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# *Extractive Resources in Victoria:* Demand and Supply Study 2015-2050

# Final Report

*Department of Economic Development, Jobs, Transport and Resources*

*Demand and supply study of extractive resources in Victoria, 2015-2050*

*May 2016*

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# Executive Summary

## Introduction

The extractive resources sector in Victoria is a vital part of the construction of public infrastructure, including roads, railways and bridges as well as commercial and residential buildings. This construction is supported by extractives products such as concrete, cement, bricks and road paving. There are some 485 quarries across Victoria producing around 40 million tonnes annually of stone, limestone, gypsum, sand and gravel. The value of production from quarries at the 'quarry gate' is estimated to be around $676 million per year.[1]

However, the building and construction sector faces a range of challenges in maintaining access to the supply of quality extractive resources, in particular:

- potential sterilisation of prospective extractive resources by urban and regional development
- encroachment of urban and regional development into existing quarrying areas
- the nearly doubling of demand for extractive resources over the 2015-2050 period will lead to an increase in the need for transport infrastructure.

These challenges were recognised by the Victorian Parliament's Economic Development and Infrastructure Committee, which in 2012 undertook the Inquiry into Greenfield Mineral Exploration and Project Development in Victoria. DEDJTR is responsible for leading and facilitating development of Victoria's earth resources. In addition, the Extractive Industries Taskforce was established in April 2014 and its work program includes identification of substantial extractive resources in Victoria, particularly those which may be strategically important to the State.[2]

PwC was engaged by DEDJTR and the Extractive Industries Taskforce to assist in:

**1** Identifying and quantifying current and forecast demand and supply profiles for Victorian extractive resources over two time periods: 2015-2025 and 2026-2050, including scenario analysis.

**2** Assessing the economic value of the State's extractive resources, in terms of implications for cost and/or availability of infrastructure and other construction activity if certain extractive resources are not available close to where they are needed for construction activity.

**3** Determining which extractive resources (including location) are likely to be of strategic value to the State. A strategic resource criteria framework and associated measures have been developed in consultation with the Department and Extractive Industries Taskforce.

[1] Department of Economic Development, Jobs, Transport and Resources (2014).

[2] The Taskforce includes both industry and Government representation and is supported by a Reference Group of broader stakeholders.

**4** Conducting spatial analysis through the production of detailed maps of extractive resource locations, including linkages to areas of current and future demand, transport corridors and market linkages, potential synergies and impediments.

## *Approach*

The current and forecast demand and supply profiles for Victorian extractive resources have been undertaken by separate service providers. This report and associated analysis details the consolidated findings and recommendations flowing from the integration of both the supply and demand components.

PwC has designed a framework that seamlessly integrates the supply and demand studies whilst maintaining the highest degree of rigour and transparency within the analysis. An overview of PwC's approach is illustrated below.

**Figure 1: Overview of extractive resource modelling approach**

***1. Demand modelling and analysis***

At the request of the Department, PwC reviewed and adjusted the extractive resource demand analysis, in order to provide greater insights into how the supply of extractive resources would be able to meet demand locations.

***2. Supply modelling and analysis***

To understand the supply of extractive resources, a three pronged approach (emails, posted letters and telephone/face to face interviews) was undertaken to provide the industry with the option to participate in an industry engagement questionnaire. All current producers within the industry were offered the opportunity to respond. From this respondent pool, 200 responses were received to the web survey and 27 interviews were conducted, representing coverage of 81% of the State's production volumes. The information collected was used to forecast the future supply of extractive resources to 2050, including identification of areas that may be critical to future developments and infrastructure projects.

***3. Demand and Supply analysis***

PwC utilised its Geospatial Economic Modelling (GEM)[3] platform to analyse the interaction between supply and demand for extractive resources across Victoria. This included a supply versus demand gap analysis including an analysis of the cost implications for potential changes in supply chain distances by extractive resources needed to service demand.

***4. Strategic resource determination***

A framework was developed that contained a transparent set of criteria which could be used to determine resources that are likely to be of strategic value to the State. This framework was tested with the Department and the Extractive Industries Taskforce. Measures and thresholds were developed against each criterion, which were informed by data from both the demand and supply analysis.

***5. Reporting and mapping***

Preliminary results of the integrated supply and demand analysis were presented to the Taskforce and Reference Group for feedback and validation. This report details the consolidated findings, mappings and recommendations flowing from the integrated analysis.

Source: PwC

[3] PwC has created a platform called the Geospatial Economic Model (GEM) that has the ability to correlate and 'layer' industry data onto any given designed 'region' of choice. Data collected through the Demand Analysis and Supply Analysis were integrated into the GEM platform.

## *Key findings*

Primary supply data were collected through comprehensive industry consultation, which comprised 81 per cent of Victorian industry as measured by the level of 2014 extractives production in Victoria. These data, which represent industry's views and plans as indicated at a point in time, were used to develop supply projections over two time periods: 2015 to 2025 and 2026 to 2050. Notably, industry respondents stated they were less confident in the response provided for the latter time period, 2026 to 2050, relative to the first time period.

The analysis has identified a set of critical resource locations within the State, based on the application of several criteria and the results of the industry data gathering. These resource locations are expected to inform a broader understanding of those regions that could be important to the State's future development. A detailed analysis of the geological endowment of Victoria was not explicitly considered in the analysis. Rather, the analysis relied upon data provided through industry consultations which to some extent implicitly accounts for the geological endowment across parts of the State.

## *Overall findings*

| | |
|---|---|
| **11 billion** | Tonnes of extractive resources are available within current and planned future Work Authorities (WAs) in Victoria in 2050. At an aggregate level, this is sufficient to meet demand for several years beyond 2050. However, shortfalls and risks emerge at the rock type and regional level |
| **2** | Rock types will be nearly depleted by 2050, however the core extractive resources will still have strong reserves at the State level |
| **34%** | Of demand for extractives in 2050 will need to be sourced from different quarries to the ones currently indicated for use by the industry (including expansion of current quarries and planned future quarries), due to resource exhaustion |
| **15** | Locations across Victoria are critical to ensuring the future supply of extractive materials at an efficient level |
| **$2 billion** | The analysis has estimated that an extra $2 billion of transport costs[4] would be incurred across 2015 to 2050 for every additional 25 kilometre distance over which material is transported. This figure represents the cost uplift of meeting the aggregate supply shortfalls across all locations from 2015 to 2050 by accessing material from quarries 25km further away than those currently used. This represents four per cent of total transport costs over the period |

- In taking an overall high-level State view, ignoring transport and locational differences, Victoria has close to sufficient resources held in current and planned future WAs to meet its extractive resource needs across the 2015 to 2050 analysis period.

[4] Externality costs comprise approximately 45 per cent of the total estimated transport costs presented here. This suggests that industry could expect to bear just under half of these estimated costs, with the remaining costs comprising social and environmental costs that would be borne by the community more broadly.

- However, in taking a more granular extractive resource by location view, including feasible supply catchment areas, important nuances can be observed. The indicated reserves of many current and planned future quarries are likely to be exhausted. Unless new deposits are identified and explored, or substitutes found, this is likely to result in:
  - potential supply shortfalls emerging in some locations, where the level of demand is greater than regionally available supply for a given rock type
  - several minor rock types nearing State-wide exhaustion of indicated current and planned future reserves.

## *Demand*

- Over the analysis period 2015 to 2050, demand for extractive resources across Victoria is expected to nearly double from 46.4 million tonnes in 2015 to 87.8 million tonnes in 2050.
- The majority of this demand is expected in central and fringe areas of Metropolitan Melbourne, driven by strong population growth projections. Key areas of future demand include Melbourne, Hume, Casey, Whittlesea and Wyndham.

In terms of growth by rock type:

- Hard rock demand is expected to grow by 109% to 63.8 million tonnes in 2050
- Sand and gravel demand is expected to grow by 34% to 16.9 million tonnes in 2050
- Limestone demand is expected to grow by 150% to 5.4 million tonnes in 2050

Clay and clay shale demand is expected to grow by 33% to 1.6 million tonnes in 2050

## *Meeting demand*

- Using PwC's GEM, the analysis has identified Victorian Local Government Areas (LGAs) and regions which will be important in support of the increased demand for 4 major rock types (hard rock, sand and gravel, limestone and clay and clay shale).
- Based on industry intentions as indicated in 2015, strong uplifts in supply will be required to meet the growth in demand identified above. The analysis has considered which resource locations could be critical to supporting this uplift; an overview of these areas is provided in Figure 2 below
- With the majority of materials entering the Greater Melbourne region, it will be critical to protect the areas which are the largest feeders into Greater Melbourne as indicated above.
- In particular, hard rock is demanded in large quantities in the State. The analysis has found that the supply of these resources is relatively constrained in certain regions within Victoria.
- The analysis has applied a set of Strategic Resource Determination criteria to identify and locate resources that are considered critical to the State's development.

- The top 5 critical resource locations below illustrate resource locations that are the best candidates for:
  - protection of existing resources
  - ensuring policy mechanisms provide for licensing of new resources.

**Figure 2: Top five strategic resource locations**

| | |
|---|---|
| **1) South Gippsland** | South Gippsland emerges as a critical location for hard rock and sand and gravel resources in Victoria, supplying approximately 33 per cent of the State's hard rock needs and 22 per cent of its sand and gravel needs across the analysis period of 2015 to 2050. Its relative proximity to key sources of demand drives this assessment.<br><br>**Critical resources: Hard rock, sand and gravel** |
| **2) Greater Geelong** | Whilst Greater Geelong is a noted location for hard rock and sand and gravel, its contribution to limestone production is most significant. The region is expected to deliver approximately 43 per cent of Victoria's supply of limestone across 2015 to 2050, in large part due to its relative proximity to Greater Melbourne. It is noted that limestone is a key input into concrete production, meaning this resource is important to all construction methods employing concrete products.<br><br>**Critical resources: Hard rock, sand and gravel, limestone** |
| **3) Mitchell** | Mitchell's primary contribution to the State's 2015 to 2050 extractive resource supply is in clay and clay shale, of which it supplies a relatively large share of total State supply. The LGA also possesses sizeable hard rock reserves along with some sand and gravel, which make Mitchell a key resource location for Victoria.<br><br>**Critical resources: Hard rock, sand and gravel, clay** |
| **4) Knox** | Knox is expected to deliver significant volumes both of hard rock resources and of clay and clay shale. Further to this, some exhaustion of current and planned future licensed reserves of these resources is anticipated in Knox. In combination this suggests that Knox is a good candidate location both for protection of existing licensed reserves and for development of new deposits in the future.<br><br>**Critical resources: Hard rock, clay** |
| **5) Cardinia** | Cardinia holds significant volumes of current and planned future licensed sand and gravel reserves. It is well positioned close to Melbourne meaning it can supply these resources at competitive costs to sites of strong demand in the city. Some hard rock resources are also present, meaning Cardinia has strong productive potential to support Victoria's future development.<br><br>**Critical resources: Hard rock, sand and gravel** |

- Regions identified as critical suppliers of hard rock across the analysis period include South Gippsland, Mitchell and Melton, along with Victoria's Inner South East region which includes areas such as Cardinia, Casey, Frankston and the Mornington Peninsula. These areas are identified as key supporters of the State's future development, which will be heavily reliant on future supplies of hard rock quarry products.

- Identified critical locations for exhaustion of current and planned future hard rock reserves include Indigo, Whittlesea and Wyndham, along with areas of Victoria's Inner South East.[5] These exhaustions could result in cost increases in Greater Melbourne for construction activities that utilise hard rock as these resources are sought from further afield.

- To avoid the realisation of supply constraints flowing from resource exhaustion, and therefore the flow-on negative impacts this will have on infrastructure development (including residential and commercial construction) and potential upward pricing pressures, it will be necessary to protect or develop new resource deposits in the regions identified in Figure 2 above.

- If market price implications were to be considered, and the industry experiences an average increase of 10% in the cost of extractive resources resulting from supply constraints, we would expect to see an average 3.5%[6] increase of project costs across the State. This would mean that the costs of a new $1 billion road project in Victoria could be $35 million higher.

- Supplementary to transport cost increases, the nearly doubling of demand for extractive resources over the 2015-2050 period will lead to an increase in the need for transport infrastructure to transport resources from quarries to the sources of demand. This may warrant examination of the need to support additional infrastructure to support this. Where demand is sourced from further afield in future, further infrastructure upgrades could be required to support delivery of this material.

- If quarry developments in the above identified areas of critical supply are not supported, this could lead to the potential supply shortfalls being realised. In turn this will have flow on effects to the industries which rely heavily on these resources, including building construction (residential and non-residential) and engineering construction (transport, energy and utilities).

- In addition to these direct effects, there will be wider impacts on the entire supply chain including industries which support the construction sector (e.g. supplier of services to the construction industry) as well as households across Victoria (e.g. employment and wages and salaries may be affected).

- These impacts would likely have a material effect on the broader economy through changes in levels of economic growth, as measured by GSP, household consumption and employment. However, these broader impacts have not been considered in this study.

[5] This includes Bass Coast, Cardinia, Casey, Frankston, Knox, Mornington Peninsula, Whitehorse and the Yarra Ranges.

[6] Through stakeholder consultations, the analysis has found that extractive products represent, on average, 35% of total project costs (this proportion comprises extractive materials costs only and excludes costs associated with transporting and handling these materials).

# Glossary of key terms

| Term | Definition |
|---|---|
| DEDJTR | Department of Economic Development, Jobs, Transport and Resources is responsible for leading and facilitating development of Victoria's earth resources. |
| Greater Melbourne | Greater Melbourne is defined within the analysis using Australian Bureau of Statistics' Urban Centre and Locality (UCL) structures. Melbourne UCL, which has been represented within this report as Greater Melbourne, is comprised of the cluster of smaller urban Statistical Areas 1 (SA1s). By excluding non-urban regions, Melbourne UCL broadly represents Melbourne's metropolitan area. See http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/05773C1D8C9F2022CA257A98001399F7?opendocument for more information. |
| Key resource depletion locations | Areas where a significant proportion of the reserves of existing and planned future quarries are exhausted for particular rock types. |
| LGA | Local Government Area. LGAs are defined by the Departments of Local Government, or their equivalent in each State or territory, excepting the Australian Capital Territory. There are 79 LGAs in Victoria as defined by the Australian Bureau of Statistics (ABS). The ABS approximates the officially defined boundaries with aggregations of Mesh Blocks. The Mesh Block is the smallest unit within the new Australian Statistical Geography Standard (ASGS). Their boundaries are contiguous and cover the whole of Australia without gaps or overlaps. There are approximately 347,600 Mesh Blocks. |
| Locations critical to supporting Greater Melbourne's future | Areas that are expected to deliver significant volumes of resource to Greater Melbourne across the analysis period. |
| Potential supply shortfall | Represents the difference between the volume of extractive resources a location demands and the supply it receives, for a given rock type and period. |
| PwC | PricewaterhouseCoopers |
| Regional LGAs | Regional LGAs are defined as those LGAs outside the Metropolitan Melbourne boundary. This includes regional city LGAs such as Ballarat and Greater Geelong, along with rural areas such as Corangamite, Indigo and East Gippsland. A full list of LGAs defined as Regional is provided at Appendix F. |
| Supply locations with significant production levels | Areas producing large volumes of extractive resources across the analysis period. |
| Strategic resource locations | Areas that are identified across two or more strategic resource criteria AND contribute a relatively significant proportion of the State's supply for a resource or resources. |
| Taskforce | Extractive Industries Taskforce was established in April 2014 and comprises Victorian Government and industry representatives. The Taskforce's work program includes identification of substantial extractive resources in Victoria, in particular those of strategic importance to the State. |
| Threatened rock types | Extractive resources that are anticipated to be in short supply by the end of the analysis period, based on industry intentions at 2015. |
| Urban growth area LGAs | The Metropolitan Planning Authority has identified seven Urban Growth Areas within Metropolitan Melbourne, where significant economic development is expected. This includes areas of Melbourne's fringe such as Melton, Whittlesea and Hume. A full list of LGAs defined as Urban growth areas is provided at Appendix F. |
| Urban infill area LGAs | The remaining LGAs within Metropolitan Melbourne that are not categorised as Urban growth area LGAs are defined as Urban infill area LGAs. This includes the inner areas of Metropolitan Melbourne including the inner city regions of Yarra, Stonnington, Whitehorse and Moreland. Established urban areas in Metropolitan Melbourne's suburbs are also considered urban infill. This includes LGAs such as Frankston, Maroondah and Nilumbik. A full list of LGAs defined as Urban infill areas is provided at Appendix F. |
| WA | Extractive industry work authority. Work authorities are required under State legislation for individuals or organisations wishing to carry out an extractive industry, unless exemptions apply. |

# Contents

# 1 Introduction

## 1.1 Background

DEDJTR is responsible for leading and facilitating development of Victoria's earth resources. Extractive industries are important contributors to the Victorian economy. In 2014, 485 operating quarries across the State produced close to 40 million tonnes of stone, limestone, gypsum, sand and gravel. These resources are used to produce concrete, cement, bricks and road paving used in the construction of public infrastructure such as roads, railways and bridges and in commercial and residential buildings. The value of production from quarries at the 'quarry gate' in 2014 is estimated to be around $676 million.[7]

The building and construction sector faces challenges in maintaining access to supplies of quality extractive resources, particularly:

- potential sterilisation of prospective extractive resources by urban and regional development
- encroachment of urban and regional development into existing quarrying areas
- the nearly doubling of demand for extractive resources over the 2015 to 2050 period will lead to an increase in the need for transport infrastructure
- exhaustion of existing licensed reserves.

These challenges were recognised by the EDIC[8] 2012 Inquiry into greenfield mineral exploration and project development in Victoria.

Subsequently, the Extractive Industries Taskforce (the Taskforce) was established to quantify resources, estimate future requirements and provide advice on ways to improve planning arrangements for extractive resources. The Taskforce includes both industry and Government representation, and is supported by a Reference Group of broader stakeholders.

## 1.2 Overview of the extractives industry in Victoria

Urban and regional development, renewal and large infrastructure projects are the primary market drivers of demand for extractive resources. The Commonwealth and Victorian Governments have established significant agendas for future infrastructure development which extend over many years. This, in turn has significant potential implications for the demand for extractive resources.

Victoria has a number of known sources and locations of extractive resources. Some of these resources are currently commercial quarrying operations, some are in development and others are prospective areas which may be considered for development in the future. The quality of extractive resources is critical as some uses (such as roads) require specific types or grades of extractive resources for which there are limited substitutes.

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[7] Department of Economic Development, Jobs, Transport and Resources (2014).

[8] Economic Development and Infrastructure Committee

Extractive (stone) resources are defined as:[9]

- sandstone, freestone or other building stone
- basalt, granite, limestone or rock of any kind ordinarily used for building, manufacturing or construction (e.g. road construction) purposes
- quartz (other than quartz crystals)
- slate or gravel
- clay (other than fine clay, bentonite or kaolin)
- peat
- sand, earth or soil
- other similar materials.

Given the large mass of extractive resources demanded compared to their value, transportation costs between sources of extractive resources and locations of use are large cost elements in the resource supply chain. Accordingly, quarries are often located in relatively close proximity to customers. While much larger transport distances are not uncommon, quarries typically service demand within 100km.[10]

As a relatively small and densely populated State, Victoria is increasingly facing pressures around competing uses for land, particularly in urban and regional fringe areas. There is the potential for competing demand by different adjacent land uses at all stages of a quarry's lifecycle, from prior to quarry development, through quarrying operations to the rehabilitation of the site.

Where there are constraints on locally sourced supplies of extractive resources supply has to be imported from further afield. The potential implications of this constraint include higher construction costs for public infrastructure and for public and private construction activity. Moreover, extractive resource production from quarries may not be sufficient to supply future demand growth needs without upward pressure on resources prices, with the potential for flow through to higher construction costs. The development of new quarries is expected to assist in addressing this issue.

Land planning decisions have the potential to facilitate or to restrict access to extractive resources. The use of land for extractive industries is directly impacted upon by planning schemes, where an extractives proposal either requires a planning permit or is deemed to be a prohibited use, especially around emerging residential areas.

There is an opportunity to ensure that urban and regional growth and land planning (particularly on the fringes of the Melbourne metropolitan area and regional cities) appropriately takes into account existing and future strategic extractive resource needs and supply sources.

It is important that these considerations are informed by robust information on potential future resource needs for specific types of extractive resources, including their existing, planned and potential supplies and locations of strategically important resources.

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[9] Consistent with the Mineral Resources (Sustainable Development) Act 1990

[10] As reported in the Extractives Industry Survey conducted by PwC as part of this analysis.

Consideration of how planning mechanisms can best be used to facilitate co-existence of extractive industries and other land uses is also important to enable the State to best manage its extractive resources. Such considerations are not part of this study.

## 1.3 Scope of this study

The Extractive Industries Taskforce commenced in April 2014. Its work program includes identification of substantial extractive resources in Victoria, particularly those which may be strategically important to the State.

Accordingly, this study has been established to:

1. identify and quantify current and forecast demand and supply profiles for Victorian extractive resources over two time periods: 2015 to 2025 and 2026 to 2050, including scenario analysis.

2. assess the economic value of the State's extractive resources, in terms of implications for cost and/or availability of infrastructure and other construction activity if certain extractive resources are not available close to where they are needed for construction activity.

3. determine which extractive resources (including location) are likely to be of strategic value to the State. A strategic resource criteria framework and associated measures have been developed in consultation with the Department and Extractive Industries Taskforce to assist in this determination.

4. conduct spatial analysis through the production of detailed maps of extractive resource locations, including linkages to areas of current and future demand, transport corridors and market linkages, potential synergies and impediments.

The current and forecast demand and supply profiles for Victorian extractive resources have been undertaken by separate service providers. This report and associated analysis detail the consolidated findings and recommendations flowing from the integration of both the supply and demand components.

The demand analysis report is included in Appendix F and provides further detail with respect to the scope of that study.

# 2 Methodology

## 2.1 Methodology and modelling framework

PwC was engaged by DEDJTR to consolidate and analyse demand, supply and industry findings to provide meaningful insights on the potential supply shortfalls faced by the State. To achieve this PwC designed a framework that seamlessly integrates the supply and demand studies whilst maintaining the highest degree of rigour and transparency within the analysis.

A modular framework was adopted to allow for the demand and supply of extractive resource profiles to be separately estimated but iteratively and holistically analysed and presented. The two components are interlinked through an agreed-upon set of assumptions and scenarios. An overview of PwC's approach is illustrated below.

**Figure 3: Overview of extractive resource modelling approach**

***1. Demand modelling and analysis***

At the request of the Department, PwC reviewed and adjusted the extractive resource demand analysis, in order to provide greater insights into how the supply of extractive resources would be able to meet demand locations.

***2. Supply modelling and analysis***

To understand the supply of extractive resources, a three pronged approach (emails, posted letters and telephone/face to face interviews) was undertaken to provide the industry with the option to participate in an industry engagement questionnaire. All current producers within the industry were offered the opportunity to respond. From this respondent pool 200 responses were received to the web survey and 27 interviews were conducted, representing coverage of 81% of the State's production volumes. The information collected was used to forecast the future supply of extractive resources to 2050, including identification of areas that may be critical to future developments and infrastructure projects.

***3. Demand and Supply analysis***

PwC utilised its Geospatial Economic Modelling (GEM)[11] platform to analyse the interaction between supply and demand for extractive resources across Victoria. This included a supply versus demand gap analysis including an analysis of the cost implications for potential changes in supply chain distances by extractive resources needed to service demand.

***4. Strategic resource determination***

A framework was developed that contained a transparent set of criteria which could be used to determine resources that are likely to be of strategic value to the State. This framework was tested with the Department and the Extractive Industries Taskforce. Measures and thresholds were developed against each criterion, which were informed by data from both the demand and supply analysis.

***5. Reporting and mapping***

Preliminary results of the integrated supply and demand analysis were presented to the Taskforce and Reference Group for feedback and validation. This report details the consolidated findings, mappings and recommendations flowing from the integrated analysis.

Source: PwC

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[11] PwC has created a platform called the Geospatial Economic Model (GEM) that has the ability to correlate and 'layer' industry data onto any given designed 'region' of choice. Data collected through the Demand Analysis and Supply Analysis were integrated into the GEM platform.

## 2.2 Demand analysis methodology and data collection

### 2.2.1 Demand analysis methodology

The detailed demand analysis for extractive resources in Victoria from 2015 to 2050 was undertaken by a separate service provider. The final report of that analysis can be found at Appendix E and a summary of the methodology applied in the analysis is provided below.

The approach to developing the long term projections of the demand for extractive resources across Victoria combines macroeconomic and demographic forecasting with a detailed analysis of the use of extractive resources within defined construction industry sectors.

The key steps involved in the demand analysis methodology are as follows:

- Identification of historic relationships between macro-economic demand drivers and construction activities.

- Identification of historic relationships between construction activities and the total production of extractive resources. This work relied on extractive resources production data provided by DEDJTR covering the period 1991 to 2014.

- Development of a high-level forecast of construction activities based on Victorian Government population and macroeconomic projections and the long term relationships between these data and various construction activities.

- Forecast of the total demand for extractive resources, focusing on four key categories of extractive resources (hard rock, limestone, sand and gravel and clay and clay shale).

- Development of a spatial allocation of the demand for these four categories to Victorian Local Government Areas (LGAs). This allocation was based on a spatial allocation of construction activities and key technical assumptions received from DEDJTR's technical advisors linking each construction activity with the use of extractive resources.

Further industry analysis was undertaken to validate and refine the initial projections to account for the complex nature of the industry and the interdependent relationships between supply and demand in certain locations.

### 2.2.2 Stakeholder consultations

Stakeholder consultations were undertaken to support the demand analysis. The aim of these consultations was to fill gaps in available data, which were mainly related to the absence of conversion metrics allowing calculating the quantity of extractive resources required per type of construction.

The detailed demand analysis was supported by consultation with several stakeholders, including:

- construction firms

- quantity surveyors

- extractive industry participants

- VicRoads

### 2.2.3 Additional data collection

The demand analysis additionally relied on consideration of several other data sources, including, but not limited to the following:

- DEDJTR, in relation to the historic production of extractive resources in Victoria, provided from 1991 to 2014, and Victoria Transport Modelling (VITM) data with respect to 2046 population projections by LGA and employment projections by LGA in 2011, 2021, 2031 and 2046.
- Victoria in the Future 2015 (VIF 2015), with respect to 2011, 2021 and 2031 population and household size projections by LGA and Statistical Areas Level 2 (SA2).
- Australian Bureau of Statistics (ABS) data, with respect to the construction value of works done by construction activity type, and other items.
- State Budget Papers in relation to historical Gross State Product (GSP) data and projections of government spending on infrastructure.
- Other Government sources (e.g. Australian Grant Commission Annual Reports, growth areas precinct plans).
- Reserve Bank of Australia (RBA) with respect to historical interest rate data.
- BIS Shrapnel – Engineering Construction Activity data to identify transport major projects planned to be developed by the Victorian Government.
- The service provider's knowledge on future infrastructure transport projects.
- Additional reports such as the Economic Contribution of the Extractive Industries in Victoria prepared for Cement Concrete & Aggregates Australia in May 2006.
- Interviews with industry stakeholders, through a formal stakeholder consultation launched by DEDJTR on 22 October 2015.
- Final inputs from DEDJTR's technical advisor that identified and quantified extractive resources used in Victoria's construction activities.

### 2.2.4 Outputs

At the request of DEDJTR, PwC disaggregated the demand forecasts to achieve consistency with the granular understanding of extractives supply. These inputs were required to feed in to the demand-supply modelling undertaken by PwC. The methodology adopted to achieve this disaggregation is described below.

## *Granular spatial redistribution of demand*

#### *Geospatial granularity of the demand study*

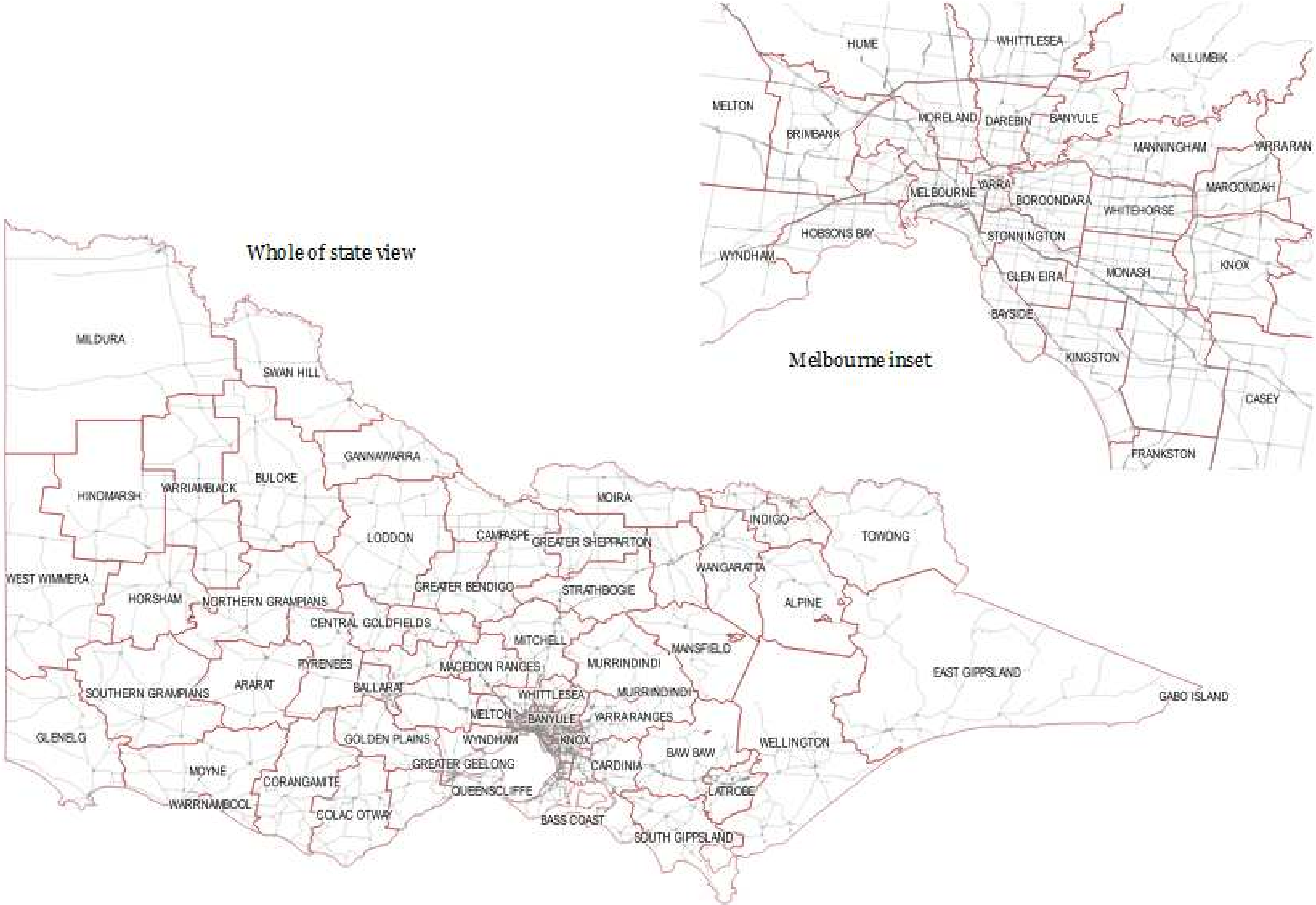
The demand analysis outputs were provided to PwC at the LGA-level for each year and rock type covered in the analysis. There are 79 LGAs in Victoria, meaning demand within the State was split among 79 sub-regions. Victoria's LGAs are depicted in Figure 4 for reference.

Many of these 79 LGAs cover a relatively large geographic area, such as East Gippsland which has an area of close to 21,000km$^2$ (or 9.2 per cent of Victoria's area) and Mildura at over 22,000km$^2$ (or 9.7 per cent of Victoria's area). Information on the underlying distributions of demand within LGAs for different rock types was not provided by the service provider in the demand analysis. Rather demand was assumed to be uniform across each LGA's surface.[12]

A more granular analysis was considered necessary to build upon the work prepared within the demand study. To meet this requirement, DEDJTR engaged PwC to re-distribute the LGA-level demand data to different localities and regions within each LGA.

[12] This approach had some limitations, including lack of accuracy in calculating transport costs as these costs are only registered when materials are sent across LGA boundaries, and assumes transport from the centre point of an LGA. These limitations are exacerbated when considering larger LGAs, such as the Yarra Ranges or Cardinia in Eastern Victoria.

**Figure 4: Victoria's Local Government Areas (LGAs)**



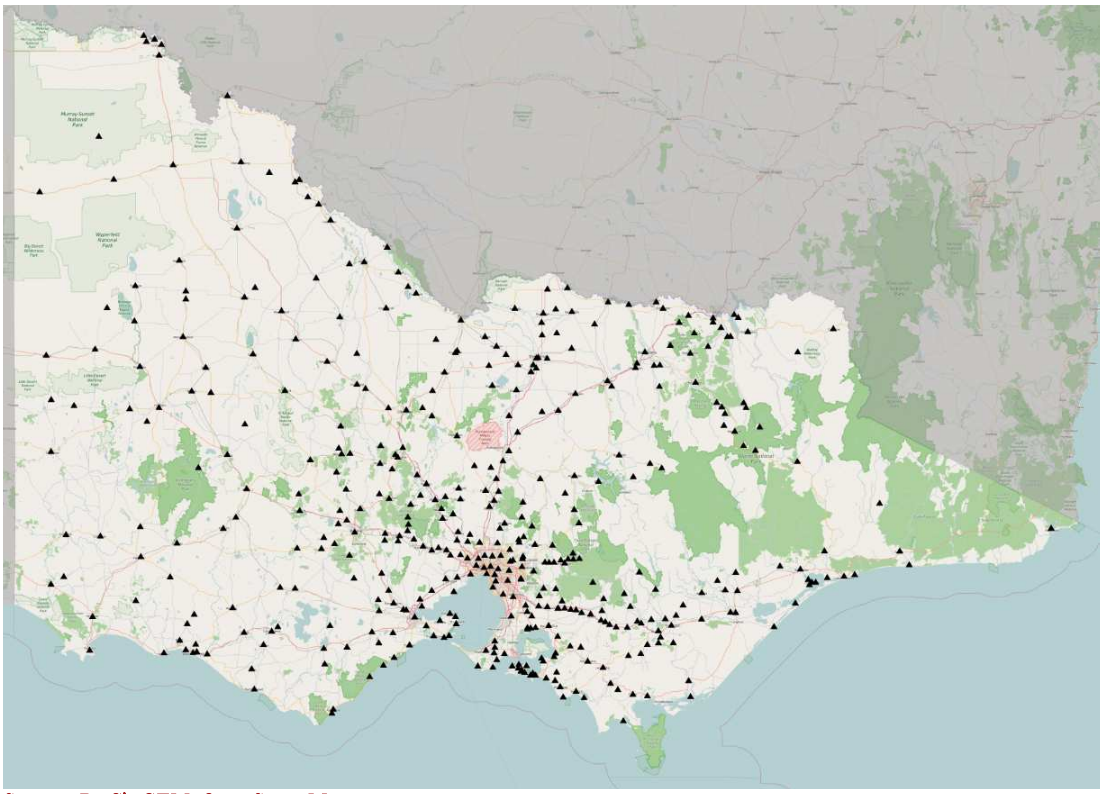

Source: PwC's GEM

*Distribution of demand to Victorian localities*

Victoria's urban centres and localities (UCLs), as defined by the ABS were utilised to re-distribute the LGA-level demand data down to a more granular level. UCLs are defined as Australian population centres exceeding 200 persons.[13] A detailed description of PwC's methodology is provided in Appendix C.

This component of the analysis resulted in a redistribution of demand from 79 LGAs to nearly 500 individual Victorian localities, offering a significantly more granular view of the demand for extractive resources within the State.[14] An illustration of Victoria's localities which were used in the analysis is provided in Figure 5 below; localities are represented as dark triangles in the figure.[15]

**Figure 5: Victorian urban centres and localities used in the analysis**



Source: PwC's GEM, OpenStreetMap.

The urban centres and localities mapped as black triangles in Figure 5 comprise:

- UCLs as defined above, which are used to understand the population-based demand for extractive resources within an LGA. Residential and commercial construction are examples of demand types that are considered to be population-based, as these construction types are undertaken close to where people live.

[13] ABS, 1270.0.55.004 - Australian Statistical Geography Standard (ASGS): Volume 4 - Significant Urban Areas, Urban Centres and Localities, Section of State, July 2011

[14] The proportion of each LGA's demand that related to engineering construction demand was allocated to the LGA centroid.

[15] Clusters of localities in the figure occur where several distinct towns and localities are located in close proximity, for instance in Southern Victoria and in the Yarra Ranges region.

- LGA centroids, which are used to understand the demand within an LGA that does not necessarily relate to population, such as engineering and utilities construction which can occur at a distance from places where people live.

Given the extractive resource supply information was collected at a Work Authority level, the re-distributed demand data provided a more appropriate level of spatial analysis for the integrated supply-demand study.

### 2.2.5 Demand scenarios

Several scenarios were considered as part of the demand analysis. Scenarios 1A and 2A reflect uniform up- and down-shifts in demand by 20 per cent respectively, while scenarios 3A and 3B consider different redistributions of demand within the State while holding the overall demand level constant. The demand scenarios are described in further detail below.

The demand study classifies Victorian LGAs into one of three categories:

1. Urban growth area – The Metropolitan Planning Authority has identified seven Urban Growth Areas within Metropolitan Melbourne, where significant economic development is expected. LGAs classified as urban growth areas are Cardinia, Casey, Hume, Melton, Mitchell, Whittlesea and Wyndham.

2. Urban infill – The remaining LGAs within Metropolitan Melbourne that are not categorised as urban growth area LGAs are defined as urban infill area LGAs. This includes the inner areas of Metropolitan Melbourne including the inner city regions of Yarra, Stonnington, Whitehorse and Moreland. Established urban areas in Metropolitan Melbourne's suburbs are also considered urban infill. This includes LGAs such as Frankston, Maroondah and Nilumbik. A full list of LGAs defined as urban infill areas is provided at Appendix F.

3. Regional – Regional LGAs are defined as those LGAs outside the Metropolitan Melbourne boundary. This includes regional city LGAs such as Ballarat and Greater Geelong, along with rural areas such as Corangamite, Indigo and East Gippsland. A full list of LGAs defined as Regional is provided at Appendix F.

The classification of LGAs undertaken in the demand study is provided in Appendix F.

*Baseline Scenario*

The baseline scenario comprises the central set of estimates based on core assumptions and expectations.

*Scenario 1A*

Scenario 1A is a 'high' scenario where population and employment growth are assumed to be 20 per cent greater than current Government projections.

Under this scenario, the demand study assumes that the 20 per cent increase in these projections would result in a 20 per cent increase in construction activities, which flows through to a 20 per cent increase in demand for extractives.

