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Recycled and Sustainable Materials at Main Roads

Reference Guide

May 2026

Contents

Amendments

Revision Number	Revision Date	Description of Key Changes
1	March 2021	Initial release
2	November 2022	Review and update
3	May 2026	Review and update

1 OVERVIEW

Main Roads Western Australia (Main Roads) is committed to recycling end-of-life materials into value-added applications within transport infrastructure. This position is consolidated by the Main Roads Circular Economy Plan (the Circular Economy Plan) and its Actions and Opportunities Program. There are currently numerous such materials that have successfully found applications in this sector. This Recycled and Sustainable Materials Reference Guide (the Reference Guide) captures the specified and non-specified recycled materials and low carbon emission alternative practices used by Main Roads, as well as those with development potential.

This Reference Guide also will act as a tool to help realise Main Roads' sustainability, net zero, and circular economy objectives; the latter of which identifies Priority Materials as the initial and optimum focus for the implementation of circular practices in road network construction. This will allow for a significant reduction in the need for raw material extraction and an increase in opportunities to utilise recycled and sustainable materials in the construction of roads and associated infrastructure.

1.1 Priority Materials

Each of the Priority Materials identified within the Circular Economy Plan has been assigned a strategic target (see Figure 1 below). This Guide facilitates the uptake and application of the Priority Materials and extends to additional recycled and sustainable materials and practices. It should be noted that the Circular Economy Plan is forward looking and anticipates the uptake of materials and innovations that are not yet industry ready. Therefore, Priority Materials such as green steel, and their potential applications may fall outside the scope of this current version of the Reference Guide.

Figure 1: Main Roads Circular Economy Plan Priority Materials and Strategic Targets

1.2 At a Glance: Current Use at Main Roads

Table 1 is an indicator of the main recycled products and respective quantities incorporated by Main Roads in various infrastructure projects. The collection of complete and current data, however, was rather challenging to achieve. Going forward, Main Roads is planning communication activities outlining the expected outcomes and benefits of the supply and publication of such data The compilation of complete and current data has presented challenges to date. To enhance transparency and support broader industry engagement, Main Roads will implement targeted communication initiatives outlining the anticipated outcomes and benefits associated with the provision and publication of this information.

Table 1: Priority Materials Uptake at Main Roads

Product Type	**Usage**	**Relevant Specification**
Crushed Recycled Concrete	Subbase, Basecourse, Structures	501, 820
Crumb Rubber	Spray seal, Asphalt	509, 511, 516, 517
Reclaimed Asphalt Pavement (RAP)	Asphalt	510, 511
Recycled Plastics	Geotextiles	503, 511
Low Carbon Concrete	Structures	820
Green Steel	Research & development	N/A

2 INTRODUCTION

There are several issues with relying on raw materials for road construction. The key concerns linked to these materials, are highlighted in Table 2, below, and encompass ecological and environmental impacts as well as the practical constraints of supply availability. Together with the increased energy and emissions associated with the extraction of these raw materials, construction practices must evolve.

It is a priority for Main Roads that our industry progresses towards the circular economy. This includes greater resource efficiency through the increased uptake of sustainable and recycled materials where possible, while ensuring long-term performance and maintaining the safety of the road network.

This Reference Guide outlines different types of sustainable and recycled materials that are or have the potential to be used for building and maintaining the Main Roads state road network. The guide is broken down into the types of construction materials and processes that can be used in road infrastructure and road structures and furniture.

Table 2: Limitations of Natural Resources

Material	Issue
Gravel	• Mining of gravel causes land degradation, biodiversity loss. • Supplies of good quality raw gravel in WA are depleted.
Sand	• Global sand crisis due to high amount of construction and population growth. • Around 10 million tonnes of sand go to landfill each year in WA.
Limestone	• Large amount of embodied energy. • 3.13 kg of $CO_{2\text{-}e}$ produced from mining 1 tonne of limestone. • Natural limestone can degrade over time from environmental conditions. • Limited good quality limestone ($CaCO_3$ content above 60%). • Finite resource
Rock/aggregate	• Rock extraction and processing have high embodied energy costs. • Significant amount of rock/aggregate required in road construction. • Limited rock sources in WA that can be extracted.
Bitumen	Finite resource imported.

A key aim of this Reference Guide and the promotion of the materials within road construction is to support the circular economy in WA, maximise up-cycling and keep materials circulating within the economy, thus reducing the need for raw, virgin material extraction.

Environmental product declarations (EPDs) are designed to, in a standardised and independent manner, report a product's embodied carbon based on life cycle assessment (LCA) results. EPDs are becoming increasingly popular among building and infrastructure construction products, which are rewarded in rating schemes across Australia and New Zealand. There are currently many infrastructure building products for which EPDs have been developed. These include:

- concrete and concrete elements
- aggregates

- asphalt mixtures
- cement and building limes
- pipes
- gutters and downpipes (EPD Australasia 2023).

2.1 Overarching Strategy and Policy Drivers

2.1.1 National

Recycling and Waste Reduction Act 2020: Regulates and limits waste exports across state and territory governments and the Australian Local Government Association

National Waste Policy Action Plan (2019): Sets targets and actions to overcome barriers to a circular economy and support sustainable resource use, including:

- **Target 3:** Achieve an 80% average resource recovery rate across all waste streams (aligned to the waste hierarchy) by 2030.
- **Target 4**: Significantly increase use of recycled content by governments and industry.

Infrastructure Policy (2023): The Australian Government's Infrastructure Policy Statement prioritised climate resilience, emissions reduction, and recycled materials.

Infrastructure Australia initiative: Used the Market Capacity Program to assess opportunities and capacity for infrastructure projects to incorporate recycled materials.

Australia's Circular Economy Framework (2024): Provides pathways for policymakers and aims to:

- Double Australia's circularity rate by 2035
- Reduce per-capita footprint by 10%
- Recover 80% of resources

2.1.2 Western Australia

Waste Avoidance and Resource Recovery Strategy 2030 targeted 70% material recovery by 2025 and 75% by 2030. Review and relevant refinements have been introduced via the following:

- Beyond WAste 2030 Strategy reinforces targets, including **80% recycling of C&D materials by 2030**.
- Beyond WAste 2030 Roadmap guides investment in **end markets for recycled materials** and supports turning waste into a commodity.
  - **Strategy Priority 2**: Promote **sustainable government procurement** to increase use of recycled products and develop local markets

These National and State policies and initiatives recognise and are driven by the Waste Hierarchy which places the disposal of waste as the least preferred practice and the avoidance of initial waste generation as the most preferred. The principles of the waste hierarchy are interlinked with circular economy principles, as demonstrated in Figure 2.

Figure 2: Talis Circular Economy Model, adapted from the National Waste Policy 2018 (left) and Waste Hierarchy (right)

2.2 Sustainability at Main Roads WA

Figure 2

2.2.1 Main Roads Sustainability Policy

The Main Roads Sustainability Policy aims to minimise environmental impact by decarbonising infrastructure, fostering the development of a circular economy, and supporting the regeneration of ecosystems. It outlines six key aspects to guide the delivery of a sustainable road network. These include:

- Sustainable Transport
- Climate Change
- Environmental Footprint
- Social Change
- Behaviour
- Governance and Performance
- Economic Legacy

2.2.2 Main Roads Circular Economy Plan

Main Roads' Circular Economy Plan is a clear acknowledgement of the need to reduce the impact of operations through the linear process of raw material extraction and end of life disposal. Circular principles seek to keep products and materials in use for as long as possible. This includes implementing a whole-of-life approach that entails identifying opportunities to reduce raw material extraction, increasing the uptake and application of recycled materials, and extending the life of products and infrastructure.

The Plan establishes a comprehensive framework, as shown in Figure 3, which guides the objective outcomes of the Actions and Opportunities Program. It identifies and leverages Priority Materials, which are featured within this Reference Guide, as a point of traction to maximise circularity within road network construction.

