DETAILED INVESTIGATION INTO EXISTING AND POTENTIAL MARKETS FOR RECYCLED CONSTRUCTION AND DEMOLITION MATERIALS
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EXECUTIVE SUMMARY

Cardno WA Pty Ltd (Cardno) have been contracted by the DEC to conduct a Detailed Investigation into the Existing and Potential Markets for Recycled Construction and Demolition (RC&D) Material. The purpose of the project is to evaluate the market for RC&D material in Western Australia, to gain an understanding of the supply and demand trends for RC&D material in a range of existing markets and to identify barriers preventing the growth of emerging markets. The study predominantly focuses on the Perth Metropolitan Region; however it will assess opportunities for market development in adjacent regional areas.

In addition to the above, the report focuses on a number of key areas including:

- profiling both existing and potential markets for RC&D;
- documentation of the extent to which RC&D materials compete with virgin quarried products;
- assessment of the level of market penetration of RC&D materials into existing markets;
- barriers affecting the growth of emerging markets for RC&D materials; and
- recent market development success stories.

Background

RC&D materials are defined as products manufactured principally from Construction and Demolition (C&D) waste consisting of civil construction materials including concrete, sand, brick, rubble, rock, scrap metals and timber products. These products currently account for the largest waste stream within Western Australia, equivalent to 50% of all waste currently being sent to landfill. Approximately 1,894,370 tonnes of C&D material was disposed to landfill in the Perth Metropolitan Region in 2006/07. This is the highest amount recorded since accurate records began in 1995 (Figure E1).

During 2006/07 approximately 400,000 tonnes (17% of C&D waste being generated) was recovered by recyclers.
Current Markets

For C&D material to be recovered, a market for their reuse is essential. Well graded, good quality recycled aggregates have the potential for use in a wide range of applications (Table E1), subject to appropriate test or performance requirements. In most cases, recycled materials can substitute virgin aggregates.

Table E1: Current Markets Available for Extracted and Recycled Materials in the Perth Metropolitan Region

<table>
<thead>
<tr>
<th>Material</th>
<th>Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virgin</td>
<td>Bricks, Pottery, Lining / Drainage</td>
</tr>
<tr>
<td>Clay</td>
<td>Roadbase, Hardstands, Foundations, Concrete</td>
</tr>
<tr>
<td>Gravel</td>
<td></td>
</tr>
<tr>
<td>Limestone</td>
<td>Bulk Fill, Sub-base, Blocks/Bricks, Groynes, Chemical Processes, Pollution Control, Cover in Landfills</td>
</tr>
<tr>
<td>Aggregates</td>
<td>Roadbase, Concrete, Bitumen</td>
</tr>
<tr>
<td>Sand</td>
<td>Bulk Fill, Concrete, Bricks, Glass, Landscaping</td>
</tr>
<tr>
<td>Timber</td>
<td>Construction, Mulch, Firewood, Animal Bedding,</td>
</tr>
<tr>
<td>Recycled</td>
<td></td>
</tr>
<tr>
<td>Concrete Aggregate (RCA)</td>
<td>Bulk Fill, Sub-base, Roadbase, Hardstands, Drainage Aggregate</td>
</tr>
<tr>
<td>Crushed Tiles</td>
<td>Bulk Fill, Landscaping, Remanufacturing</td>
</tr>
<tr>
<td>Sand</td>
<td>Bulk Fill, Landscaping, Cover in Landfills</td>
</tr>
<tr>
<td>Bricks (Whole)</td>
<td>Construction, Remanufacturing into new brick, Landscaping</td>
</tr>
<tr>
<td>Brick and Rubble</td>
<td>Bulk Fill, Cover in Landfills, Remanufacturing into new brick, Sub-base</td>
</tr>
<tr>
<td>Timber</td>
<td>Particle Board, Mulch, Animal Bedding, Firewood</td>
</tr>
</tbody>
</table>

Current consumers of C&D material, as indicated by the RC&D industry are currently private contractors, bobcat operators and in some cases Local Government.

At present, Local Government do not readily purchase RC&D material for their operations on a large scale. Larger construction companies that share a large proportion of the market also do not readily use RC&D materials. Both Local Government and larger construction companies on occasion dispose of some waste material at recycling facilities.

Potential Markets

A number of higher value processes and markets are available for the use of C&D material if the recycled material has been suitably processed and tested for appropriate specification compliance. Summarised in Table E2 are potential markets for RC&D material that have been proven through research and / or real applications.
Table E2: Potential markets for concrete and masonry aggregate

<table>
<thead>
<tr>
<th>Material</th>
<th>Bulk Fill</th>
<th>Drainage / filter</th>
<th>Road pavement</th>
<th>Pavement concrete</th>
<th>Structural concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crushed demolition debris</td>
<td>Suitable</td>
<td>Usually suitable</td>
<td>Not suitable</td>
<td>Not suitable</td>
<td>Not suitable</td>
</tr>
<tr>
<td>Graded mixed debris</td>
<td>Suitable</td>
<td>Usually suitable</td>
<td>Suitable in some cases</td>
<td>Suitable in some cases</td>
<td>Not suitable</td>
</tr>
<tr>
<td>Clean graded brick/concrete</td>
<td>Highly suitable</td>
<td>Usually suitable</td>
<td>Usually suitable</td>
<td>Usually suitable</td>
<td>Suitable in some cases</td>
</tr>
<tr>
<td>Clean graded concrete</td>
<td>Highly suitable</td>
<td>Highly suitable</td>
<td>Suitable</td>
<td>Usually suitable</td>
<td>Potentially suitable</td>
</tr>
</tbody>
</table>

Source: CSIRO (2002)

Current Demand for Building Products

Approximately 21 million tonnes of raw material was extracted from the Perth Metropolitan Region in 2006, an increase of approximately six million tonnes or 40% compared to 1995. Sand was extracted in the highest quantities during 1995 (5.1 million tonnes) and 2006 (7.6 million tonnes). Sand and hard rock experienced the greatest growth in extraction with a 49% and 86% increase respectively (Table E3). This increase can be attributed to unprecedented demand for raw construction materials from strong construction activity that has occurred particularly since 2001. During 2005/06 approximately $15 billion was spent on construction in the Perth Metropolitan Region (CCI 2007).

Table E3: A comparison of Basic Raw Material demand during 1995 and 2006 in tonnes (x1,000)

<table>
<thead>
<tr>
<th>Material</th>
<th>1995</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>5,100</td>
<td>7,600</td>
</tr>
<tr>
<td>Limestone</td>
<td>4,000</td>
<td>4,750</td>
</tr>
<tr>
<td>Clay</td>
<td>2,300</td>
<td>1,940</td>
</tr>
<tr>
<td>Hard Rock</td>
<td>3,600</td>
<td>6,700</td>
</tr>
<tr>
<td>TOTAL</td>
<td>15,000</td>
<td>20,990</td>
</tr>
</tbody>
</table>

Source: CCI (2007)

The current market for construction material is currently dominated by the virgin extractive industries. Existing demand for basic raw materials was approximately 21.4 million tonnes during 2005/06 with approximately 21 million tonnes being sourced from the virgin extraction industry and approximately 360,000 tonnes from the C&D industry. This equates to a 98% market share by extractive industries.

The construction market do not specifically target recycled product as such, rather the market requires a basic raw material for their construction activities that is equivalent to using a virgin basic raw material. Construction companies highlight material cost, transport costs, specifications and usability as the key parameters in the use of any construction material. A push for the use of C&D material by government or industry to minimise the amount of waste being sent to landfill will inevitably require uptake of the diverted material to the building and construction market.

RC&D material can be considered a basic raw material that can substitute most of the materials that are currently being extracted in the Perth Metropolitan Region. Recyclers have indicated that the market is willing to uptake this material in large quantities with demand for recycled C&D material currently outweighing supply, sometimes to an extent that recyclers run very low or exhaust all available supplies in the yard.
Future Demand

The Perth Metropolitan Region, according to the Metropolitan Regional Scheme, has designated growth corridors in which development will occur. These areas of development include:

- north along the coast (Joondalup);
- south along the coast (Mandurah);
- north east parallel to Darling Scarp (Ellenbrook);
- south east parallel to Darling Scarp (Armadale); and
- existing inner city areas

Therefore these areas can be expected to demand the highest amount of raw materials for construction activities into the future. Based on the geographical distribution of recycling companies, recyclers are well placed to supply a high amount of material to the market, especially in the north east, south east and inner city growth areas.

The greatest amount of construction material will be required in the Northern (31 million tonnes) and Southern areas (38 millions tonnes) of the Perth Metropolitan Region between 2006 and 2011. Significant quantities will also be required in inner city areas (9 million tonnes). In terms of material type, sand will be required in the highest quantities (33 million tonnes), followed by concrete / asphalt (16 million tonnes) and road base (13 million tonnes).

Competitiveness

A key difference between the production of virgin and RC&D material is the cost. This is directly related to the volumes being processed by each sector, also known as economies of scale. Extraction industries generate very high volumes of material with very efficient automated machinery and conveyor systems that reduce the processing price significantly. However, even with the extraction companies having lower processing cost recyclers can maintain cost competitiveness, especially in regard to transport costs.

In addition to competition with extractive industries for market share, recyclers also require to be cost competitive with landfill to attract a supply of material. At present inert landfill costs in Western Australia are very low and make it especially hard for recyclers to compete and attract feedstock (Table E4). Recyclers are finding it difficult to compete with Class I landfills as they are either offering the same price or are more expensive than Class I landfills.

Table E4: Tipping fees (per m³) at Perth Metropolitan Class I landfills and recycling centres

<table>
<thead>
<tr>
<th>Class</th>
<th>Material Type</th>
<th>Landfill</th>
<th>Recycling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>Clean Sand, Bricks, Gravel, Limestone</td>
<td>$9 - 14</td>
<td>Free - $10</td>
</tr>
<tr>
<td>Type 2</td>
<td>Rubble, concrete with no reinforcement</td>
<td>$12 - 14</td>
<td>$10 - 16</td>
</tr>
<tr>
<td>Type 3</td>
<td>Concrete with reinforcement</td>
<td>$12 - 14</td>
<td>$14 - 22</td>
</tr>
<tr>
<td>Type 4</td>
<td>Heavy Footing Concrete</td>
<td>$13 - 29</td>
<td>$16 - 25</td>
</tr>
<tr>
<td>Type 5</td>
<td>Mixed / Contaminated Loads</td>
<td>$12 - 16</td>
<td>$20 - 28</td>
</tr>
</tbody>
</table>

Note:
- Only Class I figures have been included in this table as the majority of C&D waste is sent to these facilities.
- Putrescible Class II and III landfills are now charging between $45 – 77 per tonne of material received.
- Landfill prices include levy ($3/m3)

Market Penetration

At present C&D recyclers have approximately 2% of the total basic raw materials market in the Perth Metropolitan Region. If all C&D waste were diverted from landfill (assuming all 1.6
million tonnes of waste material could be recovered and marketable) the C&D recycling industry could hold approximately 9% of the total basic raw material market (Table E5). Whilst this is a significant improvement, it is obvious that the majority of basic raw material required for construction in the Perth Metropolitan Region will continue to be sourced from the extraction industries to satisfy demand.

Table E5: Potential market penetration of recycled C&D material into the basic raw material market

<table>
<thead>
<tr>
<th>% Diversion from Landfill</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tonnes Diverted</td>
<td>0</td>
<td>159,553</td>
<td>319,106</td>
<td>478,659</td>
<td>638,212</td>
<td>797,765</td>
<td>1,595,530</td>
</tr>
<tr>
<td>% Market (Recycled)</td>
<td>1.7</td>
<td>2.5</td>
<td>3.2</td>
<td>3.9</td>
<td>4.7</td>
<td>5.4</td>
<td>9.2</td>
</tr>
<tr>
<td>% Market (Virgin)</td>
<td>98.3</td>
<td>97.5</td>
<td>96.8</td>
<td>96.1</td>
<td>95.3</td>
<td>94.6</td>
<td>90.8</td>
</tr>
</tbody>
</table>


**Market Barriers**

If the RC&D sector continues growth at its current rate approximately 600,000 tonnes of C&D material will be sourced by the market by 2011 / 2012. This projected demand could be considerably higher if a number of barriers were broken in regards to the use of RC&D material.

Barriers currently in place that are preventing further recycling in the Perth Metropolitan Region include:

- An uneducated market towards recycled materials;
- Cheap Landfill in the Perth Metropolitan Region;
- A lack of Clean Supply / High Contamination;
- Tender Specifications not providing options for recycled materials;
- Testing Regimes by the Department of Environment and Conservation;
- Non-compliance at Inert Landfills;
- Proximity of virgin industries and landfills to development;
- A fear of asbestos contamination;
- Difficulty in the separation of material in inner city areas;
- Cost of source separation of waste material; and
- The price of material and transport costs

Market instruments that could be used to overcome some of these barriers include education and communication, procurement policies, landfill levy increases, potential landfill bans on mixed materials, increase enforcement at inert landfills and compulsory waste management plans for industry before undertaking construction or demolition activities.

**Market Prioritisation**

Waste material that requires minimal processing, has market value, has confidence in the marketplace and can be recovered in high volumes has been targeted by recyclers and should continue to be given high priority. Recyclers should continue to focus on the eastern growth areas and inner city areas in close proximity to their operations as they are at an advantage to service inner city areas due to their close proximity and their associated reduced transport costs. A large amount of C&D activity will be occurring in inner city areas for urban renewal into the foreseeable future which will provide recyclers with supply and potential demand for RC&D materials.
Summary

The continuing strong construction activity in the Perth Metropolitan Region will see demand for construction material (including RC&D) into the foreseeable future. High construction activity will also result in the generation of significant volumes of C&D waste materials. Apart from its environmental benefits, industry is starting to recognise the benefits of the use of RC&D material including the products appropriate specifications, reduced material and transport costs and ease of use.

A focus on clean supply being diverted to recyclers coupled with continued market development in current and potential market areas has the potential to significantly reduce the amount of waste being sent to landfill in the Perth Metropolitan Region. Increased diversion of C&D waste from landfill will also reduce the demand for finite virgin resources. The uptake of RC&D material by the marketplace will provide the greatest impact on the levels of waste currently being sent to landfill and will significantly help in the Department of Environment and Conservations vision of Towards Zero Waste to landfill by 2020.
# Detailed Investigation into Existing and Potential Markets for Recycled C&D Material

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1 INTRODUCTION

C&D material is currently the largest waste stream within Western Australia with approximately 1.6 million tonnes being disposed to landfill each year, equivalent to 50% of the total waste stream. This has resulted in the Waste Authority and the Department of Environment and Conservation (DEC) giving the waste stream priority for waste reduction.

Recycled Construction and Demolition (RC&D) material is defined as products manufactured principally from C&D waste. These products consist predominantly of civil construction materials including concrete, sand, brick, rubble, rock, scrap metals and timber products. RC&D in this study does not include the packaging that accompanies C&D materials.

Currently approximately 400,000 tonnes of C&D material is being recycled within the Perth Metropolitan Region. Whilst the industry and markets for RC&D material has grown significantly over the past few years continued expansion of these markets is necessary to provide additional demand towards this “resource”.

Cardno WA Pty Ltd (Cardno) have been contracted by the DEC to conduct a Detailed Investigation into the Existing and Potential Markets for RC&D material. The purpose of the project is to evaluate the market for RC&D materials in Western Australia, to gain an understanding of the supply and demand trends for RC&D material in a range of existing markets and to identify barriers preventing the growth of emerging markets. The study predominantly focuses on the Perth Metropolitan Region; however it will assess opportunities for market development in adjacent regional areas.

In addition to the above, the report focuses on a number of key areas including:

- profiling both existing and potential markets for RC&D materials;
- documentation of the extent to which RC&D materials compete with virgin quarried products;
- assessment of the level of market penetration of RC&D materials into existing markets;
- barriers affecting the growth of emerging markets for RC&D materials; and
- recent market development success stories.

The potential demand that could be achieved in identified markets is estimated and successes in developing markets for RC&D materials in non-traditional areas documented to highlight industry achievements.

To help in evaluating market development priorities, the study also produces market growth forecasts for RC&D materials over the next 5 years and prioritises these markets based on their ease of development and likely rate of growth. It is envisaged this study will assist industry and government to develop approaches to best develop and maximise the creation of sustainable markets for RC&D material in the Perth Metropolitan Region.