*Scenario 2A*

The 'low' scenario 2A relates to a 20 per cent decrease in the government projections driving extractive resource demand in Victoria, which then flows through to a 20 per cent decrease in demand for extractives.

*Scenario 3A*

Scenario 3A assesses the impacts of greater infill development relative to the baseline scenario, therefore resulting in a redistribution of the demand for extractive resources towards those LGAs identified as urban infill. The aggregate level of demand in the State is largely unchanged from the Baseline scenario.

*Scenario 3B*

Scenario 3B considers greater development within urban growth areas, which in this case is redistributed from urban infill LGAs. As such demand for extractives is greater than baseline in urban growth areas and lower than baseline in infill areas; the aggregate level of demand in the State is largely unchanged from the Baseline scenario.

## 2.3 Supply analysis methodology and data collection

Active industry engagement was critical to the success of this study. As such, considerable effort was focused on providing all industry participants with the opportunity to participate in a constructive manner. Contact was made with all current industry participants for whom contact details were available.

In total, 27 interviews were conducted along with collection of 200 completed web surveys and several completed paper surveys, covering an estimated 81 per cent of Victorian operators (by production volume).[16]

### 2.3.1 Industry engagement – supply data collection

To understand the supply of extractive resources, including the current state of play and proposed intentions and future needs, a three pronged approach (telephone/face to face interviews, emails and posted letters) was undertaken in an attempt to provide all holders of Extractives Work Authorities in Victoria with the opportunity to participate in the industry engagement questionnaire.

An online survey was designed and launched, complemented with industry interviews and a desk-based review of literature. The information collected was used to model the current and future supply of extractive resources to 2050, including identification of areas that may be critical to future developments and infrastructure projects.

Table 1 illustrates the delivery methods used to conduct the survey and the number of work authorities and production values for each survey type.

**Table 1: Three-pronged approach: Split of WA holders by delivery method (interviews, emails, letters) for the industry survey**

| | Work Authority Holders | Work Authorities | 2013-14 Production volume (millions) | Proportion by production |
|---|---|---|---|---|
| Interviews | 30 | 128 | 31.6 | 77% |
| Emails | 342 | 573 | 6.2 | 15% |
| Letters | 188 | 189 | 3.1 | 8% |
| **Total Industry** | **560** | **890** | **40.9** | **100%** |

Source: DEDJTR 2014

### Data collection template

An industry survey was developed to collect information from the extractive industry participants with respect to their current and expected future operations. The survey was designed and tested in consultation with DEDJTR and Taskforce members to ensure all necessary and relevant information was captured to inform this study.

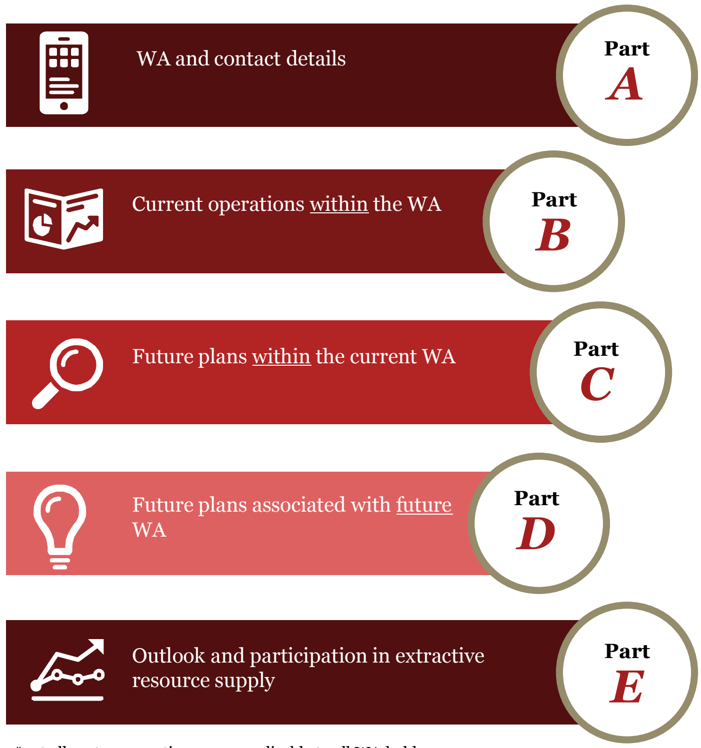
[16] Using DEDJTR records for 2013-14 extractives production in Victoria.

Leveraging the questions and format contained in the survey, an interview questionnaire was also prepared for use in face-to-face and telephone interviews with the top 30 producing industry participants, as measured by volume of production in 2013-14.

An overview of the survey's content and format is provided in Figure 6.

**Figure 6: Industry survey overview**

**The survey is composed of 5 parts*:**




*not all parts or questions were applicable to all WA holders.

## *On-line survey*

To implement the industry survey in an efficient and scalable setting, PwC developed the questionnaire using a proprietary and secure web-based survey tool. The tool provided for instant delivery of the survey to a large pool of respondents while also automating the data collection process.

Between 12 and 19 August 2015, email invitations to participate in the survey were sent to all 2013-14 WA holders with valid email addresses and included a unique link to the survey. In total, the survey was open for 10 weeks. Email invitations were sent to 558 WA holders (representing approximately 20 per cent of Victorian production in 2013-14). PwC received 200 individual responses to the web survey from WA holders totalling seven per cent of production in the State using 2013-14 production data.

## *Paper survey*

In addition to the web survey, a paper survey was issued to potential respondents whose email address details were not available. These paper surveys were issued by DEDJTR and completed responses were returned directly to PwC; approximately 190 paper surveys were issued with one return survey.

## *Face-to-face and telephone interviews*

Using historical extractives production records, the State's top 30 producers, as measured by volume of production in 2013-14, were identified and targeted for face-to-face interviews. These interviews were undertaken by PwC's industry advisor, Coffey International (a Tetra

Tech company) (Coffey). Telephone interviews were conducted in cases where respondents were unavailable to meet face-to-face.

The top 30 producers represent close to 80 per cent of Victorian extractives production volumes in 2013-14. Hence, resources were focused on understanding the current operations and future plans of these producers.

Industry interviews commenced in August 2015 and were completed by October 2015. 27 respondents provided information to support the study through this process, representing approximately 74 per cent of the State's production in 2013-14.

Across the responses from the survey and interviews, 81% of the State's production volumes were covered.

### 2.3.2 Survey respondent confidentiality

The supply survey was designed to gather information from the extractive resource industry on the current and planned future operations of quarries across Victoria. As this information was considered commercially sensitive, structures were established across the breadth of the study to secure respondents' confidential information and prevent commercial-in-confidence data from being revealed through the study's reporting.

To this end, agreements were put in place between DEDJTR and the service providers of the supply and demand studies, which included PwC and our industry advisor, Coffey. These agreements provided for the protection of industry participants' information, including data provided through the survey with respect to future commercial activities. In addition, the agreements bound PwC and its advisors to protecting the confidentiality of industry respondents through reporting on the study's findings.

Additionally, PwC has developed a process to manage confidentiality and commercially sensitive information collected during this phase of the study.

The aim of the confidentiality process was to draw together all the information gathered by PwC and Coffey, along with Government and industry knowledge and perspectives, to maintain respondent confidentiality and support stakeholder and industry confidence in the project.

This was a gated process which began with PwC aggregating and checking data. This was then supplemented by the Department and the Taskforce's views based on internal expertise within the regulation and reporting on industry outcomes and future policy considerations. This included their understanding of key industry players, industry trends and commercial sensitivities, on which it may otherwise be difficult to gain insights.

The confidentiality framework has been provided in Appendix B for reference.

### 2.3.3 Additional stakeholder consultations

To support development of the study, additional consultations were undertaken with industry participants at different stages of the supply chain. Consultations were conducted with the following sectors:

- residential, commercial and industrial construction
- quantity surveying
- VicRoads.

These interviews provided for collection of data in relation to the end uses of extractive resources across different construction modes, along with information on typical resource costs and transport arrangements.

The data collected through these consultations were used to inform several assumptions applied in the economic modelling component of the study, which are outlined in Appendix D of the report.

### 2.3.4 Integration of supply and demand

The separate demand and supply components of the study were integrated within a supply-demand model. This was used to produce outputs of individual WA production levels, depletion rates, demand locations and associated transport routes and costs.

*Matching of WAs to localities*

Within the integrated analysis each WA (including both current and planned future WAs) is matched to appropriate demand sites (localities) based on a weighted combination of population and distance. This approach was employed to appropriately reflect the following market drivers reported by stakeholders:

- buyers of extractive resources will buy from more proximal quarries in an effort to minimise the costs of delivered material
- suppliers of extractive resources prefer to serve fewer large markets rather than more numerous small markets to minimise their transaction costs.

This approach delivers an optimised supply-demand matching based on cost-efficient resource delivery.

Demand sites are served by the closest quarries across the road network, meaning transport distances and the costs of delivered resource are minimised for buyers. Additionally, this approach captures locational differences in the Victorian road network and the effects of key transport corridors. Quarries located in proximity to key roads will be favoured by resource buyers over those that are harder to access, meaning resource locations that are well serviced by roads are recognised as key areas of supply.

At the same time, quarry operators situated closest to the sites of strong future demand will deliver more resources than those quarries that are more distant from these markets. This means that the best-situated resources are exhausted first, which minimises the costs faced across the State collectively in meeting extractive resource needs.

*Demand-driven supply*

Within the integrated supply-demand model, WA operators' production levels within a given year are based on a combination of two components:

- their historical production rates, which are assumed to broadly reflect their productive capacity
- the level of demand they face for a given period.

Application of this approach results in demand-driven supply outcomes. These outcomes are optimal in the sense that no excess supply of resources arises, and hence, WA operators do not remove resources from the land that may not be sold in the market.

The supply data and projections presented in this report over two time periods, 2015 to 2025 and 2026 to 2050, have been collected through industry consultations. As such, these are based on the industry's view and plans at a point in time. Notably, industry respondents indicated they were less confident in the response provided for the latter time period, 2026 to 2050, relative to the first time period. Findings in this report were informed by significant industry data gathering, which comprised 81 per cent of Victorian industry as measured by the level of 2014 extractives production in the Victoria.

The analysis has identified a set of critical resource locations within the State, based on application of several criteria and the result of the industry data gathering. These resource locations are expected to inform a broader understanding of those regions that could be important to the State's future development. A detailed analysis of the geological endowment of Victoria was not explicitly considered in the analysis. Rather, the analysis relied upon data provided through industry consultations which to some extent implicitly accounts for geological endowments across parts of the State.

# 3 Extractive resources demand - Key findings

## 3.1 Summary of demand analysis results

The results of the demand analysis are presented in the sections to follow. A brief description of each of the demand scenarios is provided below; more detailed information on the demand scenarios can be found in Section 2.2.5.

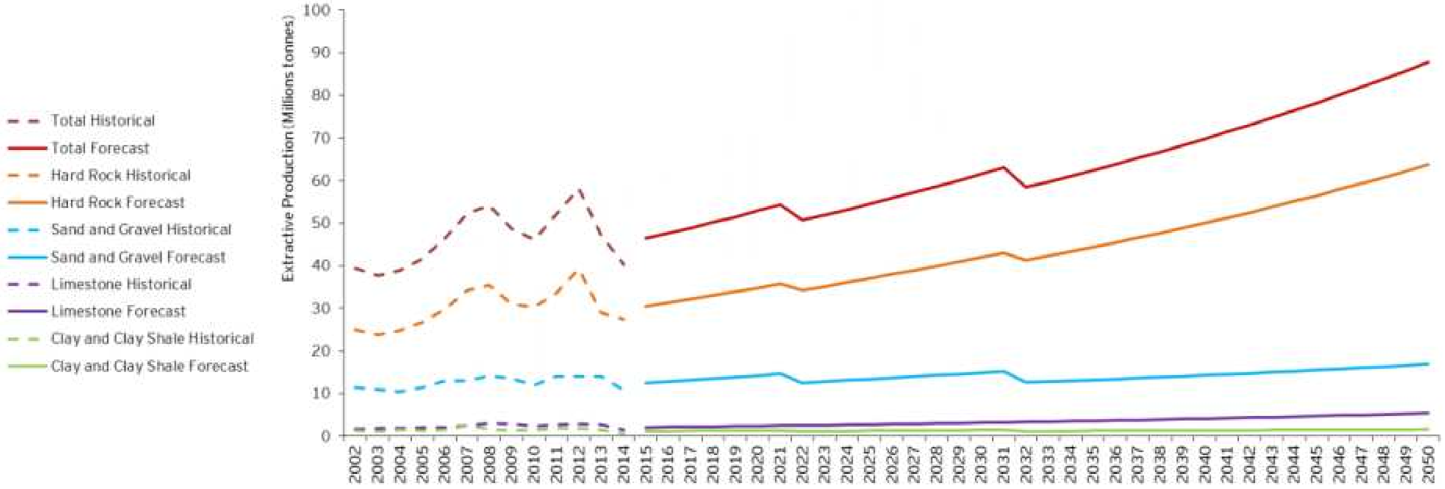
- Scenario 1A: Population and employment growth ahead of government projections in Victoria – (20% increase)
- Scenario 2A: Population and employment growth behind government projections in Victoria – (20% decrease)
- Scenario 3A: Redistribution of the growth in Metropolitan Melbourne toward Urban infill LGAs
- Scenario 3B: Redistribution of the growth in Metropolitan Melbourne toward Urban Growth Area LGAs

### 3.1.1 Baseline demand scenario

Demand for extractive resources in Victoria is expected to almost double across the forecast period. Beginning at 46.4 million tonnes in 2015, total demand for extractives is forecast to increase to 55.8 million tonnes by 2026. By 2050 total demand is to reach 87.8 million tonnes under the baseline scenario.

Figure 7 presents the consolidated trend of the year-on-year demand forecast under the baseline scenario.

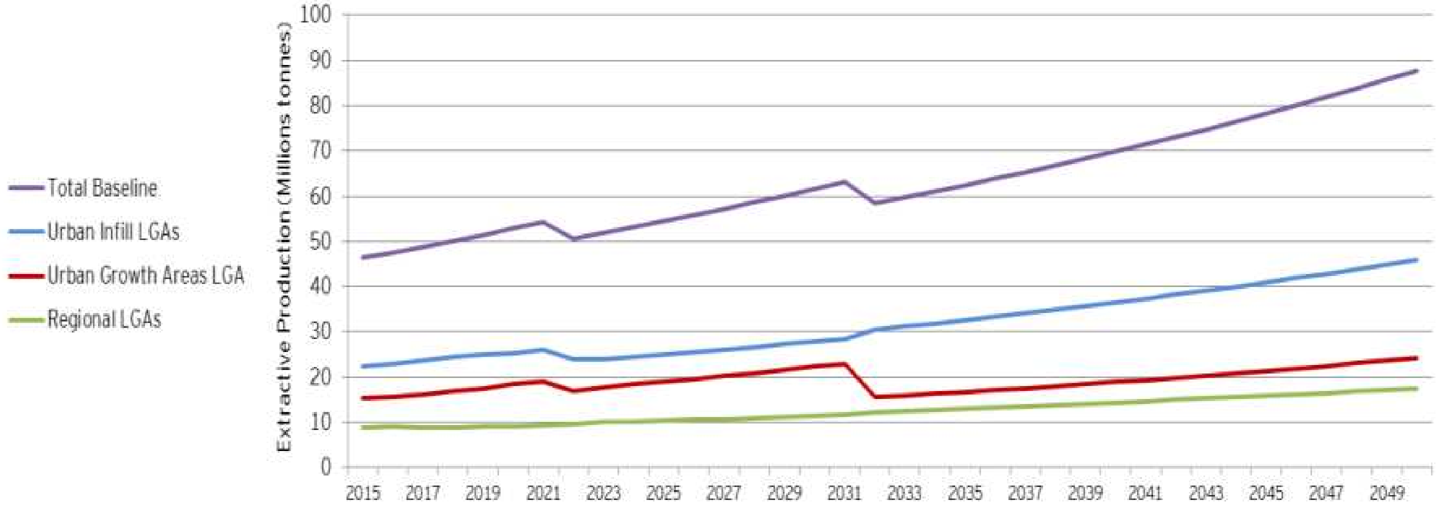
**Figure 7: Extractive resource demand - Historic data and forecast over the period 2002-50, million tonnes***




Source: EY, *Demand analysis of extractive resources in Victoria*, 2016. *In the Demand analysis, EY has indicated that steps in the forecast are related to population data and average annual growth rates provided by Government projections used in the forecast approach.

Figure 8 shows the level of demand by LGA type, including Urban Infill, Urban Growth Area and Regional LGAs. These categories are defined in the Glossary.

**Figure 8: Extractive resource demand by LGA type, million tonnes***




Source: EY, *Demand analysis of extractive resources in Victoria*, 2016. *In the Demand analysis, EY has indicated that steps in the forecast are related to population data and average annual growth rates provided by Government projections used in the forecast approach.

Looking within these LGA categories, as Figure 8 shows the majority of this demand growth is expected to occur in urban environments, which is driven by the expectation for continued strong population growth in these areas. There are strong demand increases expected in urban growth areas such as Casey, Whittlesea and Wyndham. Demand by rock type at key points of the analysis period is summarised in Table 2.

### Table 2: Demand by rock type for the Melbourne Metropolitan region (tonnes)*

| Rock type | Demand, 2015 | Demand, 2025 | Cumulative demand, 2015 to 2025 | Demand 2050 | Cumulative demand, 2026 to2050 | Cumulative demand, 2015 to 2050 |
|---|---|---|---|---|---|---|
| Hard rock | 24,764,886 | 29,953,244 | 305,250,080 | 51,029,658 | 978,295,417 | 1,283,545,497 |
| Limestone | 1,709,721 | 2,229,169 | 21,636,811 | 4,344,054 | 79,712,556 | 101,349,366 |
| Sand and gravel | 10,197,629 | 10,854,517 | 120,216,961 | 13,549,485 | 291,913,846 | 412,130,808 |
| Clay and clay shale | 976,207 | 1,053,454 | 11,645,875 | 1,319,932 | 28,417,078 | 40,062,953 |

Source: PwC analysis. *Includes Urban Growth Areas and Urban Infill Areas.

Material increases are also expected in Victoria's regional population centres, including Ballarat, Greater Bendigo and Greater Geelong. Demand by rock type for regional areas of Victoria is summarised in Table 3. A full list of the LGAs used in this analysis along with their categorisation is provided at Appendix F.

### Table 3: Demand by rock type for regional Victoria (tonnes)*

| Rock type | Demand, 2015 | Demand, 2025 | Cumulative demand, 2015 to 2025 | Demand 2050 | Cumulative demand, 2026 to 2050 | Cumulative demand, 2015 to 2050 |
|---|---|---|---|---|---|---|
| Hard rock | 5,775,731 | 7,078,040 | 68,977,360 | 12,800,520 | 247,863,637 | 316,840,997 |
| Limestone | 400,584 | 532,079 | 4,986,965 | 1,096,601 | 20,399,830 | 25,386,795 |
| Sand and gravel | 2,377,993 | 2,544,159 | 26,885,779 | 3,322,657 | 72,402,823 | 99,288,602 |
| Clay and clay shale | 230,077 | 231,779 | 2,464,569 | 298,484 | 6,529,042 | 8,993,611 |

Source: PwC analysis. *Includes all LGAs not classified as Urban Growth Areas or Urban Infill Areas.

Total State demand by resource type for key points of the analysis period is provided in Table 4.

### Table 4: Demand by rock type for Victoria, total (tonnes)

| Rock type | Demand, 2015 | Demand, 2025 | Cumulative demand, 2015 to 2025 | Demand 2050 | Cumulative demand, 2026 to 2050 | Cumulative demand, 2015to 2050 |
|---|---|---|---|---|---|---|
| Hard rock | 30,540,617 | 37,031,284 | 374,227,440 | 63,830,178 | 1,226,159,054 | 1,600,386,493 |
| Limestone | 2,110,304 | 2,761,248 | 26,623,776 | 5,440,655 | 100,112,385 | 126,736,161 |
| Sand and gravel | 12,575,622 | 13,398,676 | 147,102,740 | 16,872,142 | 364,316,670 | 511,419,410 |
| Clay and clay shale | 1,206,284 | 1,285,233 | 14,110,444 | 1,618,416 | 34,946,119 | 49,056,563 |

Source: PwC analysis

The top ten LGAs ranked by total demand across 2015 to 2025 under the baseline scenario are listed in Table 5.

**Table 5: Demand forecast (baseline) - Top ten LGAs by total resource demand, cumulative 2015 to 2025[17]**

| # | Top 10 LGAs | Total demand | Hard rock total demand | Limestone total demand | Sand and gravel total demand | Clay and clay shale total demand |
|---|---|---|---|---|---|---|
| 1. | Melbourne (C) | 51.9 | 34.5 | 2.5 | 13.5 | 1.4 |
| 2. | Wyndham (C) | 39.3 | 26.2 | 1.9 | 10.3 | 0.9 |
| 3. | Casey (C) | 36.8 | 24.6 | 1.7 | 9.6 | 0.9 |
| 4. | Whittlesea (C) | 32.8 | 21.9 | 1.5 | 8.6 | 0.8 |
| 5. | Melton (S) | 27.9 | 18.7 | 1.3 | 7.3 | 0.6 |
| 6. | Hume (C) | 26.8 | 17.9 | 1.3 | 7.0 | 0.6 |
| 7. | Greater Geelong (C) | 19.1 | 12.8 | 0.9 | 5.0 | 0.4 |
| 8. | Cardinia (S) | 18.2 | 12.2 | 0.8 | 4.8 | 0.4 |
| 9. | Moreland (C) | 15.1 | 10.0 | 0.7 | 4.0 | 0.4 |
| 10. | Greater Dandenong (C) | 15.0 | 10.0 | 0.7 | 3.9 | 0.4 |

Source: EY, Demand analysis of extractive resources in Victoria, 2016

The picture is largely similar for the second half of the analysis period. The top ten LGAs ranked by total demand across 2026 to 2050 in the baseline demand scenario are shown in Table 6.

**Table 6: Demand forecast (baseline) - Top ten LGAs by total resource demand, cumulative 2026 to 2050**

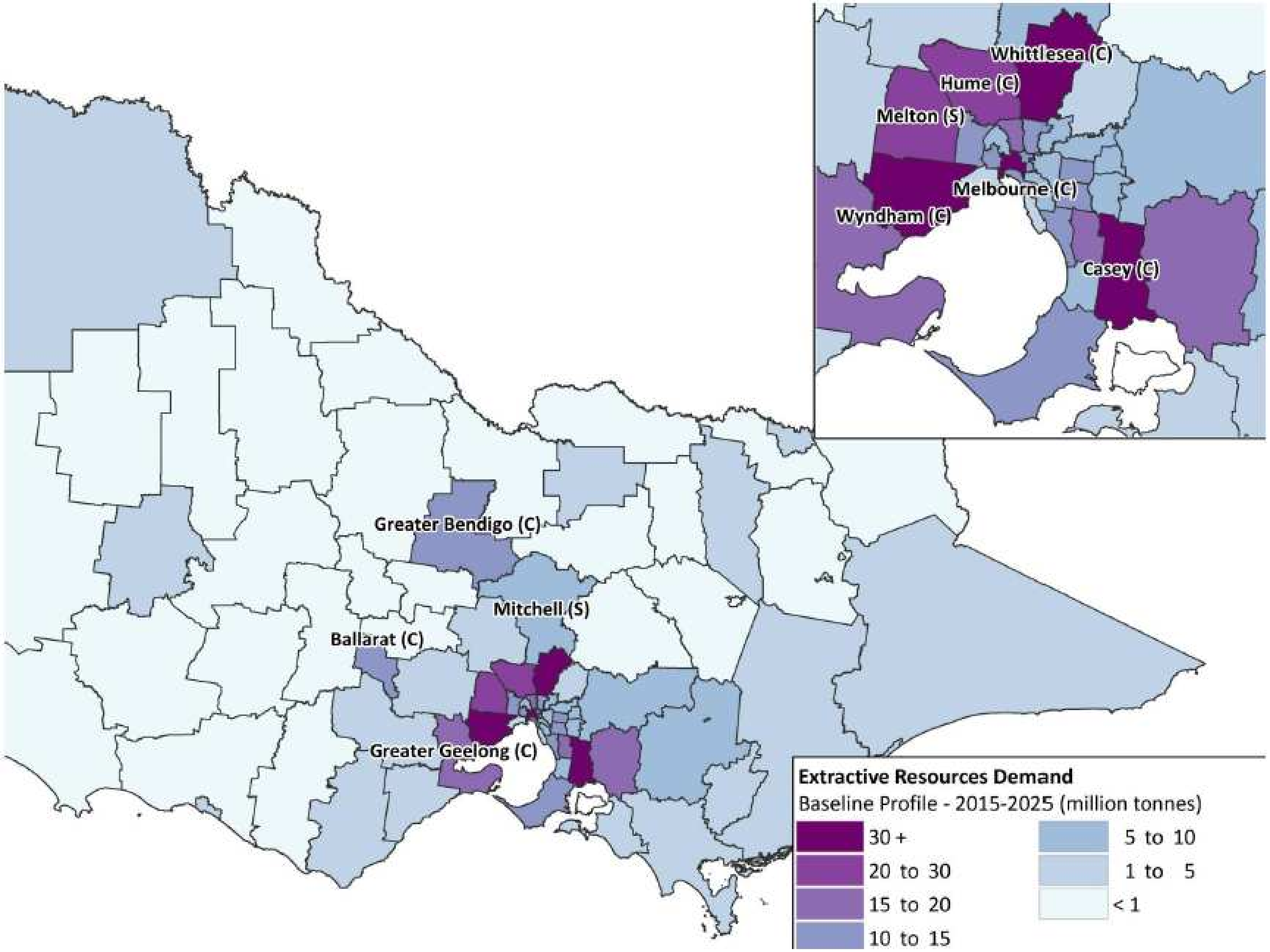
| # | Top 10 LGAs | Total demand | Hard rock total demand | Limestone total demand | Sand and gravel total demand | Clay and clay shale total demand |
|---|---|---|---|---|---|---|
| 1. | Melbourne (C) | 201.3 | 142.1 | 12.9 | 42.4 | 3.9 |
| 2. | Wyndham (C) | 114.9 | 82.7 | 6.4 | 23.7 | 2.1 |
| 3. | Melton (S) | 90.4 | 64.9 | 5.0 | 18.8 | 1.7 |
| 4. | Casey (C) | 76.5 | 54.4 | 4.3 | 16.3 | 1.5 |
| 5. | Hume (C) | 71.9 | 51.2 | 4.1 | 15.2 | 1.4 |
| 6. | Whittlesea (C) | 64.3 | 45.7 | 3.6 | 13.8 | 1.2 |
| 7. | Greater Geelong (C) | 52.6 | 37.6 | 3.1 | 10.9 | 0.9 |
| 8. | Greater Dandenong (C) | 43.9 | 31.0 | 2.6 | 9.4 | 0.9 |
| 9. | Moreland (C) | 41.4 | 29.6 | 2.3 | 8.7 | 0.8 |
| 10. | Cardinia (S) | 36.0 | 25.6 | 1.9 | 7.7 | 0.8 |

Source: EY, Demand analysis of extractive resources in Victoria, 2016

Figure 9 and Figure 10 illustrate the total level of demand for extractive resources by LGA over the periods 2015 to 2025 and 2026 to 2050 respectively.

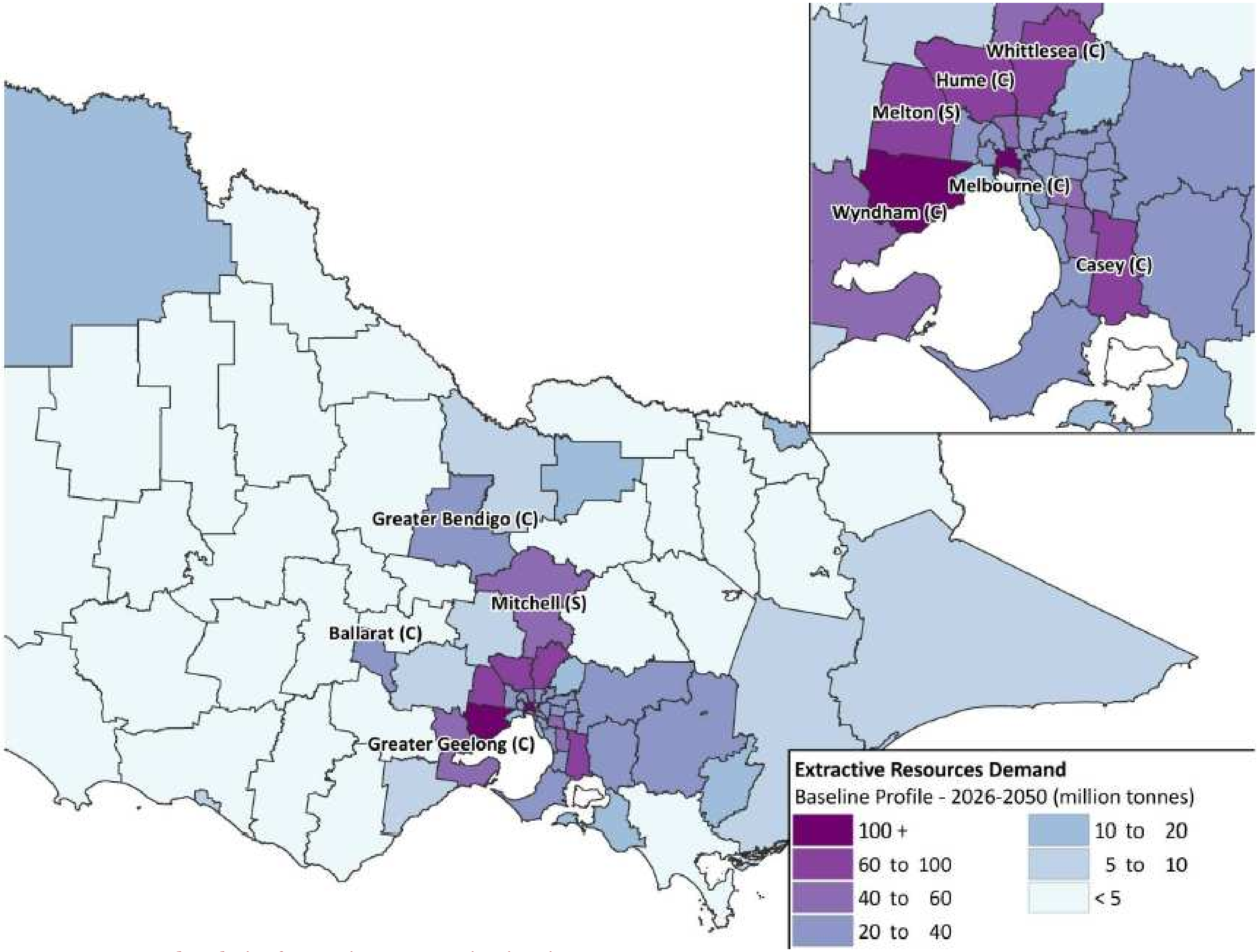
[17] (C) refers to City, (S) to Shire and (RC) to Rural City.

**Figure 9: Total demand for extractive resources by LGA over the period 2015 to 2025**




Source: EY, Demand analysis of extractive resources in Victoria, 2016

**Figure 10: Total demand for extractive resources by LGA over the period 2026 to 2050**




Source: EY, Demand analysis of extractive resources in Victoria, 2016

### 3.1.2 Demand drivers in Victoria

The demand forecasts were split into three categories under the base case scenario, which comprised extractive resource demand related to:

1. wind farm construction
2. engineering construction
3. residential and commercial construction.

Residential and commercial construction are the largest drivers of demand, comprising close to 80 per cent of total extractives demand across the analysis period. Engineering construction contributes approximately 20 per cent to total demand, with wind farm demand representing less than one per cent.

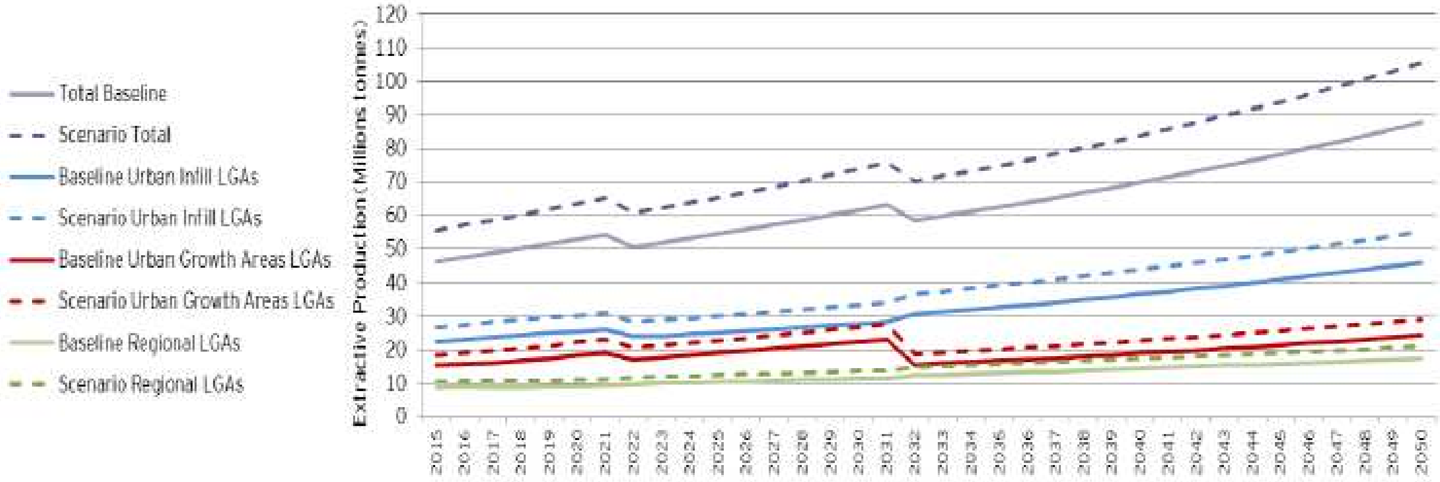
### 3.1.3 High demand scenario 1A and Low demand scenario 2A

Scenario 1A relates to the application of a 20 per cent increase on government projections driving the demand for extractive resources. This strategy implies increased population and GSP projections by 20 per cent, while holding land use patterns in line with current projections.

Under this scenario, the demand study assumes that the 20 per cent increase in these projections would result in a 20 per cent increase in construction activities, which would then flow through to a 20 per cent increase in demand for extractives.

The impacts of these assumptions relative to the baseline scenario are depicted in Figure 11.

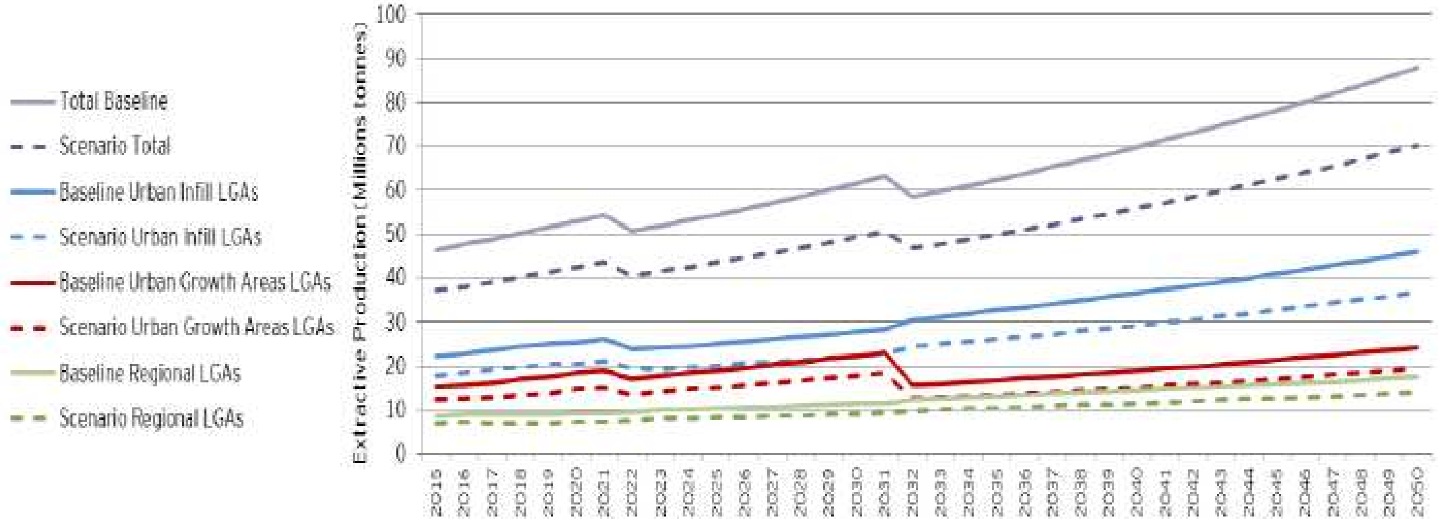
**Figure 11: Total extractive resource demand 2015 to 2050 - Baseline vs Scenario 1A***




Source: EY, *Demand analysis of extractive resources in Victoria*, 2016. *In the Demand analysis, EY has indicated that steps in the forecast are related to population data and average annual growth rates provided by Government projections used in the forecast approach.

Scenario 2A consists of assessing the impacts of a 20 per cent decrease in the government projections driving extractive resource demand in Victoria. The impact of the scenario 2A relative to the Baseline demand forecast is presented below in Figure 12.

**Figure 12: Total demand for extractive resources 2015 to 2050 - Baseline vs Scenario 2A***




Source: EY, *Demand analysis of extractive resources in Victoria*, 2016. *In the Demand analysis, EY has indicated that steps in the forecast are related to population data and average annual growth rates provided by Government projections used in the forecast approach.

