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R1891 Rev 0

February 2025

Department of Transport

Material Study
Sand & Rock Supply

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Executive Summary

Basic Raw Materials (BRMs) play a crucial role in coastal adaptation works due to their favourable physical properties and cost-effectiveness, particularly when sourced from local quarries. However, resource availability is becoming increasingly constrained, especially for Tamala Limestone in the Perth Metropolitan and Peel regions and sand suitable for fill in the Southwest Region. Simultaneously, demand for BRMs is rising, driven by large capital projects that further strain existing supplies.

The need for BRMs suitable for coastal adaptation works is expected to grow significantly in the coming years. This trend is largely attributed to Local Government Areas (LGAs) finalising their Coastal Hazard Risk Management and Adaptation Plans (CHRMAPs) to safeguard public and private infrastructure at risk from coastal erosion. Developed in accordance with State Planning Policy 2.6 – Coastal Planning (SPP2.6), most CHRMAPs advocate a strategy of "Protect" coastal assets and infrastructure in the short to medium term (0 to 50 years), with a shift towards "Retreat" foreshore assets as a long-term measure (beyond 50 years).

Coastal planning experts widely acknowledge that material availability will pose a critical risk to the implementation of both "soft" and "hard" engineered solutions for coastal protection. Without proactive strategies, the scarcity of essential BRMs could undermine future adaptation efforts.

To support sustainable management of these essential resources, a comprehensive review of existing geological data, BRM mapping, and previous studies on sand and rock availability was undertaken for Western Australia's (WA's) coastline. The study also assessed current extraction sites, government policies, and planning frameworks to identify knowledge gaps.

Stakeholder consultation played a key role in gathering insights into past and future projects, existing supply challenges, and emerging trends in BRM demand. Consultation was conducted with Local Government and Coastal Managers, as well as Suppliers and Contractors operating in the relevant regions. The number of organisations approached is detailed in Table E1. These groups were selected based on their direct or indirect involvement in the placement of sand and rock for coastal adaptation works. Information was gathered through questionnaire responses and face-to-face meetings.

Table E1 Stakeholder Consultation Overview

Regions	Coastal Managers	Government Managers	Suppliers	Contractors
Perth Metropolitan / Peel	13	4	5	3
Southwest	7	5	3	3

For coastal adaptation projects in these regions, assessed within a five-year window on either side of the present date, it was found that the projected volume of future works in the Perth Metropolitan and Peel regions closely aligns with past completed works over the same period. However, in the Southwest Region, the scale of coastal works is expected to triple.

This estimate is based on the projected budgets of both past and future projects undertaken by Local Government and Coastal Managers. Budget estimates were considered a more reliable indicator than material quantity estimates, as project managers must account for future projects when forecasting capital expenditure within capital works programs.

The review of past and future projects within the Perth Metropolitan, Peel, and Southwest regions highlighted that the sand and rock requirements for coastal adaptation works are significantly smaller than the competing demands from other industries, such as civil (road) and housing construction. However, large-scale capital projects, such as the recently completed Ocean Reef Marina (ORM) or the proposed Westport, have the potential to exceed the annual production rates of suppliers, especially when considered alongside competing demands.

Regarding the current situation of materials, stakeholders have typically identified the following issues relating to the supply of BRMs.

- Tamala limestone – Tamala Limestone is now almost entirely exhausted south of the Swan River, from Perth to Augusta, with highly restricted supplies remaining north of the Swan River. While large deposits exist in the northern areas, much of the material has been sterilised or remains inaccessible due to challenges in obtaining clearing approvals. Currently, the only known source of Tamala Limestone suitable for armour rock is at Nowergup; however, its supply remains uncertain due to ongoing difficulties in securing the necessary clearing permits.
  The inability to access these resources poses a significant risk, given that the annual demand is estimated at 1 to 2 million tonnes. Historically, Tamala Limestone has been the primary material for coastal protection, road construction, and subdivision retaining walls in the southern regions of the state.

- BRMs for Road Construction – In the Southwest Region, the availability of sand and gravel suitable for fill, as well as materials for civil (road) and housing construction, is considered the most significant risk to the industry. Large infrastructure projects, such as the recently completed Bunbury Ring Road, have placed considerable pressure on Suppliers to meet project demands.
  Recognising this challenge, MRWA has commenced its own materials study to identify and secure suitable sources of sand and rock. This initiative aims to future-proof the supply of BRMs to support the region's 10-year capital works construction program. Additionally, MRWA is exploring the use of recycled and alternative materials for fill and is developing a hard rock standard to facilitate the use of Granite or Basalt in areas where Tamala Limestone is unavailable.

Through stakeholder consultation, MRA has undertaken the following:

- Compiled a list of common materials used in coastal adaptation projects near key development nodes in WA, including an overview of material availability, advantages / disadvantages and constraints.

- Compiled a list of alternative / nonconforming materials for consideration near key development nodes in WA, including an overview of material availability, advantages / disadvantages and constraints.

- Developed a database and supporting maps of existing sand and rock sources within the Perth Metropolitan, Peel, and Southwest regions.

- Developed a database and supporting maps of potential marine sediment sources within the Perth Metropolitan, Peel, and Southwest regions.

The project has also summarised the approval pathway for material extraction and identified key factors and challenges influencing this process.

As a result, a set of key recommendations has been developed, focusing on the availability of BRMs suitable for coastal adaptation works in WA. These recommendations aim to address knowledge gaps, enhance BRM supply, streamline regulatory processes, and explore alternative materials. The overarching goal is to ensure the long-term sustainability of coastal infrastructure projects while balancing environmental and economic considerations.

Table E2 Recommendations

No.	Recommendation
Addressing Knowledge Gaps	
1	Undertake a comprehensive statewide assessment of the BRM industry, in collaboration with industry and government, to quantify demand and assess supply risks. At a high-level, the project objectives should include: • Develop a live BRM repository to catalogue extractive industry sites, their material characteristics, and constraints. • Develop a live repository for alternative / nonconforming materials to facilitate future resource planning. • Review and streamline regulatory approvals and reporting processes to remove inconsistencies and duplication.
2	Publish this Material Study and supporting database to assist Local Governments and Coastal Managers in future adaptation projects.
3	Encourage Local Governments and Coastal Managers to integrate BRM data into project planning and funding applications for construction works.
Increasing the Supply of BRMs	
4	Review exclusion areas under SPP 2.4 to reassess BRM extraction restrictions.
5	Prioritise the release and approval of tenements where BRMs have been identified as a "Significant Geological Supply."
6	Review criteria for listing a "Significant Geological Supply" to include strategically valuable materials.
7	Consider BRM importance when nominating conservation areas to avoid sterilising valuable resources.

Table E2 Recommendations (cont.)

No.	Recommendation
8	Require construction material needs to be assessed at the time of Development Approvals to prevent shortages.
9	Streamline environmental approvals by reducing conflicting regulatory conditions and improving certainty.
10	Establish a more consistent and predictable planning approval framework to reduce delays and increase efficiency.
11	Amend the Mining Act 1978 to allow on-site processing and manufacturing of extracted materials.
12	Rationalise and standardise regulatory reporting requirements across agencies to reduce administrative burdens.
Marine Sediment Sources	
13	State agencies (e.g., EPA, DBCA, DPLH, DoT, etc.) should promote the beneficial use of dredged spoil for beach nourishment, provided the marine sediment source is deemed suitable.
14	Conduct geophysical surveys with ground truthing to refine data on marine sediment sources.
15	Assess the economic viability of dredging versus trucking sand for nourishment projects.
16	Conduct environmental assessments on benthic habitat mapping, onshore sediment impacts, and coastal hydrodynamics before approving marine sediment extraction.
Alternative / Nonconforming Materials	
17	Investigate the suitability of alternative and nonconforming materials for coastal adaptation works.
18	Identify key locations where alternative materials can be sourced near development nodes.
19	Conduct pilot projects to validate the performance of alternative materials in coastal environments.
20	Develop technical standards and guidelines to support the adoption of alternative materials in construction projects.

Acronyms & Abbreviations

Acronyms / Abbreviation	Denotation
BRM	Basic Raw Materials
BFS	Bush Forever Site
ES	Essential Services
CAP	Coastal Adaptation & Protection
CCL	Cockburn Cement Ltd
CoBun	City of Bunbury
CoBus	City of Busselton
CoC	City of Cockburn
CoF	City of Fremantle
CoK	City of Kwinana
CoN	City of Nedlands
CoM	City of Mandurah
CoR	City of Rockingham
CoS	City of Stirling
CoSP	City of South Perth
CoJ	City of Joondalup
CoW	City of Wanneroo
CHRMAP	Coastal Hazard Risk Management and Adaption Planning
DBCA	Department of Biodiversity, Conservation & Attractions
DEMIRS	Department of Energy, Mines, Industry Regulation and Safety
DMP	Department of Mine and Petroleum
DPaW	Department of Parks and Wildlife
DPLH	Department of Planning, Lands & Heritage
DPIRD	Department of Primary Industries and Regional Development

Acronyms / Abbreviation	Denotation
DWER	Department of Water and Environmental Regulations
DoT	Department of Transport
DA	Development Approval
DAP	Development Assessment Panel
DevWA	Development WA
DRF	Disaster Ready Fund
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EIL	Extractive Industries Licence
FPC	Forrest Production Commission
GIS	Geographic Information System
GSWA	Geological Survey of Western Australia
GBRS	Greater Bunbury Regional Scheme
Landform	Landform Research
LGA	Local Government Authority
MRA	M P Rogers & Associates Pty Ltd
MRWA	Main Roads Western Australia
NEMA	National Emergency Management Agency
NBA	Northern Beaches Alliance
PSD	Particle Size Distribution
PSP	Principal Shared Pathway
PNP	Peron Naturaliste Partnership
RBFS	Recreational Boating Facilities Scheme
SoA/MR	Shire of Augusta/Margret River
SoC	Shire of Capel
SoD	Shire of Dardanup

Acronyms / Abbreviation	Denotation
SoG	Shire of Gingin
SoH	Shire of Harvey
SoM	Shire of Manjimup
SoN	Shire of Nannup
SoW	Shire of Waroona
SGS	Significant Geological Supplies
SWPA	South Western Planning Area
SPP	State Planning Policy
TSB	Territorial Sea Baseline
TEC	Threatened Ecological Communities
ToCa	Town of Cambridge
ToCo	Town of Cottesloe
ToMP	Town of Mosman Park
TEC	Threatened Ecological Communities
WALGA	Western Australian Local Government Association
WAPC	Western Australian Planning Commission
WRL	Water Research Laboratory

Table of Contents

Table of Figures

Table of Tables

1. Introduction

Numerous public and private assets within Western Australia (WA) are potentially under threat from ongoing coastal hazards and particularly coastal erosion. The number of assets at risk is predicted to increase with climate change. The approach to managing the coastline remains uncertain, as many Local Government Areas (LGAs) are still in the process of finalising their Coastal Hazard Risk Management and Adaptation Planning (CHRMAP). CHRMAP is a planning tool that identifies critical areas at risk and proposes risk mitigation measures in the form of coastal adaptation options.

Seashore (2019) identified that the preferred coastal adaptation option adopted by most Coastal Managers is "Protection" as prescribed in the State Planning Policy 2.6 – Coastal Planning (SPP 2.6, WAPC 2013). This requires soft (sand used for renourishment and reclamation) and / or hard (rock used for the construction of breakwaters, seawalls, revetments, groynes, and artificial headlands and reefs) engineered solutions to mitigate or delay the effects of climate change. Implementing such measures will increase the demand for Basic Raw Materials (BRMs).

BRMs include naturally occurring sand, rock, limestone, clay, gravel, and other natural products used by the community. In most cases, these materials are utilised in their natural, unprocessed state, apart from sizing for applications.

For coastal adaptation works, the primary BRMs used are sand and rock. Various types of sand and rock are needed for different construction applications. The available resources vary from location to location, influenced by differences in geology and soil composition.

- **Sand** – Sand is required for coastal construction for use in fill, concrete, beach nourishment, and other applications. There are many types of sand, including calcareous coastal sands, marine dredge sand, pure silica sands, alluvial sands, and sands containing traces of clay, heavy minerals, and organic matter. These sands vary in colour, density, compressibility, grain size, ease of use, and compatibility with the receiving environment.

- **Rock** – Rock materials used in coastal construction take many forms, such as granite, basalt, limestone, sandstone, diorite, laterite duricrust, and chert. The composition, colour, durability, density, strength, geotechnical and aesthetic properties, ease of use, and source locations vary widely among these rock types.

Sand and limestone resources are not evenly distributed across the state. In certain locations, the ideal product is either unavailable or impractical to use due to transport and environmental constraints.

The availability of BRMs for coastal adaptation works has been identified as a potential risk in completed CHRMAPs (Seashore, 2019). Several CHRMAPs indicate that BRMs face competition from industries such as construction and infrastructure development, which are necessary to support the State's anticipated population growth. This competition can potentially result in limited material availability and increased material costs. Several LGAs have independently conducted material sourcing studies to meet their future needs. However, the availability of BRMs across the State remains largely unknown.

In response to this, the Department of Transport (DoT) has engaged specialist coastal engineers, M P Rogers & Associates Pty Ltd (MRA), with geological input from Landform Research (Landform) to undertake a comprehensive assessment of BRM availability and supply (sand and rock) within the coastal regions of WA.

1.1 Purpose of this Study

The material study for sand and rock is intended to be completed for the entire WA coastline, broken down into 10 key regions as illustrated in Figure 1.1.

The study is expected to be limited to a 200 km wide strip along the WA coastline, however for individual regions/locations the inland extent will vary based on material availability.

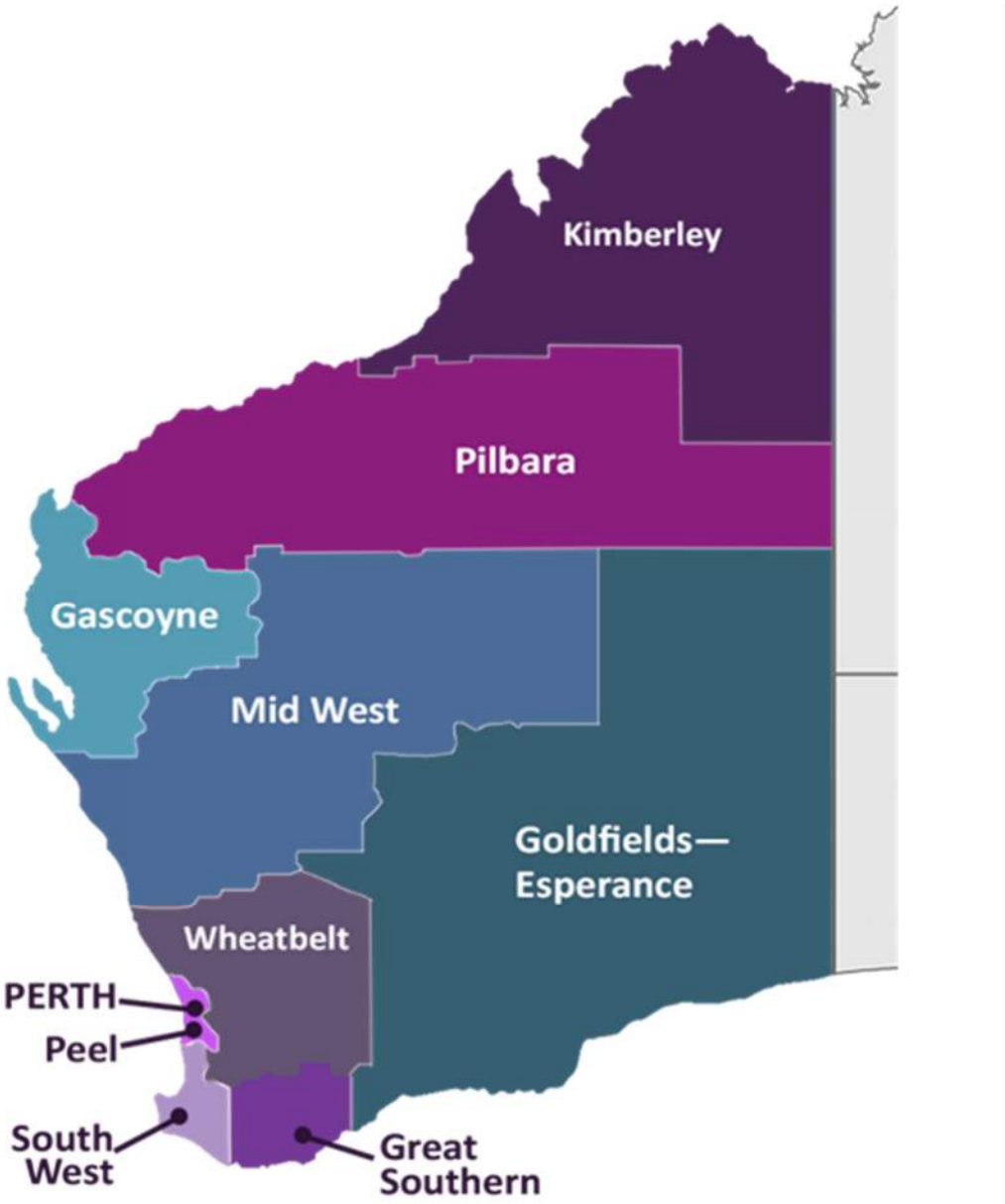

Figure 1.1 Western Australian Regions

The evaluation will involve an analysis of existing literature and discussions with key stakeholders such as Local Government and Coastal Managers, Commercial Suppliers and Contractors. The goal is to thoroughly assess the requirements and demand for BRMs in coastal works, current status of sand and rock resources in the coastal areas of WA, locate potential marine sediment sources and offer a range of suggestions for additional investigations and increasing the current supply.

Given the magnitude of the project scope, the work has been divided into 6 separate tasks/activities. A summary of the tasks are provided below.

- Task 1 – Desktop Review & Knowledge Summary
    - Review of background information relating to sand and rock supply.
    - Review geological maps and BRM mapping and works to determine sand and rock sources readily available.
    - Consult with stakeholders (Local Government and Coastal Managers, Suppliers and Contractors) and discuss past and future projects, sources, needs and other key constraints.

    Note: The information obtained from Task 1 will support the works completed in the subsequent tasks.

- Task 2 – Assessment Criteria / Material Requirements
    - Develop appropriate assessment criteria or parameters for suitable sand and rock resources for coastal protection works, with the consideration of regionally available materials.
    - High-level discussion on non-conforming materials and what risks they may pose when employed for structures.

- Task 3 – Existing Sources, Costs & Volumes
    - Identify existing sand and rock resources in WA and compile a database of the resources.
    - Prepare Geographic Information System (GIS) mapping of the resources.

- Task 4 – Potential Marine Sediment Sources
    - Identify potential marine sand sediment in WA and compile a database of the resources.
    - Prepare GIS mapping of the resources.

    Note: Only sediment sources located within “Coastal Waters” will be considered for this Study, where Coastal Waters are defined as a belt of water not exceeding 3 nautical miles from the Territorial Sea Baseline (TSB).

- Task 5 – Factors & Issues Affecting Supply
    - Identify key factors and issues that influence the supply of sand and rock materials for coastal protection works.

- Task 6 – Recommendations

- Review and summarise recommendations from the previous tasks and general study to identify knowledge gaps, barriers to increased supply and barriers to the use of resources.

Tasks will be completed Statewide or regionally as identified in Table 1.1. While DoT intends to complete the study for all regions, given the limited resources the table highlights which tasks are to be completed for which region. Tasks denoted with a "✓" are included in this report.

Table 1.1 Included Tasks

Regions	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6
Perth Metropolitan / Peel	✓	✓	✓	✓	✓	✓
Kimberley	X		X	X		
Pilbara	X		X	X		
Gascoyne	X		X	X		
Midwest	X		X	X		
Wheatbelt	X		X	X		
Southwest	✓		✓	✓		
Great Southern	X		X	X		
Goldfields/Esperance	X		X	X		

Regional tasks not included in this revision of this report may be completed and included in subsequent revisions.

2. Task 1 – Desktop Review & Knowledge Summary

2.1 General

The intent of Task 1 is to canvas the information required to complete the study. This includes understanding the following concerning sand and rock supply in WA:

- The type of sand and rock material.
- The past and future needs for coastal protection works.
- The key issues and constraints.
- The location and volume of current commercially available sources.

A comprehensive list of information reviewed for Task 1 is presented in Appendix A. The material was either provided by DoT, sourced online or from MRA and Landform's internal libraries and databases. All information was reviewed to determine its relevance to the study. The information identified to be of "High" relevance is discussed further in the report.

A lot of site specific and/or design and construction information was provided or sourced (eg design reports and drawings, technical specifications, sediment analysis, quarry test reports). Although this information is not presented in the report, it has helped with the development of subsequent tasks (Tasks 2, 3 and 4).

2.2 Statewide Information

2.2.1 State Planning Policy Documents

This section outlines various planning policies related to the supply and use of BRMs in WA.

State Planning Policy 2.4 – Basic Raw Materials (WAPC, 2021a)

SPP 2.4 (WAPC, 2021a) is a framework to guide land use planning and infrastructure to accommodate 3.5 million people by 2050 as identified in Perth and Peel @ 3.5 million (WAPC, 2018a).

Its primary objectives are:

- To ensure that BRMs are factored into the early stages of planning to safeguard BRM resources, especially for Significant Geological Supplies (SGS) areas and Essential Services (ES) from incompatible land uses.
- Promote efficient utilisation of BRMs in land use planning and development.
- Identify sequential land use opportunities for BRM extraction without compromising final land use intentions.
- Mitigate any adverse impacts on the community, water resources, and biodiversity values.

Accompanying this policy are the Planning for Basic Raw Materials Guidelines (WAPC, 2021b). These guidelines serve as an additional resource to SPP 2.4, offering support for decision-makers, proponents, and referral agencies in the implementation of the policy. The guidelines and policy together establish a comprehensive approach towards managing and utilising BRMs, ensuring sustainable development and environmental conservation within WA.

The nominated resource areas under SPP 2.4 are prepared by the Geological Survey of Western Australia (GSWA) and are accessible via the Department of Energy, Mines, Industry Regulation and Safety's (DEMIRS) "Geoview" website. These areas of Significant Geological Supplies have been modified and supplemented to account for local social, planning, and environmental factors.

The SPP 2.4 layer includes "Extraction Areas", which are primarily limited to existing approved extraction footprints. It also identifies "Exclusion Areas" where extraction is unlikely to be supported. However, smaller resource areas that may be locally significant due to their proximity to works are not identified.

State Planning Policy 2.5 – Rural Planning (WAPC, 2016)

SPP 2.5 (WAPC, 2016) aims to safeguard and maintain WA's rural land assets, recognising their critical economic, natural resource, food production, environmental, and landscape values. The policy previously considered the extraction of BRMs if they were outside the Perth and Peel planning regions and not materials mined in accordance with the *Mining Act 1978 (*this does include BRMs mined Crown Land).

Now that the revised SPP 2.4 (WAPC, 2021a) has been released, all BRM provisions detailed in SPP2.5 (WAPC, 2016) are now superseded.

State Planning Policy 2.6 – Coastal Planning (WAPC, 2013)

SPP 2.6 (WAPC, 2013) is a guideline developed by the WAPC to ensure sustainable development in coastal areas, aiming to balance environmental protection, social needs, and economic growth. This policy typically focuses on several key areas:

- Coastal Protection and Conservation.
- Sustainable Development.
- Climate Change Adaptation.
- Public Access and Recreation.
- Integrated Management.
- Hazard Risk Management.

The policy requires CHRMAP to be completed for all developments within the coastal zone to ensure that the coastal hazard risks are considered and incorporated in the decision-making process for projects.

The completion of CHRMAP often identifies the need for coastal adaptation works requiring sand and rock materials and recommendation of materials studies.

2.2.2 Western Australia Marine Parks

In WA there are currently 21 multiple-use marine parks which have been progressively established since 1987, under the *Conservation and Land Management Act 1984* (CALM Act). These are reproduced in Figure 2.1.

Within any marine park there may be four types of management zones:

- Recreational – The zone allows for conservation-focused activities and recreational fishing within specific bag, size, and seasonal limits, excluding commercial fishing, aquaculture, and pearling.

- General-Use – The zone permits sustainable commercial fishing, aquaculture, pearling, and petroleum activities, provided they preserve conservation values, although specific parks may impose further restrictions.

- Sanctuary – The zone offers the highest protection for sensitive species and habitats as 'look but don't take' areas for nature conservation and low-impact recreation, prohibiting extractive activities such as fishing and collecting.

- Special purpose – The zone is designated for specific uses or issues, such as habitat protection, wildlife breeding seasons, or particular activities, allowing only compatible uses within these areas.

Further detail will be provided for each region on other considerations that have the potential to affect marine sediment sources.

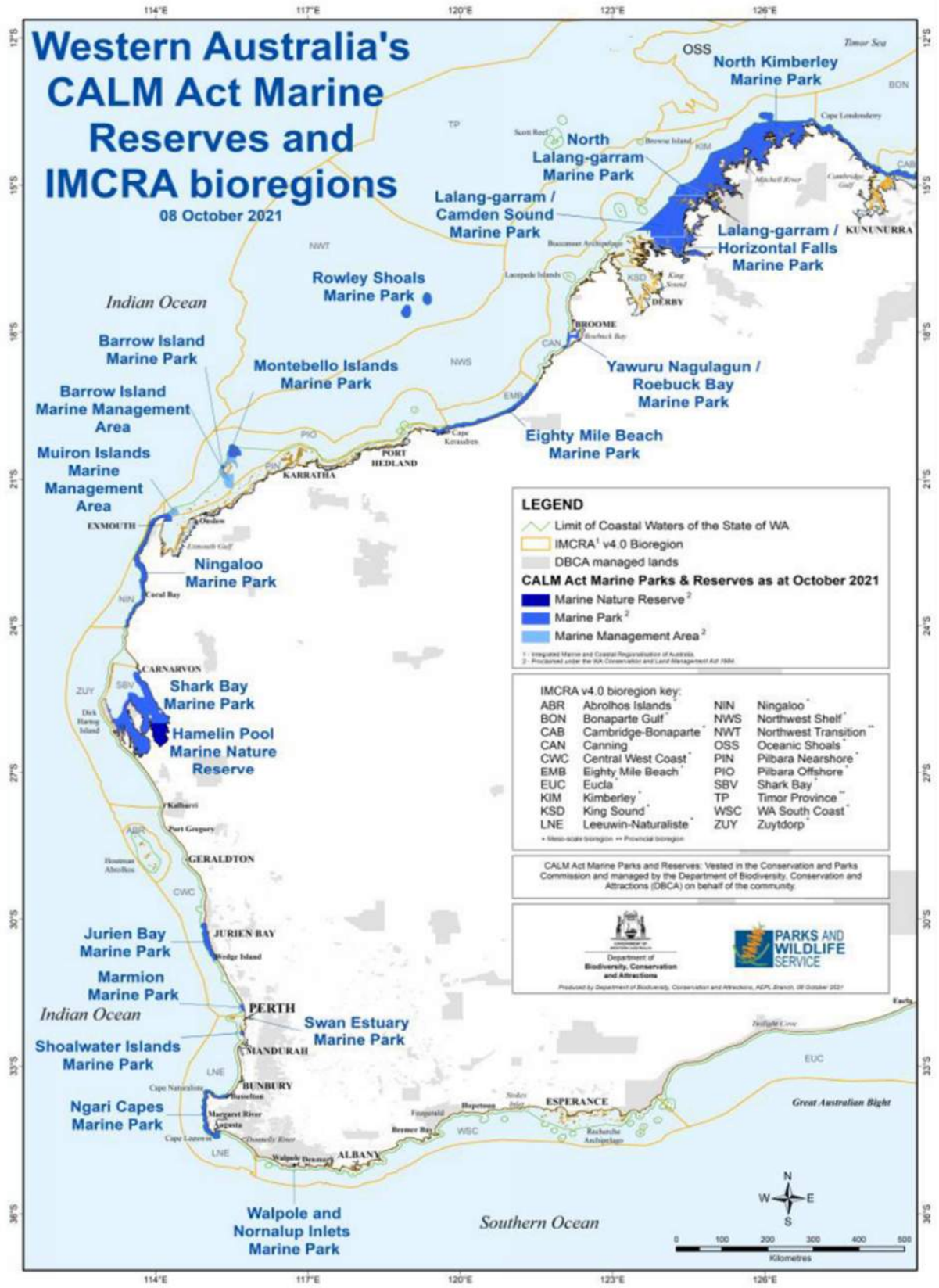

Figure 2.1 Location of Marine Nature Reserves, Marine Parks & Marine Management Areas (Courtesy of DBCA)

2.2.3 Coastal Erosion Hotspots

Seashore Engineering (Seashore, 2019)

Assessment of Coastal Erosion Hotspots in Western Australia (Seashore, 2019) was commissioned by the State Government to evaluate the potential scale and extent of the locations affected by coastal hazards within WA.

In total, 55 coastal hotspots were identified in WA and are illustrated in the Figure 2.2. 27% of the hotspots are located within the Perth Metropolitan zone, with the remainder located in other regions. An additional 31 locations were placed on a watchlist for future investigation.

The report made a list of recommendations for the governance and management of hotspots and addressed current knowledge gaps for hotspot management. One of the recommendations made, and the reason for this study, was for investigation into BRMs for coastal protection works.

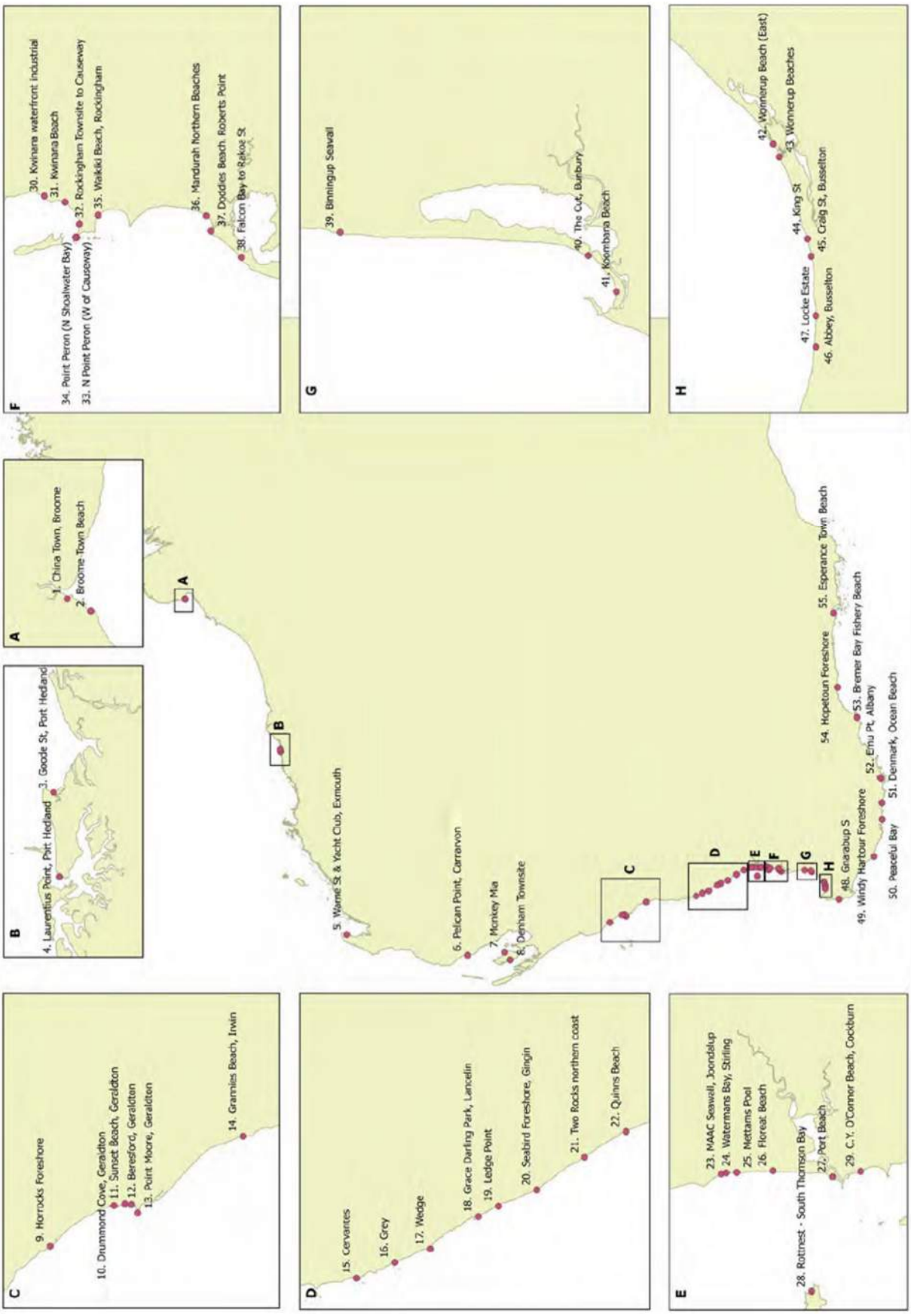

Figure 2.2 Hotspot Locations in Western Australia (Seashore, 2019)

Department of Transport (DoT, 2022)

DoT (2022) provides an update to Seashore (2019). Specifically, it provides an update on the 55 coastal hotspots over the past 3 years and reports on new hotspots identified.

The report found that of the 55 coastal hotspots, 12 had major updates, 16 had moderate updates and the remainder reported no change. Since the release of Seashore (2019) six additional hotspots were identified.

Based on DoT's review the following was recommended:

- The addition of six new coastal hotspots to be added to the original 55 locations identified in Seashore (2019).
- Reporting requirements for Coastal Managers with known coastal hotspots to improve with the management of hotspots and reduce the significant knowledge gaps.
- Combine efforts between State and Local Government Authorities for the development of a single annual survey to Coastal Managers.

Limestone & Limesand Resources of Western Australia (Abeysinghe, P.B., 1998)

Abeysinghe (1998) provides a comprehensive geological overview of limestone and limesand resources across WA. The study assesses the distribution, quality, and production of these resources across the state, focusing on their geological occurrence and economic significance.

The key findings of the study were:

- Significant high-grade limestone deposits exist in the Eucla Basin, Cape Range, Dampier Archipelago, and Perth region.
- Extensive coastal limesand deposits occur from Geraldton to Augusta, with key sites at Dongara, Cervantes, Jurien, Lancelin, Cockburn Sound, and Boranup.
- Additional reserves are present in the Lennard Shelf (Canning Basin) and the Ord and Bonaparte Basins in the Kimberley.
- Total limestone consumption at the time of the review was 4.64 million tonnes (Mt) with the Perth Metropolitan Region accounting for 97% of high-grade limestone production.
- Environmental restrictions and competing land uses are limiting limestone extraction near the Perth Metropolitan Area.
- High transport costs are the primary challenge for extracting resources from remote deposits in Cape Range and the Eucla Basin.

Silica Resources of Western Australia (Abeysinghe, P.B., 1998a)

Abeysinghe (1998a) provides a comprehensive geological overview of the state's silica resources. The study examines various geological units, detailing the distribution, quality, and characteristics of silica deposits, including sand, sandstone, quartzite, and vein quartz. It offers chemical analyses of silica content and other relevant elements for numerous locations. The report also discusses the industrial applications of these resources, such as in glass manufacturing, foundry work, and construction.

The key findings of the study were:

- Significant high-purity silica sand deposits are located in the Perth Basin, particularly in the Bassendean and Gnangara Sandplains.
- Extensive quartzite and vein quartz resources are found in the Yilgarn Craton, with notable occurrences near Southern Cross and Koolyanobbing.
- Additional silica sand deposits exist along the coastal regions, including areas near Geraldton and Bunbury.
- Annual production of silica sand in WA at the time of report was approximately 1 million tonnes, primarily for the glass and foundry industries.
- The construction industry consumed substantial quantities of lower-grade silica sand for concrete and fill material.

2.2.4 Statewide Geological Information

The table below outlines resources that can be used to identify geological materials across WA. However, more detailed information specific to each region will be provided in the corresponding sections that follow.

Table 2.1 Statewide Geological Resource Maps & Publications

Resources	Content
GeoVIEW.WA	Developed by Department of Energy, Mines, Industry Regulation and Safety (DEMIRS). The platform provides geological, cadastral, and mining tenement mapping with geophysical attributes and aerial photography overlays. Supports area measurement.
Geological Survey of Western Australia	Offers 1:250,000 geological maps with explanatory notes, available on GeoVIEW for layering with aerial imagery.
Google Earth Pro	Statewide aerial imagery with tools for drawing areas, sections, and generating 3D views.
Book and Report Publications	Key publications include the following: • Geological Survey of Western Australia (1990): Geology and Mineral Resources of Western Australia. Memoir 3. • Abeysinghe P B (1998): Limestone and Limesand Resources of Western Australia. Geological Survey of Western Australia, Mineral Resources Bulletin 18. • Abeysinghe P B (1998): Silica Resources of Western Australia. Geological Survey of Western Australia, Mineral Resources Bulletin 21.

2.3 Perth Metropolitan & Peel Regions

The Perth Metropolitan and Peel regions extend from the southernmost extent of the Shire of Waroona (SoW) to the northernmost extent of the City of Wanneroo (CoW). The foreshore

fronting the Indian Ocean is managed by 13 LGAs and has in excess of 100 separate beaches along the coastline.

2.3.1 General Information

Perth and Peel @ 3.5 million (WAPC, 2018a)

Perth and Peel @ 3.5 million (WAPC, 2018a) is a strategic suite of documents defining the urban structure over the next three decades, with an emphasis on curbing unsustainable urban sprawl, fostering housing diversity to cater to evolving community needs, and ensuring the optimal use of both existing and forthcoming infrastructure.

Four planning and infrastructure frameworks have been prepared for the Central, North-West, North-East and South Metropolitan Peel sub-regions. The guidelines delineate the allocation of new homes and employment opportunities, underscore the importance of environmental preservation, and promote the creation of vibrant communities centred around major transport nodes. A significant aspect of this plan is the encouragement of infill development, targeting the construction of at least 380,000 new homes from the anticipated 800,000 through such developments, particularly within the Central sub-region.

Environmental considerations are integral to the planning and execution of this growth, with both the State and Commonwealth governments actively assessing the environmental impacts of development within the Perth and Peel regions.

As part of the planning for 2050, it was recognised that a sustainable supply of basic raw materials is essential to support and enable development through to 2050 and beyond. These materials need to be readily accessible, located near points of use, and specifically allocated for future development.

The Geological Survey of Western Australia reviewed and identified key basic raw materials, which underpin the resource mapping referenced in State Planning Policy 2.4.

2.3.2 Sand

This section outlines the various types of sand as well as some individual studies investigating potential sand sources within the Perth Metropolitan and Peel regions.

Sand Types

Within the Perth Metropolitan and Peel regions, several different types of sand are available for construction, including for use in coastal adaptation works. Tables 2.2 to 2.6 below outline the types of sand found in these regions and provides a general overview of each.

Table 2.2 Perth Metropolitan & Peel Regions Sand Types

Quindalup Limesand – White, high-calcium carbonate ($CaCO_3$) limesand of aeolian origin	
Limesand forms in shallow coastal waters and consists mainly of shell fragments, calcareous foraminifera skeletons, and some silica sand grains. Found along the current coastline in strips ranging from a few metres to several kilometres, it also extends inland in vegetated but erosion-prone dunes. Quindalup Sands, primarily calcium carbonate ($CaCO_3$), can experience minor compression under heavy loads as grains crush and fill voids. They are also vulnerable to acid dissolution and assist with phosphate retention by forming the mineral apatite. While Quindalup Sands are widespread, access is often restricted by native vegetation or conservation areas. However, as much of the dune vegetation is well-represented in conservation areas and has lower conservation priorities access to resources is usually available although will become more restricted with time. The image to the right shows the Quindalup Sands at Lancelin.	
Rockingham and Safety Bay Sands – White, predominantly silica sands	
Rockingham and Safety Bay Sands are located within the coastal regions of Rockingham and the adjacent Safety Bay. The sands are primarily composed of highly leached white silica, known for their purity and fine grain size. However, the Rockingham and Safety Bay Sands are not accessible, as they have typically been sterilised by urban development. No image is shown of the sands as they are not accessable due to sterilisation.	**No Image Available**

Table 2.3 Perth Metropolitan & Peel Regions Sand Types (cont.)

Spearwood Sand – Yellow silica sands of aeolian origin, with some brown sands and minor amounts of clay and iron oxides

Spearwood Sands are yellow silica sands of aeolian origin, found along the coastal fringe with Tamala Limestone. They include brown sands and earthy yellow sands due to the clay coating and iron oxides stains on the silica grains, which enhance phosphate adsorption. This coloration fades with weathering. The sands originate from older calcareous coastal dunes, as calcium carbonate dissolved, leaving silica, clay, and traces of heavy minerals that contribute to staining.

These sands are limited in availability, primarily along a ridge east of Lake Clifton to Kemerton, often beneath pine plantations and native vegetation. More extensive deposits are found on agricultural land north of Yanchep. However, areas with native vegetation, such as Banksia and Tuart Woodlands, hold significant conservation value and support Threatened plant and fauna species listed under State and Commonwealth registers.

The image to the right shows the Spearwood Sands at Lake Clifton.

Bassendean Sand – White silica sands of aeolian origin, with pale yellow lower layers and minor iron oxides

Bassendean Sand is a white silica sand of aeolian origin, with occasional pale-yellow lower layers and minor iron oxides, such as those found in the Gnangara Pine Plantation. It forms similarly to Spearwood Sand but is older and more extensively leached, resulting in the removal of most colouration and clay content.

The image to the right shows the Bassendean Sands at Gnangara.

Table 2.4 Perth Metropolitan & Peel Regions Sand Types (cont.)

Yogannup Sands – Yellow, earthy sands containing significant amounts of clay	
Yoganup Sands are yellow, earthy sands with significant clay content, found along old beach strand lines near the Darling Scarp, including areas like Byford, Yoganup, and Muchea. They are often associated with heavy mineral deposits and mining activities. Due to their clay content, Yoganup Sands are generally less suitable for fill or coastal work but can be utilised when blended with silica sand or by using the upper layers, which contain less clay. The image to the right shows the Yogannup Sands at Urban Resources' Mundijong Sand Pit.	
Alluvial Sands – Coarse silica sands	
Alluvial coarse silica sands are found in alluvial paleochannels and current river deposits, such as at the lakes east of Perth, and at Gingin. These sands are primarily used for specialty projects and beach enhancement along rivers and estuaries, as their characteristics are not too dissimilar from those of typical ocean beach sands. The image to the right shows the alluvial sands found at the lakes east of Perth.	

Table 2.5 Perth Metropolitan & Peel Regions Sand Types (cont.)

Dredge Sands – Composition is highly dependent on the coastal environment where they are sourced	
Dredged materials vary in composition, ranging from calcareous to silica-rich, with differing amounts of organic matter and silts. Coarser materials are typically found in high wave-energy areas, while finer silts accumulate in quieter estuarine or bay environments. Organic content can give the material a grey or dark colour, and dredged sands from anoxic conditions may contain sulphides. Materials from harbours may also carry contaminants from human activities, such as antifouling compounds. Load capacity can vary due to changes in $CaCO_3$ content, which may also be prone to dissolution under acidic conditions and minor compressions under load. The image to the right shows the dredge sands placed as part of the beach nourishment works at Port Beach.	

Table 2.6 Perth Metropolitan & Peel Regions Sand Types (cont.)

Manufactured Sands – Typically silica-based sands produced by processes such as crushing in hard rock quarries or from crushed glass and therefore can have variable composition and properties

The manufacturing of various products generates sand byproducts, including hard rock fines and lithium tailings. These byproducts arise from different processes and have distinct characteristics, as outlined below:

- Hard Rock Fines – Produced during the crushing process in hard rock quarries, hard rock fines, along with sub-sized materials, are common byproducts. Quarry fines typically make up 20-40% of the crushed rock, depending on the type of rock. Annually, up to 1 million tonnes per annum of quarry fines are generated, primarily consisting of quartz, feldspar, and pyroxene-amphibole minerals. While stable and suitable for use as fill, their fine grain size may make them unsuitable for water-based environments unless they are sized or washed. The composition and properties of these fines can vary depending on the source rock.

- Lithium Tailings – Lithium tailings are a byproduct of mining pegmatite deposits, particularly those rich in lithium-based resources. These fine particles contain feldspars, silica, clays, and minerals such as chlorite, spodumene, and mica. The composition varies depending on the resource and geology, which can change rapidly within a mine site. Significant lithium processing occurs in regions such as Kalgoorlie, Kwinana, and Kemerton in WA. These tailings are currently being evaluated for reuse, providing opportunities for recycling.

The image to the right depicts the production of hard rock fines, a common byproduct of crushing in hard rock quarries.

City of Wanneroo – Summary Report Beach Renourishment Sand Source Feasibility Study (Cardno, 2022)

The study consisted of a desktop review of existing studies, literature, guidelines and relevant case studies to report on beach nourishment practices and identify possible future terrestrial and marine sand sources to support CoW's beach nourishment requirements.

The report investigated previously completed Particle Size Distribution (PSD) testing along the CoW's foreshore to determine the medium grain size (D_{50}). It was identified that the results show relatively consistent values with the D_{50} of Quinns Beach ranging from 0.283 to 0.444 mm and Yanchep ranging from 0.257 to 0.397 mm. However, it was noted that the sediment size is expected to be influenced by the presence of imported sand from historic nourishment activities.

Based on the location of current and future nourishment areas along the coast of the CoW, Cardno proposed terrestrial and marine sand sources assessed based on location, suitability and available volumes.

For terrestrial sources, the following was reported:

- Quarries:
    - Limesand and some Silica sand are likely to be suitable for sand nourishment given their colour however it is likely that the grain size is finer than what is required.
    - Quarries located less than 100 km from future nourishment sites within the CoW were determined to be feasible.
- Beaches: Nearby beaches were determined to be suitable for use as a nourishment source if they exhibited a history of accretion and harvesting the sand would not impact adjacent built assets.
- Developments: This was considered an opportunistic nourishment source where large volumes of sand are required to be excavated and disposed of. The viability of these type of sand sources is dependent on proximity and whether the sand exhibits the required properties in terms of grain size and physical appearance. The proposed construction of the Alkimos Desalination Plant was a project identified as a potential source of sand nourishment.