2 METHODOLOGY

Marketability of RC&D material does not solely rely on the end user of the product. A number of sectors within the building and construction chain come into play in the marketability of RC&D material. These sectors and the associated current lifecycle of C&D material is outlined in Figure 2.1. The red areas indicate resource depletion. Green areas indicate resource restoration.

Red areas (with the possible exception of extraction) can be attributed to market failures in the waste management sector in Western Australia, as potential recoverable resources are
being sent to landfill. Even material sent to recycling companies occasionally needs to be
sent to landfill due to poor source waste separation practices by waste generators
(demolition / manufacturing and construction companies). Whilst extraction of resources is
considered resource depletion, it can be unavoidable due to the demand for virgin raw
materials exceeding the supply of RC&D material (even if all waste RC&D material were
recovered).

Figure 2.1: Current life cycle of C&D material

A Market Research Plan (MRP) was produced to encompass all of the sectors outlined
above and to provide the methodology to gather information relating to existing and
emerging markets for RC&D materials.

A mix of primary (consultative) and secondary (desktop) market research tools was
undertaken to gather the information required. Consultative market research involved a
number of mediums including:

- Postal / electronic survey
- Telephone interviews
- Face to face meetings

A list of key stakeholders was identified from the following sources

- Review of Total Recycling Activity in Western Australia (2005/06) – Cardno BSD
- Issues Relating to the Generation, Collection and Treatment of Building Product
  Waste in Western Australia – Cardno BSD
- Recommendations from the DEC
- Liaison with the C&D and Manufacturing Industry

Secondary (desktop) research used publications and academia relating to product benefits,
construction activity, future metropolitan expansion, general facts and initiatives in the
Eastern States.
3 OVERVIEW OF BUILDING PRODUCT INDUSTRY AND SECTORS

3.1 Extractive Industry

3.1.1 Processing

Depending on the material desired, different extraction techniques are utilised to quarry materials. They all involve open cut mining. Softer materials such as sand, clay and gravel can be extracted using excavation equipment. Harder materials such as rock and limestone aggregates require drilling or blasting, then crushing to create a uniform sized material.

3.1.2 Facilities

The Perth Metropolitan Region and outer regional areas currently have a number of extraction industries supplying the local market with materials such as aggregates, sand, clay, rock and limestone. The major construction material suppliers are outlined below in Table 3.1.

Table 3.1: Major Building Material Suppliers in Western Australia

<table>
<thead>
<tr>
<th>Name</th>
<th>Material Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Ready Mix Group</td>
<td>Aggregate, Sand</td>
</tr>
<tr>
<td>Boral Resources (WA) Ltd</td>
<td>Gravel, Sand</td>
</tr>
<tr>
<td>WA Limestone Co.</td>
<td>Gravel, Limestone, Sand</td>
</tr>
<tr>
<td>Rocla Quarry Products</td>
<td>Sand</td>
</tr>
<tr>
<td>Tuma Holdings Pty Ltd</td>
<td>Sand</td>
</tr>
</tbody>
</table>

Appendix A outlines the extractive industry areas within or in proximity to the Perth Metropolitan Region.

3.1.3 Structure of Facilities

Many of the virgin extractive industries are vertically integrated with their own manufacturing or construction operations. Table 3.2 provides examples of a number of companies that currently vertically integrate sectors of their business.

Table 3.2: Examples of major extraction / manufacturing / construction vertical integration within the Perth Metropolitan Region

<table>
<thead>
<tr>
<th>Company</th>
<th>Extraction</th>
<th>Manufacturing</th>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boral</td>
<td>Clay, Hard Rock, Gravel, Sand</td>
<td>Bricks, Tiles, Cement</td>
<td></td>
</tr>
<tr>
<td>CSR</td>
<td>Aggregates, Limestone, Sand</td>
<td>Cement</td>
<td></td>
</tr>
<tr>
<td>BGC</td>
<td>Clay, Aggregates, Sand</td>
<td>Bricks</td>
<td>Housing</td>
</tr>
<tr>
<td>Austral</td>
<td>Clay</td>
<td>Bricks</td>
<td></td>
</tr>
<tr>
<td>Hanson</td>
<td>Aggregates</td>
<td>Cement</td>
<td></td>
</tr>
</tbody>
</table>
3.2 Recycled Construction and Demolition Industry

3.2.1 Processing

An important initial component of a recycling operation is the material acceptance protocols adopted by the recycler. This may involve a visual inspection of incoming truckloads and recording overall composition and source at the gate. The incoming vehicle carrying the feedstock is either driven over a weighbridge to calculate tonnages or cubic calculation of the trailer is estimated. The materials are stockpiled based on the primary composition of the feedstock to avoid contamination between feedstocks. It is preferable for the material to be separated at source (i.e before the material is delivered to the recycling facility) as the separation of mixed material is a labour intensive process and increases processing costs.

Equipment used to reprocess RC&D materials is similar to that used to process virgin aggregates. Typically, equipment comprises crushers incorporating sieves, sorting devices and screens. The material processing sequence can vary slightly between each recycler, however a generalised sequence is as follows:

- Separate Storage of different materials
- Broken concrete (0.4 – 0.7m maximum)
- Manual or mechanical pre-separation
- Primary Screening
- Magnetic Separation
- Manual or mechanical removal of remaining contaminants
- Crushing

Source: CSIRO 2002

The size of the aggregate desired can be adjusted on the crusher. Aggregate sizes generally vary between 20 – 50mm. Different sizes of crushed material (or blended material) are stockpiled ready for marketing and distribution.

3.2.2 Facilities

The RC&D industry in Western Australia at present comprises of a number of companies in different areas of the Perth Metropolitan Region. These RC&D companies can be split into two categories: salvage yards and reprocessing facilities.

Approximately 24 salvage yards are in operation within the Perth Metropolitan Region at present (WMB 2007). Salvage yards generally source material from demolition companies or the public. Products include scrap metal, timber, tiles, flooring, doors and windows. Approximately half of the demolition contractors operating in Perth are vertically integrated, with their own salvage yards. Older houses generally produce a more saleable product due to older, more valuable products which are easily extracted and marketed.

However, for the purpose of this study reprocessing facilities have been targeted, as they target higher volume / lower value material. At present there are approximately five major processing facilities in the Perth Metropolitan Region. These include:

- All Earth (Maddington);
- C&D Recycling (Hazelmere);
- Capital Demolition (Bayswater);
- Instant Waste (Bayswater); and
• Veolia Environmental (Jandakot).

A number of companies have recently expanded their operations to include the recycling of material. These include Red Sands (Banjup), Brajkovich Demolition (Upper Swan) and Midland Brick (Swan). Capital Demolition and Brajkovich Demolition currently have mobile crushing operations.

Recyclers generally place themselves away from inert landfills whilst still being close to market locations. Placing a recycling facility close to the generation of waste or market is not always appropriate, especially when landfill prices are very low or extraction companies are located nearby.

Appendix A and B outlines the RC&D reprocessing facilities in the Perth Metropolitan Regions.

### 3.2.3 Structure of Facilities

The structure of these RC&D companies in terms of operations and sourcing of material varies between operations. Vertically integration plays a part in many of these RC&D companies operations.

- **All Earth**, in Maddington, is a company that specialises in earthworks, plant hire, bulk cartage and recycling of inert and greenwaste. The All Earth facility acts as a transfer station for inert and greenwaste materials and vertically integrates with its recycling operations.

- **C&D Recycling**, in Hazelmere, is a drop off facility for inert materials. In addition, a stockpile of mixed inert material, predominantly consisting of sand is currently located on site. It is envisaged this material, over time, will be recycled.

- **Capital Demolition**, in Bayswater, is a demolition company vertically integrated with its recycling operations. Material is generally sourced from its own operations, however clean material is accepted from outside companies.

- **Instant Waste**, in Bayswater, is a skip bin business vertically integrated with its recycling and disposal to landfill operations. Instant Waste predominantly send material to landfill but have recently started extracting marketable RC&D materials to reduce landfill costs.

- **Veolia Environmental (Collex)**, in Jandakot, is also a skip bin business vertically integrated with recycling operations. Veolia Environmental attempt to recycle the material they receive, whether it be clean or in a mixed form.

### 3.3 Landfill Industry

#### 3.3.1 Processing

Little to no processing is involved in the landfilling of material, however crushing of material prior to landfilling is being undertaken in some areas to increase the life expectancy of the landfills.

#### 3.3.2 Facilities

There are a number of landfills throughout the Perth Metropolitan Region. The DEC *Landfill Waste Classification and Waste Definitions 1996 (As amended)* classes landfills depending on the type of material that can be accepted. Class I landfills can only receive inert waste streams, however depending on licensing conditions they may be able to
accept contaminated solid wastes and special wastes. Class II / III facilities can receive putrescible wastes in addition to inert wastes. Class IV and V are for contaminated and intractable waste streams.

Whilst inert waste can be accepted at any type of landfill, it is generally sent to Class I facilities due to lower gate fees, Class II / III and IV have higher construction and operational costs that have to be covered by their gate fee. Transfer Stations (drop off zones) throughout Perth will charge a further amount to supplement the travel costs to the nearest landfill.

Appendix B outlines the landfill facilities currently in operation within the Perth Metropolitan Region. In general, Eclipse Resources, RGC and Non-Organic Disposal operate the largest Class I landfill sites.

Major inert landfills are currently located at both the northern and southern end of the Mitchell / Kwinana Freeway. These major growth corridors generate significant amounts of construction and demolition waste and it is likely waste generated in these areas would be sent to local landfills instead of being transported to recyclers.

3.3.3 Structure of Facilities

Inert landfills throughout Perth are generally old quarry pits or natural depressions that can be landfilled easily, however vertical integration is also present in some of these operations. Sites such as RCG and Eclipse Resources have their own sand, limestone and rock extractive industries and supplement their incomes through back landfilling of inert material.

3.4 Recently Commissioned and Proposed Facilities

There are a number of facilities that may or may not come into operation over the next few years, subject to approval.

3.4.1 Extraction

It is difficult to determine specific future extraction industries, however key current and future extraction areas have been identified by the Western Australian Planning Commission (WAPC). WAPC have produced a Statement of Planning Policy No. 2.4 made under section 5AA of the Town Planning and Development Act 1928. Objectives of the policy are to:

- identify the location and extent of known basic raw material resources;
- protect Priority Resource Locations, Key Extraction Areas and Extraction Areas from being developed for incompatible land uses which could limit future exploitation;
- ensure that the use and development of land for the extraction of basic raw materials does not adversely affect the environment or amenity in the locality of the operation during or after extraction; and
- provides a consistent planning approval process for extractive industry proposals including the early consideration of sequential land uses.

The policy identifies a number of areas for protection including:

- current extraction areas;
- key extraction areas that are identified as providing long term resources for the Perth market; and
- priority resource locations that are recognised as providing future basic raw materials that should not be constrained by incompatible land uses or development
Overall, the policy is designed to facilitate the extraction of basic raw materials close to major markets in the Perth Metropolitan Region and to avoid any development close to these areas that may inhibit extraction of the resource. This policy will have implications to the RC&D industries well into the future.

**Appendix A** outlines these major extraction areas and future extraction reserves

### 3.4.2 Recycling

To increase the amount of wood waste being recycled in the eastern metropolitan region, the EMRC (formally Eastern Metropolitan Regional Council) officially opened a timber recycling facility located on Lakes Road in Hazelmere on the 12th March 2008. The process involves the shredding of any untreated material into products such as animal bedding, mulch and particleboard. It is estimated the facility will be able to divert approximately 50,000 tonnes of timber material from landfill per year within three years. Up to 9,000 tonnes will be reused by the Laminex Group in the first year with potential for recycled woodchip to comprise up to 15 per cent raw material input at the Laminex Dardanup Plant.

The City of Mandurah is proposing to construct a C&D recycling facility within its operations at the "Tims Thicket Septage and Inert Waste Disposal Site" in Mandurah. As the inert landfill is projected to be at capacity within three to four years it was decided it would be prudent to construct the facility for economic and environmental reasons. It is estimated the facility will begin operation in late 2008. Investigations will also be made into whether the inert landfill can be "mined" to extract basic raw materials and metals (pers comm. Boardmen 2008).

### 3.4.3 Landfill

Futures landfills, within or in proximity to the Perth Metropolitan Region, have been identified from published data released by the Environmental Protection Authority (EPA) under the Public Environmental Review process. Future landfills identified include:

- Class I landfill and Extractive Industry – Mooliabinnie
- Putrescible Bioreactor Landfill – Fernview Farm, Gingin
- Class I landfill – Vispo Holdings, Bullsbrook

### 4 CURRENT QUANTITIES AND TRENDS

#### 4.1 Extraction

**4.1.1 Data Availability and Quality**

A centralised database of annual extraction data within Western Australia or the Perth Metropolitan region currently does not exist. The Department of Industry and Resources (DOIR) release an annual report of minerals extracted and values within Western Australia, however only for quarries that operate on mining tenements under the Western Australian Mining Act. In the past regions were reported (e.g Perth Metro), however the reporting of these figures became commercially sensitive and they were subsequently omitted from future reports.

Extractive industries that occur on privately owned land are not included in the DOIR report. These private land areas instead come under Local Government jurisdiction. Part of the licensing conditions on private land usually requires the extractive industry to submit an annual report. These reports focus more on impacts of the operation to surrounding
landuses and the environment rather than output. Any reported tonnages are not tabulated over time by Local Government or located in a central database.

However, a periodic survey has been conducted in 1995 and recently in 2006 by the Chamber of Commerce and Industry (CCI) due to their concern over the availability of basic raw materials in the Perth Metropolitan region into the long term. Figures from these reports will be used for the purposes of this study.

The main purpose of the CCI report entitled “Basic Raw Materials Access and Availability 1996 – 2006” is to identify the central issues confronting extractive industries and establishes a current, short term and long term outlook focussing on supply and demand dynamics of each of the basic raw materials used in building and construction (sand, limestone, hard rock and clay). Unfortunately gravel is not targeted in the report. CCI points to the “State Gravel Supply Strategy (1998)” for supply and demand trends in relation to gravel, however this report mainly focuses on regional gravel supplies and fails to consider gravel supplies within the Perth Metropolitan Region (e.g. within City of Swan and City of Armadale).

### 4.1.2 Quantity and Trends

The CCI report focuses on material being extracted within a 100 kilometre radius of the Perth CBD. This 100 kilometre radius specifically targets the Shires of Gingin, Toodyay, Northam, Chittering, Wanneroo, Swan, Mundaring, Kalamunda, Gosnells, Armadale, Cockburn, Kwinana, Serpentine-Jarrahdale, Rockingham, Mandurah and Murray. The estimated total tonnage of material extracted within these Shires during 1995 and 2006 is outlined in **Table 4.1**.

It must be noted that of the major producers of basic raw materials surveyed in these areas, there was an 86% response rate. The centralised clay and hard rock industries provided 100% coverage, whereas the limestone and sand industry provided between 80 – 90% coverage and is therefore underestimated.

**Table 4.1: A comparison of Basic Raw Material extracted during 1995 and 2006 in tonnes (x1,000)**

<table>
<thead>
<tr>
<th>Material</th>
<th>1995</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>5,100</td>
<td>7,600</td>
</tr>
<tr>
<td>Limestone</td>
<td>4,000</td>
<td>4,750</td>
</tr>
<tr>
<td>Clay</td>
<td>2,300</td>
<td>1,940</td>
</tr>
<tr>
<td>Hard Rock</td>
<td>3,600</td>
<td>6,700</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>15,000</strong></td>
<td><strong>20,990</strong></td>
</tr>
</tbody>
</table>

Approximately 21 million tonnes of raw material was extracted from the Perth Metropolitan Region in 2006, an increase of approximately six million tonnes or 40% compared to 1995. Sand was extracted in the highest quantities during 1995 (5.1 million tonnes) and 1996 (7.6 million tonnes). Sand and hard rock experienced the greatest growth in extraction with a 49% and 86% increase respectively. Clay experienced an 18% decrease in the amount being extracted in the Perth Metropolitan Region. This can be attributed to a reduction in the amount of clay required for new residential housing over the past 10 years.

Quantities of virgin material and demand are discussed further in **Section 6**.
### 4.2 Landfilling

The reporting of waste data is a condition of licence for all landfill sites in the Perth Metropolitan Region. Landfill operators are required to quantify and categorise waste prior to disposal. If any waste is generated in the metropolitan area and disposed of at country landfill site, reports on waste tonnage and classification are also required from that landfill site (DEC 2003).

