that the hydraulic conductivity of the liner is less than  $1 \times 10^{-9}$  m/s. The monofill designer must provide details of how performance requirements of the liner, including the hydraulic conductivity, are to be met in a CQA plan.

### Construction Quality Assurance

The development and implementation of a Construction Quality Assurance (CQA) plan provides a means of demonstrating to the public and regulating authorities that the monofill being constructed meets its design requirements.

The CQA plan must be able to verify

- materials used comply with specifications; and
- method of construction/installation is appropriate and, as a result, design requirements have been met.

The CQA plan must contain the material/construction specifications, testing methods, testing frequency, corrective action and provide for appropriate documentation procedures.

### Sub-Grade and Clay Liners



Because of the importance of the sub-grade and clay liner in the overall liner performance, construction of these components must be accompanied by Level 1 geotechnical testing as set out in Appendix B of AS 3798-1996 Guidelines on earthworks for commercial and residential developments. This entails, among other requirements, full-time testing and inspection of all earthworks by the geotechnical testing authority, a geotechnical engineer independent of the liner constructor. An appropriately qualified engineer must provide certification that the liner has been constructed as designed.

For any monofill it must be demonstrated that the natural sub-grade and/or a constructed sub-base is able to support the monofill without affecting the integrity of the liner system as a result of differential settlement.

In the case of a clay liner, the key parameter that must be met is the hydraulic conductivity. It is dependent upon many factors, including clay composition, moisture content, compaction, field placement techniques and liner thickness.

The CQA plan must specify how the materials used to construct the liner will be tested to ensure that the hydraulic conductivity of the liner meets the specification. One means of doing this is to regularly sample the clay liner and test the samples for dry density and moisture content. The results of this testing are then compared with the required zone for dry density and moisture content necessary to ensure that the clay meets the specified hydraulic conductivity.

Where this method is to be adopted, dry density and moisture content tests need to be quick procedures with a one to two hour turnaround time for results. Timely feedback and instructions can then be given to rework any areas that do not meet compaction standards.

The minimum test frequencies are:

- properties of the clay (grain size distribution, plasticity index and moisture content) tested once every 5,000 m<sup>3</sup>; and
- field testing for liner density and moisture content at a frequency the greater of:
  - 1 test per 500 m<sup>3</sup> of soil;
  - 1 test per 2,500 m<sup>2</sup> area per clay lift; or
  - 3 tests per site visit.

Following field compaction work, direct permeability testing in the laboratory and/or in the field should be undertaken on undisturbed clay liner samples.

Suitable laboratory permeability testing procedures are described in AS 1289.6.7.1-1999, Soil strength and consolidation tests – Determination of permeability of a soil– Constant head method for a remoulded specimen.

Laboratory permeability testing has some advantages over direct field measurement methods because factors such as evaporation and soil saturation can be controlled in the laboratory to minimise discrepancies. However, only small samples can be tested in the laboratory, which can affect the accuracy and applicability of the permeability results.

Field permeability measurements can represent larger volumes/areas of soil using a device such as a Sealed Double Ring Infiltrometer (SDRI). As an SDRI should run for at least four months to ensure that the flow through the material being tested is a long-term steady state flow rather than a transient flow. This test should be conducted on a test pad that is not part of the liner but is subject to the same construction activities.

Visual inspections should check for the presence of oversized clods of clay, poorly compacted or dry areas and the homogeneity of the clay.

The CQA plan may also need to specify the measures to be taken to protect the clay liner from desiccation and erosion.

The CQA must also address the quality assurance of the thickness of the constructed liner. The liner must be surveyed at the completion of construction to confirm that the correct grades have been attained.

### Water Management

Water management relies upon the management of three water streams with the intention of minimising the volumes to be managed and avoiding mixing the streams. The three components to be kept separate are:

- stormwater;
- leachate;
- groundwater.

Reusing water onsite is always preferred to discharging the water to the environment.

### Stormwater management

Good stormwater management design incorporates interception drains that direct stormwater away from the monofill. Storage ponds and other drainage measures should be designed to contain and control rainfall runoff for a 1-in-10 year storm event for a Class I landfill or tyre monofill. Storm events up to 1-in-100 year recurrence intervals should also be considered to ensure that they do not result in any catastrophic failures such as flooding of the monofill.

Stormwater can also contribute sediment to the environment if the catchment area is erodible due to a lack of vegetative cover. By retaining and re-establishing as much vegetative cover in the catchment area as possible, erosion is minimised.