For marine sources, the following was reported:

- Dredged seabed material is used for projects throughout Australia for reclamation and/or beach nourishment and for many projects, the unit cost of dredging can be lower than onshore supplies.
- Marine sources identified were estimated based on their surface area and assuming that the depth of the sand is at least 1 m thick. Only shoals with a surface area exceeding 500 m^2 and located within the Coastal Waters were included.
- Marine sources varied significantly with respect to grain size (ranging from 0.242 to 0.431 mm with the grain size increasing offshore) and physical appearance. It was also reported that sediments may be odorous when exposed to oxygen.

Figure 2.3 highlights the location of sand nourishment sources identified in the study.

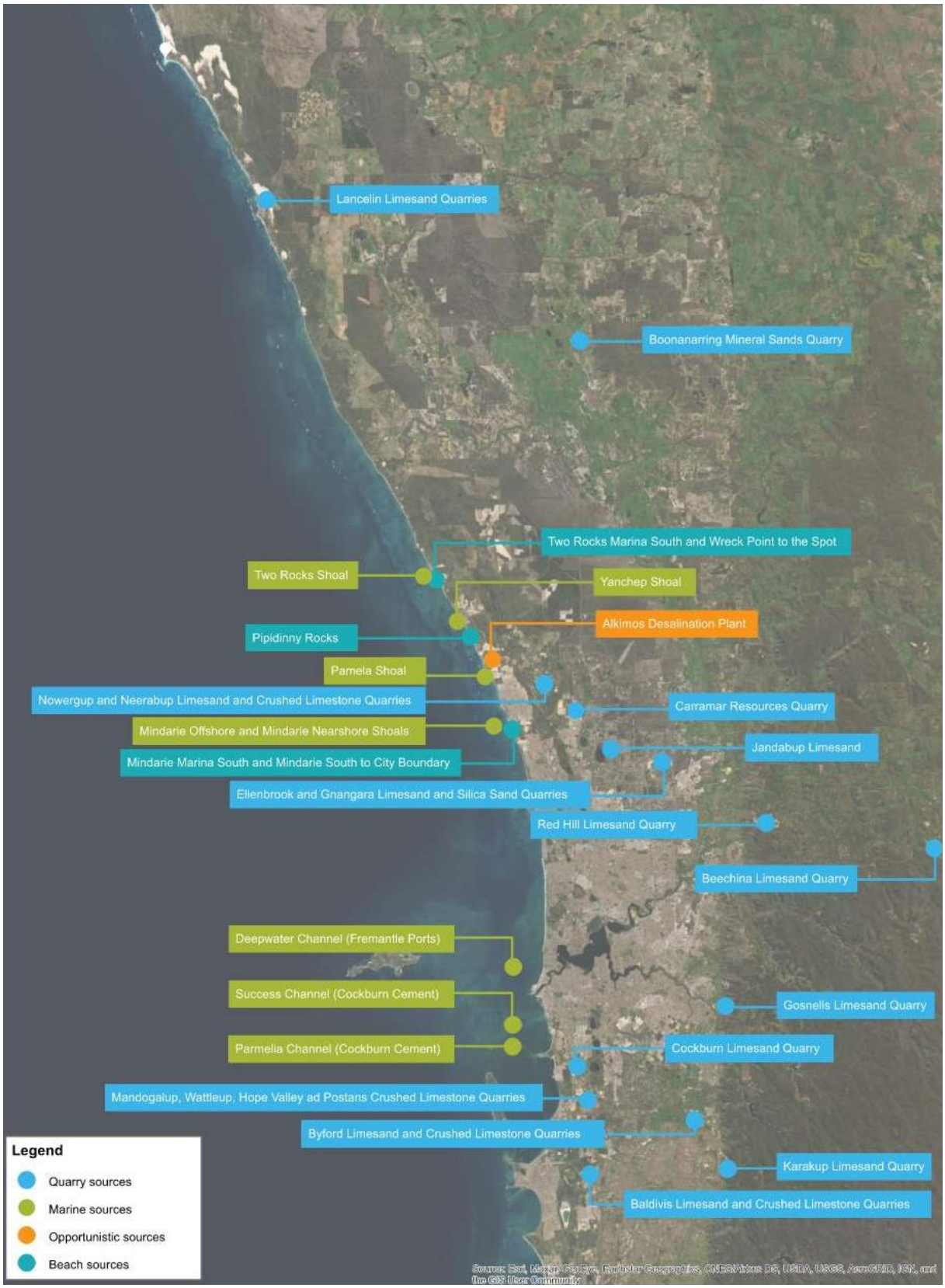

Figure 2.3 Potential Sand Sources (Cardno, 2022)

City of Cockburn – Beach Renourishment Sand Sourcing – Initial Scoping Study (Wavelength Consulting, 2023)

Wavelength (2023) presented a technical memorandum on alternative sand sources for the City of Cockburn (CoC).

The analysis includes a pre-screening of various external sand sources, evaluating them based on suitability, cost, logistical feasibility, and environmental approvals. Options considered a range of quarries, opportunistic nourishment sources (developments and dredging campaigns undertaken by neighbouring LGAs) and marine/nearshore sources including Fremantle Ports' Success, Parmelia and Deepwater Channel and Cockburn Cement dredging operations.

The document recommends the following external options be reviewed for further comparison:

- Chelydra Beach (current primary source).
- Quarries north of Perth (Muchea and Neerabup).
- Fremantle Ports' Deepwater Channel, Success and Parmelia Channels.
- Cockburn Cement Long Term Stage 2 Dredge Area.

Port Beach Sand Nourishment

MRA (2019) undertook a study at Port Beach which included a site-specific CHRMAP, per the recommendations made in Seashore (2019).

The outcome of the CHRMAP was that conducting beach nourishment via dredging was the highest-ranked option for all categories assessed (technical, social, environment and economic). Several considerations were recommended to progress the dredge option and included investigating the cost and potential offshore sand sources.

A large body of works has been undertaken to support the proposed sand nourishment, including but not limited to:

- Port Beach Nourishment – Sampling and Analysis Plan (BMT, 2020).
- Port Beach Data Gathering and Site Visit Report (MRA, 2020).
- Port Beach Sand Nourishment via Dredging – Environmental Review Documents (BMT, 2021a).
- Port Beach Sand Nourishment via Dredging – Sediment Colour Investigation (BMT, 2021b).
- Port Beach Sand Nourishment Detailed Design Report (MRA, 2021a).

To assess potentially suitable sand source options, grain size characteristics were collated for the native beach material (Port Beach) and potential nourishment sources (ie Success, Parmelia and Deep Water Channels) located offshore from the site. Success and Parmelia Channels were deemed to be inappropriate as they had medium grain size diameters of 0.19 and 0.26 mm and overfill ratios of 10 and 5 respectively. Deep Water Channel was determined to provide a more realistic opportunity given it had a medium grain size diameter of 0.39 mm and an overfill ratio of 1.3. BMT (2020) had also previously reported that there was approximately 252,807 m^3 of material available for dredging.

Aesthetically, both Success and Parmelia Channels were further determined to be an unlikely sediment source due to their grey colouration when compared to the native beach material. Conversely, the sediment collected from the Deep Water Channel did not appear to be too dissimilar in colour, albeit depending on where it was collected within the channel.

BMT (2021b) also undertook weathering experiments to determine if there was capacity for the sediment samples from Success and Parmelia Channels and Deep Water Channel to change over time due to natural weathering and become more comparable to Port Beach sediments. The experiment was conducted over a 12 month period where samples were exposed to sunlight (L) and sunlight and agitation (LA). The result from the experiment suggested that there were changes in colour for all samples, however no trends were observed over the testing period or between treatments. This suggests the sediment has the potential to bleach and/or change in colour, however, by how much would need to be investigated over a larger timeframe.

Ultimately, a large scale renourishment exercise was completed in 2022 and 2023, using sand from Deep Water Channel.

Cockburn Sound & Owen Anchorage

Cockburn Cement Ltd (CCL) run a dredging operation extracting shellsands from Success and Parmelia Banks within Owen Anchorage. CCL commenced its dredging operation of Parmelia Bank in 1972 under the *Cement Works Agreement Act 1971*. Calcium carbonate is extracted from the shellsands and is the sole raw material for lime products.

To support the ongoing dredging a large body of works has been undertaken, including but not limited to:

- Grey Calcareous Sand, Beach Colouration at Woodman Point (Steedman Science & Engineering, 1981).
- Appraisal of Lime Sand Dredging, Parmelia and Success Banks in Cockburn Sound, Western Australia - Phase 1: Desk Study of the Regional Setting of the Natural System (LeProvost Semeniuk & Chalmer, 1983).
- Compilation of Cockburn Cement Limited - Bore Hole, Lime and Shell Sand Data - Parmelia and Success Banks (Steedman R K, 1986).
- New Estimate of Shell Sand Resource - Parmelia and Success Banks (Steedman Science & Engineering, 1991).
- Estimate of Shell Sand Resource Parmelia and Success Banks Western Australia (Steedman Science & Engineering, 1992).
- Estimate of Shell Sand Resource Mewstone Area Western Australia (Steedman Science & Engineering, 1993).
- Owen Anchorage Area Success Bank Shell Sand Resources & Reserves (Leenders R and Wilkinson D, 1995).
- Long-term Shellsand Dredging Owen Anchorage – Environmental Review and Management Plan (DLA, 2000).

- Long-term Shellsand Dredging Owen Anchorage – Report and Recommendations of the Environmental Protection Authority (EPA, 2001).

- Long-term Shellsand Dredging Owen Anchorage Dredging and Environmental Management Plan – Stage 2 West Success Bank (BMT, 2017).

The body of works has included a review of each location in a regional setting to understand the bathymetry and topography, metocean conditions, and sediment provenance and budget. Environmental reviews have also been undertaken to support the continuation of the dredging operations and the inclusion of another 360 ha of dredge area within West Success Bank for Stage 2 of the dredging program.

Several reports were also completed to refine the volume estimates and identify the calcium carbonate content of the sediment deposits within Success and Parmelia Banks.

The Geomorphology & Sediments of Cockburn Sound (Geoscience Australia, 2005)

Geoscience Australia (2005) investigated Cockburn Sound to understand the geomorphology and sediments through the analysis of sediments samples taken via sediment grabs, vibracores and existing data that has been published.

Figure 2.4 illustrates the type of results collected from the study. Some key outcomes identified include.

- Sediments that reflect current and recent coastal conditions, with gravels (limestone) associated with the proximity of eroding limestone at Garden Island and along the current coast of the Swan Coastal Plain.

- The sediments increase in mud content further south with the gravel deposits typically located within the eastern shoal and the lee of Buchanan Bay. The gravels will typically be broken limestone.

- The finer sediments are located within the Central Basin whereas the coarser, sandy sediments are located within the banks and shoals as well as the margins of the sound.

- Four distinct sediment types were identified including Nearshore Quartz Sand (Gravelly shelly mixed carbonate quartz sand), Carbonate Banks (Carbonate sand), Eastern Shoal Sediment (Carbonate muddy sand) and Central Basin (Carbonate mud/mud).

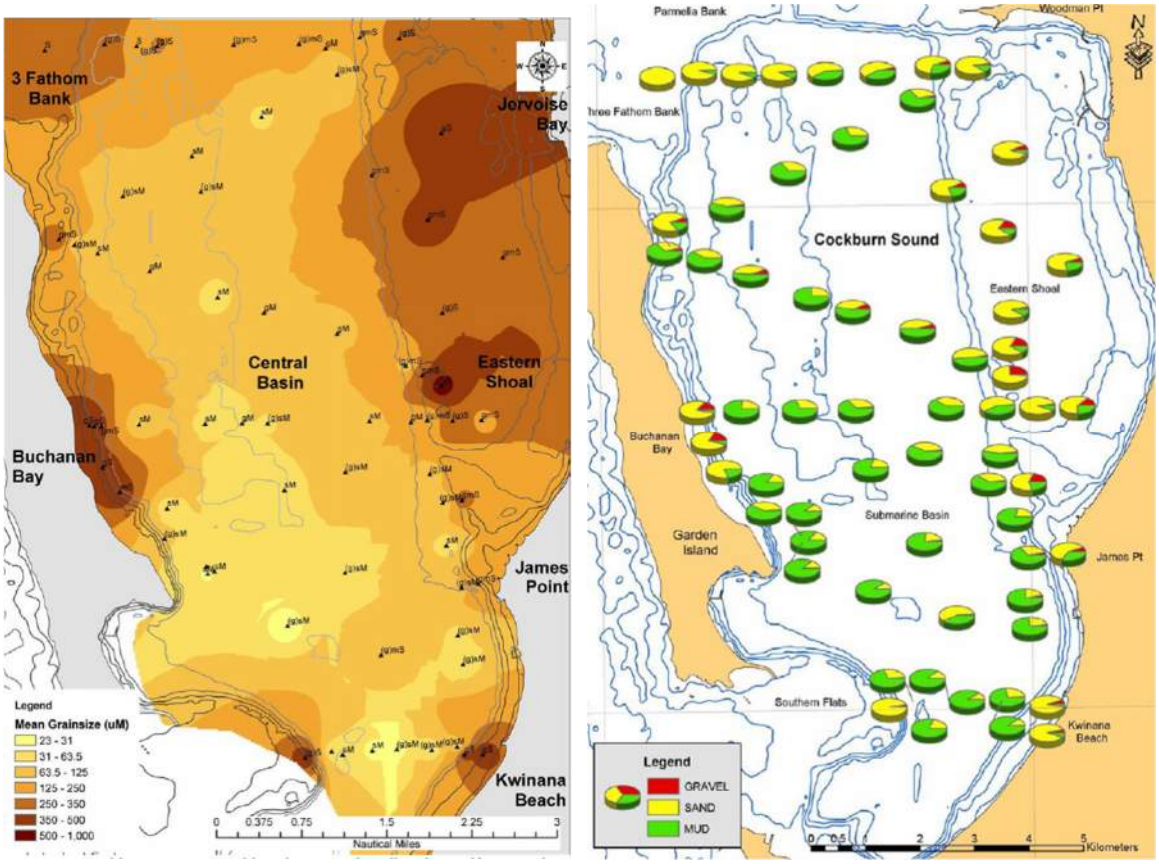

Figure 2.4 Cockburn Sound Sediment Sample Analysis: (L) Mean Grainsize (R) Proportion of Gravel, Sand & Mud

Physical Characteristics of Perth Beach, Western Australia (Stul, 2005)

The objectives of the report were to undertake numerical modelling (Simulating WAves Nearshore (SWAN)) to determine the wave processes influencing the shoreline, roughly classify the beach and sediment characteristics of Perth's beaches and determine the shoreline response to longshore waves.

The study was undertaken for the Perth Metropolitan Coast, bound by Silver Sands to the south and Two Rocks to the north, which equates to approximately 115 km of shoreline or a total of 100 beaches.

Among other things, the work involved field studies to determine the sediment characteristics. Samples were taken from the mid-wash zone and used to determine the grain size, sorting and carbonate content, with the grain size and carbonate content considered the most important parameters to differentiate sediment.

Figure 2.5 highlights the results of the study, with the key findings being:

- Peak carbonate content was observed in the Mandurah sediment cell at Waikiki Beach and is due to its location with respect to the sand bar, sand platform and seagrass beds.
- The localised peak within the Cockburn cell is due to the eroding limestone cliffs.

- The difference in carbonate content between the Cockburn cell and the City's cell (Cell 3 in Figure 2.5) is because of the construction of North Mole which altered the sediment dynamics.
- Point Peron had the coarsest grain size of 0.92 mm and Becher Point had the finest of 0.18 mm.
- The coarser sediments were found on the steep beaches perched upon underlying rock or reef.
- Many of the secondary sediment cells exhibited a fining of sediment as you move from north to south.
- Beach nourishment and sheltering of Fremantle Sailing Club, Hillarys Boat Harbour, Ocean Reef Harbour and Mindarie Keys meant they were outliers regarding the sediment collected.

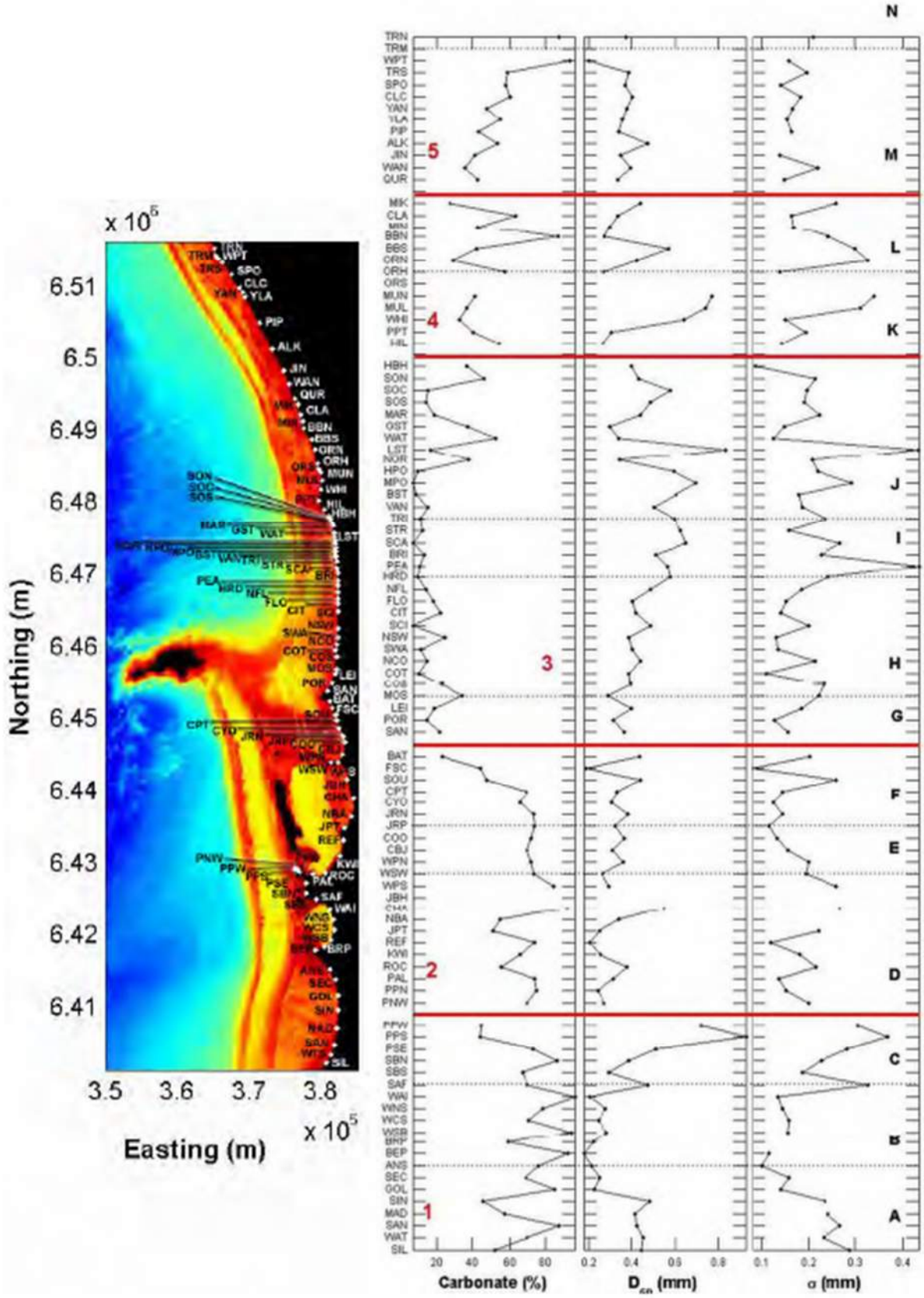

Figure 2.5 Sediment Characteristics of Perth Metropolitan Beaches (Stul, 2005)

2.3.3 Rock

This section outlines the various types of rock as well as some individual studies investigating potential rock sources within the Perth Metropolitan and Peel regions.

Rock Types

Within the Perth Metropolitan and Peel regions, several different types of rock are available for construction, including for use in coastal adaptation works. Tables 2.7 to 2.11 below outline the types of rocks found in these regions and provides a general overview of each.

Table 2.7 Perth Metropolitan & Peel Regions Rock Types

Tamala Limestone– Pale yellow to cream-coloured calcareous limestone, formed from aeolian sands cemented with calcium carbonate

High-grade, high-strength limestone suitable for coastal works is scarce, with resources largely restricted to areas between Nowergup and Yanchep. Tamala Limestone, commonly used for these applications, requires natural re-calcification with calcium carbonate to enhance strength. The top 1 to 4 metres of deposits offer the densest material, with quality diminishing at greater depths.

Accessing limestone is challenging due to conservation areas, reserves, and flora and fauna protections. Access to armour rock, which occurs only as the top caprock, is highly restricted, and it is unlikely that sufficient quantities in the Perth Metropolitan area will be available for another large coastal project. The annual demand averages 1.3 million tonnes, occasionally exceeding 2 million tonnes, such as during the Ocean Reef Marina upgrade, which required 800,000 tonnes of limestone and 400,000 tonnes of granite. The remaining extractable limestone is confined to select mining tenements and private lands. Current resources and approvals allow for only an additional 10 to 20 years of extraction, unless access to new resources is secured.

Tamala Limestone is unmatched for coastal works, offering visual harmony with the Swan Coastal Plain and requiring less energy compared to alternatives like granite or recycled materials. Granite extraction from the Darling Scarp entails deforestation and greater energy use, resulting in triple the greenhouse gas emissions. Subsequently, llimestone remains the most efficient solution for coastal engineering projects in WA.

The image to the right shows the preparation of limestone armour rock at Flynn Drive Quarry Neerabup.

Table 2.8 Perth Metropolitan & Peel Regions Rock Types (cont.)

The images to the right illustrate the varying degrees of re-calcification based on the depth at which the rock is found. The displayed material properties include Saturated Surface Dry Density (SSDD), Point Load Index (Is50), Water Absorption (WA), and Load at Failure (LaF) values.	Description: Even sandy limestone with less re-calcification. Higher density but lower strength due to lack of re-calcification. Material Properties: • SSDD (t/m^3): 1.76 • WA (%): 16.6 • Is50 (MPa): 0.96-1.63 • LaF (kN): 5.3-6.3	
	Description: Little to partically re-calcified limestone. Good solid limestone. Weaker porous material. Material Properties: • SSDD (t/m^3): 2.15 • WA (%): 16.6 • Is50 (MPa): 2.22-4.28 • LaF (kN): 5.1-3.9	
	Description: Even sandy limestone with less re-calcification. Higher density but lower strength due to lack of re-calcification. Material Properties: • SSDD (t/m^3): 1.76 • WA (%): 27.9 • Is50 (MPa): 0.96-1.63 • LaF (kN): 1.4-2.0	
	Description: Little to partically re-calcified limestone. Good solid limestone. Weaker porous material. Material Properties: • SSDD (t/m^3): 2.15 • WA (%): 11.2 • Is50 (MPa): 2.22-4.28 • LaF (kN): 2.5-4.0	

Table 2.9 Perth Metropolitan & Peel Regions Rock Types (cont.)

The image to the right illustrate the varying degrees of re-calcification based on the depth at:

- 0 to 2.7 m the limestone is re-calcified limestone.
- Below 2.7 m the limestone is weaker limestone with pores and voids.

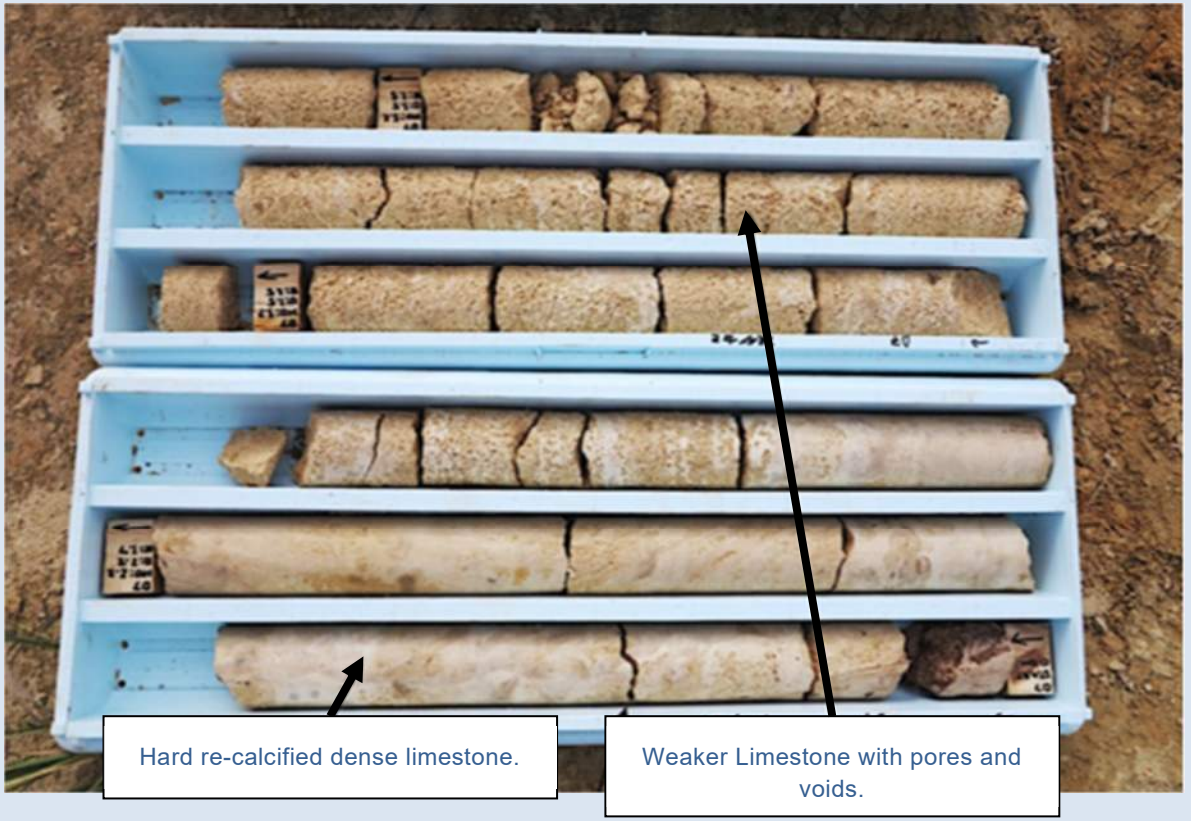

Table 2.10 Perth Metropolitan & Peel Regions Rock Types (cont.)

Granite / Diorite / Dolerite– Coarse-grained igneous rock composed mainly of quartz, feldspar, and mica, with occasional accessory minerals

Granite is a medium to coarse-grained igneous rock valued for its durability, versatility, and aesthetic appeal in construction and aggregate applications. With a density of 2.6 t/m³, granite is slightly less dense than basalt (2.8–3 t/m³), yet it offers unique advantages, particularly for coarse aggregates used in roads and structural projects.

Granite's light colour makes it desirable for lighter road surfaces. It's even-grained structure ensures that individual grains break away during wear, maintaining a high-friction surface over time, which is critical for enhancing skid resistance on roads. Despite slightly higher water absorption and lower crushing strength compared to basalt, granite remains a reliable material due to its excellent durability and performance under load.

In the southwest of WA, granites are often gneissic, featuring mineral alignments that can introduce directional strength differences. While this can affect certain applications, the consistent quality, medium-to-coarse grain size, and lighter colour of granite still make it a preferred choice over alternatives like gneiss or schist. These metamorphic rocks, though compositionally similar, have pronounced foliations and require labour-intensive processing, making them less practical for aggregate production.

Granite continues to be a cornerstone material for construction, offering a balance of strength, durability, and aesthetic appeal, particularly in applications where high skid resistance and visual harmony are critical.

The image to the right shows Hanson's Byford Quarry.

Table 2.11 Perth Metropolitan & Peel Regions Rock Types (cont.)

Laterite / Ferricrete – Iron-rich weathered rock formed through prolonged leaching and re-deposition of iron and aluminium oxides, typically found as surface capping in deeply weathered profiles.

Laterite, commonly found capping the deeply weathered granite profiles of the Yilgarn Shield, occurs east of the Darling Scarp. It forms over long periods of stability and erosion, as iron oxides are mobilised by soil moisture interacting with organic acids. These acids dissolve iron compounds, which are then re-deposited at the seasonal wetting and drying front, typically 2 to 4 metres below the surface. Over time, the iron oxides and hydroxides, such as goethite, combine with aluminium oxides like gibbsite to form a resistant rock layer composed of pisolites, gravel, and consolidated rock.

Technically classified as ferricrete, laterite is often found alongside calcrete, which forms under similar conditions in calcium-rich soils. Softer clays and weathered rock layers occur above and below the ferricrete, and erosion of the overlying materials can leave it exposed as a durable surface capping, also known as duricrust.

Due to its rocky nature, laterite is often unsuitable for agriculture and remains covered by native vegetation. It is rarely thick enough for use as coastal armour rock but can be processed for core material. While it lacks the strength of granite, it is geotechnically comparable to limestone for various applications.

The image to the right shows Bindoon Hill laterite.

Limesand & Limestone Resources between Lancelin & Bunbury, Western Australia (Gozzard J.R.,1987)

Gozzard (1987) assessed limesand and limestone resources along the coastal plain between Lancelin and Bunbury in Western Australia. The study focused on the distribution, quality, and potential applications of these resources, which are primarily associated with the Tamala Limestone and Safety Bay Sand formations. These formations contain substantial limesand and limestone deposits that have been utilised in various industrial and construction applications.

The key findings of the study were:

- The Tamala Limestone formation is widespread throughout the study area, consisting of aeolian calcarenite deposits that vary in hardness and purity.
- The Safety Bay Sand formation consists of unconsolidated calcareous sands, primarily found in coastal dune systems, contributing significantly to limesand resources.
- Calcium carbonate ($CaCO_3$) content varies across the region, with some areas containing high-purity limestone suitable for industrial use, while others contain lower-grade material more appropriate for construction.
- The report identifies existing quarries and potential extraction sites, noting that urban expansion and environmental constraints may impact future resource availability.
- Strategic land-use planning is essential to balance resource extraction with other land uses to ensure sustainable development.

2.3.4 Geological Information

The table below outlines resources that can be used to identify geological materials within the Perth Metropolitan and Peel regions.

Table 2.12 Perth Metropolitan & Peel Regions Geological Resource Maps & Publications

Resources	Content
1: 50,000 Environmental Geology Mapping	The following regions have been mapped: • Armadale • Fremantle • Lake Clifton Hamel • Muchea • Perth • Rockingham • Serpentine • Rottnest Island • Mundaring • Yanchep
1:100,000 Regionally Significant Basic Raw Materials	The following regions have been mapped: • Fremantle to Jarrahdale • Gingin to Ledge • Perth to Wooroloo • Pinjarra
Book and Report Publications	Key publications include the following: • Bruch J and M Freeman (2017): Migration of limesand dunes in Western Australia and their impacts. Department of Mines and Petroleum, Perth, Western Australia. • Fetherston J M (2007): Dimension Stone in Western Australia, Volume 1, Southwest. Mineral Resources Bulletin No. 23, Department of Mines and Petroleum.

MRA has also reviewed the GeoVIEW.WA maps, which are flagged as a statewide geological information resource for this study and filtered them to highlight the relevant features.

Figure 2.6 shows the significant geological supplies in the Perth Metropolitan and Peel regions and include sand, limestone, clay and hard rock.

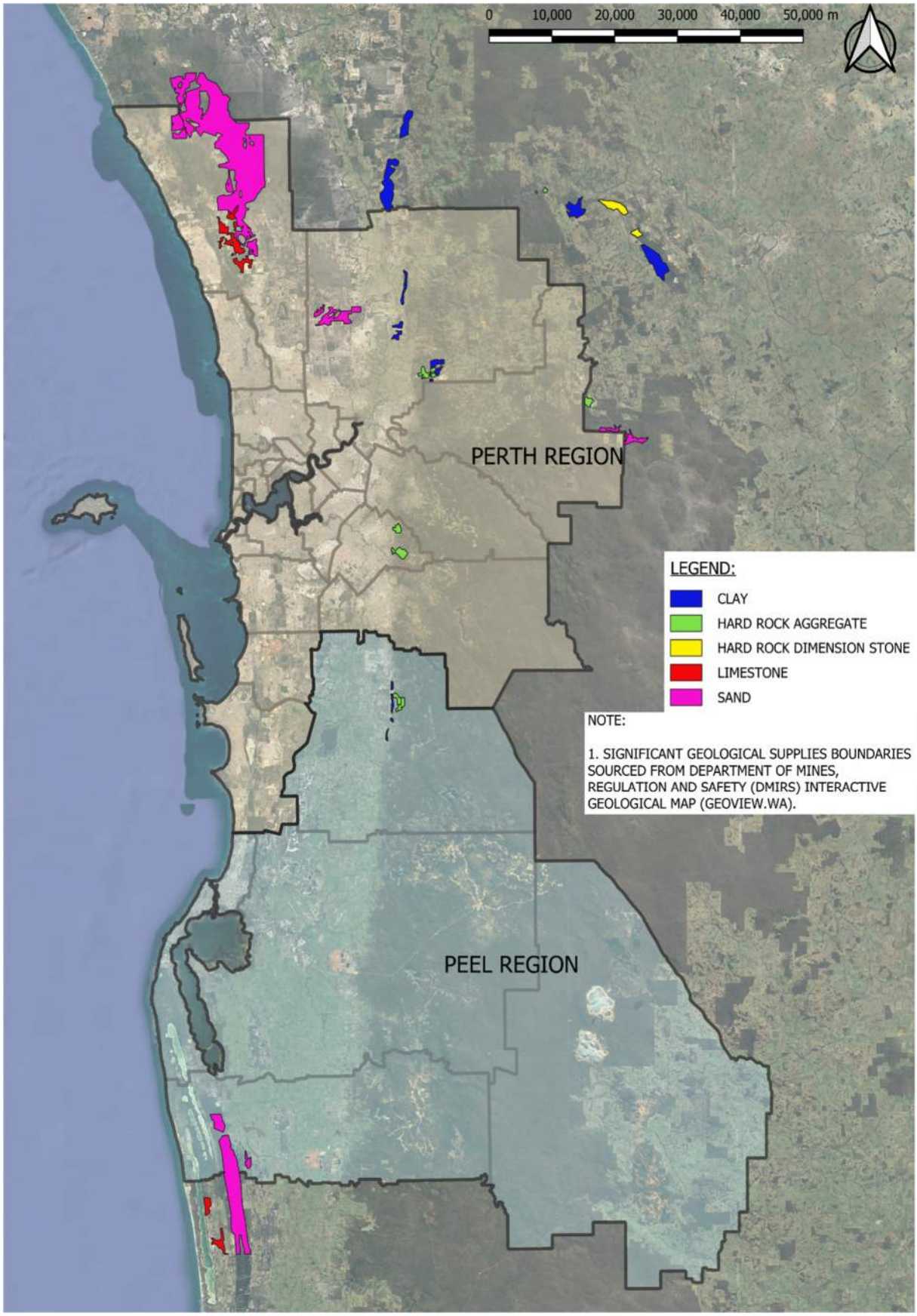

Figure 2.6 Perth Metropolitan & Peel Regions – Significant Geological Supplies

2.3.5 Marine Parks

Within the Perth Metropolitan and Peel regions there are two marine parks, the Shoalwater Island Marine Park and Marmion Marine Park.

From discussions with the DBCA, it is recognised that an expansion to the Marmion Marine Park is in the final stages of being gazetted, after which it will be issued for public review. Figure 2.7 illustrates the proposed boundary of the extension to the park. The park is expected to increase in size from 9,500 to 34,500 ha from Trigg Point to Two Rocks and is also said to increase the extent of Sanctuary Zones from 0.01 to 15 %, which is still significantly lower than global recommendations (ie 18-20%).

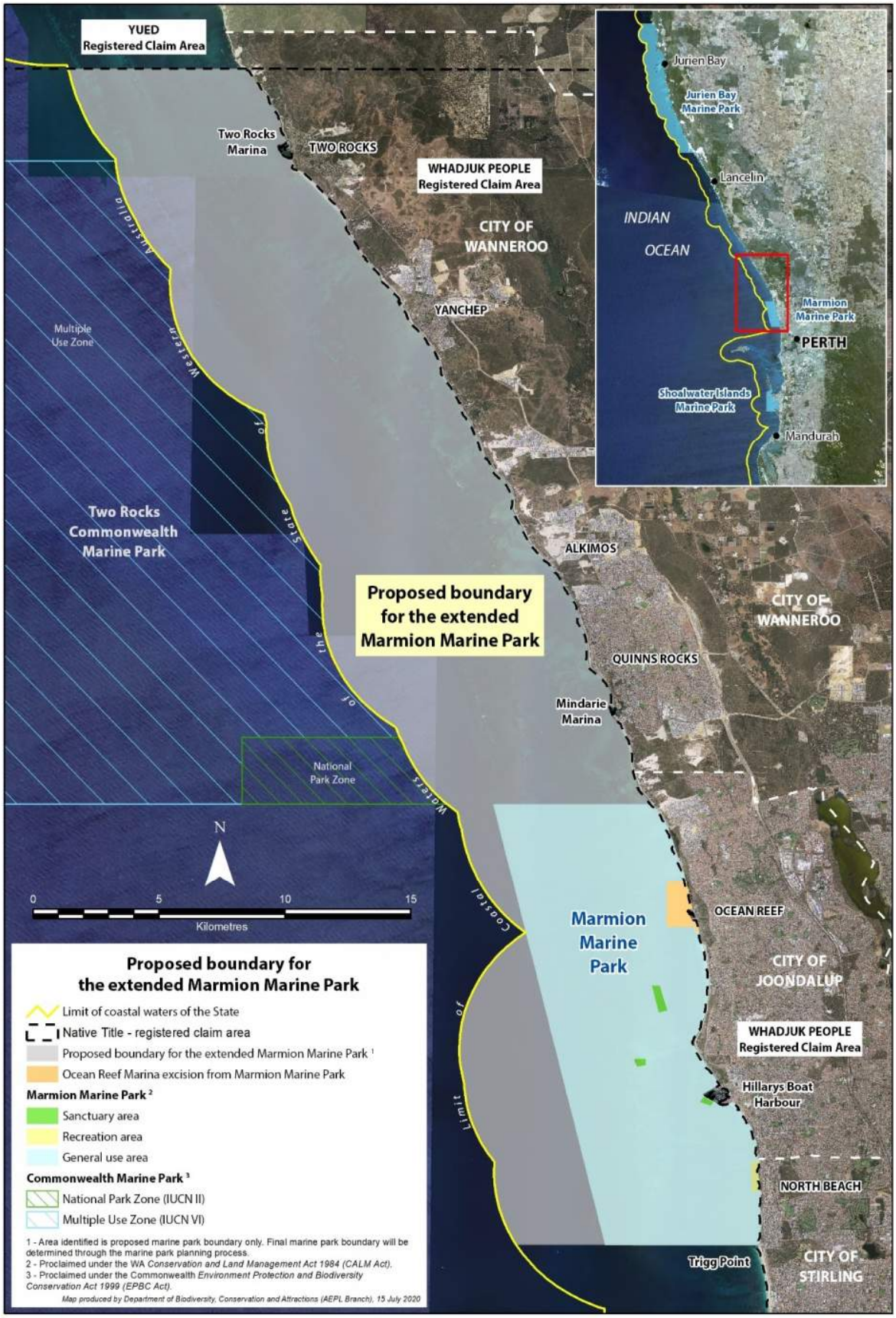

Figure 2.7 Marmion Marine Park –Proposed Extension (DBCA)

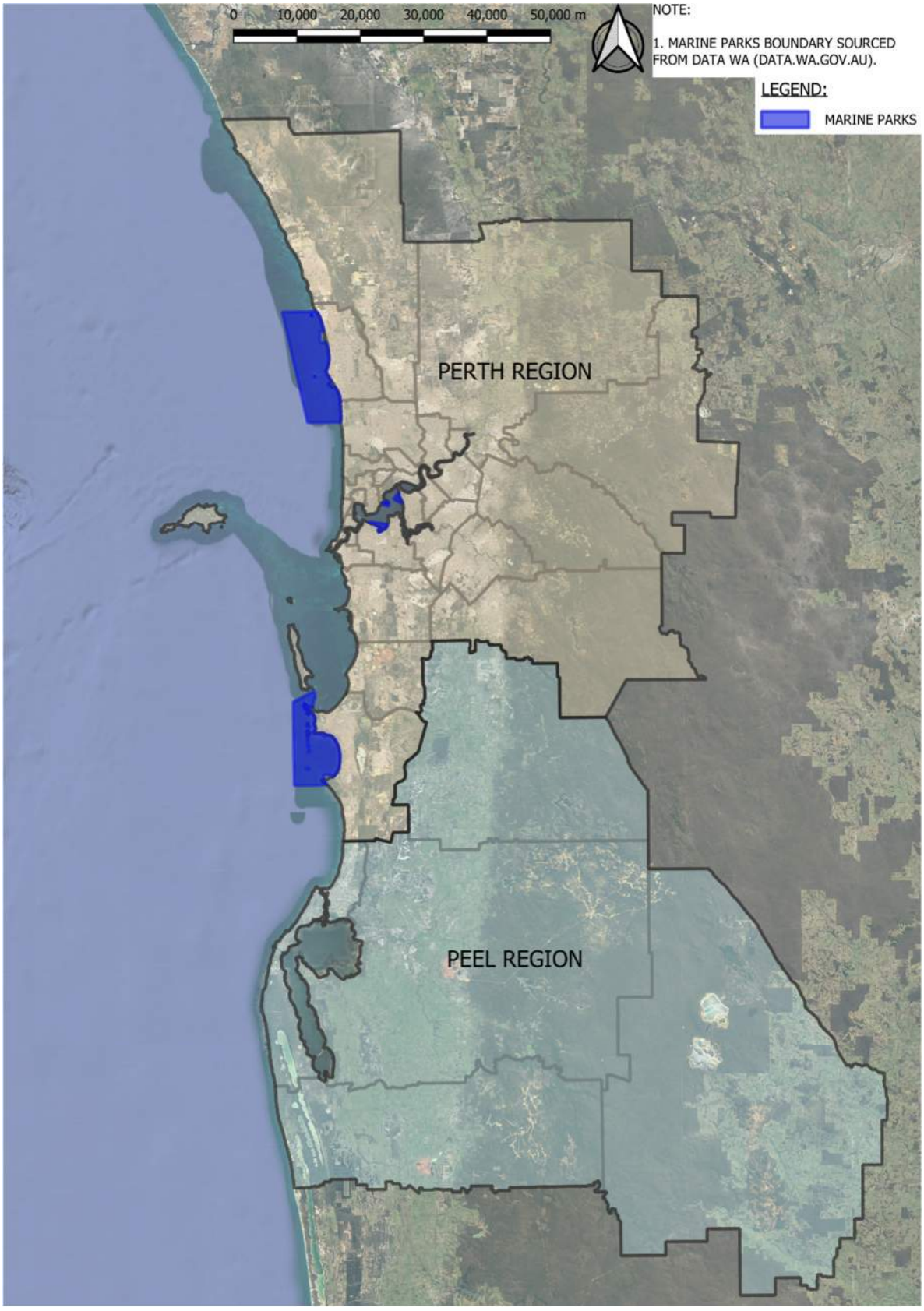

Figure 2.8 Perth Metropolitan & Peel Regions – Marine Parks

2.3.6 Benthic Habitat

Seamap Australia

The Institute for Marine and Antarctic Studies (IMAS) and University of Tasmania developed and maintain a national repository for the collection of marine habitats datasets referred to as Seamap Australia. The platform provides access to seafloor mapping datasets that align to Seamap Australia Classification Scheme.

Figure 2.9 shows the seafloor habitat in the Perth Metropolitan and Peel regions. Most of the data relevant to the Perth region was collected as part of the Perth Coastal Waters Study (Water Authority of Western Australia, 1995) and the Geomorphology & Sediments of Cockburn Sound (Geoscience Australia, 2005), which are discussed below and in Section 2.3.2 respectively.

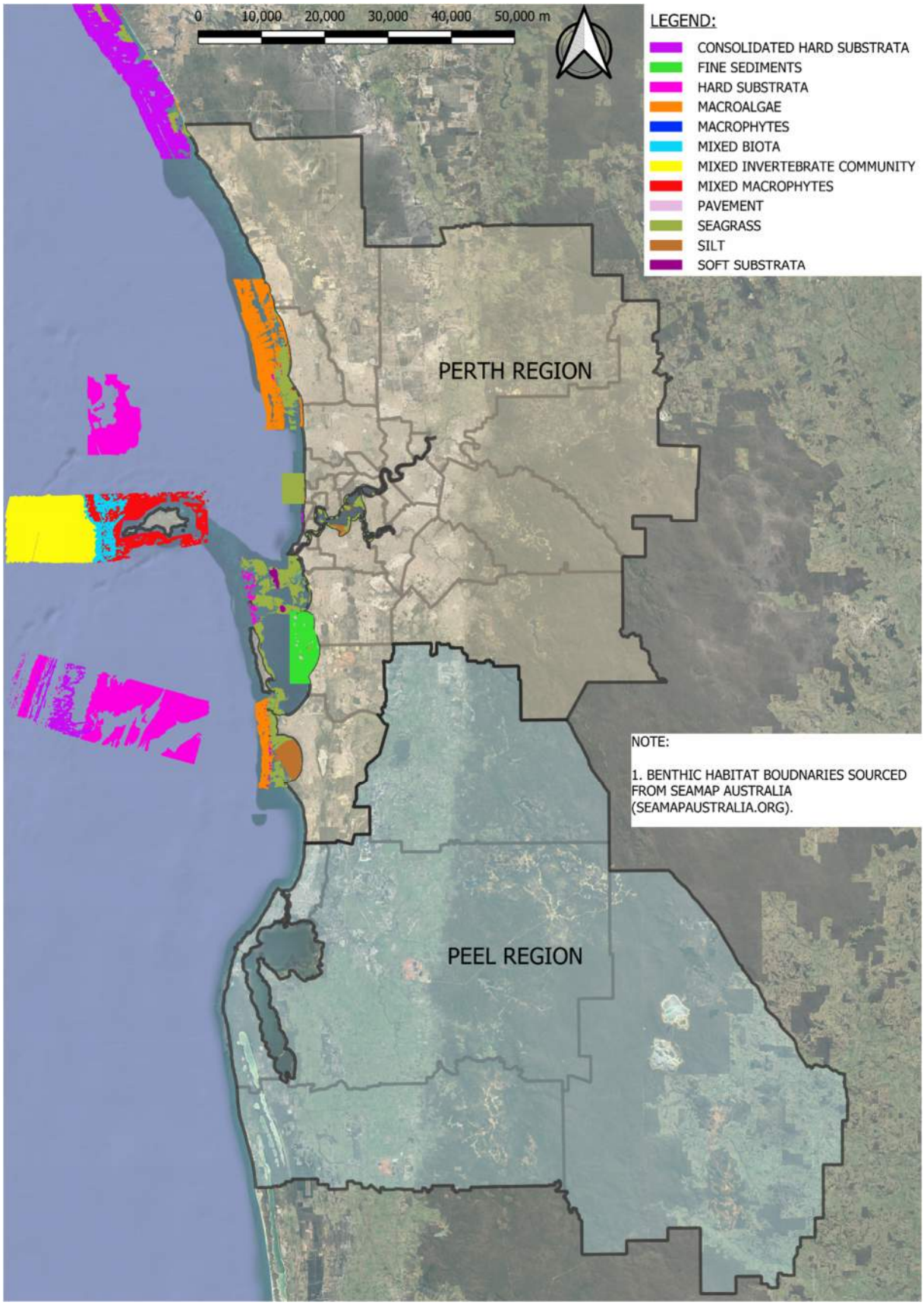

Figure 2.9 Perth Metropolitan & Peel Regions – Benthic Habitat

Perth Coastal Waters Study (Water Authority of Western Australia, 1995)

The Perth Coastal Waters Study (Water Authority of Western Australia, 1995) was undertaken to determine the allowable loads of Nitrogen in treated water that can be discharged into Perth's Coastal Waters. It was undertaken given there has been no correlation between plant growth and nutrient load and the complexity and variability associated with marine flushing/water exchange.