Approximately 1,894,370 tonnes of C&D material was disposed to landfill in the Perth Metropolitan Region in 2006/07. This is the highest amount recorded since accurate records began in 1995. For the purposes of this study 2005/06 figures will be used in the analysis so comparisons can be made with 2006 extraction tonnages. Approximately 1,709,690 tonnes of C&D material was landfilled in 2005/06. Current trends in inert landfill are outlined in Figure 4.1 below.

**Figure 4.1: Total tonnages of C&D material landfilled in the Perth Metropolitan Region between 1998/1999 and 2006/2007**

![Bar chart showing total tonnages of C&D material landfilled](chart.png)

With the exception of two reporting periods, it appears the amount of C&D waste being sent to landfill is continuing to increase. The two outliers (2000/2001 and 2001/2002) in Figure 4.1 have been attributed to the introduction of the Goods and Services Tax (GST) and a greater accuracy of the amount of C&D being recorded at disposal sites post 2001/02.

Golder Associates and Waste Audit & Consultancy Services were contracted by the DEC in 2007 to undertake a waste audit / profile of a number of landfill facilities in regards to C&D material being disposed. Detailed visual assessments of the materials disposed at each site provided a compositional analysis. Percentage composition of material being sent to municipal and inert landfills is outlined below (Figure 4.2). It must be noted that the data outlined on the following page is based on qualitative data and not quantitative, however it does give a good indication of potentially what material types are available for recycling.
If the DEC landfill data from Figure 4.1 is extrapolated against the C&D audit data, material streams can be calculated. Estimated tonnages landfilled in 2005/06 are outlined below in Table 4.2.

Table 4.2: Estimated amount of C&D material landfilled in the Perth Metropolitan Region during 2005/2006

<table>
<thead>
<tr>
<th>Material Stream</th>
<th>Tonnes Landfilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocks / Bricks</td>
<td>478,740</td>
</tr>
<tr>
<td>Soil</td>
<td>453,140</td>
</tr>
<tr>
<td>Concrete</td>
<td>332,820</td>
</tr>
<tr>
<td>Rubble</td>
<td>214,540</td>
</tr>
<tr>
<td>Wood / Timber</td>
<td>25,090</td>
</tr>
<tr>
<td>Metal / Ferrous</td>
<td>22,020</td>
</tr>
<tr>
<td>Plasterboard</td>
<td>9,730</td>
</tr>
<tr>
<td>Vegetation / Garden</td>
<td>8,700</td>
</tr>
<tr>
<td>Other</td>
<td>88,170</td>
</tr>
</tbody>
</table>

"Other" materials, which make up the total primarily consist of clay, plastic, cardboard, asphalt, glass and controlled waste. Cardboard and plastics make up approximately 10,000 tonnes of this total.

The data outlined above is the potential amount of material that could be recycled in addition to what is already being recycled in the Perth Metropolitan Region. Rocks and bricks, soil, concrete and rubble are disposed in the highest quantities and therefore have the highest potential to be diverted from landfill. This will be further discussed in Section 5.

4.3 Recycling

C&D material has been recycled in Western Australia for a considerable time, however it has only recently been tabulated. Approximately 364,370 tonnes of RC&D material was recycled in 2005/06 (Cardno BSD 2007) and approximately 403,870 tonnes of RC&D material in 2006/07 (Cardno BSD 2008), an improvement of 11%. There could be a number of possible reasons for this increase, including high construction activity, an increase in C&D recycling capacity, an increase in the landfill levy and a push towards sustainability within the state.
The majority of material recovered in the RC&D sector in 2005/06 (50% or 183,280 tonnes) was sand. This was followed by concrete / bitumen and brick and rubble (Table 4.3 / Figure 4.3).

Table 4.3 / Figure 4.3: Breakdown of C&D tonnages recovered and their proportions in the C&D waste stream in 2005/2006

<table>
<thead>
<tr>
<th>C&amp;D Material</th>
<th>Tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>183,280</td>
</tr>
<tr>
<td>Concrete / Bitumen</td>
<td>89,040</td>
</tr>
<tr>
<td>Brick and Rubble</td>
<td>71,020</td>
</tr>
<tr>
<td>Bricks (Whole)</td>
<td>10,860</td>
</tr>
<tr>
<td>Timber</td>
<td>10,170</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>364,370</strong></td>
</tr>
</tbody>
</table>

The tonnages received at recycling facilities show some slight correlation with the landfill audit data outlined Table 4.2; however sand is received in a much higher proportion. Difficulty has arisen when attempting to determine the total tonnage of C&D material historically been recycled in Western Australia, as recycling data has only recently been collected.

During 2005/06 approximately 2,074,000 tonnes of inert material was disposed or recycled in the Perth Metropolitan Region. Approximately 17.5% was recycled. Figure 4.4 shows the total amount material disposed in the Perth Metropolitan Region (landfilled and recycled). Growth is being experienced in both material being sent to landfill (19%) and recycled (21%) between 2004/05 and 2006/07.

Figure 4.4: Total disposal and recycling of C&D material in the Perth Metropolitan Region

Review of Recycling Activity 2004/05 (Hyder Consulting 2006)
Review of Recycling Activity 2005/06 (Cardno BSD 2007)
Review of Recycling Activity 2005/06 (Cardno BSD 2008)
Note: No Recycling data is available prior to 2004/05.
5 THE BUILDING PRODUCT MARKET

5.1 Materials Used

A number of raw materials are used in the marketplace for construction activities. Materials used on a large scale include clay, gravel, limestone, aggregates, sand, metals and timber. Materials used on a smaller scale include plasterboard and plastics. A number of raw materials require mixing and / or processing to produce a high strength product e.g. aggregates and cement being processed to produce concrete and clay being processed to produce bricks.

Recycled materials recovered from the waste stream can be both in their raw form such as sand and timber or processed form such as concrete and bricks. These materials are usually crushed to return them to a useable form. A more detailed description of each recycled product is outlined below.

5.1.1 Recycled Concrete Aggregate

Recycled concrete aggregate (RCA) is concrete that has been demolished and removed from pavements, buildings and foundations before being crushed in various sized fractions for reuse. Crushed concrete can substitute virgin aggregates such as gravel, limestone and rock.

5.1.2 Masonry Rubble

Masonry rubble comprises mainly fired clay products such as bricks, roofing tiles and lightweight blocks. Masonry waste can have higher contamination levels compared to concrete. Contaminants in masonry waste include Portland cement mortar, hardboard and plaster, concrete, terrazzo, gypsum, glass, wood, roofing tiles, plastic, metals and asbestos. The processing of masonry rubble is similar to recycled concrete but typically generates much lower value products. Masonry rubble can substitute virgin aggregates such as gravel, limestone and hard rocks in some applications.

5.1.3 Recycled Sand

Recycled sand is an aggregate normally derived from the screening process of a recycling operation, however clean sand can be disposed at a recycling centre and does not usually require any further processing. Recycled sand can substitute virgin sand in a number of applications; however it is usually not suitable for high specification material applications such as brick laying.

5.1.4 Timber

Timber received at recycled centres comes in a number of different shapes, sizes and wood product types. Large pieces of timber can be marketed, whilst other types of timber, depending on its type can be shredded. Recycled timber can be used as a substitute to virgin plantation or remnant vegetation.

5.2 Existing Markets

Whilst virgin and recycled materials are not identical, they can still compete for the same markets. Well graded, good quality recycled aggregates have the potential for use in a wide range of applications, subject to appropriate test or performance requirements. In most cases, recycled materials can substitute virgin aggregates. Typical uses for virgin and recycled materials in the current market are outlined below in Table 5.1.
Table 5.1: Current Markets Available for Extracted and Recycled Materials in the Perth Metropolitan Region

<table>
<thead>
<tr>
<th>Material</th>
<th>Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virgin Clay</td>
<td>Bricks, Pottery, Lining / Drainage</td>
</tr>
<tr>
<td>Gravel</td>
<td>Roadbase, Hardstands, Foundations, Concrete</td>
</tr>
<tr>
<td>Limestone</td>
<td>Bulk Fill, Sub-base, Blocks/Bricks, Groynes, Chemical Processes, Pollution Control, Cover in Landfills</td>
</tr>
<tr>
<td>Aggregates</td>
<td>Roadbase, Concrete, Bitumen</td>
</tr>
<tr>
<td>Sand</td>
<td>Bulk Fill, Concrete, Bricks, Glass, Landscaping</td>
</tr>
<tr>
<td>Timber</td>
<td>Construction, Mulch, Firewood, Animal Bedding,</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Recycled Concrete Aggregate (RCA)</th>
<th>Bulk Fill, Sub-base, Roadbase, Hardstands, Drainage Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crushed Tiles</td>
<td>Bulk Fill, Landscaping, Remanufacturing</td>
</tr>
<tr>
<td>Sand</td>
<td>Bulk Fill, Landscaping, Cover in Landfills</td>
</tr>
<tr>
<td>Bricks (Whole)</td>
<td>Construction, Remanufacturing into new brick, Landscaping</td>
</tr>
<tr>
<td>Brick and Rubble</td>
<td>Bulk Fill, Cover in Landfills, Remanufacturing into new brick, Sub-base</td>
</tr>
<tr>
<td>Timber</td>
<td>Particle Board, Mulch, Animal Bedding, Firewood</td>
</tr>
</tbody>
</table>

5.2.1 Bulk Fill

Bulk fill is the material used to raise levels of sites such as buildings or roads for levelling prior to construction. Bulk fill can be considered a lower value material in terms of complexity and application. Most RC&D materials can be used in this application depending on their rate of compaction. Compaction rates will vary with different engineering specifications.

The use of RCA in fill applications may not make the best use of this higher quality aggregate, however it is satisfactory where there is no other application available. Bulk fill applications are more suited to lower value recycled sand and crushed masonry material.

5.2.2 Road Pavement

Road material comprises of a number of layers to make it structurally sound. The general profile of a road is as follows:

```
<table>
<thead>
<tr>
<th>Wearing Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base course / Roadbase</td>
</tr>
<tr>
<td>Sub-base</td>
</tr>
<tr>
<td>Subgrade</td>
</tr>
</tbody>
</table>
```

The wearing surface of a road may be asphalt, bituminous seal or in the case of an unsealed road the upper surface of the base course. The purpose of a wearing surface is to provide a seal, which is resistant to deterioration from tyre friction, and to prevent water from entering the pavement (Landvision et al 1998).

Base course / roadbase is the part of the pavement that supports traffic load without permanent deformation and reduces stresses and strains on the subgrade to acceptable limits. The shoulder of a road is a compacted extension of the base coarse material that extends beyond the road for safety purposes. Laterite gravels are the most sought after virgin material for basecoarse because they are well graded and have good strength.
characteristics, however other naturally occurring materials can be used as base course including limestone, crushed rock and marl (Landvision et al 1998). RCA can be used to substitute virgin material in most base course applications. Whilst RCA is not as strong as hard rock or gravel it is can still meet specifications for most road applications.

Sub-base is usually an inferior base course material. Its purpose is to reduce the base thickness and therefore cost. Sub-base material may have wider size distribution limits, can be courser and does not require the same high strength as the base course. A greater range of materials is acceptable for sub-base with a correspondingly lower-cost. In the Perth Metropolitan Region this material is usually limestone, however RCA or crushed brick (with low contamination) can be used as a quality substitution.

Subgrade may consist of the material at natural ground level or can be imported fill. This material can be used to raise the pavement to improve drainage or to improve the vertical alignment of the road. Natural earth in-situ or imported virgin sand is normally used for this application; however most RC&D material can be used for this application provided it performs good compaction. Material that is not graded with some contamination is also suitable.

5.2.3 Drainage Material

Recycled crushed aggregates such as RCA or brick / rubble can be used for backfilling material for stormwater drainage lines or subsurface drainage such as soak wells. The application of aggregates reduces sediment build up and therefore increases the long term performance of drainage lines. Drainage material may also be used behind retaining walls.

5.2.4 Hardstands

A hardstand is a stabilised area required for the parking of equipment or a storage structure. Hardstands are common for any application that requires a hard stable surface or requires minimal infiltration. Hardstands are similar to a roads but are used in a confined area. Hardstands are usually created using crushed limestone, however RCA material can be used as a substitute producing results that satisfy or exceed specifications.

5.2.5 Landfill Cover

Landfills require a covering regime periodically to prevent odour and risks to public health. This covering regime normally involves the placement of aggregate material over the waste daily. All putrescible landfills in the Perth Metropolitan Region require a cover regime and normally import material if it is not readily available on site. Any type of recycled inert material is suitable for this application. This is an ideal use for low quality, possibly contaminated mixed loads of C&D waste.

5.2.6 Particleboard

Particleboard is a wood product made from wood chips and saw dust that is pressed and extruded to produce a strong wood like material. This material has many uses in the construction sector. Recycled material is desired due to it being much cheaper than virgin products. Particleboard manufacturers such as Laminex in Welshpool can use virgin or recycled clean wood product material to produce particleboard.

5.2.7 Brick Manufacture

Fired bricks can be incorporated back into the brick manufacturing process without detriment to the final brick product. Waste brick or “grog” that does not meet quality standards on site (e.g broken or discolouration) is reintroduced to the process. Recently
Midland Brick has started an initiative to accept bricks from construction companies, recycling companies and the public. This is further discussed in Section 5.8.

Austral Brick has indicated that whilst waste brick can be incorporated into the manufacturing process, waste brick even in its crushed state is not a direct substitute for clay shale. As the clay/shale is already fired, it will not undergo the required phase changes with repeated firing which is necessary to fuse / vitrify the body of the brick together. Recycled bricks can currently be used in solid brick manufacture due to there being sufficient virgin material to surround and vitrify the fired waste particles and still produce a strong finished product.

Recycled bricks and tiles can also be used in “common bricks” that are not colour specific and are likely to be rendered or painted covering the flecks of colour.

### 5.3 Current consumers

Current consumers of RC&D material, as indicated by the RC&D industry are currently smaller private contractors, bobcat operators and in some cases Local Government.

At present, Local Government do not readily purchase RC&D material for their operations on a large scale. Larger construction companies that share a large proportion of the market, also do not readily use RC&D materials. Both Local Government and larger construction companies on occasion dispose of some waste material at recycling facilities.

### 5.4 Potential Markets

The existing markets for RC&D materials are presently for more low-grade applications such as sub-base for hardstand areas and general fill applications. A number of higher value processes and markets are available for the use of RC&D material if the recycled material has been properly processed and tested for appropriate specification compliance. Summarised below in Table 5.2 are potential markets for RC&D materials that have been proven through research and / or real applications.

#### Table 5.2: Potential markets for concrete and masonry aggregate

<table>
<thead>
<tr>
<th>Recycled concrete and masonry aggregate</th>
<th>Bulk Fill</th>
<th>Drainage / filter</th>
<th>Road pavement</th>
<th>Pavement concrete</th>
<th>Structural concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crushed demolition debris</td>
<td>Suitable</td>
<td>Usually suitable</td>
<td>Not suitable</td>
<td>Not suitable</td>
<td>Not suitable</td>
</tr>
<tr>
<td>Graded mixed debris</td>
<td>Suitable</td>
<td>Usually suitable</td>
<td>Suitable</td>
<td>Suitable in some cases</td>
<td>Not suitable</td>
</tr>
<tr>
<td>Clean graded brick/concrete</td>
<td>Highly suitable</td>
<td>Suitable</td>
<td>Usually suitable</td>
<td>Usually suitable</td>
<td>Suitable in some cases</td>
</tr>
<tr>
<td>Clean graded concrete</td>
<td>Highly suitable</td>
<td>Highly suitable</td>
<td>Suitable</td>
<td>Usually suitable</td>
<td>Potentially suitable</td>
</tr>
</tbody>
</table>

Source: CSIRO (2002)

#### 5.4.1 RCA and Masonry in Road Pavement

RCA that has been processed and tested for appropriate specification compliance have generally demonstrated satisfactory performance as aggregate in base or sub-base in various applications. This is particularly the case for road pavements. Well processed RCA has properties that can equal or exceed the minimum requirements for conventional granular aggregates and can provide good load transfer (Poon and Chan 2005).
5.4.2 RCA in Kerbing / Pavement Concrete

Recycled concrete can be batched mixed, transported, placed and compacted in the same manner as conventional concrete, however due to differing specifications and attributes of RCA a number of different protocols are required to achieve the same desired outputs. Clean material is necessary as contaminants such as glass, organics, plaster and masonry can reduce the strength of the material.