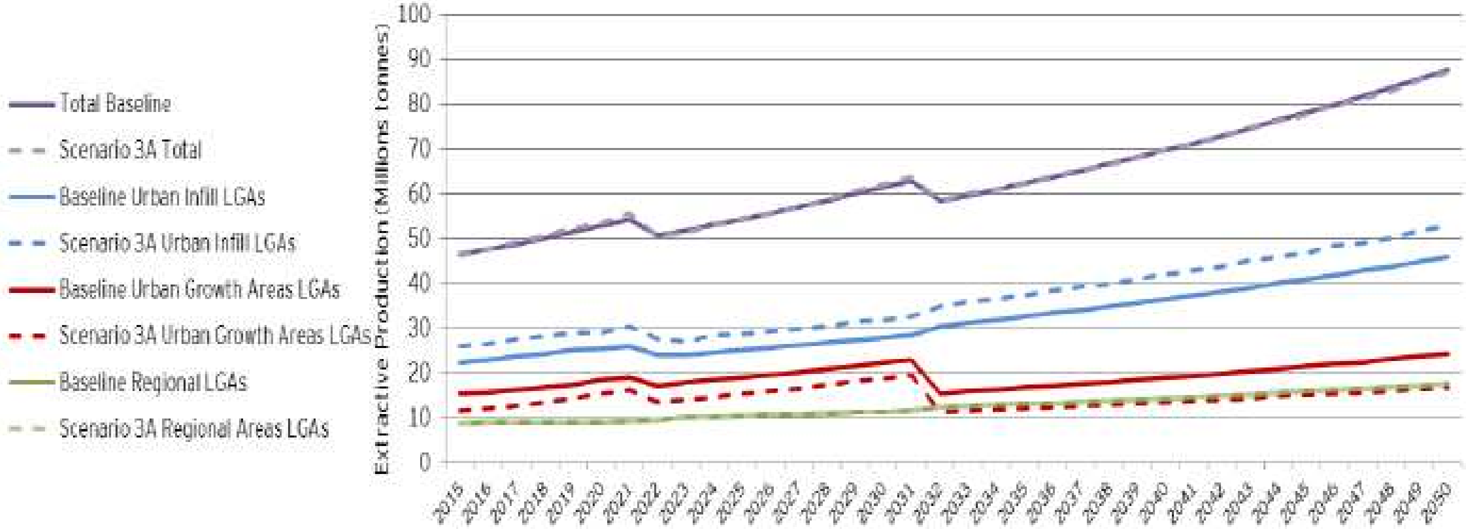
## *3.1.4 Demand scenarios 3A and 3B: Redistribution of demand*

Scenario 3A assesses the impacts of greater infill development relative to the baseline scenario, therefore resulting in a redistribution of the demand for extractive resources towards those LGAs identified as urban infill (refer to Appendix B of the Demand Report presented in Appendix F of this report for a classification of LGAs).

The aggregate level of demand under this scenario is not significantly different to that under the baseline. Within Scenario 3A the demand within LGAs identified as urban growth areas was reduced relative to baseline levels to allow for the redistribution to urban infill LGAs to occur.

The impact of scenario 3A against the Baseline demand forecast is presented in Figure 13 below.

**Figure 13: Total demand for extractive resources 2015 to 2050 - Baseline vs Scenario 3A***

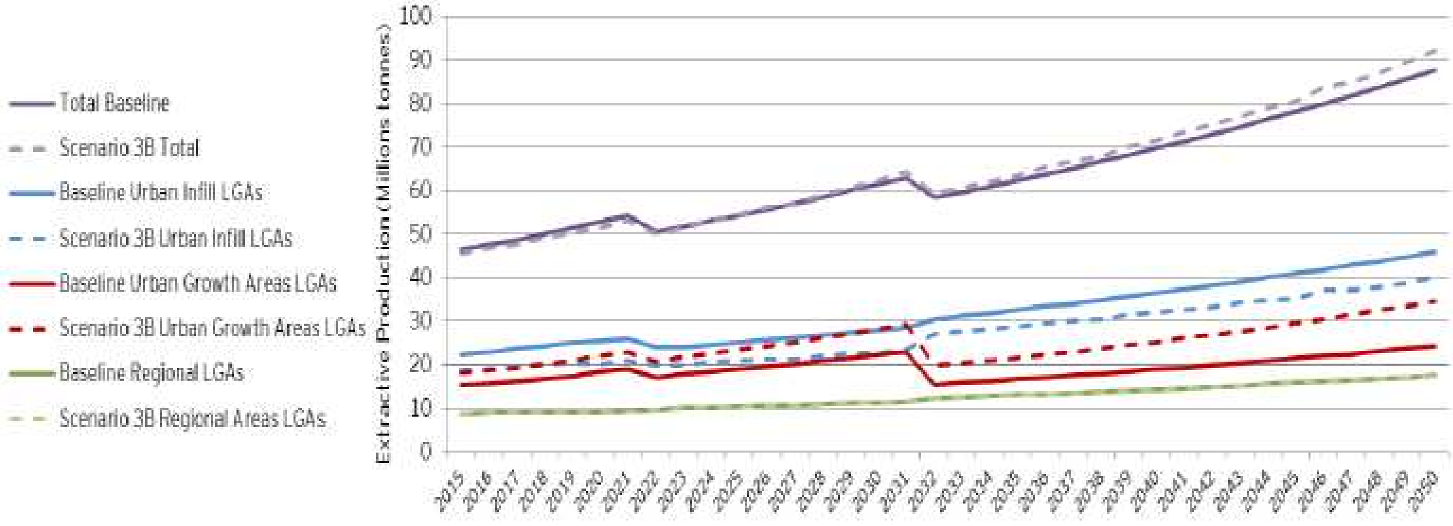



Source: EY, *Demand analysis of extractive resources in Victoria*, 2016. *In the Demand analysis, EY has indicated that steps in the forecast are related to population data and average annual growth rates provided by Government projections used in the forecast approach.

Scenario 3B considers greater development within urban growth areas, which in this case is redistributed from urban infill LGAs.

To allow the redistribution to urban growth areas, this scenario considered an increased residential development in those LGAs, involving an automatic decrease in residential development within urban infill LGAs.

**Figure 14: Total demand for extractive resources 2015 to 2050 - Baseline vs Scenario 3B***




Source: EY, *Demand analysis of extractive resources in Victoria*, 2016. *In the Demand analysis, EY has indicated that steps in the forecast are related to population data and average annual growth rates provided by Government projections used in the forecast approach.

# 4 Integrated demand and supply – high-level findings

The base case supply scenario integrates the set of findings from the detailed supply side data. It examines the extractive industry's future supply outcomes based on core assumptions and the expectations of demand for resources.

The analysis examines the State-wide setting as a first step in integrating the demand and supply profiles of extractive resources across the 2015 to 2025 and 2026 to 2050 time periods. An initial broad-brush State view provides a high level understanding of the industry's state of play, before diving deeper into the locational nuances of the industry, including the importance of where quarries are located (current and planned) and where individual rock types are located.

## 4.1 State-wide findings by rock type

In 2050, there are 11 billion tonnes of extractive resources available in Victoria. This finding illustrates there are broadly sufficient resources contained in current and future planned WAs to satisfy Victorian demand, ignoring locational differences, prices and transport costs within specific sub-regions and locations of Victoria.

These findings are summarised in Table 8, which presents the cumulative demand levels for each considered rock type for the 2015 to 2025 and 2026 to 2050 periods for the baseline scenario, along with demand for select specific years and remaining licensed reserves at 2050.

Industry data gathering undertaken in support of this analysis has identified intentions to license new resources of various sizes and types across the State. The modelling has incorporated expected production volumes and deposit depletion rates from these future WAs where relevant, based on the expected starting year as indicated by the respondent. Variations to existing WAs were modelled in a similar fashion. These different potential sources of future supply are described in Table 7.

**Table 7: Description of different sources of future supply**

| Supply source | Description |
|---|---|
| Current WA | Reserves held in a currently licensed extractive work authority |
| Variation to current WA | Planned future licensed reserves coming from an intended variation to an existing work authority. This represents an extension of the currently licensed mine area of a quarry. |
| WA Application | An application for a new work authority at a location different to the one currently operated by the work authority holder. |

Source: PwC analysis

The mix of supply from these different sources changes through the analysis period. Beginning in 2015, 100 per cent of supply is delivered from currently licensed WAs. However by 2050, numerous planned variations and new quarries begin to produce and these proportions change significantly. At 2050, 44 per cent of supply is estimated to be delivered from currently licensed reserves, with 56 per cent being delivered from applications for new WAs and less than one per cent from variations to existing WAs.

Due to incorporation of these planned future quarries and variations to existing licensed resources, reported remaining licensed reserve amounts may not align with cumulative production levels indicated.[18]

[18] Trachyte and Quartzite licensed reserves are exhausted across the analysis period. Given the relatively small volumes traded of these resources, however, these exhaustions have not been treated as critical within the context of the analysis. Additionally, Marble and Dolerite resources were considered in the supply analysis, though no demand for these resources was estimated between 2015 to 2050.

## Table 8: Demand values and remaining licensed reserves by rock type, Victoria, in tonnes

| Rock type | Demand, 2015 | Demand, 2025 | Cumulative demand, 2015 to 2025 | Remaining years of supply at 2025* | Demand, 2026 | Demand, 2050 | Cumulative demand, 2026 to 2050 | Remaining licensed reserves, 2050** |
|---|---|---|---|---|---|---|---|---|
| Basalt Old | 2,762,422 | 3,423,110 | 34,007,015 | 33 | 3,508,908 | 5,962,839 | 114,374,830 | 88,029,759 |
| Basalt New | 18,158,851 | 21,424,017 | 220,171,127 | 73 | 21,960,756 | 35,676,107 | 692,982,428 | 1,054,135,076 |
| Trachyte | 4,500 | 6,350 | 56,995 | - | 6,458 | 15,565 | 290,306 | - |
| Dolerite | - | - | - | - | - | - | - | 6,000,000 |
| Gneiss | 4,294 | 5,684 | 53,227 | 42 | 5,788 | 10,500 | 204,354 | 378,214 |
| Granite (incl. granodiorite, porphyry, microgranites) | 4,584,308 | 5,466,420 | 56,016,794 | 100+ | 5,601,111 | 9,194,780 | 178,606,934 | 656,516,857 |
| Hornfels | 7,734,762 | 9,139,632 | 94,514,804 | 15 | 9,377,095 | 15,218,366 | 294,822,350 | 36,372,509 |
| Marble | - | - | - | - | - | - | - | - |
| Quartzite | 100,031 | 112,241 | 1,138,314 | 22 | 114,614 | 194,979 | 3,792,388 | - |
| Rhyodacite (incl. dacite, rhyolite) | 2,168,192 | 2,557,255 | 26,404,028 | 71 | 2,620,604 | 4,241,658 | 82,623,494 | 137,344,859 |
| Schist | 91,347 | 147,549 | 1,246,132 | 24 | 149,880 | 339,068 | 6,385,065 | 587,468 |
| Scoria | 21,927 | 25,962 | 261,086 | 100+ | 26,533 | 46,402 | 898,882 | 280,605,955 |
| Sedimentary (usually rippable rocks incl. sandstone, shale, siltstone chert, mudstone, claystone) | 82,401 | 103,388 | 1,024,421 | 100+ | 105,819 | 190,332 | 3,647,944 | 57,353,763 |
| Slate | 1,011 | 1,203 | 11,933 | 100+ | 1,226 | 2,078 | 40,710 | 1,142,984 |
| Tuff | 2,833 | 3,783 | 35,100 | 100+ | 3,849 | 8,413 | 159,151 | 8,855,252 |
| Clay and Clay Shale | 1,876,096 | 1,969,958 | 21,909,738 | 11 | 2,012,857 | 2,480,649 | 53,564,147 | 5,915,695 |
| Limestone (incl. limesand) | 2,788,886 | 3,649,145 | 35,184,823 | 30 | 3,749,497 | 7,190,133 | 132,304,170 | 57,361,873 |
| Sand and Gravel (naturally occurring gravels, not crushed sedimentary rocks) | 14,959,208 | 15,707,629 | 174,699,141 | 100+ | 16,049,685 | 19,779,666 | 427,098,236 | 9,016,088,024 |

Source: EY, Demand analysis of extractive resources in Victoria, 2016, PwC analysis.
* Based on 2025 demand level.
**Based on output from existing and planned quarries indicated at 2015.
*** Due to incorporation of reserves held in indicated variations to existing WAs and planned future quarries and licensed resources, reported remaining licensed reserve amounts may not align with cumulative production levels indicated

The findings presented in Table 8 suggest that Victoria has close to sufficient resources held within current and planned future WAs to meet its extractive resource needs to 2050, noting potential constraints in licensing new reserves. Constraints also exist on maintaining or increasing production at some existing quarries, however it is noted that significant productive flexibility has been exhibited in recent years in Victoria where the aggregate level of extractives production has varied considerably year on year.

Other constraints that could limit the State's ability to meet future demand include:

- limited substitutability of resources for some product types, meaning some products may be less easily produced in the future
- varying quality of resource from different quarries, which suggests that different constraints could emerge for some products that require a higher-grade resource
- future economic viability of individual quarries.

Despite the findings presented above, a key component of the analysis relates to understanding how transport distances and associated costs drive market outcomes for regions and locations within the State.

Due to the low value-to-weight ratio of extractive resources, transport costs can quickly overwhelm resource values when trucking distances grow too large. This means that it is generally inefficient to transport extractive resources across long distances and users will instead seek more proximate sources or in some cases substitute resources. Survey data collected from industry as part of the study supports this finding.

These market realities have important implications for this analysis, which has necessarily considered transport distances and costs in assessing how demand is met across Victoria's geography. To reflect the importance of these realities, the study has applied several criteria to determine which resource locations are critical to the State's future; these are considered in detail in Chapter 5

Several demand locations are also identified on the basis that they are likely to experience potentially limited supply in the future. These are discussed below.

## 4.2 Demand locations facing potentially limited supply

Analysing the demand and supply for extractive resources on a location-by-location basis within Victoria reveals that numerous Victorian regions could face limited supply of some materials within the period 2015 to 2050. This emerges due to exhaustion of current and planned future reserves based on the projected level of resource demand and industry intentions as indicated at 2015.

***34 per cent of demand for extractives in 2050 will need to be sourced from different quarries to the ones currently indicated for use by the industry (including expansion of current quarries and planned future quarries), due to resource exhaustion***

The following locations are identified as having levels of resource supply materially lower than demand. The results are presented across all rock types considering supply levels from each individual WA across Victoria to the region identified.

A ***potential supply shortfall*** represents the difference between the volume of extractive resources a location demands and the supply it receives, for a given rock type in a given year.

Demand locations can receive supply from WAs in any LGA based on proximity, the rock type available and production. As such, the shortfall does not represent the difference between demand and supply in a single LGA but rather the difference between its demand and the amount of supply coming from all potential supply locations in the State. Potential shortfalls emerge where known current and planned future licensed reserves are insufficient to meet cumulative demand.

The regions are identified from the standpoint of demand ('the buyer' of the resource). These regions can therefore expect to face cost increases if new resource deposits are not licensed in relative proximity. These cost increases would arise as a result of increased transport costs, with potential flow-on impacts to resource prices.

### *4.2.1 Potential alternative sources of material*

*Licensing of new reserves*

It is expected that some redistribution of supply, including licensing of new deposits, would likely emerge to satisfy these potential supply shortfalls. This would depend on the availability of alternative deposits that are not presently managed within current or planned WAs and on the ability of current WA holders to increase their supply levels.

This study is aware of constraints to both of these responses. With respect to additional resource deposits, licences to develop new resource locations are subject to lengthy approvals processes and may not be granted where there are competing uses of the land. With respect to increases in production within current WAs, many WA work plans place limits on the production rates that can be achieved. WAs may also be otherwise capacity constrained due to technology, land confinements or other factors.

*Substitute resources*

Some substitutability of resource types was noted in the industry data gathering undertaken to support this analysis. As such, the identified potential supply shortfalls could also be met to some degree by substituting to different resources that are more readily available in a region. Notably, the demand for road base materials, for example, is based on technical specifications and resource substitutes can be dependent on the availability of rock types in a given location. The inputs used for concrete can also be substituted in some cases. The quality requirement for a mix may include durability, hardness, and friction rating, which can be met by a range of hard rock types such as basalt and hornfels.

PwC understands that recycled materials can also be substituted for extractive resources in some cases. For instance, recycled crushed brick has been initially recommended for incorporation as a supplementary material in cement treated crushed concrete pavement sub-base applications.[19] Stakeholder consultation indicated however that in many uses of extractive resources, substitution to recycled products was not possible due to the composition and/or quality of such products relative to new extractive resources.

*Imports from other States*

Imports of material from neighbouring States could also assist in meeting some of Victoria's extractives demand. To the extent this occurs it could help to alleviate the identified potential supply shortfalls.

In light of the above complexities, the extent to which the identified potential supply shortfalls could be met by material from other sources is unclear. As such the potential

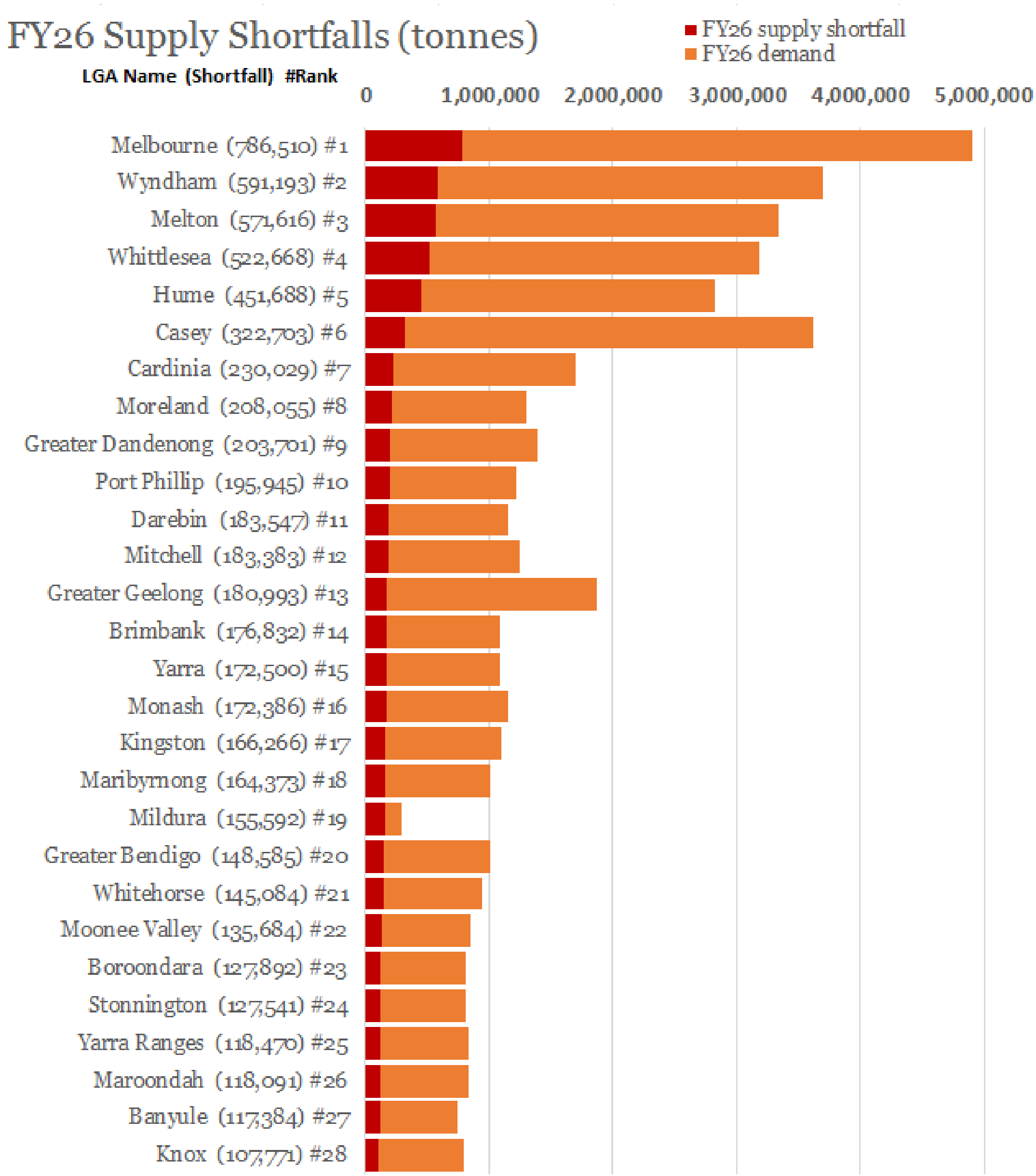
[19] Swinburne University of Technology Centre for Sustainable Infrastructure, Crushed Brick as a Supplementary Material in Cement Treated Crushed Concrete Pavement Applications, 2013.

shortfalls are reported here to provide an indication of where the impacts of supply constraints would be greatest.

### *4.2.2 Identified potential supply shortfalls in 2026*

Figure 15 identifies those Victorian LGAs with material potential supply shortfalls in 2026. A threshold of 100,000 tonne shortfall is applied in identifying these locations.

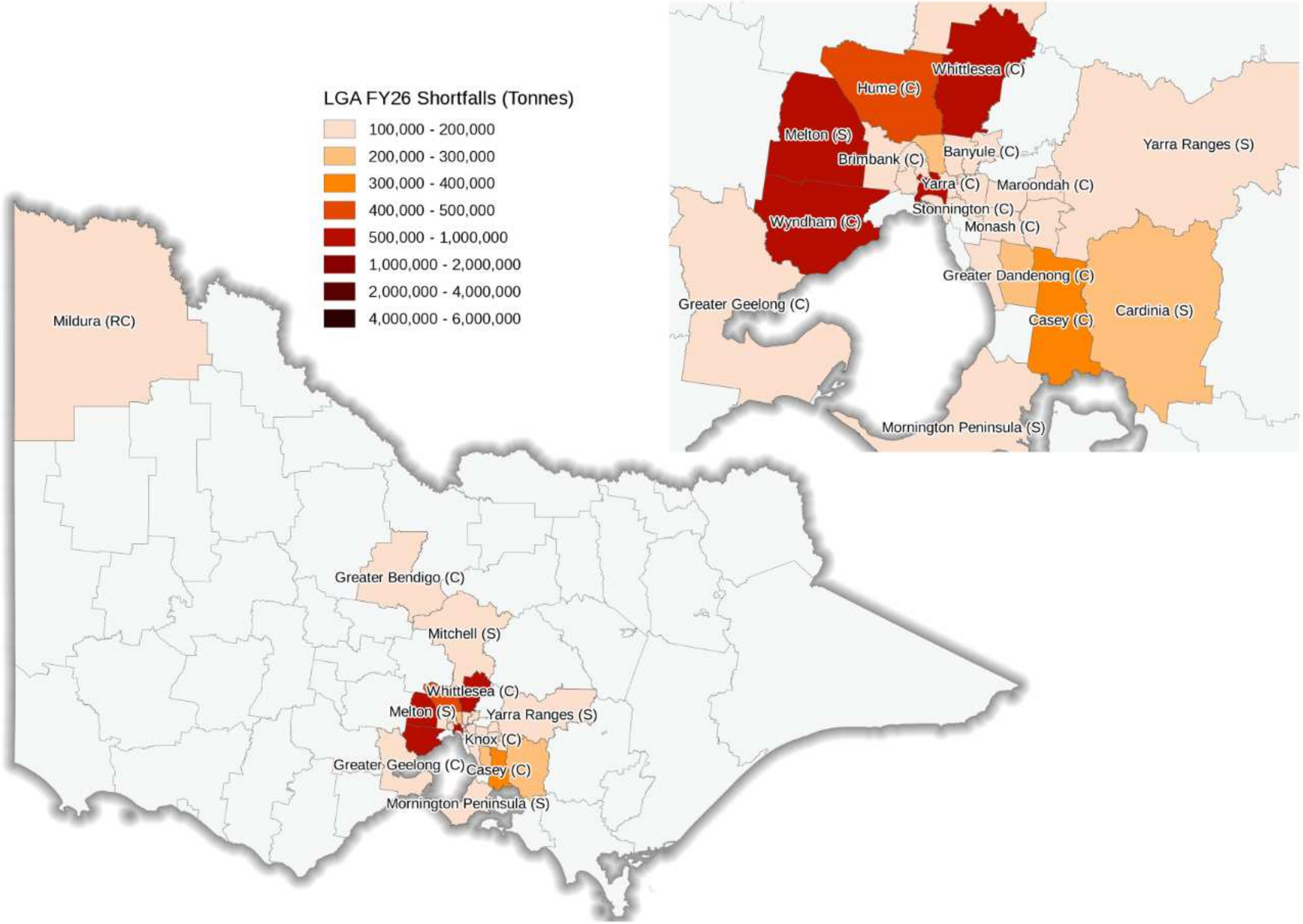
**Figure 15: Identified potential supply shortfalls by location, 2026**




Source: PwC analysis

Figure 16 below provides a graphical representation of these shortfalls by LGA.

**Figure 16: Locations demonstrating potential supply shortfalls in 2026**

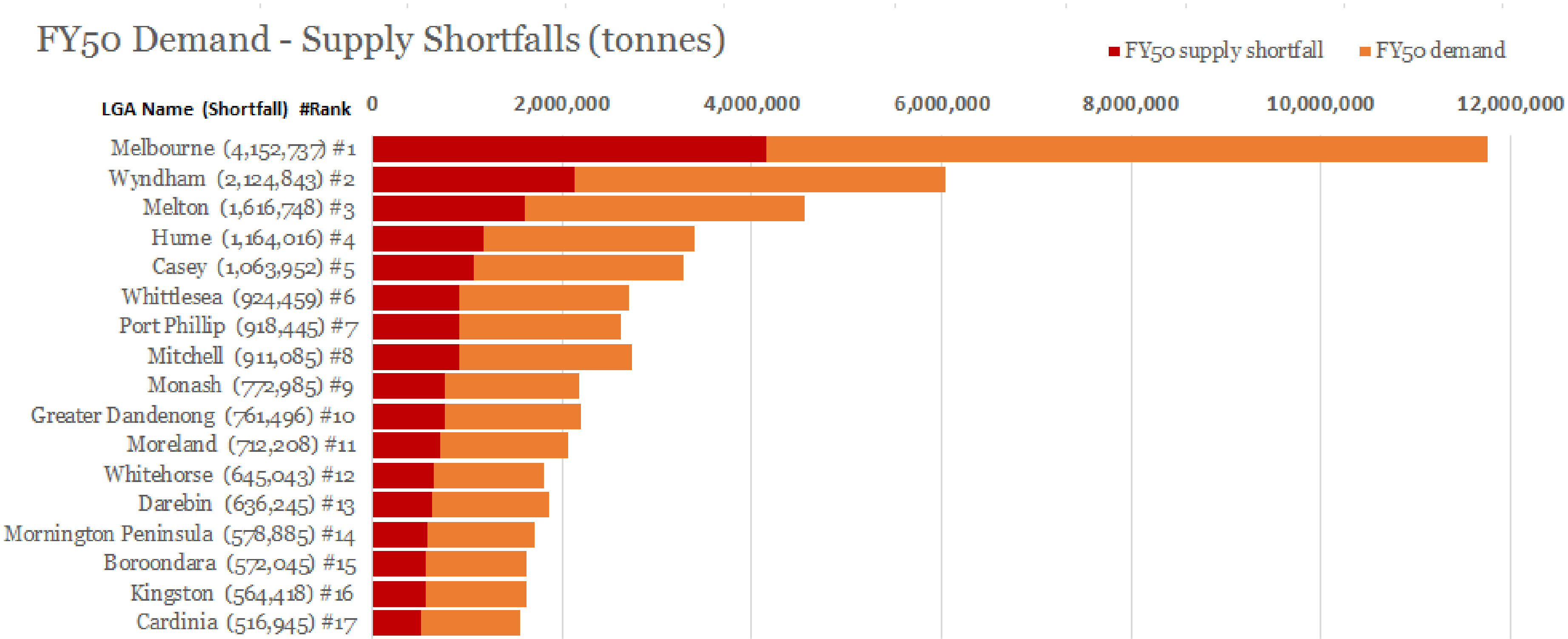



Source: PwC analysis

### *4.2.3 Identified potential supply shortfalls in 2050*

Figure 17 identifies those Victorian LGAs with material potential supply shortfalls in 2050. A threshold of 700,000 tonne shortfall is applied in identifying these locations.

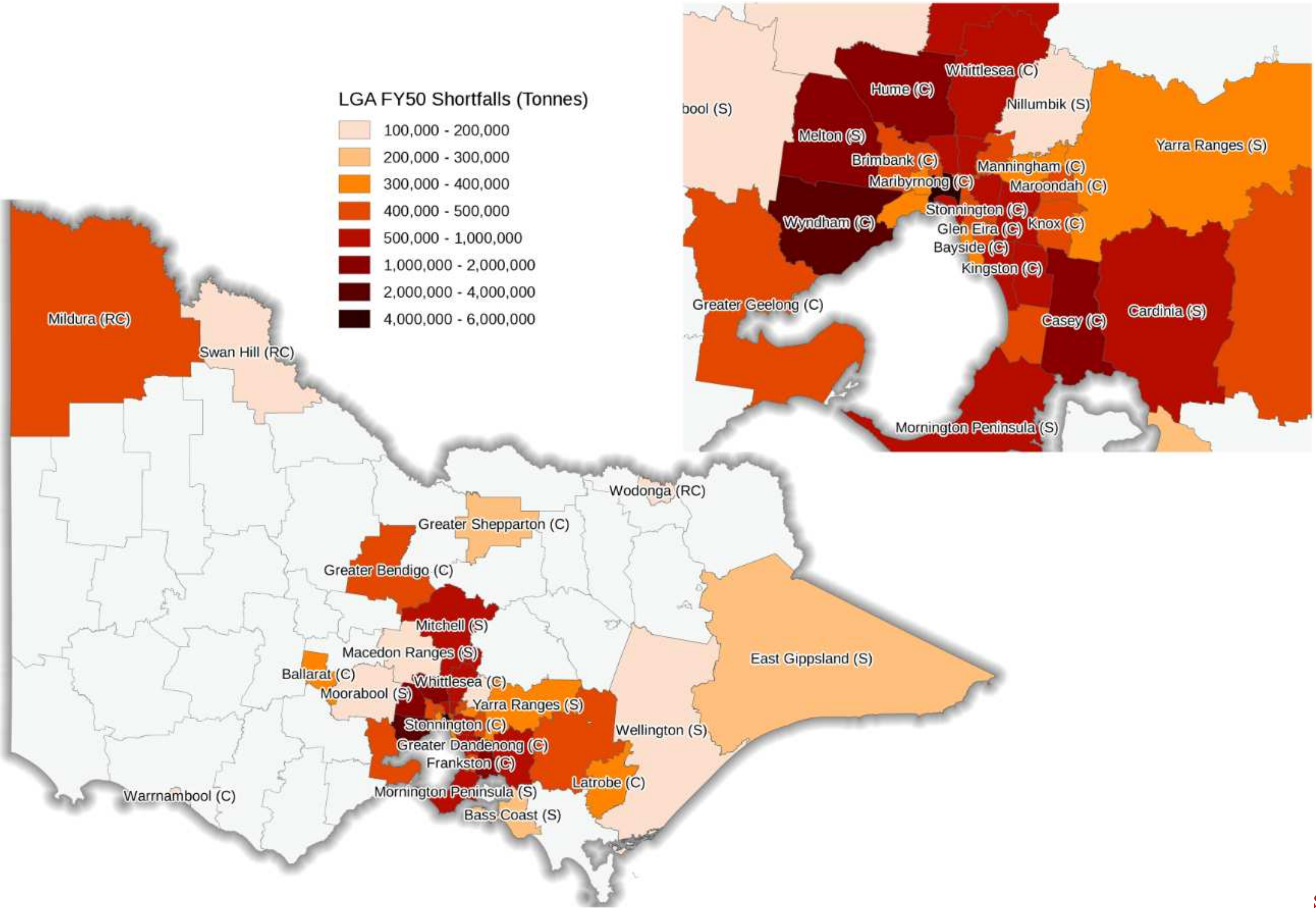
**Figure 17: Identified potential supply shortfalls by location, 2050**




Source: PwC analysis

Figure 18 below provides a graphical representation of these shortfalls. Comparing Figure 16 against Figure 18 demonstrates the progression of shortfalls through time between 2026 and 2050.

**Figure 18: Locations demonstrating potential supply shortfalls in 2050**



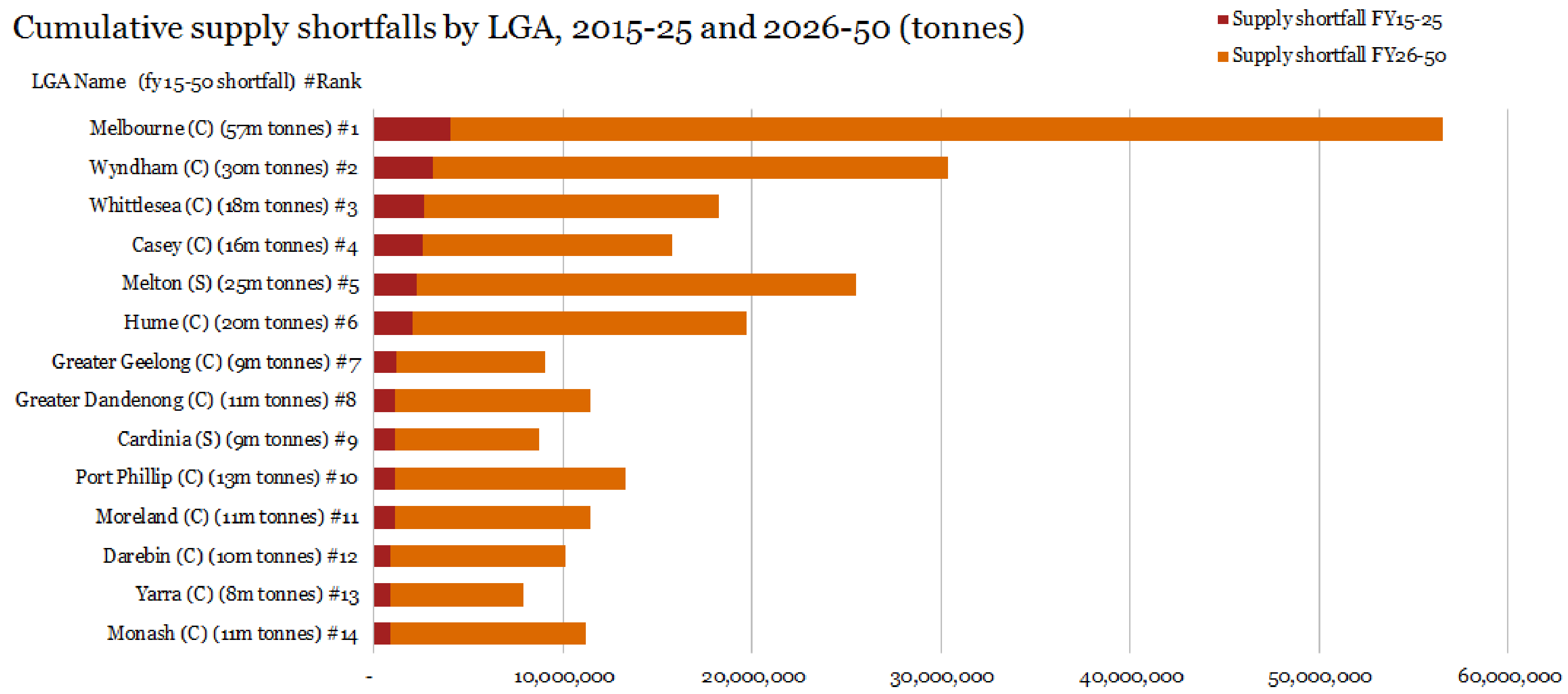

Source: PwC analysis

### *4.2.4 Cumulative potential shortfalls*

These shortfalls can similarly be computed in a cumulative sense to gain a better understanding of the total shortfalls that emerge across the analysis period.

Figure 19 provides a breakdown by location of these shortfalls, ranked by the level of the shortfall identified over the 2015 to 2025 period. Both the 2015 to 2025 and 2026 to 2050 shortages are presented in the chart, illustrating the significant level of unmet demand that it expected to emerge in the latter part of the analysis period.

**Figure 19: Locations with the largest potential cumulative supply shortfalls**




Source: PwC analysis

The above analysis demonstrates that significant potential shortfalls and associated price pressures could emerge towards the end of the analysis period if new reserves are not licensed in proximity to strong demand sites.

In 2026, among the regions identified in Figure 19, the average potential supply shortfall as a proportion of demand is approximately 13 per cent. By 2050, this proportion has grown to close to 30 per cent of demand. This means that close to 30 per cent of demand for extractive resources in these regions will need to come from new quarries by 2050. Across all Victorian LGAs, this proportion is closer to 35 per cent.

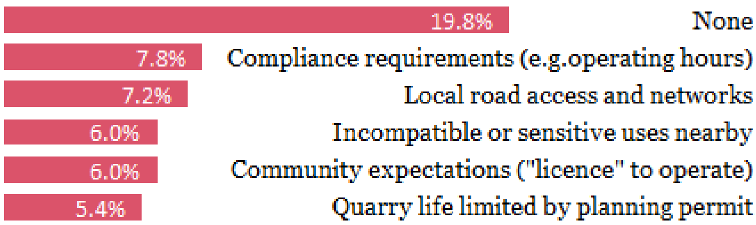
## 4.3 Other industry insights

Through industry data gathering undertaken in support of this study, WA holders were asked to identify key issues affecting their current operations and future plans.

### 4.3.1 Consolidated findings

With respect to production from current WAs, compliance requirements and road access were identified as key issues. However, one in five respondents indicated that no issues were limiting production from their quarry. Figure 20 provides a summary of the survey responses with respect to issues affecting current operations.

**Figure 20: Issues limiting production in current WAs***

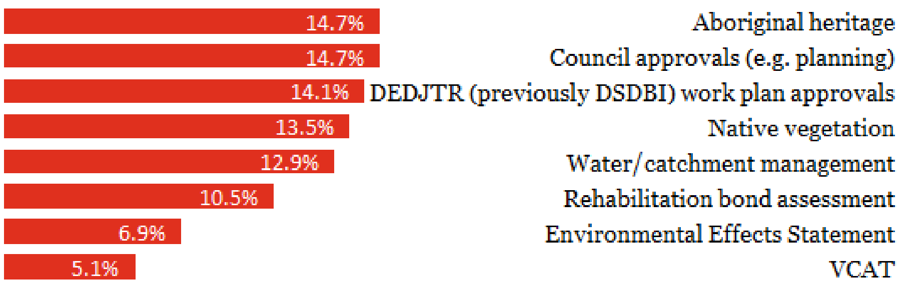



Source: PwC analysis. *Percentages illustrate proportion of respondents who indicated the issue affected them, hence numbers will not sum to 100 per cent.

Comments from stakeholders in the preliminary stages of the study suggested that licensing new resource reserves and varying the conditions of existing WAs could be subject to lengthy approvals processes. To seek industry views on these findings, survey respondents were asked to identify issues that could affect expansion of their current WA in the future.

The biggest issues limiting quarry expansion were identified as aboriginal heritage and approvals processes within both Local and State Government. Native vegetation and water/catchment management were also potential issues for many respondents. Figure 21 provides a summary of the survey responses in respect of issues affecting quarry expansion.

**Figure 21: Issues limiting expansion of current WAs**




Source: PwC analysis. *Percentages illustrate proportion of respondents who indicated the issue affected them, hence numbers will not sum to 100 per cent.

### 4.3.2 *Key issues by respondent type*

As discussed in Section 2.3, the supply data gathering was conducted in three parts: an online survey, paper surveys, and interviews with industry stakeholders. Interviews were completed with 27 respondents identified as producing large volumes of material in 2013-14, while the remaining WA holders were surveyed through an online platform and a paper version of the survey.

This approach provides for comparison of key issues by respondent type, as the results can be subset into responses from larger producers and responses from smaller producers.