The study was undertaken in both a local and a regional context, which includes:

- Local – The wastewater outlets located at Ocean Reef, Swanbourne and Cape Peron which support the wastewater treatment plants at Beenyup, Subiaco and Woodman Point respectively.
- Regional – Perth's coastal waters including a 150 km region between Yanchep in the north to Tims Thicket in the south.

One of the main tasks of this study was the mapping and the time series study of the habitat types near each of the outlets. Figure 2.10 depicts the potential area occupied by the various types of habitats while Table 2.13 provides an overview of the percentage estimates.

Table 2.13 Percentage of Each Habitat

Wastewater Outlet	Sand	Hard Substrate	Seagrass
Ocean Reef	55	36	9
Swanbourne	86	5	9
Cape Peron	50	44	6

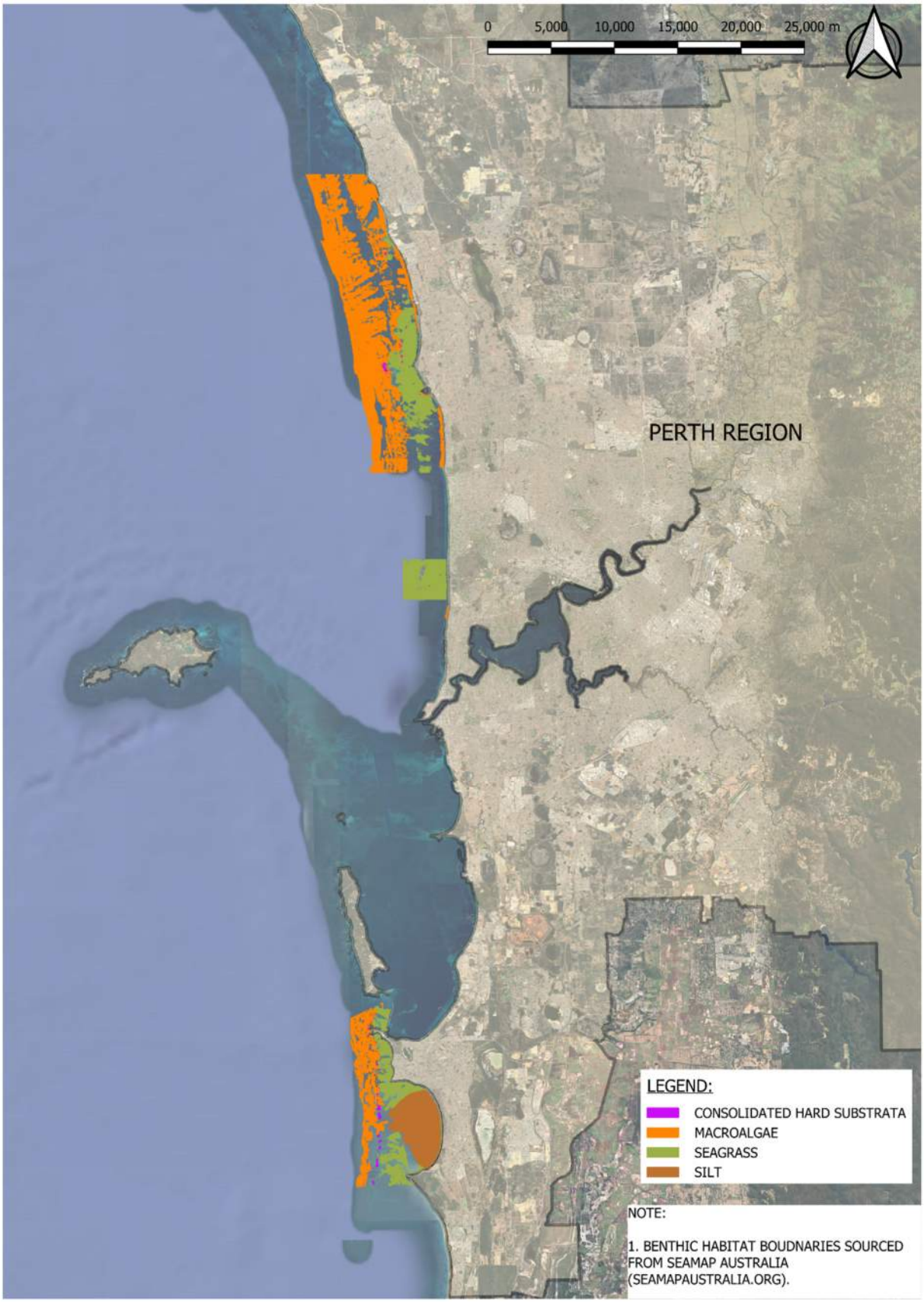

Figure 2.10 Habitat Maps Showing the Habitat Types Near the Wastewater Outlets

2.3.7 Geomorphology & Sedimentology

The following sections detail information available on the geomorphology and sedimentology within the Perth Metropolitan and Peel Regions.

MARine Sediments Database

Geoscience Australia maintains the MARine Sediments database (MARS) (Geoscience Australia: Marine Sediments (MARS) Database (ga.gov.au)), a comprehensive national repository containing data on over 40,000 marine sediment samples. These records cover diverse environments, documenting key sediment characteristics such as mud, sand, gravel, and carbonate content, along with spatial and geochemical properties, mineralogy, bulk density, and other attributes. Additionally, MARS archives sediment cores collected since the 1960s, many contributed by external organisations, for ongoing and future research.

MRA has reviewed the MARS database and found there is a lack of quantitative data concerning sediment characteristics. Figure 2.11 shows an extract of the MARS dataset and the lack of data for the Perth Metropolitan and Peel Regions.

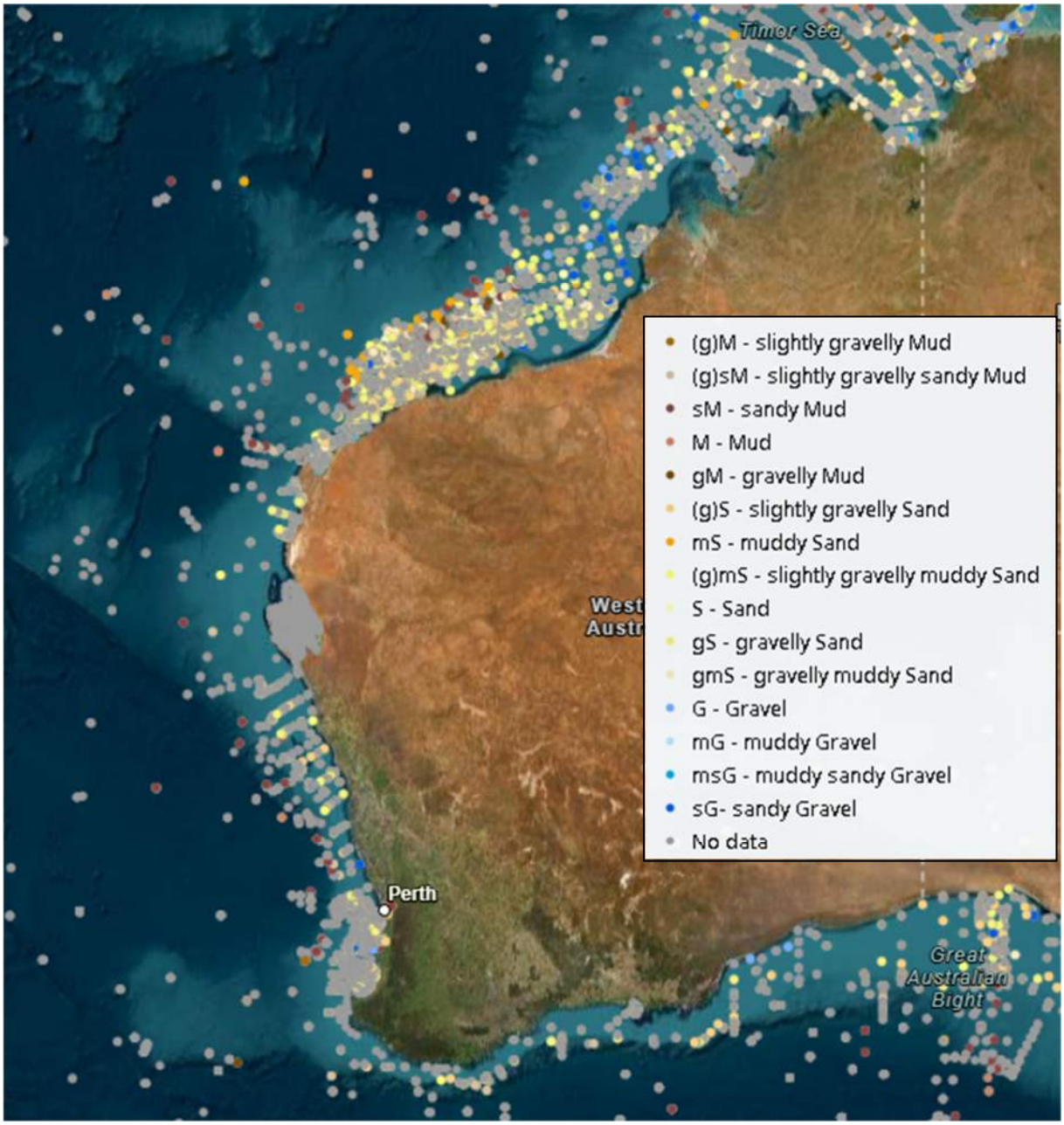

Figure 2.11 Perth Metropolitan & Peel Regions – MARine Sediment Database

dbSEABED

dbSEABED is an ocean information system developed by the University of Colorado and other collaborators. The platform offers access to a vast database of marine sediment and seabed data, primarily focusing on the seafloor's physical and compositional characteristics.

dbSEABED compiles and processes data from various sources, including sediment samples, geological surveys, and underwater imagery, providing users with integrated information on sediment type, grain size, mineral content, and other seafloor properties.

The data contained within dbSEABED is not freely accessible and as such MRA has not relied on the data for this project. dbSEABED does offer a Google Earth tool, as shown in Figure 2.12, which outlines the available dbSEABED datasets for the Perth Metropolitan and Peel Regions.

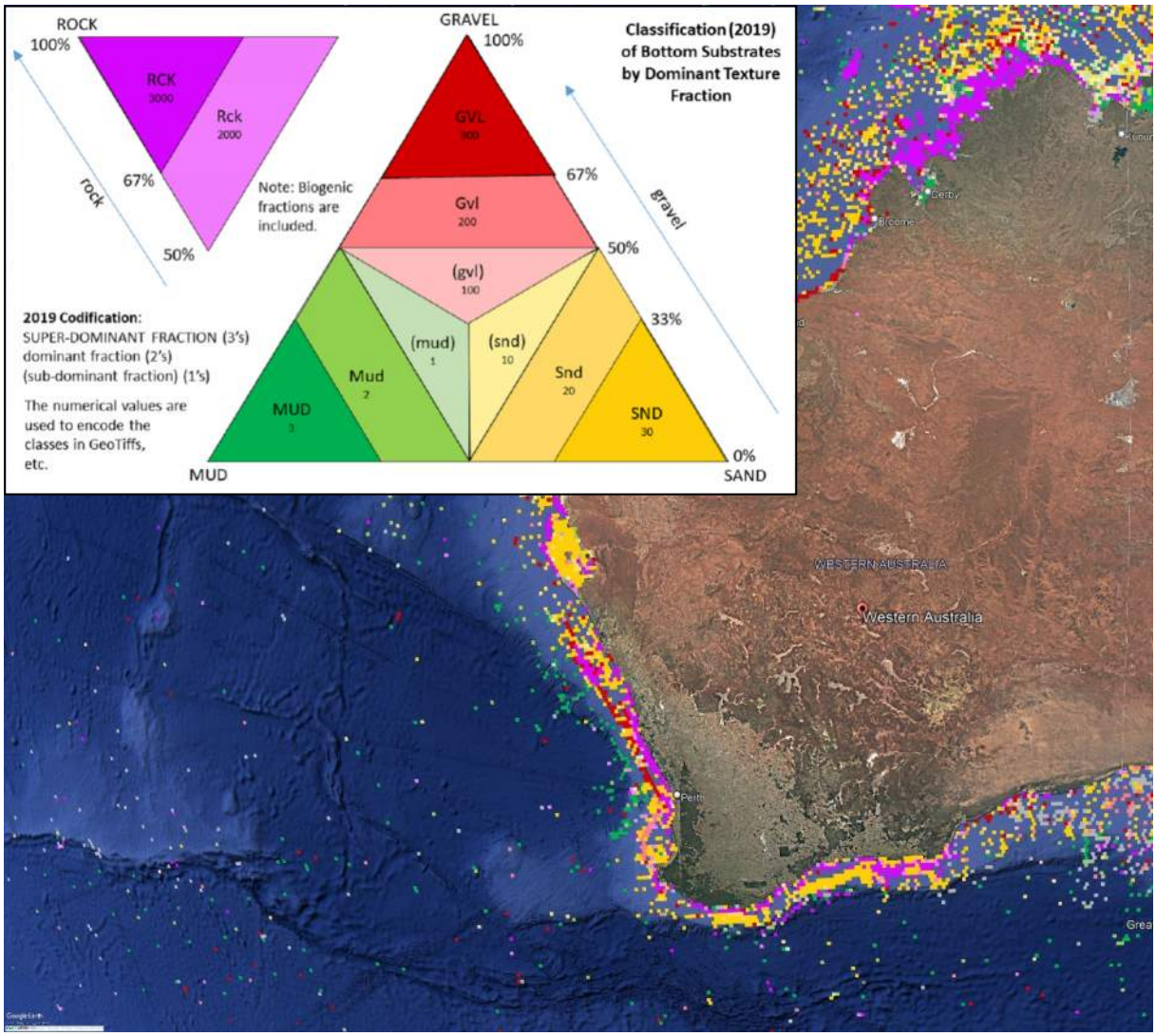

Figure 2.12 Perth Metropolitan & Peel Regions – dbSEABED Database

Multigrain Seabed Sediment Transport Modelling for the South-West Australian Shelf (Li et al., 2009)

Li et al. (2009) investigated the long-term and large-scale seabed morphological changes on the southwest Australian continental shelf, to gain a comprehensive understanding of the effects of climate change and sea level rise on sediment erosion, transport, and deposition across the shelf.

The investigation used Sedsim, a comprehensive sediment transport model developed under a consortium at Stanford University in the 1980s, which was systematically redeveloped throughout the 1990s (Li et al., 2009). The simulation covered the southwest Australian continental shelf and abyssal basin, including the Rottnest Shelf, Perth Canyon, Albany Canyons, Great Australian Bight, Lincoln Shelf, Spencer Gulf, Gulf St Vincent, and part of the Lacepede Shelf, as shown in Figure 2.13.

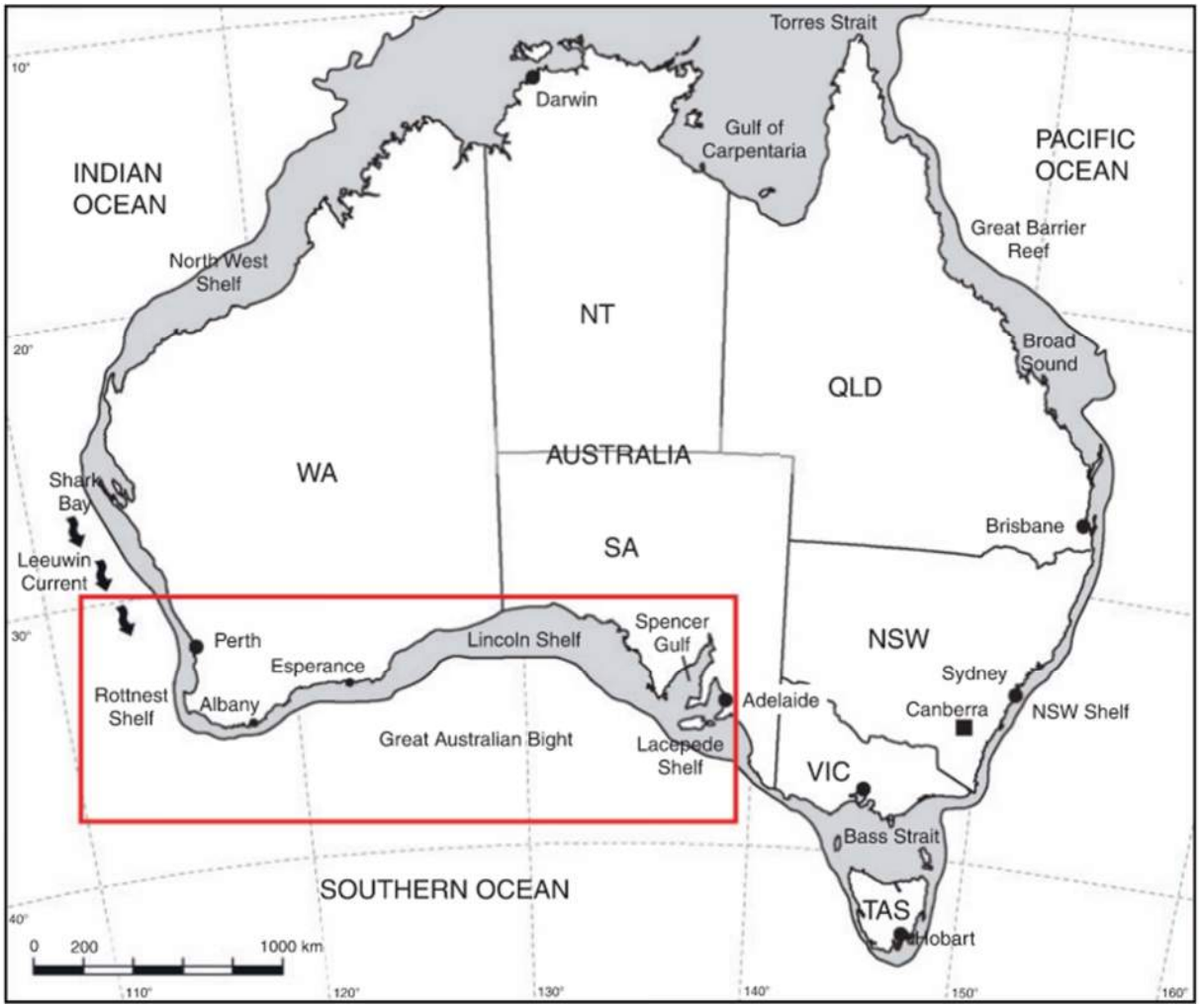

Figure 2.13 Map Illustrating the boundaries of the Sedsim Analysis (Li et al., 2009)

The report provides an overview of existing sediment sources within the study area, including seabed sediment and river inputs.

The analysis of seabed sediment relied on available samples housed in the auSEABED sediment database. Figure 2.14 illustrates the gridded median grain sizes across the study area, highlighting the following key features:

- Coarse grains (>0.5 mm) are primarily found in and around the Great Australian Bight, Spencer Gulf, Gulf St Vincent, and parts of the Lacepede Shelf.
- Medium grains (0.25–0.5 mm) are present in areas surrounding the coarse-grained facies.
- Fine-grained facies (<0.01 mm) typically occur at water depths greater than 200 m on the continental slope and abyssal basin.
- Inner shelf sediments are described as reworkable, with a thickness of 0 to 1 m, located at depths of 0 to 60 m.
- Outer shelf sediments are less affected by wave abrasion, with a thickness of 0 to 4 m, located at depths of 60 to 170 m.

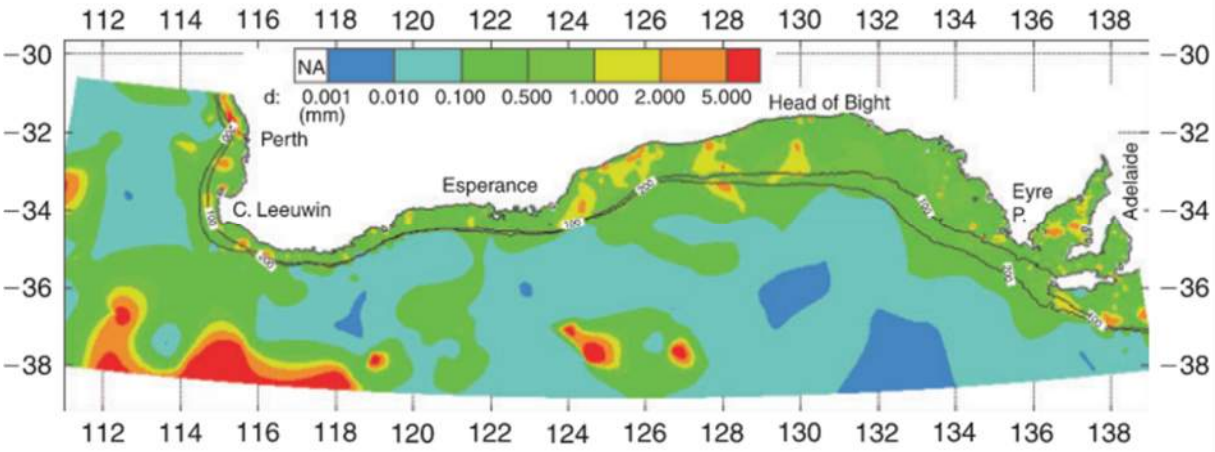

Figure 2.14 Gridded Median Grain Size (Li et al., 2009)

The analysis of the river inputs found that most of the terrigenous sediment carried down by the major rivers in the study area is trapped in inland lakes or estuaries and only a small fraction of fine-grain sediment reaches the continental shelf. The report evaluated the 17 major rivers in the study area in terms of their annual sediment carrying capacity, which is a function of the catchment area, rainfall and vegetation. Information regarding the rivers is presented in Table 2.14 with their locations shown in Figure 2.15.

Table 2.14 Major Rivers & Sediment Source Locations for the Coastal Region (Li et al., 2009)

Source	No.	Name of the source	Q ($m^3 s^{-1}$)	C ($kg m^{-3}$)	Latitude (S)	Longitude (E)
WA	1	Moore River	12.68[A]	0.052[A]	31°21′20″	115°30′41″
	2	Swan-Canning River	19.79	0.265	31°57′49″	115°50′44″
	3	Leschenault Inlet	10.00	0.068	32°35′10″	115°46′12″
	4	Peel-Harvey Estuary	19.60	0.02	33°18′20″	115°41′37″
	5	Vasse River	0.35	0.146	33°36′51″	115°25′22″
	6	Margaret River	3.82	0.033	33°58′10″	114°59′21″
	7	Hardy Inlet	29.33	0.106	34°16′43″	115°11′31″
	8	Warren Inlet	12.68	0.069	34°36′34″	115°49′51″
	9	Walpole/Nornalup Inlet	12.59	0.071	35°00′01″	116°45′10″
	10	Irwin Inlet	5.20	0.098	34°59′23″	116°57′27″
	11	Wilson Inlet	5.20	0.098	34°58′30″	117°27′38″
	12	Oyster Harbour	6.34	0.136	34°57′21″	117°58′20″
	13	Beaufort Inlet	1.14	0.75	34°27′18″	118°52′36″
	14	Culham Inlet	4.76	0.045	33°53′38″	120°04′37″
	15	Oldfield Estuary	0.25	0.9	33°52′08″	120°47′11″
SA	16	North Spencer Gulf	3.17	0.162	32°30′39″	137°45′50″
	17	Light River	3.17	0.135	34°33′02″	138°20′26″

[A]Estimated value.

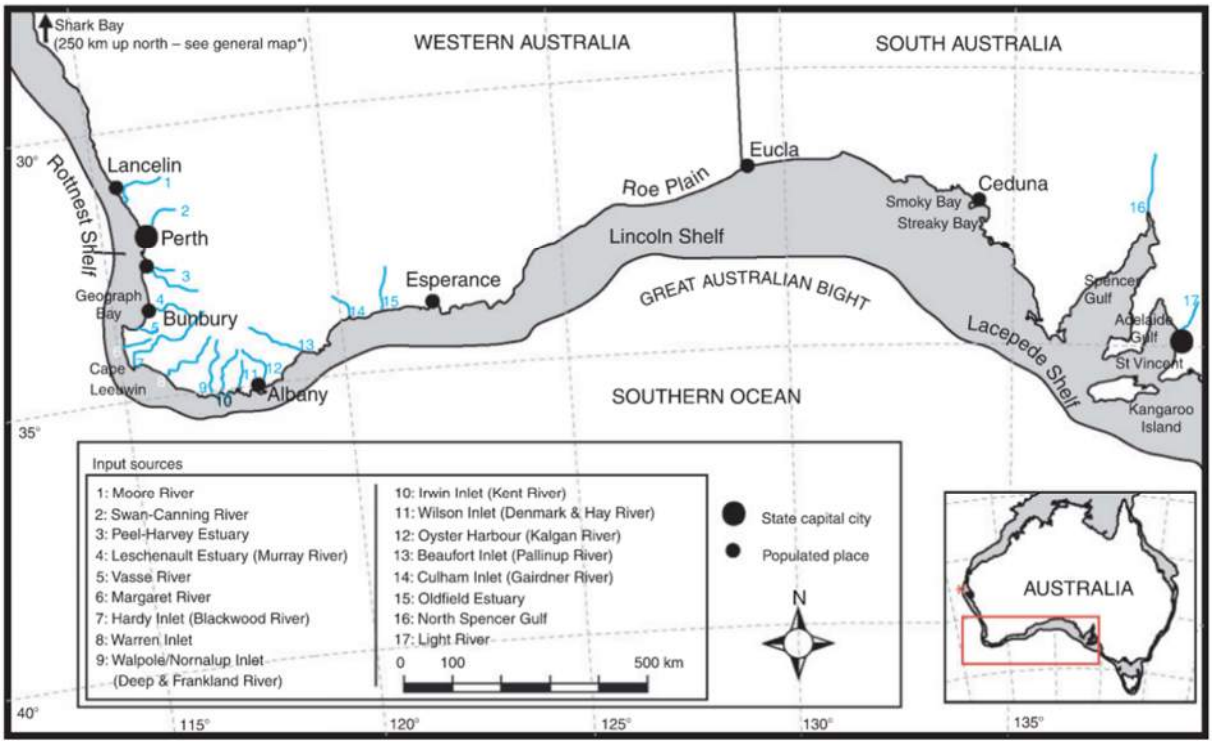

Figure 2.15 Major River Sediment Sources in the South-Western Region (Li et al., 2009)

The study found that most of the shoreline is experiencing erosion. Modelling predicts up to 1 to 2 m of morphological change over the next 50 years, driven primarily by the Leeuwin Current and the high-energy waves prevalent in the south-west region. Additionally, the limited deposition of fluvial sediment into the system is a contributing factor.

Geomorphology & Sedimentology of the South Western Planning Area of Australia (Richardson et al., 2005)

Geoscience Australia (Richardson et al., 2005) undertook an extensive investigation into the relevant literature on geomorphology and sedimentology for the South Western Planning Area (SWPA), illustrated in Figure 2.16.

The region was divided into four major physiographical provinces including Rottnest, South West, Great Australian Bight and Spencer and St. Vicent Gulfs. The Rottnest province was of particular interest as it included the Perth Metropolitan and Peel regions and comprises of the Rottnest Shelf and the southern area of the Dirk Hartog Shelf, and deep water areas out to the Perth Abyssal Plain.

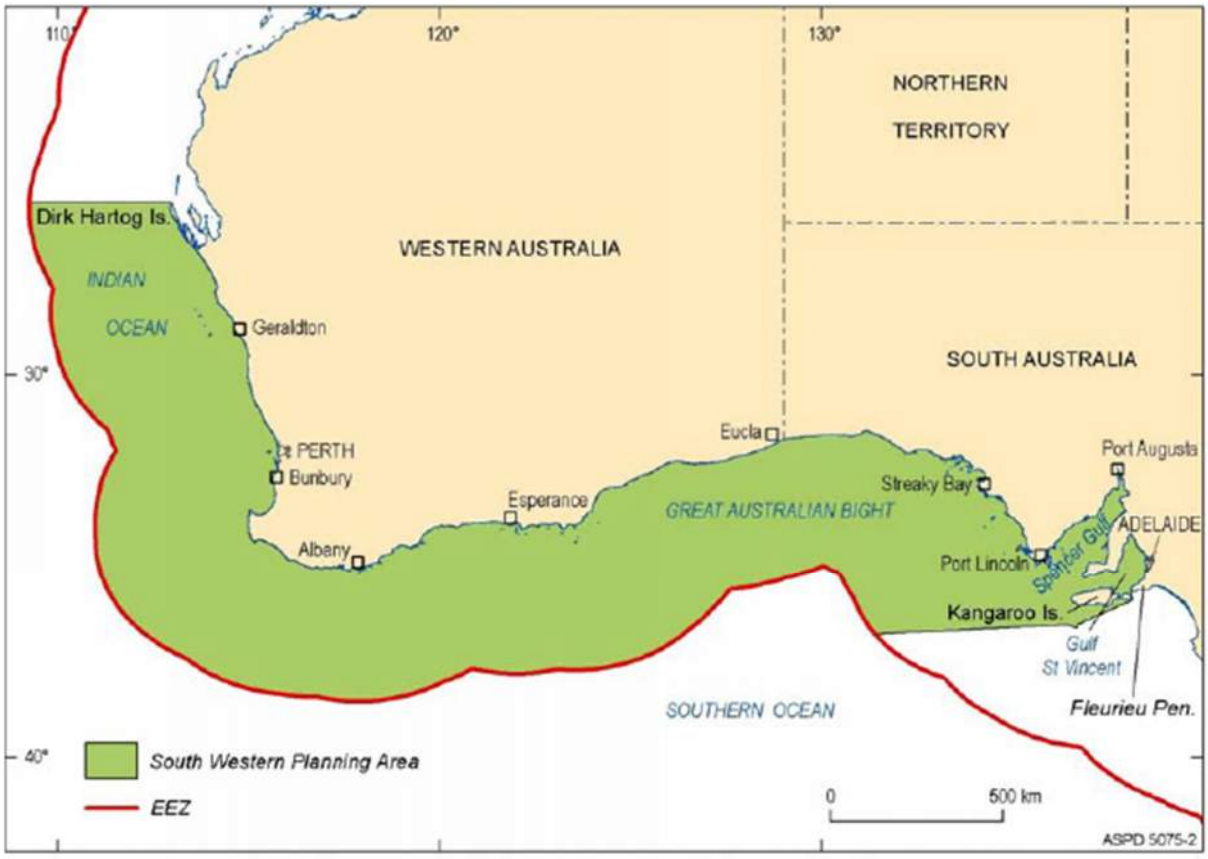

Figure 2.16 Boundaries of the South Western Planning Area Extending from the Coast to the Exclusive Economic Zone (Richardson et al., 2005)

The Rottnest Shelf extends from Geraldton in the north to Cape Leeuwin in the south and is approximately 45 to 100 km wide (Collins, 1988). The northern section of the shelf is relatively straightforward whereas the southern section has been called a 'bathymetrically complex coast' by Semeniuk (1996). Figure 2.17 depicts the northern and southern sections of the Rottnest Shelf, with the northern section predominantly a flat-bottom shelf with intermitted ridges that transition into a steepening slope away from the coast. The southern section includes nearshore ridges and depressions, smooth inner-shelf plains and shore parallel offshore ridges.

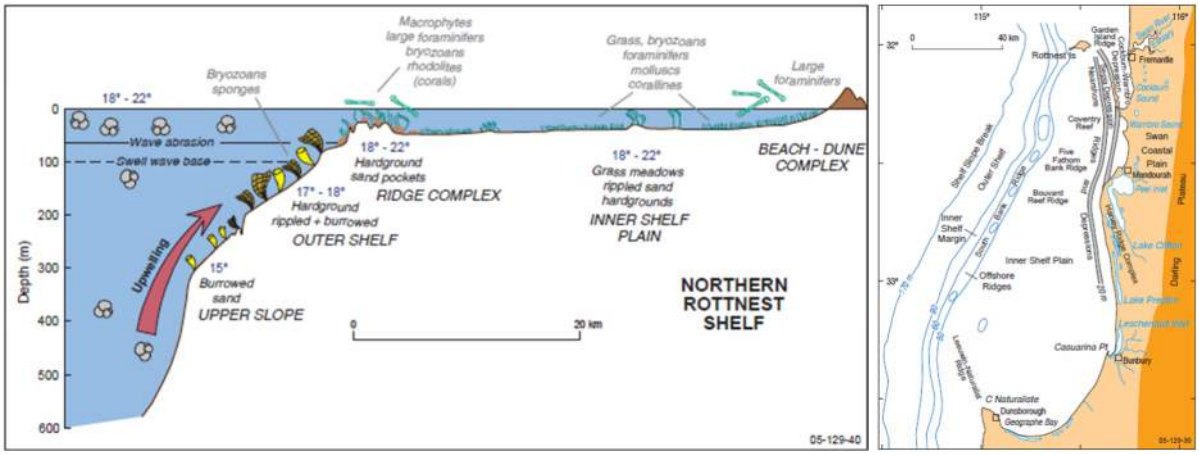

Figure 2.17 Schematic Sections of the Rottnest Shelf (L) Northern Section (James et al., 1999 Modified by Richardson et al., 2005) (R) Southern Section (Collins, 1988 Modified by Richardson et al., 2005)

Regarding sediments, the report found that only 93 of 1,012 samples stored on the MARS database for the SWPA included quantitative information pertaining to grain size and carbonate content, and most of the quantitative information is located within the Great Australian Bight.

Richardson et al. (2005) reported that Collins (1981,1986, 1988) and Collins et al. (1999) have completed several studies in which they investigated the sedimentology of Rottnest Shelf and the Inner Shelf Plain from the Abrolhos Shelf in the north to Cape Naturaliste in the south. The literature suggests the sediment generally occurs as a thin discontinuous veneer of sand over rocky substrate. Collins (1988) identified two major types of sediment this includes the Fremantle Blanket and Rottnest Blanket. Figure 2.18 shows that the sediment types run shore parallel and nearshore regions (Fremantle Blanket) consist of a thin (<1 m) layer of wave-rippled sand overlying Pleistocene limestone. There are also localised areas of algal hard grounds within the nearshore regions. The major sediment types within the Coastal Waters of the Perth Metropolitan and Peel regions include:

- Quartz Grainstone - Yellow-brown, coarse to medium-grained, moderately well rounded and well sorted sediments.
- Lithoskel Grainstone - Yellow-brown, coarse to medium-grained, well rounded and well sorted sands.

The ripples suggest that the sediment is mobile and affected by bottom currents from swell and storm events. The investigation identified rippled bedforms were present at depths less than 60 m.

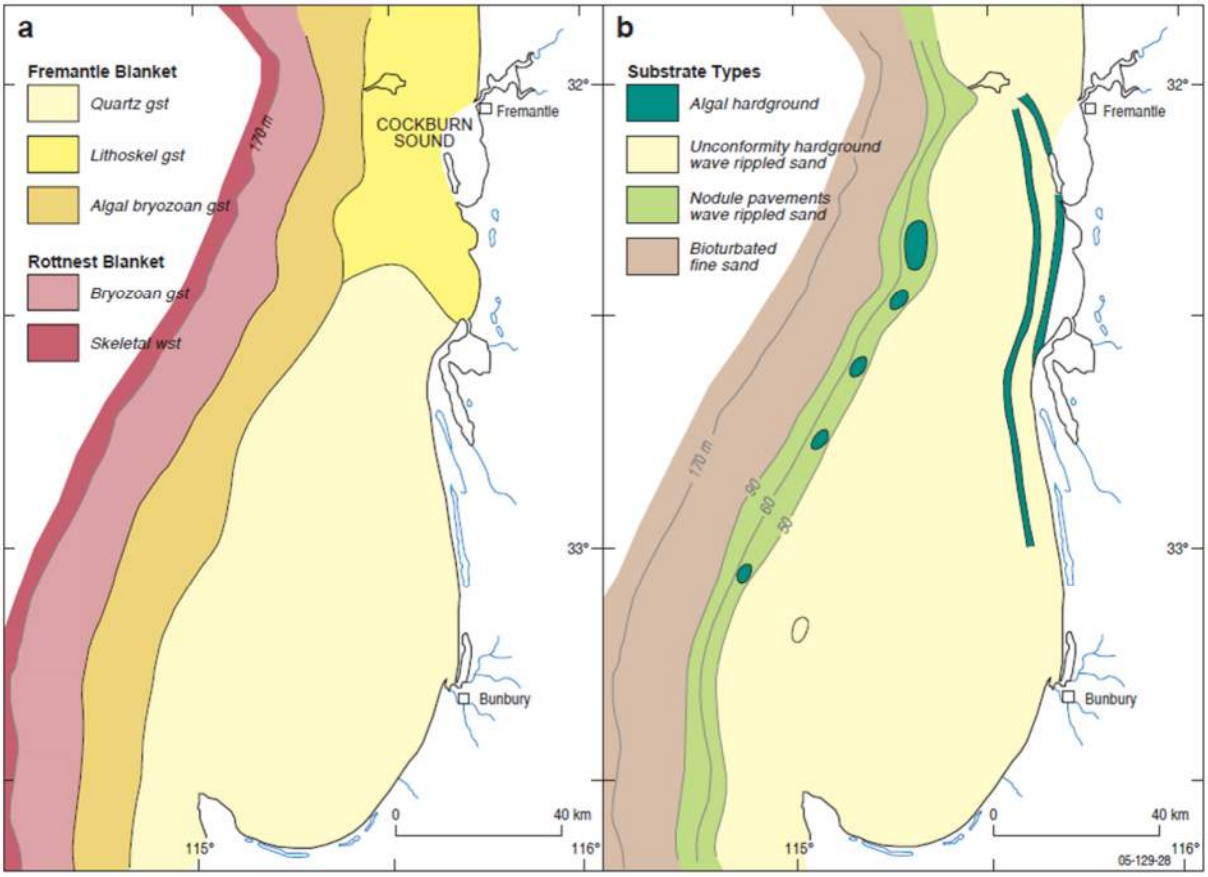

Figure 2.18 Southern Section of the Rottnest Shelf (a) Surface Sediment Facies Map (b) Substate Map & Associated Biota (Collins, 1988 Modified by Richardson et al., 2005)

2.3.8 Basic Raw Material (BRM) Exclusion Areas

As part of the development of SPP 2.4 (WAPC, 2021a), BRM exclusion areas were identified and incorporated into resource mapping (GeoVIEW.WA). These exclusion areas contain known BRM resources; however, they are deemed unsuitable for excavation due to environmental protection requirements, planning constraints, or infrastructure considerations. Consequently, there is a presumption against approval of extraction activities within these areas.

Figure 2.19 illustrates BRM exclusion zones within the Perth Metropolitan and Peel regions. Currently, BRM exclusion area resource maps have been developed solely for these regions.

Further discussion regarding the potential sterilisation of sand and rock resources will be provided in Task 5 of this report.

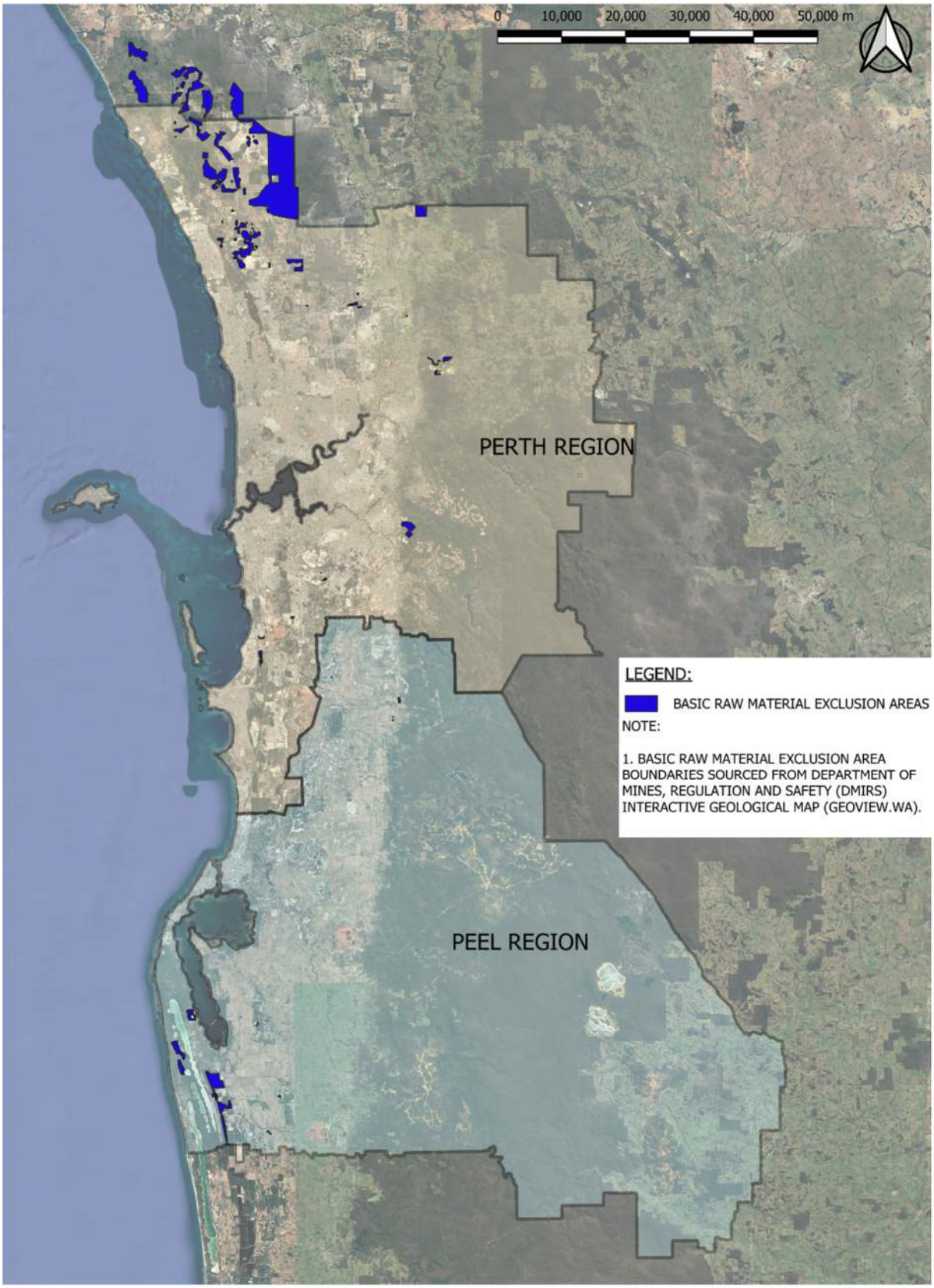

Figure 2.19 Perth Metropolitan & Peel Regions – BRM Exclusion Areas

2.4 Southwest Region

The Southwest region extends from the southernmost extent of the Shire of Manjimup (SoM) to the northernmost extent of the Shire of Harvey (SoH). The foreshore, fronting the Indian and Southern Oceans, is managed by 7 coastal LGAs.

2.4.1 General Information

Greater Bunbury Region Scheme (GBRS) (WAPC, 2012)

GBRS (2012) is a statutory land-use planning framework designed to manage growth and development in the Greater Bunbury region of WA. Administered by the WAPC, the scheme provides a coordinated approach to land use, infrastructure provision, and environmental conservation across the region. The region encompasses Lake Preston in the north, Peppermint Grove Beach in the south, eastwards to Darling Scarp, and covers the City of Bunbury (CoBun) and the Shires of Harvey, Dardanup and Capel.

Greater Bunbury Region Scheme – Strategic Minerals & Basic Raw Materials Resource Policy (WAPC, 2018b)

The WAPC (2018b) policy, designed to align with the GBRS (WAPC, 2012), was developed to identify land within the GBRS that contains mineral resources and BRMs of Sate or regional significance. The policy aims to ensure long-term access to minerals and BRMs through appropriate land use planning and development control, and is considered to respond to community and industry needs regarding:

- Facilitating the timely extraction of resources.
- Ensuring that present and future extraction of basic raw materials and mineral resources are not prejudiced.
- Minimising the impact of extraction on surrounding land uses.

The policy also emphasises the importance of balancing resource extraction with environmental protection, particularly in sensitive coastal and inland areas. The policy aims to ensure that resource development is carried out in a way that supports economic growth while safeguarding natural habitats, water resources, and landscape values.

Figure 2.20 shows the extent of the policy area.