A number of field examples in the Eastern States has shown that 100% use of RCA in concrete can be used in low impact applications such as pedestrian footpaths and kerbing applications that provide equivalent or superior performance in terms of compressive strength and shrinkage. The placement, compaction, setting and strength development behaviour of fresh RCA were found to be similar in reference to the virgin substitute. Concrete workability and bleeding characteristics were also comparable. A number of other examples showed RCA having slightly lower performance; however the concrete still met specifications (CSIRO 2002).

5.4.3 RCA in Structural Concrete

RCA can be used as a partial coarse aggregate replacement in both Portland and blended cement concrete. Past and ongoing research projects have demonstrated that quality recycled aggregates can be used as a partial substitute for virgin aggregates in concrete production (Evangelista and Brito 2006, Rao et al 2006). Essentially the incorporation of recycled materials must meet the same performance standards as conventional concrete to be regarded as technically equivalent to primary materials.

Whilst the use of RCA as a substitute for a virgin aggregate is an important step forward, a number of provisions and further experimentation are required for the use of RCA in structural concrete as RCA has a number of different properties to virgin aggregates. Further development of specifications for appropriate applications will increase the use of RCA in construction activities, as current field experience with the use of RCA for structural applications is relatively scarce.

5.4.4 RCA in Concrete Backing Blocks

Concrete blocks are permeable blocks manufactured from wet cast concrete that do not require reinforced concrete. At present they are used in a number of applications including mass gravity walls, reinforced soil structures, bridge abutments, stream channels, coastal protection, sea walls, erosion / land slippage prevention and tunnel access points. Limestone blocks are commonly placed in front of these blocks in residential areas for a more aesthetic look.

The use of RCA as a partial substitute for virgin aggregates in concrete bricks and blocks is possible (Poon et al 2002). A batching plant will be required for the process and would involve the substitution of virgin aggregates with RCA.

5.4.5 Extraction of Gypsum from Plasterboard and Gyprock

Plasterboard and gyprock from ceilings and other applications can be crushed and screened for use as a soil improver in agricultural applications. Some plasterboard can be converted into billets for the packing and transportation of new plasterboard sheets. The crushing of plasterboard and gyprock to extract the plaster and gypsum for industrial use is also potentially possible. There is also potential for the residue paper product to be separated and recycled (Ecorecycle 1998).
5.5 Current Sale Price and Processing Costs

The processing and sale of virgin and recycled products depends on a number of variables. Examples include supply and demand trends, economies of scale, processing costs, subsidies, taxes and competition with alternative products. In the case of recycled materials the sale price also depends on the external variable such as the cost of landfill. Outlined below (Table 5.3) are the typical ranges of price to produce and sell certain construction materials in the Perth Metropolitan Region. It must be noted that production costs are estimates as a deep analysis has not been undertaken by the majority of virgin and RC&D industry and processing varies greatly depending on contamination levels and efficiency of plant on site. Sale prices, especially from recyclers also vary due to the quality of product.

Table 5.3: Typical ranges in production and sale price of virgin and RC&D material in the Perth Metropolitan Region

<table>
<thead>
<tr>
<th>Material</th>
<th>Produce</th>
<th>Sale</th>
<th>Unit</th>
<th>Produce</th>
<th>Sale</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>$1 - 2</td>
<td>$5 - 12</td>
<td>Tonnes</td>
<td>$1 - 5.00</td>
<td>$2.50 - 5.00</td>
<td>Tonnes</td>
</tr>
<tr>
<td>Limestone</td>
<td>$1 - 2</td>
<td>$6 - 20</td>
<td>Tonnes</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Brick</td>
<td>$150 - 450</td>
<td>$500 - 1,500</td>
<td>per 1,000 bricks</td>
<td>$1 - 2</td>
<td>$1 - 5</td>
<td>m3</td>
</tr>
<tr>
<td>Crushed Brick</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$7 - 15</td>
<td>$4 - 6</td>
<td>m3</td>
</tr>
<tr>
<td>Concrete</td>
<td>$70 - 90</td>
<td>$120 - 180</td>
<td>m3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Roadbase</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20mm</td>
<td>$2 - 5</td>
<td>$7 - 15</td>
<td>m3</td>
<td>$7 - 15</td>
<td>$4 - 10</td>
<td>m3</td>
</tr>
<tr>
<td>40mm</td>
<td>$2 - 5</td>
<td>$7 - 15</td>
<td>m3</td>
<td>$7 - 15</td>
<td>$4 - 10</td>
<td>m3</td>
</tr>
<tr>
<td>50mm</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$7 - 15</td>
<td>$4 - 10</td>
<td>m3</td>
</tr>
<tr>
<td>Aggregates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 - 10mm</td>
<td>$2 - 5</td>
<td>$25 - 45</td>
<td>m3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>20 - 40mm</td>
<td>$2 - 5</td>
<td>$20 - 35</td>
<td>m3</td>
<td>$7 - 15</td>
<td>$4 - 12</td>
<td>m3</td>
</tr>
<tr>
<td>40 - 50mm</td>
<td>$2 - 5</td>
<td>$35 - 45</td>
<td>m3</td>
<td>$7 - 15</td>
<td>$4 - 12</td>
<td>m3</td>
</tr>
</tbody>
</table>

Note: Production costs for recycled material have high range depending on level of screening and processing required to obtain the product and the efficiency of plant on site. Therefore caution should be used in the interpretation of this data. The high sale range can be attributed to the quality of product being produced.

A key difference between the production of virgin and RC&D materials is the cost. This is directly related to the volumes being processed by each sector, also known as economies of scale. An economy of scale is when the cost of producing a unit of material falls as its output rate increases. Section 4.1 outlined the very large outputs of material being extracted in comparison to recycled products. The extraction industries also have very efficient automated machinery and conveyor systems that reduce the price significantly.

To remain cost competitive recyclers require their product to be at least a few dollars cheaper than virgin extracted material. Sales price of recycled materials is currently cost competitive with a number of virgin materials, especially aggregates and bricks. Bricks vary in weight from approximately 2.3 – 5.5 kg each depending on their properties. Therefore, 1,000 bricks would weight approximately 4 tonnes. This would result in 1 tonne of bricks costing approximately $37 to $110.

In addition to competition with extractive industries for market share, recyclers also require to be cost competitive with landfill to attract a supply of material. At present inert landfill costs in Western Australia are very low and make it especially hard for recyclers to compete and attract feedstock. Table 5.4 outlines a range of disposal fees currently in the Perth Metropolitan Region.
Table 5.4: Tipping fees (per m$^3$) at Perth Metropolitan Class I landfills and recycling centres in mid 2007

<table>
<thead>
<tr>
<th>Class</th>
<th>Material Type</th>
<th>Landfill</th>
<th>Recycling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>Clean Sand, Bricks, Gravel, Limestone</td>
<td>$9 - 14</td>
<td>Free - $10</td>
</tr>
<tr>
<td>Type 2</td>
<td>Rubble, concrete with no reinforcement</td>
<td>$12 - 14</td>
<td>$10 - 16</td>
</tr>
<tr>
<td>Type 3</td>
<td>Concrete with reinforcement</td>
<td>$12 - 14</td>
<td>$14 - 22</td>
</tr>
<tr>
<td>Type 4</td>
<td>Heavy Footing Concrete</td>
<td>$13 - 29</td>
<td>$16 - 25</td>
</tr>
<tr>
<td>Type 5</td>
<td>Mixed / Contaminated Loads</td>
<td>$12 - 16</td>
<td>$20 - 28</td>
</tr>
</tbody>
</table>

Note: - Only Class I figures have been included in this table as the majority of C&D waste is sent to these facilities. Putrescible Class II and III landfills are now charging between $45 – 77 per tonne of material received.
- Landfill prices include levy ($3/m$^3$)

Table 5.4 demonstrates that recycle centres are finding it difficult to compete with Class I landfills as they are either offering the same price or are more expensive than Class I landfills. An exception is clean material, which can easily be marketed by recycle companies and requires little to no processing costs. Type 5 or mixed loads require high gate fees at recycle centres to offset the high processing cost involved in separation of the materials and sending residual material to putrescible landfills.

Most C&D material when disposed at construction or manufacturing sites are placed into a single bin, mixing different types of material. Disposal costs at Class I landfills are much lower for this type of waste and subsequently the material is sent to these facilities. Source separation makes recycle centres much more cost competitive. Heavy concrete footings or material that is difficult to manoeuvre can receive a higher price at some inert landfills.

Whilst recyclers can be competitive with virgin materials and somewhat competitive with inert landfill for some waste streams, the margins are very tight. Recyclers have indicated that cheap landfill more so than virgin material cost is affecting their profitability. Cheap landfill is also affecting supply of material to these operations.

5.6 Barriers

Industry stakeholder consultation with contractors, manufacturers, recyclers and Local Government revealed a number of barriers that are currently present within the industry. Outlined below is a raft of barriers currently in place from the perspective of industry. The same barrier may be outlined several times, as it is a barrier faced by more than one sector.

5.6.1 Recycling Industry

The recycling industry has outlined a number of barriers that are preventing the industry increasing the amount of material being recycled and marketed. Major barriers have been described in detail whilst other barriers have been listed in point form.

Uneducated Market

The market at present is unfamiliar with recycled products in terms of benefits, location of facilities and cost. However, this is somewhat changing over time. The construction industry in the Eastern States is more aware of recycling and this increases demand for the product. This poor awareness in the Perth market place has created a stigma that recycled products are an inferior product when on the contrary well processed recycled products produced from good quality feedstock have been demonstrated to comply with most test requirements for conventional materials. Overall, recovered resources are often discriminated against on the basis of being recycled, rather than being assessed on their performance.
Cheap Landfill

Landfill costs in the Perth Metropolitan Region are some of the lowest in Australia. This can be attributed to the high number and capacity of inert landfills in the Perth Metropolitan Region and the low landfill levy. The large putrescible landfills (Class II / III) are also available for the deposition of inert products, however it is unusual for inert wastes in large volumes to be sent to these facilities as landfill prices are significantly higher. Putrescible landfills in the Perth Metropolitan Region are also rapidly reaching capacity further increasing gate fees.

The landfill levy and its effect on waste reduction is discussed further in Section 7.

Lack of Clean Supply / High Contamination

The high number of cheap landfill in the Perth Metropolitan Region has a flow on effect in that it promotes poor source separation in manufacturing, demolition and construction activities. This poor source separation results in most mixed inert wastes being sent to landfill, as costs to dispose at recycling companies is far higher due to the high processing costs. The economic viability of RC&D operations is dependant on volume to achieve the necessary economies of scale and therefore to achieve production costs that are competitive with the quarry industry. Volume is critical to justify the capital investment required.

Even a small amount of contamination increases the processing costs for recycling companies. This not only results in higher processing costs, it reduces the marketability of products due to the product having reduced performance characteristics and consequently not meeting construction specifications. Residue contaminated material removed then requires landfilling which again reduces the recycling companies bottom line. This is especially the case with mixed loads. The landfill levy is also imposed ($6/tonne) when residual unmarketable material is sent to landfill.

Tender Specifications

Almost all tender specifications, for construction projects (government and private), request the use of “virgin” or “quarry” materials. This makes it extremely difficult for recycling companies to penetrate the more high end / larger construction projects and Local Government projects. Instead, markets for recycled products are usually projects with less stringent specifications, used by contractors familiar with the product and who have confidence in its performance.

In addition, different specifications are established and maintained by Local, State and Federal Governments. Most are based on characteristics of virgin material and not on performance.

Testing Regimes by the Department of Environment and Conservation

Whilst testing regimes set by the DEC are important to protect the environment and human health from potential harm, they do place a large burden on recycling companies in terms of the associated cost involved with sampling and analysis. Analysis of one soil sample for asbestos is approximately $75 per test, whilst a sample for other contaminants such as heavy metals is approximately $200. Testing regimes for a modest sized recycling facility requires 16 tests for asbestos and 8 tests for other contaminants per day. This adds up to approximately $2,800 per day that is removed from the operations bottom line.

Non-compliance at Inert Landfills

Inert landfills within the Perth Metropolitan Region must abide by Class I licensing operations set by the DEC to remain in operation. Feedback from recyclers is that landfills
are not meeting DEC compliance and regularly accept inert loads with putrescible material exceeding limits.

**Other Barriers**

- Contractors have existing relationships with suppliers making it hard for recycled product suppliers to penetrate the market;
- It is difficult to maintain specification of recycled products due to material from different sources being disposed at recycling facilities and possible contamination of these materials. Rigid specifications from engineers make it difficult to remain in specification;
- Poor market for timber / wood waste;
- Suitable alternate locations for crushing are extremely difficult to find in close proximity to market due to surrounding landuses and objections from Local Government. At present, there are no well planned out precincts for possible recycling operations.

**5.6.2 Contractors**

*Tender Specifications / Poor Awareness*

The use of recycled materials is driven more by the client or engineering consultant than the contractor. Specifications for materials are stipulated in the construction specification. These design and material specifications are followed rigidly by contractors. If contractors use a material that is not stipulated in the specifications or does not meet design specifications, contractors will be liable for its replacement or modifications. Therefore if recycled materials are not stipulated in the specification then the contractor will not use it. However, contractors can request the use of recycled materials in their tender or during construction. It is up to the engineers and client to grant the use of this material, however this is very rare for construction projects in the Perth Metropolitan Region.

Architects, engineers and contractors at present are unaware of the benefits of using RC&D materials in construction projects. This has greatly hindered the incorporation of recycled materials in construction contracts.

*Geological Formation of the Swan Coastal Plain*

The geological formations of the Swan Coastal Plain are favourable for road construction in regards to bearing capacity. This has resulted in road specification for Western Australia to be a lower thickness than what is required in the Eastern States. Road profiles and geological formations in the Eastern States require a high amount of subgrade and sub-base material to maintain good bearing capacity, and this increases the demand for virgin resources and recycled materials.

*Proximity to Development*

The majority of development in the Perth Metropolitan Region at present is in the outer regions including Joondalup, Rockingham, Armadale and Ellenbrook. These areas are in close proximity to extractive industries and therefore transport distances are kept to a minimum. As outlined in Section 6.5, virgin materials are presently at a higher cost than recycled materials, however the distance to market is lower therefore virgin materials are most cost competitive. Contractors will choose the material that will cost them the least, yet meet specification and requirements set out in the contract.
Other Barriers

- Delays in schedule due to DEC licensing for on site crushing;
- Asbestos contamination; and
- Associated conflict with unions if there is any risk of asbestos contamination on site

5.6.3 Demolition

Asbestos

Asbestos has been identified as a major problem by the demolition industry to further recycling of C&D material. Asbestos was historically used in a number of applications for construction including roofing and insulation due to its high strength and resilience to heat and chemicals; however it was discovered that asbestos was a leading cause for lung cancer and mesothelioma in people who were exposed to airborne asbestos particles.

Whilst the majority of asbestos can be removed and disposed, the removal of asbestos can be a time consuming and expensive process. This restricts the amount of material that can be sent to a recycler. Material contaminated with asbestos requires disposal at an appropriately licensed landfill.

Asbestos and its associated health problems creates problems for the demolition industry, especially if a crusher it to be used on site to reduce the volume of material or enable recycling. Demolition contractors have indicated that Local Governments are hesitant to give approval to a crushing application due to the risk of asbestos particles being produced and becoming airborne from the crushing applications. Liability from these operations is also very high.

Recycling of Material in Inner City Areas

Whilst the uptake of recycled materials is important to reducing the amount of material being sent to landfill, the recycling of material by contractors on site can prove difficult due to space constraints. This is especially applicable in inner city areas where space is at a premium. The logistics of sending separated material to different locations also adds to disposal costs (e.g. recyclables to recyclers and residue / contamination to inert landfills).

Cost of Separation

The cost of separating waste material on site can be timely and costly, especially in high density areas with limited space available. Transport costs can be high if recyclers are not in proximity to the demolition site and if multiple trucks are required to transport the separated waste streams.

5.6.4 Local Government

Product Specifications

As discussed previously in Section 6.6.1, Local Governments can be restricted in the type of material they can accept due to their stated specifications. With the exception of the City of Canning all Local Governments surveyed (Appendix C) stipulated that virgin or quarried material should be used in construction activities.