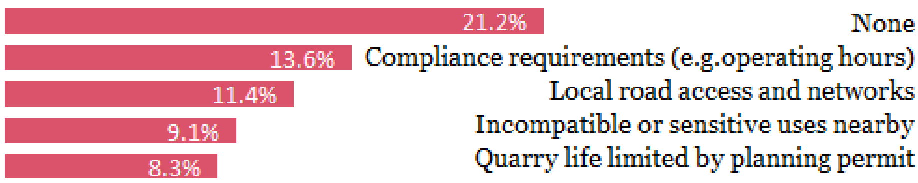
The issues identified in the industry data gathering are largely consistent across both larger and smaller producers. While some small differences exist, these would potentially disappear were a larger sample size to be considered. The key issues for each group are presented below.

*Larger producers*

As discussed above, interviews were conducted with larger industry producers instead of web or paper surveys. Larger producers were defined as those companies ranking in the top-30 of Victorian extractive industry operators, based on their 2013-14 production levels using DEDJTR records.

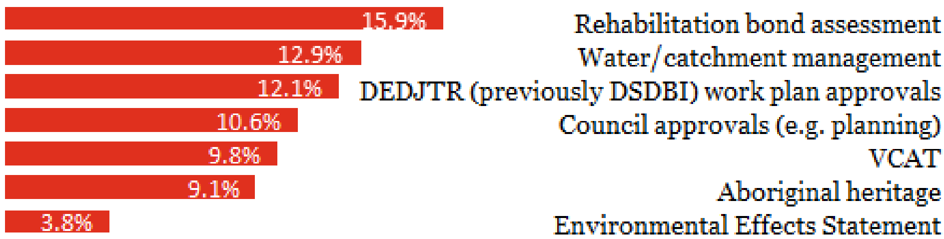
Figure 22 and Figure 23 provide summaries of the interview responses with respect to issues affecting operations of larger producers.

**Figure 22: Larger producers - Issues limiting production in current WAs***




Source: PwC analysis. *Percentages illustrate proportion of respondents who indicated the issue affected them, hence numbers will not sum to 100 per cent.

**Figure 23: Larger producers - Issues limiting expansion of current WAs***




Source: PwC analysis. *Percentages illustrate proportion of respondents who indicated the issue affected them, hence numbers will not sum to 100 per cent.

Among the larger producers, the key issues limiting production from current WAs were the same as those identified when considering all respondents: compliance requirements (13.6 per cent of respondents), local road access (11.4 per cent) and incompatible or sensitive uses nearby (9.1 per cent). 21.2 per cent of respondents indicated no issues affected them.

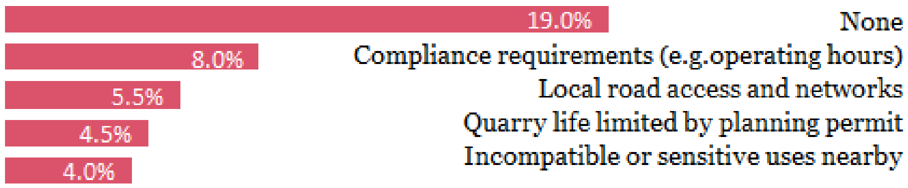
Considering future plans, the largest issue for larger producers was rehabilitation bond assessment (15.9 per cent of respondents) followed by water/catchment management (12.9 per cent) and DEDJTR work plan approvals (12.1 per cent).

*Smaller producers*

Smaller producers were identified as those survey respondents that were not ranked in the top-30 of Victorian extractives industry by 2013-14 production.

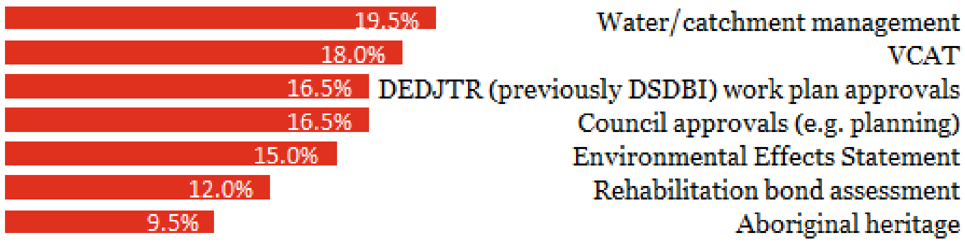
Figure 24 and Figure 25 provide summaries of the survey responses with respect to issues affecting operations of smaller producers.

**Figure 24: Smaller producers - Issues limiting production in current WAs***




Source: PwC analysis. *Percentages illustrate proportion of respondents who indicated the issue affected them, hence numbers will not sum to 100 per cent.

**Figure 25: Smaller producers - Issues limiting expansion of current WAs***




Source: PwC analysis. *Percentages illustrate proportion of respondents who indicated the issue affected them, hence numbers will not sum to 100 per cent.

Among the smaller producers, 19.0 per cent indicated no issues were currently limiting production from their quarries. 8.0 per cent indicated compliance requirements were an issue and 5.5 per cent suggested local road access and networks affected their production.

Looking at future plans of these smaller producers, 19.5 per cent of respondents suggested that water/catchment management was an issue, with VCAT at 18.0 per cent followed by DEDJTR and Council approvals at 16.5 per cent each.

# 5 Strategic Resource Determination

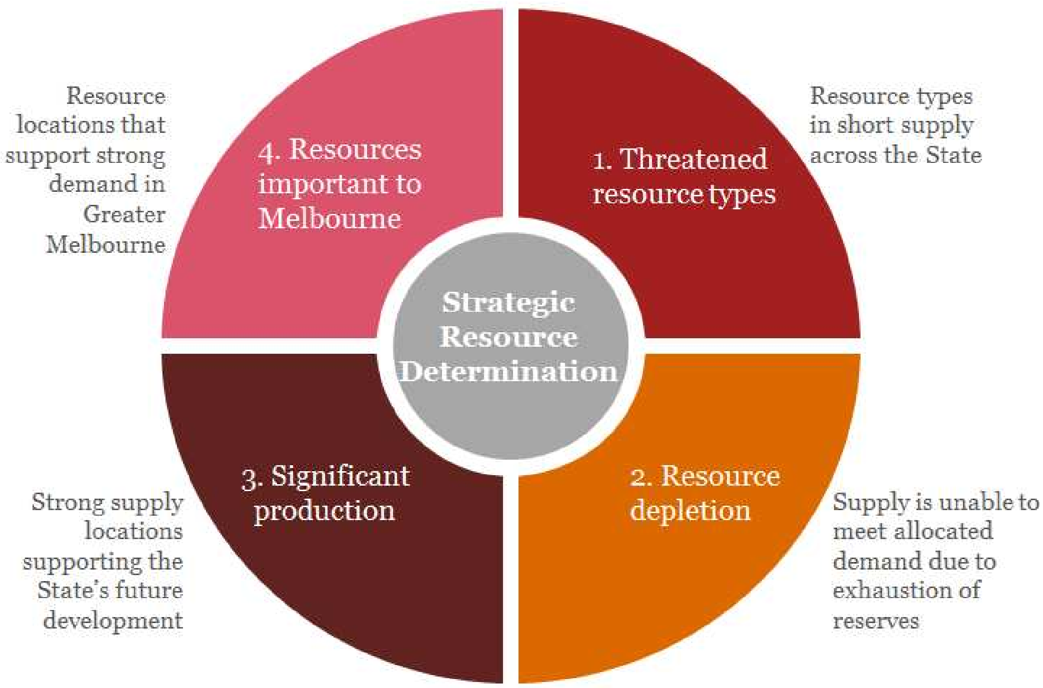
## 5.1 Overview

In consultation with DEDJTR and the Taskforce, PwC has developed a set of Strategic Resource Determination (SRD) criteria that have been applied in the analysis. These criteria provide for identification of particular extractive resources and extractive resource interest areas that may warrant increased policy focus in the future. The criteria were agreed with DEDJTR and the Taskforce prior to the collection and analysis of industry data.

Supported by the granularity of the analysis, these criteria are applied at the individual work authority and locality level throughout the State and across the analysis period. This assessment provides a detailed understanding of the particular locations and resources that could be critical to the State's development.

An overview of the SRD criteria is provided in Figure 26. Each criterion is described further below.

**Figure 26: Overview of the Strategic Resource Determination criteria**




Source: PwC

1 **Threatened resource types:** identifies particular extractive resources that are in relatively short supply in the State relative to the level of projected demand. Identification of known locations of these resources has also been undertaken, where possible. This criterion has regard to the potential substitutability of resources in considering which particular extractive resources could be subject to strong price pressures in the future.

2 **Resource depletion - Locations where supply is unable to meet demand due to exhaustion of reserves:** identifies locations in Victoria where supply is unable to match demand due to significant exhaustion of existing licensed reserves across the analysis period. This criterion points to locations where licensing of new resources will be required to replace exhausted assets, with potential implications for policies governing land use.

3 **Significant production - Locations that produce significant volumes of extractive resources:** identifies those locations that deliver large volumes of extractive resources across the analysis period. This criterion points to the Victorian locations which could be considered for protection of existing resources to support the State's development.

4 **Resources important to Melbourne - Locations critical to supporting Greater Melbourne's future:** identifies those locations that are expected to deliver significant volumes of resource to Greater Melbourne across the analysis period. This criterion will identify those locations that could result in significant infrastructure cost increases in Melbourne should encroachment or sterilisation of extractive resources occur.

Measures have been developed for each criterion and are detailed in Appendix D.

## *5.2 Respondent confidentiality*

Although the analysis has been conducted at a granular level, several aggregation triggers have been applied in the supply analysis to protect the confidentiality of survey respondents and ensure that information revealed in this report cannot be attributed to particular companies or individuals. These triggers were implemented across both the SRD criteria and the broader reporting of results.

The approach used to preserve confidentiality was developed by PwC in consultation with DEDJTR and the Taskforce. PwC's application of the triggers was subsequently vetted and approved by both DEDJTR and the Taskforce prior to the study's reports being produced.

More detail on the approach to respondent confidentiality is provided in Appendix A.

## 5.3 Strategic resource determination – Consolidated view

Resource locations that are identified only within a single SRD criterion are potentially less critical than resource locations identified across two or more SRD criteria. As such, the analysis detailed in this section takes a consolidated view across the SRD criteria to assess those resource locations deemed to be the most critical to Victoria's development.

***Strategic resource locations*** are those areas that are identified across two or more strategic resource criteria AND contribute a relatively significant proportion of the State's supply for a resource or multiple resources.

The consolidated view across SRD criteria shows those resource locations that are the best candidates for:

- protection of existing resources in the area
- ensuring policy mechanisms provide for licensing of new resources in the area.

Resource locations identified through the consolidated view are then ranked according to their proportionate contribution to the State's future extractives needs. Table 9 provides a summary of this analysis.

***Interpreting the results***

*Strategic resource areas illustrated by Victorian LGAs are listed in Table 9. The columns representing each SRD criterion contain letters denoting the rock types considered in the analysis. These are defined by:*

*H denotes Hard rock (and Ho denotes a sub category of hard rock, hornfels)*

*S denotes Sand and gravel*

*L denotes Limestone*

*C denotes Clay and clay shale*

*An LGA will be given a letter for each criterion it has been identified under. For instance, South Gippsland has the letters H and S under criterion 1, denoting that the region was identified under criterion 1 for both hard rock and for sand and gravel. Under criterion 2, South Gippsland was identified on the basis of exhausted sand and gravel resources, hence the letter S is listed under that criterion.*

Resource locations identified in two or more SRD criteria were selected as potentially critical to the State's future. These locations were then ranked based on an index of relative importance to Victoria's future supply of extractives material across the four resource categories considered, and the top 15 locations were selected as critical. These are presented below in Table 9. Those locations ranking 16th through 20th are also shown to provide context, though these are not considered as critical for the purposes of the analysis.

**Table 9: Strategic Resource Determination - Consolidated view**

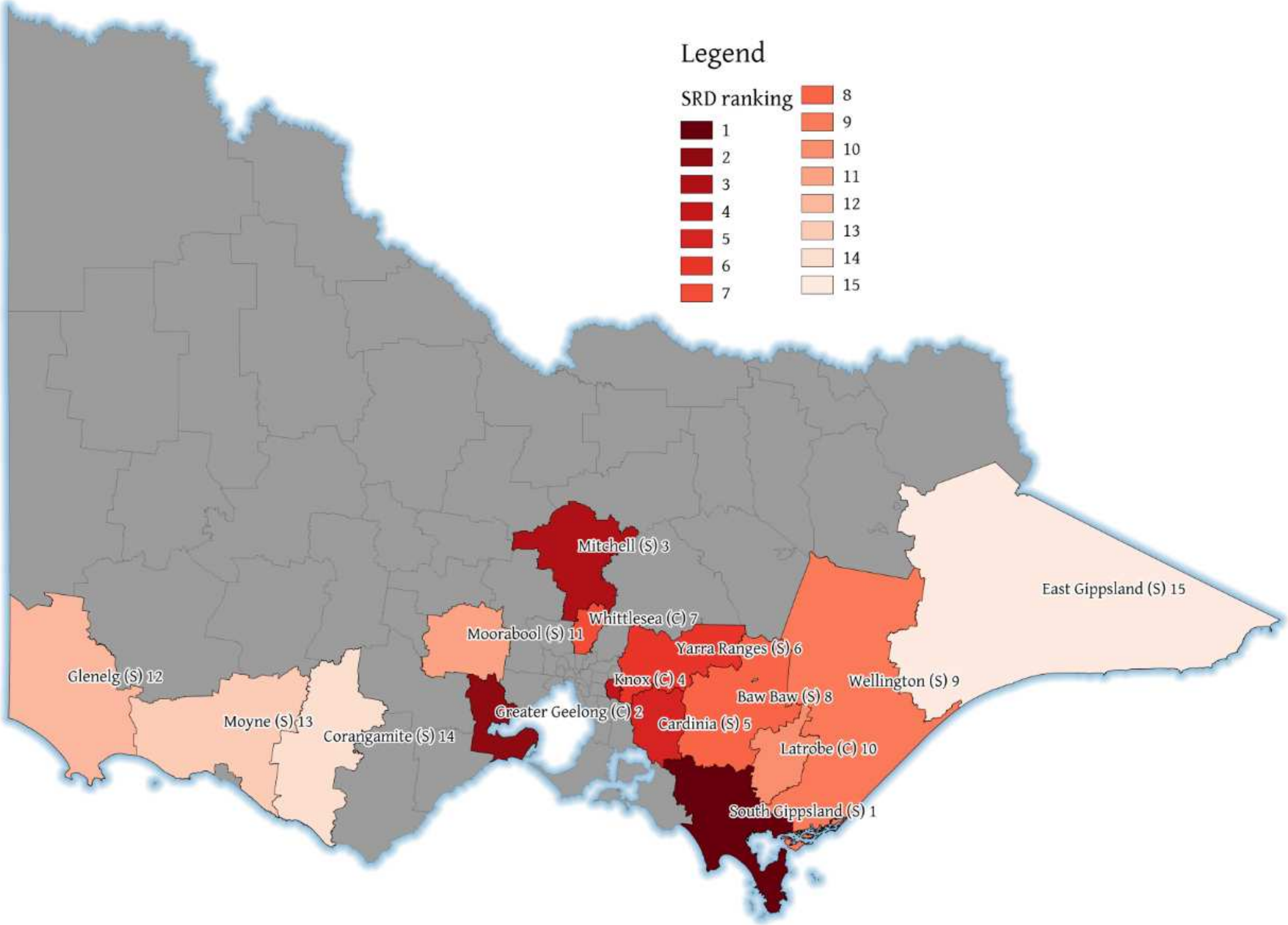
| Rank | LGA | Criterion 1: Threatened resource types | Criterion 2: Resource depletion | Criterion 3: Significant production | Criterion 4: Supports Greater Melbourne | Critical location? | Critical resource(s) |
|---|---|---|---|---|---|---|---|
| 1 | South Gippsland (S) | | S | H S | H S | Yes | Hard rock, sand and gravel |
| 2 | Greater Geelong (C) | | | H S L | H S L | Yes | Hard rock, sand and gravel, limestone |
| 3 | Mitchell (S) | C | L C | H S C | H S C | Yes | Hard rock, sand and gravel, clay |
| 4 | Knox (C) | Ho C | H L C | H C | H C | Yes | Hard rock, clay |
| 5 | Cardinia (S) | | H | H S | H S | Yes | Hard rock, sand and gravel |
| 6 | Yarra Ranges (S) | C | H L C | H L C | H L C | Yes | Hard rock, sand and gravel, clay |
| 7 | Whittlesea (C) | Ho C | H L C | H C | H C | Yes | Hard rock, clay |
| 8 | Baw Baw (S) | Ho | | H S | H S | Yes | Hard rock, sand and gravel |
| 9 | Wellington (S) | C | L C | S L C | S L C | Yes | Sand and gravel, limestone, clay |
| 10 | Latrobe (C) | C | H L C | C | C | Yes | Clay |
| 11 | Moorabool (S) | C | S L C | S C | H S C | Yes | Sand and gravel, clay |
| 12 | Glenelg (S) | | | L | L | Yes | Limestone |
| 13 | Moyne (S) | | | H L | L | Yes | Limestone |
| 14 | Corangamite (S) | | | L | L | Yes | Limestone |
| 15 | East Gippsland (S) | | S | L | L | Yes | Limestone |
| 16 | Mornington Peninsula (S) | C | H S L C | H S C | H S C | No | Hard rock, sand and gravel, clay |
| 17 | Golden Plains (S) | C | S L C | C | C | No | Clay |
| 18 | Northern Grampians (S) | Ho C | S L C | H S C | H S C | No | Hard rock, sand and gravel, clay |
| 19 | Bass Coast (S) | | H S | H S | H S | No | Hard rock, sand and gravel |
| 20 | Wyndham (C) | | H | H | H | No | Hard rock |

Source: PwC analysis. H = Hard rock, S = Sand and gravel, L = Limestone, C = Clay and clay shale, Ho = Hornfels, a sub-category of the Hard rock resource grouping.

Based on the findings detailed in Table 9, several resource locations are identified as the most critical to the State's future.

Figure 27 provides a map of the 15 critical resource locations, showing the concentration of these areas in relative proximity to Melbourne. The top-ranked critical resource locations are represented by darker shades of red in the figure relative to the lower-ranked locations. The bracketed number after each location's name shows its ranking as a critical resource location.

**Figure 27: Critical strategic resource locations - Consolidated view**




Source: PwC analysis

### 5.3.1 Top five critical resource locations, in detail

The top five critical resource locations are:

**1 South Gippsland**

South Gippsland emerges as a critical location for hard rock and sand and gravel resources in Victoria, supplying approximately 33 per cent of the State's hard rock needs and 22 per cent of its sand and gravel needs across the analysis period of 2015 to 2050. South Gippsland's relative proximity to key sources of demand drives this assessment.

While some exhaustion of sand and gravel reserves is anticipated as noted under Criterion 2, South Gippsland has sufficient indicated current and planned future hard rock reserves to support large volumes of resource production across 2015 to 2050. This makes South Gippsland a critical location to support the State's future development.

*Key demand destinations for South Gippsland's resources*

Demand for South Gippsland's resources comes largely from Greater Melbourne: In 2050, 80 per cent of South Gippsland's supply is estimated to be demanded by the city, which is driven largely by residential and commercial construction demand. The remaining 20 per cent comes in part from regional cities such as Greater Geelong and Ballarat (which are both areas where wind farm demand is present in some years) and from other areas close to Melbourne's fringe such as Mitchell and Macedon Ranges.

**2 Greater Geelong**

Whilst Greater Geelong is a noted location for hard rock and sand and gravel, its contribution to limestone production is most significant. The region is expected to deliver approximately 43 per cent of Victoria's supply of limestone across 2015-50, in large part due to its relative proximity to Greater Melbourne. It is noted that limestone is a key input into concrete production, meaning this resource is important to all construction methods employing concrete products.

*Key demand destinations for Greater Geelong's resources*

Like South Gippsland, demand for Greater Geelong's extractive resources is largely urban-driven, with approximately 76 per cent of 2050 supply going to locations within Metropolitan Melbourne. Much of this goes to Melbourne LGA (15 per cent) though significant volumes are also provided to the growth regions of Wyndham (seven per cent), Melton (five per cent) and Hume (four per cent). These growth areas are noted for significant engineering construction demand. Greater Geelong additionally satisfies a lot of its own demand, with 7 per cent of 2050 supply staying within the LGA.

**3 Mitchell**

Mitchell's primary contribution to the State's 2015 to 2050 extractive resource supply is in clay and clay shale, of which it supplies a relatively large share of total State supply. The LGA also possesses sizeable hard rock reserves along with some sand and gravel, which make Mitchell a key resource location for Victoria.

*Key demand destinations for Mitchell's resources*

Mitchell's location in Central Victoria means that it is able to deliver resources to more regional locations in the State's North. While the majority is provided to urban locations in Metropolitan Melbourne (at 69 per cent of 2050 supply), Mitchell is a strong supplier into the regional cities of Greater Bendigo (four per cent), Greater Geelong (three per cent) and Greater Shepparton (three per cent). While the majority of Mitchell's resources are estimated to satisfy residential and commercial construction demand, these regional cities demand relatively large volumes of material in relation to engineering construction. Mitchell also satisfies some of its own demand, with seven per cent of 2050 supply staying within Mitchell.

**4 Knox**

Knox is expected to deliver significant volumes both of hard rock resources and of clay and clay shale. Further to this, some exhaustion of current and planned future licensed reserves of these resources is anticipated in Knox. In combination this suggests that Knox is a good candidate location both for protection of existing licensed reserves and for development of new deposits in the future.

*Key demand destinations for resources from Knox*

Given Knox is itself an urban location, it is very well positioned to satisfy urban demand. This is reflected in the mix of destinations to which Knox supplies in the analysis, with 91 per cent of supply remaining within Metropolitan Melbourne in 2050. The majority of this demand (approximately 80 per cent) relates to residential and commercial construction. The remaining nine per cent of Knox's 2050 supply is divided among regional LGAs throughout the State.

**5 Cardinia**

Cardinia holds significant volumes of current and planned future licensed sand and gravel reserves. It is well positioned close to Melbourne meaning it can supply these resources at competitive costs to sites of strong demand in the city. Some hard rock resources are also present, meaning Cardinia has strong productive potential to support Victoria's future development.

*Key demand destinations for Cardinia's resources*

Like Knox, Cardinia lies within the Metropolitan Melbourne boundary and hence it is also well suited to meeting demand from the city. 85 per cent of 2050 supply from Cardinia is provided to locations around urban Melbourne, again satisfying in large part demand for residential and commercial construction. In terms of rural demand destinations, two per cent of Cardinia's 2050 supply goes to each of Baw Baw and Mitchell and one per cent to each of Latrobe and Bass Coast, with other rural locations also featuring. Regional cities of Greater Geelong and Greater Bendigo also receive some supply from Cardinia in 2050.

### 5.3.2 South-West Victoria

The agglomeration of three LGAs (Glenelg, Moyne and Corangamite) in the South West of Victoria comprises a significant limestone-producing region. This area delivers significant volumes of limestone both to Greater Melbourne and to regional locations in Victoria across the analysis period.

Compared to the top five locations discussed above which serve predominantly urban demand locations, this region supplies the majority of its material to regional areas. Large volumes of this area's supply in 2050 go to regional cities such as Ballarat (16 per cent), Greater Geelong (14 per cent) and Warrnambool (10 per cent). Other regional destinations include Glenelg (six per cent of 2050 supply), Surf Coast (four per cent) and Southern Grampians (three per cent). In sum, urban locations receive 27 per cent of 2050 supply from these LGAs collectively, with regional locations receiving the remaining 73 per cent.

### 5.3.3 Comparison to the current picture of extractive resource supply

Some of critical resource locations identified in Figure 27 currently produce large volumes of extractive resources; however several areas may not be recognised as strong producers of resources. Similarly, some areas currently known to industry as key locations of extractives production may not be identified as critical within the analysis.

There are numerous complexities at play here, however the key drivers of these results relate to industry intentions as provided to PwC through data gathering. For instance, areas currently producing relatively large volumes of resource include Hume and Wyndham. Industry intentions with respect to these locations have not revealed plans for significant ongoing or expanded operations in these areas when compared with some other areas. Correspondingly the contribution that Hume and Wyndham make to the level of State supply may not be as great in the future as is currently the case. This means that these locations are considered less critical from a resource protection viewpoint relative to other areas where stronger future supply is anticipated.

## 5.4 Criterion 1: Threatened rock types

The assessment presented under Criterion 1 provides a State level view for threatened rock types, mapped by the depletion of each considered resource through time. This provides an indication of how quickly known supplies of these rocks are utilised.

Identified threatened rock types include hornfels and clay and clay shale. These rock types are expected to experience significant depletion across the analysis period such that few years of supply remain after 2050.

Each of the other rock types considered in the analysis has sufficient reserves within existing and planned future licensed WAs (based on industry intentions at 2015) to support ongoing future demand beyond 2050. These findings are reflected in Table 8.[20]

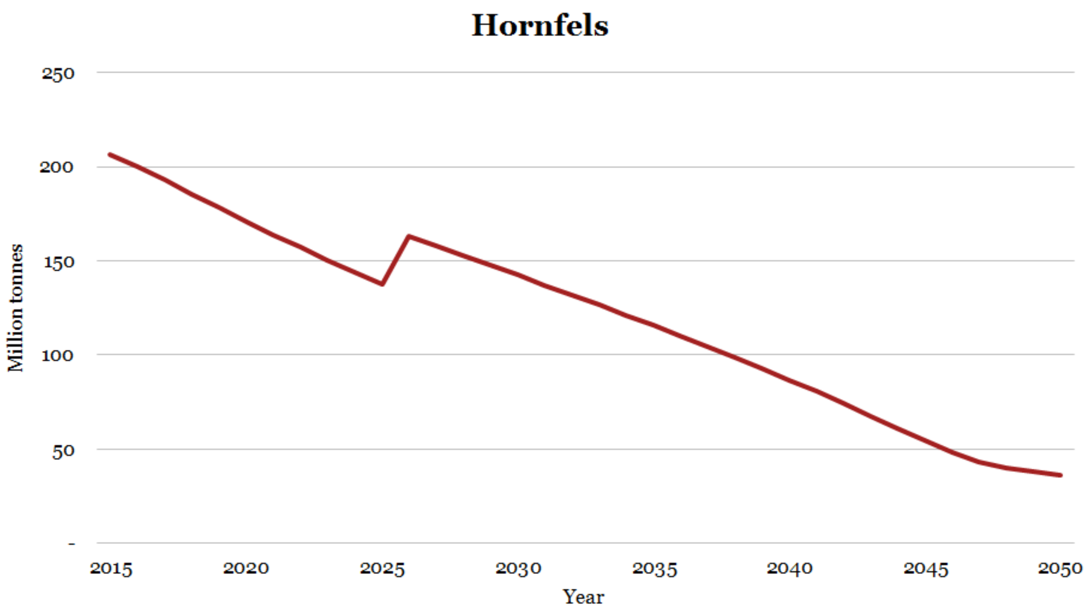
***Threatened rock types*** are those extractive resources that are anticipated to be in short supply by the end of the analysis period, based on industry intentions at 2015, at a State level.

### 5.4.1 Hornfels

The depletion profile for hornfels is mapped below, which shows the level of reserves held in current and planned future WAs in the State through time. The uplift in hornfels reserves in 2026 as shown in Figure 28 is due to new resource reserves being licensed and commencing production in that year, as indicated in the supply data gathering.

[20] Trachyte and Quartzite licensed reserves are exhausted across the analysis period. Given the relatively small volumes traded of these resources, however, these exhaustions have not been treated as critical within the context of the analysis. Additionally, Marble and Dolerite resources were considered in the supply analysis, though no demand for these resources was estimated between 2015 to 50.

**Figure 28: Hornfels depletion profile 2015 to 2050 (million tonnes)**



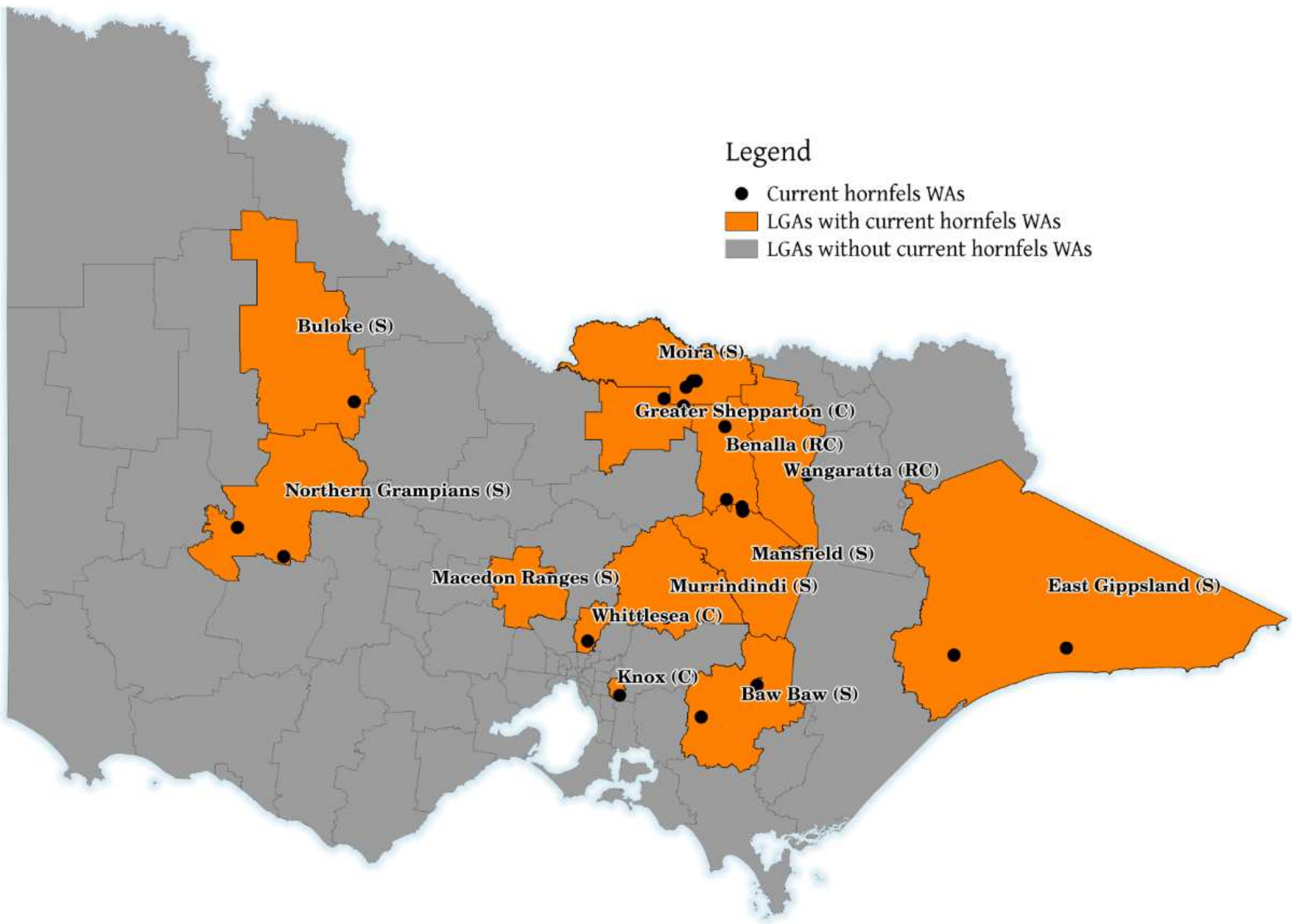

Source: PwC analysis

As relatively few hornfels quarries are currently licensed in Victoria, the analysis is not able to reveal which hornfels locations are more important than others in terms of their potential future supply. Some context is provided however by presenting the locations of currently licensed hornfels quarries; these are mapped in Figure 29.

For some quarry products, substitutes for hornfels exist. Industry data gathering undertaken in this analysis suggests that products formed by hornfels include fill, road base and road sub-base. It is noted that these products were also reported to be comprised of other rock types including granite, basalt old, basalt new, scoria and tuff, which suggests that some level of substitution is possible between these hard rock types.

The local availability of raw materials that meet specification requirements is a strong driver of whether substitute materials for hornfels may be used. A more detailed analysis of resource grades would potentially capture these regional specificities of technical requirements; however, this analysis has not been considered in this study.

**Figure 29: Locations of hornfels WAs, 2014**

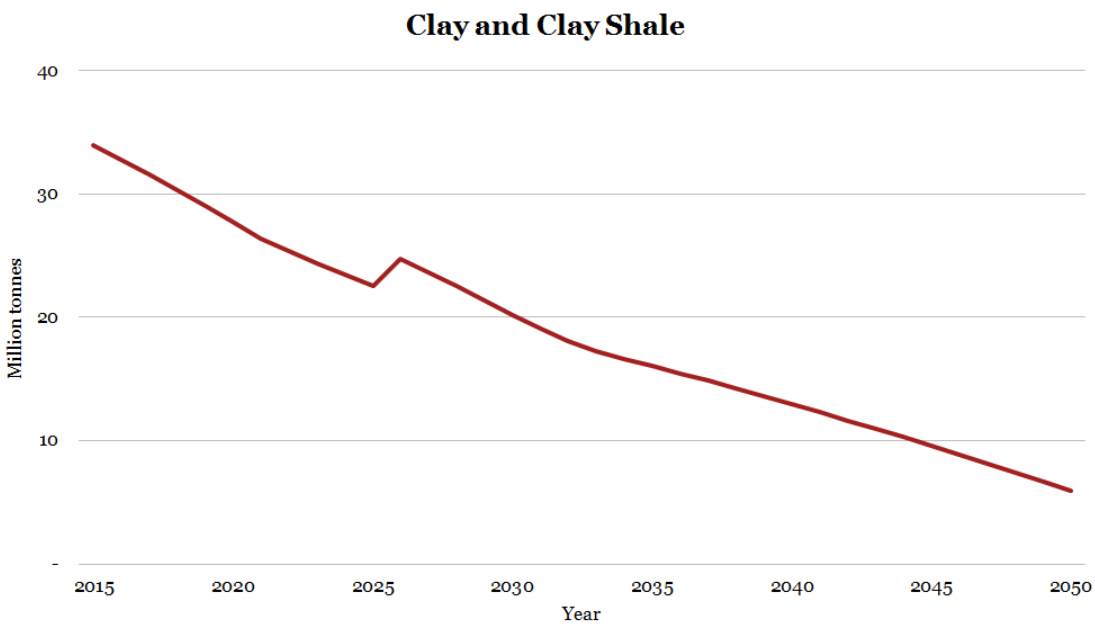



Source: PwC's GEM, DEDJTR records.

### 5.4.2 *Clay and clay shale*

The depletion profile for clay and clay shale in Victoria is detailed in Figure 30 below, which shows the level of reserves held in current and planned future WAs in the State through time. The kink in the chart represents new resources being licensed as indicated in the supply data gathering.

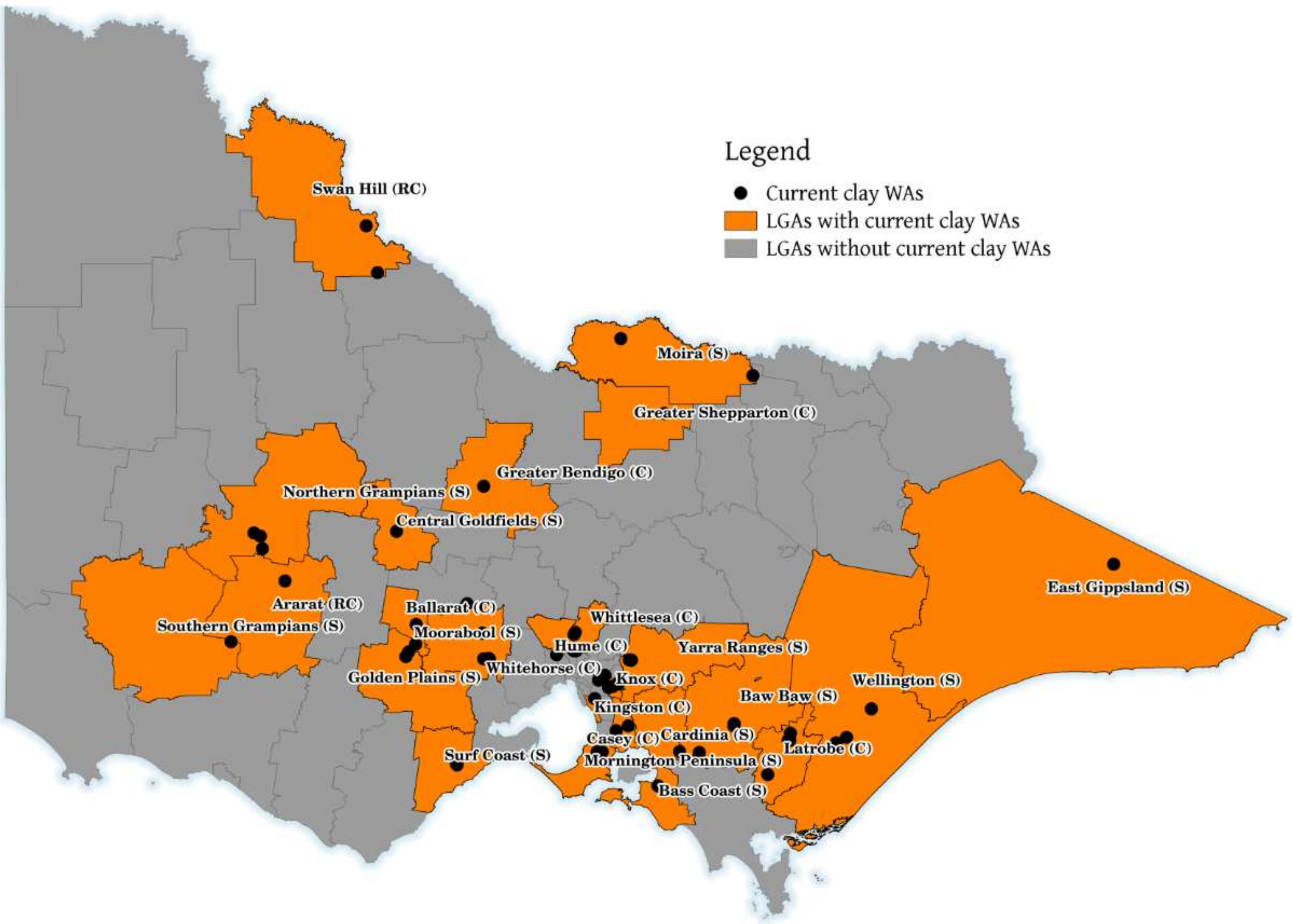
**Figure 30: Clay and clay shale depletion profile 2015 to 2050 (million tonnes)**




Source: PwC analysis

Discussion of the critical locations for clay and clay shale resources is provided under Criterion 2. The locations of currently licensed clay WAs in Victoria are mapped below in Figure 31.

**Figure 31: Locations of clay and clay shale WAs, 2014**




Source: PwC's GEM, DEDJTR records.