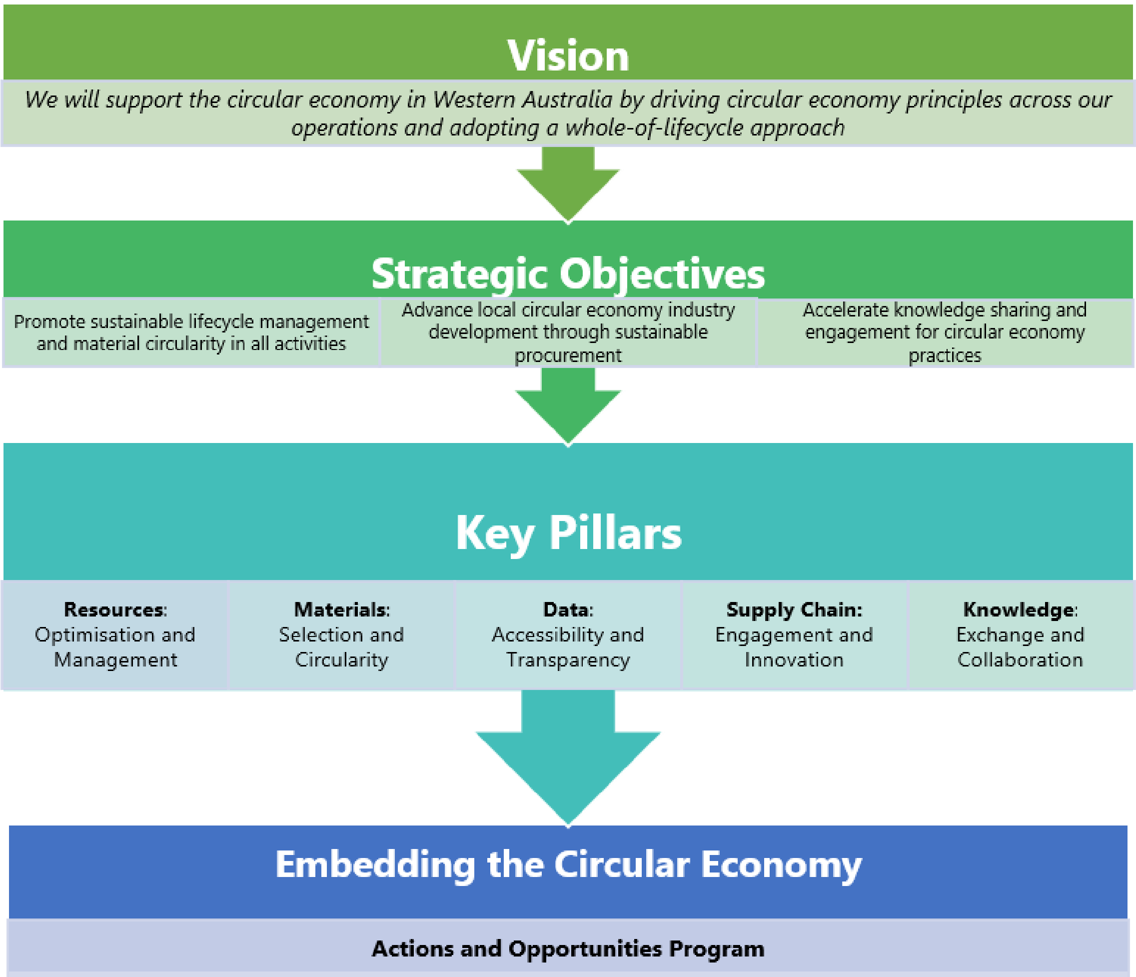

Figure 3: Main Roads Circular Economy Framework

2.2.3 Main Roads Net Zero 2050 Transition Plan

The Main Roads Net Zero 2050 Transition Plan outlines actions to help realise the government's emissions reduction targets for 2030. While its immediate focus is on Scope 1 and 2 emissions, mid to long term goals maintain relevance to the materials and processes in this Reference Guide, some of which have been specifically identified for low carbon characteristics. The Net Zero Transition Plan establishes four key intervention packages: Streetlight LED Replacement Program; Plant and Fleet Electrification Program; Green Depots Program; and the Net Zero Innovation Program

The Net Zero Innovation Program aligns directly with this Reference Guide and aims to facilitate the further uptake of recycled materials and low carbon processes and maintains shared outcomes with circular economy goals.

2.2.4 Infrastructure Sustainability Council

Main Roads has an ongoing commitment with the Infrastructure Sustainability Council (ISC) to deliver sustainable road projects. Every Main Roads project valued over $100 million is registered with ISC to receive a Planning, Design and As Built IS rating. Projects valued between $20 million to $100 million are not required to undergo formal IS verification. However, these projects complete an internal sustainability assessment to ensure sustainable initiatives are implemented where possible.

ISC rewards the development and implementation of Resource Efficiency Strategies, and associated Resource Efficiency Action Plans. The aim of the criteria is to recognise the importance of resource efficiency during the planning, design and construction phases of a major road project. It is important for each Main Roads project to have its own specific Resource Efficiency Strategy, which should include adopting the principles of industrial ecology and maximising the use of recycled construction products. To do this, projects align resource efficiency with the waste hierarchy shown in Figure 2.

3 ROAD INFRASTRUCTURE COMPONENTS

Figure 4, below can be referenced to determine differing and multiple applications of a sustainable material within pavement construction.

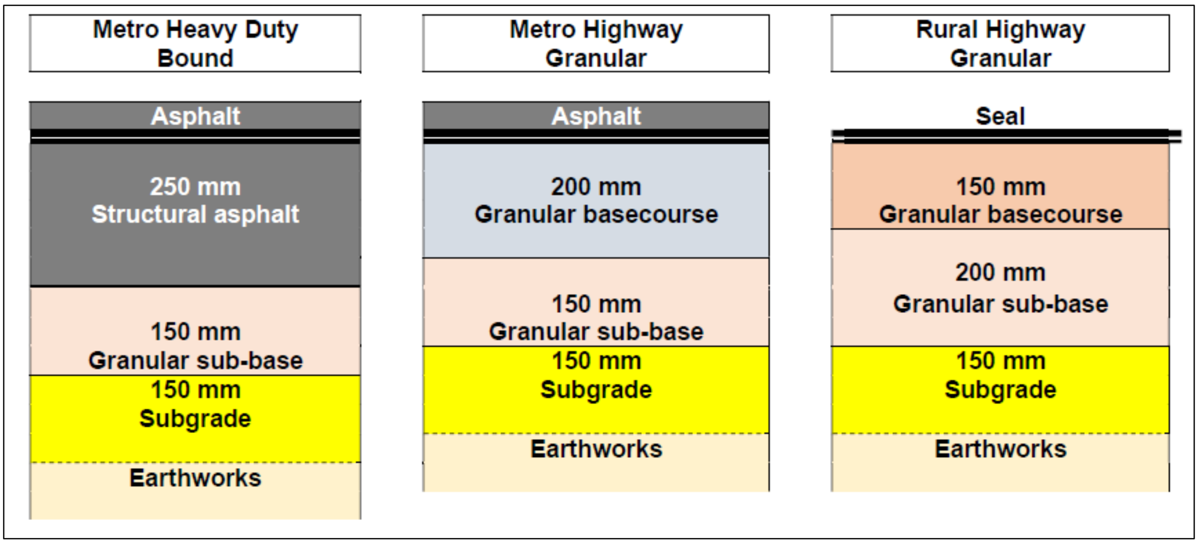

Figure 4: Typical Pavement Types and Example Thicknesses Applicable to Main Roads' Highway Network

Figure 5 was supplied by Austroads and provides a schematic representation of road infrastructure components. This diagram showcases the different elements within the road reserve environment outlined in this document.