Local Government engineers stated that the main reason for not using recycled aggregates was largely due to there being an inherent risk of using product without it being tried and tested. A Local Government engineer also queried what the implications would be if a RC&D material, supported by the DEC subsequently failed. However, most engineers were
supportive of using RC&D material in the medium to long term if RC&D materials can be tested and proven in a number of applications.

Local Government engineers also stated that due to their departments being under resourced a lot of work is outsourced to consultants and that they set the specifications. If the consultants recommended the use of a recycled product and provided the RC&D material met all relevant specifications they would accept the use of the product.

A Local Government also highlighted that there is little information on Repeat Load Triaxial (RLT) results for RC&D materials and would be reluctant to source RC&D materials without this information (this has since been completed in early 2008).

Supply of Material

Many of the Local Governments surveyed were in areas with strong demand for construction materials. This demand is largely being met by the virgin extractive industries due to their close proximity to these growth areas and therefore RC&D materials are not generally sourced due to high transport costs. This is especially the case for coastal growth areas where sand and limestone are in high supply.

For larger projects, Local Government engineers indicated that recycling companies do not have enough supply (this is acknowledged by C&D recyclers). A number of Local Governments (e.g City of Swan) also have their own extractive pits and find it difficult to justify purchasing RC&D aggregates when there is a ready cheap supply at their disposal.

Price of Material

The price of RC&D materials, especially when transport costs are included, can be higher than what can be sought for a virgin product, especially in a climate of high fuel prices. Local Government engineers also find it difficult to consider buying RC&D materials due to there not being a strong price difference between RC&D materials and virgin products. Purchasing policies of Local Government require Local Government engineers to get the best rate from the perspective of the ratepayer. However, some Local Governments who are pushing the green agenda may still source a recycled product. The City of Stirling currently reuse the asphalt when resealing roads, however this comes at an added cost when compared to sourcing virgin asphalt material.

5.6.5 Other Organisations

Main Roads

Main Roads, until very recently, have not stipulated the use of RC&D materials in any of their roads even though pavement specifications have been set. Main Roads indicate this is primarily due to their not being enough expertise in the use of RC&D material and therefore there is increased risk in its application. According to Main Roads, Local Government should firstly use the product in their roads so contractors can become familiar with the product. Once this has been achieved contractors will then start employing it in larger projects (i.e highways and freeways). Main Roads have also indicated that there is not enough RC&D material available to complete significant projects.

Main Roads, recently in early 2008, have agreed to use RC&D material in a section of road in the Perth-Bunbury Highway. This is further discussed in Section 5.8.

Landfill Construction

The use of recycled aggregates for drainage material in landfills is currently not acceptable. Sand is usually required before placement of lining material; however this sand must not contain any trace of organic material to prevent any leachate generation. This is usually
difficult for recyclers to comply with. RCA for drainage material can also not be used due to the aggressiveness of leachates in putrescible landfills. If these aggregates are degraded it may compromise the integrity of the landfill and cause leakages (pers. comm. Bruce Bowman 2007).

5.7 Success Stories

There are a number of success stories in the Perth Metropolitan Region and the Eastern States, where a RC&D material has attained market penetration into a traditionally virgin dominated market. A select number of examples are outlined below.

5.7.1 Perth to Bunbury Highway – Incorporation of RC&D material

The Perth to Bunbury Highway is major infrastructure project that will allow traffic to bypass Mandurah and Rockingham. The “Southern Gateway Alliance”, comprising of Leighton Contractors, WA Limestone and GHD have been selected by Main Roads to construct the Perth to Bunbury Highway. The proposed route is outlined in Appendix D. Sustainability principles have been proposed for the project, including green procurement and the use of RC&D material in its construction.

The use of RC&D material was considered acceptable by the alliance; however transport costs were deemed a major inhibitor as virgin quarries were in close proximity to the proposed route. To overcome this barrier the recycling industry applied for a SWIS grant to subsidise the cost of transport. This application was successful and has allowed a significant amount of material from major recyclers to be used as sub-base in a one kilometre stretch of road close to Pinjarra.

This is the first time in Western Australia RC&D material will be used in a major Main Roads project.

5.7.2 Midland Brick / Pindan Recycling Initiative

In June 2006, Midland Brick announced a brick recycling initiative aimed at reducing the amount of material being sent to landfill. Midland Brick in association with Pindan Construction formed a partnership that would see all waste bricks from a number of Pindan construction sites to be returned to Midland Brick for recycling. Midland Brick have also set up recycle centres at a number of their yards throughout the metropolitan area (Cannington, Jandakot, Joondalup, Osborne Park and Middle Swan) that can be used by the general public for brick disposal. Commercial loads can be disposed at the Middle Swan yard. Plastic strapping from the brick and paver packs can also be recycled.

At present, approximately 7,000 tonnes of brick has been recycled. This is on top of approximately 80,000 tonnes of imperfect product made at the Middle Swan, Cannington sites being re-introduced into the process. Midland Brick also have a partnership with Capital Demolition in Balcatta that recycles waste bricks from its recycling operations. Midland Brick has indicated that they are looking to increase the amount of waste brick material being recovered over the next few years, however there is a maximum proportion the firing process can accept whilst maintaining product specification (Section 5.2.7).
Brick product material must be free of contamination such as metal, cement, wood, paper and an excessive amount of mortar. Mortar when in too high concentrations contains material that is likely to explode in the firing process.

5.7.3 City of Canning - Procurement Policy in Specifications

The City of Canning has taken the initiative toward green procurement in Local Government specifications by releasing duel specifications of the incorporation of recycled and virgin material into its construction operations. C&D Recycling were recently selected by the City of Canning to provide 1,800m$^3$ of sub-base material for an 860 metre section of the Welshpool Road upgrade. Welshpool Road carries a significant number of heavy vehicles including road trains and extra wide low loaders serving several heavy engineering construction companies. The upgrade included a four lane undivided road, being widened to include a 6m median, wider lanes and turn pockets.

The RC&D material was chosen due its favourable specifications and reduced transport costs. Another advantage was that C&D waste material from other City of Canning operations could be back loaded to C&D recycling, minimising transport and landfill costs and road wear. Feedback from the City of Canning suggests that the RC&D material showed excellent workability and compaction characteristics (pers comm. Colin Leek 2007). A comparison between the recycled and virgin materials undertaken for the works, illustrated the RC&D material performed equally or better in a number of tests. Results are outlined in Appendix D.

In addition the City of Canning also now requires a minimum of 5% recycled asphalt product (RAP) in all new roads built. Pioneer Road Services (a subsidiary of Hanson) are currently stockpiling RAP for use in City of Canning projects. The City of Canning and Pioneer Road Services are also investigating the use of domestic glass as a fill material in bitumen. Whilst not strictly C&D waste, it is a possible opportunity to use the waste glass that is currently produced in large quantities at the Southern Metropolitan Regional Councils Resource Recovery Facility on Ranford Road in Canning Vale.

The City of Canning is an example of when initiative and education can influence waste stream dynamics and promote the use of used C&D material as a resource rather than a waste.

5.7.4 Waste Stream Management / Town of Kwinana / Main Roads – Pavement Specifications

Waste Stream Management in partnership with the Town of Kwinana and Main Roads constructed a road using RCA on a one kilometre stretch of Gilmore Avenue which was subject to Main Roads testing over an extended period. The road is frequented by regular passenger and heavy freight vehicles.

It was concluded that the recycled stretch of road performed better than a control virgin road in close proximity to the road. The Town of Kwinana has indicated that the control road has since started showing visual degradation whilst the road using RCA has remained in good condition (pers. comm. Kenwood Singe 2007).

Whist the test road may have proven a success, the resulting partnership between Main Roads and Waste Stream Management and the general incorporation of RCA into road projects was not as positive. A number of reasons led to the demise of Waste Stream Management providing RCA for road construction. As outlined by the Town of Kwinana these included:
• an unwillingness to import fines into the material at Main Roads request;
• the slow response and willingness to use material in future road construction by Main Roads; and
• the lowering of the price of landfill in the Kwinana area to restrict supply of material to Waste Stream Management (pers. comm. Kenwood Singe 2007)

Waste Stream Management subsequently were forced to sell the $1 million crushing equipment imported from Germany and ironically now have a Class I landfill in Medina. However, overall the partnership between Waste Stream Management, the Town of Kwinana and Main Roads resulted in Main Roads updating their pavement specifications to include alternate materials such as RCA for road construction. The project proved that RCA can be used successfully in sub-base and base course and is a viable alternate material to virgin extracted products.

5.7.5 CSR/ResourceCo (SA) and BORAL / Delta Demolition (VIC) Partnership

In the Eastern States demolition / recycling companies have formed partnerships with extraction / manufacturing companies to produce products consisting of high quality recycled materials. Whilst these partnerships have generally formed due to the different building and construction industry environment in the Eastern States, such as higher transport distances and good quality materials becoming scarcer close to markets, there has been a shift in thinking since specifications were established for major roads and recycling companies were awarded major government contracts. As a result of recycling companies penetrating the market, large suppliers of raw materials have formed an interest in developing recycled products from recovered C&D waste. One of the reasons for Boral moving towards recycling was that another extraction company had formed a partnership with a recycling company. This began the partnership between Delta Demolition and Boral. CSR Readymix have also formed a strong partnership with ResourceCo in South Australia.

It is envisaged that once recycling companies in the Perth Metropolitan Region further penetrate into the virgin market by winning major contracts that virgin extraction / manufacturing industries will become much more interested in the use of a recycled product in their operations. This could possibly see partnerships established and accelerated use of recycled products in construction operations due to greater confidence in a established brand such as Boral or CSR Readymix.

5.7.6 Council House 2 – Melbourne Central Business District

Council House 2, in the Melbourne CBD, has set the new benchmark in sustainable office design in Australia. The building has been awarded a six star rating by the Green Building Council of Australia, and has been recognised by the United Nations for best practice.

The building incorporates a number of design attributes including water and energy efficiency, however the design attribute relevant to this project is the use of RCA and recycled timber in a number of applications throughout the building.

Boral, in partnership with Delta Demolition have developed a “green concrete” that incorporates the use of RCA. Energy intensive Portland Cement is partially replaced with Fly Ash (a waste product from Coal Fired Power Stations). The cement also uses alternate sources of energy (tyres, used oil and fat).
As the project was a first in Australia, Boral required experimentation on a number of specifications for the project to meet Green Star Office Criteria. It was determined that the use of RCA in some applications was not possible due to concerns about the effects of residual cement on binding strength, shrinkage and other technical performance characteristics, however in these instances unused virgin concrete from other BORAL operations were sourced preventing wastage at these sites. In areas identified that did not have structural risk, RCA was used as a virgin substitute.

6 MARKET DEMAND

6.1 Economic Forecast and Trends

The demand for construction materials generally follows economic activity and growth in the construction sector. Figure 6.1 illustrates actual construction activity and associated growth between 1998/1999 and 2006/007 and predicted construction activity over the next five years.

Figure 6.1: Actual Construction Activity and Associated Growth

Construction activity in the Perth Metropolitan Region has been unprecedented since 2001/2001 with very high growth in all construction sectors, especially the engineering sector (earthworks and roads). During 2005/06 approximately $15 billion was spent on construction in the Perth Metropolitan Region (CCI 2007).

Residential construction activity in the Perth Metropolitan Region is predicted to decline over the 2006/07-2009/10 period; however it is predicted to increase in 2010/2011. Non-residential activity in the Perth Metropolitan region is predicted to remain strong until at least 2011/2012. Engineering activity is predicted to remain strong, however is predicted to decline slightly post 2009/2010. Overall construction in the Perth Metropolitan Region is predicted to remain strong into the near future.
6.2 Existing Demand

The current market for construction material is currently dominated by the virgin extractive industries. Existing demand for basic raw materials (as outlined in Section 5) was approximately 21.4 million tonnes during 2005/06 with approximately 21 million tonnes being sourced from the virgin extraction industry and approximately 360,000 tonnes from the RC&D industry. This equates to a 98% market share by extractive industries.

In terms of demand for construction materials by industry sector (i.e Local Government, State Government, manufacturing industries, small private companies and large private companies) actual demand / tonnages become difficult to predict. Extraction companies and recycling companies generally do not know what their products are being used for unless they have vertically integrated manufacturing or construction industries.

The CCI “Basic Raw Materials Access and Availability 1996 – 2006” report was able to determine a market in terms of material type for hard rock and limestone raw materials (Table 6.1 and Table 6.2 respectively). Unfortunately the report does not give a market split in regards to sand or clay; however it can be assumed that most clay is used in the manufacturing of bricks and sand for fill and building requirements.

Table 6.1: Existing demand and market for virgin hard rock materials in the Perth Metropolitan Region in tonnes (x1000) in 2006

<table>
<thead>
<tr>
<th>Hard Rock</th>
<th>Tonnes (x 1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td></td>
</tr>
<tr>
<td>Premixed Concrete</td>
<td>2,230</td>
</tr>
<tr>
<td>Concrete Products</td>
<td>690</td>
</tr>
<tr>
<td>Asphalt</td>
<td>860</td>
</tr>
<tr>
<td>Roadbase</td>
<td>2,920</td>
</tr>
<tr>
<td>TOTAL</td>
<td>6,700</td>
</tr>
</tbody>
</table>

Approximately 6.70 million tonnes of hard rock was required for construction purposes in the Perth Metropolitan region during 2006. The majority of hard rock extracted from the Perth Metropolitan Region is for roadbase (44%) and the premixed concrete industry (33%).

Table 6.2: Existing demand and market for virgin limestone materials in the Perth Metropolitan Region in tonnes (x1000) in 2006

<table>
<thead>
<tr>
<th>Limestone</th>
<th>Tonnes (1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td></td>
</tr>
<tr>
<td>Cement / Lime</td>
<td>2,560</td>
</tr>
<tr>
<td>Other</td>
<td>2,190</td>
</tr>
<tr>
<td>TOTAL</td>
<td>4,750</td>
</tr>
</tbody>
</table>

Approximately 4.75 million tonnes of limestone was required for construction purposes in the Perth Metropolitan region during 2006. Over half of limestone extracted from the Perth Metropolitan Region is used for lime to be used in cement (54%). The remainder is predominantly used for road base, roadwork and building stone.

Recyclers have indicated that the majority of the product used would be for hardstands, sub-base / Roadbase, drainage aggregate and deep fill. Table 6.3 estimates the amount of material used in key recycling markets in the Perth Metropolitan Region during 2005/06.
### Table 6.3: Existing demand and markets for RC&D MATERIAL Material in the Perth Metropolitan Region (2005/06)

<table>
<thead>
<tr>
<th>Material</th>
<th>Markets</th>
<th>2005/06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bricks (Whole)</td>
<td>Reuse / New Bricks</td>
<td>10,860</td>
</tr>
<tr>
<td>Brick and Rubble</td>
<td>Sub-base / Hardstands / Cover Material</td>
<td>71,020</td>
</tr>
<tr>
<td>Concrete / Bitumen</td>
<td>Sub-base / Roadbase / Hardstands</td>
<td>89,040</td>
</tr>
<tr>
<td>Sand</td>
<td>Deep Fill</td>
<td>183,280</td>
</tr>
<tr>
<td>Timber</td>
<td>Particleboard</td>
<td>10,170</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>364,370</strong></td>
</tr>
</tbody>
</table>

Source:  Review of Recycling Activity in Western Australia 05/06 (Cardno BSD)

The construction market do not specifically target recycled product as such, rather the market requires a basic raw material for their construction activities that is equivalent to using a virgin basic raw material. Construction companies highlight material cost, transport costs, specifications and usability as the key parameters in the use of any construction material. A push for the use of RC&D material by government or industry to minimise the amount of waste being sent to landfill will inevitably require uptake of the diverted material to the building and construction market.

Recyclers have indicated that the market is willing to uptake this material in large quantities. The demand for RC&D material currently outweighs supply, sometimes to an extent that recyclers run very low or exhaust all available supplies in the yard.

### 6.3 Future Demand for Basic Raw Materials

#### 6.3.1 Geographical Area

Demand for basic raw materials (virgin and recycled) is obviously in areas experiencing construction activity. The Metropolitan Regional Scheme (MRS) is a large town planning scheme for landuse in the Perth Metropolitan Region adopted by the Western Australia Planning Commission (WAPC). The MRS defines future growth in the metropolitan area by dividing it into broad zones and reservations and therefore can be used to predict where there will be demand for basic raw materials into the future.