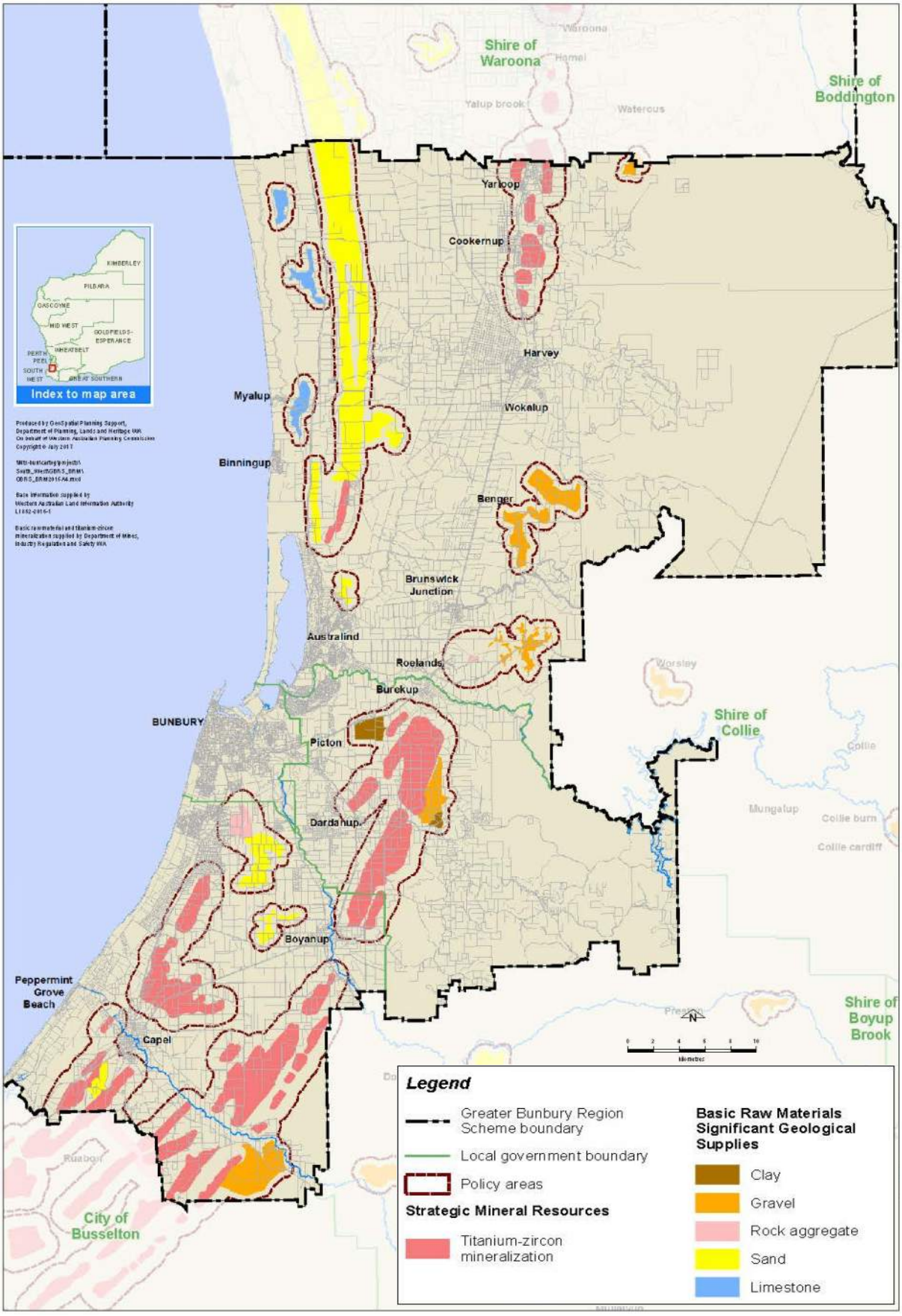

Figure 2.20 Strategic Minerals & BRMs Resource Policy Map (WAPC, 2018b)

Review of Basic Raw Material for Coastal Projects (Shore Coastal, 2024)

Shore Coastal (2024 - draft) provided a desktop review of BRM supply and demand for coastal projects in the CoBus. It assesses past studies, current commercial sources, and inspections of eight quarries and sand pits from Bunbury to Margaret River.

The report highlights high BRM demand driven by residential and major projects. While geologic formations contain suitable materials, extractive industries face access constraints.

For the CoBus, natural beach sand remains the preferred option for nourishment and dune resilience, due to suitability and cost, though ongoing monitoring is required. Commercial sand sources should be evaluated per project, with sand from Southern Ports (Bunbury) considered for large-scale dune projects, subject to logistics and trucking cost assessments. Offshore sand sources require further investigation, particularly the potential for transporting dredged sand from Bunbury to Geographe Bay.

For rock armour, granite remains available from quarries east of Bunbury, though high demand necessitates early procurement. Ironstone and limestone filter rock are available in reasonable quantities in the Busselton region.

Figure 2.21 provides an overview of sand (natural and commercial) and rock locations within the Capes Region.

Figure 2.21 BRM Supplies for Coastal Projects near Busselton (Shore Coastal, 2024)

City of Busselton Coastal Management Plan (Shore Coastal, 2020)

Shore Coastal (2020) presents a ten-year coastal management plan for the Geographe Bay foreshore, prepared for the City of Busselton (CoBus). This plan replaces the previous coastal management plan and aims to facilitate strategic, effective, and sustainable coastal adaptation, covering 34 km of sandy coastline from Dunsborough in the west to Wonnerup Inlet in the east.

The plan includes a review of previous coastal adaptation and monitoring works completed between 2013 and 2020.

Additionally, the plan proposes a coastal management program for the ten years from 2021 to 2030, outlining a continued commitment to monitoring metocean conditions and beaches, coastal surveys and coastal investigations. The report also details the path for implementing preferred coastal adaptation options for strategic areas along the foreshore.

In total, seven coastal adaptation projects are planned to be delivered over the next ten years. These projects are listed in Table 2.15, with a visual representation of their locations shown in Figure 2.22.

Table 2.15 Proposed Coastal Adaption Works (2021-2031)

Coastal Management Area	Site	Coastal Adaptation Works
Abbey	Forth St	Sand nourishment and beach scraping are being undertaken in the short term to maintain the foredune buffer (Stage 1). A new GSC groyne is proposed in Year 1 (Stage 2) to protect Geographe Bay Rd, with subsequent stages in Years 3 subject to monitoring.
West Busselton	Broadwater	Future stages of Coastal Adaptation works at Broadwater Beach are subject to coastal monitoring of Stage 1 (completed). However, Stage 2 (2 x GSC groynes) is programmed for Year 2, and Stage 3 (1 x GSC groyne) for Year 4.
West Busselton	Gale St	A trial Beach Scraping exercise was completed in 2020 to reinstate the foredune. However, there is a long-term depletion of sediment in the West Busselton coastal management area, therefore coastal adaptation works are allowed for in Year 3 and 5 (subject to Monitoring).
Wonnerup	Baudin Reserve	Interim coastal stabilisation structures were built by the City in 2017 at Baudin Reserve, followed by further works in 2020 involving maintenance to the low profiled rock groynes and construction of new GSC groynes to the east. However, the success remains entwined with the sediment supply available through management of Port Geographe by DoT. The program allows for extension of the groyne field if required.
Geographe Bay	To be determined	Mitigation of Coastal Flooding (Dune Rebuilding): Adaptation measures for coastal dunes were recommended in the Coastal Flooding Risk, Response and Mitigation Report (27) and have been included in the program. The coastal dunes are the primary defence against coastal flooding of residential areas along the beach ridge. A recent trial has been undertaken at Margaret St. This project requires detailed survey prior to implementation. The project allows for targeted dune works in selected areas, based on the detailed survey in Year 1.
Geographe Bay	To be determined	Mitigation of Coastal Flooding (Drain Modifications): Adaptation measures for coastal drains were recommended in the Coastal Flooding Risk, Response and Mitigation Report (27) and have been included in the program. The project includes inspecting City of Busselton stormwater outlets to the coast and retrofitting non-return flap valves or similar where required, which become a path for storm surge flooding.
West Busselton	To be determined	Strategic sand nourishment is planned at 5-years intervals in this program. This concept is based on a larger scale 'seeding' of the littoral transport system with large pulses of sediment in strategic locations. Nominally this is based on nourishment of 25,000m³ to 40,000m³ every five years.

Note: Reproduced from Shore Coastal (2020).

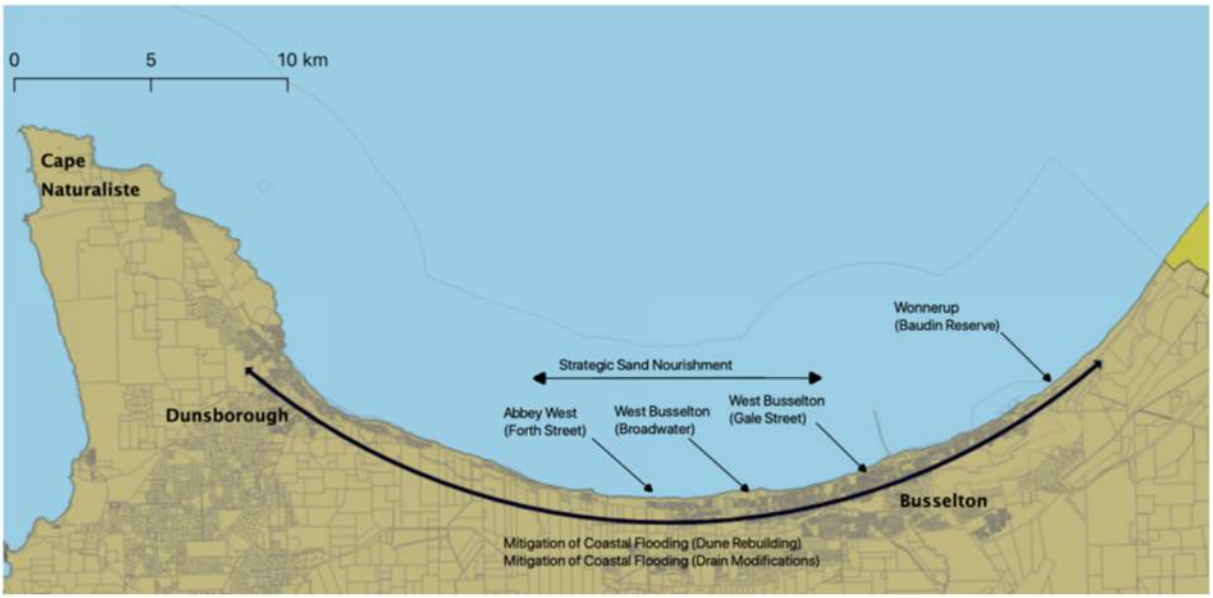

Figure 2.22 Proposed Location of Coastal Adaption Works within Geographe Bay (2021-2031) (Shore Coastal, 2020)

Basic Raw Materials – Demand and Supply Study for the Bunbury-Busselton Region (WAPC, 2012)

The WAPC (2012) study, conducted to support the GBRS (WAPC, 2012), evaluated the adequacy of BRMs in the Bunbury-Busselton region, including the LGAs of Harvey, Dardanup, Bunbury, Capel and Busselton. This study provided a regional supply and demand analysis for BRMs such as sand for fill and buildings (e.g., mortar and plaster), limestone for road base, cement, and agricultural lime, and crushed hard rock for concrete and road surfaces.

The study found that extractive industries need to produce 104,231,000 m^3 of BRMs to meet the region's requirements up to 2030. Sand has the highest demand at 43,753,000 m^3, primarily for residential developments. Limestone has a demand of 30,359,000 m^3, mainly for agricultural use. Hard rock, including gravel and granite, is estimated at around 19,000,000 m^3 for residential and commercial construction and 37,000 m^3 for coastal protection works. When comparing the predicted hard rock quantities for coastal protection works against those discussed by stakeholders (refer to Section 2.5), it is evident that the required material has been vastly underestimated.

Data from the GSWA division of the Department of Mines and Petroleum (DMP) indicates a substantial potential supply of BRMs to meet future regional demand, except for limestone, lime sand, and clay. The study also noted that the supply estimates only considered areas meeting GSWA's significant supply criteria, suggesting that the actual potential supply of BRMs could exceed those estimates provided.

This suggests that there is likely to be a shortfall in the supply of lime and clay products within the Bunbury-Busselton region. However, all other materials are likely to meet the future regional demand, especially given the study is considered to underpredict the BRMs available to supply the market.

Appendix C shows the extractive industry licence sites located in the study area.

Port Geographe Development Sand & Rock Investigations

During the construction of Port Geographe in the 1990s, Cossill & Webley (1995, 1996) were commissioned to investigate suitable sand for fill and rock for groynes and revetments. Cossill & Webley (1995) examined 10 potential rock sources and 5 potential sand sources. It was concluded that the available materials would meet the development requirements of Port Geographe, estimated at 1,000,000 m³ of sand and 100,000 tonnes of rock. The materials included grey, white and yellow silica sands, as well as granite, sandstone, laterite, basalt and limestone rock.

Following this initial investigation, Cossill & Webley (1996) carried out sampling and testing of the potential rock sources in the Busselton area. Four of the original ten rock quarries were tested to assess particle density and water absorption, point load strength, and sodium soundness.

The assessment determined that granite from the Ellenbrook Road site was the preferred source of armour rock. Although ferricrete performed poorly against the assessment criteria, a significant amount of this material had been used along Busselton's coastline and had provided adequate service. Therefore, it was deemed suitable for secondary protection.

2.4.2 Sand

This section outlines the various types of sand as well as some individual studies investigating potential sand sources within the Southwest Region.

Sand Types

Within the Southwest Region, the following sand types are available:

- Quindalup Limesand.
- Yogannup Sands.

Further information on these sand types can be found in Section 2.3.2 of this report. It is worth noting that areas south of Kemerton have been extensively extracted or sterilised due to conservation, with only minor deposits available for use.

Bunbury Coastal Enhancement Project: Sediment Analysis (DLA, 2001)

A series of studies were conducted to understand the coastal processes along Back Beach as part of the Bunbury Coastal Enhancement Project. As part of this work, DLA (2001) was engaged by MRA to undertake a sediment analysis to determine the sediment provenance in this area, with specific aims to:

- Identify the province of the material in relation to the littoral zone.
- Provide a geological description of the sediment origins.
- Test the grading and calcium carbonate content.

The study area is located south of Bunbury and extends approximately 5.5 km south of Casuarina Point.

Sediment samples were collected from 40 sites along a series of eight shore-normal transects. Along each transect, grab samples were collected at nominal water depths of 0, 2.5, 5, 7.5, and 10 metres. Additionally, at each grab location, the sea floor features were recorded, including the presence of bedforms, reef outcrops and seagrasses.

Tables 2.16 and 2.17 detail the physical and compositional properties of sediments within the three sediment zones, respectively.

Table 2.16 Physical Properties of the Sediment (DLA, 2001)

Sedimentary Zone	Modal Grain-Size	Grain Skewness	Size Sorting	Sphericity	Proportion of Subangular Grains
Shoreline	Medium to coarse sand	Symmetric to strongly fine	Moderately to moderately well	Moderate to low	50%
Inshore slope	Medium to fine sand	Symmetrical to strongly coarse	Moderately	Moderate to low	55-75%
Offshore	Coarse sand	Fine to strongly fine	Moderately to moderately well	Variable	40%

Table 2.17 Compositional Properties of the Sediment (DLA, 2001)

Sedimentary Zone	Calcium Carbonate	Proportions of Main Grain-Types (%)			
		Quartz	Size Sorting	Sphericity	Proportion of Subangular Grains
Shoreline	17-23	60-65	8-18	19/27	2-4
Inshore slope	44-77	10-47	1-8	44-88	1-5
Offshore	6-25	54-76	3-10	9-29	4-8

Port Geographe

Research has been undertaken within Geographe Bay to understand the sediment dynamics and provenance in the area.

Damara (2010) collected sediment samples primarily focused on the Port Geographe development. The sediment characteristics and spatial variations were analysed to investigate sediment transport processes along the coast. The analysis relied upon prediction methods to determine sediment transport direction and delineate sediment cells. The result is a sediment transport model shown in Figure 2.23.

As illustrated in Figure 2.23 by the red (westward) and blue (eastward) arrows, there was variability and reversal of sediment transport in Port Geographe. The variability in sediment characteristics used to predict transport direction was said to be largely attributed to marine and terrestrial sediment feed from sandbars and drains respectively, as well as seasons, metocean conditions, nearshore bathymetry, wrack accumulation, groyne, and beach nourishment and bypassing.

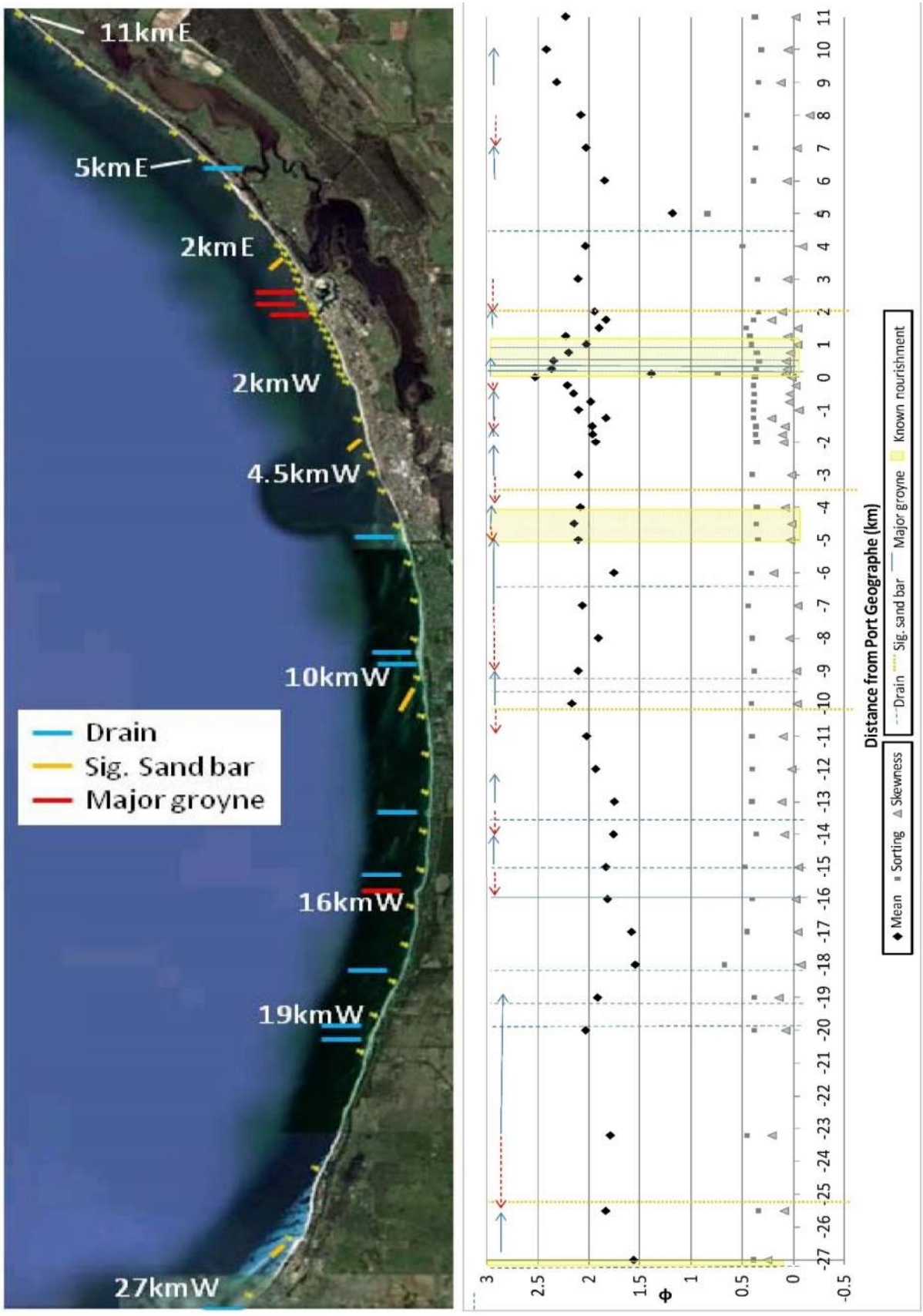

Figure 2.23 Geophysical Sediment Measures & Interpretation of Sediment Transport Direction (Damara, 2010)

Carter (2012) elaborated on this study by analysing the nearshore subaqueous dunes and nearshore sandbars within Geographe Bay, to determine whether the marine sediment sources are a primary source of sediment for the coastline. In total 23 subaqueous sediment samples and three onshore samples were taken from Geographe Bay (refer to Figure 2.24).

The report identified there is a fairly narrow margin of sediment grain sizes that have the ability to be transported onshore via natural processes. Medium-grained carbonate (0.25-0.5 mm) is transported to the beach effectively, while quartz stays in the nearshore system. Most quartz in Geographe Bay's subaqueous dunes and nearshore sandbars is not available for natural beach nourishment due to the hydrodynamics. Thus, carbonate material from nearshore sand formations contributes the most to the beach sediment supply.

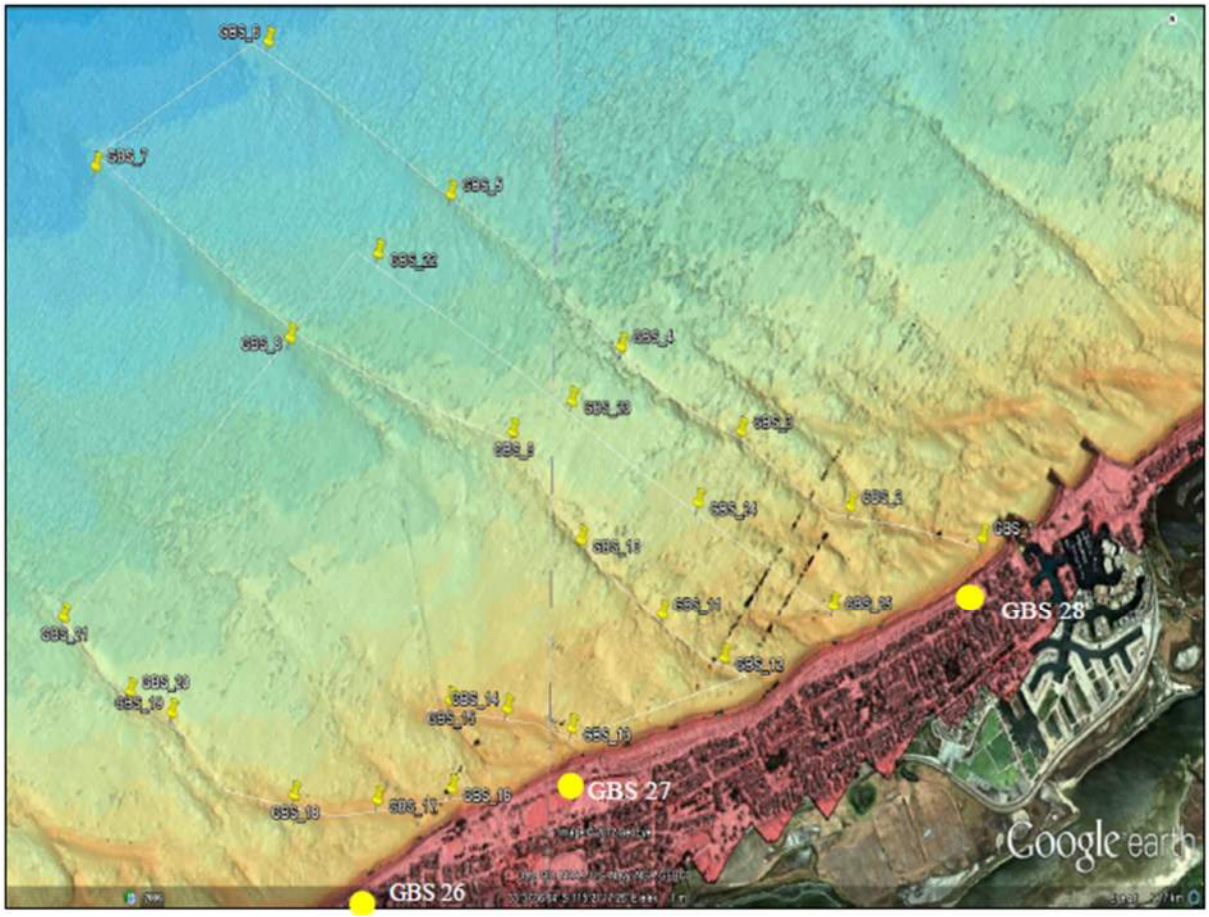

Figure 2.24 Sampling Sites in Geographe Bay (Carter, 2012)

Port Geographe Maintenance Dredging

A significant amount of work has been undertaken to support the previous sand bypassing operations and maintenance dredging campaigns within and around Port Geographe. Maintenance dredging is necessary to prevent navigational hazards from forming within the waterways, which involves removing accumulated material, predominantly seagrass wrack, to maintain navigable channels.

Dredging of Port Geographe began in 2004 (DoT, 2021). A summary of the historical dredging at Port Geographe is presented in Table 2.18. The dredging campaign typically occurs annually, involving an average dredge volume of 30,000 m³.

Dredging areas and disposal locations are shown in Figure 2.25. The dredged material is generally disposed of in three locations, depending on its quality:

- Discharge Area 2 (Offshore Disposal Area) is the preferred option for material with a high wrack content.
- Discharge Area 1 can only be used for material with high wrack content if Discharge Area 2 (Offshore Disposal Area) is unsuitable.
- Discharge Area 3 (Wonnerup Beach) is the preferred option for material with a high sand content.

BMT (2019) also conducted sediment sampling within the Port Geographe Coastal Management Area to support the dredging and bypassing campaigns as part of the Dredging Environmental Impact Assessment. Sediment samples were taken from areas near the marina, including beaches directly adjacent to it, as well as dredging and discharge locations.

Table 2.18 Previous Dredging Campaigns (DoT, 2021)

Year	Dates	Weeks	Quantity (m^3)	Disposal Area
2004	Sep04 to Dec04	15	43,700	Eastern end off previous eastern groyne / revetment [Previously known as Discharge Area 1]
2005	Sep04 to Dec04	14	49,547	Eastern end off previous eastern groyne / revetment [Previously known as Discharge Area 1]
2006 / 2007	Dec06 to Feb07	6	7,150	Offshore (in Discharge Area 2 vicinity)
2007	Nov07 to Dec07	4	10,000	Offshore (in Discharge Area 2 vicinity)
2012	Jan12 to Apr12	10	8,800	Offshore (in Discharge Area 2 vicinity)
2012 / 2013	Dec12 to Feb13	7	7,500	Offshore (in Discharge Area 2 vicinity)
2013 / 2014	Sep13 to Jul14	42	94,600	Offshore (in Discharge Area 2 vicinity), Western Beach
2014	Aug14 to Nov14	15	35,663	Offshore (in Discharge Area 2 vicinity), Wonnerup Beach
2016 / 2017	Dec16 to Apr17	18	33,972	Discharge Area 1 & 3
2017	Sep17 to Dec17	11	25,086	Discharge Area 1 & 3
2018 / 2019	Oct18 to Apr19	18	27,155	Discharge Area 2 & 3
2019	Oct19 to Dec19	8	18,905	Offshore (in Discharge Area 2 vicinity), Wonnerup Beach

These volumes do not include sand and seagrass wrack bypassing operations. Historically, sand and seagrass wrack bypassing operations occurred annually, but have been replaced by dredging operations following reconfiguration of the groynes.

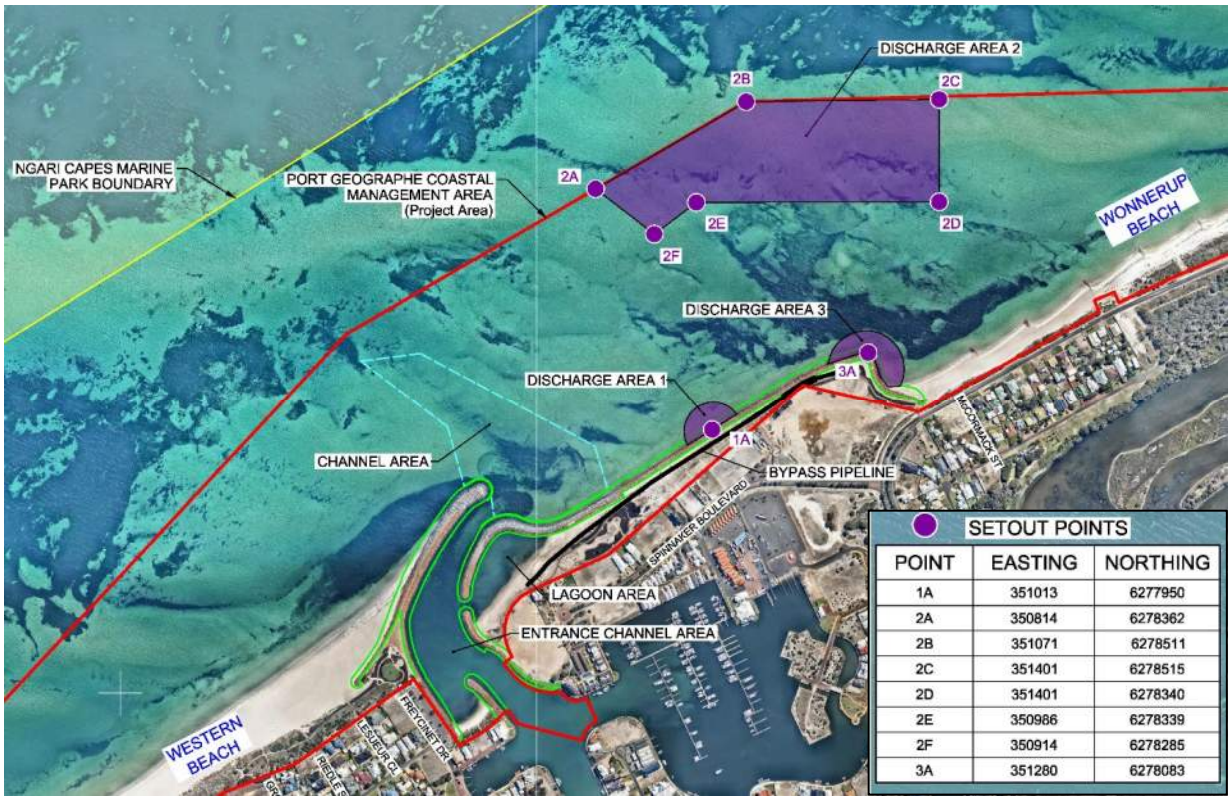

Figure 2.25 Port Geographe Dredge Area & Discharge Locations (BMT, 2021c)

Busselton Sand Nourishment Review (Shore Coastal, 2015)

Shore Coastal (2015) undertook a desktop review of the CoBus's beach nourishment activities over 7 years (between 2008 to 2014), to provide recommendations and supervise the CoBus's 2015 sand nourishment program.

Between 2008 to 2014, the CoBus placed 52,600m³ of sand, with annual maintenance accounting for 50% of this volume. The average annual rate of sand placement was 3,800m³, costing approximately $76,000 /year at rate of $14.00 /m³. Variation in the average annual rate of sand placed was determined to be driven by the metocean conditions, where in a relatively calm year only 500 m³ of sand was required compared to 16,900 m³ required for a stormy year.

Several potential sand sources within the CoBus and surrounding areas were also reviewed as part of this study. The review included both commercial sand pits and areas along the Geographe Bay foreshore that have been accreting sand in recent years. The report documented the sediment characteristics and overfill ratios for three nourishment locations.

Augusta Sediment Samples (DoT, 2011)

Sediment samples have been collected by the DoT for the shoreline extending from the eastern side of Cape Leeuwin to the mouth of the Blackwood River, as shown in Figure 2.26. Based on the limited information provided, sand was collected at two locations at each site: (a) at the waterline and (b) 5 metres shoreward from the waterline. At each location, sand was dug out of a hole approximately 0.5 metres deep and mixed prior to taking a sample.

Data collected as part of the sampling includes particle size distribution, calcium carbonate content, density, and the analysis of total, total inorganic, and total organic carbon concentration.

Sample Name	Lat.	Long.
S1(a)	34°22.157'	115°08.255'
S1(b)		
S2(a)	34°22.066'	115°08.863'
S2(b)		
S3(a)	34°21.761'	115°09.778'
S3(b)		
S4(a)	34°21.527'	115°09.915'
S4(b)		
SB1	34°21.34’	115°09.97’
NB1	34°21.12’	115°10. 04’
S5	34°20.71’	115°10.16’
S6(a)	34°19.676'	115°10.305'
S6(b)		

Figure 2.26 Sediment Samples Collected (DoT, 2011)

2.4.3 Rock

This section outlines the various types of rock as well as some individual studies investigating potential rock sources within the Southwest Region.

Rock Types

Within the Southwest Region, the following rock types are available:

- Granite / Diorite / Dolerite.
- Laterite / Ferricrete.
- Basalt.
- Donnybrook Sandstone.

Information on Granite / Diorite / Dolerite and Laterite / Ferricrete can be found in Section 2.3.3 of this report, whereas details regarding Basalt and Donnybrook Sandstone are provided in Table 2.19 below.

Table 2.19 Southwest Region Rock Types

Basalt– Fine to coarse-grained igneous rock, typically dark in colour, formed from solidified lava flows

Basalt, with a density of 2.8 to 3 t/m³, surpasses granite (2.6 t/m³) in strength, durability, and resistance to wear, making it an ideal choice for construction and road aggregates. It features lower water absorption, higher crushing resistance, and superior performance in durability tests, with a 10–20% loss on the Los Angeles abrasion test compared to granite's 25–50%.

Bunbury Basalt, specifically, is highly regarded for its consistent quality, as it lacks mineral foliation or planar weaknesses, providing uniform strength in all directions (Freeman, 1997). This fine-grained, dark grey rock has excellent wear properties, bonding strongly to bitumen even when wet, making it particularly effective for asphalt and hot-mix applications. However, its finer grain may polish under wear, giving granite an advantage for coarse wearing surfaces requiring skid resistance.

The image to the right shows Hanson's Bunbury Quarry, Gelorup.

Donnybrook Sandstone – Medium to fine-grained siliceous/feldspathic sandstone that is hard but exhibits significant localised variation in colour, primarily due to differences in the intensity of goethite staining.

The Cretaceous Donnybrook Sandstone is the only rock outcrop in the area. It has been subjected to laterization on the upper ridges.

The sandstone is limited to the Donnybrook area and is confined to just 3–4 pits, which are further restricted by native vegetation and approval requirements. The rock is not suitable for aggregates, as it lacks the required strength and exhibits significant lateral and vertical variation. It is also unsuitable for wetting and drying conditions or saline environments, as salt crystallisation rapidly breaks down the rock. The crystal growth forces apart the silica grains, leading to degradation.

The image to the right shows the Donnybrook Stone Quarry located at Upper Capel Road, Donnybrook.

Augusta Boat Harbour Breakwaters

The Augusta Boat Harbour was constructed by the DoT to provide a haven for vessels. The facility includes a public boat launching facility, a service wharf, boat pens, and land-based infrastructure. Armour rock was required to construct the two breakwaters, which when combined had an overall length of approximately 800 m, as well as a 320 m long revetment (Barr el al., 2015).

During the planning and design phase of the project, geotechnical investigations identified that material for the project could be sourced from an onsite quarry as there was fresh rock ranging from 5 m at the southern end and 16 m at the northern end of the site (Golder & Associates Pty Ltd, 2011). A joint venture between Contractors WA Limestone and Italia Stone Group was established for both the extraction of rock and the construction of the harbour.

In total, 500,000 tonnes of rock was extracted from the site to satisfy 13 different rock classes. The daily quarrying rates ranged from 1,000 (earlier on in the works) to 5,000 tonnes/day (once a number of work fronts were established). The biggest control to the production rates of rock was the required closure of the local roads during blasting and environmental approval which only permitted a limited blasting window due to conditions required to protect migratory whales.

Busselton Coastal Management Program: Coastal Structures Review Report on Sources of Rock for Armour Stone (GHD, 2015)

The study consisted of a desktop review of available rock sources and an assessment of the materials for the use in maintenance and construction of new coastal structures in Busselton. The scope of works involved an assessment of relevant rock quarries for the supply of armour rock, preparation of a geotechnical report that included quarry description, geology, production constraints and cost estimates, assessment matrix for available sources and a general armour rock specification for the CoBus.

The review included quarries leased by the CoBus and those which are privately owned. The five quarries investigated are listed below and shown in Figure 2.27. Excluding the Byford Quarry (located approximately 191 km from Busselton), all other quarries were found to be feasible regarding cartage.

- City of Busselton – Chapman Hill Road.
- City of Busselton – Piggotts Road.
- Holcim Australia – Gelorup.
- Department of Transport (operated by Italia Stone Group) – Roelands.
- WA Limestone – Whitby (Byford Quarry).

Given the lack of information available for the abovementioned quarries, GHD grouped quarries with similar rock types and provided an assessment on the suitability of the material characteristic for use in either coastal maintenance or construction works in Busselton. Based on the typical wave climate three different rock classes were identified to be required including two armour rock grades (A) armour rock ranging from 1.0 to 3.0 tonnes (B) armour rock ranging from 0.5 to 1.0 tonne, and grade (C) filter rock ranging from 100 to 500 mm.

The report found all locations could be suitable for use, however, suggested that further investigations are required to determine rock quality and cost. The report also identified that Slee

Road in Hithergreen, which was formally managed by the Department of Parks and Wildlife (DPaW, now DBCA), could be a potential new lease site for rock extraction and advised that negotiations over its potential future use of the site are currently being had between the two parties.

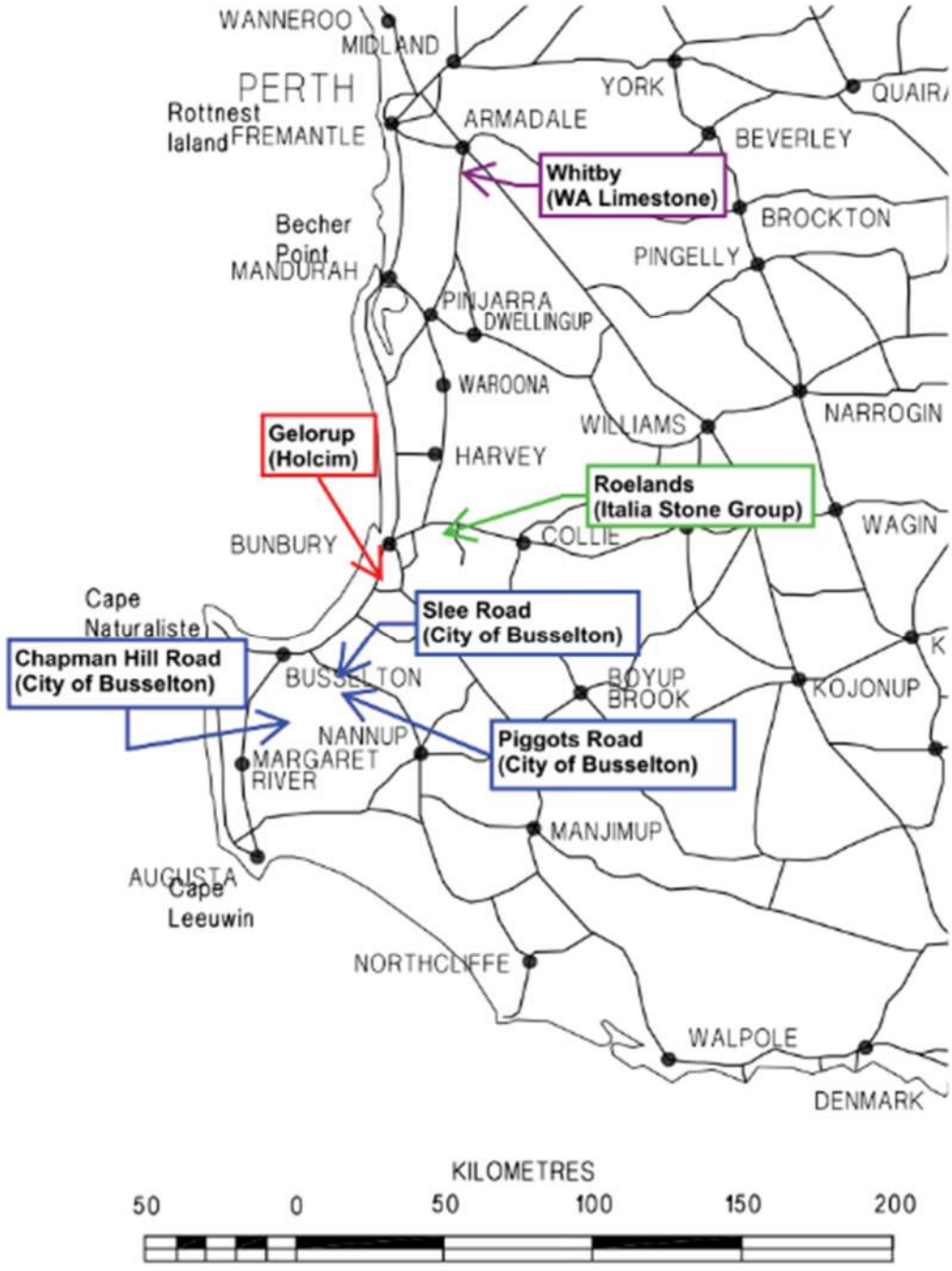

Figure 2.27 Quarry Locations (GHD, 2015)

2.4.4 Geological Information

The table below outlines resources that can be used to identify geological materials within the Southwest Region.

Table 2.20 Southwest Region Geological Resource Maps & Publications

Resources	Content
1: 50,000 Environmental Geology Mapping	The following regions have been mapped: • Yallingup • Busselton • Capel • Collie • Muja
1: 50,000 Regolith Mapping	The following regions have been mapped: • Collie Cowaramup to Mentelle • Karridale to Tooker • Leeuwin
1: 100,000 Regionally Significant Basic Raw Materials	The following regions have been mapped: • Bunbury • Clairault to Busselton • Donnybrook
1: 200,000 Regionally Significant Basic Raw Materials	The following regions have been mapped: • Morawa to Perenjori
Book and Report Publications	Key publications include the following: • Bruch J and M Freeman (2017): Migration of limesand dunes in Western Australia and their impacts. Department of Mines and Petroleum, Perth, Western Australia report 2017. • Fetherston J M (2007): Dimension Stone in Western Australia, Volume 1, Southwest. Mineral Resources Bulletin No. 23, Department of Mines and Petroleum. • Gozzard J R (1987): Limesand and Limestone Resources between Lancelin and Bunbury, Western Australia. GSWA Record 187/5. • Department of Agriculture and Food: Bulletin 4660: Survey of Western Australia agricultural lime sources. • Ormsby W R (2006): Field Inspection of the Donnybrook Sandstone on Lot 301, Shire of Donnybrook-Balingup. Geological Survey of Western Australia, appended as Attachment 2. • Wyatt B A (undated): Report on the Sandstone Deposits of Donnybrook. Geological Survey of Western Australia. • WAPC: Gelorup Basalt Buffer Study — Bunbury WA. Prepared by Orica, 2001. • Western Australian Geological Survey (2007): Composition of the Bunbury Basalt (BB1) and Kerba Monzogranite (KG1) Geochemical Reference Materials, and assessing the contamination effects of mill heads.

MRA has also reviewed the GeoVIEW.WA maps, which are flagged as a statewide geological information resource for this study and filtered them to highlight the relevant features.

Figure 2.28 shows the significant geological supplies in the Southwest Region and include sand, limestone, clay and hard rock.

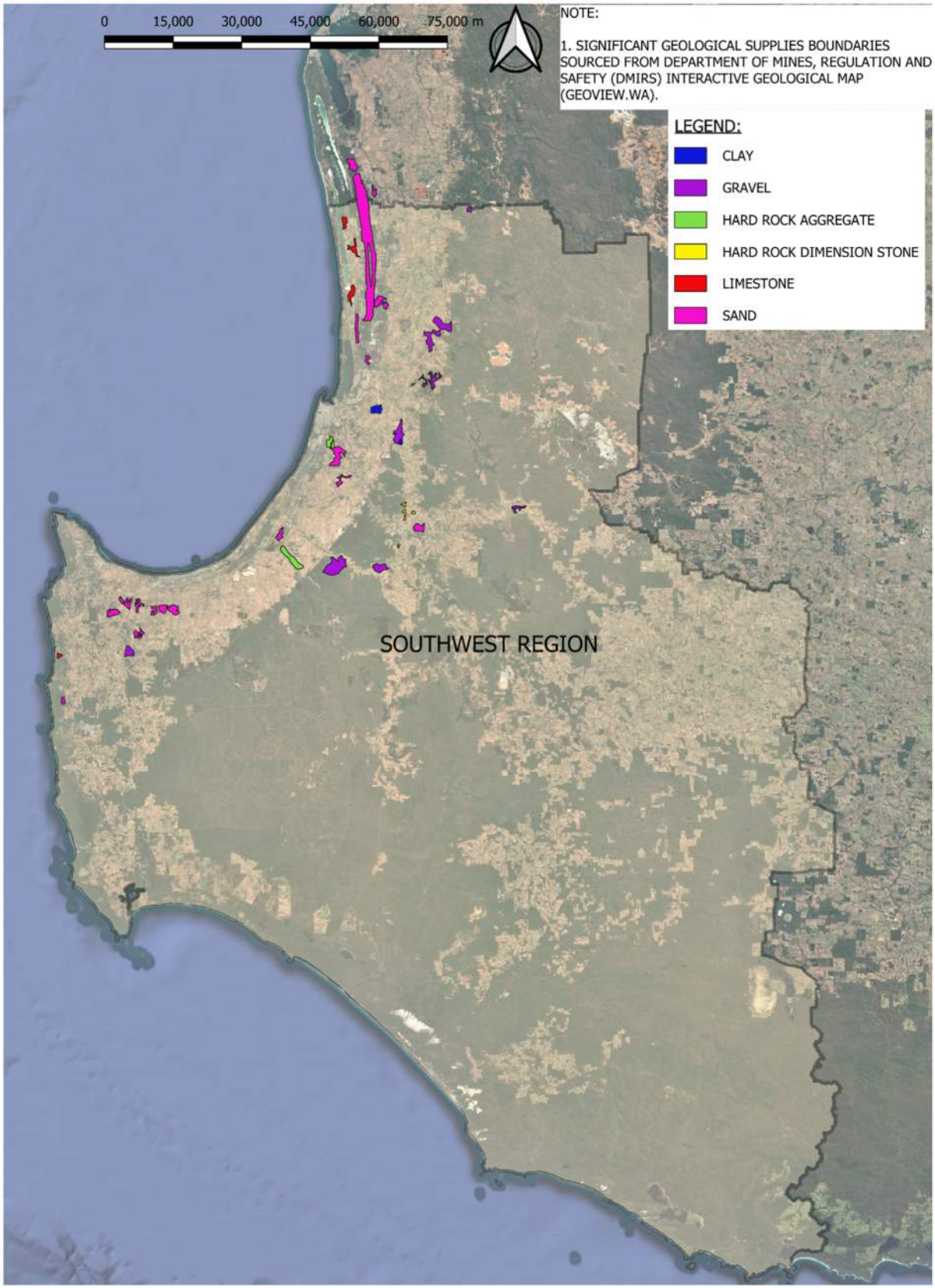

Figure 2.28 Southwest Region – Significant Geological Supplies

2.4.5 Marine Parks

The only marine park within the southwest region is the Ngari Capes Marine Park. The marine park extends from Busselton in the north to Augusta in the south and includes the following zones.