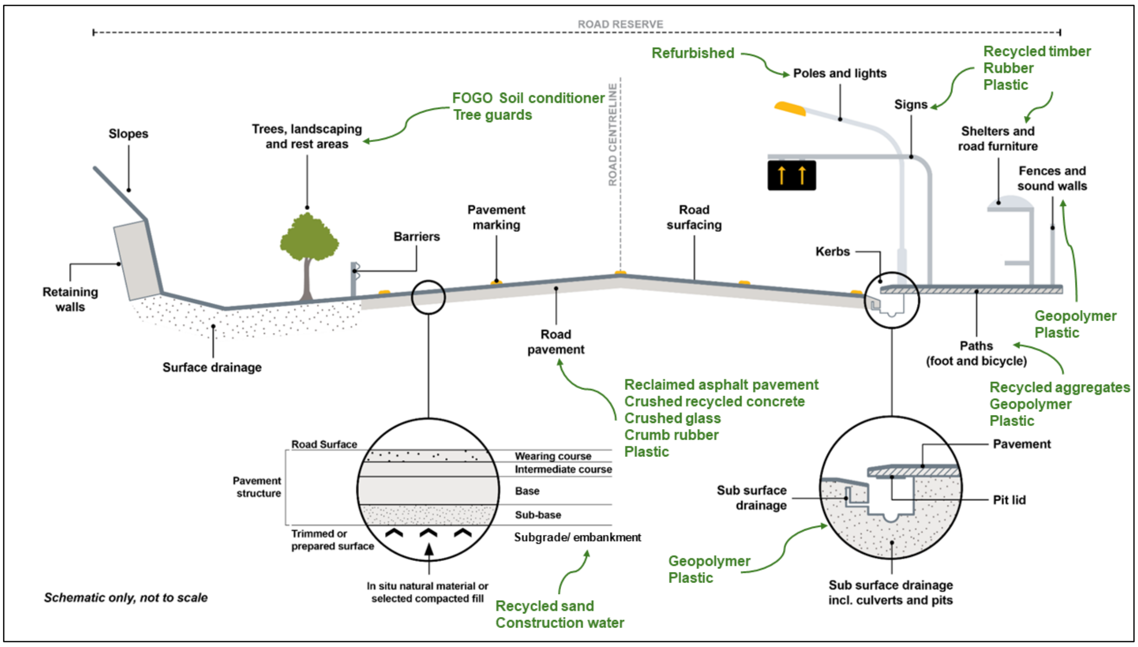

Figure 5 Schematic diagram of a road reserve (source: Austroads 2021)

3.1 Crushed Recycled Concrete

Application	Specification
Subgrade	501
Basecourse	501

Used in:
- subbase under full depth asphalt
- basecourse under low traffic local roads

Key Properties	Optimum Use of Material	Alternative Use in Roads
• **Re-cements**	• Reuse in new concrete	• Recycle into road base • Recycle into drainage backfill

Crushed Recycled Concrete (CRC) is a road building product derived from C&D waste consisting primarily of concrete, but also containing sand, brick, tile, asphalt and glass. Extensive research and long-term trials have demonstrated the material is suitable for use as subbase under full-depth asphalt (FDA) pavements on the Main Roads network. CRC is a high strength and durable product with self-cementing properties, meaning the stiffness of the product increases over time. Crushed limestone is traditionally used in subbase applications beneath FDA. Over time, CRC increases in strength and stiffness, due to reactivation of the dehydrated cement content, and behaves similar to lightly bound materials. The level of re-cementation varies significantly, depending on the cement content and age of the source material.

Main Roads has set a target to use 200,000 tonnes of CRC per annum from 2025–26 onward, with an aspirational target of 400,000 tonnes, and has reinstated the Main Roads Subbase CRC Specification (Specification 501). There are now three Roads to Reuse approved suppliers of CRC in the Perth Metropolitan Area. Independent audit testing overseen by the Waste Authority (for compliance with contamination criteria) continues to demonstrate that the Roads to Reuse–approved suppliers have robust systems in place to safely manage asbestos and other potentially hazardous contaminants, and ongoing independent audit testing is essential to its success. In 2023–24 more than 28,000 tonnes of CRC were used in road construction projects in WA, bringing the cumulative total to above 220,000 tonnes.

Construction contractors that have undertaken work for Main Roads have provided positive feedback regarding the use of CRC, including:
- CRC is workable
- CRC produces a tight surface finish
- CRC provides a stiffness benefit in design, resulting in approximately a 10mm reduction in FDA pavement thickness.

There are a number of additional benefits of CRC use, including:
- reduced demand for virgin materials
- reduced amount of C&D waste sent to landfill
- a durable and high-strength finish to the road
- the material has self-cementing properties

- the production of a strong subbase under FDA, creating a stiff underlying layer helping extend the pavement life
- less water required for compaction compared to limestone
- less mixing is required
- the product is a more consistent material and works similar to conventional granular materials
- the product can withstand moderate traffic from construction traffic without further material breakdown. Conventional materials are more likely to breakdown under the same traffic volume.

There are technical risks that need to be considered on road projects that are considering the use of CRC. These risks and how Main Roads mitigate them are listed in Table 3.

Table 3: Risks Associated with Crushed Recycled Concrete

Risk	Cause	MRWA Mitigation Measures
Cracking	Reactivation of cement	Use as subbase under FDA. Do not use as basecourse under heavy traffic. Apply geofabric seal if used as basecourse.
Popping	Expansive contaminants (e.g. aluminium, gypsum)	None identified (steel is removed) – remove and replace if occurs
Hazardous Contaminants	Asbestos and other hazardous materials not removed in demolition	Refer to Roads to Reuse Specification and Guidelines. Robust management systems. Supplier end-product testing. DWER independent audit testing.
pH	Reactivation of cement	Do not use near wetlands or groundwater sources.

There is a minor risk when using CRC in close proximity to water bodies. The alkalinity level of CRC may leach contaminants into water bodies. The greatest risk of leaching during construction is likely to occur from precipitation and dust control measures required on site. The Contractor is responsible for considering and monitoring the risk of leaching. Additionally, Main Roads requires that CRC is not used in applications that are potentially subject to moisture ingress.

The risk of leaching from CRC under road pavement once laid is low. Due to this, the DCCEEW relaxed the setback requirement for using CRC near wetlands, changing it from '*not within 100 m*' to '*implement site specific controls to minimise run off into sensitive environmental receptors*'. However, CRC supplies must be from a DWER approved manufacturer.

3.2 Crumb Rubber

Application	Specification
Open-graded Asphalt	511, 516, 517
Gap-graded Asphalt	501
Spray Seals	509, 511

Key Properties	Optimum Use of Material	Alternative Use in Roads
• Elastomeric • Affinity to bitumen	• Reuse into new rubber products	• Recycle into bitumen/asphalt

Crumb Rubber (CR) is produced from the recycling of waste tyres from light and heavy vehicles. CR contains valuable polymers and carbon black that are combined with bitumen, asphalt mix or sprayed seal to increase elasticity, rut resistance and durability. The use of this material in road construction also helps to solve the challenge of dealing with the large number of tyres sent to waste each year. Other benefits of using CR in asphalt mixes (dependent on mix type) include longer service life, resistance to crack reflection and greater aggregate adhesion.

Main Roads has a long history of using CR in sprayed bituminous seals, with 600–700 tonnes of scrap rubber used annually for this application. Granulated rubber is used in seals to reduce reflection cracking and improve stone retention. CR modified (CRM) bitumen is typically used for water proofing membranes on bridge decks, limited surfacing applications and widespread resealing where cracking is known to occur. CR has predominantly been imported from Victoria; however, there are suppliers currently established in Perth producing an excess of 2,600 tonnes per year.

Main Roads has set a strategic target of using more than 2,500 tonnes of CR per annum and has mandated CR open graded since 2022–23 for all open-graded asphalt. This is the only open-graded asphalt specified.

WA has a long history of using CR in spray sealing operations as the practice presents a significant opportunity for recycling. Since the 2023–24 spray season, Main Roads has mandated, where practicable, for all resealing to be with S45R (S15R update to national terminology).

During 2023–24, Main Roads used approximately 2,850 tonnes of CR in metropolitan and regional WA. This is an increase from the 2,753 tonnes used in 2020–21.

3.3 Reclaimed Asphalt Pavement

Application	Specification
Asphalt	510, 511

Used in:

- structural layers of asphalt pavement.

Key Properties	Optimum Use of Material	Alternative Use in Roads
• **Asphalt with oxidised binder**	• Reuse in new asphalt	• Recycle as hardstand/shoulder

Reclaimed Asphalt Pavement (RAP) is the material reclaimed from an asphalt wearing or intermediate course by re-processing, crushing and/or screening recycling asphalt into new asphalt. There are strict specification requirements surrounding the use of RAP. Main Roads specifications allow up to 10% RAP to be incorporated into the structural layers of FDA pavements without additional mix design requirements.