The Perth Metropolitan Region, according to the MRS, has designated growth corridors in which development will occur. These areas of development include:

- north along the coast (Joondalup);
- south along the coast (Mandurah);
- north east parallel to Darling Scarp (Ellenbrook);
- south east parallel to Darling Scarp (Armadale); and
- existing inner city areas

Therefore these areas can be expected to demand the highest amount of raw materials for construction activities. Based on the geographical distribution of recycling companies as outlined in Appendix B, recyclers are well placed to supply a high amount of material to the market, especially in the north east, south east and inner city growth areas.

Future major roads have also been proposed by Main Roads that correlate with these growth corridors (Appendix E). These roads will require significant quantities of material for their construction.
6.3.2 Forecasts

As outlined in Section 6.2 construction activity and therefore demand for basic raw materials is likely to remain strong for at least the next five years in all construction sectors (engineering, residential and non-residential).

The CCI “Basic Raw Materials Access and Availability 1996 – 2006” report assessed likely basic raw material building requirements for 2006 – 2011 for the Perth Metropolitan Region. The forecast was based on a number of variables attained from various organisations including

- West Australian Planning Commission population projections;
- Landvision forecasts based on ABS, Housing Industry Forecast Group and Australian Housing and Urban Research Institute projections;
- Dwelling completion figures obtained by the ABS; and
- ABS average basic raw material requirement for the typical single residential dwelling

An estimate of the amount of material required for the next five years by region is outlined in Table 6.4.

Table 6.4: Basic Raw Material Requirements – Perth Metropolitan Region, Peel and WA Sector 2006 – 2011 in tonnes (x 1,000)

<table>
<thead>
<tr>
<th>Material</th>
<th>Market</th>
<th>Northern</th>
<th>Inner / Middle</th>
<th>Southern</th>
<th>Peel</th>
<th>WA</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>Fill / Brick Sand</td>
<td>11,850</td>
<td>3,350</td>
<td>14,300</td>
<td>3,400</td>
<td>-</td>
<td>32,900</td>
</tr>
<tr>
<td>Limestone</td>
<td>Cement / Lime</td>
<td>3,580</td>
<td>1,010</td>
<td>4,320</td>
<td>1,030</td>
<td>1,380</td>
<td>11,320</td>
</tr>
<tr>
<td></td>
<td>Roadbase / Site works /</td>
<td>3,060</td>
<td>870</td>
<td>3,700</td>
<td>880</td>
<td>1,180</td>
<td>9,690</td>
</tr>
<tr>
<td></td>
<td>building stone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay</td>
<td>Bricks</td>
<td>2,530</td>
<td>930</td>
<td>3,050</td>
<td>780</td>
<td>2,940</td>
<td>10,230</td>
</tr>
<tr>
<td>Hard Rock</td>
<td>Roadbase</td>
<td>4,590</td>
<td>1,300</td>
<td>5,540</td>
<td>1,320</td>
<td>-</td>
<td>12,750</td>
</tr>
<tr>
<td></td>
<td>Concrete / Asphalt</td>
<td>5,940</td>
<td>1,680</td>
<td>7,170</td>
<td>1,700</td>
<td>-</td>
<td>16,490</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>31,550</td>
<td>9,140</td>
<td>38,080</td>
<td>9,110</td>
<td>5,500</td>
<td>93,380</td>
</tr>
</tbody>
</table>


Note: Figures have been developed based on residential basic raw material requirement for the residential sector extrapolated against assumed consumption for all construction sectors including market. Therefore caution should be used in any interpretation.

The greatest amount of construction material will be required in the Northern (31 million tonnes) and Southern areas (38 millions tonnes) of the Perth Metropolitan Region between 2006 and 2011. Significant quantities will also be required in inner city areas (9 million tonnes).

In terms of material type sand will be required in the highest quantities (33 million tonnes), followed by concrete / asphalt (16 million tonnes) and road base (13 million tonnes).

RC&D materials fit into the figures presented in Table 6.4 as they can be considered a basic raw material that can substitute most of the materials that are currently being extracted in the Perth Metropolitan Region, however high specification markets such as “brickie” sand and cement / lime will continue to require virgin materials. Potential future markets, as outlined in Section 5.4 include concrete and asphalt in pavement and even possibly structural concrete, however this would require much further investigation. Market prioritisation is discussed further in Section 8.
6.3.3 Future Recycled Building Product Demand

If current trends continue it is likely there will be growth in the RC&D sector over the coming five years, however this is highly dependant on whether recyclers can continue to secure clean supply. In addition many variables exist that will influence the recycling of C&D waste including future landfill capacity, price of virgin materials, procurement policies by government and industry, competition, landfill prices and an increase in landfill levies over time. Figure 6.2 highlights the likely future growth in the RC&D sector over the next five years if current trends continue.

Figure 6.2: Current market demand for RC&D material and projected future market demand over the next five years.

If the RC&D sector continues growth at its current rate approximately 600,000 tonnes of C&D material will be sourced by the market by 2011 / 2012. This projected demand would be considerably higher if a number of barriers were broken in regards to the use of RC&D as outlined in Section 5.6.

6.3.4 Regional opportunities

There are potential regional opportunities for C&D recycling, especially in major regional centres such as Albany and Geraldton. These centres are currently generating significant amounts of C&D waste due to population growth and high construction activity. Steps have already been taken in both of these regional centres in terms of future incorporation of RC&D into operations. The City of Albany has recently purchased a trummel and crusher to process C&D waste whilst the City of Geraldton-Greenough are stockpiling material for possible future recycling.

Regional town sites are also beginning to stockpile material to preserve landfill space lending to the possibility that economies of scale may be reached in certain regional councils in regards to recycling of C&D materials.
6.4 Potential Demand for RC&D Material

It is encouraging that RC&D materials are finding markets, however there is potential for this to be much larger if a greater amount of C&D material could be diverted from Perth’s inert and putrescible landfills. Recyclers have indicated that all material from Perth’s landfills could be absorbed by the existing recyclers and marketed; such is the demand for construction material at present.

6.4.1 Potential Demand

The potential supply of RC&D material has been calculated through extrapolation of DEC C&I and C&D landfill data with the composition analysis of C&I and C&D material conducted by Golder Associates and Waste Audit and Consultancy Services. Results are outlined in Table 6.5.

Table 6.5: Potential Demand for Recycled Building Product in the Perth Metropolitan Region in tonnes

<table>
<thead>
<tr>
<th>Material Stream</th>
<th>Landfilled</th>
<th>Recycled</th>
<th>Potential Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil / Sand</td>
<td>484,310</td>
<td>183,280</td>
<td>667,590</td>
</tr>
<tr>
<td>Rocks / Bricks</td>
<td>507,680</td>
<td>10,860</td>
<td>518,540</td>
</tr>
<tr>
<td>Concrete</td>
<td>351,890</td>
<td>89,040</td>
<td>440,930</td>
</tr>
<tr>
<td>Rubble</td>
<td>251,650</td>
<td>71,020</td>
<td>322,670</td>
</tr>
<tr>
<td>Metal / Ferrous</td>
<td>55,660</td>
<td>24,310</td>
<td>79,970</td>
</tr>
<tr>
<td>Wood / Timber</td>
<td>151,140</td>
<td>10,170</td>
<td>161,310</td>
</tr>
<tr>
<td>Plasterboard</td>
<td>14,050</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Other</td>
<td>439,450</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2,255,830</td>
<td>388,680</td>
<td>2,191,010</td>
</tr>
</tbody>
</table>

DEC – Landfill Data (Perth Metropolitan Region) (2005/06)
Review of Recycling Activity 2005/06 (Cardno BSD 2007)

Note: Waste audit is qualitative not quantitative

The greatest amount of material going to waste that could potentially be diverted from landfill is rocks / bricks with approximately 507,680 tonnes being dumped to landfill in 2005/06. This is followed by soil / sand (484,310 tonnes), concrete (351,890 tonnes) and rubble (251,650 tonnes). Approximately 55,660 tonnes of high value scrap metal from the C&D and C&I waste stream was also sent to landfill in 2005/06. Timber and plasterboard (Section 5.4) are also potentially recyclable. The majority of “other” includes potentially recyclable plastics, paper and cardboard. Overall (excluding plasterboard and other) approximately 1.8 million tonnes of C&D material was dumped into landfill and approximately 388,680 tonnes of C&D material recycled in 2005/06. Therefore there is approximately 2.2 million tonnes of material potentially able to be recovered for recycling.

6.4.2 Potential Market Penetration

Based on the current level of sand, concrete, brick and rubble material being sent to landfill and recycled at present in the Perth Metropolitan Region an estimate can be made of potential market penetration if specific quantities of waste were diverted from landfill (Table 6.6).
Table 6.6: Potential market penetration of RC&D material into the basic raw material market

<table>
<thead>
<tr>
<th>% Diversion from Landfill</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tonnes Diverted</td>
<td>0</td>
<td>159,553</td>
<td>319,106</td>
<td>478,659</td>
<td>638,212</td>
<td>797,765</td>
<td>1,595,530</td>
</tr>
<tr>
<td>% Market (Recycled)</td>
<td>1.7</td>
<td>2.5</td>
<td>3.2</td>
<td>3.9</td>
<td>4.7</td>
<td>5.4</td>
<td>9.2</td>
</tr>
<tr>
<td>% Market (Virgin)</td>
<td>98.3</td>
<td>97.5</td>
<td>96.8</td>
<td>96.1</td>
<td>95.3</td>
<td>94.6</td>
<td>90.8</td>
</tr>
</tbody>
</table>

Source: Landfill data - Department of Environment and Conservation
Note: Extrapolation of data excludes metals, timber, plasterboard and "other"

At present C&D recyclers have approximately 1.7% of the total basic raw materials market in the Perth Metropolitan Region. If all C&D waste were diverted from landfill (assuming all 1.6 million tonnes of waste material could be recovered and marketable) the C&D recycling industry could hold approximately 9.2% of the total basic raw material market (an increase of 7.5%). Whilst this is a significant improvement, it is obvious that the majority of basic raw material required for construction in the Perth Metropolitan Region will continue to be sourced from the extraction industries to satisfy demand. This is illustrated graphically in Figures 6.3 and 6.4.

Figure 6.3 and Figure 6.4: Current and potential market penetration of RC&D material in the Perth Metropolitan Region

![Current Market Penetration](chart_current.png)

![Potential Market Penetration](chart_potential.png)

Note: Figure 6.4 excludes metals, timber, plasterboard, vegetation and “other” and assumes all waste material can be recovered

Products that would be displaced would obviously be virgin extracted materials equivalent to RC&D material, i.e., brick, rubble and RCA would displace limestone and gravel, recycled sand would displace virgin sand and recycled bricks would displace clay. A number of industry sectors (Local Government and major construction companies) outlined their desire to use RC&D material in their operations if the product was comparable to virgin products in terms of specification, workability, price differentials and transport costs.

Due to the small scale of the recycling industry in the Perth Metropolitan Region and its associated low market penetration of around 2%, it is unlikely virgin quarries would start competing in a price war with recyclers in the short term, however if recyclers were to start gaining market share (say 5%) virgin quarries may consider other means to reduce recyclers presence in the market or as outlined in Section 5.8 begin recycling themselves.
7 IMPACT OF INCREASED SUPPLY / DECREASED DEMAND INTO THE FUTURE

7.1 Landfill Price Increases

As outlined earlier in the document, the low cost of landfill in the Perth Metropolitan Region is a major factor in the low recovery rate of RC&D material at present. This high proportion of material being sent to landfill puts a strain on the supply of material being diverted to recyclers.

An increase in the cost of landfill, especially inert landfills will provide a strong driver to divert material away from these facilities. Material will instead flow towards recyclers increasing their available supply to meet the current strong demand for construction material in the marketplace.

The Environmental Protection (Landfill) Levy Act 1998 was enacted so a levy could be subjected to both inert and putrescible waste streams. A landfill levy was introduced by the West Australian State Government in 1998 to provide the following functions:

- to increase the comparative price of landfill and make recycling more cost competitive; and
- to provide resources for the State Government to strategically invest in recycling initiatives (Four Scenes 2007)

Between 1998 and 2006 the landfill levy remained largely steady at $3/tonne for putrescible waste and $1/m$^3$ for inert wastes. During 2006 a decision was made by the State Government to increase the levy for putrescible waste and inert waste to $9/tonne and $9/m^3$ by 2010/11 respectively. It was proposed that the levy for inert waste material would increase by $2/m^3$ each year from 2008/09 (Four Scenes 2007).

A levy on inert material waste has more significance than putrescible waste, as it represents a much larger proportion on the total cost of landfilling the material. Based on figures provided in Section 5.5, the inert landfill levy (currently $3/m^3$) represents approximately 10–30% of the total cost of landfilling the material. As the cost for landfilling putrescible material is high ($44 – 77 /tonne) the levy (currently $6/tonne) has much less effect on the total cost (approximately 8 -14% of the total cost of landfilling).

Recyclers welcomed an increase in the levy in 2006 and reported an increase in supply and tonnages being recovered, however as outlined in Section 5.5 costs to landfill inert material are still more cost competitive than recycling even with the levy being imposed. The price differential between landfills and recyclers is especially high for mixed waste streams which makes up the highest proportion of C&D waste disposed. This price differential was likely to close somewhat with the annual increase in the levy until 2010/11.

As of July 1st 2008, the landfill levy for inert waste was scheduled to increase to $5/m^3$, however a decision was made in June 2008 by the new Waste Authority to freeze any increase for at least six months whilst a review process is undertaken on the Category 63 landfill levy (inert waste). The reasons for this decision are unknown; however the Waste Authority will be conducting stakeholder consultation before stating their position in late 2008.

Until there is a critical price differential between landfill and recycling of C&D material, a "cultural change" in how inert waste is disposed in the Perth Metropolitan Region will be unlikely. Closing of the current price differential will drive waste producers to source separate material to reduce gate fees. This in turn will increase the supply of clean material to recyclers, reducing processing costs and increase the marketability of RC&D materials.
An increase in landfill prices will assist recyclers to further off-set the high cost of processing waste material and may also promote innovation in the marketplace as recyclers will have additional funds to push less traditional low value markets.

### 7.2 Economic Fluctuations

As outlined in Section 7.1, whilst there has been a recent slowing in the construction industry, the demand for basic raw materials is set to remain strong in the Perth Metropolitan Region for at least the next five years in all construction sectors (engineering, residential and non-residential). As generation of C&D waste is correlated with economic activity, it is also likely the generation / potential supply of C&D waste will remain strong. Therefore the supply of waste C&D material and future demand for basic raw materials (including RC&D material) will remain high.

If there were to be an economic downturn, this would inevitably reduce the amount of C&D waste supply in the marketplace and would likely reduce the amount of waste being sent to C&D recyclers and landfill. This downturn would in turn reduce the economies of scale of recycling facilities and increase production costs. Markets for RC&D material would largely remain the same. Many recyclers can shield the effects of economic activity and demand for material due to the structure of their operations. As outlined in Section 4.2 many recyclers are vertically integrated with other parts of their operations. Capital Demolition has interests in demolition and logistics, All Earth in earthmoving and waste transfer and Veolia and Instant Waste in skip bin waste transfer. C&D Recycling at present is solely focussed on recycling activity; as such it leaves the business exposed to economic volatility in terms of supply and demand of clean RC&D material. C&D Recycling therefore require the construction and demolition market to remain strong to ensure supply and demand of material and therefore revenue.

A further shield for the recycling industry to remain viable is for a continual increase of material being diverted from landfill regardless of the economic situation in the Perth Metropolitan Region. Recyclers are confident that demand would still outweigh supply if there were to be an economic downturn.

The cost for virgin basic raw materials has fluctuated during the last 10 years, however even with the current high demand for basic raw materials; prices have remained within a similar cost range in 2006 to that recorded in 1996. The price stability can be attributed to industry restructuring, improved technology, economies of scale and market competitiveness as well as adequate supply of material close to the Perth Metropolitan region (CCI 2007). In light of this, the cost for recycled materials will also need to remain steady to maintain competitiveness.

In the presence of an economic downturn supply of material to recyclers may be reduced. This could result in a reduction of economies of scale and prices for RC&D material may need to rise. This highlights the importance of maintaining adequate supply to recyclers regardless of an economic downturn through diversion of material from landfill.