- 15 Sanctuary Zones occupying 11% of the marine park.
- Special Purpose Zones (Surfing and Shore Based Activities) occupying 0.12% of the marine park.
- Recreational Zones occupying 0.01% of the marine park.
- General Use Zone occupying the remaining area.

Figure 2.29 shows the location of the marine parks within the Southwest Region.

Figure 2.29 Southwest Region – Marine Parks

2.4.6 Benthic Habitat

Seamap Australia

Figure 2.30 shows the seafloor habitat in the Southwest Region from Seamap Australia.

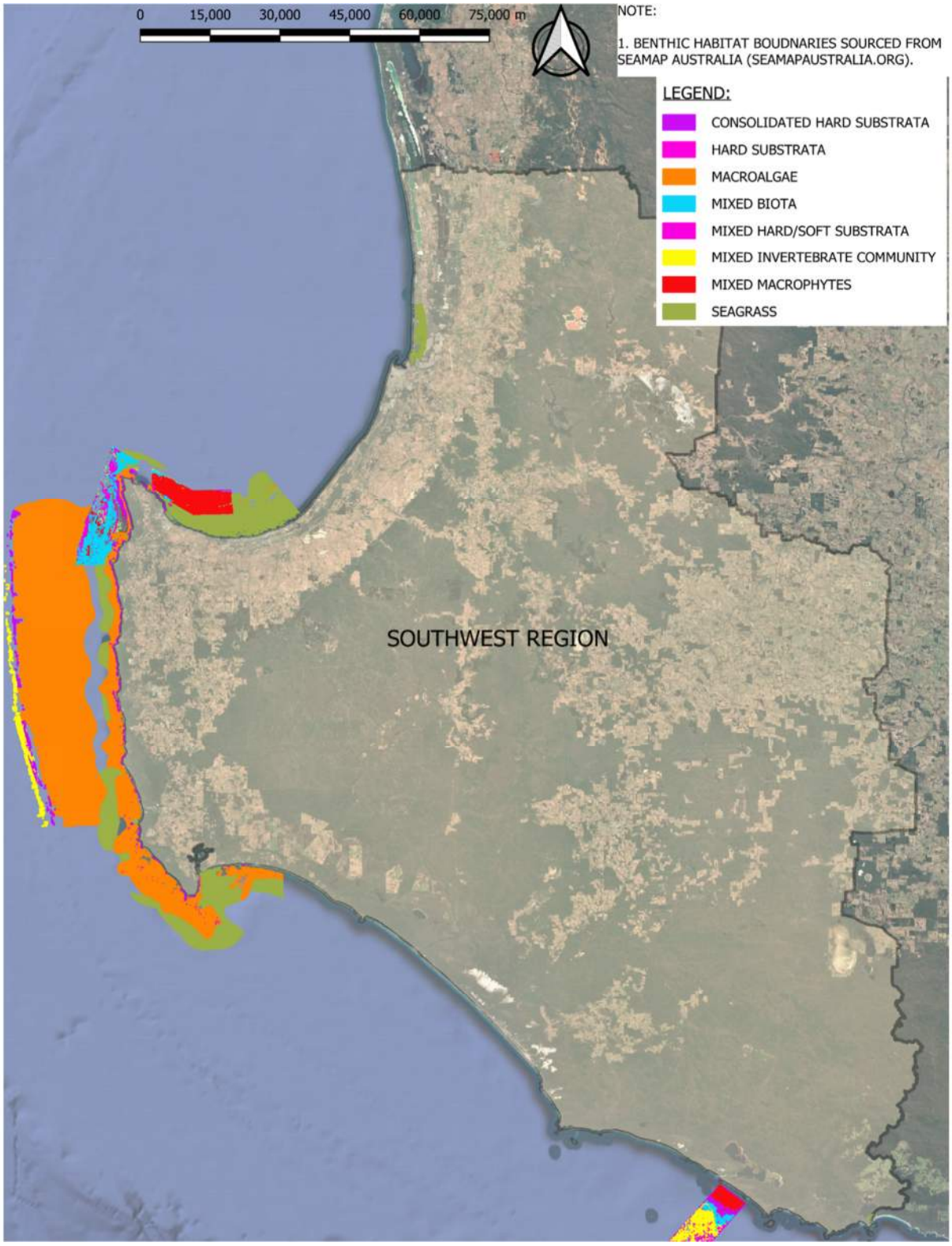

Figure 2.30 Southwest Region – Benthic Habitat

2.4.7 Geomorphology & Sedimentology

The following sections detail available information on the geomorphology and sedimentology within the Southwest region.

MARine Sediments Database (MARS)

Geoscience Australia maintains the MARine Sediments database (MARS) (Geoscience Australia: Marine Sediments (MARS) Database (ga.gov.au)), a comprehensive national repository containing data on over 40,000 marine sediment samples.

A review of this database was provided in Section 2.3.7 of this report.

dbSEABED

The University of Colorado and other collaborators developed the dbSEABED repository for marine sediments and seabed data. A review of this database was provided in Section 2.3.7 of this report.

Multigrain Seabed Sediment Transport Modelling for the South-West Australian Shelf (Li et al., 2009)

Li et al. (2009) investigated the long-term and large-scale seabed morphological changes on the southwest Australian continental shelf, to gain a comprehensive understanding of the effects of climate change and sea level rise on sediment erosion, transport, and deposition across the continental shelf.

A review of this study was provided in Section 2.3.7 of this report.

Geomorphology & Sedimentology of the South Western Planning Area of Australia (Richardson et al., 2005)

Geoscience Australia (Richardson et al., 2005) undertook an extensive investigation into the relevant literature on geomorphology and sedimentology for the South Western Planning Area (SWPA) of Australia. The region is divided into four major physiographical provinces: Rottnest, South West, Great Australian Bight, and Spencer and St. Vicent Gulfs.

The Southwest Region of this study extends across both the Rottnest and South West provinces. The geomorphology and sedimentology of the Rottnest province were detailed in Section 2.3.7 of this report. The details pertaining to the South West are provided below.

The South West region of the SWPA extends from Cape Naturaliste in the west to Cape Pasley in the east. It is characterised by a narrow continental shelf with nearshore reefs and islands. Extending further seawards from the western-facing shoreline (Cape Naturaliste to Cape Leeuwin), the continental slope descends from the shelf to a mid-slope terrace and then onto the Naturaliste Plateau, Australia's deepest submarine plateau. In contrast, on the southern-facing shoreline (Cape Leeuwin to Cape Pasley), the continental slope drops off to the Diamantina Fracture Zone, a region of rough topography. The continental slope in this area is incised by numerous, well-developed submarine canyons.

Richardson et al. (2005) reported that the South West region of the SWPA is structurally complex. It includes the southern parts of the Perth Basin, the Mentelle Basin, Yallingup Shelf, three sub-basins of the Bight Basin, the Naturaliste Plateau, and the Diamantina Zone (refer to Figure 2.31).

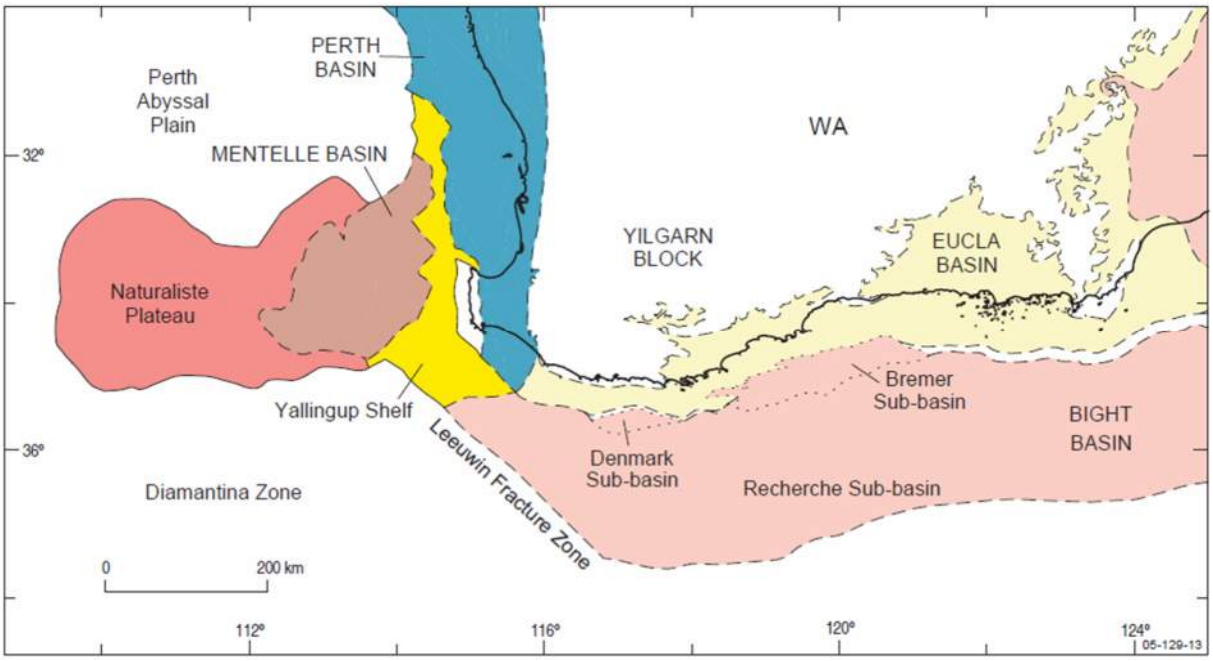

Figure 2.31 Geological setting of South West Region (Bradshaw et al., 2003 Modified by Richardson et al., 2005)

Similar to the Rottnest province, there is a lack of quantitative sediment data concerning the grain size and carbonate content for the South West province. Richardson et al. (2005) reported that there have only been a few sedimentology surveys conducted by Carrigy and Fairbridge (1954) and Carrigy (1956), as well as more recent work by Conolly and von der Borch (1967), Cann and Clarke (1993), Li and McGowran (1998), Li et al. (1999), and Geoscience Australia's sediment samples from the Albany Canyons (Blevin, 2005).

With respect to surface sediment on the Rottnest and Recherche Shelfs, it was reported that:

- Up to 60-83% of the sediment was calcareous fragments, with lesser amounts of quartz, shell fragments, foraminifers, and faecal pellets.
- Sediments collected in the western areas contained quartz, feldspar, and terrigenous fragments, which were suggested to be supplied by the onshore crystalline shield rock.
- Offshore from Albany is mainly coarse calcareous sands with local rhodolith beds.
- On the inner Recherche Shelf generally comprised of a mixture of recent and relict bioclastic carbonate sand.
- Due to the sediment on the middle to outer shelf still being affected by bottom currents from swell and storm events, the sand was reported to be well-sorted and rounded.
- In water depths of less than 40 m, seabed sediments grade from quartz sand in nearshore regions to coarse bioclastic carbonate sand with lithic material further offshore.

Figure 2.32 shows the location of major surface sediments. It is suggested that the sediments are dominated by calcareous components with minor terrigenous material and have been divided into facies based on their grain size.

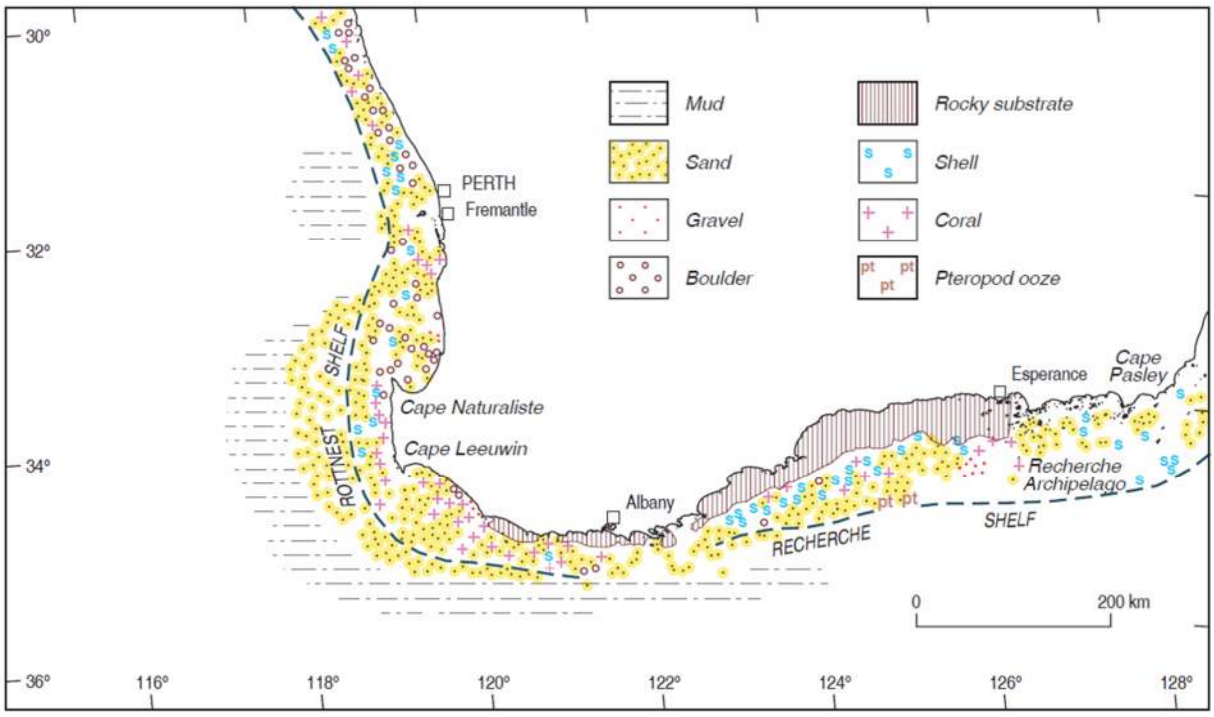

Figure 2.32 Distribution of Major Surface Sediment Facies (Carrigy & Fairbridge, 1954 Modified by Richardson et al., 2005)

2.4.8 Basic Raw Material (BRM) Exclusion Areas

BRM exclusion areas are yet to be identified and incorporated into resource mapping (GeoVIEW.WA) for the Southwest Region.

Further discussion regarding the potential sterilisation of sand and rock resources will be provided in Task 5 of this report.

2.5 Stakeholder Consultation & Requirements

Consultation was undertaken with Local Government and Coastal Managers, Suppliers and Contractors within the relevant regions. These groups were chosen as they are indirectly or directly involved in the placement of sand and rock used for coastal adaptation works.

Coastal and Local Government Managers were sent a questionnaire which they were asked to respond to and return, or for those Managers who preferred to talk through their responses, meetings were organised. Meetings were also organised with Suppliers and Contractors once they had been provided some prompt questions.

A comprehensive list of stakeholders contacted for each region is presented in Appendix B while a brief overview is presented in Table 2.21.

Table 2.21 Stakeholder Consultation Overview

Regions	Coastal Managers	Government Managers	Suppliers	Contractors
Perth Metropolitan / Peel	13	4	5	3
Southwest	7	5	3	3

The objectives of the consultation varied slightly depending on the stakeholder. The following was the typical information sought from each stakeholder.

- Local Government and Coastal Managers
    - Significant coastal projects requiring sand and rock that have occurred in the last 5 years. Including information pertaining to material type, characteristics and source location, volume, cost, Contractor, etc.
    - Significant coastal projects requiring sand and rock that is in the pipeline over the next 5 years. Including information pertaining to material type, characteristics and source location, volume, cost, Contractor, etc.
    - Funds allocated for coastal adaptation projects for the next 5 years.
    - Measures in place to ensure there is enough sand and rock available for future coastal adaptation projects.
    - Identify main issues, challenges, and constraints for sand and rock sources.
- Suppliers
    - General list of sand and rock sources that could be used to supply coastal projects.
    - List of quarry locations for sand and rock supplies.
    - List of stockpiled material readily available for coastal projects and an indicative timeframe for the availability of each type of material.
    - Measures in place or that could be put in place to ensure there is enough sand and rock available for future coastal adaptation projects.
    - Key factors leading to cost escalation of coastal projects and the supply of raw materials.
    - Identify main issues, challenges, and constraints for sand and rock sources.
- Contractors
    - Primary sources of sand and rock supply used for coastal adaptation projects.

- Key factors leading to cost escalation of coastal projects.
- Identify main issues, challenges, and constraints for sand and rock sources.

Not all of the information canvassed from stakeholders is presented in this section of the report. Most of the information sought from Suppliers and Contractors relates specifically to later tasks (ie Task 3 and onwards).

It is understood that not all suppliers of BRMs or Contractors who use BRMs in coastal works have been consulted with. However, a cross-section of key parties and those willing to participate have been included.

2.5.1 Perth Metropolitan & Peel Regions

Local Government & Coastal Managers

From the 17 organisations contacted, seven responded to the survey. Of those organisations who responded, four advised that no coastal adaptation works involving sand and rock had happened or are planned to happen within the allotted timeframe (ie 5 years either side of the present date), while all others completed the survey to the best of their knowledge.

It should be highlighted that the majority of LGAs are in the process of finalising their CHRMAPs, making it probable that the projects envisioned for the future represent the preferred adaptation strategies of the LGAs, but not necessarily the community. Consequently, there is no guarantee that the adaptation strategies outlined will be realised in the future.

Tables 2.22 to 2.27 present a list of significant past and future projects within the Perth Metropolitan and Peel regions. The information was collated with input from Local Government & Coastal Managers however also relied upon MRA's extensive knowledge of projects within the regions. Where information was not provided however there is irrefutable evidence that work has or is planned to happen, MRA has included this information to the best of our knowledge.

For simplicity, ongoing works including nourishment and general maintenance programs have been compiled and summated for a five-year period to estimate volumes/tonnage and cost.

Table 2.22 Significant Past Projects (Within the Last 5 Years)

	Projects	Description of the Works	Material Type	Characteristics ($D_n(50)$ / tonnage range)	Volume / Tonnage (m^3 / tonnes)	Cost	Contractor / Supplier or Source
City of Wanneroo (CoW)	Quinns Beach Coastal Management Works	Construction/extension of groynes and beach nourishment	Sand	0.37 mm	33,000 tonnes	$7 million	WA Limestone & Italia Stone JV (Contractor/Supplier)
			Limestone Rock	1 - 6 tonnes	31,000 m^3		
	Mindarie Breakwater Upgrade	The breakwater upgrades	Limestone Rock	0.5 - 10 tonnes	40,000 tonnes	$9 million	WA Limestone (Contractor/Supplier)
			Limestone Core	-	1,500 tonnes		
	Beach Renourishment Program	Annual beach renourishment at Quinns Beach (3 locations) and Yanchep Lagoon	Sand	0.35 mm	50,000 m^3 (10,000 m^3/yr)	$1.2 million	WA Limestone (Contractor) / Carramar Resource Industries (Contractor) / Urban Resources (Supplier)
	General Maintenance	Minor maintenance to coastal structures	Limestone Rock	1 - 3 tonnes	1,500 tonnes (300 tonnes/yr)	$77,000	WA Limestone (Contractor/Supplier)
City of Joondalup (CoJ)	Sand Bypassing Program[1]	Annual sand bypassing from Sorrento Beach around Hillarys Boat Harbour	Sand	0.45 mm	50,000 m^3 (10,000 m^3/yr)	$1.6 million	MMM (Contractor) / Sorrento Beach (Source)
	West Coast Drive Drainage Outfall[1]	Emergency works for the drainage outfall along West Coast Drive	Sand	0.45 mm	1,200 m^3	$160,000	Curnow (Contractor) / Sorrento Beach (Source)
City of Stirling (CoS)	Mettams Pool Beach Nourishment Works[1]	Beach nourishment works, placement of sand sourced from Trigg Point	Sand	-	25,000 m^3 (3,000-5,000 m^3/year)	-	Sorrento / Trigg Point (Source)
Town of Cambridge (TOCa)	No known coastal adaptation works were completed for their coastline.						
City of Nedlands (CoN)	No known coastal adaptation works were completed for their coastline.						
Town of Cottesloe (ToCo)	No known coastal adaptation works were completed for their coastline.						
Town of Mosman Park (ToMP)	No known coastal adaptation works were completed for their coastline.						
City of Fremantle (CoF)	Port Beach Nourishment	Beach nourishment works, placement of sand dredged from Fremantle Port's Deep-Water Channel	Sand	0.3 mm	150,000 m^3	$1.9 million	Rhode Nielsen Dredging (Contractor) / Fremantle Port's Deep-Water Channel (Source)
	Port Beach Seawall	Construction of a temporary limestone seawall along the foreshore fronting the Coast Restaurant	Limestone Rock	1 - 3 tonnes	2,100 tonnes	$118,000	WA Limestone (Contractor) / WA Limestone (Supplier)

Table 2.23 Significant Past Projects (Within the Last 5 Years) (cont.)

	Projects	Description of the Works	Material Type	Characteristics (Dn(50) / tonnage range)	Volume / Tonnage (m3 / tonnes)	Cost	Contractor / Supplier or Source
City of Cockburn (CoC)	C.Y. O'Connor Beach Nourishment[1]	Beach nourishment works, placement of sand sourced from Chelydra Beach and Island St Groyne	Sand	-	47,000 m^3 (approx. 10,000 m^3/year)	$480,000	MCS Civil (Contractor) / CGC Dredging Solutions (Contractor) / Aussie Earthworks (Contractor) / Chelydra Beach & Island St Groyne (Source)
	Coogee Beach Nourishment[1]	Beach nourishment works involved the placement of sand sourced from Chelydra Beach	Sand	-	15,500 m^3	$280,000	CGC Dredging Solutions (Contractor) / Chelydra Beach (Source)
City of Kwinana (CoK)	No known coastal adaptation works were completed for their coastline.						
City of Rockingham (CoR)	Mersey Point Seawalls	Construction of a granite seawall at Mersey Point	Granite Rock	0.8 - 2.5 tonnes	-	$2.8 million	Neo Civil (Contractor) / WA Limestone (Contractor) / WA Limestone (Supplier)
	Point Peron Refurbishment Works	Construction of a breakwater, spur groyne and refurbishment of an existing seawall	Limestone Rock	0.5 - 5 tonnes	-	$1.2 million	WA Limestone (Contractor) / WA Limestone (Supplier)
	Northern Warnbro Sound Nourishment[1]	Beach nourishment works, placement of sand sourced from Point Peron.	Sand	0.3 mm	50,000 m^3 (10,000 m^3/yr)	$420,000	Erceg & Co. (Contractor) / Pont Peron (Source)
	Kwinana Beach Renourishment[1]	Beach nourishment works, placement of sand sourced from Point Peron.	Sand	0.3 mm		$150,000	Erceg & Co. (Contractor) / Pont Peron (Source)
City of Mandurah (CoM)	General Maintenance	Minor maintenance to coastal structures	Limestone Rock	1 - 8 tonnes	5,700 tonnes	$1.2 million	Various
			Laterite Rock	1 - 8 tonnes	300 tonnes		
Shire of Waroona (SoW)	No known coastal adaptation works were completed for their coastline.						
Main Road Western Australia (MRWA)	Riverside Drive Riverwall	Construction of a revetment along Riverside Drive	Limestone Rock	0.5 – 1.5 tonnes	3,000 tonnes	$500,000	Natural Area (Contractor) / WA Limestone (Supplier)
			Limestone Core	50 - 600 mm	840 tonnes		
	Thelma to Cale St Revetment	Construction of a revetment along Kwinana Freeway	Limestone Rock	0.4 – 1.2 tonnes	7,000 tonnes	$3.0 million	Miraplex Group (Contractor) / Italia Stone Group (Supplier)
			Limestone Core	50 - 600 mm	2,400 tonnes		
Development WA (DevWA)	Ocean Reef Marina	Expansion of an existing boat harbour located at the Ocean Reef site.	Sand	0.3 mm	14,000 m^3	$61 million	WA Limestone & Italia Stone JV (Contractor/Supplier) / Georgiou (Contractor)
			Granite Rock	1 - 10 tonnes	279,000 tonnes		
			Limestone Rock	0.3 - 1.5 tonnes	50,000 tonnes		
			Limestone Core	50 - 1,200 mm	1,100,000 tonnes		

Table 2.24 Significant Past Projects (Within the Last 5 Years) (cont.)

	Projects	Description of the Works	Material Type	Characteristics (Dn(50) / tonnage range)	Volume / Tonnage (m3 / tonnes)	Cost	Contractor / Supplier or Source
Fremantle Ports	No known coastal adaptation works were completed by Fremantle Ports.						
Department of Biodiversity, Conservation and Attractions (DBCA)	General Riverine Projects/Maintenance Works	Revetment works along the Swan River foreshore (ie Black Swan Habitat, Ascot Racecourse Foreshore Stabilisation and East Perth Foreshore Erosion Control)	Limestone Rock	0.3 - 1.5 tonnes	2,500 tonnes	$1.5 million	Various

Notes:

1. Denotes sand sourced from sand traps and beaches and is not included in the volume and cost estimates of sand.

Table 2.25 Significant Future Projects (Within the Next 5 Years)

	Projects	Description of the Works	Material Type	Characteristics ($D_n(50)$ / tonnage range)	Volume / Tonnage (m^3 / tonnes)	Cost	Supporting Studies
City of Wanneroo (CoW)	Yanchep Coastal Management Works	The works includes the upgrades/maintenance to groynes, sand nourishment and potentially new coastal protection structures	Sand	0.35 mm	-	$1.0 million	Coastal management study commencing in March / April 2024
			Limestone Rock	1 - 6 tonnes			
	Beach Renourishment Program	Continued beach nourishment for Quinns Beach (3 locations) and Yanchep Lagoon	Sand	0.35 mm	50,000 m^3 (10,000 m^3/year)	$1.2 million	Coastal monitoring recommendations
	General Maintenance	Minor maintenance to coastal structures	Limestone Rock	1 - 3 tonnes	1,500 tonnes (300 tonnes/yr)	$77,000	Coastal engineering condition assessment
	Upgrade to Quinns Beach Carpark	Upgrade to informal seawall located at Quinns Beach Carpark	Limestone Rock	1 - 3 tonnes	2,000 tonnes	$500,000	Detailed design underway
City of Joondalup (CoJ)	Sand Bypassing Program[1]	Annual sand bypassing from Sorrento Beach around Hillarys Boat Harbour	Sand	0.45 mm	50,000 m^3 (10,000 m^3/yr)	$1.6 million	Coastal monitoring program, CHRMAP development and coastal hazards assessment
	Sand Nourishment[1]	Sand nourishment to the eroded shoreline identified in the CHRMAP	Sand	0.45 mm	-	-	
	MAAC Seawall Maintenance	Maintenance of the seawall in front of the MAAC located at Marmion Beach.	Limestone Rock	2 - 4 tonnes	4,000 tonnes	$265,000	Asset condition assessment
	Sorrento Beach Groyne Repair	Repair of south and central groyne located at Sorrento Beach.	Granite Rock	3 - 7 tonnes	7,000 tonnes	$720,000	
City of Stirling (CoS)	Watermans Bay Coastal Protection	To be determined	-	-	-	-	CHRMAP recommendation and coastal adaptation assessment options development
	Mettams Pool Coastal Protection	To be determined	-	-	-	-	
Town of Cambridge (TOCa)	City Beach Refurbishment	Refurbishment of the Floreat Groyne and City Beach Seawall.	Granite Rock	3 - 7 tonnes	950 tonnes	$350,000	Coastal monitoring program
City of Nedlands (CoN)	No known coastal adaptation works are planned for their coastline.						
Town of Cottesloe (ToCo)	No known coastal adaptation works are planned for their coastline.						
Town of Mosman Park (ToMP)	No known coastal adaptation works are planned for their coastline.						
City of Fremantle (CoF)	No information was provided by this stakeholder.						

Table 2.26 Significant Future Projects (Within the Next 5 Years) (cont.)

	Projects	Description of the Works	Material Type	Characteristics (Dn(50) / tonnage range)	Volume / Tonnage (m3 / tonnes)	Cost	Supporting Studies
City of Cockburn (CoC)	Rock Revetment Upgrades	Upgrade of the rock revetments located at Port Coogee Marine	Limestone Rock	-	-	$500,000	Technical specification
	C.Y. O'Connor Beach Nourishment[1]	Beach nourishment works, placement of sand sourced from Chelydra Beach and Island St Groyne	Sand	-	255,000 m^3	$2.5 million	Coastal monitoring program
	Port Catherine Groyne Maintenance	Upgrade of the groyne located at Port Catherine	Limestone Rock	-	-	-	Technical specification
	GSC Wall Extension	Extension of GSC wall located at C.Y. O'Connor Beach, this includes the placement of rock and sand nourishment	Granite Rock	-	-	-	-
			Sand	-	-		
City of Kwinana (CoK)	No known coastal adaptation works are planned for their coastline.						
City of Rockingham (CoR)	Port Kennedy Boat Ramp Facility Expansion	Construction of a breakwater and spur groyne at Mersey Point	Granite Rock	0.8 - 2.5 tonnes	-	$15 million	Feasability and concept design
	Mersey Point Coastal Stabilisation Structures	Construction of a groyne or offshore breakwater at Mersey Point	Granite Rock	0.8 - 2.5 tonnes	-	$2 million	Planned data collection and numerical modelling and concept design
	Hymus Street Seawall Reconstruction	Construction of a seawall in combination with beach nourishment at Hymus Street seawall	Limestone Rock	0.5 - 5 tonnes	-	$1 million	Planned review of existing design
	Kwinana Beach Renourishment Works[1]	Beach nourishment works, placement of sand sourced from the Point Peron	Sand	0.3 mm	-	$250,000	-
City of Mandurah (CoM)	Doddies Beach Coastal Protection Works	Construction of a seawall to mitigate the risk of further coastal erosion at Doddies Beach	Limestone Rock	-	-	-	Coastal adaption options assessment and 10-year capital works program
	Town Beach Seawall Coastal Project Works	Construction of a seawall to mitigate the risk of further coastal erosion at Town Beach	Limestone Rock	-	-	$1.5 million	10-year capital works program
	Mandurah Maintenance Plan	Repack/replenish or rebuild existing dilapidated seawalls throughout the city	Limestone Rock	-	-	$2.8 million	
			Ferricrete Rock	-	-		
Shire of Waroona (SoW)	No known coastal adaptation works are planned for their coastline.						

Table 2.27 Significant Future Projects (Within the Next 5 Years) (cont.)

	Projects	Description of the Works	Material Type	Characteristics (Dn(50) / tonnage range)	Volume / Tonnage (m^3 / tonnes)	Cost	Supporting Studies
Main Road Western Australia (MRWA)	Stirling and Scott Street Revetments	Replacement of an existing sloping rock wall with a rock revetment at Stirling and Scott Street	Limestone Rock	0.5 – 1.5 tonnes	1,800 tonnes	$2.1 million	Detailed design and Infrastructure Protection Strategy for the Kwinana Freeway
			Limestone Core	50 - 600 mm	700 tonnes		
	South Terrace to Comer Street Revetment	Replacement of a GSC wall with a rock revetment at South Terrace to Comer Street	Limestone Rock	0.5 – 1.5 tonnes	2,800 tonnes	$2.5 million	
			Limestone Core	50 - 600 mm	1,500 tonnes		
Development WA (DevWA)	No information was provided by the stakeholder.						
Fremantle Ports	No information was provided by the stakeholder.						
Department of Biodiversity, Conservation and Attractions (DBCA)	General Riverine Projects/Maintenance Works	Revetment works along the Swan River foreshore (ie Esplanade Foreshore and Burswood Park Stabilisation and McCallum Park and Taylor Reserve Remediation Works)	Limestone Rock	0.3 - 1.5 tonnes	5,000 tonnes	$2.6 million	Asset condition assessment

Notes:

1. Denotes sand sourced from sand traps and beaches and is not included in the volume and cost estimates of sand.

Considering those projects which have been reported on by Local Government and Coastal Managers, the total quantities of imported BRMs which may be required have been estimated for a period of 5 years either side of the present date (Table 2.28). The Ocean Reef Marina Redevelopment has been excluded from these numbers, as that is a large scale development which is outside the ability of LGAs to fund.

Local Government and Coastal Managers can often only give high level information on future projects (ie little is known regarding the required volumes or tonnage the project), however are required to consider future projects when determining budgets. Comparing the past and future costs of projects will provide insight into the amount of material required for coastal adaption works.

Table 2.28 Past & Future Project Totals

	Past Projects (5 years)			Future Projects (coming 5 years)		
	Sand	Rock	Cost	Sand[1]	Rock[1]	Cost / Budget
Totals	260,000 m^3	98,000 tonnes	$29M	5,000 m^3	22,000 tonnes	$34M

Note: 1. The amount of sand and rock required for future coastal adaption works is far lower than in previous years, although this is more likely to be due to the uncertainty of future projects, rather than needs.

Table 2.28 indicates that an annual average of around 50,000 to 60,000 m^3 of sand and 20,000 t of rock has been required by LGAs for coastal adaptation in the past 5 years. The estimated material requirements for the coming 5 years is far lower than this, although this is more likely to be due to the uncertainty of future projects, rather than needs. Future LGA budgets are comparable for the coming 5 years to that of past projects and it could therefore be expected that requirements for BRMs are also comparable.

Based on the responses, Local Government and Coastal Managers were very rarely involved in the sourcing of BRMs and it was generally left to the Contractor. Factors said to influence where the material was sourced from included the project requirements and how far the material was from site. These are generally outside the control of the LGA.

A list of approvals required for some of the projects listed in Tables 2.22 to 2.27 is provided below. The approvals required were dependent on the location of the work and given that only Fremantle had sourced marine sediments, only the Port Beach project could be referred to for potential marine approval requirements.

- Section 18 Heritage Approval.
- Clearing Permit.
- Environmental Approvals (various)

For future works, of those Coastal Managers who replied, most of the planned projects were either annual maintenance and nourishment programs or those that have resulted from the recommendations made in the LGA CHRMAPs or site-specific CHRMAPs for coastal hotspots. Most of the projects planned for the next five years are in the early and late stages of design or being procured.

On average, Local Government and Coastal Managers have approximately $4.5 million allowance for coastal adaption projects. Most planned to use grants like the Coastal Management Plan Assistance Program (CMPAP), Coastal Adaption and Protection (CAP) grant and Recreational Boating Facilities Scheme (RBFS) to co-fund their projects. To help fund works along the Kwinana Freeway Foreshore, MRWA, the City of South Perth (CoSP) and DBCA have been successful in funding through the Disaster Ready Fund (DRF) run by the Australian Government's National Emergency Management Agency (NEMA).

One question asked in the survey was "*Has your LGA put any measures in place to ensure there is enough sand and rock available for future coastal adaptation projects*?" Of those who responded, only the CoW, with support from the Northern Beaches Alliance (NBA), and the CoC are actively investigating potential sources of marine sediment for beach nourishment. The NBA is a partnership between the CoN, ToCa, CoS, CoJ, CoW, and the Shire of Gingin (SoG). This alliance has been involved in the development and implementation of coastal monitoring programs and sand sourcing studies.

All responses received from Local Government and Coastal Managers concerning issues, challenges and constraints for the supply of BRM's will be discussed in Task 5.

Suppliers

Of the five Suppliers contacted, four provided information used to assist with this study. The information canvassed from Suppliers is presented in subsequent tasks as it relates to sand and rock sources and factors influencing supply.

Contractors

Of the three Contractors contacted, two provided information used to assist with this study. The information canvassed from Contractors is presented in Task 5 as it relates to factors influencing supply.

2.5.2 Southwest Region

Local Government & Coastal Managers

From the 12 organisations contacted, 9 responded to the survey. Of those organisations who responded, 4 advised that no coastal adaptation works involving sand and rock had happened or are planned to happen within the allotted timeframe (ie 5 years either side of the present date), while all others responded to the best of their knowledge.

Similarly to the Perth and Peel Regions, the following should be noted about the information provided in the tables below.

- Some LGAs are in the process of finalising their CHRMAPs, making it probable that the projects envisioned for the future represent the preferred adaptation strategies of the LGAs and not necessarily the community. Consequently, there is no guarantee that the adaptation strategies outlined will be realised in the future.

- For simplicity, ongoing works including nourishment and general maintenance programs have been compiled and summated for a five-year period to estimate volumes / tonnage and cost.

Tables 2.29 to 2.32 present a list of significant past and future projects within the Southwest Region.

Table 2.29 Significant Past Projects (Within the Last 5 Years)

	Projects	Description of the Works	Material Type	Characteristics ($D_n(50)$ / tonnage range)	Volume / Tonnage (m^3 / tonnes)	Cost	Contractor / Supplier or Source
Shire of Harvey (SoH)	General Maintenance	Annual maintenance to the coastal infrastructure	Sand	-	200 m^3 (40 m^3/yr)	$100,000	B & T Versaci (Contractor) / Private Quary at Lake Preston (Source)
City of Bunbury (CoBun)	Koombana Bay Beach Nourishment[1]	Nourishment at Koombana Bay, placement of sand sourced from SPA sand traps.	Sand	-	200 m^3 (20 m^3/yr)	$50,000	CoB (Contractor) / Adjacent Beaches (Source)
Shire of Capel (SoC)	No known coastal adaptation works are planned for their coastline.						
Shire of Busselton (SoBus)	Annual Beach Nourishment	Beach nourishment works, placement of sand sourced from commercial suppliers and beach scraping	Sand	-	40,000 m^3 (8,000 m^3/year)	$750,000	Earth and Stone (Contractor) / Local Supplier (Source)
	Seawall Refurbishment	Refurbishment of the rock seawall along Geographe Bay Road from Craig Street to Earnshaw Road	Granite Rock	-	-	$1.5 million	Leeuwin Civil (Contractor) / Local Supplier (Source)
	Groyne Refurbishment	Refurbishment of rock groynes located at Wonnerup, Broadwater and Craig Street	Granite Rock		-	$880,000	Leeuwin Civil (Contractor) / BCP Group (Contractor) / Local Supplier (Source)
Shire Augusta/Margret River (SoA/MR)	Gnarabup Beach Nourishment	Beach nourishment works, placement of sand sourced from local quarries.	Sand	-	200 m^3 (completed in 2021 & 2022)	$60,000	Earth and Stone (Contractor) / Guthrie's Sand Pit (Source)
	Cape Leeuwin Rock Revetment	Construction of a revetment along Leeuwin Road to protect the coastal pathway	Granite Rock	0.4 – 1.1 tonnes	-	$150,000	Earth & Stone (Contractors / Local Supply (Source)
			Granite Core	100 – 300 mm	-		
Shire of Nannup (SoN)	No known coastal adaptation works are planned for their coastline.						
Shire of Manjimup (SoM)	No known coastal adaptation works are planned for their coastline.						
Main Road Western Australia (MRWA)	No known coastal adaptation works are planned for their coastline.						
Southern Ports Authority (SPA)	Inner Harbour Groyne	Refurbishment of a rock groyne at the entrance of Port of Bunbury's Inner Harbour	Basalt Rock	2 – 6 tonnes	4,400 tonnes	$660,000[4]	Italia Stone Group (Contractor) / Italia Stone Group (Supplier)
	Inner Harbour Spur Groyne	Construction of a rock spur groyne at the entrance of Port of Bunbury's Inner Harbour	Basalt Rock	2 – 6 tonnes	2,000 tonnes	$1.0 million[4]	Italia Stone Group (Contractor) / Italia Stone Group (Supplier)
			Basalt Core	400 – 700 mm	4,800 tonnes		
	Outer Harbour Groyne	Refurbishment of a rock groyne at the entrance of Port of Bunbury's Outer Harbour	Basalt Rock	3 – 6 tonnes	1,100 tonnes	$220,000	Italia Stone Group (Contractor) / Italia Stone Group (Supplier)

Table 2.30 Significant Past Projects (Within the Last 5 Years) (cont.)

	Projects	Description of the Works	Material Type	Characteristics ($D_n(50)$ / tonnage range)	Volume / Tonnage (m^3 / tonnes)	Cost	Contractor / Supplier or Source
Department of Transport (DoT)	Bunbury Maintenance Work (Inner Harbour Entrance Groyne)	Refurbishment of a rock groyne at the entrance of Port of Bunbury's Inner Harbour	Basalt Rock	-	2,000 tonnes[3]	$1.0 million[4]	TBA[2]
			Basalt Core	-	4,800 tonnes[3]		
	Transforming Bunbury's Waterfront (Stage 2)	Refurbishment of the causeway revetment within Koombana Bay	Basalt Rock	0.06 – 1 tonnes[3]	10,400 tonnes[3]	$2.8 million[3 & 4]	TBA[2]
			Basalt Core	150 – 300 mm[3]	7,400 tonnes[3]		

Notes:

1. Denotes sand sourced from sand traps and beaches and is not included in the volume and cost estimates of sand.
2. Denotes projects that are known to MRA however no information has been provided by the stakeholder.
3. Values are conservatively estimated based on the worst credible cross-section provided in the design documentation (ie drawings and design report) and has not been confirmed by the stakeholder.
4. Cost of materials has been estimated assuming a rate of $150 / tonnes for the supply and placement of rock, $60 / m^3 for supply and placement of sand and does not consider project preliminaries and management costs.

Table 2.31 Significant Future Projects (Within the Next 5 Years)

	Projects	Description of the Works	Material Type	Characteristics ($D_n(50)$ / tonnage range)	Volume / Tonnage (m^3 / tonnes)	Cost	Supporting Studies
Shire of Harvey (SoH)	General Maintenance	Annual maintenance to the coastal infrastructure	Sand	-	-	$100,000	-
City of Bunbury (CoBun)	Koombana Bay Beach Nourishment[1]	Annual beach nourishment at Koombana Bay, placement of sand sourced from SPA sand traps and in-situ locations.	Sand	-	200 m^3 (20 m^3/yr)	$50,000	CHRMAP recommendation and site audits
	Storm Surge Channel Refurbishment	Upgrade of "The Plug" located at Leschenault Inlet	Basalt Rock	-	-	$5 million	
Shire of Capel (SoC)	No information was provided by the stakeholder.						
Shire of Busselton (SoBus)	Annual Beach Nourishment	Beach nourishment works, placement of sand sourced from commercial suppliers and beach scraping	Sand	-	40,000 m^3 (8,000 m^3/year)	$750,000	Annual beach monitoring and the development of a 10 Year Coastal Management Plan
	Seawall Refurbishment	Refurbishment of the rock seawall at Vinent Street	Basalt Rock	-	-	$1.2 million	
	West Busselton Coastal Protection Works	Refurbishment of rock and GSC groynes and beach nourishment located at west Busselton	Sand	-	-	$2.2 million	
			Basalt Rock	-	-		
Shire Augusta/Margret River (SoA/MR)	Gnarabup Beach Nourishment	Beach nourishment works, placement of sand sourced from local quarries.	Sand	-	500 m^3 (100 m^3/year)	$150,000	Technical report prepared for the beach nourishment work
Shire of Nannup (SoN)	No known coastal adaptation works are planned for their coastline.						
Shire of Manjimup (SoM)	No known coastal adaptation works are planned for their coastline.						
Main Road Western Australia (MRWA)	No known coastal adaptation works are planned for their coastline.						

Table 2.32 Significant Future Projects (Within the Next 5 Years) (cont.)

	Projects	Description of the Works	Material Type	Characteristics (Dn(50) / tonnage range)	Volume / Tonnage (m3 / tonnes)	Cost	Supporting Studies
Southern Ports Authority (SPA)	No information was provided by the stakeholder.						
Department of Transport (DoT)	Transforming Bunbury's Waterfront (Stage 3a & 3B)	Refurbishment of a rock revetment within DoT's Bunbury (Casuarina) Boat Harbour	Sand	-	300 m^3	$10 million[4]	Business case prepared for Bunbury's coastal structures
			Basalt Rock	0.3 – 0.8 tonnes[3]	15,000 tonnes		
			Basalt Core	100 – 300 mm^3	51,000 tonnes		
	Outer Harbour Seawall	Refurbishment of a rock seawall at the Port of Bunbury's Outer Harbour	Basalt Rock	8 – 12 tonnes[3]	70,000 tonnes	$11 million[4]	Business case prepared for Bunbury's coastal structures
	BP Groyne & Seawall	Refurbishment of a rock groyne and seawall located along Casuarina Drive	Basalt Rock	4 – 12 tonnes[3]	67,000 tonnes	$10 million[4]	Business case prepared for Bunbury's coastal structures
	Koombana Bay Breakwater	Refurbishment and extension of a rock breakwater located at the Koombana Bay Sailing Club	Basalt Rock	0.3 – 6 tonnes[3]	49,000 tonnes	$17 million	Business case prepared for Bunbury's coastal structures
			Basalt Core	150 – 500 mm^3	370,000 tonnes		
	Northern Breakwater	Construction of a rock breakwater at the entrance of the Casuarina Boat Harbour	Sand	-	16,000 m^3	$50 million	Business case prepared for Bunbury's coastal structures
			Basalt Rock	0.3 – 2 tonnes[3]	49,000 tonnes		
			Basalt Core	100 – 300 mm^3	370,000 tonnes		
	Leschenault Inlet Training Wall Repairs	Refurbishment of a rock structures within the engineered entrance channel to Leschenault Inlet	Basalt / Granite Rock	-	22,000 tonnes	$5.8 million	Technical report prepared for the repair to Leschenault Inlet
			Basalt / Granite Core	-	4,000 tonnes		

Notes:

1. Denotes sand sourced from sand traps and beaches and is not included in the volume and cost estimates of sand.
2. Denotes projects that are known to MRA however no information has been provided by the stakeholder.
3. Cost of materials has been estimated assuming a rate of $150 / tonnes for the supply and placement of rock, $60 / m^3 for supply and placement of sand and does not consider project preliminaries and management costs.

The review of past and future coastal adaptation works within the Southwest Region was heavily reliant on Local Government & Coastal Managers.

It is clear from the information provided by the LGAs that they primarily serve as project officers or managers and are not deeply familiar with the specific material requirements of coastal engineering projects. However, they still bear the responsibility of managing and reporting on project budgets. Given this context, more emphasis should be placed on the cost of the works rather than the volumes or tonnage of BRMs. Table 2.33 presents the total quantities of imported BRMs which may be required and have been estimated for a period of 5 years either side of the present date.

Again, comparing the past and future costs of projects will provide insight into the amount of material required for coastal adaption works. Larger projects like “Transforming Bunbury’s Waterfront” have been excluded from these numbers, as it is a large-scale development which is largely outside the ability of LGAs to fund.