## 5.5 Criterion 2: Resource depletion - Locations where supply is unable to meet demand due to exhaustion of reserves

### 5.5.1 Identified resource depletion locations

The following Victorian locations are identified on the basis that they are subject to significant exhaustion of current and planned future licensed reserves across the analysis period. The high exhaustion rate occurring in these locations indicates that they receive high levels of allocated demand from localities in relative proximity (both within the LGA and in other LGAs), which suggests that they could be well-suited geographically to delivering extractive resources to support Victoria's development.

Given this, resource locations identified under Criterion 2 are considered to represent good candidates for development of new WAs in the future.

Criterion 2 considers which current and future planned WAs could experience exhaustion of their licensed reserves within the 2015 to 2050 analysis period. For confidentiality reasons WAs are then grouped together by region and resource type to understand which Victorian resource locations could experience the greatest level of exhaustion of current and future planned WA reserves.

Criterion 2 is measured for four rock categories: hard rock, sand and gravel, limestone and clay and clay shale. The level of resource exhaustion is measured by the difference between allocated demand for a resource location and its production volume, which is referred to as the production shortfall. Locations with the greatest production shortfall are those which, due to exhaustion of current and planned future reserves, are unable to meet their level of allocated demand.

***Key resource depletion locations*** represent those areas where a significant proportion of the reserves of existing and planned future quarries are exhausted for particular rock types in a given year.

### *5.5.2 Hard rock*

Table 10 lists those locations expected to experience significant exhaustion of current and future planned WA reserves across the period 2015 to 2050. These locations are mapped in Figure 32.

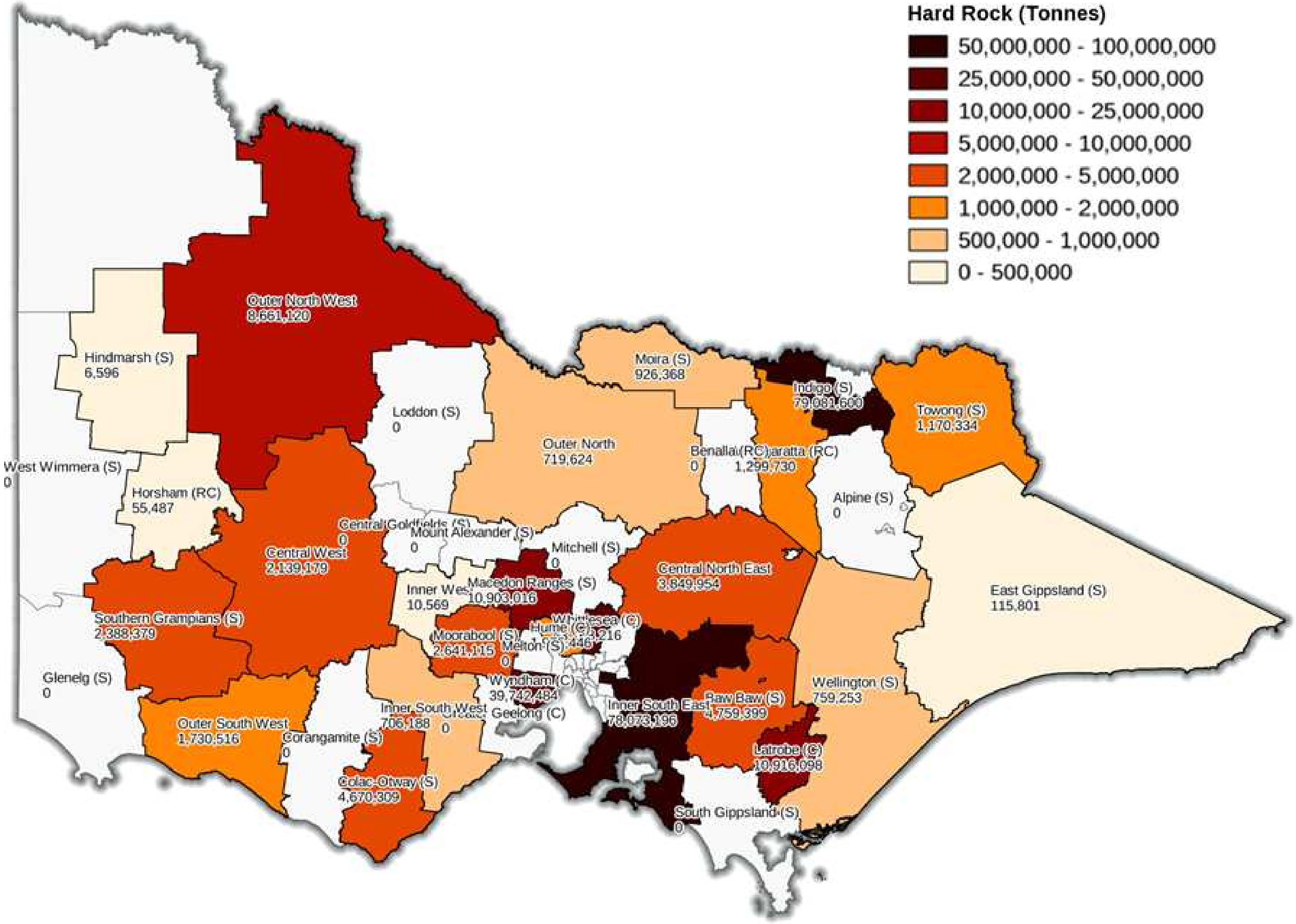
**Table 10: Key resource depletion locations – Hard rock, cumulative potential production shortfall 2015 to 2050**

| Region name | LGAs in region | Cumulative production shortfall 2015 to 2050 (tonnes) |
|---|---|---|
| Indigo (S) | Indigo (S) | 79,081,600 |
| Inner South East | Bass Coast (S),Cardinia (S),Casey (C),Frankston (C),Knox (C),Mornington Peninsula (S),Whitehorse (C),Yarra Ranges (S) | 78,073,196 |
| Whittlesea (C) | Whittlesea (C) | 43,168,216 |
| Wyndham (C) | Wyndham (C) | 39,742,484 |
| Outer North | Campaspe (S),Greater Bendigo (C),Greater Shepparton (C),Strathbogie (S) | 2,139,179 |
| Hume (C) | Hume (C) | 719,624 |

Source: PwC analysis

Indigo Shire region and the Inner South East region have been identified as critical areas of hard rock WA exhaustion, with significant production shortfalls of over 79 million tonnes and 78 million tonnes respectively. As most quarries of any significance produce between 500,000 tonnes to 1 million tonnes per annum, shortfalls of this magnitude would require approximately two new large quarries in these areas to satisfy the demand they face.

**Figure 32: Key resource depletion locations – Hard rock (cumulative potential production shortfall 2015 to 2050)**




Source: PwC analysis

### *5.5.3 Sand and gravel*

Table 11 lists those locations expected to experience significant exhaustion of current and future planned sand and gravel reserves across the period 2015 to 2050. These locations are mapped in Figure 34.

**Table 11: Key resource depletion locations – Sand and gravel, cumulative potential production shortfall 2015 to 2050**

| Region name | LGAs in region | Cumulative production shortfall 2015 to 2050 (tonnes) |
|---|---|---|
| Inner South East | Frankston (C),Kingston (C),Mornington Peninsula (S) | 25,334,499 |
| Inner West | Macedon Ranges (S),Moorabool (S) | 20,838,334 |
| Bass Coast (S) | Bass Coast (S) | 11,477,834 |
| Golden Plains (S) | Golden Plains (S) | 7,252,991 |
| Surf Coast (S) | Surf Coast (S) | 6,147,105 |
| South Gippsland (S) | South Gippsland (S) | 2,592,732 |
| Outer North East | Indigo (S),Towong (S),Wodonga (RC) | 2,128,664 |
| Outer North | Campaspe (S),Greater Shepparton (C) | 500,118 |

Source: PwC analysis

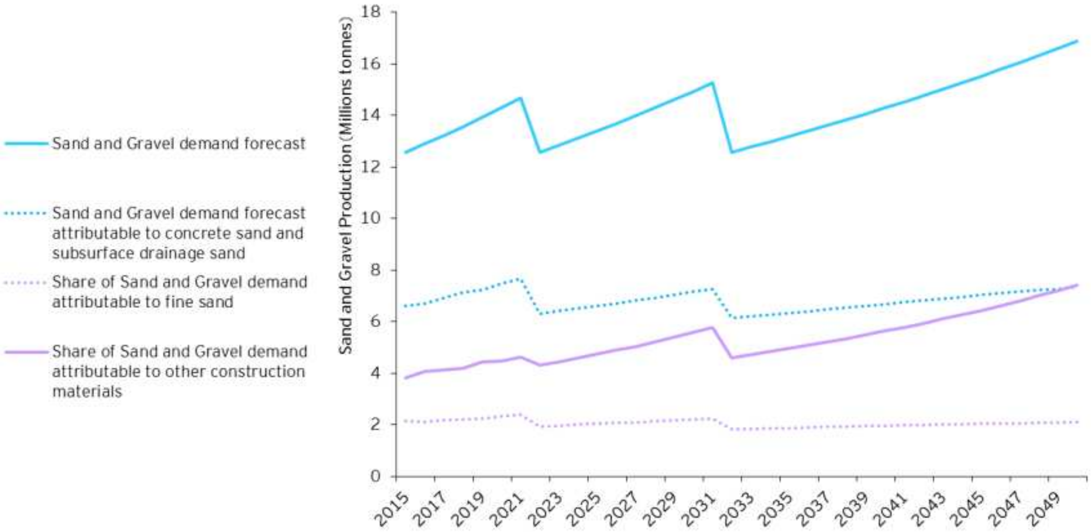
The Inner South East and Inner West regions are identified as critical areas under Criterion 2, with potential production shortfalls of 25 million tonnes and 21 million tonnes respectively over the 2015 to 2050 period.

Due to data limitations, sand and gravel are counted within the analysis as a single resource. However PwC understands that these are not necessarily identical products. Some information has been provided to PwC with respect to the potential breakdown of demand within this category.

The demand analysis indicates that approximately 48 per cent of forecast demand for sand and gravel could relate to demand for concrete sand and subsurface drainage sand. Fine sand was estimated to represent 15 per cent of sand and gravel projected demand. These estimates are based on an average applied across all projected years 2015 to 2050. Figure 33 provides a year-on-year indicative breakdown of the sand and gravel resource category into its expected uses.

The figure shows a reduction over time in the growth of the Sand and Gravel share attributable to concrete and fine sand. The demand analysis indicates that this is mainly driven by a changing construction mix that has been forecast over the analysis period.

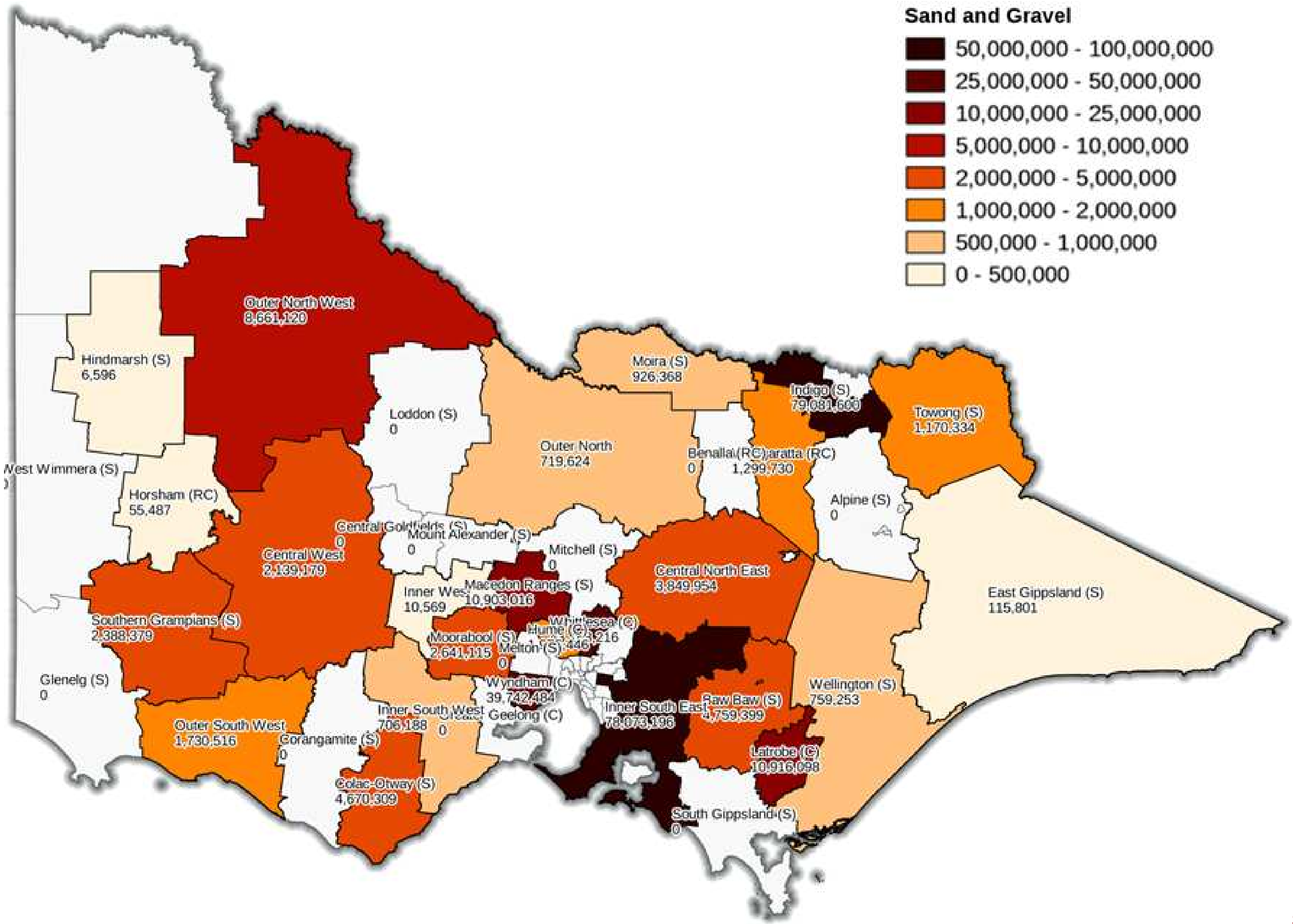
**Figure 33: Projected sand and gravel demand – indicative breakdown by usage type**




Source: EY, Demand analysis of extractive resources in Victoria, 2016

On the supply side, PwC's industry data gathering collected information from respondents on extractive product types. In relation to concrete sand, approximately 36 per cent of sand and gravel producers indicated they could produce that product from the resources mined in their quarries. Volumes produced of concrete sand have not been quantified within the analysis.

**Figure 34: Key resource depletion locations – Sand and gravel (cumulative potential production shortfall 2015 to 2050)**




Source PwC analysis

### *5.5.4 Limestone*

Key limestone locations are listed in Table 12 ranked from highest to lowest in terms of the level of resource exhaustion across 2015 to 2050. These locations are mapped in Figure 35.

**Table 12: Key resource depletion locations – Limestone, cumulative potential production shortfall 2015-2050**

| Region name | LGAs in region | Cumulative production shortfall 2015 to 2050 (tonnes) |
|---|---|---|
| Peri-urban | Greater Geelong (C),Yarra Ranges (S) | 22,100,081 |
| Outer South West | Corangamite (S),Glenelg (S),Moyne (S),Warrnambool (C) | 13,736,810 |
| Outer North East | East Gippsland (S),Strathbogie (S),Wellington (S) | 6,614,060 |
| Outer North West | Hindmarsh (S),Horsham (RC),Mildura (RC),Swan Hill (RC),Yarriambiack (S) | 2,171,303 |

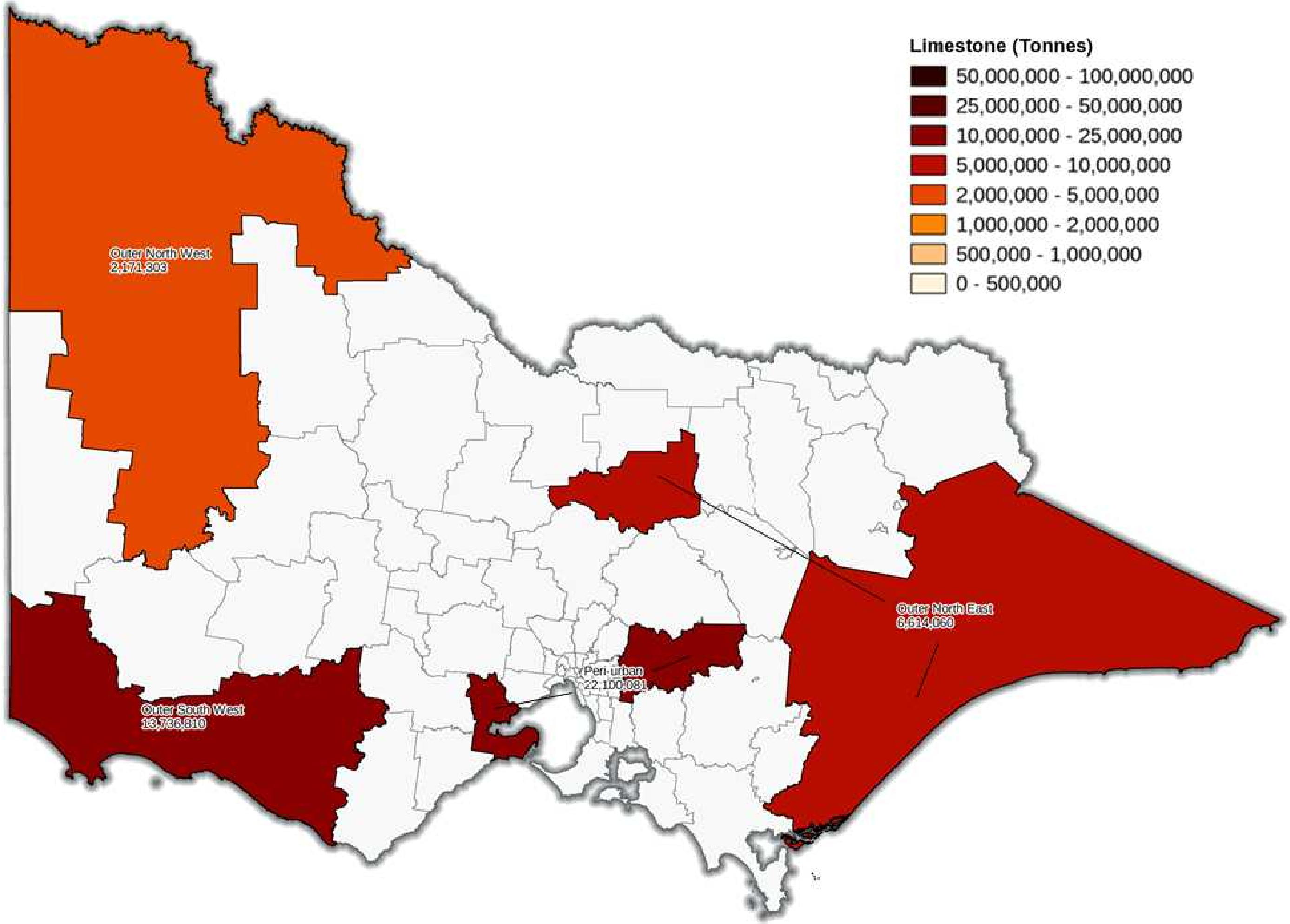
Source: PwC analysis

The Peri-urban and Outer South West regions have been identified as critical areas of limestone resource exhaustion; these locations exhibit potential production shortfalls across 2015 to 2050 of 22 million tonnes and nearly 14 million tonnes respectively.

The production shortfall in the Peri-urban region is in part a result of the ceased operations of Sibelco's Lilydale quarry site in the Yarra Ranges after 138 years of producing quicklime, hydrated lime and associated products.[21]

[21] Sibelco Australia is a sand, soil and gravel supplier operating in Victoria.

**Figure 35: Key resource depletion locations – Limestone (cumulative potential production shortfall 2015 to 2050)**




Source: PwC analysis

### 5.5.5 Clay and clay shale

Key clay and clay shale resource depletion locations are listed in Table 13.

**Table 13: Key resource depletion locations – Clay and clay shale, cumulative potential production shortfall 2015 to 2050**

| Region name | LGAs in region | Cumulative potential production shortfall 2015 to 2050 (tonnes) |
|---|---|---|
| Inner West | Ballarat (C),Golden Plains (S),Moorabool (S) | 7,720,142 |
| Outer North East | Latrobe (C),Moira (S),Wellington (S) | 4,741,395 |
| Inner East | Knox (C),Mornington Peninsula (S),Whitehorse (C),Yarra Ranges (S) | 3,185,546 |
| Outer West | Northern Grampians (S),Southern Grampians (S) | 403,256 |
| Inner North | Greater Bendigo (C),Mitchell (S),Whittlesea (C) | 43,630 |

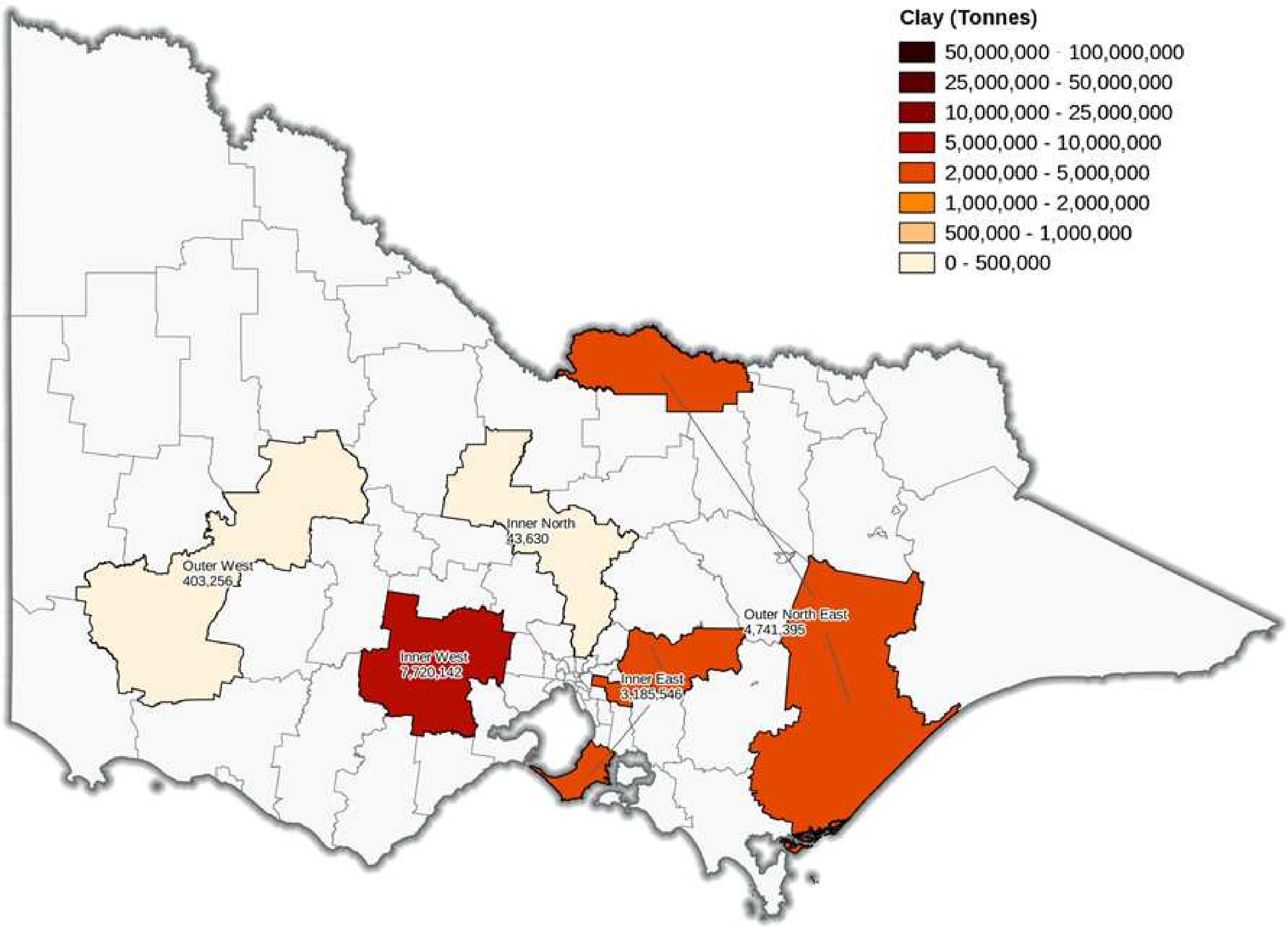
Source: PwC analysis

This shows that although the Inner North area is a top location for identifying new quarries in an attempt to replace depleting clay and clay shale, the Inner West area (represented by Ballarat, Golden Plains, and Moorabool) will experience a significant potential production shortfall of clay and clay shale of nearly 8 million tonnes.

Additional areas with emerging potential production shortfalls over the 2015 to 2050 include the Outer North East, as represented by Latrobe, Moira and Wellington, and the Inner East, as represented by Knox, Mornington Peninsula, Whitehorse and the Yarra Ranges, with potential shortfalls of nearly 5 million tonnes and over 3 million tonnes respectively.

These findings are illustrated in Figure 36 below.

**Figure 36: Key resource depletion locations - Clay and clay shale (cumulative potentially supply shortfall 2015 to 2050)**




Source: PwC analysis

# 5.6 Criterion 3: Significant production

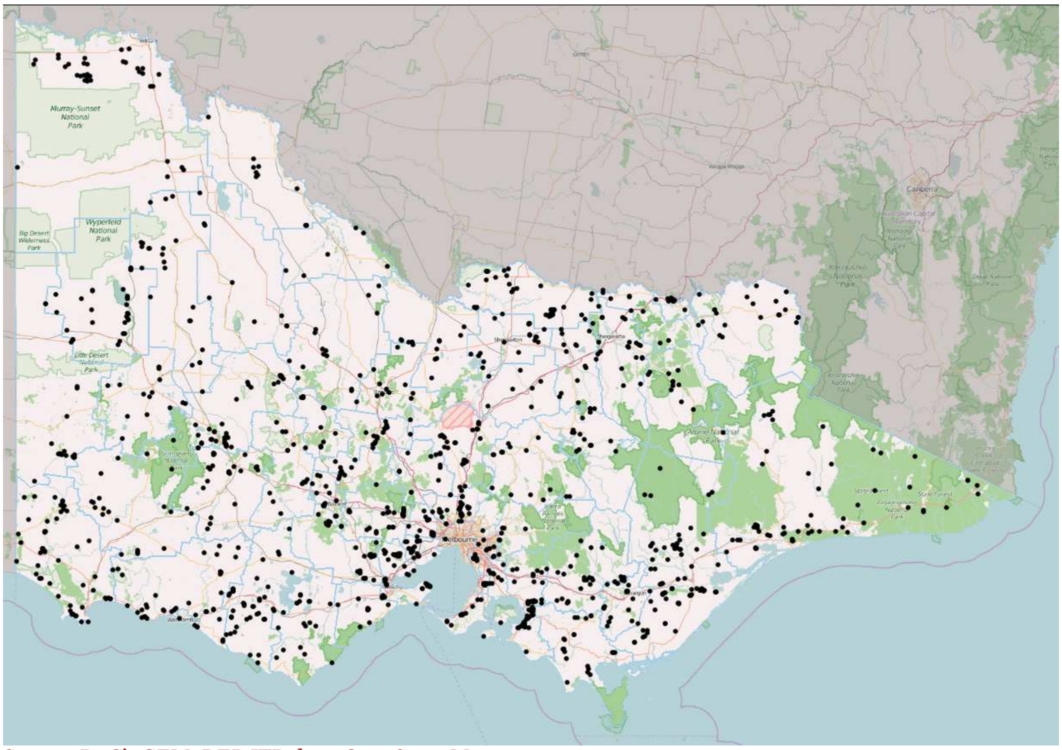
Criterion 3 identifies supply locations with significant production levels.

***Supply locations with significant production levels*** are those areas that produce large volumes of extractive resources across the analysis period, 2015 to 2050.

## 5.6.1 The current picture: WAs and WA applications in Victoria

Current WAs and WA applications are well distributed across the State. These are represented as black circles in Figure 37. Due to survey respondent confidentiality, future planned WAs have not been presented in Figure 37.

**Figure 37: Current WAs and WA applications**



Source: PwC's GEM, DEDJTR data, OpenStreetMap

*Geospatial granularity of reporting*

While the analysis is undertaken for each work authority and locality in Victoria, results by location are aggregated in most cases to the LGA-level and above to preserve the confidentiality of individuals and organisations who responded to the industry survey. Therefore, regional aggregations will differ across rock types, as they are dependent on the number of work authorities in a given area and must satisfy a set of confidentiality triggers.

Further details of PwC's approach to respondent confidentiality can be found in Appendix A.

## *5.6.2 Hard rock*

Victorian locations producing significant volumes of hard rock across the analysis period are listed in Table 14, ordered by their respective levels of 2050 hard rock supply. Identified production shortfalls are also listed in the table. The production shortfall refers to the difference between the level of demand allocated to a location, which is based on its current and planned future licensed reserves and production levels, and the level of production from that location. The locations listed in Table 14 are recognised as producing at least one million tonnes of hard rock material in 2050.

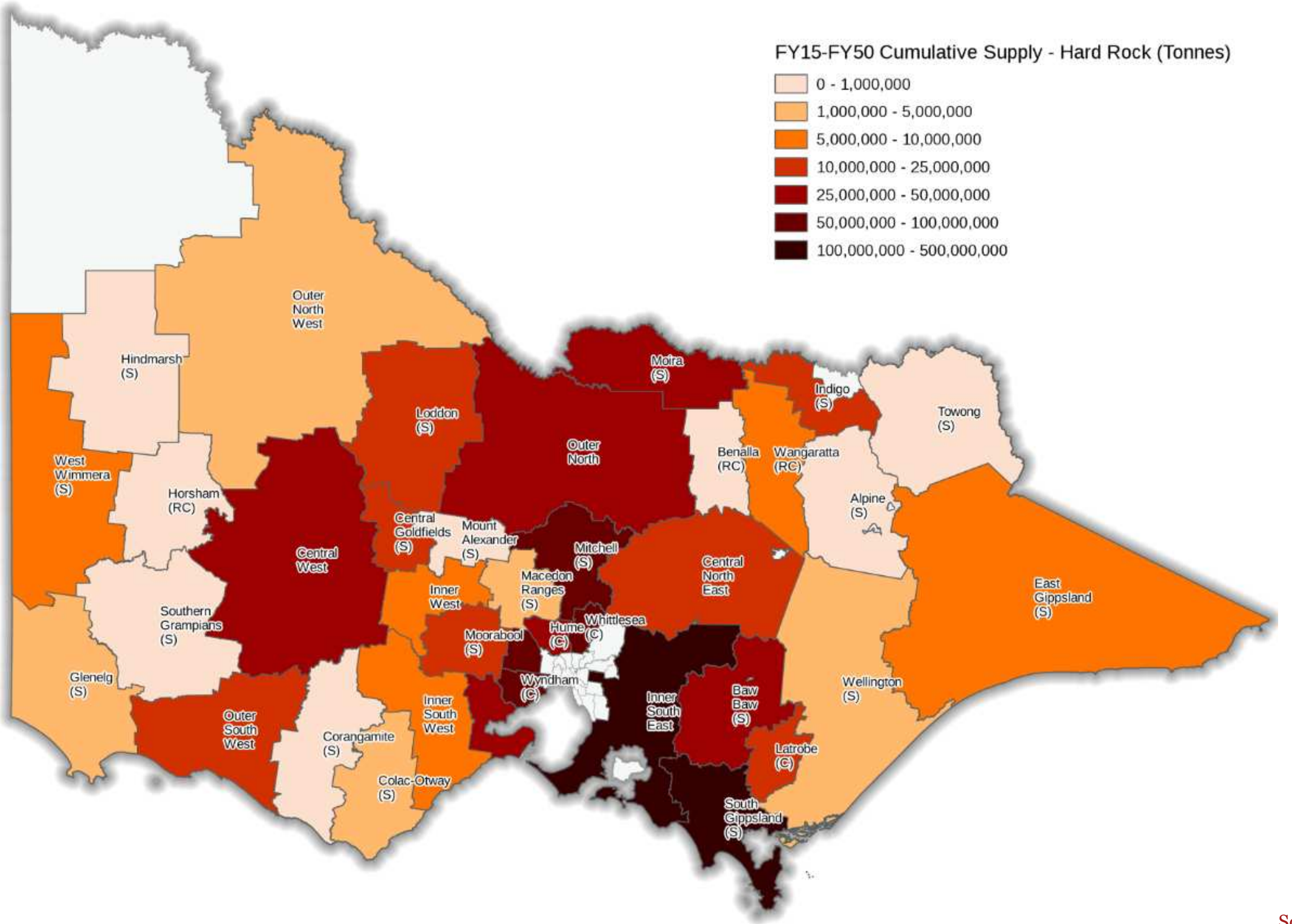
Figure 38 maps the level of cumulative production by locations in Victoria for hard rock across the entirety of the analysis period; that is, from 2015 to 2050. The figure demonstrates that significant levels of production are expected from the region to the South East of Melbourne, which incorporates LGAs such as South Gippsland, Bass Coast, Cardinia, Casey, Frankston, Knox, Mornington Peninsula and Whitehorse.

**Table 14: Criterion 3 – Supply locations with significant production levels: Hard rock**

| Region name | LGAs in region | Allocated demand, 2015 | Allocated demand, 2025 | Supply, 2025 | Production shortfall, 2025 | Allocated demand, 2050 | Supply, 2050 | Production shortfall, 2050 |
|---|---|---|---|---|---|---|---|---|
| South Gippsland (S) | South Gippsland (S) | 120,252 | 10,781,036 | 10,781,036 | - | 17,781,095 | 17,781,095 | - |
| Inner South East | Bass Coast (S),Cardinia (S),Casey (C),Frankston (C),Knox (C),Mornington Peninsula (S),Whitehorse (C),Yarra Ranges (S) | 5,610,471 | 6,742,753 | 5,997,552 | 745,201 | 12,401,506 | 6,000,341 | 6,401,165 |
| Mitchell (S) | Mitchell (S) | 1,212,194 | 1,290,656 | 1,290,656 | - | 2,987,698 | 2,987,698 | - |
| Melton (S) | Melton (S) | 2,700,498 | 1,296,960 | 1,296,960 | - | 2,186,543 | 2,186,543 | - |
| Whittlesea (C) | Whittlesea (C) | 2,942,876 | 2,357,738 | 1,419,835 | 937,904 | 3,969,252 | 1,938,030 | 2,031,222 |
| Wyndham (C) | Wyndham (C) | 2,919,225 | 2,700,346 | 1,790,038 | 910,308 | 4,125,562 | 1,870,013 | 2,255,549 |
| Greater Geelong (C) | Greater Geelong (C) | 2,054,037 | 982,681 | 982,681 | - | 1,654,279 | 1,654,279 | - |
| Outer North | Campaspe (S),Greater Bendigo (C),Greater Shepparton (C),Strathbogie (S) | 1,163,519 | 985,112 | 985,112 | - | 1,718,806 | 1,488,932 | 229,874 |
| Hume (C) | Hume (C) | 1,655,712 | 949,091 | 949,091 | - | 1,413,937 | 1,238,500 | 175,437 |
| Central West | Ararat (RC),Northern Grampians (S),Pyrenees (S) | 753,708 | 922,722 | 922,722 | - | 1,647,740 | 1,106,338 | 541,402 |

Source: PwC analysis

**Figure 38: Criterion 3 – Supply locations with significant production levels: Hard rock**




Source: PwC analysis

### *5.6.3 Sand and gravel*

Victorian locations producing significant volumes of sand and gravel resources across the analysis period are listed in Table 15, ordered by their respective levels of 2050 production. Identified production shortfalls are also listed in the table. The production shortfall refers to the difference between the level of demand allocated to a location, which is based on its current and planned future licensed reserves and production levels, and the level of production from that location.

The locations listed in Table 15 are recognised as producing at least four hundred thousand tonnes of sand and gravel material in 2050.

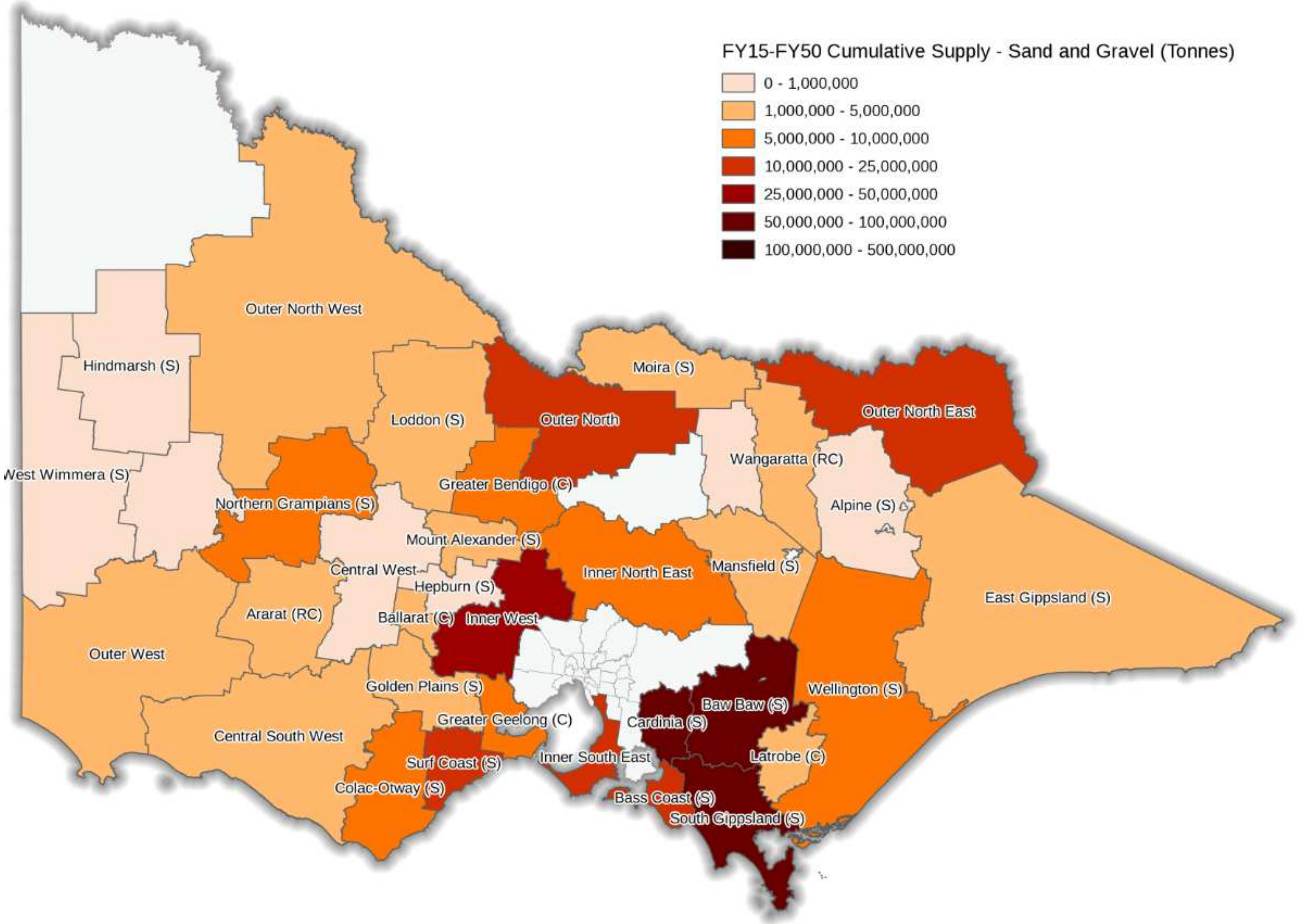
Figure 39 maps the level of cumulative production by locations in Victoria for sand and gravel across the entirety of the analysis period; that is, from 2015 to 2050. The figure demonstrates that significant levels of production are expected from the region to the South East of Melbourne, which incorporates LGAs such as South Gippsland, Cardinia, Baw Baw, Bass Coast, Frankston, Kingston and Mornington Peninsula. The Inner West region comprising Macedon Ranges and Moorabool is also expected to produce large volumes of Victoria's sand and gravel requirements, with strong production also being located in the State's Northern locations such as Greater Shepparton and Indigo, among others.