Other means for minimising erosion are to have stormwater flow over a lower gradient or flatter slopes, or to spread the water across the slope. By minimising erosion the need for a settlement pond is reduced.

Sediment control features may be required where there are large stockpiles of earth or expanses of cleared land in the catchment area. Sediment control features should be designed to enable both silty sediments (able to settle out under gravity) and clayey sediments (will not settle out without flocculating agents) to be removed from the water. Typical features that may remove silty and clayey sediments include shallow, heavily vegetated stormwater control ponds and swales. The need for sediment control features will depend on:

- the topography and how this will influence water velocity;
- the nature of the water environment into which the eventual discharge from the site would occur;
- the typical intensity of storm events; and
- the extent of vegetative cover on the catchment area.

Further guidance on sediment control may be found in EPA Victoria Publication 275 Construction techniques for sediment pollution control and EPA Victoria Publication 480 Environmental guidelines for major construction sites.

Where a water supply dam is constructed to provide water for fire fighting, dust suppression or irrigation purposes, water from sediment control features should be channelled into the water supply dam. This places an additional control on the discharge of potentially turbid water, ensuring that the environment is better protected. It also maximises the use of this water. All dams should have spillways with erosion-control measures such as rocks and erosion-resistant vegetation.

The discharge of stormwater from the site should only occur from dams, and only after confirmation that the water is not contaminated. This confirmation should at least be visual where the only possible contaminant source is sediment, but where other contaminants are possible, the water should be tested prior to discharging. The degree of testing will be determined by the risk of contamination and the sensitivity of the receiving environment. Water is not to be discharged if it is suspected or found to be contaminated.

#### Groundwater Monitoring

Monitoring bores may be installed to:

- establish the groundwater background quality and levels (in mAHD);
- establish the local groundwater flow direction and rate;
- act as an early indicator of leachate contamination in groundwater prior to offsite migration;
- measure compliance with the site licence or notice; and
- provide an indication of the downstream groundwater quality that a permitted groundwater user may find.

The bore(s) to establish the background groundwater quality should be placed up-gradient of the landfill, where they will not be influenced by seepage out or into the landfill or affected by surface water features, such as dams. The location of these bores should also take into account potential impacts from surrounding landfills, such as localised changes in groundwater quality or flow direction.

Monitoring should occur in all aquifers that may be affected by the monofill. The number of monitoring bores should match the size of the facility, the risk of contamination and the nature of the groundwater environment. At least four groundwater bores are required to understand the direction of groundwater flow. Further guidance on groundwater monitoring programs is contained in EPA Victoria Publication 668 Environmental Guidelines for Hydrogeological Assessments (Groundwater Quality).

The bores established in close proximity to the monofill are screened so as to intercept any leachate-contaminated groundwater. For a monofill located above the watertable, the top three to five metres of the watertable aquifer would normally be sampled. 'Nested' or multiple bores screened at various depths in the aquifer may be used to establish the water quality profile.

Monitoring of groundwater downgradient of the site provides an indicator of the groundwater quality that a downgradient-permitted groundwater user may extract. It also provides additional assurance that the monofill has not polluted the groundwater.

Permission must be obtained from the Department of Water to install a groundwater bore, and all groundwater monitoring results should be forwarded to the State Groundwater Database.

### Air Quality

The only risk to air quality from a tyre monofill is from dust, therefore the objective for air quality management at a monofill is:

- no reduction in amenity or health impacts due to dust.

Dust can be generated in any large area where the land has been disturbed and is subject to vehicular traffic. Other potential dust sources are stockpiles of earth and the delivery of dusty loads.

The magnitude of the impact will depend on the:

- type and size of the operation;
- prevailing wind speed and direction;
- adjacent land use;
- occurrence of natural and/or constructed wind breaks; and
- wind-abatement measures or buffers.

The PM<sub>10</sub> dust concentration set in the NEPM of 50 ug/m<sup>3</sup> must be achieved beyond the premises boundary. Measures to achieve this dust level include:

- Vegetation of exposed areas;
- Formation of internal roads, including sealing roads that are used regularly; and
- Use of water or other dust suppressants on roads or stockpiles that are not sealed or vegetated.

While direct measurement of PM<sub>10</sub> or dust may only occur at those sites that have been identified as a dust hazard, periodic monitoring should still occur at all sites, even if by visual means only.

## Noise

Landfill operations including monofills generally involve the use of noisy plant equipment and can impact detrimentally on the amenity of surrounding areas. Sources of noise include truck and earthmoving vehicle noise (body, engine and exhaust), reversing sirens, external telephone bells, and mobile machinery.