At present there are cost savings in construction / demolition companies’ source separating materials and sending to a recycler instead of landfilling, however, in the current economic boom waste disposal costs to waste generators (construction demolition companies) can be considered to be of little significance and therefore not seen as a priority in terms of cost savings. If there were to be a sudden economic downturn combined with the continual increase of landfill prices with the landfill levy, it may drive waste generators into source separating materials to reduce waste disposal costs, likewise if landfill prices were to significantly increase eating into waste generators bottom line.
7.3 Increased Supply on Market Prices

An increased supply of material to recyclers is unlikely to affect the price of RC&D material even if economies of scale were to be increased and processing costs reduced. Rather recyclers would aim to maintain their cost competitiveness against virgin materials and instead use any financial gain elsewhere in operations to further grow the business such as marketing, more efficient machinery and staff.

Due to the small scale of the recycling industry in the Perth Metropolitan Region and its associated low market penetration of around 2% it is unlikely virgin quarries would start competing in a price war with recyclers in the short term, however if recyclers were start gaining additional supply and market share (a maximum of 9%) virgin quarries may consider lowering prices to reduce recyclers presence in the market, however gaining 9% market share would be very unlikely even in the long term.

The landfill industry, however would have a much greater incentive to reduce landfill prices if material were beginning to flow towards recyclers. As outlined in Section 6.8 this was the case when Waste Stream Management began crushing material and attaining market share in the Kwinana area. Landfill operators in the region reduced their gate fees, restricting Waste Stream Management in the attainment of material. The reduction in material in turn reduced the economies of scale of the operation and Waste Stream Management were forced to move back into the landfilling industry.

Whilst it is unknown whether inert landfill industry could sustain the undercutting of the recycling market, there is potential for inert landfills to at least undercut the market for a short period of time. The landfill levy reduces this risk somewhat by forcing a cost on the disposal of waste to landfill. An increase in the levy would only reduce the ability of inert landfill companies to undercut recycling operators. It is likely with an increase in the landfill levy over time, inert landfill operators will look towards installing recycling infrastructure themselves, further increasing competition in the RC&D market. This is already apparent with a number of transfer stations and inert landfill operators purchasing sorting or crushing equipment to reduce the cost of sending waste to landfill and / or to preserve landfill space. Some recyclers have commented that these operations do not follow best practice procedures and produce material that is inferior in quality, in turn effecting confidence in the marketplace towards the use of RC&D material.

Due to the size of the West Australian market and close proximity of virgin quarries to the Perth Metropolitan Region it is unlikely, at present, virgin extraction companies will begin recycling materials or form partnerships with recycling companies (as what has happened in the Eastern States). If virgin quarries could not meet demand in the future for whatever reason (e.g material becoming scarce), prices are likely to increase. CCI envisages that reserves of good quality limestone and sand in the Perth Metropolitan Region are likely to become critical over the next 30 years if further reserves are not secured or licences not extended.

If reserves cannot be secured, it will only increase the price of raw materials and make recycling waste C&D material more attractive to the marketplace.

8 MARKET PRIORITISATION

Market prioritisation is dependant on what the desired outcomes are in the C&D waste sector, whether it’s the reduction of waste being sent to landfill (primarily the goal of the DEC) or creating an environment that is most viable and attractive to the recycling industry (primarily the goal of reprocessors). It must be noted that these two outcomes are not mutually exclusive and share many of the same market priorities.
Current and potential markets and their prioritisation (material type, geographical area and market sector) are based on feedback received from the marketplace and recyclers gathered during the consultation process.

### 8.1 Material Type

Material in high volumes that requires minimal processing and have market value and market confidence have been targeted by recyclers and should continue to be given high priority. Potential markets that recyclers have begun to investigate include the use of recycled concrete aggregate in higher specification roadbase / basecourse and concrete pavement and backing blocks.

Pursuing higher grade material (roadbase / basecourse, pavement etc) with more stringent specifications has been the focus of a select number of recyclers, however some recyclers view the penetration of this market unnecessary when there are already mature markets available. Nevertheless all the major recyclers (Veolia, Capital, All Earth, C&D Recycling) are participating in a testing regime (funded by a SWIS grant) to determine whether their material can meet Main Roads Pavement 501 specifications. If the material can return successful results over a period of time it is another market each recycler can consider in addition their already established markets.

As discussed in Section 5.8, trials and testing have begun for RCA to be used in a section of the Perth – Bunbury Highway by Main Roads and a section of Welshpool Road by the City of Canning. The City of Canning is also investigating whether RCA can be used in pavement concrete. If these trials are successful (based on initial testing the product is performing beyond stated specifications) this will only increase demand for RC&D material in the marketplace.

A matrix of market prioritisation is outlined in Table 9.1. The table lists all current and potential markets for RC&D materials and associated market factors (supply, demand, price, ease implementation, specification) that will affect their uptake by the market. Each material has been given a rank between 1 and 5 (1 - low prioritisation and 5 – high prioritisation) in regards to each market factor. Barriers to market penetration of each material are outlined in Table 9.2. Each of these barriers are discussed in more detail in Section 5.6. These barriers provide the basis of the ranking given to each current and potential RC&D material market.

Markets that should continue to be given high priority (rank greater than 3.5) are the already established markets of bulk fill (sand), hardstands (rubble / concrete), landfill cover (all material), drainage aggregate and sub-base (low specification RCA / rubble). Recyclers established these markets due to cost benefits to the market (material cost and transport distances) whilst meeting required specifications.

An emerging market that has high potential, and therefore should be given greater prioritisation is the use of recycled brick in brick manufacture. Other emerging markets including high specification sub-base and roadbase should also be given a priority; however these markets should not be pursued at the expense of already established markets. Rather the pursuit of high specification markets should complement the mature markets and provide recyclers with the opportunity to diversify their markets should demand increase significantly for this higher specification material.

Markets that should be given a lower priority include the use of material in very high specification material such as structural concrete. Whilst a considerable amount of research has been undertaken in the use of RCA as a substitute for virgin aggregate in concrete manufacture, and findings suggest there is some potential for some integration, it should not be given priority by recyclers in the short to medium term when there are many other markets available.
8.2 Geographical Distribution

In terms of market penetration in geographical terms recyclers should continue to focus on the eastern growth areas and inner city areas in close proximity to their operations. Recyclers are at an advantage to service inner city areas due to their close proximity (Appendix A). A large amount of demolition and construction activity will be occurring in inner city areas for urban renewal in the foreseeable future. Network City, a new strategic framework for guiding Perth towards a sustainable future by the Department of Planning and Infrastructure, envisages that approximately 60% of required future dwellings will be provided in existing urban areas.

Inner city Local Governments and redevelopment authorities such as the East Perth Redevelopment Authority and Subiaco Redevelopment Authority are organisations that generate significant amount of waste material in their operations and subsequently require material for their renewal operations. These are examples of existing markets and potential markets for RC&D material from both a supply and demand perspective.

Major construction projects such as the Perth-Bunbury Highway requiring large amounts of material including RC&D material are cost prohibitive in terms of transportation from recycler. Whilst it is positive that RC&D material will be incorporated into a section of the highway and will potentially show the strong characteristics of RC&D material to the marketplace, having to subsidise transportation cost is not economically sustainable over the long term. Markets that do not require subsidies should remain the focus.

8.3 Industry Sector

A number of industry sectors are available to utilise RC&D material. These sectors can broadly be split into Local Government, State Government, manufacturing industries, small private contractors and large private contractors. As discussed in Section 6.2 market penetration in terms of specific market sectors become difficult to predict as basic raw material providers are uncertain of where material is being used and by whom. The CCI report outlined the same issue in its prediction of future market demand by industry sector.

However, generally there will always be a need for basic raw materials in the marketplace in all market sectors. The extent of usage of RC&D material and its potential penetration is unlimited as long as the market is educated in its benefits and specifications, is cost competitive and transport costs are minimised. A number of industry sectors (Local Government and major construction companies) outlined their desire to use RC&D material in their operations if the product was comparable to virgin products in terms of specification, workability, price differentials and transport costs.

The successful use of RC&D material has already been demonstrated in most constructions applications and therefore all industry sectors should therefore be pursued. An exception for market penetration may be the large vertically integrated operations such as BGC, CSR Readymix and Boral which have made significant investments into raw extraction industries to obtain material at a very low cost (Section 3.1). However, Midland Brick (a subsidiary of Boral) has begun accepting waste bricks as a substitute for virgin clay material.
Table 9.1: Market Prioritisation based on factors influencing the market and associated rank (1 low priority – 5 high priority)

<table>
<thead>
<tr>
<th>Market</th>
<th>Bulk Fill</th>
<th>Subbase</th>
<th>Hardstands</th>
<th>Roadbase</th>
<th>Drainage Aggregate</th>
<th>Recycled Brick</th>
<th>Landfill Cover</th>
<th>Backing Block</th>
<th>Pavement Concrete</th>
<th>Structural Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sand</td>
<td>Concrete / Brick</td>
<td>Concrete / Brick</td>
<td>Concrete / Brick</td>
<td>Brick</td>
<td>All Materials</td>
<td>Concrete</td>
<td>Concrete</td>
<td>Concrete</td>
<td>Concrete</td>
</tr>
<tr>
<td>RC&amp;D Supply</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>1</td>
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<tr>
<td>Market Demand Raw Material</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>RC&amp;D Price Competitiveness</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>1</td>
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<td>Specifications Required</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Ease of RC&amp;D Penetration</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Value Adding to RC&amp;D sector</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Average Rank</strong></td>
<td><strong>4.5</strong></td>
<td><strong>4.3</strong></td>
<td><strong>4.0</strong></td>
<td><strong>3.7</strong></td>
<td><strong>3.5</strong></td>
<td><strong>3.8</strong></td>
<td><strong>3.8</strong></td>
<td><strong>2.8</strong></td>
<td><strong>3.3</strong></td>
<td><strong>2.2</strong></td>
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</tbody>
</table>

Table 9.2: Barriers to implementation and penetration of market

<table>
<thead>
<tr>
<th>Market</th>
<th>Bulk Fill</th>
<th>Subbase</th>
<th>Hardstands</th>
<th>Roadbase</th>
<th>Drainage Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Transport to market</td>
<td>- Adequate Supply</td>
<td>- Adequate Supply</td>
<td>- Specifications</td>
<td>- Demand</td>
<td></td>
</tr>
<tr>
<td>- Transport to market</td>
<td>- Adequate Supply</td>
<td>- Transport to market</td>
<td>- Adequate Supply</td>
<td>- Transport to market</td>
<td>- Transport to market</td>
</tr>
<tr>
<td>- Market Confidence</td>
<td>- Cost</td>
<td>- Cost</td>
<td>- Market Confidence</td>
<td>- Local trials</td>
<td>- Local trials</td>
</tr>
<tr>
<td>- Cost</td>
<td>- Cost</td>
<td>- Cost</td>
<td>- Cost</td>
<td>- Cost</td>
<td>- Cost</td>
</tr>
<tr>
<td>Recycled Brick</td>
<td>Landfill Cover</td>
<td>Backing Blocks</td>
<td>Pavement Concrete</td>
<td>Structural Concrete</td>
<td></td>
</tr>
<tr>
<td>- Demand (volume)</td>
<td>- Demand (volume)</td>
<td>- Specifications</td>
<td>- Specifications</td>
<td>- Specifications</td>
<td></td>
</tr>
<tr>
<td>- Cost</td>
<td>- Cost</td>
<td>- Demand</td>
<td>- Demand</td>
<td>- Demand</td>
<td></td>
</tr>
<tr>
<td>- Cost</td>
<td>- Cost</td>
<td>- Research / Local trials</td>
<td>- Research / Local trials</td>
<td>- Research / Local trials</td>
<td></td>
</tr>
<tr>
<td>- Cost</td>
<td>- Cost</td>
<td>- Cost</td>
<td>- Cost</td>
<td>- Cost</td>
<td></td>
</tr>
</tbody>
</table>
9 MARKET INSTRUMENTS TO OVERCOME BARRIERS

As discussed throughout the document, a number of barriers are currently in place in Western Australia restricting the amount of waste C&D material being diverted from landfills. The following section outlines potential measures that should be considered to overcome barriers currently in place. These instruments were first recommended in the Cardno report completed for the DEC in 2006, entitled “Issues Relating to the Generation, Collection and Treatment of Building Product Waste in Western Australia”.

9.1 Education and Communication

Education of the marketplace is central to any proposed initiatives, programmes or targets to promote the recycling of C&D waste. Without a dedicated and co-ordinated communication, education and implementation strategy / programme, with demanding but achievable targets and appropriate resources and funding, any measures that are implemented will be far less effective.

The role of this measure would include the engagement of stakeholders and co-ordination with industry bodies and associations to develop partnership programmes. Its purpose would include developing links between the industry and the implementation programme team and provide a forum for the stakeholders to provide feedback relating to the development of the programme. Ultimately, the objective would be for the industry and stakeholders to embrace and have ownership of the overall objective, which is to provide safe disposal, increased recycling and sustainable development within the construction and building industry. Ideally the waste reduction programs would eventually be communicated by construction and demolition industry rather than the DEC, the Waste Management Association of Australia (WMAA) or similar organisations. An example is the recent release of a Commercial Construction Waste Management Guide by the Master Builders Association created in collaboration with the Waste Management Branch at the DEC.

This measure would require a significant long-term investment from the DEC, however this is a critical part of linking any initiatives and programmes together and ensuring all stakeholders are aware of the overall programme and have a service to provide them with any information they require. This measure should be funded by the existing landfill levy.

9.2 Procurement Policies

To increase market demand for RC&D materials, procurement and tendering practices within Local and State Government need to be changed so RC&D materials are represented instead of just “quarried” or “virgin” material. There is potential to rapidly create a large demand for recycled materials using this approach allowing an opportunity for the recycling sector to compete with virgin materials in the procurement process. The City of Canning has recently eliminated from road construction tender documents the condition that road base must be produced from virgin crushed rock. As outlined in Section 5.8, this has provided the opportunity for C&D Recycling to supply recycled aggregate for a section of Welshpool Road early in 2008 and the entire recycling industry to supply material for a section of the Perth to Bunbury Highway.

If even stronger demand for RC&D material was desired, procurement and tender specifications could stipulate a minimum percentage (e.g. 5%) of recycled content to be incorporated into construction project. The percentage of recycled material contained can be included as an assessment criterion for tenders, therefore promoting contractors and organisations to increase the recycled content of construction project beyond the minimum requirement but obviously to an extent where specifications could still be achieved.
If a procurement policy were to be introduced it would need to be backed up by an appropriate amount of clean supply. Without additional clean supply it is likely demand would far outweigh supply, especially for large scale projects and could possibly increase RC&D material prices, therefore imposing additional costs on construction projects. A large construction project (e.g. Perth – Bunbury Highway) that required 5% RC&D content would far exceed the available waste material in the Perth Metropolitan Region.

This measure would require a funding programme to communicate the strategy with all government departments including WALGA, designers, engineers, councillors, procurement departments, consultants and contractors.

9.3 Landfill Levy Increases

The cost to dispose of mixed wastes to inert landfills, even with the current levy ($3/m\(^3\)) imposed, is still relatively cheap. The low cost of landfill encourages the disposal of wastes rather than the recycling of the waste and also does not reflect the true environmental cost of the landfilling material and or the subsequent additional raw material extraction required to offset the waste.

As outlined in Section 7.1, as of July 1\(^{st}\) 2008, an increase in the landfill levy to $5/m\(^3\) for inert waste has been frozen by the new Waste Authority for at least six months whilst a review process is undertaken. This review process will involve consultation with a number of stakeholders in the industry.

A continual increase of the landfill levy will provide a clear signal to the industry and stakeholders that the recycling of these wastes (including source separation) will become a more cost effective than their disposal. The landfill industry and waste producers are likely to be opposed to this measure, however, most would be aware that landfill levies in the Eastern States are already far higher than the levy in Western Australia.

9.4 Landfill Bans

A landfill ban is a strong market instrument that will generate considerable change in the waste disposal marketplace and will increase the supply of material sent to recyclers. An appropriate landfill ban would involve the State Government issuing a ban on unsorted C&D waste loads being disposed of at landfills. This would drive waste generators to separate waste products prior to disposal or recycling and facilitate the recycling of the majority of the wastes produced, as separated materials can be recycled more economically than mixed loads. Whilst increased costs will be imposed on the waste producer in source separating material, it is likely that the cost will be offset by savings in regards to waste disposal. A lead in timeframe similar to the recently proposed ban on tyres being sent to landfill would be appropriate.