**Table 15: Criterion 3 – Supply locations with significant production levels: Sand and gravel**

| Region name | LGAs in region | Allocated demand, 2015 | Allocated demand, 2025 | Supply, 2025 | Production shortfall, 2025 | Allocated demand, 2050 | Supply, 2050 | Production shortfall, 2050 |
|---|---|---|---|---|---|---|---|---|
| South Gippsland (S) | South Gippsland (S) | 2,344,090 | 2,563,219 | 2,551,794 | 11,425 | 3,156,098 | 2,830,829 | 325,269 |
| Cardinia (S) | Cardinia (S) | 439,302 | 2,209,826 | 2,209,826 | - | 2,620,890 | 2,620,890 | - |
| Baw Baw (S) | Baw Baw (S) | 23,393 | 1,465,513 | 1,465,513 | - | 1,743,002 | 1,743,002 | - |
| Inner West | Macedon Ranges (S),Moorabool (S) | 2,072,254 | 1,416,978 | 1,358,593 | 58,385 | 1,710,791 | 686,296 | 1,024,495 |
| Bass Coast (S) | Bass Coast (S) | 894,340 | 638,687 | 277,857 | 360,830 | 1,095,401 | 668,260 | 427,141 |
| Inner South East | Frankston (C),Kingston (C),Mornington Peninsula (S) | 1,210,939 | 799,533 | 146,946 | 652,587 | 1,242,775 | 466,938 | 775,837 |
| Outer North | Campaspe (S),Greater Shepparton (C) | 558,460 | 383,549 | 360,342 | 23,207 | 466,208 | 437,940 | 28,268 |
| Outer North East | Indigo (S),Towong (S),Wodonga (RC) | 460,337 | 368,547 | 368,547 | - | 431,756 | 431,756 | - |

Source: PwC analysis

**Figure 39: Criterion 3 – Supply locations with significant production levels: Sand and gravel**




Source: PwC analysis

### *5.6.4 Limestone*

Limestone is extracted in relatively few locations in Victoria. Table 16 lists these locations along with their levels of allocated demand, supply and production shortfall for various years of interest.

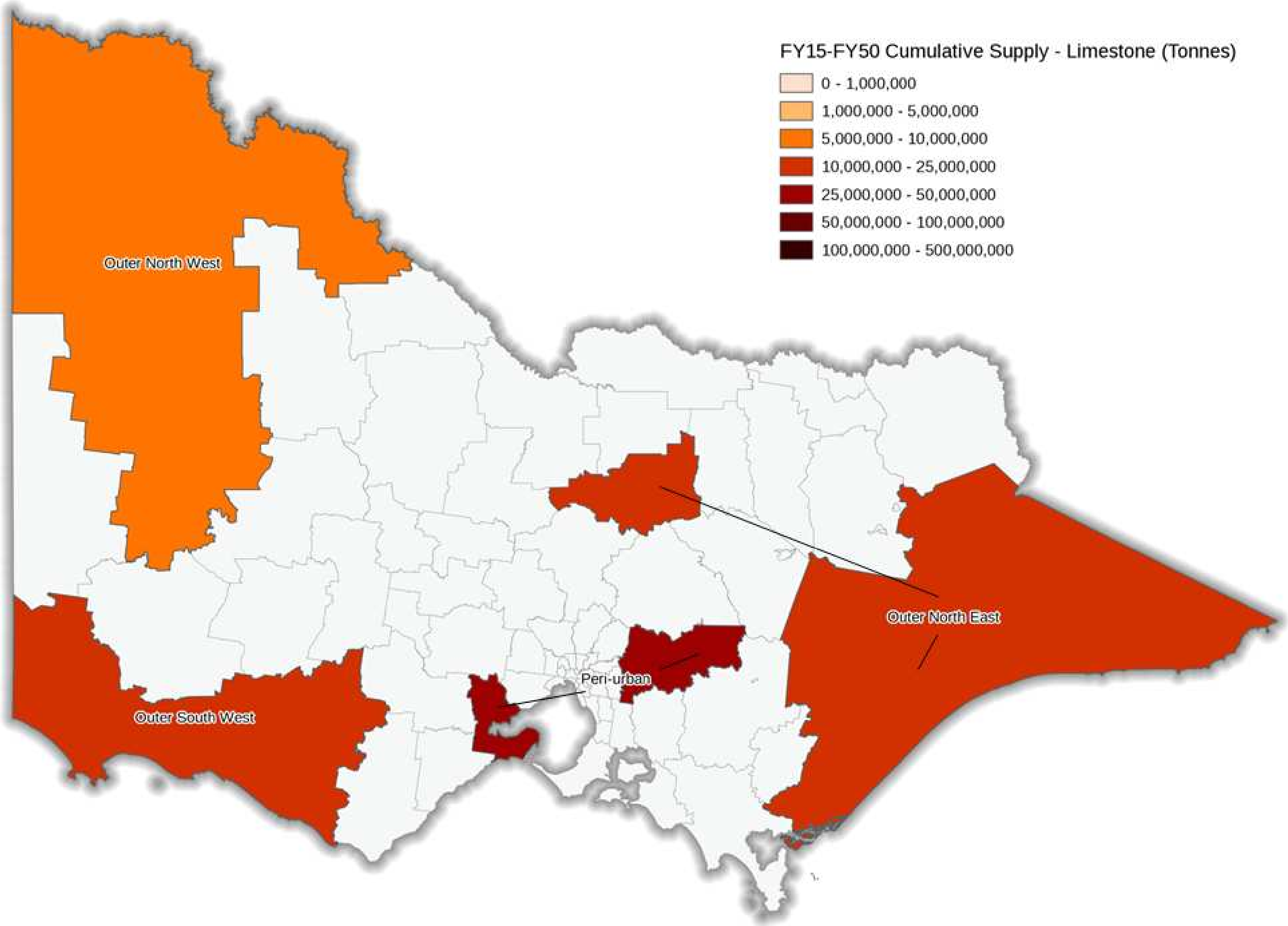
The Peri-urban region, comprising Greater Geelong and Yarra Ranges, is expected to produce by far the largest proportion of State supply of limestone. Lower levels of limestone production are anticipated in the corners of Victoria in locations including East Gippsland, Warrnambool and Mildura, with some production occurring in Central Victoria. Figure 40 maps these locations along with their cumulative production levels from 2015 to 2050.

**Table 16: Criterion 3 – Supply locations with significant production levels: Limestone**

| Region name | LGAs in region | Allocated demand, 2015 | Allocated demand, 2025 | Supply, 2025 | Production shortfall, 2025 | Allocated demand, 2050 | Supply, 2050 | Production shortfall, 2050 |
|---|---|---|---|---|---|---|---|---|
| Peri-urban | Greater Geelong (C),Yarra Ranges (S) | 1,198,855 | 1,516,082 | 1,516,082 | - | 2,969,244 | 1,281,246 | 1,687,997 |
| Outer South West | Corangamite (S),Glenelg (S),Moyne (S),Warrnambool (C) | 519,453 | 723,636 | 631,162 | 92,473 | 1,412,855 | 290,781 | 1,122,074 |
| Outer North East | East Gippsland (S),Strathbogie (S),Wellington (S) | 286,544 | 369,031 | 369,031 | - | 724,349 | 222,700 | 501,649 |
| Outer North West | Hindmarsh (S),Horsham (RC),Mildura (RC),Swan Hill (RC),Yarriambiack (S) | 105,453 | 152,500 | 138,550 | 13,949 | 334,207 | 170,741 | 163,467 |

Source: PwC analysis

**Figure 40: Criterion 3 – Supply locations with significant production levels: Limestone**




Source: PwC analysis

### 5.6.5 Clay and clay shale

Like limestone, clay and clay shale are extracted in relatively few locations across Victoria. Among these locations, supply is greatest in Greater Bendigo, Mitchell and Whittlesea which are grouped here as the Inner North region. Significant volumes of production are also anticipated in the State's inner East and West as demonstrated in Table 17. Exhaustion of known and planned reserves in anticipated in the Outer North East and Outer West regions listed in Table 17, as indicated in the industry data gathering undertaken in support of this study. These locations are unable to support the level of allocated demand they receive in 2050.

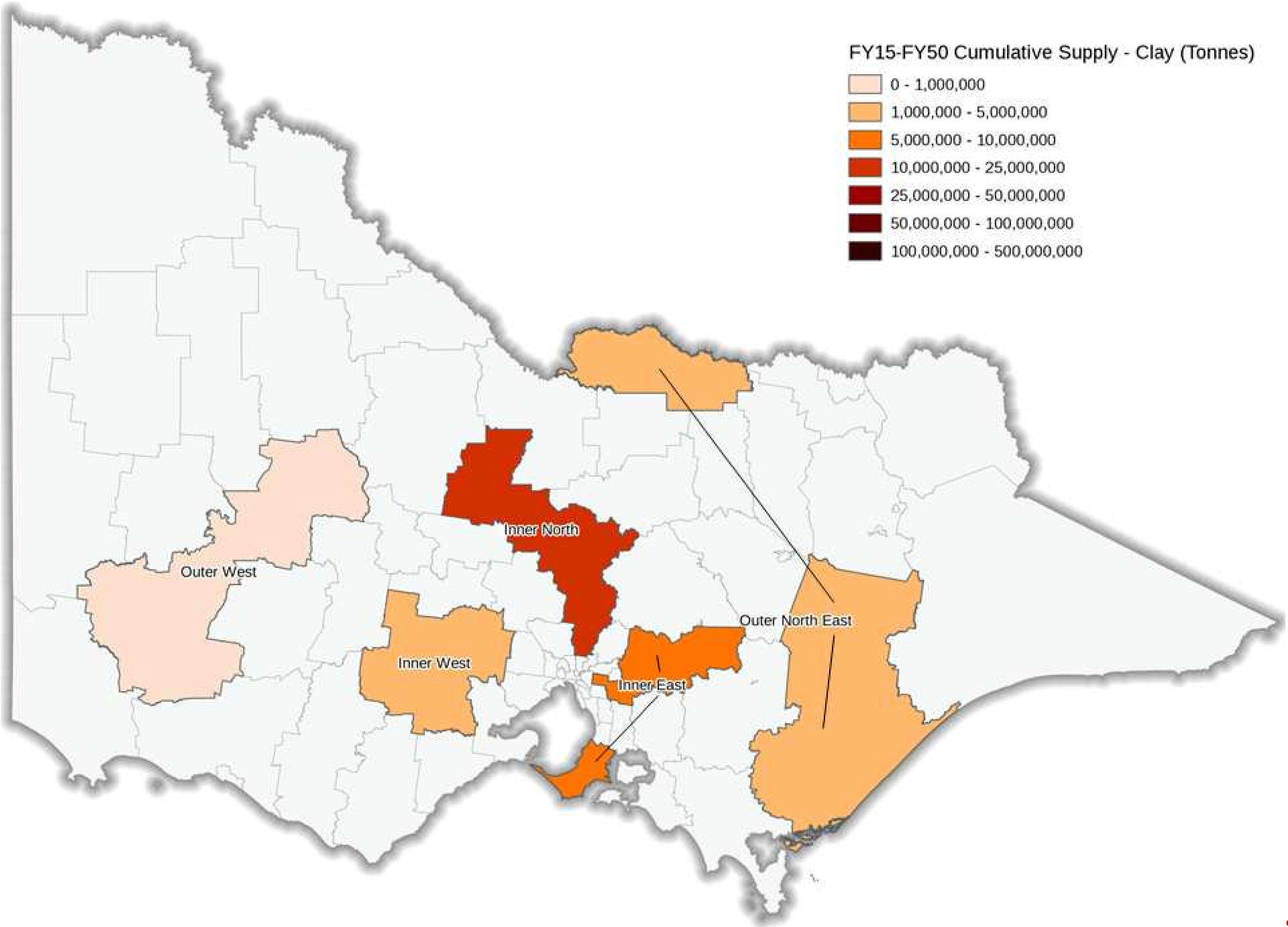
Figure 41 maps the clay and clay shale producing locations in Victoria along with their cumulative production levels across the 2015 to 2050 analysis period.

**Table 17: Criterion 3 – Supply locations with significant production levels: Clay and clay shale**

| Region name | LGAs in region | Allocated demand, 2015 | Allocated demand, 2025 | Supply, 2025 | Production shortfall, 2025 | Allocated demand, 2050 | Supply, 2050 | Production shortfall, 2050 |
|---|---|---|---|---|---|---|---|---|
| Inner North | Greater Bendigo (C),Mitchell (S),Whittlesea (C) | 167,628 | 453,792 | 453,792 | - | 570,300 | 567,584 | 2,715 |
| Inner East | Knox (C),Mornington Peninsula (S),Whitehorse (C),Yarra Ranges (S) | 369,925 | 281,734 | 168,701 | 113,033 | 354,481 | 142,495 | 211,986 |
| Inner West | Ballarat (C),Golden Plains (S),Moorabool (S) | 319,956 | 277,026 | 39,398 | 237,628 | 352,422 | 47,596 | 304,825 |
| Outer North East | Latrobe (C),Moira (S),Wellington (S) | 321,507 | 249,870 | 249,870 | - | 310,031 | - | 310,031 |
| Outer West | Northern Grampians (S),Southern Grampians (S) | 23,380 | 18,031 | 18,031 | - | 24,062 | - | 24,062 |

Source: PwC analysis

**Figure 41: Criterion 3 – Supply locations with significant production levels: Clay and clay shale**




Source: PwC analysis

## 5.7 Criterion 4: Locations critical to supporting Greater Melbourne's future

One of the themes of this analysis has been the trend towards increasing competition amongst alternative uses for land on Greater Melbourne's fringe. For reasons including noise, dust, traffic, environmental and amenity impacts, extractive industries cannot always coexist with other land uses, such as residential development. PwC understands that encroachment by residential and other development types is increasingly threatening the supply of extractive resources in peri-urban locations in Victoria.

This criterion has been applied to identify those locations that would result in infrastructure cost increases in Greater Melbourne should sterilisation of their extractive resources occur. Locations are ranked according to the proportion of total State production they deliver across the 2015 to 2050 period, for each of the rock types considered.

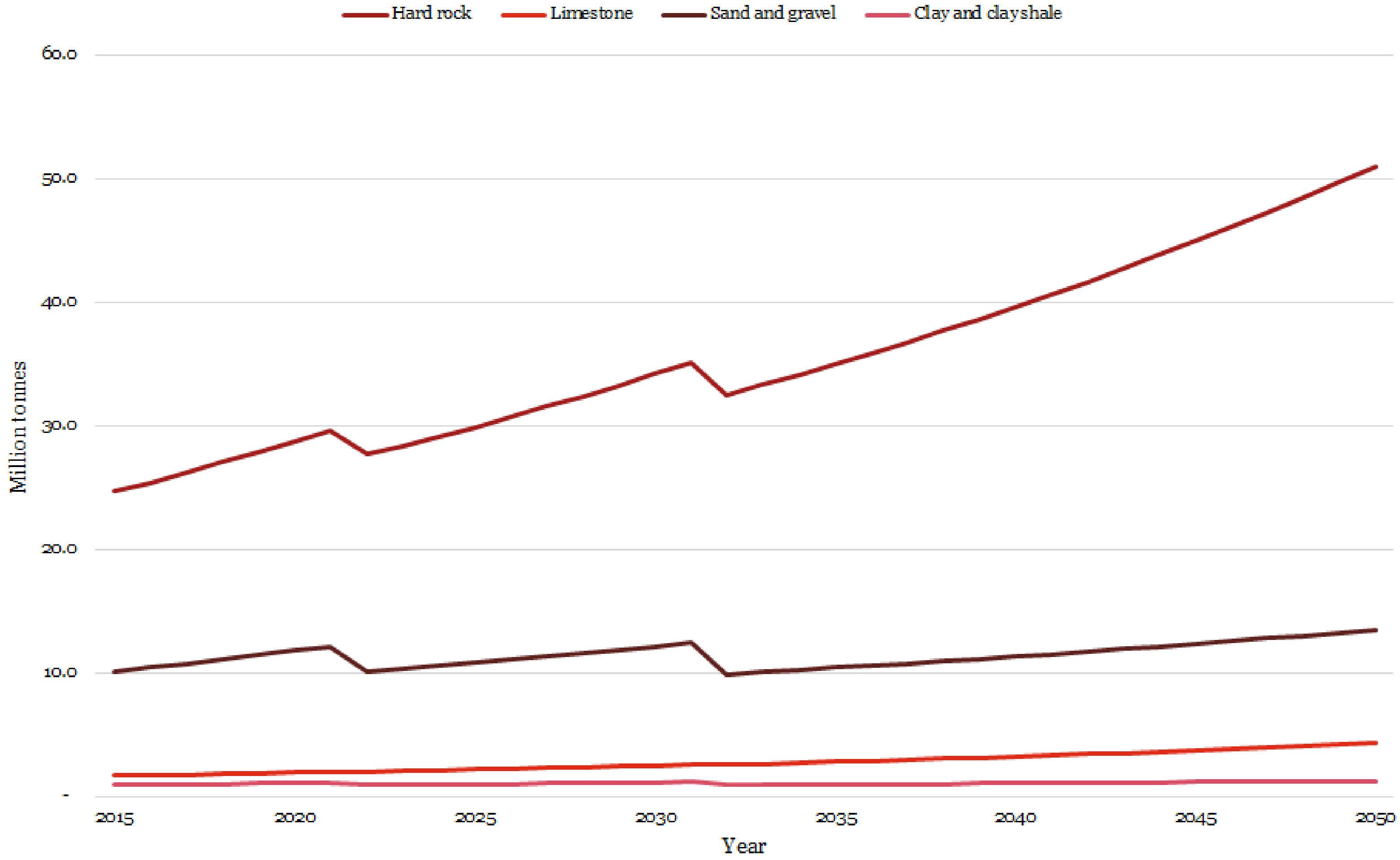
Across all construction types, hard rock resources represent approximately 65 per cent of Greater Melbourne's demand in 2015, followed by sand and gravel at 27 per cent, limestone at five per cent and clay and clay shale at three per cent. Greater Melbourne's demand for different extractive resource types is illustrated in Figure 42. A summary table of cumulative demand levels for Greater Melbourne is provided at Table 18.

**Table 18: Demand for extractive resources in Greater Melbourne for select years (tonnes)**

| Rock type | Demand, 2015 | Demand, 2025 | Cumulative demand, 2015 to 2025 | Demand 2050 | Cumulative demand, 2026 to 2050 | Cumulative demand, 2015 to 2050 |
|---|---|---|---|---|---|---|
| Hard rock | 24,764,886 | 29,953,244 | 305,250,080 | 51,029,658 | 978,295,417 | 1,283,545,497 |
| Limestone | 1,709,721 | 2,229,169 | 21,636,811 | 4,344,054 | 79,712,556 | 101,349,366 |
| Sand and gravel | 10,197,629 | 10,854,517 | 120,216,961 | 13,549,485 | 291,913,846 | 412,130,808 |
| Clay and clay shale | 976,207 | 1,053,454 | 11,645,875 | 1,319,932 | 28,417,078 | 40,062,953 |

Source: PwC analysis

**Figure 42: Greater Melbourne's demand by rock type, 2015 to 2050***




*Source: PwC analysis.* *The demand study supplier has indicated that steps in the forecast are related to population data and average annual growth rates provided by Government projections used in the forecast approach.

Although Greater Melbourne demands a lot of resources, it should be noted that there is potential for cross jurisdictional extractive resource supply of this material. Resources held in Victorian quarries could equally be purchased by buyers in neighbouring States. Quarries exist on or near the Victoria border that could potentially supply to interstate markets. However, given the demand profile is constructed for Victoria alone and disregards demand from neighbouring States, the analysis has necessarily assumed that no interstate markets are accessed by suppliers and that all demand is satisfied from within Victoria. This is a noted limitation of the study.

***Locations critical to supporting Greater Melbourne's future*** are those areas that are expected to deliver significant volumes of resource to Greater Melbourne across the analysis period, 2015 to 2050.

### 5.7.1 Hard rock

Key locations of hard rock supply are listed in Table 19, which indicates that South Gippsland and the Inner South East region together are expected to deliver over 50 per cent of Greater Melbourne's hard rock material across 2015 to 2050. This is due in part to planned development of new resource deposits in some of these locations in the near term.

**Table 19: Criterion 4 – Key supply locations to Greater Melbourne: Hard rock**

| Region name | LGAs in region | Supply to Greater Melbourne, 2015 to 2025 (tonnes) | Supply to Greater Melbourne, 2026 to 2050 (tonnes) | Supply to Greater Melbourne, 2015 to 2050 (tonnes) | % of total supply to Greater Melbourne, 2015 to 2050 |
|---|---|---|---|---|---|
| South Gippsland (S) | South Gippsland (S) | 58,348,438 | 212,601,595 | 270,950,032 | 34 |
| Inner South East | Bass Coast (S),Cardinia (S),Casey (C),Frankston (C),Knox (C),Mornington Peninsula (S),Whitehorse (C),Yarra Ranges (S) | 43,114,947 | 124,172,781 | 167,287,728 | 21 |
| Wyndham (C) | Wyndham (C) | 18,489,400 | 30,283,542 | 48,772,943 | 6 |
| Mitchell (S) | Mitchell (S) | 8,442,290 | 30,695,295 | 39,137,585 | 5 |
| Melton (S) | Melton (S) | 10,349,185 | 24,728,624 | 35,077,810 | 4 |
| Whittlesea (C) | Whittlesea (C) | 12,381,381 | 22,477,747 | 34,859,129 | 4 |
| Central West | Ararat (RC),Northern Grampians (S),Pyrenees (S) | 6,831,928 | 19,199,738 | 26,031,666 | 3 |
| Hume (C) | Hume (C) | 8,566,339 | 15,433,092 | 23,999,431 | 3 |
| Greater Geelong (C) | Greater Geelong (C) | 6,932,939 | 16,507,540 | 23,440,478 | 3 |
| Outer North | Campaspe (S),Greater Bendigo (C),Greater Shepparton (C),Strathbogie (S) | 5,871,402 | 16,001,291 | 21,872,693 | 3 |
| Moira (S) | Moira (S) | 4,614,245 | 13,577,723 | 18,191,968 | 2 |
| Baw Baw (S) | Baw Baw (S) | 5,423,921 | 11,941,415 | 17,365,336 | 2 |
| Indigo (S) | Indigo (S) | 16,792,015 | 214 | 16,792,229 | 2 |
| Central North East | Mansfield (S),Murrindindi (S) | 4,015,412 | 9,702,970 | 13,718,382 | 2 |
| Moorabool (S) | Moorabool (S) | 3,935,260 | 7,861,537 | 11,796,797 | 1 |

Source: PwC analysis. Supply volumes relate to residential and commercial construction demand.

### *5.7.2 Sand and gravel*

Sand and gravel production is concentrated in a similar area of the State to that of hard rock. South Gippsland is identified as a key supplier of sand and gravel resources to Greater Melbourne, along with other South-Eastern locations including Cardinia and Baw Baw.

**Table 20: Criterion 4 – Key supply locations to Greater Melbourne: Sand and gravel**

| Region name | LGAs in region | Supply to Greater Melbourne, 2015 to 2025 (tonnes) | Supply to Greater Melbourne, 2026 to 2050 (tonnes) | Supply to Greater Melbourne, 2015 to 2050 (tonnes) | % of total supply to Greater Melbourne, 2015 to 2050 |
|---|---|---|---|---|---|
| South Gippsland (S) | South Gippsland (S) | 14,918,985 | 42,123,237 | 57,042,222 | 22 |
| Cardinia (S) | Cardinia (S) | 7,835,512 | 37,011,485 | 44,846,997 | 18 |
| Baw Baw (S) | Baw Baw (S) | 10,503,799 | 23,913,591 | 34,417,390 | 14 |
| Inner West | Macedon Ranges (S),Moorabool (S) | 11,915,961 | 9,794,439 | 21,710,400 | 9 |
| Bass Coast (S) | Bass Coast (S) | 4,246,998 | 9,215,007 | 13,462,004 | 5 |
| Outer North | Campaspe (S),Greater Shepparton (C) | 3,268,715 | 5,601,668 | 8,870,383 | 3 |
| Inner South East | Frankston (C),Kingston (C),Mornington Peninsula (S) | 1,636,949 | 6,135,125 | 7,772,074 | 3 |
| Surf Coast (S) | Surf Coast (S) | 3,188,416 | 4,492,145 | 7,680,561 | 3 |
| Outer North East | Indigo (S),Towong (S),Wodonga (RC) | 2,210,313 | 3,759,592 | 5,969,905 | 2 |
| Greater Bendigo (C) | Greater Bendigo (C) | 2,043,972 | 3,643,394 | 5,687,366 | 2 |
| Northern Grampians (S) | Northern Grampians (S) | 2,433,679 | 2,600,303 | 5,033,982 | 2 |
| Inner North East | Mitchell (S),Murrindindi (S) | 1,784,529 | 3,183,045 | 4,967,574 | 2 |
| Greater Geelong (C) | Greater Geelong (C) | 1,574,096 | 3,210,826 | 4,784,922 | 2 |
| Wellington (S) | Wellington (S) | 1,294,702 | 2,145,821 | 3,440,523 | 1 |
| Colac-Otway (S) | Colac-Otway (S) | 1,236,918 | 1,907,440 | 3,144,358 | 1 |

Source: PwC analysis. Supply volumes relate to residential and commercial construction demand.

### 5.7.3 Limestone

As discussed earlier, production of limestone in Victoria is isolated to a select few regions. These are listed in Table 21 ordered by the proportion of Greater Melbourne's limestone requirements each location is expected to deliver. The Peri-urban region comprising Greater Geelong and Yarra Ranges is by far the largest source for Melbourne's limestone needs, delivering approximately 70 per cent of the city's demand. The Outer South West region ranks next with approximately 19 per cent of Greater Melbourne's demand.

**Table 21: Criterion 4 – Key supply locations to Greater Melbourne: Limestone**

| Region name | LGAs in region | Supply to Greater Melbourne, 2015 to 2025 (tonnes) | Supply to Greater Melbourne, 2026 to 2050 (tonnes) | Supply to Greater Melbourne, 2015 to 2050 (tonnes) | % of total supply to Greater Melbourne, 2015 to 2050 |
|---|---|---|---|---|---|
| Peri-urban | Greater Geelong (C),Yarra Ranges (S) | 11,990,945 | 25,063,133 | 37,054,077 | 70 |
| Outer South West | Corangamite (S),Glenelg (S),Moyne (S),Warrnambool (C) | 4,399,954 | 5,885,657 | 10,285,611 | 19 |
| Outer North East | East Gippsland (S),Strathbogie (S),Wellington (S) | 2,267,699 | 2,681,596 | 4,949,296 | 9 |
| Outer North West | Hindmarsh (S),Horsham (RC),Mildura (RC),Swan Hill (RC),Yarriambiack (S) | 297,790 | 338,315 | 636,105 | 1 |

Source: PwC analysis. Supply volumes relate to residential and commercial construction demand.

### *5.7.4 Clay and clay shale*

Key locations supplying clay and clay shale to Greater Melbourne are listed in Table 22, ordered by the proportion of Greater Melbourne's clay and clay shale requirements each location is expected to deliver. The Inner North region comprising Greater Bendigo, Mitchell and Whittlesea provides for the majority for Greater Melbourne's clay needs, delivering approximately 50 per cent of the city's demand across 2015 to 2050, with the Inner East delivering 25 per cent.

**Table 22: Criterion 4 – Key supply locations to Greater Melbourne: Clay and clay shale**

| Region name | LGAs in region | Supply to Greater Melbourne, 2015 to 2025 (tonnes) | Supply to Greater Melbourne, 2026 to 2050 (tonnes) | Supply to Greater Melbourne, 2015 to 2050 (tonnes) | % of total supply to Greater Melbourne, 2015 to 2050 |
|---|---|---|---|---|---|
| Inner North | Greater Bendigo (C),Mitchell (S),Whittlesea (C) | 2,792,129 | 7,239,137 | 10,031,266 | 53 |
| Inner East | Knox (C),Mornington Peninsula (S),Whitehorse (C),Yarra Ranges (S) | 1,838,342 | 2,848,046 | 4,686,388 | 25 |
| Outer North East | Latrobe (C),Moira (S),Wellington (S) | 1,624,598 | 1,012,136 | 2,636,734 | 14 |
| Inner West | Ballarat (C),Golden Plains (S),Moorabool (S) | 995,559 | 562,950 | 1,558,510 | 8 |
| Outer West | Northern Grampians (S),Southern Grampians (S) | 102,356 | 45,982 | 148,338 | 1 |

Source: PwC analysis. Supply volumes relate to residential and commercial construction demand.

# 6 Scenario analysis

## 6.1 Overview

By varying levels and assumptions of both the supply and demand analyses, the scenario analysis provides some insights into the key drivers of the results. These scenarios have been implemented on the basis of PwC's discussions with industry operators, including their views on the outlook of the industry.

## 6.2 Supply scenarios

Four separate supply scenarios were modelled in the supply analysis to provide a broad picture of potential future outcomes for the industry under differing assumption sets. The scenarios implemented include:[22]

1. **Base case scenario**: the base case scenario represents the central analysis scenario under core assumptions

2. **Low supply scenario**: under this scenario industry conditions deteriorate and extractive resource outputs shrinks relative to core expectations. This could be prompted by:

   a. Poor industry outlook among industry participants

   b. Increased sterilisation of extractive resource deposits due to encroachment

3. **Medium (redistribution) supply scenario**: As part of the data gathering process, PwC and its advisors collected information from extractives industry participants on their plans for future WAs, including the locations of these WAs. The base case scenario measures the supply of extractives from current and future planned WAs based on their reported locations in the industry survey.

   Under the Medium (redistribution) scenario, identified future WAs are assumed to be situated in different locations than those used in the base case.

   Rather than the regions specified in the survey for future WAs, these are assumed to be located alongside an existing WA held by the respondent. This leads to a redistribution of future resource deposits with implications for market outcomes across the analysis period.

   This scenario has been implemented on the basis of PwC's discussions with industry operators, which point to the fact that locations proximal to existing licensed resources are likely to be identified for development of future quarries.

[22] A high supply scenario was considered in early stages of the analysis but not implemented as part of the final suite of modelling. As a high supply outcome was unlikely against any demand setting other than high demand, and a matching of high supply to high demand would not reveal significantly different results to those seen under the base case, this scenario was abandoned.

## 6.3 Integrated supply-demand scenarios

Within the integrated supply-demand analysis, seven separate scenarios were examined. Each corresponding demand and supply scenario is outlined and described in the following table.

**Table 14: Overview of the integrated supply-demand scenarios***

| Integrated supply-demand scenario | Demand scenario | Supply scenario | Description |
|---|---|---|---|
| 1 | Baseline | Base case | Reflects the most likely future outcomes based on core assumptions, expectations and survey responses |
| 2 | 1a (High) | Base case | Potential supply capacity Is unchanged but demand is 20 per cent stronger than expected under the base case. The scenario captures the potential future outcome where significant demand is expected but supply does not lift accordingly. |
| 3 | 3a (Medium – Infill) | Base case | Potential supply capacity is unchanged, however the distribution of demand is different to the base case. More demand is expected in urban infill areas and less in urban growth regions. This scenario is expected to demonstrate how a changed future growth profile toward greater urban infill for Melbourne could impact on extractives markets. |
| 4 | Baseline | Low | Supply faces greater constraints than under the base case with demand at baseline levels. Scenario 4 assesses the extent to which demand can be met in the future in Victoria where supply is constrained, and examines how this plays out in resource locations across the State. |
| 5 | 1a (High) | Low | Supply capacity is reduced; demand is 20 per cent stronger than expected under the base case. Scenario 5 is an 'extreme' case where constrained supply is expected to struggle to match strong future demand for extractives in the State. |
| 6 | 3b (Medium – Growth area) | Base case | Potential supply capacity is unchanged, however the distribution of demand is different to the base case. More demand is expected in urban growth areas and less in urban infill regions, capturing a scenario where Melbourne grows at a greater rate in fringe areas relative to current projections and infill development is lower. |
| 7 | Baseline | Medium - redistribution | Demand is at baseline levels. The distribution of supply is changed; new resource deposits are assumed to be licensed in different areas to those modelled under the supply base case. Scenario 7 examines how a different future distribution of planned future quarries could impact on extractives markets in Victoria. |

Source: PwC. *Details on the demand scenarios assumptions and results can be found in Appendix E.

## 6.4 Results of the integrated supply-demand scenarios

Table 23 provides a summary of the potential supply shortfalls that are expected to occur under each scenario for a select number of LGAs. These shortfalls are calculated from the point of view of the demand location as discussed in Section 4.2.

**Table 23: LGA potential supply shortfalls in FY50 for select LGAs under the various scenarios considered, tonnes**

| LGA | Scenario 1 (base case) | Scenario 2 | Scenario 3 | Scenario 4 | Scenario 5 | Scenario 6 | Scenario 7 |
|---|---|---|---|---|---|---|---|
| Melbourne (C) | 4,152,737 | 5,241,271 | 4,709,428 | 4,370,818 | 6,071,079 | 2,498,229 | 4,190,852 |
| Wyndham (C) | 2,124,843 | 2,661,594 | 842,026 | 2,219,081 | 3,204,345 | 3,494,815 | 2,119,499 |
| Melton (S) | 1,616,748 | 2,027,871 | 713,248 | 1,690,847 | 2,404,581 | 2,332,078 | 1,617,130 |
| Hume (C) | 1,164,016 | 1,465,186 | 1,032,799 | 1,220,988 | 1,699,527 | 1,524,513 | 1,186,107 |
| Casey (C) | 1,063,952 | 1,332,028 | 1,300,097 | 1,110,024 | 1,534,183 | 1,481,922 | 1,090,251 |
| Whittlesea (C) | 924,459 | 1,165,457 | 977,383 | 971,214 | 1,338,723 | 1,262,234 | 942,215 |
| Port Phillip (C) | 918,445 | 1,159,544 | 1,101,405 | 966,981 | 1,338,943 | 511,981 | 926,745 |
| Mitchell (S) | 911,085 | 1,194,537 | 380,469 | 995,447 | 1,469,000 | 1,120,634 | 927,416 |
| Monash (C) | 772,985 | 971,846 | 901,938 | 809,871 | 1,103,675 | 758,109 | 780,892 |
| Greater Dandenong (C) | 761,496 | 956,014 | 854,153 | 796,678 | 1,085,169 | 662,431 | 772,785 |
| Moreland (C) | 712,208 | 904,519 | 853,234 | 753,766 | 1,050,224 | 535,756 | 723,686 |
| Total Victoria | 29,995,373 | 38,160,104 | 30,308,877 | 31,843,455 | 44,896,589 | 31,448,089 | 29,807,369 |

Source: PwC analysis

### 6.4.1 Key differences between scenarios

The two materially different scenarios from the base case are scenarios 2 and 5.

In scenario 2, where high demand is considered against the base case supply profile, the top 11 LGAs presented above are estimated to experience an average additional supply shortfall of 26 per cent, compared to the base case.

Under scenario 5, the analysis has considered a 'severely constrained' scenario where supply capacity is reduced and demand is higher than baseline. In this scenario, the top 11 LGAs presented above are estimated to experience an average additional supply shortfall of 47 per cent or nearly one-and-a-half times higher, compared to the base case.

Under scenario 3, the analysis has considered a base case supply profile against a redistribution of demand. This time the analysis was undertaken using a demand profile which considers more infill development through increased residential development. These results for the top 11 LGAs presented above illustrate, on average, a reduction of supply shortfall against the base case of 10 per cent will occur.

In scenario 7, the analysis has considered baseline demand levels against a redistribution of supply. Under this scenario, new work authority applications are assumed to be lodged for sites in close proximity to existing work authorities rather than the sites nominated by respondents in the surveys and interviews. These results are not materially different from the base case only resulting in an additional supply shortfall of 1 per cent.

### 6.4.2 Regional analysis

Significant regional differences emerge among the scenarios in terms of potential supply shortfalls.

For example, Ballarat faces a potential supply shortfall of 388,000 tonnes in FY50 under the base case, however under scenario 2 the estimated potential shortfall is 34 per cent greater at 521,000 tonnes. Similarly, Greater Bendigo experiences a 47 per cent increase in its estimated potential supply shortfall in FY50 under scenario 2 relative to the base case. On the other hand, the differences for Melton are lower. Its potential supply shortfall under scenario 2 is 25 per cent greater than under the base case, which is significantly lower than the increases seen in Ballarat and Greater Bendigo.

These results emerge under scenario 2 despite demand in each region increasing by 20 per cent relative to the base case and supply remaining unchanged across the State.

These relativities highlight the varied underlying supply profiles of different regions and how Victorian localities are seen to compete for scarce extractive resources. Despite demand increasing uniformly across each Victorian locality, the increased exhaustion of some resources before others that results from this can have varied effects by location. With the largest, most populous locations drawing a larger share of available supply, there are winners and losers in terms of potential locational supply shortfalls in the State.

### 6.4.3 Sensitivity analysis

The key differences between scenarios highlighted above provide some indication of the sensitivity of the results to different assumptions and input values. The value of resource demand by location appears to be the key driver of these differences between scenarios.

In total across all LGAs, the potential supply shortfall under the base case is estimated to be 30 million tonnes in FY50. Under scenario 2 where supply is at base case levels and demand is 20 per cent above the base case, this potential shortfall is 27 per cent higher at 38.2 million tonnes. In scenario 4 where supply is constrained and demand is at base case levels, the potential aggregate shortfall is only six per cent different to base case levels at 31.8 million tonnes in FY50.

These findings suggest that extractive resource demand is the key driver of the differences between scenarios, while lowering supply capacity is less influential.