FDA pavements on the Main Roads network typically have greater than 250 mm total asphalt thickness. It is important to note that the specifications for the use of RAP outline that the material is not permitted in the production of wearing course (surfacing) asphalt for the Main Roads network. This is due to the negative impact on cracking and skid resistance.

Main Roads used 22,500 tonnes of RAP in 2024-25. There are several local suppliers in Perth that have Main Roads–approved mixes with 20–25% RAP content, and asphalt suppliers in Perth have existing RAP stockpiles that they use. Contact Main Roads for further information on these suppliers.

It is anticipated that a mix with approximately 22% RAP will deliver positive design outcomes, be manageable with respect to mix design and maintain a balance between the supply and use of RAP. It is important to note that 'Level 2' RAP (11–25%) can only be applied to 20 mm asphalt intermediate course for FDA.

3.4 Recycled Glass

Application	Specification
Earthworks	302

Used in:

- fill
- temporary tracks in heavy clay to reduce bogging of equipment
- bedding sand
- drainage
- retaining walls.

Key Properties	Optimum Use of Material	Alternative Use in Roads
• **Gravel** • **Robust** • **Reusable** • **High embodied energy content**	• Refill and reuse • Reuse cullet back into new glass	• Recycle into drainage layer • Recycle into sand

The preference for glass is to be reused in its initially intended application as it contains significant embedded energy and does not degrade over time. Where reuse is not possible, Main Roads recommends recycling glass to produce other new glass products.

Main Roads accepts that the use of recycled glass in roadbuilding is a low-value application (down-cycling) of the material but recognises that it is part of an interim solution to reduce waste glass sent to landfill. The use of any glass cullet in road construction must meet the requirements outlined in Main Roads Specification 302 Earthworks (302.10.1). Main Roads specifications permit the use of glass cullet in fill material.

Research and development are underway to enhance the economic sustainability of using crushed recycled glass and glass cullet, with the aim to reduce costs associated with milling the glass to a consistent grading and washing to remove contaminants (e.g. paper, adhesive, organic matter). Using recycled glass has environmental benefits, including conserving virgin materials and reducing environmental disturbance.

3.5 Recycled Sand

Application	Specification
Earthworks	302

Used in:
- embankment/ subgrade.

In 2021, the Director General of the Transport Portfolio WA committed to exploring the opportunities of increasing the use of recycled sand in road construction. A recycled sand specification is currently being prepared by the Department of Water and Environmental Regulation (DWER) in collaboration with Main Roads and the Waste Authority.

As outlined in MRWA Specification 302, recycled sand must be material sourced from recovered construction and demolition waste and shall be free of contaminated soils and other deleterious materials. Recycled sand can be used in embankments or the subgrade layer of the road as a substitute for traditional construction sand, gravel, clay and silt. All recycled sand used in Main Roads projects must come from Roads to Reuse–approved suppliers to avoid risks associated with the material, including warranty implications with the materials, metal corrosives in the sand and perceived risks associated with using this material.

Contractor feedback suggests using recycled sand can be cost effective; however, the use of the product needs to align with the project schedule. There are many factors which need to be considered when using the product including the availability of the material itself and that of trucks to cart the material. Contact Main Roads Materials Engineering Branch for further information regarding the use of recycled sand.

3.6 Excess Site-won Fill

Application	Specification
Embankment	302
Subgrade	501

WA passed legislation in April 2018 allowing the use of excess site-won or uncontaminated fill in road construction without having to pay a waste levy (Government of Western Australia 2018). The aim of this legislation was to increase the recycling of materials in construction projects and significantly reduce the amount of material that was headed to landfill. The Department of Climate

Change, Energy, the Environment and Water (DCCEEW) determine whether recycled fill is contaminated through the *Landfill Waste Classification and Waste Definitions* document. The guidance was amended in 2019 when this legislation was passed.

3.7 Mining Waste (Overburden)

Application	Specification
Embankment / subgrade	302, 501
Basecourse	501
Subbase	501

Sourcing road building materials from gravel and borrow pits is becoming more challenging for all roads across the state. Main Roads is continually looking for more sustainable alternatives to these traditional road building materials. One such alternative is mining waste from different mining pits across WA. Materials produced differ by mine and can be used as fill in embankments or subgrade, subbase or basecourse layers of roads.

The extraction of traditional road building materials typically requires the clearing of native vegetation, followed by a rehabilitation period once the pit has been exhausted. Using excess mining waste reduces the need to extract virgin material for road construction, while also enhancing the circular economy in WA. Mining waste (overburden) can and has been used to extend and maintain the state network across regional WA.

The ability for Main Roads to utilise waste materials for road construction will also benefit mine operators, as it can reduce closure costs given less material will be going into waste rock landforms.

Pacific Niugini Nicholson's Gold Deposit
This Gold Deposit mine is located 50 km west of Halls Creek on the Great Northern Highway. Initial testing of the waste rock material from this mine showed that it has potential to be used as sealing aggregate, in subbase and in rock spalls. This mine site is in close vicinity to the Laura River quarry and would be a suitable replacement for the deposit. It is important to note that there are heritage and environmental constraints with this quarry.

Novo Resources – Beaton's Creek
The waste material from this mine has been tested and classified as subbase quality. The site is close to Nullagine town site, and Novo Resources are using this material for their access roads.

Kimberley Region – Savannah Nickel Waste Rock
Waste rock from the Savannah Nickel Mine has the potential to be used in basecourse. The rock was trialled in 2016 on a short section of the Great Northern Highway. This material was nominated in an Information for Tenders contract document, and Main Roads liaised with the mine to determine a preferred proponent in sourcing basecourse material. The trial section is now 3 years old and is performing well.

Rio Tinto Argyle Diamond Mine

Rio Tinto recently shut down their Argyle Diamond Mine in the Kimberley after 37 years in operation. Main Roads is currently liaising with the Mine Manager to collect samples and evaluate if any waste materials can be used on the road network.

Fortescue Metals Group channel iron deposit CID
Main Roads and Fortescue Metals Group (FMG) have been collecting bucket samples and undertaking visual site inspections of the CID deposit in the Pilbara. The site is favourably located, and the large deposit possesses basecourse quality material. FMG is continuing investigations into what is waste and what may contain low-grade ore.

3.8 Crusher Dust

Application	Specification
Embankment / subgrade	302

Crusher dust is a by-product of the rock crushing process. It is used in road construction in the pavement layer and embankment or subgrade layer and is generally 5 mm or less (Boral 2022). The Leach Highway and Welshpool Road Interchange have used crusher dust that is a by-product from the basecourse material laid on the project.

This initiative has been used on a number of our previous projects and supports a reduction in the waste going to landfill allowing more of a resource to be used.

3.9 Alcoa Red Sand

Application	Specification
Subbase	302

Main Roads does not currently use Alcoa Red Sand in its construction processes as it does not meet DWER’s health and safety standards.

3.10 Paver-laid Basecourse

Application	Specification
Subbase	302

Laying basecourse with pavers is an alternative method to using graders. However, paver-laid basecourse is not supported by Main Roads as the process and outcome are complex and can lead to noncomplying pavement, thereby increasing maintenance.

3.11 Fly Ash

Application	Specification
Concrete	820
In-situ stabilisation	515
Asphalt as filler	501

Fly ash is a by-product of the black coal combustion industry that is the lightweight portion of generated ash with variable particle sizes. Fly ash primarily comprises silicon dioxide, aluminium oxide and ferric oxide (Hall et al. 2022).

Fly ash has been used as a supplementary cementitious material and a replacement to Portland cement as it forms a cementitious compound when reacted with lime. It has been found to increase strength, durability and workability and to reduce setting time. In addition, it avoids the generation of GHG emissions and mercury that are often associated with the production of cement (Hall et al. 2022).

Fly ash can replace lime and Portland cement in the stabilisation of fine-grained soils. In such applications, it has been found to provide various benefits including a decrease in permeability, swelling shrinkage and plasticity potential, and an increase in compressive and tensile strength (Hall et al. 2022).