Site operations should be set out to minimise noise impacts by using natural and/or constructed features such as earthen bunds and depressions as well as minimising steep-haul roads. Another means of minimising noise is by planning to schedule potentially noisy activities to minimise impacts on the community.

Where noise is considered an actual or potential concern (due to changing land use), then the predicted noise levels at the nearest current or future sensitive receptor should be derived. Where operations are likely to occur outside normal business hours, noise-control measures need to be investigated and adopted.

The requirements of the *Environmental Protection (Noise) Regulations 1997* must be met at all times.

### Traffic Considerations

Truck movement on local roads may cause concern to local residents and councils, including safety concerns, noise, road grime and the increased cost of road maintenance.

Limiting access routes and speeds of vehicles and limiting the hours of operation, can minimise noise disturbance to the local community. The design of the site layout should ensure that trafficked areas, such as the location of parking, the entrance gate and the weighbridge, are away from sensitive land uses.

Provision of traffic control devices, such as traffic islands and merging lanes at the entrance to the monofill, may need to be considered to minimise the impact of traffic. Recessing the entrance into the monofill helps to minimise vehicles queuing along public roads, as well as assisting in the control of dirt from the site.

Vehicles exiting via a wheel wash or some other equivalent wheel and underbody cleaning mechanism can avoid the accumulation of dirt on sealed external access roads. The road layout within the facility should encourage the use of wheel-cleaning devices by truck drivers, and be placed so that the gatehouse attendant can visually check that the vehicle has been cleaned. Where external access roads are sealed, the road from the wheel wash should also be sealed and regularly cleaned to reduce dirt. Internal roads should also be sealed as far as possible into the site to reduce the amount of dirt accumulating on the vehicle and allow more time for dirt already accumulated on the vehicle to fall off before it leaves the site.

### Site Security and Fencing

Active landfill sites can present a safety risk to the public and livestock. The site should be securely fenced to prevent the unauthorised entry of people or livestock. When unattended, the gates should be securely locked. Fencing should be regularly inspected and any damage to the fence that would allow unauthorised access be repaired as quickly as possible. When designing a fence, consider the probability that unauthorised people will want to gain entry to the site. The minimum fencing requirement for an inert landfill or tyre monofill is a wire mesh fence at least two metres high constructed around the site perimeter.

### Best practice operation

Protection of the environment from tyre storage activities goes beyond the design of the facility to include operational practices, which further enhance the protection of the environment. In particular, the elements of a landfill's operations that need to be considered are:

- financial assurance;
- waste acceptance;

- waste pre-treatment;
- waste placement
- waste cover;
- fires;
- contingency planning;
- management of chemicals and fuel;
- disease vector control;
- noxious weed control; and
- performance monitoring and reporting.

### Financial Assurance

Monofill operators may be required to provide a financial assurance to guarantee that any costs incurred in the operation, closure and aftercare of a facility are not borne by the community in the event that the landfill operators abandon the site, become insolvent or incur clean-up costs beyond their financial capacity.

A financial assurance has three components:

- remedial action;
- site rehabilitation; and
- site aftercare.

The financial assurance should be held for the period that the monofill requires monitoring to ensure there is no risk to the environment.

The EPA Victoria Publication 777 Determination of financial assurance for landfills provides guidance on the development of an appropriate level of financial assurance.

### Acceptance of Tyres

There should be signs advising where to place baled or unbaled or oversize tyres. Tyre loads will need to conform with the requirements of the Controlled Waste Tracking System under the *Environmental Protection (Controlled Waste) Regulations 2004*.

Prior to monofilling tyres will need to be stored above ground in accordance with the Guidelines for Tyre Stockpiles<sup>95</sup>.

---

<sup>95</sup> Recovery of Tyres in Remote Locations, GHD for the Department of Environment WA, July 2006.