Taking a view within a particular LGA also supports these findings. For instance, in comparing the potential FY50 shortfalls identified for Melbourne LGA under scenarios 2 and 4, the difference against the base case potential shortfall (4.2 million tonnes) is much greater in scenario 2 (5.2 million tonnes) than it is in scenario 4 (4.4 million tonnes).

It is noted that the results under scenario 7, where some redistribution of supply is modelled, are also not significantly different from those under the base case.

### 6.4.4 Potential for further market impacts

In light of the potential supply shortfalls identified in Table 23, some impacts to extractive resource prices are anticipated to occur in the future. These impacts would likely be different depending on the relative size of the potential shortfalls, meaning the different scenarios could result in different outcomes for extractives market prices.

While measurement of the expected downstream market impacts is beyond the scope of this study, some discussion these impacts is provided as context for the scenario analysis.

Scenarios 2 and 5 are expected to result in the greatest potential supply shortfalls among the scenarios considered. Due to these large potential shortfalls, existing suppliers could gain greater market pricing powers and could put upward pressure on the price of extractive resources. These inflationary effects would likely be passed on to consumers throughout the supply chain.

However, as prices start to rise, it would become more attractive for new firms to enter the industry, or alternatively, for previous participants to re-enter the industry. This could erode the market power of existing suppliers and lead to some moderation of extractives prices, and potentially also increase the relative attractiveness of recyclable materials.

As an illustrated illustrative example, an industry survey participant noted it was currently more profitable to convert their existing quarry site into a temporary landfill. Price rises for extractive resources could lead such operators to re-enter the market as the profitability of quarrying could subsequently outweigh that of operating a landfill site.

Therefore, these scenarios should not be considered in absolute and the potential impact of these market dynamics should be recognised.

# 7 Transport cost analysis

## 7.1 Overview of the transport cost analysis

The granular integrated supply and demand modelling undertaken by PwC as part of this study utilises an origin-destination matrix of WAs (origins) and Victorian localities (destinations) to understand transport distances across the road network for extractive resources. This means that for each Victorian WA and locality considered in the analysis, the distance by road between each is known.

In addition to these transport distances, the modelling measures the resource volumes flowing from each origin WA to the set of matching demand destinations. These two items can be combined with the Cost Reckoner[23] to compute the transport cost associated with each resource flow from WA to demand site in the State from 2015-50.[24] Both the transport costs to industry and the associated non-market costs to society, described here as externality costs, are measured using this approach.

Respondents to the industry survey issued as part of this study were asked to indicate how their extractive resources were delivered to market. Overwhelmingly respondents indicated that trucks and trucks with trailers were used to transport these materials within the State, with only a single survey participant indicating limited use of rail transport.

Given these findings, the study has considered only those transport costs associated with road transport of quarry materials. The potential for different modes to be used in future is acknowledged, however. PwC understands, for instance, that extractive resources are regularly transported via the rail network in New South Wales (NSW).[25]

It is noted however that the rail network in NSW is more extensive than the existing Victorian network, which could limit the potential for Victorian industry operators to utilise the local network in the near term. Despite this the analysis acknowledges that any future additions to the Victorian rail network and/or increased cost competitiveness of rail versus other transport modes could induce greater utilisation of rail for transporting quarry products in the State.

## 7.2 Estimation of transport costs

The volume (in tonnes) of extractive resources flowing from each work authority to each demand location and the associated distances travelled were analysed. The data was then summarised into 6 distance bands up to a maximum threshold of 300kms and the unit transport costs were then applied.

The results of the analysis suggest that in order to meet the demand for extractive resources over the 2015 to 2050 analysis period, consumers will need to source some materials from further away as existing quarries and associated resource become exhausted. A methodology

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[23] The Cost Reckoner provides a breakdown of transport costs by tonne-kilometre for extractive resources in Victoria. The reckoner specifies different models for different region types (urban stop-start, urban free-flow and rural) and was issued to PwC by EY as part of the Demand study.

[24] PwC has applied the Cost Reckoner based on information provided by EY in relation to its development and application of the Reckoner for its own analysis. PwC has not verified or otherwise the appropriateness of the Reckoner for use in this case; rather PwC relies on DEDJTR in assuming that the Reckoner has been correctly developed, tested and validated and that its use in this context is appropriate.

[25] PwC, *Sydney construction materials supply chain investigation: Phase 1 and 2*, 2016.

to estimate potential transport costs for extractive resources was developed to reflect these expectations. This methodology is summarised in Figure 43 below.

**Figure 43: Method for estimating transport costs**


Source: PwC

Where demand is sourced from further afield in future, further infrastructure upgrades could be required to support delivery of this material. This could result in additional costs that are not identified here.

Estimates of transport cost increases prepared using the above methodology have been combined with industry rules-of-thumb for typical construction project extractives costs. This analysis provides for estimation of potential cost increases that could occur in future Victorian construction projects.

The estimates of transport costs presented below comprise costs faced by industry along with those borne by society in terms of social and environmental costs associated with the transport of quarry materials across Victorian roads. A further breakdown of these costs is provided in Section 7.3.4 below.

## 7.3 Results

The results presented here represent conservative estimates of extractive resource input cost increases. This is examined solely through a transport cost lens and does not capture any potential additional flow-on market impacts that could result from these transport costs. Section 6.4.4 provides some discussion of potential flow-on market dynamics and their potential impact in the context of this study.

This is a conservative estimate of the overall impact. Stakeholder consultation has revealed that extractive resources represent on average 35 per cent of total project costs for a typical residential or commercial construction project, when considering only the material costs.[26], As this is a relatively large proportion of overall project costs, market price implications flowing from potential supply constraints and increases in transport costs may also need to be considered. If the industry experiences an average increase of 10 per cent in the cost of extractive resources resulting from supply constraints, this could represent an average 3.5 per cent increase of project costs across the State.

The analysis has estimated that an extra $2 billion of transport costs[27] would be incurred across 2015 to 2050 for every additional 25 kilometre distance over which material is delivered. This figure represents the cost uplift of meeting the aggregate supply shortfalls across all locations from 2015 to 2050 by accessing material from quarries 25km further away than those currently used.

If this cumulative shortfall amount was instead sourced from quarries 50km further away, this would result in $4 billion of additional transport costs instead.

In addition to transport cost increases, the nearly doubling of demand for extractive resources, from 46.4 million tonnes in 2015 to 87.8 million tonnes in 2050, will lead to an

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[26] Excludes the costs associated with transporting these materials and any associated labour costs.

[27] This transport cost figure represents the additional cost to industry and associated social and environmental (or 'externality') costs to society.

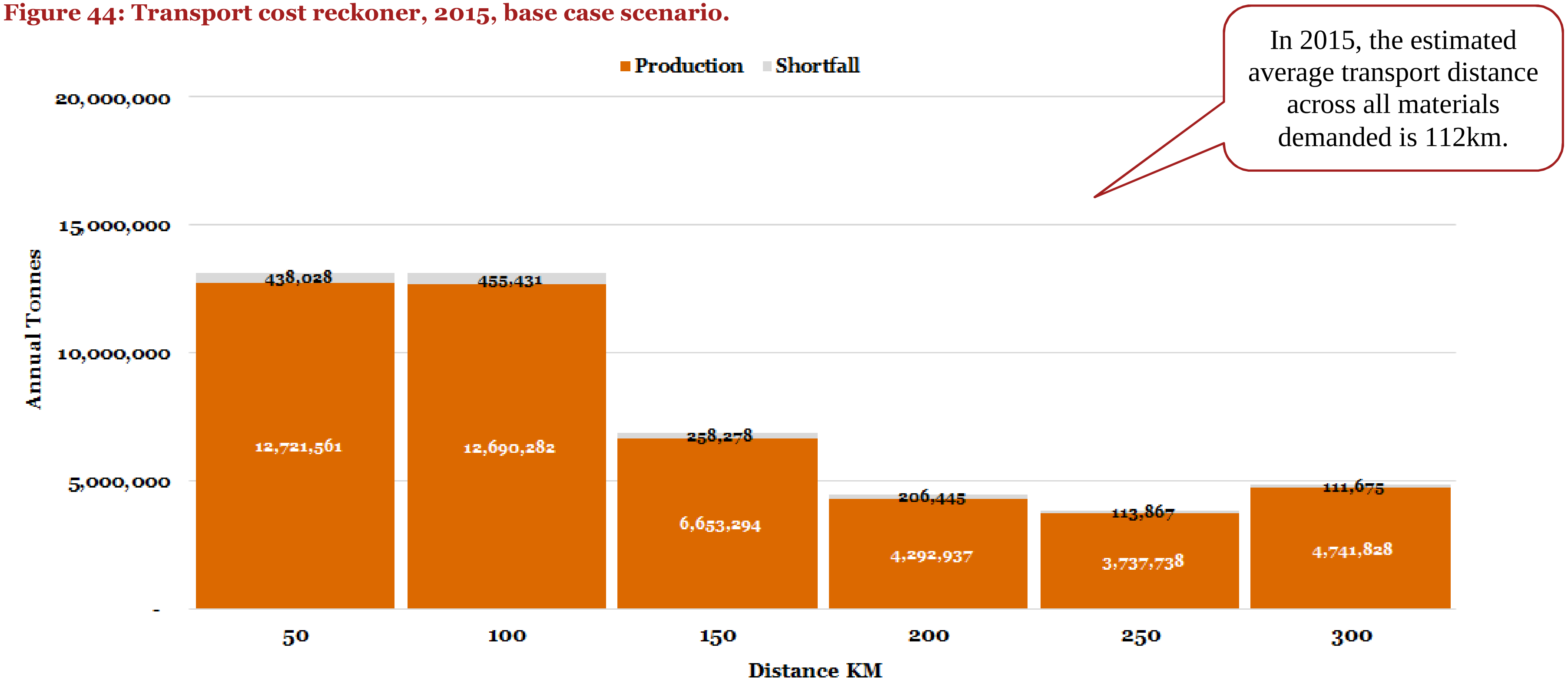
increase in the need for transport infrastructure to transport resources from quarries to the sources of demand. This may warrant examination of the need to support additional infrastructure to support this.

Currently in Victoria, all extractive resources are being transported via the road network with the exception of one company which uses a combination of the rail network and truck transport. Industry consultations undertaken in support of the analysis have ascertained there is an established truck network with some companies owning their own truck fleet for purposes of delivering resources from quarry site to demand point.

### *7.3.1 Detailed results: 2015*

Figure 44 describes the volumes of production and potential supply shortfalls across the six distance bands in 2015. For example, the figure shows that 12.7 million tonnes of material is estimated to be transported between zero and 50km, while the potential supply shortfall within this distance band is 0.4 million tonnes.

**Figure 44: Transport cost reckoner, 2015, base case scenario.**




Source: PwC analysis

Table 24 provides detailed results of the transport cost estimation for 2015. The table details the level of production supplied by distance band in tonnes and the estimated cost associated with this production level. These results are summed across the distance bands to provide a total cost estimate for production supplied in 2015 of approximately $600 million.

Table 24 also details the average distance travelled for production supplied within each distance band; in the 50-100km distance band this distance is 72.9km, for example. The average cost per tonne/kilometre is also presented, illustrating the average cost associated with delivering a tonne of material across each distance band.

The total transport cost within each distance band is estimated as the sum of the transport costs associated with production supplied and that of delivering the potential supply shortfall from the next distance band. The cost uplift amount captures the increase in transport cost that emerges due to potential shortfalls being satisfied by quarries in the next distance band, and the proportional cost uplift of delivering the shortfall represents the percentage increase in transport costs that results from this.

**Table 24: Transport cost reckoner, 2015, base case scenario.**

| # | Distance Band (km) | 0-50 | 50-100 | 100-150 | 150-200 | 200-250 | 250-300 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| 1 | Total Production Supplied (tonnes) | 12,721,561 | 12,690,282 | 6,653,294 | 4,292,937 | 3,737,738 | 4,741,828 | 44,837,640 |
| 2 | Total Shortfall (tonnes) | 438,028 | 455,431 | 258,278 | 206,445 | 113,867 | 111,675 | 1,583,724 |
| 3 | **Transport Cost - Production Supplied ($)** | **56,174,410** | **127,800,838** | **100,866,786** | **85,547,755** | **91,444,409** | **138,417,371** | **600,251,569** |
| 4 | Avge. km / tonne | 29.7 | 72.9 | 121.9 | 172.8 | 224.8 | 276.9 | |
| 5 | Avge. Transport $ per tonne / km | 0.149 | 0.138 | 0.124 | 0.115 | 0.109 | 0.105 | |
| | **Incremental transport cost of delivering shortfall against next distance band** | | | | | | | |
| 6 | At current band ($) | 1,934,192 | 4,586,539 | 3,915,609 | 4,113,953 | 2,785,764 | 3,259,866 | 20,595,922 |
| 7 | At next band ($) | 4,411,272 | 6,904,530 | 5,146,855 | 5,050,722 | 3,323,845 | 3,848,573 | 28,685,797 |
| | **Cost Uplift ($)** | **2,477,080** | **2,317,991** | **1,231,246** | **936,770** | **538,081** | **588,707** | **8,089,875** |
| | **Total Transport Cost ($)** (Equal to #3 + #7) | **60,585,682** | **134,705,367** | **106,013,641** | **90,598,477** | **94,768,255** | **142,265,944** | **628,937,367** |
| | Proportional cost uplift of delivering shortfall | 4.3% | 1.8% | 1.2% | 1.0% | 0.6% | 0.4% | 1.3% |

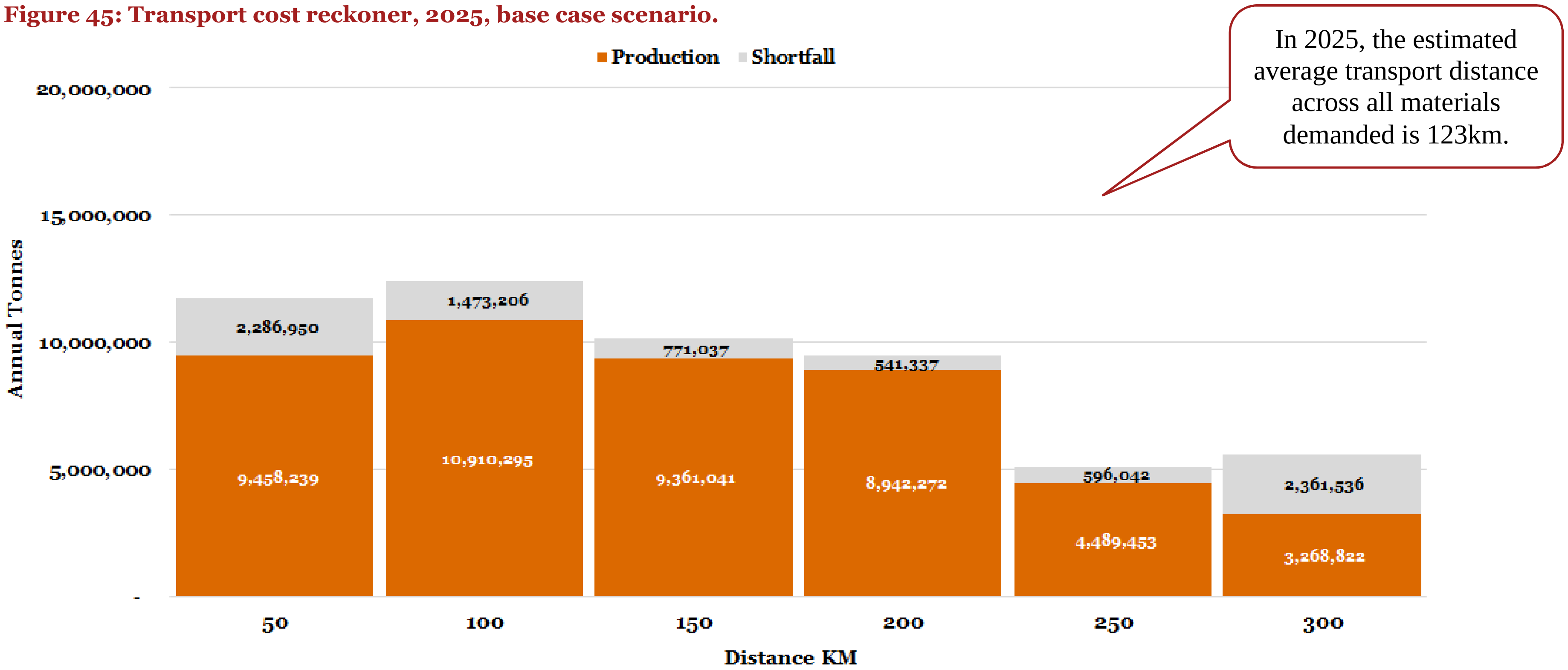
Source: PwC analysis

## *7.3.2 Detailed results: 2025*

Key insights into the transport cost reckoner can be drawn from comparing the changes in distance bands across the milestone years presented.

Figure 45 describes the volumes of production and potential supply shortfalls across the six distance bands in 2025. Comparing these results against Figure 44 demonstrates how the potential supply shortfalls are expected to grow through time due to exhaustion of current and planned future licensed reserves.

**Figure 45: Transport cost reckoner, 2025, base case scenario.**




Source: PwC analysis

Table 25 details the transport cost estimates for the 2025 year.

**Table 25: Transport cost reckoner, 2025, base case scenario.**

| # | Distance Band (km) | 0-50 | 50-100 | 100-150 | 150-200 | 200-250 | 250-300 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| 1 | Total Production Supplied (tonnes) | 9,458,239 | 10,910,295 | 9,361,041 | 8,942,272 | 4,489,453 | 3,268,822 | 46,430,122 |
| 2 | Total Shortfall (tonnes) | 2,286,950 | 1,473,206 | 771,037 | 541,337 | 596,042 | 2,361,536 | 8,030,108 |
| 3 | **Transport Cost - Production Supplied ($)** | **48,529,781** | **126,050,306** | **159,521,807** | **215,540,309** | **129,868,747** | **109,917,787** | **789,428,738** |
| 4 | Avge. km / tonne | 29.8 | 73.5 | 124.8 | 171.6 | 225.5 | 275.6 | |
| 5 | Avge. Transport $ per tonne / km | 0.172 | 0.157 | 0.137 | 0.140 | 0.128 | 0.122 | |
| | **Incremental transport cost of delivering shortfall against next distance band** | | | | | | | |
| 6 | At current band ($) | 11,734,232 | 17,020,449 | 13,139,265 | 13,048,126 | 17,242,005 | 79,409,281 | 151,593,359 |
| 7 | At next band ($) | 26,421,902 | 25,104,958 | 18,584,711 | 15,659,530 | 20,042,561 | 93,814,322 | 199,627,984 |
| | **Cost Uplift ($)** | **14,687,670** | **8,084,509** | **5,445,446** | **2,611,404** | **2,800,556** | **14,405,041** | **48,034,625** |
| | **Total Transport Cost ($)** (Equal to #3 + #7) | **74,951,683** | **151,155,264** | **178,106,518** | **231,199,839** | **149,911,308** | **203,732,109** | **989,056,722** |
| | Proportional cost uplift of delivering shortfall | 24.4% | 5.7% | 3.2% | 1.1% | 1.9% | 7.6% | 5.1% |

Source: PwC analysis

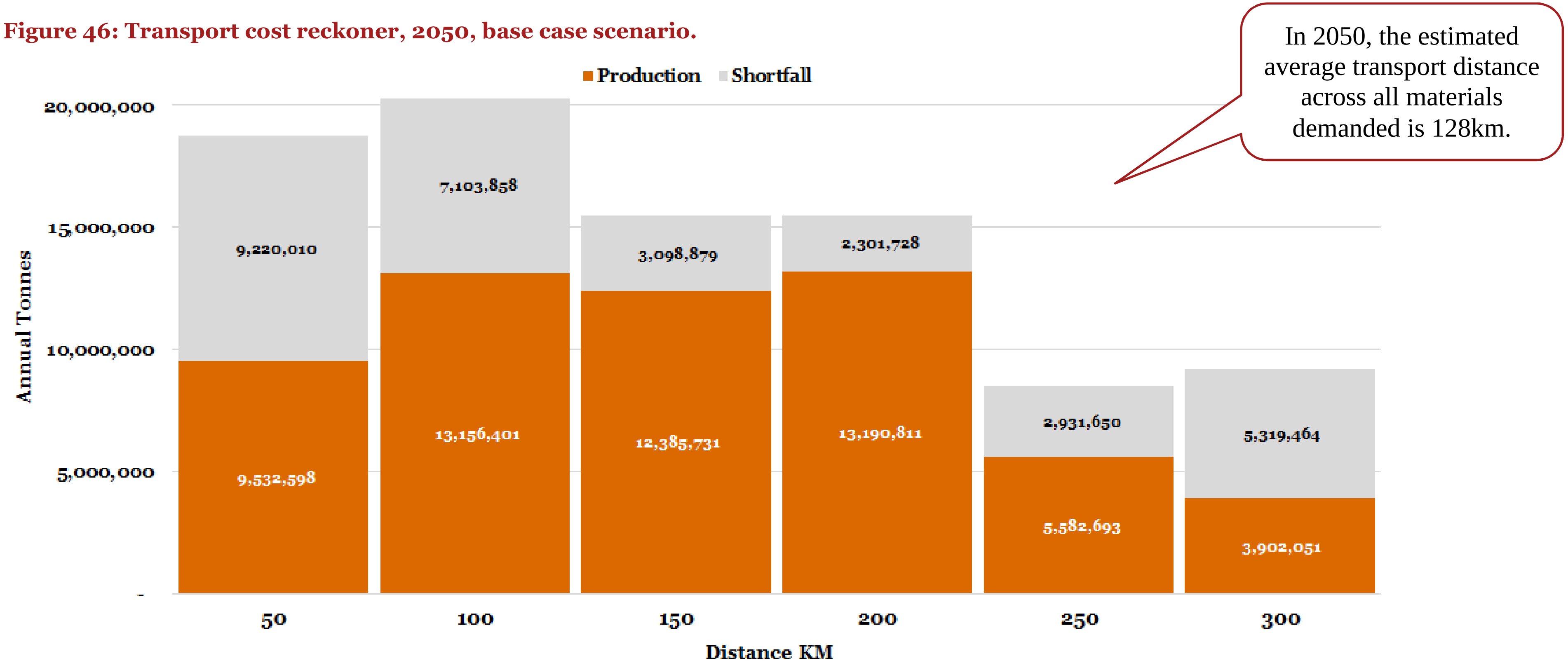
The estimates presented in Table 25 suggest that transport cost increases can be expected across all distance bands relative to 2015, due in part to increases in potential supply shortfalls across the period and associated growth in the estimated cost uplift of meeting that demand. For example, the potential supply shortfall in the 0-50km distance band in 2025 is 2.3 million tonnes compared to 0.4 million tonnes in 2015. The cost of delivering this shortfall volume from the next distance band in 2025 is $26.4 million, while in 2015 this amount was $4.4 million.

Total transport costs in 2025 are estimated to be close to $1 billion, up from $629 million in 2015.

## *7.3.3 Detailed results: 2050*

Figure 46 describes the volumes of production and potential supply shortfalls across the six distance bands in 2050, illustrating the large potential supply shortfalls that are expected to emerge across all distance bands by this time.

**Figure 46: Transport cost reckoner, 2050, base case scenario.**




Source: PwC analysis

Table 26 details the transport cost estimates in 2050.

**Table 26: Transport cost reckoner, 2050, base case scenario**

| # | Distance Band (km) | 0-50 | 50-100 | 100-150 | 150-200 | 200-250 | 250-300 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| 1 | Total Production Supplied (tonnes) | 9,532,598 | 13,156,401 | 12,385,731 | 13,190,811 | 5,582,693 | 3,902,051 | 57,750,285 |
| 2 | Total Shortfall (tonnes) | 9,220,010 | 7,103,858 | 3,098,879 | 2,301,728 | 2,931,650 | 5,319,464 | 29,975,589 |
| 3 | **Transport Cost - Production Supplied ($)** | **79,029,214** | **238,684,404** | **336,788,038** | **498,137,441** | **254,590,090** | **206,675,656** | **1,613,904,844** |
| 4 | Avge. km / tonne | 29.9 | 73.2 | 125.7 | 170.7 | 225.8 | 275.4 | |
| 5 | Avge. Transport $ per tonne / km | 0.277 | 0.248 | 0.216 | 0.221 | 0.202 | 0.192 | |
| | **Incremental transport cost of delivering shortfall against next distance band** | | | | | | | |
| 6 | At current band ($) | 76,437,732 | 128,878,715 | 84,263,529 | 86,922,401 | 133,693,343 | 281,750,218 | 791,945,938 |
| 7 | At next band ($) | 167,270,113 | 193,165,370 | 117,025,989 | 104,966,746 | 155,277,479 | 332,905,307 | 1,070,611,005 |
| | **Cost Uplift ($)** | **90,832,382** | **64,286,655** | **32,762,460** | **18,044,345** | **21,584,136** | **51,155,089** | **278,665,067** |
| | **Total Transport Cost ($)** (Equal to #3 + #7) | **246,299,328** | **431,849,774** | **453,814,028** | **603,104,187** | **409,867,570** | **539,580,962** | **2,684,515,849** |
| | Proportional cost uplift of delivering shortfall | 58.4% | 17.5% | 7.8% | 3.1% | 5.6% | 10.5% | 11.6% |

Source: PwC analysis

Significant growth in the transport costs associated with delivering extractive resources is expected between 2025 and 2050. As Table 26 shows, total transport costs are estimated to reach approximately $2.7 billion by 2050, compared to just under $1 billion in 2025. The cost uplift associated with delivering supply from further afield is approximately 11.6 per cent, at $279 million.

Considering growth between estimated current transport costs and 2050 illustrates that significant increases are expected in transport costs across all distance bands. Within the 0-50km band a four-fold increase is expected between 2015 and 2050, with total estimated transport costs increasing from $60.6 million to $246.3 million. A more than three-fold increase is seen in the 50-100km band, growing from $134.7 million in 2015 to $431.8 million in 2050. Similar increases are seen across other distance bands.

## *7.3.4 Costs to industry and to society*

The transport cost reckoner estimates presented here comprise a combination of transport costs to industry and associated social and environmental (or 'externality') costs to society. These externality costs comprise the following items:

- air pollution
- greenhouse gas emissions

- noise pollution
- water pollution
- nature and landscape
- urban separation
- upstream and downstream costs.[28]

Externality costs comprise approximately 45 per cent of the total estimated transport costs presented here.[29] This suggests that industry could expect to bear just under half of these estimated costs, with the remaining costs comprising social and environmental costs that would be borne by Victorian society more broadly.

### *7.3.5 Comparison to other scenarios*

Different levels of estimated transport costs are associated with each scenario. This is largely due to differing distributions and/or levels of demand and licensed reserves in each region and the associated changes in potential supply and production shortfalls in different resource locations.

The analysis has considered in detail the transport cost estimates under scenario 6, which considers a shift in demand towards urban growth areas with less demand in urban infill regions, while holding supply at base case levels.

Results are presented for the 2050 analysis year to provide for a comparison against the transport cost estimates presented above under the base case scenario. Figure 47 describes the volumes of production and potential supply shortfalls across the six distance bands in 2050 under scenario 6.

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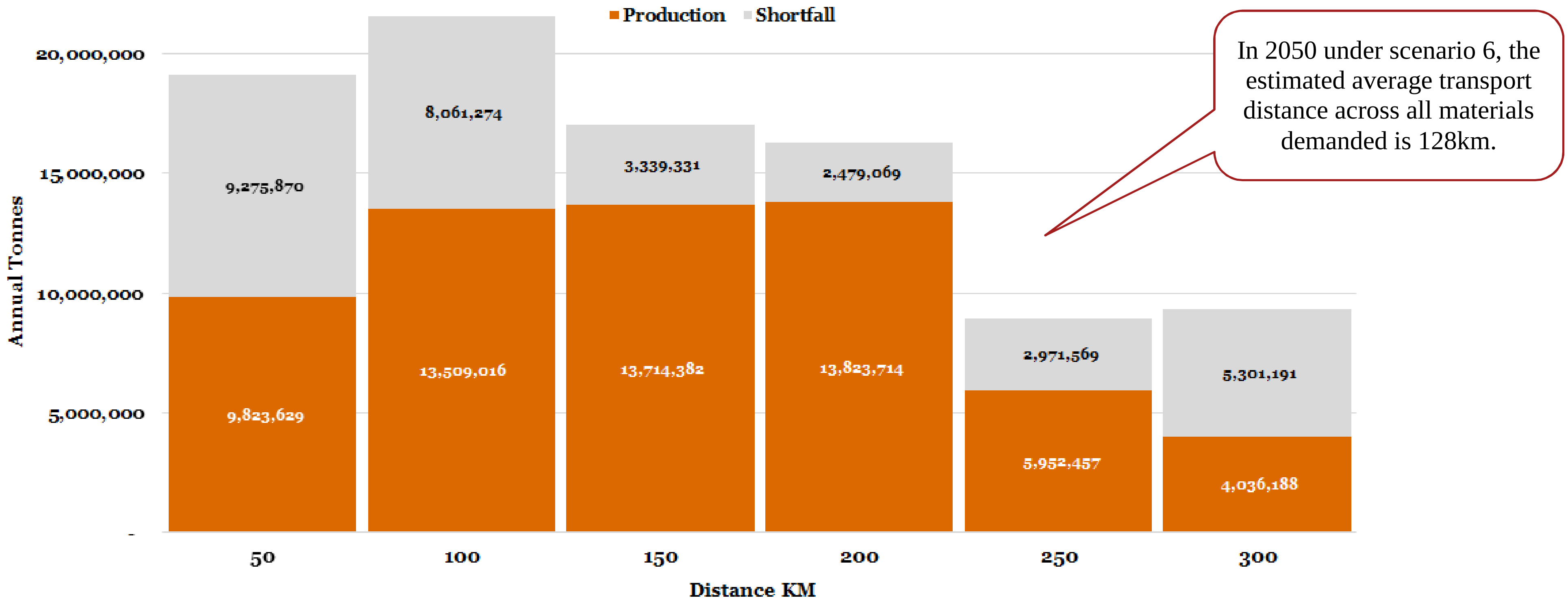
[28] EY, Demand analysis of extractive resources in Victoria, 2016

[29] On average, across the 2015-2050 analysis period.

**Figure 47: Transport cost reckoner, 2050, Scenario 6 (base case supply and increased demand in urban growth areas)**




Source: PwC analysis

The level and distribution of potential supply shortfalls in 2050 under scenario 6 differ from those under the base case scenario for the same period. For example, the potential supply shortfall in the 250-300km distance band is 5.30 million tonnes under scenario 6, while the corresponding amount under the base case is 5.31 million tonnes. In the 50-100km distance band the shortfall amount under scenario 6 is 8.1 million tonnes while under the base case this amount is 7.1 million tonnes.

As expected, these differences are reflected in the estimated transport costs under each scenario. Table 27 presents the detailed transport cost estimates under scenario 6.

**Table 27: Transport cost reckoner, 2050, Scenario 6 (base case supply and increased demand in urban growth areas)**

| # | Distance Band (km) | 0-50 | 50-100 | 100-150 | 150-200 | 200-250 | 250-300 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| 1 | Total Production Supplied (tonnes) | 9,823,629 | 13,509,016 | 13,714,382 | 13,823,714 | 5,952,457 | 4,036,188 | 60,859,387 |
| 2 | Total Shortfall (tonnes) | 9,275,870 | 8,061,274 | 3,339,331 | 2,479,069 | 2,971,569 | 5,301,191 | 31,428,304 |
| 3 | **Transport Cost - Production Supplied ($)** | **78,028,294** | **245,787,850** | **373,919,374** | **535,326,156** | **271,615,255** | **213,477,063** | **1,718,153,991** |
| 4 | Avge. km / tonne | 29.4 | 73.0 | 124.9 | 173.9 | 226.0 | 275.7 | |
| 5 | Avge. Transport $ per tonne / km | 0.270 | 0.249 | 0.218 | 0.223 | 0.202 | 0.192 | |
| | **Incremental transport cost of delivering shortfall against next distance band** | | | | | | | |
| 6 | At current band ($) | 73,677,486 | 146,669,686 | 91,046,075 | 96,002,463 | 135,595,022 | 280,384,022 | 823,374,755 |
| 7 | At next band ($) | 168,768,484 | 219,788,710 | 129,316,288 | 113,121,873 | 157,168,543 | 331,241,255 | 1,119,405,152 |
| | **Cost Uplift ($)** | **95,090,998** | **73,119,025** | **38,270,213** | **17,119,409** | **21,573,520** | **50,857,233** | **296,030,397** |
| | **Total Transport Cost ($)** (Equal to #3 + #7) | **246,796,777** | **465,576,560** | **503,235,662** | **648,448,029** | **428,783,797** | **544,718,318** | **2,837,559,143** |
| | Proportional cost uplift of delivering shortfall | 62.7% | 18.6% | 8.2% | 2.7% | 5.3% | 10.3% | 11.6% |

Source: PwC analysis

Comparing transport cost estimates under scenario 6 with those under the base case scenario, the analysis notes that the total transport cost under scenario 6 is greater under every distance band. This is in part because the total level of demand is greater under scenario 6 than the base case, meaning a greater volume of material needs to be delivered across the road network.

The average distance travelled within each distance band is lower in scenario 6 for the 0-50, 50-100 and 100-150km ranges at 29.4, 73.0 and 124.9km respectively compared with 29.9, 73.2 and 125.7km under the base case. However, within the more distant ranges the trend is reversed, with scenario 6 showing that material in these bands travels further, on average, compared to the base case.

Importantly, these differences are reflected in the average cost per tonne figures for each distance band. This means that under scenario 6, material is delivered at slightly lower costs in the closer distance bands and at slightly higher cost in the more distant bands, relative to the base case. Across all of the distance bands these differences would be expected to balance out, which suggests that the differences in total transport costs between the two scenarios in 2050 are largely due to their different underlying levels of resource demand.

This could in part reflect the fact that the distribution of demand is not largely different under scenario 6 when compared to the base case. A more divergent distribution would be expected to result in more significant differences in transport cost estimates that is presented above. This could emerge for example where significantly greater urban development was expected in Victoria's regions compared to base case projections, which would result in greater volumes of material being transported to different demand destinations than is currently anticipated.

# 8 Conclusions

*The industry faces current challenges…*

The extractive resources industry currently faces challenges in maintaining access to supplies of quality extractive resources. This is due to a combination of rising demand and encroachment of urban and regional development into existing resource areas.

*…and the analysis suggests these could constrain the future supply of extractive resources.*

Despite relatively significant volumes of material held in current and planned future licensed WAs, the granular analysis presented here suggests that Victoria could potentially face constrained supply of some extractive resources in the future. This is because many of these resources are not necessarily ideally located to service projected demand. This could be due in part to the issue of encroachment mentioned above.

*The costs flowing from these constraints could be significant.*

Any such supply constraints would be expected to have flow-on impacts in terms of increased transport costs as resources must be sourced from more distant locations to those currently used.

In addition to transport cost increases, the nearly doubling of demand for extractive resources over the period will lead to an increase in the need for transport infrastructure to transport resources from quarries to the sources of demand. This may warrant examination of the need to provide additional infrastructure to support this.

*The analysis provides a guide to which areas should receive the greatest focus to address these potential costs…*

Chapter 5 identifies 15 key extractive resource areas within Victoria that are likely to be critical to the State's future development. The assessment detailed in Chapter 5 provides a framework that could be used to guide future decision making around prioritisation of different activities where competition for the same or adjacent pieces of land emerge.

*…along with some indication of the price of inaction.*

If quarry development in the above identified areas of critical supply is not supported, this could lead to potential supply shortfalls emerging. This will, in turn, have flow on effects to the industries which rely heavily on these resources including, building construction (residential and non-residential), and engineering construction (transport, energy and utilities).

In addition to these direct effects, there will be wider impacts on the entire supply chain including industries which support the construction sector (e.g. supplier of services to the construction industry) as well as households across Victoria (e.g. employment and wages and salaries may be affected, which in turn affect household consumption of goods and services). These economy-wide impacts will likely have a material effect on the broader economy through changes in levels of economic growth, as measured by GSP, household consumption and employment. However, these economy-wide impacts have not been specifically considered in this study.

Industry participants have advised PwC that licensing new resource deposits is costly and time consuming. Issues such as these could limit Victoria's capacity to respond quickly to any future scenario where the supply of extractive resources is constrained. The potential cost impacts that could flow from such a scenario, as discussed above, provide some indication of the price to the State of allowing the status quo to continue.

# Appendices

# Appendix A *Response confidentiality*

*Aggregation triggers*

The aggregation triggers to preserve respondent confidentiality include:

- **Aggregation by region**

  a) Grouping of work authorities of the same rock type by LGA

  b) Grouping of LGAs into broader regions representing groups of two or more LGAs in cases where aggregation a) does not ensure respondent confidentiality

- **Aggregation by rock type**

  a) Grouping of work authorities across two or more rock types within a particular region, provided the grouping is still meaningful to the reader (i.e. information on the characteristics of the underlying resource(s) is not lost in the aggregation). Table 28 in Appendix D provides further detail on how rock types have been grouped into rock categories for this purpose.