In asphalt, it can partially replace natural mineral fillers and has been found to increase rut resistance and resistance to moisture damage (stripping) (Hall et al. 2022).

3.12 EME2

Application	Specification
Asphalt	Contract 514

Key Specification: Main Roads Specification 514 – Contract only have adopted interim specification limits that are in line with the national specification framework; Main Roads has internal targets to attain before open specification publication.

Used in:

- structural layers of asphalt pavement.

Enrobés à Module Elevé 9, which translates to High Modulus Asphalt, is a class 2 asphalt mixture. Referred to as EME2, this asphalt technology was developed in France where it was used under roads with heavy traffic, including airports. As outlined on the WARRIP website, ‘EME2 technology offers the prospect of reduced asphalt thickness for heavy duty pavements’ (WARRIP 2022). EME2 can be used as a replacement for full depth asphalt by replacing the intermediate layers. Main Roads projects currently in the development phase are investigating the opportunity to use EME2 in construction. Mixes of EME2 are created using a hard penetration grade bitumen which is applied at a higher binder content compared to traditional asphalt. Benefits of using EME2 have been identified following trials undertaken in both Queensland and Perth to demonstrate the use of the material on local aggregate.

A reduction in asphalt thickness of up to 55 mm can be achieved using EME2, which also significantly reduces the amount of carbon emissions from pavement construction. This 55 mm reduction equals a 25–30 per cent reduction in EME2 asphalt pavements compared to traditional pavement.

There are also economic sustainability benefits of EME2, given the reduction in materials lowers both the upfront costs associated with the material and the long-term maintenance costs of the material, given there is a 'longer time between maintenance' (WARRIP 2022). There is also a time-saving benefit during construction due to a reduction of layers.

There are currently multiple suppliers of EME2 in Perth. For further information on the use of this material, please contact the Main Roads Materials Engineering Branch.

3.13 Warm Mix Asphalt

Application	Specification
Asphalt	502, 504, 510, 511, 516

Warm mix asphalt has been used for a number of years in Western Australia and is referred to as a workability additive. Warm mix asphalt is produced using a workability additive which results in the production of asphalt at a lower temperature, whilst remaining workable. Main Roads uses stone mastic asphalt (502) open-graded CR asphalt and gap-graded CR asphalt which mandate the use of a warm mix additive. These are mandated to reduce fuming and enhance safety and ensure compaction is achieved with these hard-to-work mixtures, ensuring optimum life is achieved.

Specifications of wearing course (504) and intermediate course (510) asphalt allow the use of warm mix additives for workability, temperature and as a temperature reducer.

Currently, two products are permitted for use on the Main Roads network: Sasol Sasobit and Evotherm. These products are referred to in Specification 502, 504, 510, 511,516 and 517.

Note that the alternative treatment of applying of cold mix asphalt is not yet endorsed by Main Roads. Projects should liaise with the Materials Engineering Branch if they are investigating using this product.

3.14 Emulsions

Application	Specification
Spray Seals	511

Bitumen emulsion is an alternative method for hot bitumen spraying. The use of emulsions in spray seals does not only decrease energy requirements (90 °C for emulsions versus 180 °C for cutback bitumen) but also the need to use cutters (Austroads 2014).

Bitumen emulsion stabilisation is applicable to granular materials that have low cohesion and plasticity. Bitumen emulsion stabilisation is less energy and materials intensive when compared to the construction of full depth asphalt, making it a more sustainable alternative.

3.15 Foamed Bitumen

Application	Specification
In-situ stabilisation	515

Foamed Bitumen Stabilisation (FBS) has been used over the past 30 years in WA. This is a maintenance treatment to utilise in-situ failed or end-of-life pavement by enhancing its properties. This maintenance process thereby extends the life of existing bitumen and reduces the raw material extraction, energy use, and emissions that would result from a replacement strategy.

3.16 Lime

Application	Specification
In-situ stabilisation	515

Main Roads includes hydrated lime in all metropolitan asphalt mixes. It is an activator, meaning the product promotes bonding between bitumen and aggregate materials. It also assists in managing stripping in the pavement, which is caused from a loss in the bonds between the aggregate and bitumen.

Lime can also be used to stabilise clay subgrades, as lime binds to clay particles to make it less susceptible to moisture changes. This allows material which is not suitable to be utilised.

3.17 Type LH Cement

Low heat (LH) cement is similar to S50M but contains 35% Glass Powder (GP) and 65% Ground Granulated Blast Furnace Slag (GGBFS). LH cement is almost exclusively utilised in cement stabilisation; however, it is also allowed in mass concrete applications. Contact the Main Roads Materials Engineering Branch for more information on type LH cement.

LH cement is manufactured with lower heat generation than ordinary Portland cement. Main Roads allow for the use of type LH cement in mass concrete applications. LH cement has been used on the Main Roads network previously.

4 ROAD STRUCTURES AND FURNITURE

4.1 Cement and Concrete Products

4.1.1 Low Carbon Concrete

Application	Specification
Concrete for Structures	820

The cement manufacturing process is a significant contributor to the total emissions resulting from human activity. The mining and transportation of raw materials accounts for approximately 10% of the total emissions associated with the process, approximately 40% is from the pyro-processing unit, while the calcination process is responsible for half of the CO_2 emitted (Althoey et al. 2023).

Low carbon concrete includes a broad range of materials and technologies, such as Supplementary Cementitious Materials (SCMs) that can reduce the use of traditional Ordinary Portland Cement, the production of which is highly energy intensive. Therefore, SCMs have the capacity to reduce emissions associated with the manufacture of concrete. One such method is the replacement of conventional clinkers with alternative waste materials with high content of calcium dioxide, such as clay, slag and fly ash (Althoey et al. 2023).

4.1.2 Supplementary Cementitious Materials

4.1.2.1 Silica fume

Application	Specification
SCM	820

Silica fume is a by-product of the production of silicon and silicon alloys in electric arc furnaces. It is in the form of spherical very fine powder, although it may also be processed as a water-based slurry or pelletised. Silica fume, irrespective of its form, can be ground with Portland cement clinker to produce concrete products with comparative performance to that of virgin materials (Panesar 2019).

4.1.2.2 S50M concrete

Application	Specification
SCM	820

Main Roads uses S50M (50 MPa class concrete) that is a blended cement comprising 32 per cent type GP (general purpose) cement, 60 per cent GGBFS and 8 per cent silica fume. Silica fume is added to concrete to improve properties such as compressive strength, bond strength and abrasion resistance. GGBFS, when in the presence of an activator such as hydrated lime, has cementitious properties.

S50M concrete is used for mass concrete placement, as it has reduced thermal expansion and a consequent reduction in cracking. This type of concrete is also implemented in environments that have been or are exposed to sulphate and chloride attack, due to its high tolerance and resistance levels, such as marine environments.

4.1.2.3 Ground granulated blast furnace slag

Application	Specification
SCM	820

Ground granulated blast furnace slag (GGBFS) is a fine pozzolanic material that is a by-product of iron manufacturing. The material has been previously used successfully on Lancelin Road, where a 70/30 blend of GGBFS and quicklime was applied at 3 per cent by mass to the upper 100 mm of a limestone basecourse.
Used in:

- precast structural elements
- piles
- buried structures.

4.1.3 Geopolymer Concrete

Application	Specification
Low Strength Products	N/A – In development

Geopolymer concrete is a particular category of LCC and refers to the specific production process. Commonly, activated waste fly ash is used as the binder. Geopolymer concrete used in Main Roads projects must consist of a mixture of fly ash, slag, sodium silicate, and sodium hydroxide in solution or solid form, and extra water constituting an alkaline solution comprising coarse aggregate and fine aggregate. Geopolymer concrete is a low-calcium product and is resistant to sulphate attack.

Main Roads has undertaken a number of feasibility studies and trials of geopolymer concrete. These investigations found that geopolymer concrete could be used in structural works, providing a more environmentally sustainable alternative to commonly used Ordinary Portland Cement (OPC). OPC emits approximately 1 tonne of carbon dioxide per 1 tonne of cement produced. Main Roads is also working with Curtin University to assess the performance of geopolymer concrete in precast applications. Investigations to date have shown that it is feasible to produce high strength box culverts using geopolymer concrete with some modification of current precast concrete practices.