Table 2.33 Past & Future Project Totals

	Past Projects (5 years)			Future Projects (coming 5 years)		
	Sand	Rock	Cost	Sand[1]	Rock	Cost / Budget
Totals	40,000 m^3	37,000 tonnes	$5.3M	43,000 m^3	44,000 tonnes	$15.2M

Table 2.33 indicates that, over the past 5 years, an annual average of approximately 8,000 m^3 / tonnes of sand and rock respectively has been required by LGAs for coastal adaptation projects. The estimated material requirements for the next 5 years for sand and rock is nearly identical. The quantities of BRMs for both past and future projects are considered significantly underestimated, especially when considering the total cost of these projects. Based on the projected total cost of future projects, it appears that the demand for BRMs will triple over the coming 5 years though cost escalation may limit / reduce this demand.

The funding allocated to LGAs for coastal adaptation projects generally depends on the stage they are at in implementing their CHRMAPs. For instance, the CoBun has reported significant funding over the next five years to implement the recommendations of its CHRMAP. One such recommendation includes refurbishing "The Plug" storm surge channel to mitigate the risk of inundation. In contrast, the SoM, SoA/MR, and SoH, who are still in the process of finalising their CHRMAPs, have more modest budgets, ranging from $100,000 to $500,000, primarily allocated for developing their planning documents and undertaking general foreshore maintenance. The CoBus is an outlier, as it has not finalised its CHRMAP but still has a significant budget for coastal adaptation works over the next five years. The CoBus has undertaken extensive data collection and planning efforts to support its future projects (as referenced in Section 2.4 above). A review of online information suggests that LGAs within the Southwest Region have predominantly sought funding from the CMPAP and CAP grants to co-fund their projects.

Similar to the Perth and Peel regions, most Local Government and Coastal Managers within the Southwest Region are rarely involved in sourcing BRMs directly; this responsibility is generally left to the Contractor. Factors influencing the source of materials include project requirements and proximity to the site, which are typically beyond the control of the LGA.

Among the Coastal Managers who responded, most did not report on the approvals required to complete their projects listed in the tables above. This is either because no approvals were needed or because obtaining approvals was the Contractor's responsibility as part of their engagement. The Coastal Manager at CoBus was the only LGA representative to report on approvals, advising that approvals were generally required from the DBCA and the Department of Water and Environmental Regulation (DWER), largely due to the extensive wetlands, estuaries and drains that may be impacted by works in the area.

The CoBun and CoBus were the only two LGAs with significant projects in the pipeline for the next five years. The stage of each project varied depending on its planned delivery timeline, with projects ranging from the concept design stage to being out to tender for construction services.

Most Coastal Managers who responded indicated that they have not implemented measures to ensure sufficient sand and rock availability. However, as detailed in Section 2.4 of this report, extensive investigations into BRMs have been conducted within the Geographe Bay region, though these may not have been commissioned by Local Government and Coastal Managers.

All responses received from Local Government and Coastal Managers concerning issues, challenges and constraints for the supply of BRM's will be discussed in Task 5.

Suppliers

Of the three Suppliers contacted, two provided information used to assist with this study. The information canvassed from Suppliers is presented in subsequent tasks as it relates to sand and rock sources and factors influencing supply.

Contractors

Of the three Contractors contacted, two provided information used to assist with this study. The information canvassed from Contractors is presented in Task 5 as it relates to factors influencing supply.

2.6 Potential Large Coastal or Port Developments

2.6.1 Perth Metropolitan & Peel Regions

From the review of significant past and future projects within the Perth Metropolitan and Peel regions, it is evident that the sand and rock requirements of Local Government & Coastal Managers are far smaller than competing demands from other industries, such as the civil (road) and housing construction industry.

For instance, the Perth Metropolitan branch of MRWA directed MRA to its Infrastructure Delivery Plan developed for the period between 2024 and 2029, summarised in Tables 2.34 to 2.36. The projects displayed are those currently funded for construction.

Based on the projects listed, approximately $8.9 billion in funding is allocated to MRWA infrastructure projects over the next five years, with around $3.2 billion for projects currently being delivered, $1.8 billion for projects in procurement, and $3.9 billion for projects under development. Although the dollar values in the tables below represent the entire project budget and account for design services, approvals, management, and other associated costs, BRMs are expected to constitute a significant portion of the total. This suggests that the project costs still reflect the volume of materials required within the Perth Metropolitan area and illustrate that BRMs for coastal protection works are relatively minor compared to competing industries.

Table 2.34 MRWA Funded Projects

Descriptions	Project Budget	Timeframes
Awarded (Under Construction)		
Bunbury Outer Ring Road (Stage 2 and 3)	$1.5 billion	Delivery: Q4 2024
Smart Freeways Mitchell Southbound (Hester to Warwick)	$210 million	Delivery: Q4 2024
Swan River Crossing	$430 million	Delivery: Q4 2026
Stephenson Ave Extension + Stirling Bus Bridge	$461 million	Delivery: Q2 2025
Causeway Pedestrian and Cycle Bridge	$106 million	Delivery: Q4 2024
Smart Freeways Mitchell Southbound (Reid to Vincent)	$214 million	Delivery: Q4 2024
GNH Halls Creek to Kununurra (Kimberley Bridges)	$33 million	Delivery: Q4 2025
Mandurah Estuary Bridge Duplication	$110 million	Delivery: Q1 2026
Bindoon Bypass (Aboriginal development) Packages	$56 million	Delivery: Q2 2025
Gt Eastern Hwy and Bypass Interchanges	TBD	Delivery: TBD
New Brooking Channel Bridge	$106 million	Delivery: Q1 2025
Belmont Park Redevelopment accommodation work	$25-30 million	Delivery: Q1 2025
Scarborough Beach Road / Green, Brady and Main St - Intersection upgrade	$8 million	Delivery: Q2 2025

Table 2.35 MRWA Funded Projects (cont.)

Descriptions	Project Budget	Timeframes
Procurement		
Tonkin Hwy Extn & Thomas Road Upgrade Package 1	$755 million	Procurement: Q4 2024 Delivery: Q3 2028
Tonkin Hwy Extn & Thomas Road Upgrade Package 2	$290 million	Procurement: Q4 2024 Delivery: Q3 2028
Reid Highway Grade Separations (Altone Rd and Drumpellier Drv)	$225 million	Procurement: Q4 2025 Delivery: Q2 2027
Fiona Stanley Hospital Carparks	$235 million	Procurement: Q4 2024 Delivery: Q1 2029
Tonkin Hwy Grade Separations - Hale and Welshpool Rd	$224 million	Procurement: Q2 2025 Delivery: Q1 2028
Toodyay Road Upgrade	$75 million	Procurement: Q2 2025 Delivery: Q1 2027
In Development		
Great Northern Highway - Bindoon Bypass (46km)	$200 million	Development: Q1 2025 Procurement: Q4 2025 Delivery: Q4 2027
Tonkin Hwy Grade Separations - Kelvin Rd	$122 million	Procurement: Q1 2026 Delivery: Q3 2028
Manuwarra (Red Dog) Hwy Stg 4	TBD	Procurement: Q2 2025 Delivery: Q4 2027
Reid Highway / West Swan Road Grade Separation	$175 million	Procurement: Q2 2025 Delivery: Q4 2026
Wanneroo Road (Dunstan to Romeo) Duplication	$20-25 million	Procurement: Q3 2025 Delivery: Q3 2027
Pinjarra Heavy Haulage Deviation	$250 million	Development: Q4 2026 Procurement: Q2 2027 Delivery: Q2 2029
Morrison Road Level Crossing	$200 million	Development: Q2 2025 Procurement: Q2 2027 Delivery: Q2 2029

Table 2.36 MRWA Funded Projects (cont.)

Descriptions	Project Budget	Timeframes
In Development		
Tonkin Hwy (North Ellenbrook) Interchange	$100 million	Development: Q2 2027 Procurement: Q1 2028 Delivery: Q4 2029
Canning Bus Bridge Interchange	$150 million	Development: Q2 2025 Procurement: Q2 2026 Delivery: Q4 2028
Outback Hwy / Great Central Road	$500 million	Development: Q4 2024 Procurement: Q2 2025 Delivery: Q4 2029
Nicholson Road/Garden Street/Yale Road Grade Separation	$80 million	Development: Q4 2024 Procurement: Q1 2025 Delivery: Q2 2029
Congdon St Bridge replacement	TBD	Development: Q4 2024 Procurement: Q3 2025 Delivery: Q3 2027
Westport Roads Program - Anketell Rd/Kwinana Fwy	$2.0 billion	Development: Q3 2026
Gt Eastern Hwy Upgrade (Coates Gully Stage 2 and Walgoolean Southern Cross Package 8B - 2 Construct Only Contracts)	$50 million	Procurement: Q3 2025 Delivery: Q4 2026

Larger coastal developments like the Ocean Reef Marina redevelopment required a vast quantity of materials, in the order of 1,150,000 tonnes of limestone, 279,000 tonnes of igneous rock, and 1,200,000 m^3 of fill material. Similarly, the proposed Westport development, an initiative to construct a new port and supporting infrastructure (revetment and breakwater) in Kwinana, may also require significant raw materials, with estimated quantities in the order of 4,500,000 tonnes of limestone, 2,360,000 tonnes of igneous rock and up to 2,000,000 m^3 of fill.

Subsequently, it is large projects that have the potential to significantly affect the quantity of BRMs that remain, exceed the annual production rates of Suppliers and result in challenges in supply to additional projects and increased costs.

Future large development projects known to MRA that have the potential to impact the supply of BRM are listed below.

- Westport – The proposed construction of a new port and supporting infrastructure (revetment and breakwater) in Kwinana.
- South Thomson Bay (Rottnest) – The proposed redevelopment of the Army Groyne within South Thomson Bay to create a new barge operations area.

- Australian Marine Complex – The proposed redevelopment of the Australian Marine Complex (AMC) located in Cockburn.

- Private Development – Several large private developments are known to be in the pipeline however they cannot be discussed due to non-disclosure agreements.

2.6.2 Southwest Region

During stakeholder consultations in the Southwest Region, MRA met with the Southwest branch of MRWA. Their jurisdiction extends from Mandurah in the north to Walpole in the south and as far inland as Albany Highway. Based on their 10-year construction program for capital works alone, MRWA anticipates completing 115 projects that are expected to require 2.5 billion tonnes of gravel and 30 billion tonnes of fill material. Over the next 40 years, MRWA also predicts they will spend a total of $580 billion, in today's value, on materials for operational and capital projects. Inflationary costs, which have affected all areas of the industry and have resulted in an estimated 40% increase in BRMs since 2017, are considered a significant concern. For this reason, the Southwest branch of the MRWA has been investing time and money into their own material studies within the Southwest Region.

It is evident from discussions with MRWA, the sand and rock requirements of Local Government & Coastal Managers are significantly smaller than competing demands from other government organisations.

Regarding BRM demand for coastal adaptation works, most Local Governments and Coastal Managers are still in the preparation or early implementation stages of their CHRMAP and have not reported any significant projects in the short term (less than 5 years). However, the projects documented in available planning documentation include the following:

- CoBun's CHRMAP: This document heavily relies on the construction or refurbishment of groynes, storm surge barriers, and levees to combat the effects of climate change and coastal erosion. The report suggests that the cost of these works could reach up to $150M, with an expected delivery timeframe between 2023 and 2035.

- CoBus's Coastal Management Program (2021–2031): This program details both annual and strategic beach nourishment activities over the next 7 years to combat climate change and coastal erosion. The estimated volume of sand required is approximately 5,000 m^3 annually and 25,000–40,000 m^3 for strategic nourishment every 5 years. While these quantities may not appear large, they are significant within the Southwest Region, given the availability of sand with suitable material characteristics (e.g., grain size and colour).

Transforming Bunbury's Waterfront is another large-scale project currently being undertaken within the Southwest Region which will require a vast quantity of materials, with estimated quantities in the order of 850,000 tonnes of basalt and 16,000 m^3 of fill.

3. Task 2 – Assessment Criteria / Material Requirements

3.1 General

The intent of Task 2 is to develop a typical assessment criteria/material requirement for sand and rock which is suitable for use in coastal protection works. This includes sand used for renourishment and reclamation and rock used for the construction of breakwaters, seawalls, revetments, groynes, and artificial reefs.

3.2 Guidelines & Literature

The following section provides an overview of standards, guidelines and literature to be considered when planning to design and construct coastal protection infrastructure.

3.2.1 General

Climate Change Adaptation Guidelines in Coastal Management and Planning (Engineers Australia, 2012)

The guideline is designed to help coastal managers and planners working in Local and State Governments to identify risks associated with decisions or solutions, guiding them to ask the right questions when gathering data, designing monitoring programs, preparing consulting briefs, or evaluating options. Chapters 7 and 8 delve into shoreline and offshore protection options which discusses both soft and hard engineering options.

Hard engineering options explored in the report include seawalls, groynes, breakwaters (attached or detached) and artificial reefs. The guideline documents design considerations for the structures and provides a brief overview of systems appropriate for energetic and milder wave conditions. Engineers Australia (2012) also suggests that most hard engineering structures are modular, therefore, if the site conditions change, the structures can be easily upgraded to accommodate them.

Sand nourishment was explored as a soft engineering option. The report discussed potential sand sources such as quarries or developments (terrestrial), dredging or dredging spoil from navigation channels or harbour developments (marine), and accreting beaches that have a significant buffer (coastal deposits). The guideline also highlighted key considerations for the design of a beach nourishment program including sand properties, overfill ratios to ensure the beach stability, methods of placements and environmental impacts.

3.2.2 Sand

Coastal Engineering Manual: Part V Chapter 4 – Beach Fill Design (CEM, 2006)

The chapter delivers a comprehensive overview of beachfill design. It discusses the evaluation of sediment sources, project longevity, beach fill stabilisation, construction issues, plan and specifications, monitoring, and operations and maintenance.

The chapter discusses the pros and cons associated with the “Borrow” source type which includes terrestrial, backbarrier, offshore and navigational channels, and the environmental factors affecting borrow operations. CEM (2006) recommends that for borrow site exploration a preliminary office study should be undertaken which involves the review of maps, charts, aerial photographs, literature, and the like, to identify areas that might contain potential fill material.

The chapter identifies that the most important physical property of the potential fill material is the grain size in order to have a stable beach (overfill factor). The less important physical properties are mechanical strength, resistance to abrasion, and chemical stability.

As a general recommendation, a nourishment project should use fill material with a composite median grain diameter equal to that of the native beach material, and with an overfill factor within the range of 1.00 to 1.05.

Beach Sand Nourishment Scoping Study (AECOM, 2010)

The report was prepared as a scoping study to maintain the amenity of Sydney's Beaches. The study was designed to scope a nourishment programme for the whole of Sydney while key considerations were investigated for three of Sydney's beaches (ie Collaroy-Narrabeen, Manly and Bate Bay).

The report identified that beach nourishment is a sound strategy for the present planning timeframe given that the alternative options "retreat" and "prevent" are either difficult to implement or require support and unification beyond the boundaries of NSW and Australia. The report also examines beach nourishment volumes (native and source), sand extraction considerations, nourishment techniques and nourishment costs.

Guidelines for Sand Nourishment: Science & Synthesis for NSW (WRL, 2017)

The report is a comprehensive guideline developed for sand nourishment in NSW. The guideline discusses sediment compartments, sand sources and properties, extraction transport and placement considerations, environmental impacts, monitoring, and policy and legal frameworks.

The guideline has been developed to assist with site-specific studies for the consideration of sand nourishments as a potential option for coastal adaptation.

3.2.3 Rock

Coastal Engineering Manual: Part VI Chapter 4 – Material & Construction Aspects (CEM, 2006)

The chapter delivers an overview of the materials utilised in coastal engineering projects, including earth and sand, stone, Portland cement and asphalt concretes, steel, wood, geotextiles, and plastics. It identifies the primary criteria for selecting these materials, emphasising their physical properties and strength, durability, adaptability, cost-effectiveness, availability, handling and maintenance requirements, and environmental implications.

Furthermore, the chapter offers valuable insights into the application of stone in coastal construction, detailing the types of rocks available (igneous, sedimentary, and metamorphic) and discussing their engineering properties. It examines the durability of each rock type and summarises various tests designed to assess rock durability, providing guidelines for determining their suitability. The chapter also addresses the considerations involved in the placement of rocks, enhancing understanding of their practical application in coastal protection and construction efforts.

Aggregate & Rock for Engineering Purposes (AS 2758.6:2005)

The Australian Standard Guideline was developed to support designers and specifiers with the selection of natural rock for use as armour rock when constructing sea walls, harbours and river foreshores and dam walls.

It provides comprehensive criteria for the physical and mechanical properties of armour rock, ensuring these materials possess the necessary durability, density, and strength to withstand the harsh marine environment and the dynamic forces exerted by waves and currents.

The guideline details common methodologies for evaluating the quality of rock, including specific tests for abrasion resistance, water absorption, and specific gravity, among others. The guideline

also provides advice on the appropriate sizing, grading, and placement techniques, which are vital for achieving structural integrity and desired hydraulic performance. The standard also discusses the importance of rock size and shape to achieve good interlocking capability and resistance to displacement by hydrodynamic forces.

Clause 8.2 of the guideline states that sedimentary rock, with the possible exemption of some limestones, is considered unsuitable for any risk category above low. Fissile sedimentary and metamorphic rocks such as shales, mudstones, claystones, bedded sandstones or slates are unsuitable for armour rock.

WA's Tamala Limestone is of higher quality than general limestone, however, given the limitations of the standard, some of the requirements presented in the guideline are not appropriate for the assessment of limestone.

The Rock Manual (CIRIA, 2007)

The Rock Manual has been developed as a comprehensive guide for the use of rock in hydraulic engineering, encompassing applications in coastal, river, and canal works, estuary and river closure works. The manual is tailored for planners, developers, engineers, architects, Contractors, and many others involved in hydraulic engineering.

Figure 3.1 is an excerpt from the Rock Manual and shows the general layout. Outlined in the figure, the resources highlight the relationship between material, site-specific conditions and physical processes that need to be considered for the development of rock-based solutions. The manual is considered to encompass the entire project lifecycle from planning and designing of rock works to monitoring, inspections, maintenance and repair.

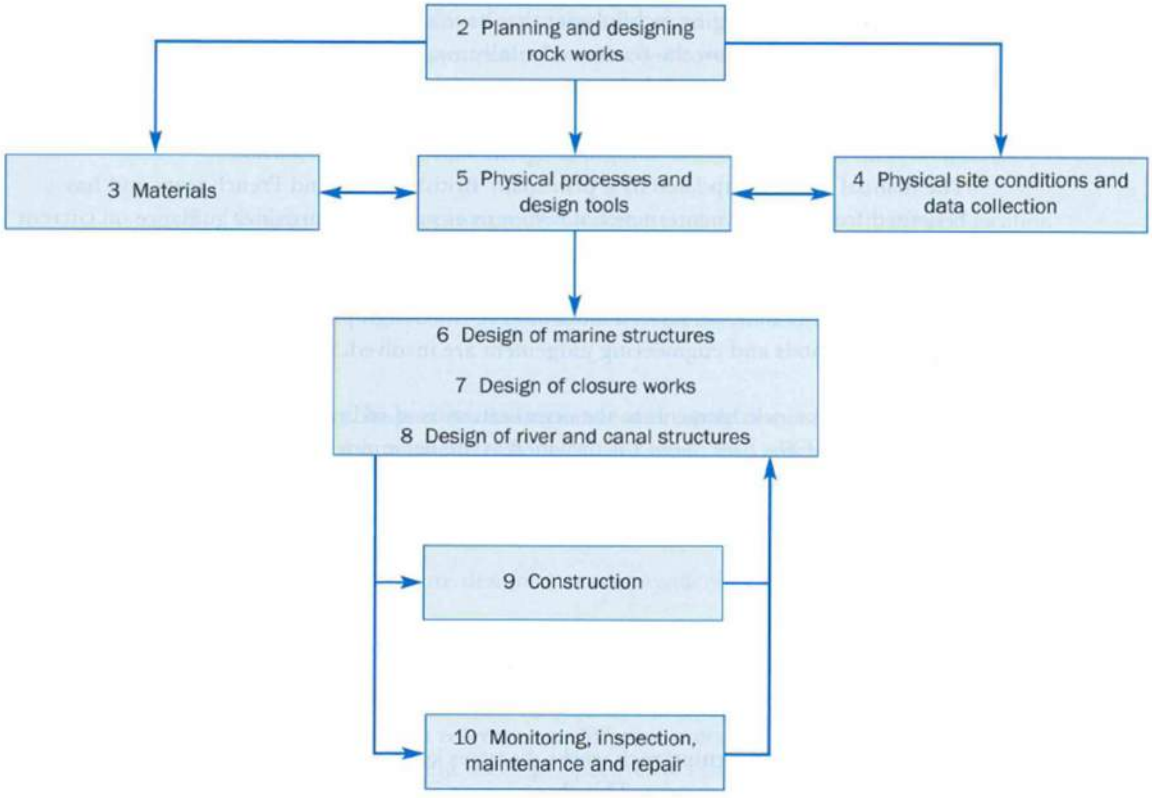

Figure 3.1 Flow Chart Illustrating the Links Between Design Considerations (CIRIA 2007)

3.3 Common Materials Used in Coastal Adaptation Works

Figure 3.2 presents common materials used in coastal adaptation projects near key development nodes in WA. It also provides a high-level overview of material availability, considering factors such as existing approvals, resource size, location, and potential future constraints. Further details on these materials are provided in Tables 3.1 to 3.7.

The assessment of common materials used in coastal adaptation projects is based on a review of materials utilised in similar projects completed in recent years within the region. While materials such as Tamala Limestone and Granite are expected to be available near key development nodes, they are excluded in cases where they are unlikely to be suitable for coastal adaptation works (eg armour rock).

For example, Tamala Limestone found in some locations may not meet the high-grade, high-strength requirements necessary for coastal applications but may still be suitable for road base and other construction purposes. These materials are classified as 'alternative / nonconforming rock' and are detailed in Section 3.4.

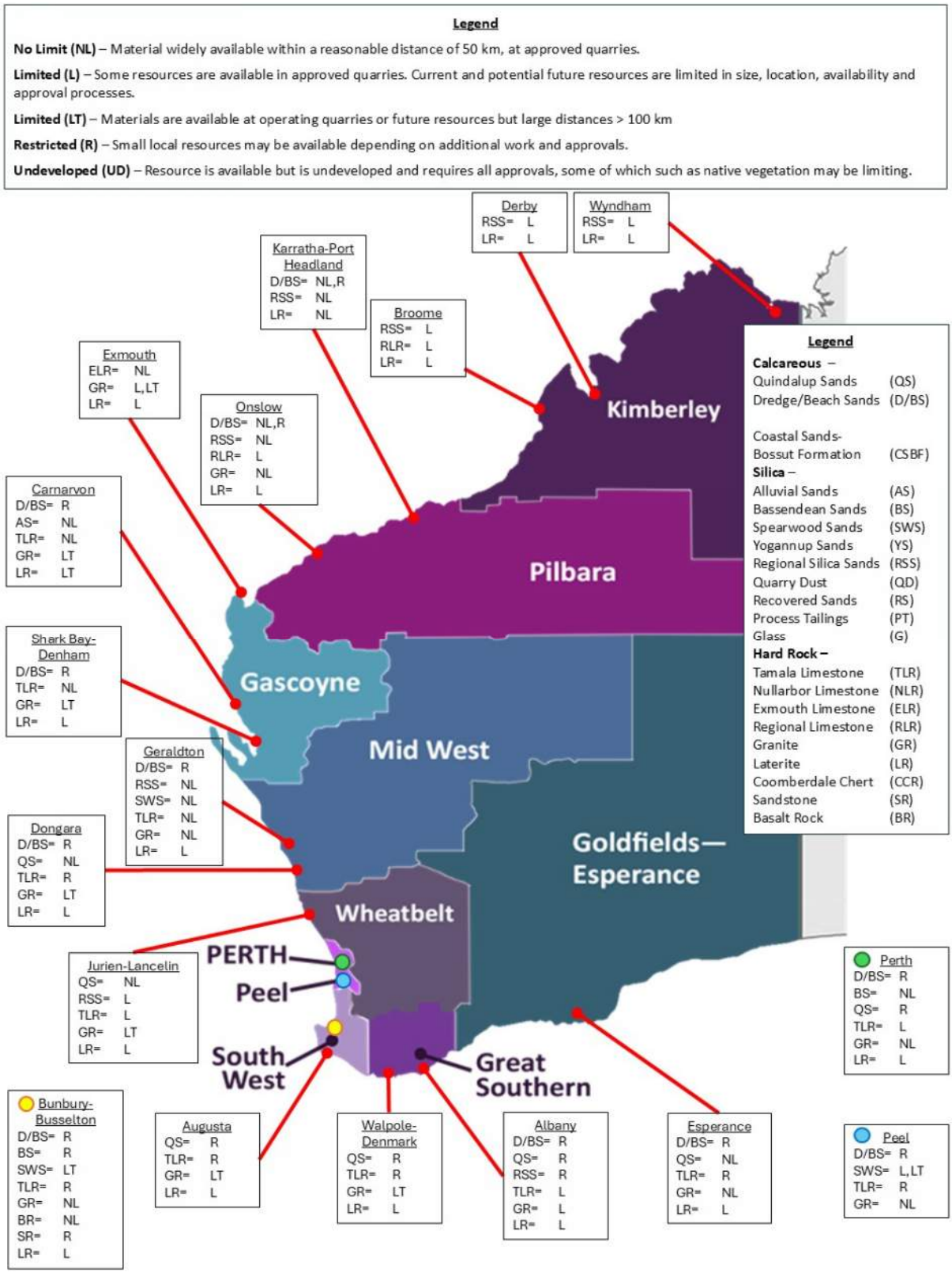

Figure 3.2 Common Materials Used for Coastal Adaptation Works Near Key Development Nodes

Table 3.1 Common Sand & Rock Materials for Coastal Adaptation Works

Use	Material Type	Size	Appearance	Regions	Availability	Advantages/Disadvantages	Approval Considerations
Silica Sand							
Beach Creation (Riverine System)	Alluvial Sands	0.35 - 0.6 mm		Pilbara Gascoyne Perth Metropolitan / Peel	**Perth to Bunbury:** • Small, primarily for special purposes such as filter sand, river replenishment, and limited use as fill sand. • Highly restricted to a small area, with minor deposits found in paleochannels east of Perth. **Regional:** • River gravels and sands are widely used from Carnarvon to the Pilbara for screened sands and aggregates.	**Advantages:** • Suitable for river sand replenishment. **Disadvantages:** • Lack of fines means it doesn't always provide good fill.	• Areas are mostly covered by native vegetation and forest, requiring approvals for clearing. • Approvals are challenging to obtain, and offsets are required to minimize the impact of clearing. • Extraction of regional river sands requires Mining Tenements and are partially constrained by river vegetation.
Beach Nourishment	Bassendean Sands	0.35 - 0.6 mm		Midwest Perth Metropolitan / Peel Southwest	**Perth to Bunbury:** • Millions of tonnes required annually, fluctuating based on major construction projects (e.g., urban developments, Bunbury Outer Ring Road, Tonkin Highway extension). • Available in Gnangara (under pine plantations) and further north, but scarce south of Perth. **Regional:** • Significant silica sand deposits are found inland along the coast, extending northwards to Geraldton.	**Advantages:** • High quality silica sand • White colour matches beach aesthetics. **Disadvantages:** • Typically, does not match the coastal sand composition or form (of aeolian origin therefore typically finer). • Restricted availability to Gnangara and northwards. • Requires large transport distances.	• Covered by pine plantations, which are used by listed "Threatened" species under the *Environment Protection and Biodiversity Conservation (EPBC) Act* 1999, such as Black Cockatoos. • Natural vegetation predominantly consists of Banksia Woodland, which is also listed as "Threatened" under State and EPBC legislation. • Applications for land use or clearing are difficult and expensive to gain due to the various environmental protection legislations. • Several local authorities have policies aimed at minimizing the clearing of Banksia Woodland. • Compensation for clearing pine plantations is required, along with extensive offsets for any vegetation clearing.

Table 3.2 Common Sand & Rock Materials for Coastal Adaptation Works (cont.)

Use	Material Type	Size	Appearance	Regions	Availability	Advantages/Disadvantages	Approval Considerations
Calcareous Sand							
Beach Nourishment	Dredge / Beach Sands	0.35 - 0.6 mm		Kimberley Pilbara Gascoyne Midwest Wheatbelt Perth Metropolitan / Peel Southwest Great Southern Goldfields / Esperance	**Perth to Bunbury & Regional:** • Sand for coastal projects is only available when dredging occurs, limiting consistent supply. • There is potential for large sand volumes from the Gulfs in the Kimberley, but most of these areas are now under Mining Tenement, making them unavailable for extraction.	**Advantages:** • Reduces costs by sourcing materials locally. • Utilizes materials from coastal excavations. **Disadvantages:** • Beach sands are only available in areas with excess sand, such as near groynes where bypassing is possible. • Dredge sands vary in composition and geotechnical properties, which may make them unsuitable for coastal requirements.	• Extracting materials from the sea floor raises environmental concerns, particularly regarding impacts on marine habitats. • Dredging and beach works often attract high public interest, requiring careful management and stakeholder engagement.

Table 3.3 Common Sand & Rock Materials for Coastal Adaptation Works (cont.)

Use	Material Type	Size	Appearance	Regions	Availability	Advantages/Disadvantages	Approval Considerations
Limestone							
Armour /Core / Filter / Fine Core	Tamala Limestone	Armour: • 1 - 6 tonnes • 50% > Dn(50) Core / Filter / Fine Core: • < 1 tonne • 50% > Dn(50)		Kimberley Pilbara Gascoyne Midwest Wheatbelt Perth Metropolitan / Peel Goldfields / Esperance	**Perth to Bunbury:** • 1–2 million tonnes per year in the Perth Metropolitan Area. • Widespread, but almost completely sterilised south of Yanchep due to conservation and urban development. • Limited materials are available from excavation in Hope Valley – Wattleup. • North of Yanchep, limestone quality is lower, and only limited amounts are suitable for good road bases. • Likely only 20 years of supply remaining if access to Neerabup to Nowergup is granted. • The largest remaining deposit is at Neerabup to Nowergup, which is likely to provide significant armour and core rock for coastal work. • Existing approved pits are limited by clearing restrictions, and unlikely to support large projects like Ocean Reef Marina. • Other areas are unlikely to provide sufficient rock for coastal work. • Tamala limestone under Spearwood Sand (Myalup to Kemerton) is of low grade. **Regional:** • North of Yanchep to Dongara, the limestone is of lower grade. • North from Dongara, the limestone increases in volume and width through to Shark Bay, generally widespread except in delta alluvial areas.	**Advantages:** • Visually and geotechnically compatible with the current coastline. • Limestone ($CaCO_3$) is highly suitable for aggregates to manufacture reconstituted blocks, reducing cement usage to around 7–8%, compared to granite aggregate concrete (17%), leading to significant savings in cement and greenhouse gas emissions. **Disadvantages:** • Limited resources, primarily located on previously disturbed land like the Department of Primary Industries and Regional Development (DPIRD) Medina Agriculture facility. • The only suitable material for coastal armour and core rock is found in the Neerabup to Nowergup area, making transport expensive and potentially prohibitive for many locations.	• Most limestone resources are overlain by a proposed National Park, which restricts development and extraction. • Obtaining approvals for clearing native vegetation is very difficult, requiring both State and Commonwealth approvals. • The only available resource area between Neerabup and Nowergup is restricted by vegetation communities listed as "Threatened" under Commonwealth and State legislation. • Vegetation not listed as "Threatened" is classified as "Priority" on State databases, further complicating the approval process. • The resource forms feeding habitat for Black Cockatoos, adding to its conservation value.

Table 3.4 Common Sand & Rock Materials for Coastal Adaptation Works (cont.)

Use	Material Type	Size	Appearance	Regions	Availability	Advantages/Disadvantages	Approval Considerations
Armour /Core / Filter / Fine Core	Nullarbor Limestone	Armour: • 1 - 6 tonnes • 50% > Dn(50) Core / Filter / Fine Core: • < 1 tonne • 50% > Dn(50)		Goldfields / Esperance	**Regional:** • Widespread from east of Kalgoorlie to South Australia.	**Advantages:** • Large volumes of rock available from a pit under care and maintenance at Rawlinna, capable of producing armour, core rock, and aggregates.	• Approvals are already in place for mining, which may streamline the extraction process, but may still be subject to ongoing environmental regulations and conditions due to the sensitive ecological context.
	Exmouth Limestone	Armour: • 1 - 6 tonnes 50% > Dn(50) Core / Filter / Fine Core: • < 1 tonne 50% > Dn(50)		Gascoyne	**Regional:** • Large reserves are available for occasional coastal constructions at Exmouth, where substantial resources are found.	**Advantages:** • One large pit under care and maintenance at Exmouth capable of producing aggregates, core, and armour rock. • Two smaller pits produce aggregates and road base.	• Approvals are in place for the mining of construction materials, facilitating the extraction process. • Environmental approvals have been granted, but significant environmental issues remain, particularly if the materials are to be exported via shipping. • These issues likely involve concerns such as marine ecosystem protection, shipping impacts, and coastal management.

Table 3.5 Common Sand & Rock Materials for Coastal Adaptation Works (cont.)

Use	Material Type	Size	Appearance	Regions	Availability	Advantages/Disadvantages	Approval Considerations
Siliceous Igneous Rock							
Armour /Core / Filter / Fine Core	Granite & Diorite	Armour: • 1 - 12 tonnes • 50% > Dn(50) Core / Filter / Fine Core: • < 1.5 tonnes • 50% > Dn(50)		Kimberly Pilbara Gascoyne Midwest Wheatbelt Perth Metropolitan / Peel Southwest Great Southern Goldfields / Esperance	**Perth to Bunbury:** • Licensed for around 10 million tonnes per year, with production varying based on project needs (often around half of the licensed amount). • Most quarries do not produce armour rock for coastal work, and there is limited capacity to support future projects. • Ocean Reef Marina used almost all the large armour rock available from all quarries within 300 km of Perth. • Granite is widely available along the Darling Scarp, but suitable quarry sites are limited and restricted to existing quarries, with little potential for new extraction sites. • Diorite-Dolerite resources are limited to narrow dykes through granite, usually too narrow to extract separately. • Resources are likely sufficient for 50+ years, depending on growth in the Perth / Peel / Bunbury areas. **Regional:** • Found along the coast from the Pilbara to Esperance, in some places up to 50–100 km from the coast. • Available at Esperance, Albany, Wellington, Geraldton, Onslow, and Pilbara. • The only quarry near Broome and Derby is located on the Gibb River Road at Wombarella, 150 km from Derby and 370 km from Broome.	**Advantages:** • Strong rock suitable for high wave energy conditions. • Inert and dense, with a density of around 2.6 t/m³. **Disadvantages:** • Granite aggregate blocks and concrete use 17% cement, more than double the amount needed for reconstituted limestone blocks. • Armour rock production differs from aggregate production, and most quarries lack the capability to produce armour rock. • Expensive to produce. • Large transport distances to the coast. • Grey color doesn't match natural coastal materials, except south of Cape Leeuwin. • Jointing patterns can limit block size in some quarries. • Limited use of granite to replace Tamala Limestone due to approval limitations, conservation concerns, aesthetics, and production and transport costs.	• The resources are significantly restricted by conservation values, visual amenity concerns, and community objections. • All resources are located within high conservation value areas, with "Threatened" and "Priority" species associated with granite outcrops. • Extracting the resources requires clearing high-quality vegetation, which triggers the need for future offsets to mitigate environmental impacts.

Table 3.6 Common Sand & Rock Materials for Coastal Adaptation Works (cont.)

Use	Material Type	Size	Appearance	Regions	Availability	Advantages/Disadvantages	Approval Considerations
Armour /Core / Filter / Fine Core	Basalt	Armour: • 1 - 12 tonnes • 50% > Dn(50) Core / Filter / Fine Core: • < 0.6 tonnes • 50% > Dn(50)		Southwest Great Southern	**Bunbury:** • Less than 1 million tonnes of rock are extracted each year, varying based on construction needs. • Restricted to one locality at Gelorup, limited by the road network and proximity to dwellings. • Likely 20 to 40 years of supply, depending on land use restrictions. • One small, low-quality resource south of Capel, thought to be uneconomic. **Regional:** • Present in the Pilbara, where they form dense, heavy rock with a density of 3.0 t/m³. • In the Kimberley, basalts are present but are too far distant for practical use.	**Advantages:** • Dense and heavy, with a density of around 2.8–3.0 t/m³. • Suitable for heavy rock uses, such as anchoring structures. **Disadvantages:** • Restricted to one location at Gelorup. • High transport costs for use in other locations. • Prominent jointing limits block sizes to small blocks, unsuitable for much coastal work	• The resources are located in pasture areas, with long-term approvals already in place. • There is limited potential for future expansion of the resource area due to approval restrictions, primarily caused by the presence of dwellings and roads
Laterite Duricrust & Gravel							
Armour /Core / Filter / Fine Core	Laterite / Ferricrete	Armour: • 1 - 3 tonnes • 50% > Dn(50) Core / Filter / Fine Core: • < 0.5 tonnes • 50% > Dn(50)		Kimberly Pilbara Gascoyne Midwest Wheatbelt Perth Metropolitan / Peel Southwest Great Southern Goldfields / Esperance	**Perth to Bunbury:** • Laterite is widely available, but much of it lies within State Forest, making access more difficult. • Some deposits are located further inland, requiring longer transport hauls to coastal sites. **Regional:** • Laterite is widely available across most areas. • Some resources are set back from the coast, leading to long transport distances for delivery.	**Advantages:** • Widely used for country road construction. • Can be used for core stone and, occasionally, armour rock. • Provides phosphate retention capability for water bodies. **Disadvantages:** • Difficult to obtain armour rock due to a lack of suitable sizes. • Variable rock strength and geotechnical properties.	• Many resources are located in State Forrest, where government policies make access difficult. • Clearing State Forrest now requires offsets, increasing the cost of resource extraction. • In the Southwest, clearing in forest areas often requires Commonwealth referral under the EPBC, leading to additional complications and approval delays.

Table 3.7 Common Sand & Rock Materials for Coastal Adaptation Works (cont.)

Use	Material Type	Size	Appearance	Regions	Availability	Advantages/Disadvantages	Approval Considerations
Siliceous Sandstone & Chert							
Armour /Core / Filter / Fine Core	Kimberly Sandstone	Armour: • 0.5 - 3 tonnes • 50% > Dn(50) Core / Filter / Fine Core: • < 0.6 tonnes • 50% > Dn(50)		Kimberly	**Derby:** • Situated at Jowlaena, 135 km east of Broome. • Currently only extracted from a small number of pits is used for dimension stone extraction.	**Advantages:** • 10-tonne blocks are available. **Disadvantages:** • Not recrystallised, so it does not have the same strength as granite. • May break up under salt crystallization in wet and dry conditions, near the water table or in saline soils.	• The resource is located under native vegetation on a pastoral station. • Clearing is unlikely to be an impediment unless “Priority” or “Threatened” species are identified, which would trigger additional environmental assessments and approvals.
Blockwork	Donnybrook Sandstone	N/A		Southwest	**Donnybrook:** • Very limited production, primarily used for decorative pavers and blocks. • Availability is restricted to the Donnybrook area, limited to 3–4 pits. These pits are further constrained by native vegetation and approval restrictions.	**Advantages:** • 10-tonne blocks are available. **Disadvantages:** • Not suitable for aggregates due to insufficient strength. • Unfit for wetting and drying conditions or saline environments, as salt crystallization breaks down the rock by forcing apart the silica grains. • Highly variable both laterally and vertically.	• The resources are generally located under parkland pasture, with some areas under native forest. • Areas under native forest will require offsets due to the need for clearing. These areas also provide important fauna habitats, which may further complicate extraction and approval processes.

3.4 Material Characteristics of Common Materials Used in Coastal Adaptation Works

General

Some sand, armour and core characteristics remain consistent irrespective of the type of material selected for a project, these are presented in the bullet points below. All other characteristics are considered material dependent and are included within the allotted subsections.

- Sand
    - Clean fill – The material must be clean, cohesionless, free draining and granular material, completely free of all silty, organic or other deleterious inclusions.
    - Environmental – The material must be certified clean and free from disease.
    - Colour – The material shall be a similar colour to that of the existing natural beach sand.
- Armour Rock
    - Shape – AS 2758.6:2008 and the Rock Manual (CIRIA 2007) suggest limiting the proportion of rock with a Length (L) to Thickness (T) ratio (LT) greater than 3 to ensure reasonable interlocking and limit the damage from breaking induced by transporting and construction.
    - Defects – The rocks shall be free of any cleavages, fractures, fissures, or weak planes.
- Core Rock
    - Quarried material – The material is to be freshly quarried broken out by explosives and of such strength that it will not break when handling and placing.

Sand

The grain size distribution of the sand used for nourishment will affect the cross-shore shape of the beach profile, the erosion rate and how the beach responds to storms (CEM, 2006). CEM (2006) recommends that nourishment projects use material with particle size equal to, or larger than, the native beach material, which corresponds to an overfill factor within the range of 1.00 to 1.05.

Nonconforming material can be considered however it should be recognised that an overfill ratio of 1.0 indicates an equivalent performance of the sourced material, whereas a value above 1.0 relates to the percentage of extra volume required for equal performance. Subsequently, overfill ratios greater than those recommended in CEM (2006) will increase the volume of material required but also reduce the beach stability.

Physical properties can also restrict the use of potential sand sources. This is more due to the social amenity rather than the performance of the material. Currently, local communities are often not willing to accept sand with different colouration to the native beach material.

Tamala Limestone

- Armour

- Saturated Surface Dry Density (SSDD) > 2.1 tonnes/m^3
- Point Load Index (Is50) > 0.7 MPa

- Core
  - Saturated Surface Dry Density (SSDD) > 1.9 tonnes/m^3
  - Point Load Index (Is50) > 0.7 MPa

A nonconforming limestone material commonly requested by stakeholders is “biscuit rock.” The material does not meet the dimensionality requirements stipulated above (the LT ratio) therefore should only be considered for structures of low risk, as defined in the AS 2758.9:2008.

Care should also be taken with the use of low-grade limestone. Typically, the rock used for coastal protection works is high-grade limestone found within the cap rock of the deposits. Below the cap rock, the quality of the limestone decreases until it reaches a grade where it is determined to be unusable for all applications (approximately 65% calcium carbonate ($CaCO_3$) content). Listed below are the limits for the grading of limestone appropriate for coastal works, which are dependent on the proportion of calcium carbonate ($CaCO_3$) and quartz sands:

- High-Grade Hard Limestone – Considered to have a $CaCO_3$ content of not less than 75%.
- Moderate-Grade Hard Limestone – Considered to have a $CaCO_3$ content of not less than 65%.

For the use of moderate-grade hard limestone, the material should be tested in accordance with AS 2758.9:2008 to determine its suitability.

Igneous Granite

- Armour & Core
  - Saturated Surface Dry Density (SSDD) > 2.65 tonnes/m^3
  - Point Load Index (Is50) > 0.7 MPa

No nonconforming Igneous Granite materials are considered relevant given that it is traditionally located within highly energetic wave climates.

Ferricrete / Ironstone

- Armour & Core
  - Saturated Surface Dry Density (SSDD) > 2.35 tonnes/m^3
  - Point Load Index (Is50) > 0.6 MPa

Kimberley Quartzite

- Armour & Core
  - Saturated Surface Dry Density (SSDD) > 2.65 tonnes/m^3
  - Point Load Index (Is50) > 0.7 MPa

Given the natural jointing and fracturing of Kimberley Quartzite deposits, the material typically does not meet the dimensionality requirements stipulated above (the LT ratio). However, there have been projects where the designer has considered the use of tabular armour rocks without the material being damaged during transport, construction and in-service conditions.

To determine the suitability of a Kimberley Quartzite deposit, it is recommended that a targeted study of available sites be undertaken as the yield of some quarries may be significantly low due to the rock defects and joint spacing. It is also recommended to test the material's abrasion resistance in accordance with AS 2758.9:2008. The most common abrasion test in Australia is the Los Angeles (LA) abrasion test.

Igneous Basalt

- Armour & Core
    - Saturated Surface Dry Density (SSDD) > 2.65 tonnes/m^3
    - Point Load Index (Is50) > 0.7 MPa

Due to the combination of mineral composition and geomorphic processes of Igneous Basalt deposits, the material can be brittle. This is particularly problematic as the material can be damaged during transport, construction and in-service conditions.

To determine the suitability of an Igneous Basalt deposit, it is recommended to test the material for rock defects in accordance with AS 2758.9:2008. The most common test used to determine the defects is the "drop" test.

Donnybrook Sandstone

- Blockwork
    - Saturated Surface Dry Density (SSDD) > 1.8 tonnes/m^3
    - Point Load Index (Is50) > 7 MPa

Research into Donnybrook Sandstone determined that the material could not be assured over a 50-year design life when assessed against AS:2756 (BFP Consultants Pty Ltd, 2004).

The material did not meet the minimum wet compressive strength or the maximum sulphate soundness requirements. A visual inspection of the samples also suggested that due to the high feldspar content, porosity and resulting weak cementation of the silica grains some of the rock could have poor long-term durability in a seawall environment.

Donnybrook Sandstone is generally not recommended as suitable for coastal adaptation works.

3.5 Alternative / Nonconforming Materials

Figure 3.3 presents alternative / nonconforming materials near key development nodes in WA.

Figure 3.3, along with Tables 3.8 to 3.7, provides the same information as Section 3.3. For previously discussed materials, including Tamala Limestone, Granite and Laterite, refer to Tables 3.1 to 3.7 for further details.