Instituting a ban would require a minimal cost to DEC, however the subsequent enforcement would be expensive and resource intensive. For the ban to be effective a comprehensive communications plan relating to the regulation would be required and dedicated landfill inspectors would need to be employed to ensure the ban was being implemented. After an initial period of intensive communication and enforcement it is likely that the frequency of inspections could be reduced. A ban on mixed waste streams being sent to landfill is likely to be resisted from the C&D industry until the separation of wastes became accepted as normal operating practice. A number of companies including Multiplex already source separate material on their construction sites and have found considerable cost savings.
9.5 Increased Enforcement of Landfill Acceptance

The acceptance criteria of material at some inert landfills, in the Perth Metropolitan Region, can be considered questionable, with unacceptable material (cardboard, plastics, timber, residual greenwaste) regularly being accepted at some sites in mixed loads. This material is unacceptable under the Landfill Waste Classification and Waste Definitions 1996 (As amended).

The enforcement of clean mixed inert wastes, whilst not segregated, would improve the economics of recycling these materials and therefore assist in diverting these materials from landfill. For enforcement to be effective a comprehensive communications plan would be required and dedicated landfill inspectors would need to be employed to ensure landfills were regularly meeting compliance. Large fines for non-compliance should also be considered.

The DEC did shake up of the inert landfill industry in 2007 when DEC officers enforced the licence conditions of inert landfill operators in regards to their acceptance of timber waste. This increased enforcement of material provided an immediate effect on the destination of waste timber. The Tamala Park Class II putrescible landfill reported a large increase in the amount of timber waste being disposed after the DEC enforcement of licence conditions (pers comm. Mike Myring 2007). This initiative showed how effective enforcement can be in relation to targeting certain waste streams.

9.6 Compulsory Waste Management Plans

Any application for development approval should include a Waste Management Plan outlining how the developer intends to manage waste generated during the project. To gain approval from Local or State Government the developer would need to demonstrate that proper arrangements were in place to deal with the waste generation at the development site.

There is likely to be some initial resistance from both Local Government, who will have to enforce the measure, and developers, who will have to comply with the measure, however, the actual extra work involved for both parties is minimal relative to getting developments approved.

10 CONCLUSIONS

The continuing strong construction activity in the Perth Metropolitan Region will see demand for construction material (including RC&D) into the foreseeable future. High construction activity will also result in the generation of significant volumes of C&D waste materials. Apart from its environmental benefits, industry is starting to recognise the benefits of the use of RC&D material including the products appropriate specifications, reduced material and transport costs and ease of use.

A focus on clean supply being diverted to recyclers coupled with continued market development in current and potential market areas has the potential to significantly reduce the amount of waste being sent to landfill in the Perth Metropolitan Region. Increased diversion of C&D waste from landfill will also reduce the demand for finite virgin resources. The uptake of RC&D material by the marketplace will provide the greatest impact on the levels of waste currently being sent to landfill and will significantly help in the Department of Environment and Conservations vision of Towards Zero Waste to landfill by 2020.
## 11 SUMMARY TABLES

### Table 10.1: Summary of product, process, processing cost, sale cost and viability of the virgin basic raw materials

<table>
<thead>
<tr>
<th>Product End Use</th>
<th>Product</th>
<th>Process</th>
<th>Cost to produce from virgin materials</th>
<th>Sale Price of Product</th>
<th>Unit</th>
<th>Viability / practicality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Fill</td>
<td>Sand</td>
<td>Screen</td>
<td>$1 - 2</td>
<td>$5 - 12</td>
<td>Tonnes</td>
<td>Very High</td>
</tr>
<tr>
<td>Subbase</td>
<td>Limestone</td>
<td>Extract / Screen / Crush</td>
<td>$2 - 5</td>
<td>$6 - 20</td>
<td>Tonnes</td>
<td>Very High</td>
</tr>
<tr>
<td>Hardstand</td>
<td>Limestone</td>
<td>Extract / Screen / Crush</td>
<td>$2 - 5</td>
<td>$7 - 15</td>
<td>m3</td>
<td>Very High</td>
</tr>
<tr>
<td>Roadbase</td>
<td>Gravel / Hard Rock</td>
<td>Extract / Screen / Crush</td>
<td>$2 - 5</td>
<td>$7 - 15</td>
<td>m3</td>
<td>Very High</td>
</tr>
<tr>
<td>Drainage Aggregate</td>
<td>Hard Rock</td>
<td>Extract / Screen / Crush</td>
<td>$2 - 5</td>
<td>$25 - 45</td>
<td>m3</td>
<td>Very High</td>
</tr>
<tr>
<td>Whole Brick</td>
<td>Clay</td>
<td>Extract / Extrude / Fire</td>
<td>$37 - 110</td>
<td>$125 - 375</td>
<td>Tonnes</td>
<td>Very High</td>
</tr>
<tr>
<td>Landfill Cover</td>
<td>Sand</td>
<td>Screen</td>
<td>$1 - 2</td>
<td>$5 - 12</td>
<td>Tonnes</td>
<td>Very High</td>
</tr>
<tr>
<td>Backing Block</td>
<td>Concrete</td>
<td>Screen / Crush / Mix</td>
<td>$70 - 90</td>
<td>$120 - 180</td>
<td>m3</td>
<td>Very High</td>
</tr>
<tr>
<td>Pavement Concrete</td>
<td>Concrete</td>
<td>Screen / Crush / Mix</td>
<td>$70 - 90</td>
<td>$120 - 180</td>
<td>m3</td>
<td>Very High</td>
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<tr>
<td>Structural Concrete</td>
<td>Concrete</td>
<td>Screen / Crush / Mix</td>
<td>$70 - 90</td>
<td>$120 - 180</td>
<td>m3</td>
<td>Very High</td>
</tr>
</tbody>
</table>

### Table 10.2: Summary of product, process, processing cost, sale cost and viability of the recycled basic raw materials

<table>
<thead>
<tr>
<th>Product End Use</th>
<th>Product</th>
<th>Process</th>
<th>Cost to produce from recycled materials</th>
<th>Sale Price of Product</th>
<th>Unit</th>
<th>Viability / practicality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Fill</td>
<td>Sand</td>
<td>Screen</td>
<td>$1 - 5</td>
<td>$2 - 5</td>
<td>Tonnes</td>
<td>Very High</td>
</tr>
<tr>
<td>Subbase</td>
<td>Brick / Concrete</td>
<td>Screen / Crush</td>
<td>$7 - 15</td>
<td>$3 - 12</td>
<td>m3</td>
<td>Very High</td>
</tr>
<tr>
<td>Hardstand</td>
<td>Brick / Concrete</td>
<td>Screen / Crush</td>
<td>$7 - 15</td>
<td>$3 - 12</td>
<td>m3</td>
<td>Very High</td>
</tr>
<tr>
<td>Roadbase</td>
<td>Concrete</td>
<td>Screen / Crush</td>
<td>$7 - 15</td>
<td>$3 - 12</td>
<td>m3</td>
<td>High</td>
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<tr>
<td>Drainage Aggregate</td>
<td>Concrete</td>
<td>Screen / Crush</td>
<td>$7 - 15</td>
<td>$3 - 12</td>
<td>m3</td>
<td>Very High</td>
</tr>
<tr>
<td>Whole Brick</td>
<td>Brick</td>
<td>Screen</td>
<td>$1 - 2</td>
<td>$1 - 5</td>
<td>m3</td>
<td>Very High</td>
</tr>
<tr>
<td>Landfill Cover</td>
<td>All Material</td>
<td>Residual Material</td>
<td>$0 - 1</td>
<td>--</td>
<td>m3</td>
<td>Very High</td>
</tr>
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<td>Backing Block</td>
<td>Concrete</td>
<td>Screen / Crush / Mix</td>
<td>Unknown</td>
<td>--</td>
<td>--</td>
<td>High</td>
</tr>
<tr>
<td>Pavement Concrete</td>
<td>Concrete</td>
<td>Screen / Crush / Mix</td>
<td>Unknown</td>
<td>--</td>
<td>--</td>
<td>High</td>
</tr>
<tr>
<td>Structural Concrete</td>
<td>Concrete</td>
<td>Screen / Crush / Mix</td>
<td>Unknown</td>
<td>--</td>
<td>--</td>
<td>Low</td>
</tr>
</tbody>
</table>

**Note:** The type of product used depends on specifications required (e.g. limestone or aggregate / rubble or concrete) and therefore cost. Caution should be used in the interpretation of this data. Higher processing cost for recyclers is offset by gate fees. Processing cost is highly dependent on extent of source separation of material and efficiency of plant at different recyclers.
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APPENDIX A

Extractive and Recycling Infrastructure Locations
APPENDIX B

Landfill and Recycling Infrastructure Locations
APPENDIX C

Stakeholder Contact List
<table>
<thead>
<tr>
<th>Sector</th>
<th>Company</th>
<th>Contact</th>
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</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>Boral</td>
<td>Julian Walters</td>
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<tr>
<td></td>
<td>Austral Brick</td>
<td>Damien Sier</td>
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<tr>
<td></td>
<td>Midland Brick</td>
<td>David Allbeury</td>
</tr>
<tr>
<td></td>
<td>ReadyMix</td>
<td>Garry Price</td>
</tr>
<tr>
<td></td>
<td>Hanson / Pioneer</td>
<td>Als Deangelo</td>
</tr>
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<td></td>
<td></td>
<td>Peter Denham</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medda Sico</td>
</tr>
<tr>
<td>Construction</td>
<td>Ertech</td>
<td>Frank Cosoletto</td>
</tr>
<tr>
<td></td>
<td>Georgiou Group</td>
<td>Lambros Siamos</td>
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<tr>
<td></td>
<td>Western Plant Hire</td>
<td>Terry Willcocks</td>
</tr>
<tr>
<td></td>
<td>Prompt Settlements</td>
<td>Bruce Bowman</td>
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<td>JJ MacDonald</td>
<td>Rohan Stephens</td>
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<tr>
<td>Demolition</td>
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<td>Adrian Brajkovich</td>
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<td></td>
<td>Statewide Demolition</td>
<td>Nic Stewart</td>
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<td>Gregg Collins</td>
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<td>Geoff Hodges</td>
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<td>Heidi Dauth</td>
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<td>C&amp;D Recycling</td>
<td>Adrian Lester</td>
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<td>Midland Brick</td>
<td>Garry Price</td>
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<td>Glenn Hollands</td>
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<tr>
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<td>Main Roads</td>
<td>Simon Kenworthy</td>
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<td>Southern Gateway Alliance</td>
<td>David Dallabonna</td>
</tr>
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<td>Urban Pacific</td>
<td>Eddy Wajon</td>
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<tr>
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<td>Cardno BSD</td>
<td>Danielle Williams</td>
</tr>
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<td>Local Government / Engineers</td>
<td>City of Wanneroo</td>
<td>Harminder Singe</td>
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<td>Yurgon Gosman</td>
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<td>Bob Sutton</td>
</tr>
<tr>
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<td>City of Swan</td>
<td>Usha Patel</td>
</tr>
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<td>City of Subiaco</td>
<td>Ian Linge</td>
</tr>
<tr>
<td></td>
<td>City of Canning</td>
<td>Cheree Little</td>
</tr>
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<td></td>
<td>City of Bunbury</td>
<td>Colin Leek</td>
</tr>
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<td></td>
<td>Town of Kwinana</td>
<td>Nigel Arch</td>
</tr>
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<td></td>
<td>City of Stirling</td>
<td>Kenwood Singe</td>
</tr>
<tr>
<td></td>
<td>Shire of Busselton</td>
<td>Viet Nyson</td>
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<td>Jason Vaugh</td>
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<td>Other</td>
<td>GHD</td>
<td>Bill Grace</td>
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<td>East Perth Redevelopment Authority</td>
<td>Steve Gilligan</td>
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<td>David Dallabonna</td>
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<td>MWAC</td>
<td>Rebecca Brown</td>
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<td>Landfill</td>
<td>Waste Stream Management</td>
<td>Mike Rumford</td>
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</table>
APPENDIX D

Results from City of Canning – Welshpool RC&D Application
Repeat Load Tri-axial Testing

Repeat Load Tri-axial (RLT) testing of the recycled road base products was undertaken by Main Roads Western Australia and the modulus values at 98% of MDD, 80% of OMC, 240kPa vertical stress and 125kPa confining stress were compared to testing previously undertaken by ARRB Transport Research for the City. Comparison between recycled material from C&D Recycling (Hazelmere) and unnamed Virgin Extraction companies is outlined below.

- Co-mingled 25mm C & D Recycled Base 500MPa
- Pure crushed concrete 25mm C & D Recycled Base 430MPa
- Conventional 20mm Non Plastic Roadbase Company A 410MPa
- Conventional 20mm Low Plasticity Roadbase Company A 370MPa
- Cement Modified 20mm Roadbase Company A 470MPa
- Conventional 20mm Low Plasticity Roadbase Company B 650MPa

Shear Box Testing

The results of the shear box test determine the apparent cohesion and shear strength of a material. Results are outlined below:

<table>
<thead>
<tr>
<th>Material</th>
<th>Normal Stress (kPa)</th>
<th>Max Shear Stress (kPa)</th>
<th>Apparent Cohesion (kPa)</th>
<th>Shear angle (Deg)</th>
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</thead>
<tbody>
<tr>
<td>Virgin Roadbase</td>
<td>146</td>
<td>339</td>
<td>16</td>
<td>64</td>
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<tr>
<td></td>
<td>299</td>
<td>630</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>445</td>
<td>987</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commingled Recycled</td>
<td>146</td>
<td>390</td>
<td>237</td>
<td>47</td>
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<td></td>
<td>229</td>
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<tr>
<td></td>
<td>445</td>
<td>724</td>
<td></td>
<td></td>
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<tr>
<td>Recycled Concrete</td>
<td>146</td>
<td>414</td>
<td>24</td>
<td>68</td>
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<td></td>
<td>229</td>
<td>729</td>
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<tr>
<td></td>
<td>445</td>
<td>1185</td>
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</tbody>
</table>

Note: - Care must be taken with this test, as it is only applicable to the test conditions of normal stress and moisture conditions, which are undertaken on saturated samples. Normal loads are significantly less than during traffic by trucks.

The very high apparent cohesion demonstrated by the commingled recycled material is likely due to particle shear rather than internal friction influencing the results at high normal load.
Deflection and Curvature Testing

Mains Roads Western Australia tested the completed sub-base and on the completed base course prior to asphalt surfacing using a Falling Weight Deflectometer (FWD). The results are tabulated below:

<table>
<thead>
<tr>
<th>Pavement Construction</th>
<th>Test Level</th>
<th>Deflection</th>
<th>Curvature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean (mm)</td>
<td>Std Dev (mm)</td>
</tr>
<tr>
<td>250mm Co-mingled recycled/150mm Roadbase</td>
<td>Top base</td>
<td>0.59</td>
<td>0.06</td>
</tr>
<tr>
<td>400mm Co-mingled recycled</td>
<td>Top base</td>
<td>0.46</td>
<td>0.05</td>
</tr>
<tr>
<td>250mm 50mm Co-mingled recycled</td>
<td>Top sub-base</td>
<td>0.79</td>
<td>0.08</td>
</tr>
<tr>
<td>250mm Recycled concrete</td>
<td>Top sub-base</td>
<td>0.81</td>
<td>0.22</td>
</tr>
<tr>
<td>250mm 50mm Co-mingled recycled/150mm Recycled concrete</td>
<td>Top base</td>
<td>0.46</td>
<td>0.05</td>
</tr>
<tr>
<td>400mm Recycled concrete</td>
<td>Top base</td>
<td>0.49</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Curvature values for the recycled pavements were significantly less than that for the pavement constructed with a new quarried road base, indicating that the recycled materials are providing at least initially, a stiffer pavement than a good quality road base.
APPENDIX E

Future Growth and Transport Corridors
APPENDIX F

Useful Links and Suggested Reading
Reports

- Cardno BSD (2007) *Review of Recycling Activity in Western Australia 2005/06*
- Cardno BSD (2008) *Review of Recycling Activity in Western Australia 2006/07*
- Hyder Consultants (2006) *Review of Recycling Activity in Western Australia 2004/05*

Websites