### Pre-treatment of Tyres

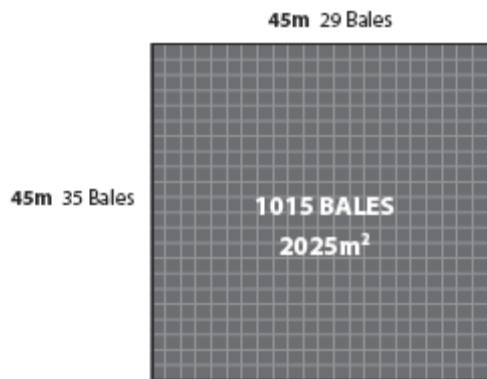
Tyres smaller than 2m in diameter should be baled and compressed prior to monofilling. The preferred size for bales is approximately 1.27 m wide, 1.53 m long and 0.77m deep, with a weight of approximately 1 tonne. Baling may be done on site or prior to arrival at the site. Baling has several advantages including:

- Preserving monofill space;
- Excluding oxygen so reducing fire risk;
- Excluding water, so reducing fire risk and the risk of contaminants leaching;
- Providing uniform units that can be neatly stacked in the monofill;
- Creating easy to manage units for future retrieval and transport; and
- Excluding dirt and water so preventing contamination that may interfere with future reprocessing.

Tyres too large to be baled may be monofilled in one section of an open cell or in a dedicated cell. Their location should be recorded.

### Placement of tyres in the monofill

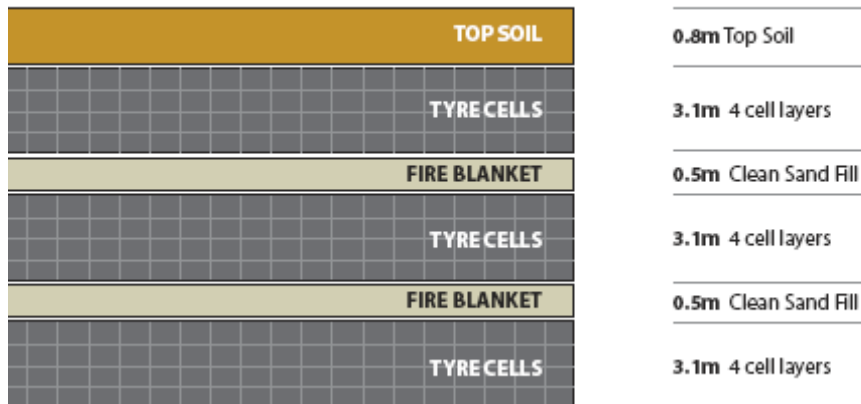
Bales should be arranged in cells measuring 45m x 45 m (that is 35 bales x 29 bales, with a weight of 1015 tonnes).



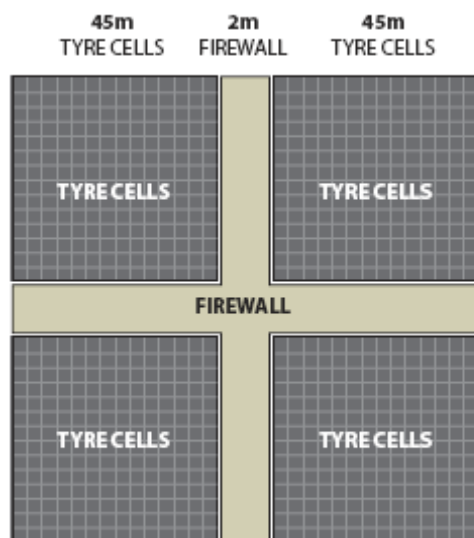
TOP VIEW OF SINGLE TYRE CELL

Cells may be buried up to 4 layers deep with a minimum of 0.5 m clean fill as a fire blanket between each set of layers. The top layer should be dressed with a minimum of 0.8m top soil allowing for plant growth.

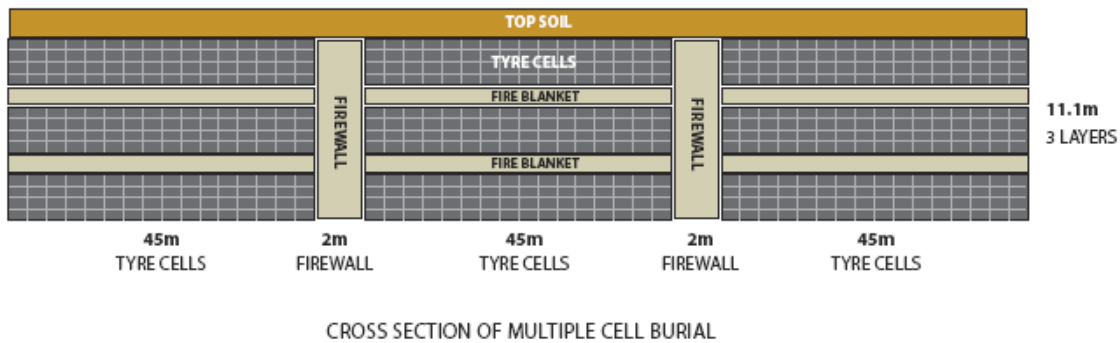




A minimum of 2m clean fill should be used between cell stacks.