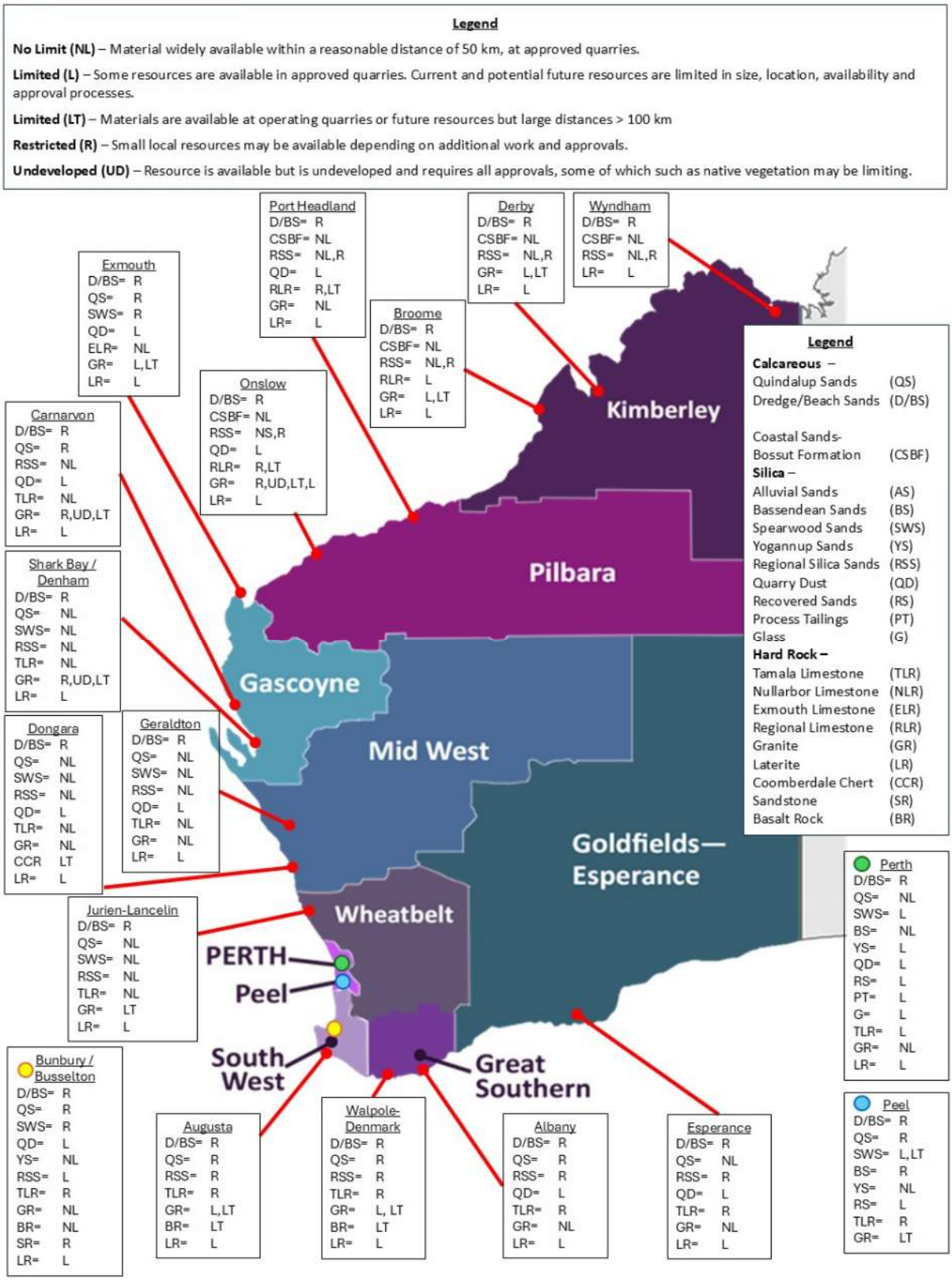

Figure 3.3 Alternative / Nonconforming Materials Near Key Development Nodes

Table 3.8 Alternative / Nonconforming Sand & Rock Materials

Material Type	Regions	Availability	Advantages/Disadvantages	Approval Considerations
Silica Sands				
Spearwood Sands	Midwest Wheatbelt Perth Metropolitan / Peel Southwest	**Perth to Bunbury:** • Millions of tonnes required annually. • Demand fluctuates based on major construction projects such as urban land development, Bunbury Outer Ring Road, and Tonkin Highway extension. • Significant annual demand in the Peel Region. • Available between Lake Clifton and Kemerton under pine plantations on Crown land, requiring mining leases. • Located on agricultural land north of Yanchep. • Conservation and clearing restrictions have sterilised large, thick resource areas north of Kemerton. **Regional:** • Some silica sands occur inland along the coast northwards to Geraldton. • Small, scattered resources are associated with coastal limestones extending north to Exmouth.	**Advantages:** • High quality silica sand. • Areas with high phosphate-retaining sand. **Disadvantages:** • Variable distribution leads to large transport distances. • Yellow in colour. • Does not match the coastal sand composition or form.	• Covered by pine plantations, which are used by listed "Threatened" species under the EPBC, such as Black Cockatoos. • The removal of pines is regulated by EPBC Guidelines. • Natural vegetation includes predominantly Banksia Woodland and Tuart Woodland, both listed as "Threatened" under State and EPBC legislation, making approvals difficult, time-consuming, and expensive, even within pine plantations. • Several local authorities have policies that aim to minimize the clearing of Banksia Woodland. • Obtaining approvals for extraction, particularly on Mining Leases, is challenging. • Compensation for clearing pine plantations is required through the Forrest Production Commission (FPC). • Extensive and costly offsets are required for clearing native vegetation, further increasing costs.
Yogannup Sands	Perth Metropolitan / Peel Southwest	**Perth to Busselton:** • Not commonly used for fill sand due to its physical characteristics. • Found in varying quantities from north of Perth to Busselton.	**Advantages:** • Often found in pastureland. **Disadvantages:** • Usually too much clay to be suitable for fill. • Strong yellow colour. • Requires transport to the coast. • Significant disturbance due to heavy mineral sands mining.	• Areas of native vegetation are common and are listed as Threatened Ecological Communities (TEC), such as those in the Perth Metropolitan Area and the Whicher Scarp near Busselton. • These areas are home to high conservation species. • In agricultural regions, much of the land is covered by pasture.
Regional Siliceous Sands	Kimberley Pilbara Gascoyne Midwest Wheatbelt	**Regional:** • Variable coastal and inland siliceous sand dune systems exist inland from the coast between Shark Bay and Broome. • Little to no silica sands are present in Kalgoorlie and Esperance.	**Advantages:** • Often found in pastureland. **Disadvantages:** • Often red or yellow-brown in colour.	• Some locations may contain heritage materials, which could require special consideration and approval for development or extraction activities.

Table 3.9 Alternative / Nonconforming Sand & Rock Materials (cont.)

Material Type	Regions	Availability	Advantages/Disadvantages	Approval Considerations
Quarry Dust	Kimberley Pilbara Gascoyne Midwest Wheatbelt Perth Metropolitan / Peel Southwest Great Southern Goldfields / Esperance	**Perth to Bunbury:** • Used as fill sand in certain situations. • All hard rock quarries produce it, with up to 1 million tonnes per year in Perth and limited quantities in other areas. **Regional:** • Some hard rock mines that use crushing processes generate significant amounts of quarry fines in the tailings.	**Advantages:** • Fines are readily available and can be used effectively for some purpose. • Contains trace elements that aid in revegetation. • Use of recovered material may reduce the need for native sand extraction to a limited extent. **Disadvantages:** • Grain sizes can be an issue. • Can be dusty.	• Typically covered by existing quarry approvals, which may simplify the process for extraction, though they could still be subject to specific conditions and restrictions.
Recovered Sands	Perth Metropolitan / Peel Southwest	**Perth to Bunbury:** • Used when available through screening of recovered materials. • Limited and dependent on the characteristics of ongoing developments.	**Advantages:** • Normally has good geotechnical properties. **Disadvantages:** • Quality may vary. • Requires screening and processing. • Colour may not match local conditions. • Limited volumes available. • Risk of contamination with chemicals like dieldrin or fine asbestos if not controlled. • Not commonly specified due to variability, colour, and risk aversion.	• Requires extensive testing to assess quality, suitability, or environmental impact before approval for use.
Process Tailings	Perth Metropolitan / Peel Goldfields / Esperance	**Perth to Bunbury:** • Lithium refineries are located in Kwinana and Kemerton. • Some hard rock mines using crushing processes produce significant amounts of quarry fines in the tailings. **Regional:** • A lithium refinery is located in Kalgoorlie.	**Advantages:** • Large volumes produced that may be suitable for some purposes. • Good use of recovered material, potentially reducing native sand extraction and clearing large tailing storages. **Disadvantages:** • Can be dusty. • May contain clay. • Very fine-grained.	• Typically covered by existing plant approvals, which facilitate ongoing operations. • May require additional approvals at the placement site, depending on local regulations or environmental considerations.
Glass	Perth Metropolitan / Peel	**Perth to Bunbury:** • Minimal currently use. • Widely available in Perth.	**Advantages:** • Available as a recycled material. **Disadvantages:** • Does not combine well to form fill sand. • Has very restricted properties and suitability. • Unnatural in form and colour.	

Table 3.10 Alternative / Nonconforming Sand & Rock Materials (cont.)

Material Type	Regions	Availability	Advantages/Disadvantages	Approval Considerations
Calcareous Sands				
Quindalup Sands	Gascoyne Midwest Wheatbelt Perth Metropolitan / Peel Southwest Great Southern Goldfields / Esperance	**Perth – Bunbury:** • 1–2 million tonnes needed for agriculture. • Found along most of the coast, but restricted by development and conservation areas. Much of the resource is covered by native vegetation. • Most available limesand is used for agricultural lime. **Regional:** • Widespread calcareous dunes along the coast to Geraldton, with scattered locations extending north to Exmouth.	**Advantages:** • Available in coastal areas. • Used for treating acidic soil conditions. **Disadvantages:** • Can crush under heavy loading.	• Mostly located on Crown land, requiring Mining Leases for extraction. • Some areas, particularly south of Bunbury, have very high conservation and community values, complicating approval processes. • Significant portions of the land are overlain by coastal reserves or National Parks, further restricting access and usage.
Coastal Dunes, Bossut Formation	Kimberly Pilbara	**Regional:** • Coastal lime sands from the Pilbara to Broome, likely equivalent to the Tamala Limestone.	**Advantages:** • Available in coastal areas. • Used for treating acidic soil conditions. **Disadvantages:** • Can crush under heavy loading.	• Mostly situated on Crown land, requiring Mining Leases for extraction. • Some areas, particularly south of Bunbury, hold very high conservation and community values, which can complicate approval processes. • Significant portions are overlain by coastal reserves or National Parks, adding further restrictions to land use and extraction.
Siliceous Sandstone and Chert				
Coomberdale Chert	Midwest	**Coomberdale:** • Small amounts, currently only used for concrete aggregates. • Located solely at Coomberdale and further north. • Only one pit is currently operating. • Very limited due to conservation values.	**Advantages:** • More compatible with the coast than granite. • Strong rock with a density of around 2.6 t/m³. **Disadvantages:** • Very limited in area and supply. • High transport distances and limited availability.	• A significant portion of the resource is covered by native vegetation, potentially of high conservation value, particularly as part of the Coomberdale Chert Threatened Ecological Community. • Some of the resource is located under farmland, which may require additional considerations for land use and environmental impact.

4. Task 3 – Existing Sand & Rock Sources

4.1 General

The intent of Task 3 is to identify existing sand and rock sources within WA and develop a comprehensive database. The database will include key information for each sand and rock source, including:

- Site Details – Site name, lot/tenement number, region, location, owner/operator, contact information, constraints and additional comments.
- Material Characteristics – Material type, quantity, yield, production rate, cost, expected lifespan and historic testing (sand and rock).

The information presented has been gathered from existing studies, stakeholder input, geological maps, and Landform's knowledge. Resource volumes and associated data have been provided by the respective operators. Where such details were not supplied, indicative values for resource volumes and annual production have been estimated based on operational knowledge, historical trends, and analysis of current and past aerial imagery. These estimates have been developed in a manner that ensures company confidentiality is maintained.

For clarity, a tenement is a licence, permit or lease that provides the holder with exclusive rights to explore for and / or extract minerals under the surface of an area of land.

4.2 Stakeholder Consultation

Consultation was undertaken with Local Government and Coastal Managers, Suppliers and Contractors within the relevant regions. The key items raised in context with the existing terrestrial sand and rock sources are discussed below.

4.2.1 Perth Metropolitan & Peel Regions

Local Government & Coastal Managers

Although it was not reported on as part of the stakeholder consultation, MRA was heavily involved in the Port Beach sand nourishment works via dredging. Overall, the project was considered extremely successful especially as it was the first large scale capital dredging campaign, for the sole purpose of providing a source of beach nourishment, completed in WA in decades.

Over 150,000 m^3 of sediment was dredged from Deepwater Channel. The sediment was of sound quality given its grain size (relatively coarse material), colour and was suitably clean from contaminants. With the area having been dredged for both the Port Beach project and previous Deepwater Channel capital dredging works in 2010, dredgeabilty has been proven. MRA estimates in the order 400,000 m^3 of reasonably suitable nourishment material currently remains available in the Deepwater Channel.

The unit cost of dredging sediment from Deepwater Channel and rainbowing it into the swash zone of Port Beach was approximately \$10-15/m^2, which is estimated to be half the unit cost of sand nourishment via trucking of sand from terrestrial sources. The unit cost of the dredging works was low due to several unique circumstances which may not occur for other projects. However, it was suggested that if a collaborative and flexible approach is adopted in the management of the project and procurement of a dredging Contractor, the cost of similar projects can be optimised.

From an environmental and public interface perspective, the project had minimal negative impacts. There were no exceedances of the environmental triggers and the turbid plume created by the works tended to remain within the immediate vicinity of the placement area and usually dissipated within a few hours. Owning to the fact that the project was considered extremely successful, environmental investigation and approvals are expected to be simpler for dredging of Deepwater Channel compared to other sources such as natural seabed areas.

When speaking with the Perth Metropolitan division of MRWA, they advised that the task of procuring BRMs for capital projects is typically delegated to the Contractor. However, they understand that, unlike the Southwest Region, the Perth Metropolitan area does not experience shortages in materials used as pavements. Due to material shortfalls in the Southwest, roadworks there have needed to migrate towards using harder materials, which is not MRWA's typical approach.

MRWA also mentioned that future projects are exploring options to use recycled or alternative fill materials, including the following:

- Tunnelling Spoil – Extracted from projects such as the MetroRail City Tunnel project. This material is typically fine and unsuitable for infrastructure projects unless adequately blended.
- Red Sand – A byproduct of alumina refineries. Currently, it is not cost-effective to use as fill due to the post-processing needed to reduce alkalinity levels.
- Delithiated Beta Spodumene (DBS) – A byproduct of lithium refining. At present, using DBS as fill is not cost-effective due to the necessary post-processing to reduce fines and improve water-shedding properties.

Suppliers

Responses from Suppliers indicated that, while the industry is also grappling with inflationary pressures, the most significant contributors to cost escalations are regulatory and environmental approvals, as well as cartage.

Most lots / tenements identified in the study faced constraints related to the extraction of BRMs. These constraints included Bush Forever Sites (BFS), groundwater, neighbouring land use, future planning, services and infrastructure, Threatened Ecological Communities (TEC) and native flora and fauna. In some cases, these constraints sterilised more than half of the available resources. Consequently, obtaining the necessary licences and approvals from all three levels of government (Local, State, and Federal Government) was reported to be cumbersome and almost cost prohibitive. These constraints also meant that BRMs meeting project specific specifications and located close to a project cannot be easily accessed due to the required approvals.

Cartage was identified as the most significant influence on cost. Fuel was reported to constitute 30% of the overall value for producing materials near Perth, while for remote sites, it accounted for 40% of the supply costs. Additionally, cartage costs were affected by material specifications where, based on the material requirements, a portion of each trailer may be left unutilised due to the size of the armour units. It was suggested that engaging with Suppliers early could potentially reduce cartage costs as alternative transport options (rail transport) or quarries could be considered.

For sand, specific requirements including colour and washing incurred greater cost. As an example, washed white sand was suggested to cost $20 /tonne, whereas unwashed sand was significantly less at $2-4 /tonne. These values are exclusive of cartage costs.

Suppliers confirmed that the production of armour rock is more specialised and more resource intensive than production of other quarry materials, and as such, not all Suppliers are keen on manufacturing armour rock. Many prefer to focus on a specific market, providing other materials such as roadbase or aggregate, which often has a higher demand and quicker turnover.

Some suppliers suggested that previously, they had broken down larger armour rocks that were a by-product of typical quarrying operations, to form aggregate or roadbase. Now, these are being stockpiled and stored in quarries to ensure that if larger quantities of armour rock are needed in the future, the Suppliers have an available stockpile on hand.

Several suppliers mentioned that they had been approached by other government agencies conducting their own material studies. This indicates that BRMs have not been adequately quantified in the Perth Metropolitan and Peel regions, and the lack of supply of BRMs is a perceived risk to ongoing and future projects.

Regarding the future supply of BRMs for coastal adaptation works, the following was noted by the Suppliers:

- Sand – There is currently a surplus of sand in the Perth Metropolitan and Peel regions that is not expected to run out soon. However, this resource may become unusable due to sterilisation. The main limitation of using terrestrial sand in coastal adaptation projects is its material properties, such as colour and grain size. This limitation is often for aesthetic or social, rather than technical, reasons.

- Rock – The available rock supply in the Perth Metropolitan and Peel regions is deemed to be sufficient for general coastal adaptation works. However, large-scale coastal and port projects will significantly impact this supply. The primary restriction on supply is the sterilisation of resources.

Contractors

Similarly to the response from Suppliers, the Contractors also identified that the entire industry is grappling with inflationary pressures, including the cost of fuel, materials, and labour. It was identified that a potential issue, challenge and constraint to the supply of sand or rock for coastal adaptation works was the limited number of Suppliers.

Contractors who responded also noted that project specific specifications also influenced the cost. The more bespoke / unique material (ie larger size armour units, biscuit rock, specific colour or type of sand) attracted a higher cost.

The Contractors also noted that competing projects contributed to cost increases in coastal projects. Respondents indicated that these competing projects could affect the availability of materials, trucks, and quarry processing resources, with larger orders typically being prioritised.

Respondents also provided information on the cost of having BRMs delivered to site. They reported that sand was typically $50-60 /tonne and limestone filter and armour rock ranged between $60-80 /tonne. These rates relate to supply costs only and do not include placement of materials on site.

No additional details were provided around cartage distance or material specifications for the products brought to site.

4.2.2 Southwest Region

Local Government & Coastal Managers

Most LGAs that responded reported that sourcing suitable materials for coastal adaptation work is becoming prohibitively expensive due to several factors, including statutory approval requirements, project proximity, inflationary pressures, and competition for materials with other LGAs and government organisations, such as MRWA.

For low-lying areas within the Southwest Region like CoBus and CoBun, LGAs suggested that significant amounts of coastal protection work will likely be required to protect the foreshore and surrounding infrastructure. Given the increasing scarcity of BRMs, LGAs did suggest they might have to consider alternative protection methods. One potential solution raised by a respondent involved collaborating with local developers to source BRMs from civil works for commercial and residential subdivisions, with the option to stockpile these materials for future use. The scarcity of BRMs appears to be particularly pressing in the Southwest Region, as many LGAs are finalising their CHRMAPs, suggesting that the demand for BRMs will continue to rise as they progress from planning to implementation.

One LGA respondent noted that since they usually outsource BRM supply to the Contractors engaged for the works, they have been unaware of the challenges related to availability and location of BRMs. However, with the finalisation of their CHRMAP, they intend to address this issue in future projects. Another respondent mentioned that all coastal protection work has traditionally been funded through capital grant funding, with no operational or maintenance funding allocated in the annual budget for ongoing structure upkeep.

When speaking with the Southwest division of MRWA, they acknowledged the risk of BRM supply shortages, which is why they have commenced a desktop review to identify potential BRM sources within the Southwest Region and beyond. This review is being conducted in collaboration with a consulting geologist, and all identified potential sources will require ground-truthing. So far, only minimal ground-truthing has been conducted. Preliminary findings indicate that of the 200 to 300 potential locations identified, material quantities at most sites differ from those shown on geological maps. Typically, ground truthing has suggested fewer potential sources than previously thought.

The work has identified two locations in the Southwest Region (around the Capel-Busselton and Dunsborough areas) that appear to have substantial quantities of fill, and approvals are currently being sought. One location is estimated to contain approximately 100 million tonnes of fill, along with an undetermined quantity of limestone. MRWA intends to make these resources available to local governments and regional agencies at the cost of extraction plus a levy for future rehabilitation.

MRWA also reported an approximate 40% cost increase across all areas of the industry, including BRM supply. The rates presented in Table 4.1, provided by MRWA, illustrate cost increases over the past seven years related to BRM production. Traditionally, BRM sourcing is based on a quarry's proximity to the project site, as fill material is generally considered a cost-effective means of achieving necessary levels without structural elements. However, as BRMs become scarcer, transportation costs make their use increasingly prohibitive. MRWA noted that transporting BRMs from more than 50 km away from a site can increase their cost by 25%, which is significant for civil works.

Table 4.1 7 Year Material Cost Comparison (MRWA (Southwest Region))

Materials	2017	2021	Present
Sand	$7.5 / tonne	$8.5 / tonne	$10-15 / tonne
Gravel	Not Provided	Not Provided	$20-25 / tonne
Hard Rock	$15 / tonne	$20 / tonne	$30-35 / tonne

Note: Values presented in the table are "out of the pit" costs therefore do not consider cartage.

One of the main issues identified by MRWA is competition with other industries. MRWA is not permitted to purchase directly from landowners and can only compensate them at a rate of $1.89 / m^3 for material, which includes costs associated with land rehabilitation. This restriction limits MRWA's ability to compete with private industries that do not face similar constraints. The following industries were identified as major consumers of fill within the Southwest Region:

- Residential and commercial developments.
- Lithium refineries.
- International companies (due to a global shortage of construction sand).

Those listed above are substantial consumers of fill. Moreover, these industries have significantly greater purchasing power than MRWA, as they are able to buy directly from landowners.

Suppliers

Suppliers have advised that, depending on the requirements for developing a quarry, the approval process can take three to six months for a site with no clearing required, and can experience significant delays when clearing is necessary. Several respondents mentioned facing delays of more than five years for Development Approvals (DAs) where clearing is required. Additionally, there is no set timeframe for the approval process, leaving suppliers uncertain about how long it may take or even if their application will ultimately be approved. This lack of predictability creates significant uncertainty for suppliers when lodging a DA or appealing an outcome.

It was suggested that the approval process could be streamlined, as approvals are currently required from LGAs, DEMIRS, and DWER for extractive industries. Due to the complexity of obtaining approvals, most suppliers hire consultants to prepare the necessary DA documentation. One supplier reported that the cost of engaging a consultant has increased by 1,000–3,000% over the past ten years. Additionally, Suppliers are required to pay for a rehabilitation bond, conduct annual third-party audits, and cover DEMIRS compliance costs, all of which have also risen substantially in recent years.

Further constraints on extractive industries include BFS, groundwater restrictions, neighbouring land use, future planning considerations, infrastructure, TEC, and native flora and fauna protections. Suppliers in the Southwest also cited other reasons why a resource may be rendered unusable, including inadequate road networks, contract agreements with landowners who are demanding higher royalties, and haulage costs, with cartage being identified as a major factor influencing costs.

All suppliers who responded identified a shortage of BRMs in the Southwest Region and noted a growing demand for materials due to large-scale infrastructure projects.

Contractors

Contractors who responded suggested that the entire industry is grappling with inflationary pressures, which are currently being exacerbated by large-scale infrastructure projects. One such project is the Bunbury Outer Ring Road, which is reported to have driven up both the demand for and cost of materials.

Contractors also cited conditions, processes, and timeframes imposed by LGAs and statutory authorities as challenging aspects under current contracts. Respondents provided information on the costs of BRMs, noting that sand typically costs $8–15 /tonne, gravel $20–26 /tonne, and limestone around $20 /tonne. However, no further details were provided regarding cartage distances or material specifications for these products when delivered to site.

One Contractor shared rates from two different Suppliers in the Southwest region; however, these rates only applied to BRMs used in civil works, not for coastal protection works.

4.3 Perth Metropolitan & Peel Regions

Figure 4.1 presents the locations of existing sand and rock sources in the Perth Metropolitan and Peel regions. Appendix C provides additional details on each lot or tenement, including their number, location, owner/operator, and resources. Additional details on each Lot or Tenement, including their number, location, owner / operator and resource is presented in Appendix D.

For more information on each resource, refer to the comprehensive database developed as part of Task 3.

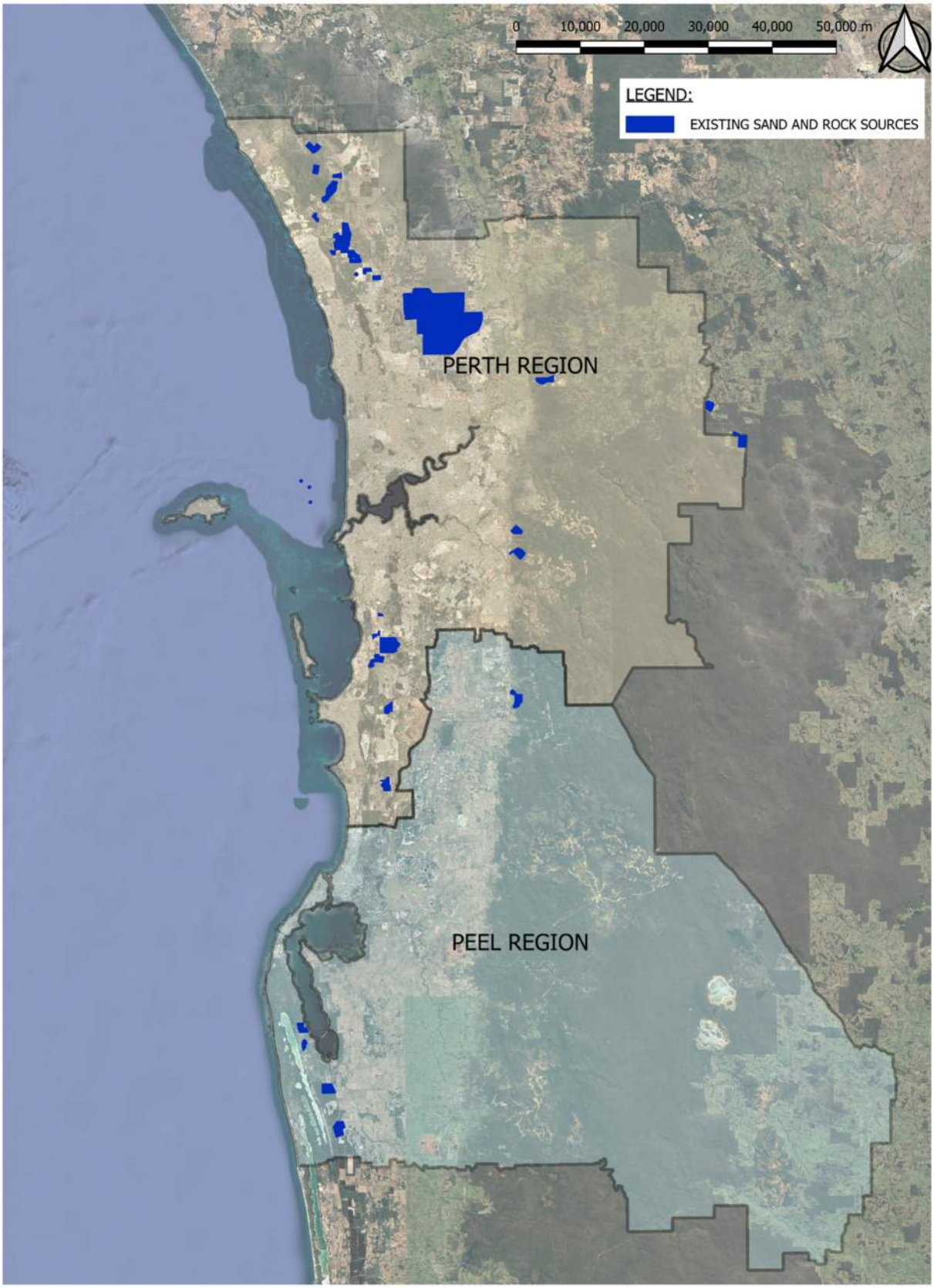

Figure 4.1 Locations of Existing Sand & Rock Sources(Additional Details Provided in Appendix D)

4.3.1 Managed Sources

Along with commercial supplies and lots and tenements identified for BRM, sand for coastal adaptation projects is also often sourced from sand traps and beach sources. These sources are not identified as resources, as they are managed by LGAs or Coastal Managers, typically for nourishment activities within their municipal boundaries. This exclusion does not imply that these sources are unimportant or that they do not provide a significant resource.

Table 4.2 provides information on identified beach sources within the Perth Metropolitan and Peel regions. The beach sources listed in the table only include locations which are subject to ongoing sand bypassing programs or plans, as they are a reliable source of sand for beach nourishment works. Other locations of significant accretion, such as Trigg Point and Two Rocks, have been used as a source of sand however not regularly enough to consider them as a reliable ongoing source.

Table 4.2 Beach Sources – Perth Metropolitan & Peel Regions

Location	Median Grain Size	Estimated Volume	Comments
Pyramids Beach	-	120,000 to 200,000 m^3/year	The responsibility of the beach is vested with the CoM. Sand is bypassed around Dawesville Cut to nourish the northern beaches (Avalon Beach, Falcon Beach, etc.).
Halls Head	-	100,000 to 200,000 m^3/year	The responsibility of the beach is vested with the CoM. Sand is bypassed around Mandurah Inet to nourish the northern beaches (Town Beach, Silver Sands Beach, etc.).
Tern Bank Sandbar	-	15,000 m^3/year (approx.)	The responsibility of the beach is vested with the CoR. Sand was used to renourish Apex Beach and Safety Bay however it was determined to be unsuitable due to its colour and is now disposed of.
Point Peron	0.3 mm	10,000 m^3/year	The responsibility of the beach is vested with the CoR. Sand is used to renourish Northern Warnbro Sound and Kwinana Beach.
Chelydra Beach	-	5,000 m^3/year (approx.)	The responsibility of the beach is vested with the CoC. Sand is primarily for bypassing to Coogee Beach.
Sorrento Beach	0.45 mm	10,000 m^3/year	The responsibility of the beach is vested with the CoJ. Sand is used to renourish the beaches north of Hillarys.

4.3.2 Case Studies

Case Study 4.1 – City of Joondalup Sand Bypassing Works

Sand bypassing has been completed by the City of Joondalup around Hillarys Boat Harbour since December 2018. The sand bypassing operations generally target around 10,000 m^3/year.

The work involves excavating scraping and excavating sand from the waterline, beach berm and backshore area to win the desired volume. To date, sand has only been harvested from the beach between Hillarys Boat Harbour and the northern most groyne at Sorrento.

Heavy plant is required to harvest and stockpile the material on Sorrento Beach, where it is then loaded and carted approximately 1.2 km to the northern side of Hillarys Boat Harbour. The sand is then deposited on the beach berm and back of the beach at Hillarys Beach Park using land based heavy plant. Plant and machinery access is relatively unconstrained at both the extraction and disposal sites.

Due to concerns around access, impacts on beach use and the local community, the sand bypassing activities around Hillarys Boat Harbour are required to occur at night. The works are completed by a tendered Contractor and managed internally by the City of Joondalup.

The City of Joondalup confirmed that the contract for the 2024 sand bypassing works has been finalised. The bypassing is scheduled to take place in November during typical work hours due to community pressure. The contract value is approximately $160,000 (ex GST) to bypass 10,000 m^3, equating to around $16 /$m^3$. The tender includes a schedule of rates, with an additional $9 /$m^3$ for any extra material bypassed.

The following aspects are considered to affect the cost of similar projects.

- The volume of the sand required to be bypassed / back passed.
- Access requirements at the excavation and disposal areas.
- Any constraints on excavation or placement areas or methodologies.
- The distance between where the excavation and disposal areas.
- Whether the work can be completed in / outside of typical working hours (eg nightworks).
- Management of beach use or restrictions.
- Completion and management of the works by internal or external resources.

Figure 4.2 City of Joondalup Sand Bypassing Works

Case Study 4.2 – Port Beach Sand Nourishment via Dredging

Sand nourishment via dredging at Port Beach was completed between July 2022 and March 2023, during which a total of 150,000 m³ of sand was dredged from Fremantle Port's Deepwater Channel and placed at the southern end of Sandtrax Beach via "rainbowing".

The work was completed through 24-hour operations or intermittently, depending on prior dredging arrangements. In total, 160 loads were extracted from Deepwater Channel over a period of 9 months. The overall cycle time (ie the time to dredge, sail to Port Beach, discharge, and sail back to the dredge area) throughout the campaign was approximately 3.3 hours. The average dredging and nourishment production rate over the entire campaign was approximately 286 m³ per operational hour. The distance from Port Beach to the dredge area is estimated to be approximately 9 km.

The hopper dredge, referred to as "Modi R," was used for the project. The machine has a draft of 3.8 m when fully loaded and can bottom dump or rainbow sediment. The draft can limit how close the vessel can approach the beach and thus affect the placement of sand via rainbowing.

The Modi R is equipped with a trailing suction hopper system, to extract sediment from the seafloor and stockpile it within the vessel's hopper for transport to the discharge location. The vessel is stated to be capable of dredging at depths of up to 28 m, with the possibility of extension. Once at the discharge location, the sediment is discharged as a slurry, rainbowed onto the beach and nearshore area.

The following aspects are considered relevant to affect the cost of similar projects.

- The volume of sediment to be dredged / placed.
- The proximity of the dredge area to the nourishment area.
- The required environmental approvals and any conditions of these approvals.
- The required dredge equipment.
- Any constraints on disposal or discharge of the sediment.
- Management of beach use or restrictions.
- Any additional land-based works to earthwork the placed material.

The works cost approximately $1.9M (ex GST) to dredge and place approximately 150,000 m^3, which equates to approximately $10-15 /m^3. The cost of the works at Port Beach are considered low due to several unique circumstances which may not occur for other projects.

Figure 4.3 Port Beach Sand Nourishment via Dredging Works

Case Study 4.3 – CY O'Connor Beach Renourishment

The City of Cockburn has conducted numerous historic renourishment activities for CY O'Connor Beach, located both north and south of Catherine Point. This case study focuses on the renourishment undertaken in November 2019, during which 15,000 m^3 of sand was placed on the southern side of Catherine Point at CY O'Connor Beach.

The work involved scraping and excavating sand from the waterline and beach berm area to obtain the desired volume. Sand was harvested from the sand trap at Chelydra Beach, which is typically used to facilitate sand bypassing around Port Coogee Marina to Coogee Beach, mitigating potential impacts of the marina development on coastal processes.

An excavator was used to harvest the material at Chelydra Beach, where it was directly loaded onto "Moxy" dump trucks and transported approximately 1.5 km along CY O'Connor Beach to the southern side of Catherine Point. The sand was then profiled on the beach berm and back of the beach using a front-end loader. Plant and machinery access was relatively unconstrained at both the extraction and disposal sites.

During the works, the entire stretch of foreshore between Catherine Point and Chelydra Beach was demarcated as a "construction site," with public access restricted. This allowed the works to be completed during typical working hours. The works were completed by a tendered Contractor and managed internally by the City of Cockburn.

The 2019 renourishment works cost approximately $105,000 (ex GST) to bypass 15,000 m^3 of sand, equating to approximately $7 /$m^3$.

Several factors can influence the cost of similar projects, including:

- Material quantities.
- Requirements for double handling of the material (ie transporting the sand via main roads).
- Any constraints on excavation or placement areas or methodologies.
- The distance between excavation and disposal areas.
- Whether the work can be completed during or outside of typical working hours (eg night works).
- Management of beach use or restrictions.
- Whether the works are completed and managed using internal or external resources.

Figure 4.4 CY O'Connor Beach Renourishment (City of Cockburn)

Case Study 4.4 – Ocean Reef Marine (ORM) Breakwater Construction

This project involved the removal of the existing breakwaters and the construction of two new breakwaters, with a combined length of approximately 2 km, requiring a total of 1.3 million tonnes of rock. Initially not included in the original project scope, the works later incorporated a variation that involved the placement of 500,000 m³ of fill, 70,000 tonnes of limestone for the construction of an internal revetment (approximately 1 km in length), and the dredging of 50,000 m^3 of seabed material.

The construction of the two breakwaters took place between April 2021 and July 2023, delivered under a lump sum contract valued at $62M (ex GST). The additional earthworks, revetment construction, and dredging, carried out as a variation, occurred between August 2022 and May 2024, with a value of $20M (ex GST).

Limestone was primarily sourced from DevelopmentWA's Neerabup Quarry and supplemented by 13 other sources. Granite was mainly obtained from WA Bluemetal's Byford Quarry, with additional supplies from 18 other quarries, including some as far away as Esperance. The extraction of limestone from DevelopmentWA's Neerabup Quarry was specifically requested as a Principal's Project Requirement. This was not only to create the design levels for the next stage of the Meridian Park industrial site (another DevelopmentWA initiative) but also because royalties were not required for material extraction, helping to reduce overall costs.

The project faced several constraints that affected its delivery, including stringent environmental approval conditions, maintaining unimpeded access to the boat ramps, sea sports club, and marine rescue facilities, and ensuring the continued use of the wastewater treatment facility.

Several factors can influence the cost of similar projects, including:

- Material characteristics and quantities.
- The distance between the quarries and the site.
- Royalty costs associated with the supply of BRMs.
- The required environmental approvals and any conditions associated with these approvals.
- Any constraints on excavation or placement areas or methodologies.
- Whether the work can be completed during or outside of typical working hours (eg night works).

The unit rates for limestone filter and armour rock were $62 /m³ and $50 /tonne, respectively. Granite armour rock was typically $97 /tonne for all classes (ie Class I (6.0 to 10.0t, 50% > 8.0t) to Class IV (1.0 to 3.0t, 50% > 2.0t)). The cost of the works at ORM is considered low due to several unique circumstances which may not occur in other projects.

Figure 4.5 Ocean Reef Marine (ORM) Breakwater Construction

Case Study 4.5 – Mersey Point Seawalls

The City of Rockingham constructed a 450-metre-long seawall along the foreshore fronting Arcadia Drive, between Mersey Point Jetty and Tern Island. The works were completed in three separate stages in 2021, 2022, and 2023.

The first two stages of the project were completed by Neo Civil, with the final stage undertaken by WA Limestone. The works involved removing and replacing the old limestone revetment, constructing a new beach access, and various landscaping works.

The project faced several challenges. Stage 1 included works within Heritage Place 22891 (Mersey Point Burial) and required the clearing of native vegetation. Strict enforcement of a Cultural Heritage Management Plan was necessary, with traditional owners and an archaeologist required to be present on site during all ground disturbing works. Additionally, vegetation clearing was kept to a minimum.

The site's proximity to a road and residential development necessitated a two-phase traffic management plan to ensure continued public access while allowing the supply of rock, sand, and other materials throughout the project.

Granite rock was used for the project, which was sourced from WA Bluemetal's Byford Quarry, located approximately 50 km from the site. The contract value of the project was approximately $2.8M. The project required 7,900 m^3 of sand / fill, 7,000 tonnes of core and 12,000 tonnes of armour, with an average unit rate of approximately $10 /$m^3$, $94 /tonne, and $104 /tonne respectively.

Several factors can influence the cost of similar projects, including:

- Material characteristics and quantities.
- The distance between the quarry and the site.
- Any constraints on excavation or placement areas or methodologies.
- Dewatering requirements of the project.
- The required heritage and environmental approvals and any conditions of these approvals.
- Whether the work can be completed during or outside of typical working hours (eg night works).
- Whether the works are completed and managed using internal or external resources.

Figure 4.6 Mersey Point Seawalls (Westpeak Engineering)

Case Study 4.6 – Port Beach Temporary Seawall

In March 2020, the City of Fremantle constructed a temporary seawall along the shoreline fronting Coast Restaurant at Port Beach. This project was unique because the seawall was designed with a 3-year lifespan, knowing that sand nourishment via dredging was planned for the Port Beach area soon.

The works generally involved the excavation of the beach and dune, construction of an approximately 110 m armour rock seawall, backfilling and reinstatement of the sand dune, creation of an access track, and clearing and rehabilitation. All aspects of the works were completed within the Contractor's allotted 24-day program.

The project was carried out by WA Limestone and managed internally by the City of Fremantle. The specified armour stone was limestone, sourced from WA Limestone's Millar Road Baldivis Quarry, located approximately 40 km from the site. The work area was demarcated for public safety throughout the duration of the project, which was completed during typical working hours.

The contract value in 2020 was approximately $290,000 (ex GST), with a total of 1,800 tonnes of armour rock used.

Several factors can influence the cost of similar projects, including:

- Material characteristics and quantities.
- The distance between the quarry and the site.
- Project specific contract requirements.
- Any constraints on excavation or placement areas or methodologies.
- Whether the work can be completed during or outside of typical working hours (eg night works).
- The management of beach use or restrictions.
- Whether the works are completed and managed using internal or external resources.

Figure 4.7 Port Beach Temporary Seawall

4.4 Southwest Regions

Figure 4.8 presents the locations of existing sand and rock sources in the Southwest Region. Appendix C provides additional details on each lot or tenement, including their number, location, owner/operator, and resources.

Additional details on each Lot or Tenement, including their number, location, owner / operator and resource is presented in Appendix D.

For more information on each resource, refer to the comprehensive database developed as part of Task 3.

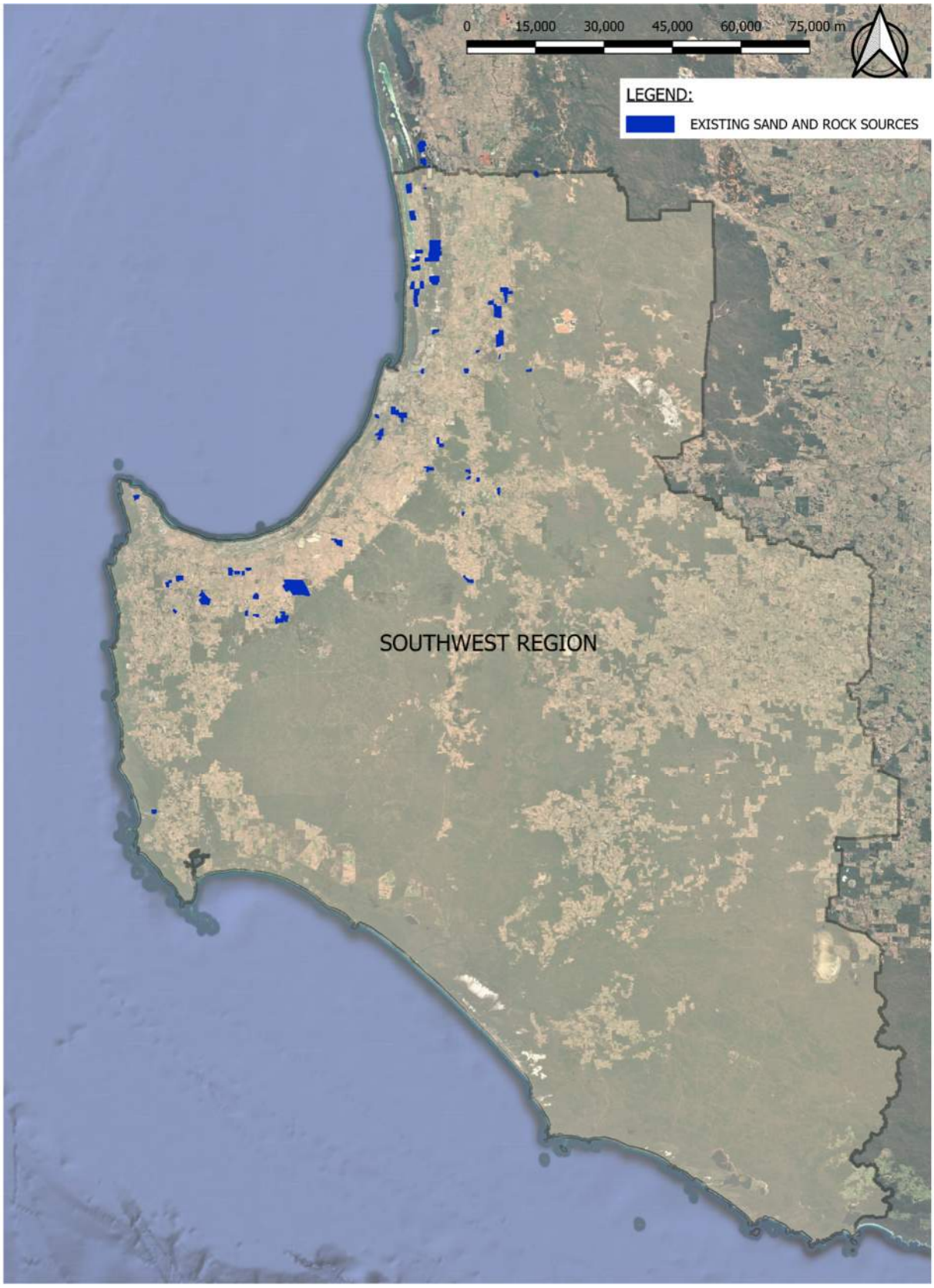

Figure 4.8 Locations of Existing Sand & Rock Sources (Additional Details Provided in Appendix D)

4.4.1 Managed Sources

As for the Perth Metropolitan and Peel regions, sand for coastal adaptation projects is often sourced from sand traps and beach sites. These sources are typically managed by LGAs or Coastal Managers, for nourishment activities within their municipal boundaries. While these sources are not classified as existing sand reserves, they remain significant and have therefore been included as beach sources.

Table 4.3 provides details of identified beach sources within the Southwest Region that are part of ongoing sand bypassing programs or plans. These sources are considered reliable for supporting beach nourishment works.

Table 4.3 Beach Sources – Southwest Region

Location	Median Grain Size	Estimated Volume	Comments
Bunbury Outer Harbour Sand Traps[1]	0.55 mm or 0.85 mm[1]	100,000 m^3	The responsibility of the sand traps is vested with Southern Ports Authority (SPA). Sand has previously been used to renourish Koombana Bay Beach (approximately 5,000 m^3 every 3-5 years).
Port Geographe Marina	-	20,000 - 40,000 m^3/year	The dredging of Port Geographe entrance channel is managed by DoT. Dredging is completed annually, and depending on the wrack content the spoil is disposed of either at Wonnerup Beach or offshore from Port Geographe Marina.
Quindalup Boat Ramps[2]	0.30 mm[2]	2,000 m^3/year	The responsibility of the beach is vested with the CoBus. Sand harvested from the Quindalup Boat Ramps has been used to renourish the wider Geographe Bay foreshore.
Dolphin Road Boat Ramp[2]	0.23 mm[2]	1,000 m^3/year	The responsibility of the beach is vested with the CoBus. Sand harvested from the Dolphin Road Boat Ramp has been used to renourish the wider Geographe Bay foreshore.

Notes:

1. Shore Coastal (2009) undertook a volumetric analysis and estimated there to be in the order of 65,000 m^3 and 35,000 m^3 at the Western spur groyne and in the Outer Harbour sand trap respectively.
2. Shore Coastal (2010) investigated sediment characteristics of potential borrowed sources within the Geographe Bay area.