Ongoing research will assess the long-term strength and durability of box culverts (used in road works and drainage) using geopolymer concrete. The primary objectives of this research are to:

- investigate the long-term strength of geopolymer concrete
- assess precast construction requirements
- assess the durability of geopolymer concrete in normal and aggressive environments
- develop a specification for box culverts.

4.1.4 Reconstituted structural blocks

Application	Specification
Retaining walls	905

Main Roads uses limestone retaining walls for a number of projects every year. There has been research into making retaining walls out of eco-friendly recycled materials, such as CRC, rubble and crushed recycled glass. The combination of these recycled materials can minimise the use of concrete in footings, reducing the amount of cement used on Main Roads projects. This initiative reduces the environmental impacts associated with cement production, including carbon dioxide emissions and chemicals leaching into waterways. It is important to note that CRC used in retaining walls must meet Main Roads Specification 501.92.

Eco-blocks are a reconstituted structural block made of recycled materials including CRC. The Kwinana Freeway Northbound Widening Project (Russell Road to Roe Highway) used over 35,000 eco-blocks in the construction of the retaining walls. Eco-blocks replaced the need to use reconstituted limestone blocks on the project, avoiding the use of the limited limestone resource. Eco-blocks have the same texture and appearance as reconstituted limestone and are favourable given the quality and consistency of these blocks compared to traditional limestone.

Other materials such as Delithiated Beta Spodume (DBS) and bottom ash can be used to build structural blocks. Tonkin Gap installed approximately 4.5 tonnes of retaining wall blocks with DBS and bottom ash content. The blocks underwent strength testing to meet Main Roads Specification 905 limestone retaining walls. The specification requires 2.5 MPa and 1,500 kg/m^3 density. Testing resulted in 4.5 MPa and 1,800 kg/m^3 density for bottom ash and 3.5 MPA and 1,880 kg/m^3 density for DBS mixed with C&D waste.

4.2 Recycled Plastics

Application	Specification
Guideposts	602
Noise Walls	904
Geotextiles	403
Pipes	403

4.2.1 Guideposts

A number of projects are mandating the use of recycled plastic star pickets for different temporary uses. There are companies that can collect these star pickets once used and recycle them into new products. The Bunbury Outer Ring Road currently has a commitment to investigate the use of these pickets for temporary works, and once they are finished being used on the project, they will be recycled back into another form of plastic.

4.2.2 Noise Walls

Plastic noise walls were used on a short section of Roe Highway in the Roe Highway Duplication: Tonkin Highway to Orrong Road Project. The plastic noise walls were used to reduce the amount of deadload on the freight rail bridge between Tonkin Highway and Orrong Road. Projects looking to use plastic noise walls should also consider the use of recycled plastic, including High Density Polyethylene (HDPE) plastic. Investigations have commenced into the use of recycled plastic noise walls on projects currently in the planning phase.

Projects investigating the use of plastic noise walls need to consider the following:

- Plastic noise walls should not be placed in locations where they can be tampered with by the public e.g. avoiding damage and graffiti.
- Plastic noise walls should be designed to be fire resistant in all areas, especially bushfire-prone areas.

4.2.3 Geotextiles

Recycled plastic can be used in geotextile reinforced seals (GRS) for soil reinforcement, separation and filtration and can fully or partly replacing virgin polymer materials. Main Roads incorporated 32,000 m^2 of recycled GRS across projects in 2024.

4.2.4 Pipes

Plastic piping is usually manufactured from thermoplastics such as Polyvinyl Chloride, allowing for long life and 100% recyclability (PIPA, 2022). Recycled plastic piping presents approximately 10% of the embodied energy of virgin plastic pipes and have been trialled by Main Roads in the BORR project.

4.3 Tyre Rubber

Application	Specification
Guideposts	602

Guideposts produced from waste tyre rubber are preferable over timber guideposts due to their durability, service life and resistance to impact and termites (compared to timber posts). These posts have been used across many projects across the state network. The type of recycled rubber commonly used in guideposts is composed of a plastic sleeve on a rubber leg drilled into the ground. Rubber guideposts are able to recover to their original upright position after being hit by a motor vehicle and are less likely to crack or split upon impact from a vehicle or extreme weather. They also positively impact the circular economy as recycled tyres get a second use.

4.4 Glass Beads

Application	Specification
Pavement markings	604

Recycled glass is used to manufacture glass beads that are applied to road marking paint to provide better visibility at night and in wet conditions. They act as a reflector to vehicle lights in the paint. There is potential for heavy metal contaminants to be present in some recycled products. The exclusion of heavy metals in glass beads is managed through a specification for the supply of glass beads for pavement markings, allowing them to be used on WA roads.

4.5 Food and Garden Organics

Application	Specification
Landscaping	AS 4454, AS 4419

Used in:

- topsoil
- soil conditioner
- mulch.

Food Organics and Garden Organics (FOGO) has been identified as a product that has the potential use as a soil conditioner, mulch and topsoil. The FOGO-derived Soil Conditioner, Mulch and Topsoil; Companion Document and Product Specification (SWA, 2022) is available to help facilitate the use of FOGO on infrastructure projects and should be used in conjunction with AS 4454 or AS 4419.

The product specification outlines that managing the use of FOGO on site will need to be undertaken in accordance with Main Roads relevant specifications.

There are environmental benefits associated with the use of FOGO. Reusing FOGO in infrastructure projects reduces the amount of food and garden waste that is sent to landfill, where it generates methane gas. Further details on the environment benefits and the risk mitigation when using FOGO can be found in the product specification.

4.6 Future opportunities

4.6.1 Bio-based materials

Concerns surrounding the scarcity of resources based on which we build the world around us have risen in the most recent years (Pittau et al. 2018). the construction industry is heavily reliant on such resources. In recent years, the use of bio-oils and bio-binders has been explored as an alternative to bituminous products for pavement applications (Austroads 2012). Bio-oils and bio-binders derive from the processing of biomass (plants or other organic materials), and so, their properties vary depending on the selected biomass, processing method and processing parameters (Wang et al. 2020). Research undertaken so far has demonstrated the potential of bio-oils for use as extenders (Zhang et al. 2018; Yang et al. 2015) and rejuvenating oils (Borghi et al. 2017). However, the technology is still in its infancy, and further research and development of these products is required.

5 CASE STUDIES

5.1 Crushed recycled concrete

5.1.1 Main Roads trial of Roads to Reuse–specified crushed recycled concrete

In 2019–20, Main Roads undertook the pilot trial of Roads to Reuse–specified CRC, using over 25,000 tonnes of the material as subbase under FDA pavements. The trial was undertaken on the Kwinana Freeway Widening between Russell Road and South Street. The majority of this CRC material was sourced from the demolition of Subiaco Oval, demonstrating the circular economy in Perth. This pilot program was a success, and the material was compliant. This initiative was delivered under the Roads to Reuse pilot program with DWER and the Waste Authority. This Roads to Reuse program controls environmental and Occupational Health and Safety risks (e.g. hazardous materials and leachate) associated with CRC.

5.1.2 Armadale Road North Lake Road Bridge Project

CRC was used on the Armadale Road North Lake Road Bridge (ARNLRB) Project, laid under the intersection of North Lake Road, and under the new Public Transport Authority carpark. The project used approximately 29,000 tonnes of CRC from a Roads to Reuse–approved supplier.

Grader crews mixed, compacted and trimmed the CRC, similarly to traditional pavement materials with similar daily production rates. The CRC pavement was designed to be 300 mm thick and was laid in two 150 mm layers.

From using the product this way, the following observations were noted:

- CRC is a generally consistent product; however, given it is not from traditional quarried materials, there can be inconsistencies in the material, and the consistency of the waste making up the CRC has a significant impact on the material.
- During wetter months, the CRC held more moisture and did not dry as quickly as traditional quarried materials. This is due to the type of waste products dominating that particular mix of CRC, e.g. if it is not drying as quickly the material may have more clay-based materials.
- CRC has been deemed low risk to use in carparks in liaison with Main Roads Material Engineering Branch; therefore, it was highly suitable for use on this project.