TOP VIEW OF MULTIPLE CELL BURIAL STACKS



Ideally no more than two cells should be open at any one time. If more cells are open tyres must be stacked in a stable formation.

#### Cover

The purpose of cover is to:

- prevent the spread of fire;
- control disease vectors such as flies, mosquitoes and rodents; and
- ensure that the monofill is trafficable.

Tyre cells should be covered at the end of every day. A typical cover thickness is 0.3 metres.

Material such as gravel may be used. Cover material with a high moisture content, such as slimes from sand mining operations, should be avoided as such material may release water into the tyres.

Untreated acid sulfate soils are not appropriate for use as cover material as they oxidise and produce acid run-off when exposed to the atmosphere. Once started, this reaction continues in the absence of oxygen, after the cover material has been filled over. As cover material may be open to the atmosphere for extended periods, acid sulfate soil in cover material would be expected to generate acid. Use in a tyre monofill could lead to breakdown of the tyre compounds and the release of contaminants into groundwater.

Where soil is used for cover, a stockpile of soil to be used as cover material needs to be provided. Regardless of the material used as cover, sufficient material should be available at the tipping face for at least two weeks of operations.

#### Fires

Tyre fires can cause significant impacts on local air quality through odour and smoke. They can also spread outside the facility, triggering a grass or bushfire. Subterranean fires may burn for many years before they are detected.

Once started, tyre fires are difficult to extinguish, so the primary objective should be to prevent a fire from starting. This is done, as far as is practical, by removing potential ignition sources from the tipping area. Smoking should not be permitted near the monofill or above ground storage areas. Other measures include not burning waste and not lighting fires on or near areas where tyres are being stored.

If a fire should start, every effort must be made to extinguish it before it gets established. Equipment to extinguish a fire must be readily available at any time to enable a prompt response to any part of the premises. A water supply, either reticulated water or from dams or tanks, combined with a means of delivery (pump and hoses or a tanker truck) allows the prompt extinguishment of a fire on the site. Groundwater and stormwater stored in dams might be suitable for combating a fire. Where reticulated water is not provided, at least 50,000 litres should be stored onsite for the purpose of combating small fires. In the event of a significant fire, this volume will need to be supplemented by another source of water.

It is not usually possible to extinguish deep-seated fires using water except where the operator has sufficient plant and water to excavate and extinguish all burning waste. Where extinguishment is not possible, adding water to the monofill exacerbates the fire because the water adds oxygen to the fire. To combat deep-seated fires, key elements are to minimise oxygen getting to the fire by capping off the area, and displacing oxygen from the fire by injecting an inert gas, such as nitrogen, into the fire.

In some areas, the local fire authority might require a firebreak to prevent the spread of fire into or out of the site. This, in conjunction with developing a fire management plan with the local fire authority, is best practice in areas where grass or bushfires might be a concern.

### Contingency Planning

Contingency plans should be developed to deal with any incident or anomaly. All staff at the facility should be trained in the implementation of the contingency plan.

The contingency plan should consider all impacts discussed in this guideline, and in particular:

- the detection of contamination of surface or groundwaters;
- fires; and
- dust beyond the boundary of the premises.

The contingency plan should be reviewed after the occurrence of any incident covered by the plan to ascertain the effectiveness of the contingency plan and where, if necessary, it could be further improved

### Management of Chemicals and Fuels

The storage and handling of flammable and combustible liquids should be in accordance with the provisions of the AS 1940:1993, The Storage and Handling of Flammable and Combustible Liquids, and/or the requirements of the Department of Industry and Resources.

Particular measures include keeping inventories to a minimum, bunding liquid storage areas and locating them away from waterways or areas prone to flooding, and having a contingency plan for the management of any spills.

### Disease Vector Control

Water storage areas and water sitting in tyres attracts flies and mosquitoes. Tyres may also provide opportunities for rats and mice to breed and for the spread of weeds. The Guidelines for stockpiles include measures to control pests in tyres stored above ground. Covering monofill cells daily and eliminating any waterbodies not required for fire control will also assist.

Professional pest exterminators should be employed to reduce problem infestations of vermin.