*Rationale for the triggers*

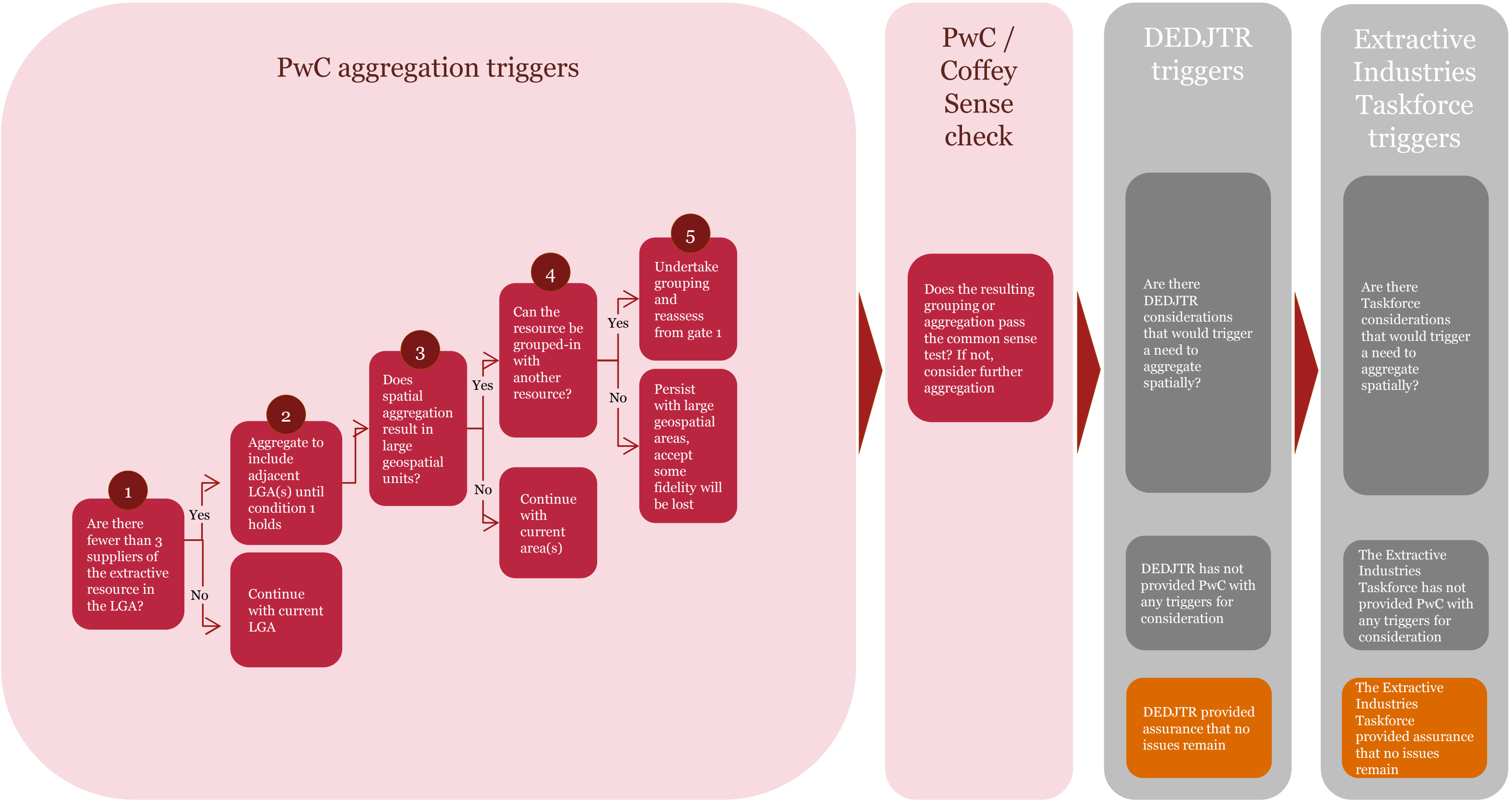
The confidentiality triggers were tested and confirmed with DEDJTR and the Taskforce as being the most appropriate mechanisms for aggregation to protect survey respondent confidentiality while also allowing for meaningful presentation of the study's results.

The regional aggregation triggers were seen to offer a strong mechanism to preserve confidentiality while also providing sufficient spatial granularity as to be meaningful for policy consideration purposes. Aggregation by rock type was suggested as a potential alternative to regional aggregation in situations where spatial aggregation could result in significant loss of fidelity, as it allows for preservation of relatively small geospatial reporting areas.

*Implications for reporting of results*

While the analysis occurs at the level of each individual work authority and resource, application of these triggers means that reporting of strategic resources and resource locations generally occurs at the LGA level or higher. In some cases, resource 'categories' are presented instead of individual resources. Similarly, the broader results presented in this report are aggregated spatially or otherwise in many cases.

**Figure 48: Overview of the confidentiality triggers**




Source: PwC

# Appendix B *Assumptions*

## *Rock type categorisation*

The analysis has assessed the supply and demand for 18 separate rock types. These rock types correspond to those listed in Schedule 2 to the *Mineral Resources (Sustainable Development) (Extractive Industries) Regulations 2010*. The rock types considered were agreed with DEDJTR on commencement of the study.

Due to the high number of resources considered in the analysis, several rock types were grouped together under a common category for reporting purposes. This relates primary to resources considered within the industry as 'hard rock'. The basis for this grouping was agreed with DEDJTR and based on the advice of industry experts.

The 18 resources considered in the analysis and their associated resource categories are described in Table 28 below.

**Table 28: Rock type mapping to resource categories***

| Rock/resource type | Resource category |
|---|---|
| Basalt Old | Hard rock |
| Basalt New | Hard rock |
| Trachyte | Hard rock |
| Dolerite | Hard rock |
| Granite (Incl. Granodiorite, Porphyry, Micrograntes) | Hard rock |
| Rhyodacite (Incl. Dacite, Rhyolite) | Hard rock |
| Scoria | Hard rock |
| Tuff | Hard rock |
| Gneiss | Hard rock |
| Hornfels | Hard rock |
| Marble | Hard rock |
| Quartzite | Hard rock |
| Schist | Hard rock |
| Slate | Hard rock |
| Sedimentary (Usually Rippable Rocks Incl. Sandstone, Shale, Siltstone Chert, Mudstone, Claystone) | Hard rock |
| Clay And Clay Shale | Clay and clay shale |
| Sand And Gravel | Sand and gravel |
| Limestone | Limestone |

Source: PwC, DEDJTR. *Soil and peat were not considered in the analysis despite being considered extractive resources.

## *Missing data items*

Due to missing and incomplete survey responses, methods were developed to attribute assumed production and deposit values for some existing WAs. These methods leveraged DEDJTR records in combination with available survey data to appropriately account for missing information. The assumptions applied in this regard are detailed below.

*Missing production rate data*

The DEDJTR database of Victorian WAs provided to PwC contained 2013-14 production rate data for each Victorian WA. These values assumed to be relevant for 2014-15 production for WAs where survey data was missing or incomplete.

For indicated future WA applications where planned production rate information was not available, the attributable production rate was assumed to be 1/50 of the provided deposit. This ratio was applied based on the levels seen among other survey respondents in terms of deposit sizes and production rates.

It is noted that in both of the above cases, the production rate values were not necessarily applied for 2014-15 or later production but rather provided a guide as to the productive capacity of the WAs.

*Missing WA resource deposit values*

For WAs where no deposit size information was provided in the survey, deposit tonnages were calculated as follows:

1. The average time to depletion (in years) was calculated for each rock type considered, based on available survey information for other Victorian WAs of that rock type.

2. This average was then multiplied by the known current or historical production rate for each WA for which deposit information was missing, for each applicable rock type. The calculation resulted in a unique deposit size for each of these WAs that accounted for differences in rock type and WA size and capacity (as measured by the current or historical production rate).

These assumptions and calculations were then validated against similar quarries where deposit sizes were known, which found that appropriate values had been developed using the approach.

The results were also tested to determine whether deposit sizes could differ by respondent type – that is, whether large-scale producers typically held larger or smaller deposits than small-scale producers. The results of this test illustrated that no such relationship existed and that the approach resulted in attributed deposit sizes that were broadly in line with known deposits, for those resources.

WAs that were missing both production rate and deposit information from the industry survey and the DEDJTR WA database were not included in the analysis.

*Missing rock type information*

For WAs where no rock type information was provided in the survey, the DEDJTR database reported rock type was assumed. WAs missing both survey and DEDJTR rock type information were excluded from the analysis.

For some quartzite WA holders, no deposit sizes were indicated in the industry survey. In order to generate deposit values for WAs producing quartzite, known production data were interacted with an assumed quarry life of 20 years to attribute a deposit value.

*Missing locational information*

For some future WA applications indicated in the industry survey, limited locational information was provided. In these instances, the WA was assumed to be positioned at the centre of the LGA (also known as the ‘LGA centroid’).

# *WA production and capacity*

*Production is relatively scalable to meet demand*

The model considers current or recent production rates when attributing output levels to individual WAs, though historical production does not necessarily limit future production. Instead, production is assumed to be relatively scalable to meet the level of demand.

The analysis has given some consideration to the implications of this assumption by calculating the percentage increase in production between 2013-14 levels (sourced from DEDJTR) and modelled levels for FY15. These increases were found to be within reasonable bounds.

*Factors limiting production increases at WAs can generally be overcome*

It is acknowledged that some WA operators may face constraints in increasing their production levels. Survey respondents indicated that these constraints related to compliance requirements, road access issues or planning permits, among others.

Many respondents however indicated that the prices received for product simply were not high enough to support increasing production. This suggests that for many operators, production can be increased where the level of demand is sufficient to support adequate resource prices being paid.

In relation to planning permits, it is noted that these can specify an expiration date for WAs or in some cases limit the volumes extracted from WAs. However as variations to planning permits are possible on request (subject to DEDJTR assessment and council approval) and each permit is unique, the model has assumed that these arrangements are relatively flexible within the time horizon considered.

For instance, while a planning permit may specify a WA's expiration at 2025, an operator facing strong demand could consider a new WA or applying for a variation to the existing licence in order to meet that demand. This could represent an increase in production as captured in the model. While this production could potentially be delivered from a new resource location, absent information on the new location the model assumes that production continues from the same location.

# Appendix C *Detailed supply study methodology*

## *Industry engagement – supply data collection*

To understand the supply of extractive resources, including current state of play and proposed intentions and future needs, a three pronged approach (telephone/face to face interviews, emails and posted letters) was undertaken to provide the industry with the opportunity to participate in an industry engagement questionnaire.

We designed and launched an online survey, which was complemented with industry interviews and desk-based review of literature. The information we collected was used to model the future supply of extractive resources to 2050, including identification of areas that may be critical to future developments and infrastructure projects. Table 29 illustrates the delivery methods used to conduct the survey and the number of work authorities and production values for each survey type.

**Table 29: The three-pronged approach: Split of WA holders by delivery method (interview, email, letter) for the industry survey**

| | Work Authority Holders | Work Authorities | 2013-14 Production volume (millions) | Proportion by production |
|---|---|---|---|---|
| Interviews | 30 | 128 | 31.6 | 77% |
| Emails | 342 | 573 | 6.2 | 15% |
| Letters | 188 | 189 | 3.1 | 8% |
| **Total Industry** | **560** | **890** | **40.9** | **100%** |

Source: DEDJTR, 2014

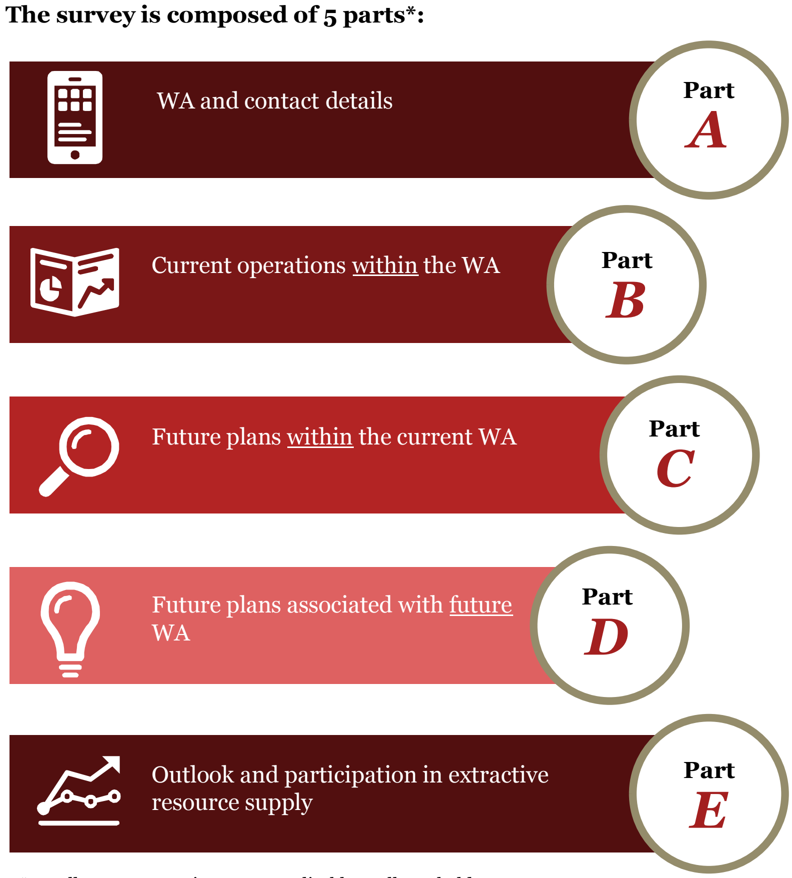
### *Data collection template*

An industry survey was developed to collect information from extractive industry participants in respect of their current and expected future operations. The survey was designed and tested in consultation with DEDJTR and Taskforce members to ensure all necessary and relevant information was captured to inform this study.

Leveraging the questions and format contained in the web survey, an interview questionnaire was also prepared for use in face-to-face and telephone interviews with industry participants.

An overview of the survey's content and format is provided in the figure below.

**Figure 49: Industry survey overview**




*not all parts or questions were applicable to all WA holders.

## *On-line survey*

To implement the industry survey in an efficient and scalable setting, we developed the questionnaire using a proprietary and secure web-based survey tool. The tool allowed us to instantly issue the survey to a large pool of respondents while also automating the data collection process.

Between 12 and 19 August 2015, email invitations to participate in the survey were sent to all 2013-14 Work Authority (WA) holders with valid email addresses and included a unique link to the survey. In total, the survey was open for 10 weeks. Email invitations were sent to 558 WA holders (representing approximately 20 per cent of Victorian production in 2013-14). PwC received 200 individual responses to the web survey from WA holders totalling seven per cent of production in the State using 2013-14 production data.

## *Survey mailout*

In addition to these 200 responses to the web survey, several paper responses were also received from respondents whose email address details were not available. Paper versions of the web survey were issued to these respondents by DEDJTR; we understand that approximately 190 paper surveys were issued.

## *Face-to-face and telephone interviews*

Using historical extractives production records, the State's top 30 producers were identified and targeted for face-to-face interviews. Telephone interviews were conducted with these respondents where they were unavailable to meet face-to-face.

As the top 30 producers represented close to 80 per cent of Victorian extractives production in 2013-14, focusing interview time on larger producers was expected to be important to gaining sufficient data to form an accurate picture of the State's future production.

Interviews were conducted using an interview guide based on the web survey template. However, the personalised nature of the interviews allowed a more flexible approach to be adopted that provided for collection of additional data and industry insights.

Industry interviews commenced in August 2015 and were completed by October 2015. 27 respondents provided information to support the study through this process, representing approximately 74 per cent of the State's production in 2013-14.

### *Survey respondent confidentiality*

The extractive industry supply survey was designed to gather information from respondents relating to their current and planned future operations. As this information was considered commercially sensitive, structures were established across the breadth of the study to secure respondents' confidential information and prevent commercial-in-confidence data being revealed through the study's reporting.

To this end, agreements were put in place between DEDJTR and the suppliers, including PwC and its contractors. These agreements provided for the protection of industry participants' information, including data provided through the survey in respect of future commercial activities. In addition the agreements bound the suppliers to ensuring the confidentiality of industry respondents through reporting on the study's findings.

### *Additional stakeholder consultations*

To support development of the study, additional consultations were undertaken with industry participants at different stages of the supply chain. Consultations were conducted within the following sectors:

- construction firms
- quantity surveyors
- extractive industry participants
- VicRoads.

These interviews provided for collection of data in relation to the end uses of extractive resources across different construction modes, along with information on typical resource costs and transport arrangements.

The data collected through these consultations were used to inform several assumptions applied in the economic modelling component of the study.

# Development of the supply database

The data gathered through the industry survey was used in conjunction with DEDJTR's WA database, which contains 2013-14 production records and other information for Victorian WA holders, to develop a set of key supply modelling inputs.

## Key supply modelling input 1: The WA reference database

Survey data on current and future production rates and deposit sizes were gathered through the industry survey for current WAs and WA applications and for planned future WA applications. These data were linked with DEDJTR records to understand, for each current and future WA:

- its geospatial coordinates
- the rock and product types produced by each
- the amount of resources remaining in the deposit
- historical, current and planned future production rates
- a breakdown of typical transport distances for resources produced
- any factors inhibiting production

### Missing and incomplete survey information

Several assumptions were applied in cases where survey data were missing or incomplete. These assumptions are detailed in Appendix B.

### Format of the WA reference database

The finalised WA reference database comprised a single input table detailing, for each WA, its identification number, rock type, location, remaining deposit and current production rate.

## Key supply modelling input 2: The origin-destination matrix

Using the geospatial coordinates of each WA in the WA reference database along with the coordinates of the set of Victorian demand locations, an origin-destination matrix (OD matrix) was prepared. The matrix used the VicRoads Declared Roads network[30] to measure the optimal transport route and associated distance, across the Victorian road network, from each Victorian WA to each Victorian locality.

The OD matrix additionally measured the distance travelled between each WA and locality that traversed Greater Melbourne. This Melbourne traversal distance serves as a core input into calculation of transport costs, as the Cost Reckoner differentiates between rural/regional and urban roads in terms of cost.

The OD matrix together with the WA reference database comprises the supply database used in the detailed geospatial economic modelling undertaken as part of this study.

[30] Available from data.vic

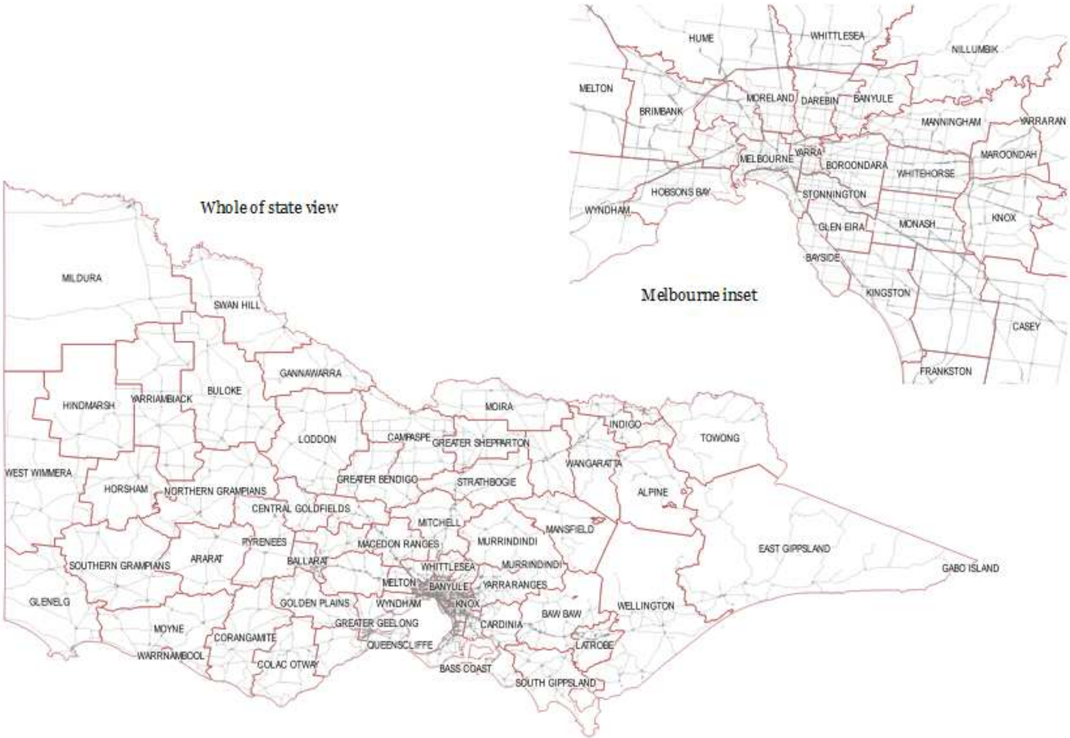
# *Granular spatial redistribution of demand*

### *Geospatial granularity of the demand study*

The demand analysis outputs were provided to PwC at the LGA-level for each year and rock type covered in the analysis. There are 79 LGAs in Victoria, meaning demand within the State was split among 79 sub-regions. Victoria's LGAs are depicted in the figure below.

Many of these 79 LGAs cover a relatively large geographic area, such as East Gippsland which has an area of close to 21,000km$^2$ and Mildura at over 22,000km$^2$. Information on the underlying distributions of demand for different rock types within these LGAs was not provided by the demand analysis deliverable. Rather demand was assumed to be uniform across each LGA's surface.

**Figure 50: Representation of Victoria's Local Government Areas (LGAs)**




Source: PwC's GEM.

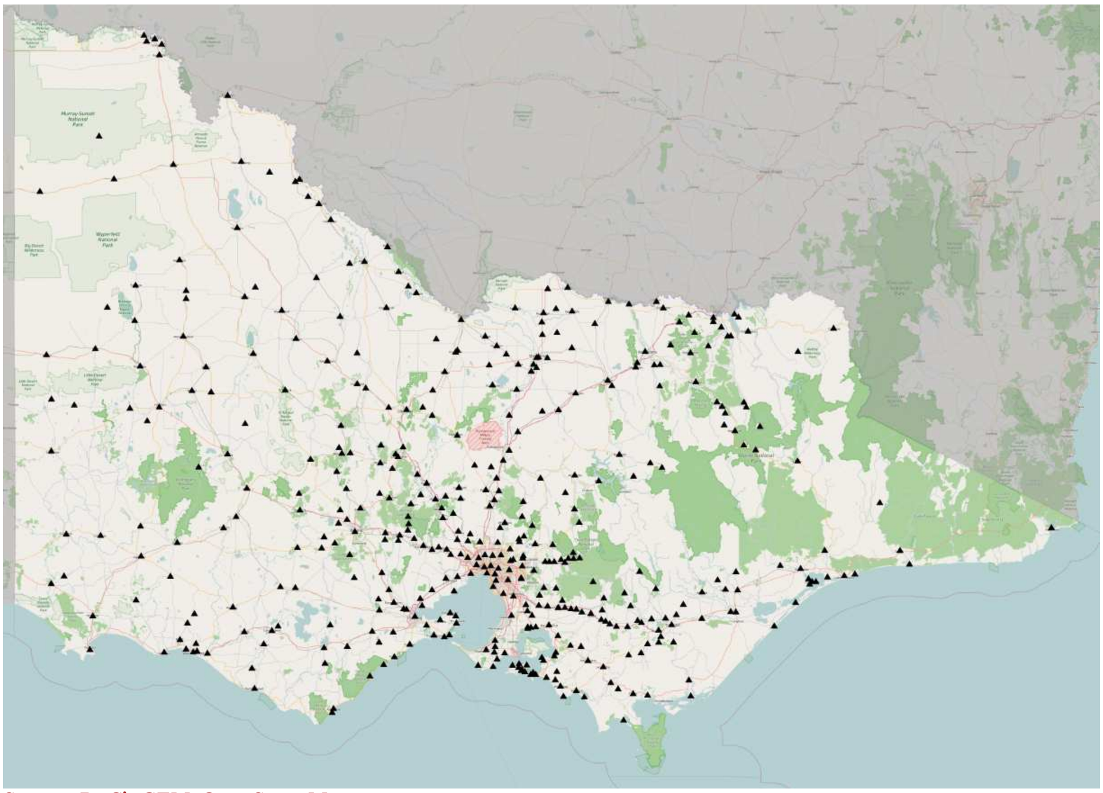
### *Distribution of demand to Victorian localities*

To provide for increased geospatial granularity of the supply-demand analysis it was necessary to distribute the LGA-level demand data to different localities and regions within each LGA. Victoria's urban centres and localities were used for this purpose, as defined by the ABS.[31]

[31] ABS, 1270.0.55.004 - Australian Statistical Geography Standard (ASGS): Volume 4 - Significant Urban Areas, Urban Centres and Localities, Section of State, July 2011

This component of the analysis resulted in a redistribution of demand from 79 LGAs to almost 500 individual Victorian localities, offering a significantly more granular view of the demand for extractive resources within the State. Victoria's localities are represented by the dark triangles depicted in Figure 51.

**Figure 51: Representation of Victorian localities used in the analysis**



Source: PwC's GEM, OpenStreetMap.

This level of granularity provided a more appropriate match for that of the supply analysis, which was performed at the level of each individual work authority.

# The gravity model

A gravity model was then developed in order to integrate the detailed supply database with the outputs of the granular redistribution of demand.

## Context of the gravity model: demand-driven supply

Within the gravity model, WA operators are attributed production levels within a given year based on a combination of their historical production rates, which are assumed to broadly reflect their productive capacity, and the level of demand they face for the period.

Application of this methodology results in demand-driven supply outcomes. These outcomes are optimal in that no excess supply arises and hence WA operators do unearth resources that may not be sold in the market.

## Matching of WAs to localities based on distance and capacity

The goal of the gravity model was to understand the most likely flows of extractive resources, across the Victorian road network, between WAs and localities. This assessment necessarily accounted for the following market realities:

- due to the high weight-to-value ratio of extractive resources, buyers will purchase from more proximal quarries to minimise the costs of delivered material
- miners of extractive resources prefer to serve fewer large markets rather than more numerous small markets to minimise their transaction costs, which increase with the number of markets served.

Reflecting these realities, the gravity model computes a dynamic matching of WAs and localities through time based on a weighted combination of distance and productive capacity. The weighting is computed as a combination of the WA view and Locality view as discussed below.

A distance threshold of 300km was applied in the analysis to limit the matching to WAs and localities across the Victorian road network. This distance reflects a reasonable maximum given information on typical maximum travel distances provided by respondents to PwC through the industry survey.

### *Weighting: WA view*

WAs are matched to localities that are nearby and exhibit a positive demand for the resource produced at the WA. The closest localities with the strongest demand will receive a higher 'weighting', meaning the WA will supply the most resources to these locations. Close-by localities with no demand for the resource will receive no tonnage from the WA.

### *Weighting: Locality view*

Localities assign weights to WAs based on the following conditions:

- the WA produces a rock type that the locality exhibits positive demand for
- the WA is relatively close by
- the WA produces the demanded rock type in positive volumes in 2015

The closest quarries with the largest production values are attributed the highest weighting.

### *Combined weighting*

These two weighting components are combined to attribute a set of weights to each WA considered in the analysis for each year considered. A single weight value exists for each WA a locality is matched to. The weights for each WA sum to one so that the WA's productive capacity is fully utilised. Similarly, the weights for each locality and rock type sum to one so that under optimal supply conditions, its demand will be met. These weights are calculated each year to account for the addition of new resource deposits emerging within current and planned WA applications.

An example weighting is provided in the table below for a hypothetical demand location and set of supplying WAs. Note that the weights sum to one for each rock type- and locality- combination listed in the table.

### Table 30: Example gravity model weights

| Locality | Rock type | WA | 2015 Weight |
|---|---|---|---|
| Bendigo | Hornfels | WA_123451 | 0.10 |
| Bendigo | Hornfels | WA_123452 | 0.30 |
| Bendigo | Hornfels | WA_123453 | 0.60 |
| Bendigo | Basalt new | WA_123454 | 0.30 |
| Bendigo | Basalt new | WA_123455 | 0.10 |
| Bendigo | Basalt new | WA_123456 | 0.15 |
| Bendigo | Basalt new | WA_123457 | 0.45 |
| Castlemaine | Hornfels | WA_123451 | 0.60 |
| Castlemaine | Hornfels | WA_123452 | 0.40 |

Source: PwC analysis.

## *Calculation of WA production and depletion*

### *Demand allocation to WAs*

Using the gravity weights calculated above, optimal demand amounts for Victorian locations are attributed to the WAs to which they are matched.

Using the example provided in Table 30, if Bendigo's demand for Hornfels in 2015 was 100 tonnes, 10 tonnes would optimally come from WA_123451 (100 x 0.10), 30 tonnes would optimally come from WA_123452 (100 x 0.30) and 60 tonnes would optimally be delivered from WA_123453 (100 x 0.60).

From the WA perspective, its production is calculated as the sum of the demand it faces across all localities. Again using Table 30, if Castlemaine's demand for Hornfels in 2015 is 200 tonnes, WA_123451's production would be the sum of 100 x 0.1 = 10 tonnes supplied to Bendigo and 200 x 0.60 = 120 tonnes supplied to Castlemaine, which is equal to 130 tonnes in total for 2015.[32]

### *Resource depletion and the emergence of supply shortfalls*

The optimal demand amounts that result from the demand allocation to WAs are optimal in the sense that subject to WAs existing for that rock type, all demand is satisfied. We know however that resource deposits are not unlimited and that subject to strong demand, some deposits will be depleted within the forecast period.

To calculate the rate and timing of resource depletion for each WA, its optimal demand is cumulatively summed across the analysis period and subtracted from its starting resource deposit. This assessment highlights those quarries that will be depleted before 2050, the rate at which that depletion occurs and the timing of that depletion.

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[32] As the weights have been calculated taking into account each WA's current and/or historical production levels, the level of demand attributed to each WA for each year does not exceed its known capacity to produce by a great degree.

# Detailed supply and demand outputs

In combination, the granular demand data matched with detailed supply information through the gravity model provides a comprehensive picture of the market for extractive resources in Victoria from 2015-50.

The detailed supply and demand outputs broadly comprise:

- the resource volumes produced by year from each Victorian WA, both current and planned
- the demand destinations to which these volumes are delivered
- the transport distances between each WA-locality pair across the Victorian road network
- the transport costs associated with the resource flows between each of these
- how each WA's resources are depleted through time
- the extent to which each locality's demand for resources is satisfied through time
- the cost implications of differences between supply and demand, by location.

*Strategic resource determination*

These detailed outputs are considered in the context of the SRD Criteria, as described in Section 5, to understand which rock types and resource locations are likely to be of strategic value to the State.

*Supply scenarios*

Different supply-demand scenarios are also considered to provide some context around potential alternative future outcomes for the industry under a range of assumptions. These scenarios are detailed below.

# Scenario analysis

## Supply scenarios analysed

Three separate supply scenarios were modelled in the supply analysis to provide a broad picture of potential future outcomes for the industry under differing assumption sets. The scenarios implemented include:[33]

1. **Base case scenario**: the base case scenario represents the central analysis scenario under core assumptions and expectations.

2. **Low supply scenario**: under the low supply scenario, industry conditions deteriorate and extractive resource outputs shrinks relative to core expectations. This could be prompted by:

    a. A poor industry outlook among participants

    b. Increased sterilisation of extractive resource deposits due to encroachment

    This scenario is implemented in the gravity model by applying a universal 20 per cent reduction in reported and calculated remaining deposit sizes in Victorian WAs.

    The results of this reduction are such that supply capacity in the State is 20 per cent lower than under the base case, meaning resource depletions and supply shortfalls occur more quickly, all else equal.

3. **Medium (redistribution) supply scenario:** under this scenario, new work authority applications are assumed to be lodged for sites in close proximity to existing work authorities rather than the sites nominated by respondents in the survey. This leads to a redistribution of future resource deposits with implications for market outcomes across the analysis period.

    This scenario has been implemented on the basis of discussions with industry operators, which point to the fact that locations proximal to existing known resources are likely to be identified for development of future quarries.

## Demand scenarios analysed

The associated demand analysis similarly considered a set of future scenarios and their implications for the future demand for extractive resources in Victoria. These are listed along with informing assumptions associated results in the demand report, which forms Appendix F to this report.

Several of these scenarios were assessed in combination with the above supply scenarios to form the following integrated supply-demand scenarios.

## Integrated supply-demand scenarios

A set of integrated supply-demand scenarios was assessed as part of this study to provide an indication of potential future outcomes for extractive resources in Victoria. To form these integrated scenarios, the considered supply scenarios were matched up with appropriate demand scenarios based on the likelihood that each could occur and whether the associated results of the matching were likely to provide a valuable counterpoint to the base case results.

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[33] A high supply scenario was considered in early stages of the analysis but not implemented as part of the final suite of modelling. As a high supply outcome was unlikely against any demand setting other than high demand, and a matching of high supply to high demand would not reveal significantly different results to those seen under the base case, this scenario was abandoned.

The integrated supply-demand scenarios considered are listed in Table 31.

**Table 31: Overview of the integrated supply-demand scenarios***

| Integrated supply-demand scenario | Demand scenario | Supply scenario | Description |
|---|---|---|---|
| 1 | Baseline | Base case | Reflects the most likely future outcomes based on core assumptions, expectations and survey responses |
| 2 | 1a (High) | Base case | Potential supply capacity is unchanged but demand is 20 per cent stronger than expected under the base case. The scenario captures the potential future outcome where significant demand is expected but supply does not lift accordingly. |
| 3 | 3a (Medium – Infill) | Base case | Potential supply capacity is unchanged; however the distribution of demand is different to the base case. More demand is expected in urban infill areas and less in urban growth regions. This scenario is expected to demonstrate how a changed future growth profile toward greater urban infill for Melbourne could impact on extractives markets. |
| 4 | Baseline | Low | Supply faces greater constraints than under the base case with demand at baseline levels. Scenario 4 assesses the extent to which demand can be met in the future in Victoria where supply is constrained, and examines how this plays out in resource locations across the State. |
| 5 | 1a (High) | Low | Supply capacity is reduced; demand is 20 per cent stronger than expected under the base case. Scenario 5 is an 'extreme' case where constrained supply is expected to struggle to match strong future demand for extractives in the State. |
| 6 | 3b (Medium – Growth area) | Base case | Potential supply capacity is unchanged; however the distribution of demand is different to the base case. More demand is expected in urban growth areas and less in urban infill regions, capturing a scenario where Melbourne grows at a greater rate in fringe areas relative to current projections and infill development is lower. |
| 7 | Baseline | Medium - redistribution | Demand is at baseline levels. The distribution of supply is changed; new resource deposits are assumed to be licensed in different areas to those modelled under the supply base case. Scenario 7 examines how a different future distribution of planned future quarries could impact on extractives markets in Victoria. |

Source: PwC. *Details on the demand scenarios assumptions and results can be found in Appendix G.

# Appendix D *Strategic Resource Determination Criteria*

| | Criterion | Detail | Measure |
|---|---|---|---|
| 1 | **Threatened resource types** | Identifies particular extractive resources that are in short supply in the state relative to the level of projected demand.<br><br>Identification of known locations of these resources will also be undertaken. This criterion will consider the potential substitutability of resources in considering which particular extractive resources could be subject to strong price pressures in future. | Those resources with less than 5 years of supply from current and planned future licensed reserves are identified under this criterion. |
| 2 | **Key supply locations where significant depletion of resources is anticipated** | Identifies locations in Victoria subject to significant exhaustion of current and planned future licensed reserves across the analysis period. The high exhaustion rate occurring in these locations indicates that they receive high levels of allocated demand, which suggests that they are well suited geographically to delivering extractive resources support Victoria's development | Thresholds applied under Criterion 2 are different for each rock type:<br><br>– Hard rock: a cumulative production shortfall of greater than 700,000 tonnes between 2015-50<br>– Sand and gravel: a cumulative production shortfall of greater than 500,000 tonnes between 2015-50<br>– Limestone: a cumulative production shortfall of greater than 2 million tonnes between 2015-50<br>– Clay and clay shale: a positive cumulative production shortfall between 2015-50 |

| | Criterion | Detail | Measure |
|---|---|---|---|
| 3 | **Significant production - Locations that produce significant volumes of extractive resources** | This criterion identifies those locations that deliver large volumes of extractive resources across the analysis period. This criterion points to the Victorian locations which could be considered for protection of existing resources to support the State's development. | Again, the thresholds for this criterion differ by rock type:<br>– Hard rock: a supply volume of 1 million tonnes or greater in 2050<br>– Sand and gravel: a positive supply volume of 400 thousand tonnes or greater in 2050<br>– Limestone: a positive supply volume in 2050<br>– Clay and clay shale: a positive supply volume in 2050. |
| 4 | **Supply locations critical to supporting Greater Melbourne's future** | Identifies particular extractive resources that are in short supply in the State relative to the level of projected demand.<br><br>Identification of known locations of these resources will also be undertaken. This criterion will consider the potential substitutability of resources in considering which particular extractive resources could be subject to strong price pressures in future. | This criterion was chosen to aid in identification of those supply locations critical to Greater Melbourne's future development. The outputs of this criterion are expected to help to inform planning arrangements supporting the city's growth.<br><br>A threshold was applied consistently across rock types under this criterion. Resource locations were identified on the basis that they supplied at least one per cent of the total State supply to Greater Melbourne in relation to residential and commercial construction demand, for a particular rock type. |

Source: PwC analysis

# Appendix E *Demand analysis report*

# Appendix F *Classification of LGAs used*

| Victorian Local Government Area (LGA) | Classification |
|---|---|
| Alpine (S) | Regional |
| Ararat (RC) | Regional |
| Ballarat (C) | Regional |
| Banyule (C) | Urban infill |
| Bass Coast (S) | Regional |
| Baw Baw (S) | Regional |
| Bayside (C) | Urban Infill |
| Benalla (RC) | Regional |
| Boroondara (C) | Urban Infill |
| Brimbank (C) | Urban Infill |
| Buloke (S) | Regional |
| Campaspe (S) | Regional |
| Cardinia (S) | Urban Growth Area |
| Casey (C) | Urban Growth Area |
| Central Goldfields (S) | Regional |
| Colac-Otway (S) | Regional |
| Corangamite (S) | Regional |
| Darebin (C) | Urban Infill |
| East Gippsland (S) | Regional |
| Frankston (C) | Urban Infill |
| Gannawarra (S) | Regional |
| Glen Eira (C) | Urban Infill |
| Glenelg (S) | Regional |
| Golden Plains (S) | Regional |
| Greater Bendigo (C) | Regional |
| Greater Dandenong (C) | Urban Infill |
| Greater Geelong (C) | Regional |
| Greater Shepparton (C) | Regional |
| Hepburn (S) | Regional |
| Hindmarsh (S) | Regional |
| Hobsons Bay (C) | Urban Infill |
| Horsham (RC) | Regional |
| Hume (C) | Urban Growth Area |
| Indigo (S) | Regional |
| Kingston (C) | Urban Infill |
| Knox (C) | Urban Infill |
| Latrobe (C) | Regional |
| Loddon (S) | Regional |
| Macedon Ranges (S) | Regional |
| Manningham (C) | Urban Infill |
| Mansfield (S) | Regional |

| Victorian Local Government Area (LGA) | Classification |
|---|---|
| Maribyrnong (C) | Urban Infill |
| Maroondah (C) | Urban Infill |
| Melbourne (C) | Urban Infill |
| Melton (C) | Urban Growth Area |
| Mildura (RC) | Regional |
| Mitchell (S) | Urban Growth Area |
| Moira (S) | Regional |
| Monash (C) | Urban Infill |
| Moonee Valley (C) | Urban Infill |
| Moorabool (S) | Regional |
| Moreland (C) | Urban Infill |
| Mornington Peninsula (S) | Urban Infill |
| Mount Alexander (S) | Regional |
| Moyne (S) | Regional |
| Murrindindi (S) | Regional |
| Nillumbik (S) | Urban Infill |
| Northern Grampians (S) | Regional |
| Port Phillip (C) | Urban Infill |
| Pyrenees (S) | Regional |
| Queenscliffe (B) | Regional |
| South Gippsland (S) | Regional |
| Southern Grampians (S) | Regional |
| Stonnington (C) | Urban Infill |
| Strathbogie (S) | Regional |
| Surf Coast (S) | Regional |
| Swan Hill (RC) | Regional |
| Towong (S) | Regional |
| Wangaratta (RC) | Regional |
| Warrnambool (C) | Regional |
| Wellington (S) | Regional |
| West Wimmera (S) | Regional |
| Whitehorse (C) | Urban Infill |
| Whittlesea (C) | Urban Growth Area |
| Wodonga (RC) | Regional |
| Wyndham (C) | Urban Growth Area |
| Yarra (C) | Urban Infill |
| Yarra Ranges (S) | Regional |
| Yarriambiack (S) | Regional |

Source: EY, Demand analysis of extractive resources in Victoria, 2016