Figure 6 CRC - Armadale Road North Lake Road Bridge Project

Figure 7 Trimmed and compacted CRC - Armadale Road North Lake Road Bridge Project

5.2 Crumb Rubber Market Development

While the use of crumb rubber in road construction is not new, traditionally used in spray sealing, Main Roads has collaborated to trial and develop further scaled, reliable, and consistent applications for crumb rubber. This initiative led to the introduction of crumb rubber into open-graded asphalt (OGA) through the development of Specification 516 and application through full-scale trial sections on the Kwinana Freeway. In parallel, crumb rubber was also incorporated into gap-graded asphalt via Specification 517, supported by trial works undertaken as part of the Marmion Avenue upgrade. These specifications require a minimum of 18% crumb rubber, by mass of total binder to be used in crumb rubber modified asphalt binder.

The incorporation of crumb rubber delivers circular economy benefits by reducing tyre waste to landfill and lowering reliance on petroleum-based raw materials. Furthermore, it improves the Whole of Life Cost by improving pavement durability and performance and strengthens local supply chains, further key circular economy principles.

Early reliance on imported crumb rubber helped stimulate domestic demand and catalyse industry investment, leading to the establishment of a local recycling supply chain. This is now underpinned by Main Roads' mandate for Tyre Stewardship Australia–endorsed crumb rubber in resealing programs, and the WA Reseal Program has been leveraged to stimulate demand. In 2024, 2,853 tonnes of crumb rubber binders were used, exceeding the original target of 1,200 tonnes.

Main Roads continues to work with WALGA to expand the use of crumb rubber across local government roads. The program's success reflects a structured approach that can be applied to other emerging materials, combining feasibility assessment, industry engagement, research and development, and staged implementation.

5.3 Reclaimed Asphalt Pavement in the NorthLink Project

The use of Reclaimed Asphalt Pavement (RAP) is an established practice, with 10% RAP in new asphalt accepted under Specification 510. Level 2 and level 3 asphalt mix designs allow for up to 25% RAP, and up to 40% RAP respectively, under Draft Engineering Road Note (ERN) 13B. Full scale trials of 10% RAP include the NorthLink 2 Project, with up to 25% RAP content trialled in the NorthLink 3 Project.

5.4 Low Carbon Concrete in the Swan River Crossings Project

The Swan River Crossings Project conducted a Concept Design Life Cycle Assessment to determine opportunities to reduce the Global Warming Potential (GWP) across the project. Concrete is a highly carbon intensive material, largely due to the traditional cement manufacturing processes. Concrete was shown to account for nearly half of the Scope 3 emissions on the project, with approximately 10,500m^3 required. Using SCMs can significantly reduce embodied carbon, and a preferred supplier was selected for the project based on GWP performance through SCM concrete mixes provided.

5.5 Recycled Plastics in the Tonkin Highway Extension Project

Local collaboration on the Tonkin Highway Extension project demonstrates tangible progress toward a circular economy and reflects the intent and practical rollout of the Main Roads Circular Economy Plan. Recycled plastic (RP) noise walls are now being deployed at scale, with approximately 10,000 m^2, or around 3,449 panels, scheduled for installation. WA-owned HALO Civil Engineering has been contracted to supply these noise walls, which are designed and manufactured in Wangara using problematic soft plastics and recycled HDPE (milk-bottle grade high-density polyethylene). The panels contain up to 80% recycled content and are fully recyclable at end of life.

5.6 Green Steel in the Swan River Crossings Project

Green Steel, including low carbon reinforcement steel, has potential to significantly reduce carbon emissions. 3,350t or 75% of the Swan River Crossing Project's reinforcement steel requirements are supplied by NatSteel, which uses an energy efficient Electric Arc Furnace. This technology allows for a 71% reduction in embodied carbon, compared to traditional steel production methods. It should be noted that local Green Steel technologies are still in early stages of development, as are standardised applications and related specifications.

5.7 Glass cullet at the NorthLink 3 Project

The NorthLink 3 (northern section) Project was able to use approximately 70,000 tonnes of crushed recycled glass as embankment fill. The material was used in earthworks to stabilise clay-based soils and materials, and it was also used for dust suppression in the embankment layer as the amount of water this material holds is greater than limestone. The Contractor on the project adhered to Specification 302, which allows up to 20% of the fill content to be crushed recycled glass.

There were a number of considerations and challenges to overcome in using the material. These issues included overcoming the absence of any glass recycling facility in WA, the amount of embodied energy required to process the glass cullet (in terms of the project's environmental footprint) and the cost of using this material compared to using virgin materials. Another key issue was whether glass properties would be able to behave in a similar way to limestone in this context. However, these challenges were overcome, and the benefits of using the material included:

- a reduction in virgin materials used
- reduced amounts of land cleared to store virgin material stockpiles
- proving its advantages to leadership and setting a standard for future Main Roads projects assisting in transforming the WA market of recycled glass products.

5.8 Excess site-won fill at the Reid Highway Dual Carriageway

At a Main Roads project level, the Reid Highway Dual Carriageway used excess site-won fill from the Matagarup Bridge Project. It was needed for the construction of the westbound carriageway and the Arthur Street Bridge. This opportunity to reuse the material was identified during the tender stage of the Reid Highway Project. The material was fill containing an outer layer of rock armour and inner compacted hardstand.

The contract for this project outlined specifications to ensure the material was successfully implemented. This included the potential need to further crush or blend the material in order to meet both Australian and Main Roads standards.

The material was excavated from the Matagarup Bridge site within a hardstand area established within the Optus Stadium precinct. This hardstand area was built for the project to assemble key bridge components and to enable construction material to operate under the bridge. Approximately 100,000 m^3 of the material was transported to the Reid Highway Project site for use.

After being awarded the Reid Highway contract, the Contractor tested the stockpile of this extracted material immediately and confirmed that it was suitable to be used on the project. The Contractor found that the larger rock in the stockpile could be used in the first layer of embankment in wetter areas. This allowed the material to 'bridge' the areas of high-water table, meaning subsequent layers could be built above this on the dryer earth.

Through using this material in the lower layers of embankment and in the Arthur Street Bridge embankment, all of the 100,000 m^3 stockpile was used on the Reid Highway Dual Carriageway. The benefits associated with reusing this material included delivering significant cost savings, preserving virgin resources and reducing the amount of waste sent to landfill.

5.9 Mining by-products

5.9.1 Pilbara Region

Marandoo Rio Tinto Iron Ore Deposit
Main Roads collaborated with Rio Tinto to test the material within their waste rock landforms coming from the Marandoo mine site. Test results were positive, and 40,000 tonnes of waste rock was carted to a hardstand area on the Paraburdoo-Tom Price Road for widening work. No further crushing or screening of the material was required, and the rock was used as embankment fill rather than basecourse, given the quantity of the material was relatively small.

5.9.2 Goldfields Region

Austral Pacific ex Paris & HHH mines

This mine site is approximately 30 km east of Coolgardie Esperance Highway near Higginsville. Austral have liaised with the Department of Energy, Mines, Industry Regulation and Safety regarding the reuse of mining waste and have engaged Golder Associates to test and assess the suitability of this waste material. To date, the petrographic testing has come back positive. A trial is being undertaken to assess whether crushing will generate fines with plasticity to improve the properties of the material. Austral are interested in pursuing the materials potential to supply it to projects in the Kalgoorlie-Norseman area.

5.9.3 Wheatbelt Region

Dalwallinu Gold Mine

The Pithara upgrade of Great Northern Highway used material from an old open-cut gold mine that is close to the Pithara town site. Material was used as rock protection and blended with local gravel to be used as a basecourse material for the upgrade in 2018–19.

5.9.4 Great Southern Region

Mt Cattlin Mine Site – Galaxy Resources, Ravensthorpe

Granite and basalt from rock and soil waste stockpiles from this mine have previously been used as rock protection on road projects. Additionally, crushed product has been used as embankment fill for bridge approaches and basecourse for pavement construction on the Phillips River Bridge project. A blend of crushed waste rock and imported laterite gravel was also used as basecourse on pavement overlay works in the region.