### Noxious Weed Control

Where noxious weeds become established at a landfill, these weeds can spread through surrounding areas and impact on farming activities or natural ecosystems. Noxious weeds can become established through colonisation or through introduction by contaminated seed- or weed-infested mulch used to revegetate exposed areas of earth. To minimise the risk of introducing weeds through planting, only-high quality seed, free from any noxious weeds, should be used. Where an area is to be mulched, ensure that the mulch is free of noxious weeds. Regularly inspect for noxious weeds and eradicate any weeds present

### Performance Monitoring and Reporting

In order to assess the performance of the measures taken to protect the environment from the impacts of tyre storage in monofills, monitoring, assessment and reporting of the results are required.

A monitoring program should include monitoring of groundwater. Monitoring should be conducted at least twice a year, with quarterly monitoring for the first few years to establish an accurate baseline. All water sampling should be conducted in accordance with the Department of Water's monitoring guidelines and or the requirements in the monofill licence.

Environmental conditions such as atmospheric pressure, temperature, precipitation and stream flows should be recorded when samples are taken.

Monitoring results should be interpreted and analysed to identify either long-term trends or significant changes between sampling events. A plot of analyte levels facilitates this over time.

Where analytes change significantly between sampling events, a further sampling round should be conducted immediately to verify the result. If either a long-term trend is identified or a significant change between sampling events is verified, the DEC should be advised and the reason for the change investigated as a matter of priority.

For any perceived long-term trends to be true trends rather than normal fluctuations in environmental quality, they need to be based on a number of years of data.

The results of the monitoring program should be reported to the DEC in accordance with licence conditions. Problems should be reported as soon as possible after being identified. This report should include details of any complaints received and their resolution, the effectiveness of programs to control dust and details of any extraordinary events that occurred at the facility over the year, such as fires.

Where there is community interest in the monofill operation, the facility operator should also report to the community. This is particularly important in the event of a highly visible incident – the community should be advised immediately of what happened and what is being done to rectify the situation and prevent a recurrence.

Monitoring reports will include the raw data, plots of the data over time and an analysis and interpretation of what the results mean. An expert in the field should conduct this analysis and interpretation. The report will also contain a statement of volumes of tyres received. The report is intended to examine the operations during the preceding year, as well as to identify trends and potential areas of improvement. In particular, the report will identify areas for improvement in environmental management.

#### Aftercare

Unlike a standard landfill, the purpose of a monofill is storage of used tyres until such time as they are recovered for the resources embodied within them. The site cannot be rehabilitated for other uses until after this has occurred.

During the storage period vegetation of the site will be needed to prevent dust and erosion and provide further stability. The top-most layer must be able to support vegetation and be of sufficient depth to ensure that roots do not penetrate the cap, providing a conduit for water into the landfill and water out of the landfill.

The surface layer should reflect the type and depth of top soils normally found in the local area. Where it is not possible to duplicate the local topsoil conditions or the natural soil is too thin to

support adequate vegetation for erosion control, then an appropriate mix of soils 200 to 300 millimetres thick should be used provided it is capable of sustaining vegetation. Any mulch used in the cap should be pasteurised to remove weed seeds, plant pathogens and pests.

Introduced plantings on the landfill should not include any noxious weed variety for that area, nor should the monofill provide a haven for weeds migrating from the surrounding area. Advice should be sought on species selected for planting to prevent them from becoming local pests. It is advised that planting be restricted to species indigenous to the area and of local provenance, to:

- avoid inappropriate planting;
- ensure the species are adapted to the local climate; and
- enhance the local habitat.

When preparing the aftercare management plan consider:

- Maintenance of the cap, in particular to prevent/control erosion and restore/maintain vegetation.
- Environmental monitoring of groundwater; surface water; and settlement.

Unlike a mixed landfill settlement should be minimal. As there is considerable uncertainty regarding the length of time tyres will be stored, funds should be allocated during the operational life of the monofill to provide for aftercare management for a minimum of ten years.

The aftercare management plan should address the level of monitoring and frequency of inspection of the landfill and infrastructure. These depend on the location of the landfill, and the landfill's environmental performance. During the aftercare period, the frequency of monitoring and inspection may be decreased, frequency being based on the stability of the cap and the consistency of environmental monitoring results.

To ensure in the long-term that prospective owners of the land are aware that it contains a tyre storage facility, measures such as a caveat on the land title or a planning overlay can alert people of the prior use of the site. The DEC may also serve an Environmental Protection Notice on the site to ensure ongoing management of the site and place the site on the Contaminated Sites Register to ensure that all potential future stakeholders are aware of the ongoing management requirements of the site.