5.9.5 Mid-West Gascoyne Region

Plutonic Mine

The Plutonic Mine is located east of Great Northern Highway near Kumarina. Overburden stockpiles from the mine may potentially be used as basecourse or subbase. A small quantity was used for pavement repairs in 2017 and is currently performing well. Other mines south of Kumarina along Great Northern Highway were contacted in the 2019–20 financial year to discuss potential rock protection and construction material for floodway upgrades in the vicinity of the Gascoyne River.

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Australian Standards

AS 4419-2003, Soils for landscaping and garden use

AS 4454-2003, Composts, soil conditioners and mulches.

7 APPENDIX A GLOSSARY OF TERMS

Glossary & Definitions		Source
Acid Sulfate Soils (ASS)	Natural sediments/soil that contain iron sulphides, which can be harmful to the environment when disturbed or exposed to air. When exposed, ASS can release substances including heavy metals into the surrounding environment, including waterways.	WA Department of Water and Environmental Regulation. (N.D). Acid Sulfate Soils. https://www.der.wa.gov.au/your-environment/acid
Additives	Materials added to the cement to improve the properties of the cement.	Allan, P. (2012). Australian Waste Definitions. https://www.awe.gov.au/sites/default/files/documents/australian-waste-definitions.pdf
Basecourse	One or more layers of material usually constituting the uppermost structural element of a pavement on which the surfacing may be placed.	Main Roads Western Australia. (2021). Specification 501: Pavements. https://www.mainroads.wa.gov.au/globalassets/technical-commercial/technical-library/specifications/500-series-pavements/specification-501-pavements.pdf
Construction and Demolition Waste	Waste produced by demolition and building activities.	Waste Authority. (2019). Waste Avoidance and Resource Recovery Strategy. https://www.wasteauthority.wa.gov.au/images/resources/files/Strategic_Direction_Waste_Avoidance_and_Resource_Recovery_Strategy_203 0.pdf
Containers for Change	WA's state-wide container deposit scheme allowing the community to cash in eligible recyclable containers for 10c each.	City of Perth. (N.D). Containers for Change. https://perth.wa.gov.au/containers-for-change
Contaminated Material	Materials containing a hazardous waste substance.	Allan, P. (2012). Australian Waste Definitions. https://www.awe.gov.au/sites/default/files/documents/australian-waste-definitions.pdf
Cut and Fill	A procedure undertaken at construction sites where embankments are created by removing earth from one point on site and using it as fill in another. The process offers time and cost savings.	Scott, P. (2022). What is cut and fill? https://www.aboutmechanics.com/what-is-a-cut-and-fill.htm
Embankment / Subgrade	The trimmed or prepared portion of the formation on which the pavement is constructed. The Subgrade may comprise in situ or imported materials.	Main Roads Western Australia. (2021). Specification 501: Pavements. https://www.mainroads.wa.gov.au/globalassets/technical

Glossary & Definitions		Source
		commercial/technical-library/specifications/500-series-pavements/specification-501-pavements.pdf
Landfill	An unlined waste disposal site used for the controlled deposit of solid wastes onto or into land. Landfills in Australia and New Zealand have multiple classes which dictate what types of waste they will accept.	Department of Water and Environmental Regulation. (1996). Landfill Waste Classification and Waste Definitions 1996. https://www.der.wa.gov.au/images/documents/our-work/licences-and-works-approvals/WasteDefinitions-revised.pdf
Off-road	Off-road refers to all stationary energy emissions or fuel use (non-transport), as per the National Greenhouse Accounts Factors. This covers all the stationary combustion of liquid fuels.	Department of Industry, Science, Energy and Resources. (2021). National Greenhouse Accounts Factors. https://www.industry.gov.au/sites/default/files/August%202021/document/national-greenhouse-accounts-factors-2021.pdf
On-road	On-road refers to all fuel emissions, fuel use and fuel combustion for transport purposes, as per the National Greenhouse Accounts Factors.	Department of Industry, Science, Energy and Resources. (2021). National Greenhouse Accounts Factors. https://www.industry.gov.au/sites/default/files/August%202021/document/national-greenhouse-accounts-factors-2021.pdf
Organic Waste / FOGO	Waste materials from plant or animal sources, including garden waste, food waste, paper and cardboard.	Waste Authority. (2019). Waste Avoidance and Resource Recovery Strategy. Strategic_Direction_Waste_Avoidance_and_Resource_Recovery_Strategy_2030.pdf
Raw / Virgin Material	Materials or substances used in the primary production or manufacturing of goods. These materials are commodities bought and sold on commodities exchanges worldwide.	Investopedia. (2021). Raw Materials. https://www.investopedia.com/terms/r/rawmaterials.asp
Recycled Materials	Recovering material from waste and turning it into new products. The original product is destroyed usually through a melting process and used to form new products.	Terracycle. (2022). Recycling Terms and Definitions. https://www.terracycle.com/en-US/pages/definitions
Reused Materials	Items capable of being used again after minimal processing. In road construction they can be processed and reused onsite, or on other project sites.	Adapted from Law Insider. (2013-2022). Reused Materials Definition. https://www.lawinsider.com/dictionary/reusable-materials.
Road Furniture	All the fixtures on the road and within the road reserve that are intended to provide information or safety to a road user, including traffic lights, signposts, traffic signs, guardrails, marker posts, fences, reflectors and centre line pads.	Law Insider. (2013-2022). Road Furniture Definition. https://www.lawinsider.com/dictionary/road-furniture.

Glossary & Definitions		Source
Road Structures	Definitions for different structures are provided on the Main Roads website. Different structures include the bridge, precast box unit bridge, culvert, and gantry.	Main Roads Western Australia. (2017-2020). https://www.mainroads.wa.gov.au/technical-commercial/technical-library/structures-engineering/asset-management/structure-locations/
Road Surface / Pavement	The portion of the road placed above the design subgrade level including shoulders.	Main Roads Western Australia. (2021). Specification 501: Pavements. https://www.mainroads.wa.gov.au/globalassets/technical-commercial/technical-library/specifications/500-series-pavements/specification-501-pavements.pdf
Scope 1 Emissions	Scope 1 emissions are direct greenhouse gas (GHG) emissions from "sources that are owned or controlled by a company" (World Resources Institute, N.D).	World Resources Institute. (N.D). A Corporate Accounting and Reporting Standard. https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf
Scope 2 Emissions	Scope 2 emissions are indirect emissions produced "from the generation of purchased electricity consumed by a company" (World Resources Institute, N.D).	World Resources Institute. (N.D). A Corporate Accounting and Reporting Standard. https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf
Scope 3 Emissions	Scope 3 emissions are indirect emissions produced "from the consequence of the activities of a company, but occur from sources not owned or controlled by that company" (World Resources Institute, N.D).	World Resources Institute. (N.D). A Corporate Accounting and Reporting Standard. https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf
Spoil / General Fill	Uncontaminated excavated clay, gravel, sand, soil or rock that is not mixed with any other type of waste and resulting from construction and demolition activities. Acid Sulphate Soils are not included in this, and no organic matter is typically found in general fill.	Infrastructure Sustainability Council of Australia. (2018). Infrastructure Sustainability Rating Tool Version 2.0 Technical Manual. https://www.iscouncil.org/
Subbase	The material laid on the Subgrade and below the Basecourse either for the purpose of making up the additional pavement thickness required, to prevent	Main Roads Western Australia. (2021). Specification 501: Pavements. https://www.mainroads.wa.gov.au/globalassets/technical-

Glossary & Definitions		Source
	intrusion of the Subgrade into the base, or to provide a working platform.	commercial/technical-library/specifications/500-series-pavements/specification-501-pavements.pdf
Topsoil	Upper, most outer layer of soil with the highest concentration of organic matter and microorganisms.	Infrastructure Sustainability Council. (2018). Infrastructure Sustainability Rating Tool Version 2.0 Technical Manual. https://www.iscouncil.org/

The above definitions are taken from the Main Roads Contractor Monthly Reporting Form - Reference Guide.