4.4.2 Case Studies

Case Study 4.7 – Point Busaco Revetment

The Point Busaco revetment was constructed in 2015 to address ongoing erosion west of the Southern Port Authority's Inner Harbour. The project involved building a 230 m long rock revetment to protect Cristal's lease area and maintain pedestrian and emergency vehicular access along the existing track.

Italia Stone Group was the Contractor engaged to construct the revetment. The works were scheduled to occur between April and June 2015 and were delivered under a lump sum contract valued at $ 1.02M (ex GST). The scope of works included excavation of the existing slope, placement of geofabric, core and armour rock to form the revetment, and the installation of cement-stabilised limestone directly behind the crest of the structure. Provisional sums were included in the contract for the construction of a small spur groyne at the western extent of the revetment, as well as the supply and placement of beach fill.

Granite rock for the project was sourced from the Department of Transport's Roelands Quarry, operated by Italia Stone Group, located approximately 26 km from the site. The core material, consisting of basalt, was sourced from one of the two Gelorup aggregate quarries, situated 12 km south of the site. Sand fill was recovered from the Southern Ports Authority's sand traps, located on the western side of the Bunbury Port Outer Harbour breakwaters.

The project required 10,000 m³ of sand, 2,700 tonnes of core rock, and 5,500 tonnes of armour rock, with average unit rates of approximately $9 /m³, $31/tonne, and $79/tonne, respectively. Three rock classes were prescribed for the project:

- Toe rock: Mass between 0.85 and 1.5 tonnes.
- Armour rock: Mass between 0.4 and 1.2 tonnes.
- Core rock: Size between 150 and 500 mm in diameter.

As the project was located within "Security Regulated Port Land," workers were required to complete the relevant online inductions and obtain the necessary clearances.

Several factors can influence the cost of similar projects, including:

- Material characteristics and quantities.
- The distance between the quarries and the site.
- Access requirements at the site, including clearances.
- Royalty arrangements between government organisations.

Figure 4.9 Point Busaco Revetment

Case Study 4.8 – City of Busselton Beach Renourishment

The City of Busselton has undertaken numerous renourishment activities along the Geographe Bay foreshore to address beach erosion. Both capital and maintenance sand nourishment commitments are outlined in the City's Coastal Management Plan (2021–2031) (Shore Coastal, 2020).

The works are typically managed and executed by City employees. Borrowed materials for nourishment have been sourced from commercial pits and areas of sediment accumulation within the greater Busselton region. All sources have been evaluated for suitability based on sediment characteristics, overfill ratios, colour, distance from site, and available volumes. The following sources have been deemed appropriate for beach nourishment operations for the Geographe Bay foreshore:

- BCP Kaloorup: Located 15 km from Busselton's Central Business District (CBD).
- Dolphin Road Boat Ramps: Located 5 km from Busselton's CBD.
- Abbey Road Boat Ramp: Located 14 km from Busselton's CBD.

Within the City's Coastal Management Plan, an annual budget of $100,000 is allocated for 5,000 to 8,000 m³ of beach renourishment along the City's foreshore between 2021 and 2031. This equates to approximately $11–18/m³, factoring in a 10% allowance for project preliminaries.

Beach renourishment is typically funded through CAP grant funding. However, a review of DoT's CAP grant website indicates that the City's funding request for 2024/2025 was rejected. The reason for the 2024/2025 rejection is unknown.

The cost of similar projects can be influenced by several factors, including:

- Funding source (grant funding vs City's capital/maintenance budget).
- Management of beach use or restrictions.
- Availability of sediment from accumulation areas vs. commercial pits.
- Distance between excavation and disposal areas.
- Whether the works are completed and managed using internal or external resources.

Figure 4.10 City of Busselton Beach Renourishment

Case Study 4.8 – Geographe Bay Road Seawall

The City of Busselton completed the refurbishment of a rock seawall along Geographe Bay Road, spanning from Craig Street West to Earnshaw Road.

The scope of works involved the excavation and stockpiling of the existing rock revetment for reuse, alongside the construction of a 600 m long seawall. The project was delivered in two stages during 2021 and 2022. Stage one extended the seawall from Earnshaw Road to Craig Street Groyne located between Bower Road and Craig Street West, including the construction of beach access stairs at Bower Road. Stage two continued the revetment westward to Earnshaw Road and included the installation of additional access stairs. Both stages were undertaken by Leeuwin Civil under a lump sum contract valued at $1.5M.

The project encountered several challenges, particularly due to its proximity to a roadway and residential areas. This required the implementation of a comprehensive traffic management plan to maintain public access to houses and beaches while facilitating the delivery of rock, sand, and other materials throughout construction.

The project also reused the existing ironstone groyne as both underlying core and amour material while the final layer of armour rock was constructed from imported granite rock. The Contractor was also required to incorporate existing timber groynes and a stormwater outlet into the construction of the rock revetment.

Information could only be canvassed for the Stage 2 scope of work (ie 220 m section of wall). Stage 2 scope required 1,400 tonnes of laterite ironstone core, 2,000 tonnes of laterite ironstone armour and 2,000 tonnes of granite armour and cost approximately $574k.

Several factors can influence the cost of similar projects, including:

- The ability to reuse existing materials.
- Material characteristics and quantities.
- Incorporating existing assets and infrastructure into the works.
- Whether the work can be completed during or outside of typical working hours (eg night works).
- Whether the works are completed and managed using internal or external resources.

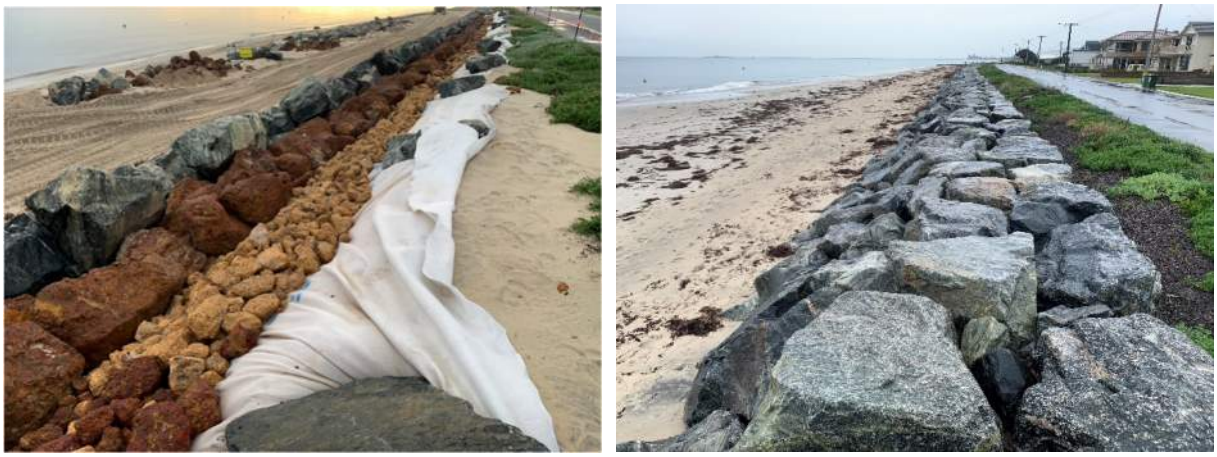

Figure 4.11 Geographe Bay Road Seawall

Case Study 4.9 – Gnarabup Beach Nourishment

This project was planned to be an annual sand nourishment operation at Gnarabup Beach in the Shire of Augusta Margaret River. The works was completed in 2021 and 2022 and was also scheduled to occur in 2024/25 period. However, the City did not secure funding through the Coastal Adaptation and Protection (CAP) program, nor were they able to fund the works themselves.

The works aimed to protect coastal infrastructure, including the Gnarabup boat ramp, associated carpark, and coastal walkway. Earth and Stone Contractors completed the 2021 and 2022 projects under a lump sum contract valued between $20,000 and $30,000, depending on the grant funding obtained through the CAP program.

The project involved the import and placement of 120–200 m³ of sediment sourced from Guthries Quarry in the City of Busselton. The quarry material was selected for its similarity in grain size and colour.

During one of the sand nourishment operations, scour protection measures were implemented. Geotextile Sand Containers (GSCs) and limestone rock were placed at the tie-in between the boat ramp and adjoining carpark to mitigate the risk of scouring.

Gnarabup Beach is located within Reserve 45145, and the adjacent ocean is part of the Capes Ngari Marine Park. As such, the works required approvals to proceed.

Sand for the project is sourced from Guthries Quarry, located approximately 40 km from the site. The project requires 150–200 m³ of sand annually.

Several factors can influence the cost of similar projects, including:

- Material characteristics.
- Preliminaries (ie mobilising, demobilising, insurances and construction plans) are likely to be disproportionate to the scope of the works given the minor sand nourishment quantities.
- The required approvals and any conditions associated with these approvals.

The reason why the 2024/25 CAP grant funding was rejected, was due to dissimilar sediment characteristics between the borrowed and native materials. It was determined that the finer material would likely lead to higher erosion rates and increased windblown issues.

Figure 4.12 Gnarabup Beach Nourishment (L) North (R) South

4.4.3 MRWA's Potential Terrestrial Sand & Rock Sources

The Southwest branch of MRWA has been dedicating significant time and resources to material studies within the Southwest Region. This effort stems from MRWA's projection that they will spend a total of $580 billion, in today's value, on materials for operational and capital projects to be delivered over the next 40-years. The investigation has primarily focused on identifying sand and soft rock (Ferricrete/Ironstone) suitable for use in their projects.

Figure 4.13 illustrates the locations of potential terrestrial sand and rock sources identified by MRWA. Appendix F provides further details on each potential source, including the type of material, location and whether, based on MRWA's initial investigations, the material is present and considered a viable Basic Raw Material (BRM) source.

From MRWA's initial desktop review, 184 potential terrestrial sources were identified:

- 124 were soft rock (Ferricrete/Ironstone);
- 42 were sand; and
- 18 remained undetermined.

MRWA conducted ground-truthing for 116 of these sources, with the following results:

- 97 were found to have no material potential;
- 13 were identified as having material potential;
- 6 were confirmed to have material present; and
- 68 are yet to be investigated.

In discussions with MRWA regarding their material study, they provided the following insights:

- For many sites identified during the desktop review, which involved collaboration with industry experts and the use of aerial imagery, geological maps, and other available information, the expected material was not present when ground-truthed, despite indications from the maps.
- Of the 13 sites identified as having material potential, two are considered of significant interest. MRWA is currently seeking approval to extract BRMs from these sites, located in the Capel-Busselton and Dunsborough areas.

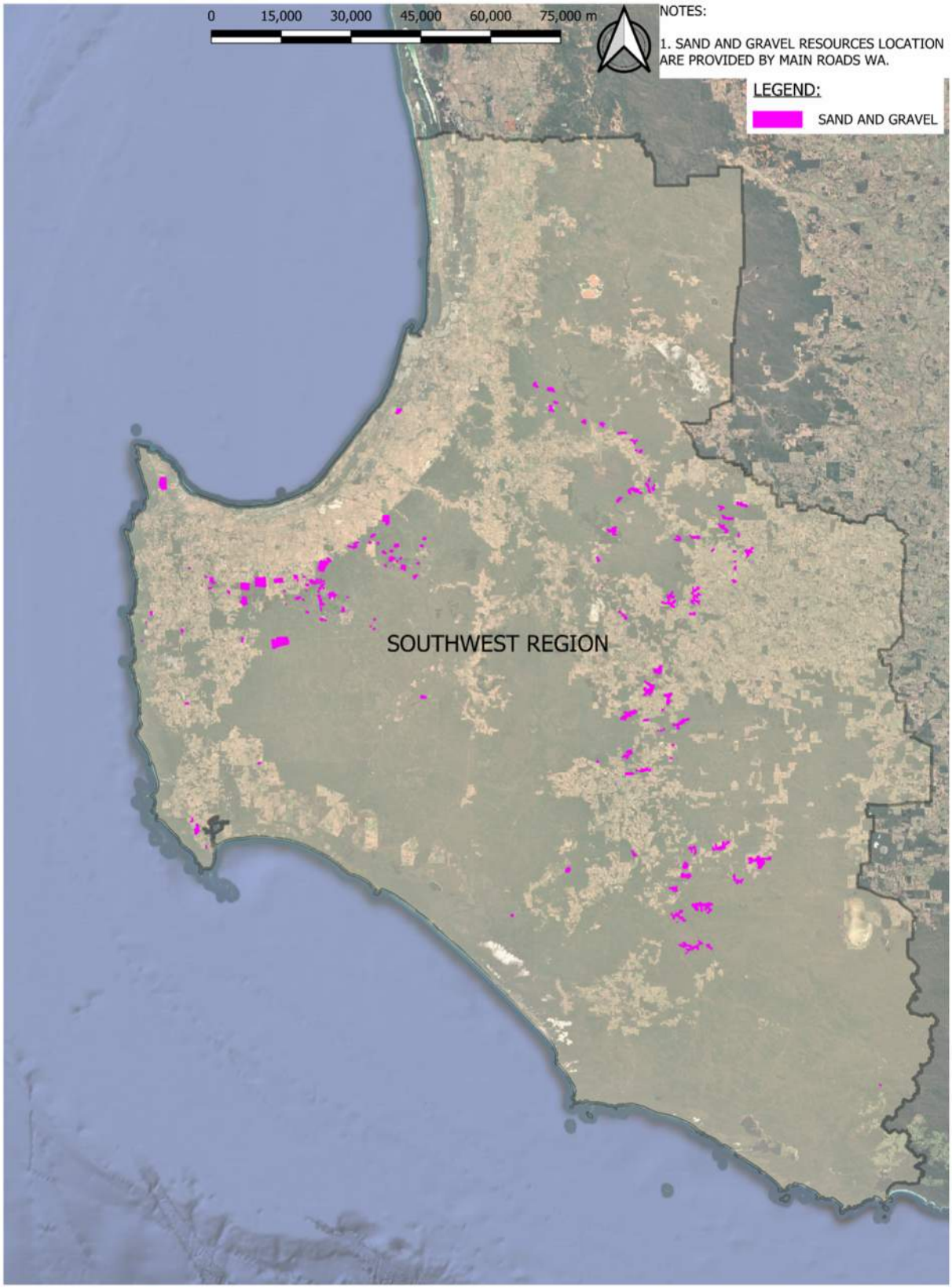

Figure 4.13 Location of MRWA's Potential Terrestrial Sand & Rock Sources (Additional Details Provided in Appendix F)

5. Task 4 – Potential Marine Sediment Sources

5.1 General

The intent of Task 4 is to identify potential marine sediment sources within WA and develop a comprehensive database. The database will include key information for each of the sediment sources, including:

- Site Details – Site name/location, region, water depth, distance offshore, estimated volume, site specific constraints and additional comments/recommendations.
- Material Characteristics – historic testing, if available.

The information has been canvassed from existing studies, navigational/nautical charts, bathymetric surveys, aerial imagery, benthic habitat data, marine parks and stakeholders.

5.2 Stakeholder Consultation

Consultation was undertaken with Local Government and Coastal Managers, Suppliers and Contractors within the relevant regions. The key items raised in context with the potential marine sediment sources are discussed below.

5.2.1 Perth Metropolitan & Peel Regions

Local Government & Coastal Managers

The CoW, with support from the NBA, has completed a Beach Renourishment Sand Source Feasibility Study (Cardno 2022) in which they investigated nearshore shoals and other known marine sediment sources (Deepwater, Success and Parmelia Channels).

Since the release of the report, the CoW has continued to investigate the identified nearshore shoals, however, have encountered the following issues:

- Dredging within the Marine Park – DBCA provided advice on the complexities of obtaining extraction approvals within marine parks. As a result of the consultations, the sites within the current and proposed extension of the Marmion Marine Park were excluded as potential sediment source options.
- Overestimation of Volume – Core samples (diver push cores) were taken for those sites outside the marine park boundary (ie Mindarie Offshore Shoal) and it was identified that the sediment was only 100-500 mm deep. Cardno (2022) previously estimated 1 m of sand could be dredged from this location, and as a result, the site is now believed to have 50 to 90% less sand than previously thought.

Suppliers

CCL has environmental approvals for the dredging of shellsands on the east side of Success and Parmelia Bank (Stage 1 – 2002-2014) and the west side of Success Bank (Stage 2 – 2015-2034). CCL noted that dredge spoil could be used as a potential sediment source given that they are only interested in sediments with a high calcium carbonate content (greater than 85%). CCL also advised that the dredge used for the extraction of shellsands has been used in other dredging projects within the Perth Metropolitan area (Port Beach Renourishment).

5.2.2 Southwest Region

For the Southwest Region, stakeholders did not provide any information regarding the availability or use of marine sediments for coastal adaptation projects. However, it is worth noting that Carter

(2012) investigated the subaqueous dunes and nearshore sandbars within Geographe Bay to assess whether these marine sediment sources significantly contribute sediment to the coastline.

Although the study did not focus on identifying potential marine sediment sources, it highlighted the following:

- Subaqueous dunes and sandbars rise up to 2 m above the seafloor.
- No specific differences in grain size or composition were observed between the subaqueous dunes and sandbars.
- Medium-grained carbonate material (0.25-0.5 mm) from nearshore sand formations serves as the primary sediment source feeding the beaches.
- Most quartz within Geographe Bay's subaqueous dunes and nearshore sandbars is not available for natural beach nourishment due to prevailing hydrodynamic conditions.

This suggests a potentially significant marine sediment source that is currently not actively contributing to the beaches of Geographe Bay. However, as the subaqueous dunes and sandbars are located within the Ngari Capes Marine Park, they have not been considered a viable sediment source.

5.3 Criteria for Identifying Potential Marine Sediment Sources

Criteria were developed by MRA for this study to assess potential marine sediment sources. The key features that were considered for assessing marine sediment sources are discussed below.

5.3.1 Extent of Search Area

WRL (2017) created a comprehensive guideline for sand nourishment in NSW, detailing the suitability and capabilities of different types of dredgers. Among the offshore dredgers reviewed, the maximum dredging depth is up to 100 m, with wave heights being the primary limitation for the equipment. All machines are limited to an operational wave height of less than 2 m, therefore sediment sources that are afforded some protection from fringe reefs or islands are expected to be more appropriate.

Given that the project is an assessment of materials within WA, the investigation of potential marine sediment sources will be limited to Coastal Waters (approximately 3 nautical miles from the Territorial Sea Baseline (TSB)). The TSB is typically defined as approximately the shoreline at low water. Coastal Waters range in depth from 0 to -50 m AHD. As outlined in Table 5.1, these water depths are achievable for most offshore dredging equipment.

Table 5.1 presents details and characteristics of potential dredgers which are possible. However, there is no guarantee these types of dredgers are available in Western Australia. Historically, the market for dredging works in Western Australia, particularly for reasonably small volumes, is extremely shallow. It is recommended specific consultation with potential dredging Contractors is undertaken early in any project.

Table 5.1 Suitability & Capability of the Different Types of Dredgers (WRL, 2017)

	Bucket Dredge	Grab Dredge	Backhoe Dredge	Suction Dredge	Cutter Dredge	Trailer Dredge	Hopper Dredge
Size	0.03 to 1.2 m^3 bucket	1 to 200 m^3 bucket	1 to 20 m^3 bucket				300 to 33,000 m^3 hopper
Dredging sandy materials	yes	yes	yes	yes	yes	yes	yes
Anchoring wires	yes	no	yes	no	yes	no	no
Max dredge depth (m)	30	>100	20	70	25	100	50
Accurate dredging	yes	no	yes	no	yes	no	no
Offshore dredging	no	yes	no	yes	no	yes	yes
Pipeline transport	no	no	no	yes	yes	no	no
Operating wave height				1 to 1.2 m	1 to 1.2 m	2 m	2 m

Waters within 500 m from the TSB (ie close to shore) were also excluded from the review of potential sediment sources given the following:

- Wave limitations – As detailed in Table 5.1, the dredgers are limited to an operational wave height of less than 2 m. Therefore, excluding areas within the wave breaking zone or areas where high seas are expected the majority of the time will ensure appropriate production rates when dredging.

- Environmental and Public Interface – Dredging nearshore is likely to be viewed unfavourably and likely, rightly or wrongly, to be linked by the public to any future coastal erosion in the area. This concern is valid, as extracting sediment will change the bathymetry, potentially altering the onshore supply or nearshore sea state. Investigations into such changes are typically carried out as part of the environmental approvals process.

- Dredge Plume – Based on the plume sketches from Port Beach sand nourishment works, it was reported that the turbid plume generated by the placement of sediment at Port Beach covered an area of approximately 1,000 m x 700 m and extended approximately 200 m offshore. Dredging at Deepwater Channel on the other hand, was localised to the dredge area however extended approximately 100 m outside the area. Therefore, all efforts should be taken to mitigate the likelihood of a turbid plume effecting the coastline.

The search for marine sediment sources in each region is limited to their municipal boundaries.

Table 5.2 Water Depths & Extent of Search Area

Regions	Water Depth[1] (mAHD)	Extent
Perth Metropolitan / Peel	-1 to -50	The search area encompasses the waters between 500 m seaward of TSB and the boundary of the Coastal Waters and extends from the southernmost point of the SoW to the northernmost point of the CoW.
Southwest	-2 to -20	The search area encompasses the waters between 500 m seaward of TSB and the boundary of the Coastal Waters and extends from the southernmost point of the SoH to the easternmost point of the SoM.

Note:
1. The range in water depth was estimated from available coastal bathymetry.

5.3.2 Habitat

Marine Parks

The general approach was to ensure all proposed sediment sources were located outside the marine parks and any proposed extensions to marine parks within the Coastal Waters. Consultation with DBCA noted that while licences can be sought for activities within certain management zones in marine parks, they are difficult to obtain. DBCA advised that the Proponent for such proposals would need to demonstrate they could not effectively complete the activities elsewhere, which does not seem appropriate for dredging activities. Therefore, as a first pass, all marine parks have been excluded entirely.

The marine parks listed in Table 5.3 were excluded from each region.

Table 5.3 Marine Parks

Regions	Marine Park Exclusions
Perth Metropolitan / Peel	Marmion Marine Park & Marmion Marine Park Extension
	Shoalwater Island Marine Park
Southwest	Ngari Capes Marine Park

Benthic Habitat

The general approach was to ensure that all proposed sediment sources did not affect known benthic communities. Benthic habitat data was sourced from Seamap Australia; an online repository for the collection of marine habitat datasets mapped following the Seamap Australia Classification Scheme.

Table 5.4 provides an overview of the review of benthic habitats for each region.

Table 5.4 Benthic Habitats Review

Regions	Benthic Habitat
Perth Metropolitan / Peel	Section 2.3.6 reviewed the benthic communities within the Perth Metropolitan and Peel regions. The review discovered a significant knowledge gap for this section of the coastline. Based on the available data, the following benthos are anticipated to be in the area: seagrass, hard and soft substrates, macroalgae, mixed macrophytes, and mixed biota. Most of the data was gathered before 2008. Given the transitional nature of the benthic communities and the limited data available, it is recommended that the seafloor habitats be mapped in detail to support each of the proposed sediment sources.
Southwest	Section 2.4.6 reviewed the benthic communities within the Southwest Region. The review highlighted a limited amount of information is available for the section of coastline located outside Ngari Capes Marine Park. Given this lack of data, it is recommended that detailed mapping of the seafloor habitats be undertaken to support the assessment and use of each proposed sediment source.

5.3.3 Geomorphology & Sedimentology

Table 5.5 provides an overview of geomorphology and sedimentology for each region.

Table 5.5 Geomorphology & Sedimentology Review

Regions	Geomorphology & Sedimentology
Perth Metropolitan / Peel	Section 2.3.7 reviewed the geomorphology and sedimentology within the Perth Metropolitan and Peel regions. The review discovered most of the seabed within State Water is “unconformity hardground wave rippled sand” with minor areas of shore parallel “algal hardground”. Unconformity hardground wave rippled sand is said to consist of a thin (<1 m) layer of wave rippled sand overlying Pleistocene limestone. The sediment within this area is either Quartz or Lithoskel Grainstones. The investigation into potential sediment sources will be limited to the unconformity hardground wave rippled sand where it is assumed that the shoals / banks can be dredged to an average depth of 1 m. It is recommended that geophysical surveys, sub-bottom surveys or sediment core sampling be undertaken to support each of the proposed sediment sources.
Southwest	Section 2.4.7 reviewed the geomorphology and sedimentology within the Southwest Region. For the area north of Cape Naturaliste, the geomorphology and sedimentology of the Rottnest province is detailed above. South of Cape Naturaliste, the seabed within State Waters lies on a narrow continental shelf primarily composed of coarse calcareous sands interspersed with local rhodolith beds. Shelf-edge sediments consist of fine to coarse-grained grey-yellow calcareous sands, containing 50-80% bryozoan fragments, planktic and benthic foraminifers, sponge spicules, and relict calcareous grains. Li et al. (2009) detailed that the inner shelf sediments are described as reworkable, with a thickness of 0 to 1 m, located at depths of 0 to 60 m. Therefore, similarly to the Perth Metropolitan and Peel regions, it is assumed that shoals / banks can be dredged to an average depth of 1 m. It is recommended that geophysical surveys, sub-bottom profiling, or sediment core sampling be conducted to confirm and support the suitability of each proposed sediment source.

5.4 Perth Metropolitan & Peel Regions

Figure 5.1 shows the location of potential marine sediment sources in the Perth Metropolitan and Peel regions. Appendix E provide additional details on each marine source, including their number, location, owner/operator, and resources.

For more information on each resource, please refer to the comprehensive database developed as part of Task 4.

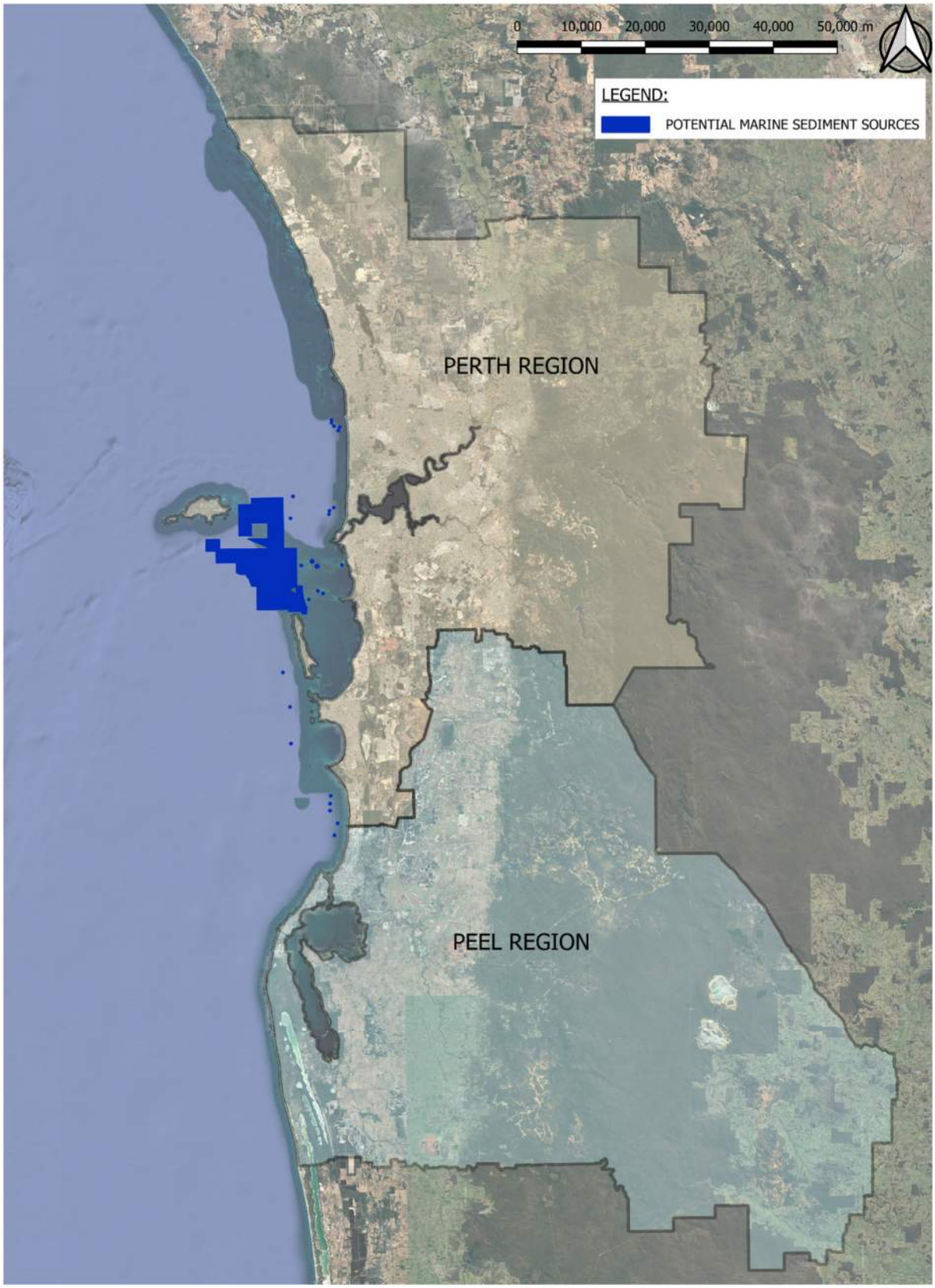

Figure 5.1 Locations of Potential Marine Sediment Sources (Additional Details Provided in Appendix E)

5.4.1 Potential Dredging Sourcing

Operational and maintenance dredging is required at several locations within the Perth Metropolitan and Peel Regions. Tables 5.6 and 5.7 outline the known dredging locations, providing details on the scope, constraints, environmental considerations, and required approvals. The information in the tables has been sourced from the *Department of Transport – Dredge Book 2021* (BMT, 2021) and other relevant sources.

It is recommended that this table not be relied upon solely to determine the necessary environmental considerations and approvals. Further inquiries should be made to confirm whether the potential dredging sources listed in the table are viable sources of sediment.

Table 5.6 Potential Dredging Sources – Perth Metropolitan & Peel Regions

Location	Frequency	Comments
Two Rocks Marina	Infrequent	The most recent dredging campaign was undertaken in 2021 and included dredging the entrance channel and inner marina areas, with an option to dredge the outer marina area as well. Dredge spoil was either disposed of on beaches north of the marina or redistributed through ploughing into deeper areas of the marina. Historical monitoring results identified elevated concentrations of tributyltin and copper. Additionally, the marina is situated within the Whadjuk Indigenous Land Use Agreement (ILUA) area, meaning that any potential impacts on Aboriginal heritage and cultural needs must be carefully considered. Sediment sampling has been conducted previously.
Ocean Reef Marina	Annually	The Ocean Reef Marina has undergone significant change over recent years; therefore, previous dredging requirements are no longer relevant. The redevelopment of Ocean Reef Marina has altered the scope of environmental considerations, necessitating a reassessment of requirements moving forward. This is guided by a targeted coastal monitoring and management plan.
Hillarys Boat Harbour	Never	No maintenance dredging has been conducted since the marina's construction.
Barrack Street Jetty	Infrequent	The last dredging campaign at Barrack Square was completed in 2016 and was associated with the Elizabeth Quay project. Material was dredged from the eastern side of Jetty 1 and to form a new berth for the Duyfken at the former Jetty 6. Sediment sampling associated with these works indicated the presence of asbestos, making the dredge spoil unsuitable for use as fill. As the dredging area is within the Swan and Canning Rivers, it is subject to approvals from the DBCA and the Swan River Trust, particularly regarding disposal requirements. Additionally, Barrack Square is located within the Whadjuk ILUA area, necessitating the consideration of potential impacts on Aboriginal heritage and cultural needs.

Table 5.7 Potential Dredging Sources – Perth Metropolitan & Peel Regions (Cont.)

Location	Frequency	Comments
Fremantle Ports' Inner Harbour	Infrequent	Maintenance dredging of Fremantle Ports' Inner Harbour is planned to occur between 2024-2029 to remove sediments that have accumulated since the capital dredging undertaken in 2010. The works will involve dredging approximately 80,000 m³ of sand from the Inner Harbour, with disposal at the Gage Road offshore disposal site. The works require Section 18 approval as the area is located within registered Aboriginal Heritage Sites. Additionally, consultation with the Whadjuk Aboriginal Corporation (WAC) and their Cultural Advice Committee was necessary for the project. Sediment sampling has also been conducted to support the works.
Fremantle Fishing Boat Harbour	Infrequent	The last dredging campaign at Fremantle Fishing Boat Harbour was carried out in 2018 and involved dredging the channels, with the material used for seabed levelling. The harbour is located within the Whadjuk ILUA area, requiring consideration of potential impacts on Aboriginal heritage and cultural needs. Sediment sampling has been conducted previously.
Sticks Channel	Never	No maintenance dredging has been undertaken since the site was originally dredged. Sediment sampling has been conducted previously.
Murray and Serpentine River Mouths	Infrequent	The last dredging campaign was conducted in 2021 and involved dredging the navigational channels within the deltas of the Murray and Serpentine Rivers. The dredged material was placed on Brindley Shoal. The works required a Native Vegetation Clearing Permit and a Licence to Dredge. The works is also located within a registered Aboriginal Heritage Site. The Murray and Serpentine River mouths are situated within the Gnaala Karla Booja ILUA area, necessitating consideration of potential impacts on Aboriginal heritage and cultural needs. Sediment sampling has been previously completed.
Point Grey Channel	Infrequent	The last dredging campaign was undertaken in 2018 and focused on dredging the northern and middle sections of the navigational channel. The dredged material was deposited further north within the Peel-Harvey Estuary. The works required a Native Vegetation Clearing Permit and a Licence to Dredge. The works is also located within a registered Aboriginal Heritage Site. The Point Grey channel lies within the Gnaala Karla Booja ILUA area, necessitating consideration of potential impacts on Aboriginal heritage and cultural needs. Sediment sampling has been previously completed.

5.5 Southwest Region

Figure 5.2 shows the location of potential marine sediment sources in the Southwest Region. Appendix E provide additional details on each marine source, including their number, location, owner/operator, and resources.

For more information on each resource, please refer to the comprehensive database developed as part of Task 4.

An investigation into potential marine sediment sources was conducted using information provided by DoT and freely accessible online resources. Within the Southwest Region, available data is limited to densely populated coastal areas, including the regions north of Cape Naturaliste, Margaret River, Augusta, and Nornalup Inlet. Consequently, significant knowledge gaps exist in assessing Coastal Waters for potential sediment sources.

Despite these gaps, available data has been utilised where possible to identify potential sediment sources. However, the following areas within the Southwest Region cannot be evaluated due to insufficient information:

- Waters between Cape Clairault and Gracetown.
- Waters between Gnarabup and Augusta.
- Waters between Augusta and Nornalup Inlet.

Figure 5.2 Locations of Potential Marine Sediment Sources (Additional Details Provided in Appendix E)

5.5.1 Potential Dredging Sources

Similarly to the Perth Metropolitan and Peel regions, operational and maintenance dredging is required at several locations within the Southwest Region. Table 5.8 outlines the known dredging locations, providing details on the scope, constraints, environmental considerations and required approvals.

This table should not be relied upon solely to determine the necessary environmental considerations and approvals. Further inquiries should be made to confirm whether the potential dredging sources listed in the table are viable sources of sediment.

Table 5.8 Potential Dredging Sources – Southwest Region

Location	Frequency	Comments
Casuarina Boat Harbour	Never	No maintenance dredging has been undertaken since the original capital dredging.
Collie River	Infrequent	The last dredging campaign was carried out in 2007, during which 17,000 m³ of material was removed from the navigation channel. The dredged spoil was deposited on the northern side of Bar Island. The works required a Licence to Dredge and is located within a registered Aboriginal Heritage Site. The Collie River lies within the Gnaala Karla Booja ILUA area, necessitating consideration of potential impacts on Aboriginal heritage and cultural needs. Sediment sampling has been previously completed.

6. Task 5 – Factors & Issues Affecting Supply

6.1 General

The intent of Task 5 is to summarise the approval pathway for material extraction and identify key factors and challenges influencing sand and rock supply in WA. This includes examining constraints that are expected to:

- Limit the production of sand and rock material.
- Restrict the expansion of existing sources.
- Hinder the development of new sources.
- Constrain the placement of material at coastal project sites.

This analysis aims to provide a clearer understanding of the regulatory, environmental, and logistical barriers affecting material availability for coastal adaptation projects.

6.2 Sourcing & Use of Basic Raw Materials

6.2.1 Use of Basic Raw Materials on Port Land & Private Property

Basic raw materials such as sand, limestone, and rock can be used within properties without specific approval if the construction is part of an approved development. This also applies to Port Land as defined under the *Port Authorities Act 1999*.

This means that materials such as rock or sand can be excavated from one part of a property and relocated or used elsewhere on the same site. However, on private property and mining tenements, approval is required for excavation or structural modifications.

6.2.2 Port Land – *Port Authorities Act 1999*

Port Authorities have broad discretion to extract and use materials on Port Land without requiring planning or mining approvals. However, environmental and other regulatory approvals may still apply.

For example, if there is sand, rock, or limestone on Port Land, it can be used for construction purposes. A historical example is the original quarry at Esperance Port, which supplied granite for its construction.

6.2.3 Sourcing Materials Offsite from a Port

When sourcing materials externally, the approval requirements depend on land tenure. Extraction of materials such as sand, hard rock, and limestone typically requires multiple approvals under various legislation, primarily the *Mining Act 1978* and the *Planning and Development Act 2005*.

Case Study 5.1 – Roelands & Esperance Quarries

Historical quarries such as Roelands and Esperance demonstrate how land tenure impacts material sourcing. While Roelands Quarry originally supplied Bunbury Port, increasing constraints have led to its near closure. Similarly, Esperance Port was constructed using onsite rock, but the quarry has since been sterilised due to land tenure and environmental considerations.

The consequence of these constraints is that rock for port construction must now be sourced from commercial operations at greater distances, increasing transport costs.

6.2.4 Extraction Approvals Based on Land Ownership

Crown Land – *Mining Act 1978*

The *Mining Act 1978* determines the ownership of BRMs, which dictates the necessary approval processes for extraction. The Act primarily applies to minerals, precious metals, and petroleum and specifically excludes BRMs such as sand, limestone, granite, and clay on private land. However, BRMs on Crown Land require approval under the *Mining Act 1978*.

A Mining Lease is required for extraction on Crown Land. This process involves several key steps:

- Prospecting Licence or Extractive Industry Licence – Required for initial site investigations.
- Mining Lease Application – Must be pegged under the *Mining Act 1978*.
- Mining Proposal – Mine Closure Plan – Required for environmental and regulatory compliance.

The approval process for a Mining Lease typically takes 6 to12 months and requires strict compliance with legislative requirements. Mining leases are issued with conditions and require annual reporting on compliance, closure and rehabilitation, mining activities, production, and expenditure.

If a BRM undergoes processing (eg silica sand refined into pure silica), it is classified as a mineral under the Act, regardless of whether it is on Crown or private land.

Mining tenements can only be granted on “available” Crown Land, meaning land without existing mining tenements. Maps of mining tenements are accessible on the Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) website via TENGRAPH or GeoVIEW.

Private Land – *Planning & Development Act 2005*

On private land, extraction is regulated by local authorities under town planning schemes. Unlike Crown Land, where approvals fall under the *Mining Act 1978*, private land extraction approvals are obtained through the local planning framework. The key approvals required include:

- Development Approval – Required for land development, typically issued for 10 to 20 years. DAs apply to the land and permit activities such as excavation and ancillary works.
- Extractive Industry Licence (EIL) – Most local authorities have an Extractive Industry Bylaw under the *Local Government Act 1995*. The EIL allows for material extraction, processing, and sale. It is usually issued for 1 to 5 years and requires ongoing compliance reporting.

Planning approvals typically take at least three months for small operations in rural areas. Larger projects, or those affecting environmentally sensitive areas, may require six months or more for approval.

Development Approvals – Planning and Development Act 2005

To extract BRMs, Planning Approval must be obtained under the *Planning and Development Act 2005* through the Local Authority, which regulates land use via Town Planning Schemes. A DA is required under these schemes.

In areas with State Regional Overlays, such as the Perth Metropolitan Region, Peel Region, and Bunbury Region, an additional layer of approval is required from the WAPC.

- In the Perth Metropolitan Area, Development Applications are assessed by the WAPC.
- In the Peel and Bunbury Regions, WAPC's determination is often delegated to the Local Authority.

The DA enables extraction activities, including excavation, processing, and associated operations. However, if no material is transported offsite, an EIL is not required.

Extractive Industry Licence

In addition to a DA, most Local Authorities require an EIL, issued under the *Local Government Act 1995* through an Extractive Industry Bylaw.

The EIL authorises:

- Extraction, processing, sale, and transport of materials offsite.
- Road maintenance requirements.
- Rehabilitation bonds.
- Other operational controls.

The EIL is typically issued for 1 to 5 years and requires annual fees and compliance reporting. It is generally applied for concurrently with the DA.

Some Local Authorities do not have an Extractive Industry Bylaw, and therefore do not issue an EIL.

Approval Process & Required Information

In most cases, DAs and EILs include similar conditions and require detailed information on:

- Nature, size, and operation of the proposed extraction.
- Environmental impacts (e.g., noise, dust, flora, fauna, land use, heritage).
- Transport routes.
- Closure and rehabilitation plans.
- Geological, hydrological, and landform studies.

This structured process ensures extraction activities are appropriately regulated and environmentally managed, while also addressing community and infrastructure impacts.

6.2.5 Conclusion

The approval pathway for material extraction varies significantly based on land tenure and applicable legislation.

- On Port Land, extraction does not require planning, development, or mining approvals but is subject to environmental and regulatory considerations.
- On Crown Land, extraction is governed by the *Mining Act 1978*, requiring a Mining Lease and associated compliance processes.
- On Private Land, extraction falls under the *Planning and Development Act 2005*, requiring DA and, in most cases, an EIL.

Understanding these distinctions is crucial for ensuring compliance and securing the necessary approvals for material extraction projects.

6.3 Additional Approvals

In addition to the primary approvals previously discussed, several other permits and licences are typically required for extractive industry operations in WA. The specific requirements can vary depending on the location, scale, and nature of the proposed activities. Key additional approvals may include those listed in Tables 6.1 to 6.3.

Table 6.4 lists other useful resources for extractive industry operations in WA.

Table 6.1 Additional Approvals

Relevant Legislation	Factor Regulated / Affected	Relevant Approval/Requirement & Status
Land Administration Act 1997	Land use for special purposes on Crown land.	Approvals may be required for specific purposes, and a lease under the Act can be provided through the Minister.
Mining Act 1978	Approvals to extract minerals on all land and basic raw materials on Crown land.	Mining proposals and / or Mining Development and Closure Proposals are required.
Planning and Development Act 2005	Development approval under the Local Planning Scheme or Region Scheme.	Required only for private land. SPP 2.4 - Planning for Basic Raw Materials is relevant for the protection and staged use of basic raw materials.
Native Title Act 1993	Native Title.	Native Title is extinguished on private land, but applies on Crown land unless extinguished or no claims exist. Approval to commence mining will not be issued until Native Title has been cleared or an agreement with traditional owners has been made.
Aboriginal Heritage Act 1972	Traditional owner heritage.	Heritage sites are listed under Section 15 of the *Aboriginal Heritage Act 1972*. Even in areas covered by the South-West Native Title Agreement, heritage database searches, field searches, considerations, or agreements may be required.
Heritage of Western Australia Act 2018	Identified heritage sites listed on DPLH databases.	Relates to non-traditional owner heritage considerations.
Environmental Protection Act 1986 – Part IV (Assessment)	Environmental factors that may be significantly impacted.	If a project is likely to cause significant environmental impact, it will be referred to the EPA and may be assessed formally under Part V of the *Environmental Protection Act 1986*.

Table 6.2 Additional Approvals (cont.)

Relevant Legislation	Factor Regulated / Affected	Relevant Approval/Requirement & Status
Environmental Protection Act 1986 – Part V (DWER Licence)	Licensing for screening and crushing plants.	If screening or crushing exceeds 5,000 tonnes per year, a DWER Licence is required.
Environmental Protection (Noise) Regulations 1997	Environmental noise.	All operations must comply with the Noise Regulations at both sensitive and non-sensitive premises at all times.
Environmental Protection (Clearing of Native Vegetation) Regulations 2004	Clearing and disturbance of native vegetation.	Where native vegetation is to be cleared, a Clearing Permit is required from DWER for planning approvals and through DEMIRS under delegated authority. Clearing of up to 10 hectares per year does not require a clearing permit if located in pastoral areas or non-environmentally sensitive areas and provided there are no significant species flora or fauna species or vegetation. Assessment and approval can be a minimum of 3 to 6 months.
Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)	Matters listed on the EPBC database.	Any matters listed under the Commonwealth EPBC Act 1999 will require referral to the Commonwealth if the proposal triggers a guideline referral statement. Assessment and approval can be very time-consuming, sometimes taking up to 12 months. Flora studies are only acceptable when completed in spring in the south of Western Australia, which can delay applications.
Contaminated Sites Act 2003	Contaminated materials that may arise from excavation or be used in excavation and processing.	Will only apply to pollution and non-natural materials or wastes.
Health Act 1911	Environmental and health impacts from wastewater treatment and community health.	Administered by the Local Authority.
Dangerous Goods Safety Act 2004	Potential for fuels or explosives to impact the environment.	Applies to fuelling and blasting.

Table 6.3 Additional Approvals (cont.)

Relevant Legislation	Factor Regulated / Affected	Relevant Approval/Requirement & Status
Road Traffic Act 1974	Regulates road use.	Transport along public roads, road upgrades, and maintenance may be triggered by the Road Traffic Act.
Rights in Water and Irrigation Act 1914	Water quality and management of water and licensing.	In many locations, the taking of water requires a licence.
Bushfires Act 1954	Fire protection.	The legislation may be triggered, and fire risks may need to be evaluated.
Work Health and Safety Act 2020 and WHS Regulations 2022	Provides for the operational safety of all mines and quarries and the health and safety of workers, whether on private land or mining leases.	All operations must be registered. Risk assessments and Safety Management Plans must be prepared, and staff must be suitably qualified.

Table 6.4 Other Resources Relevant to Extractive Industry Operations in Western Australia

Document	Relevant Approval/Requirement and Status
State Planning Policy 2.4 – Basic Raw Materials: Guidelines	Provides guidelines on the requirements for development applications for extraction.
Basic Raw Materials Policy 2.4 – Basic Raw Materials Policy 2023	Provides direction on the requirements for planning approval applications for quarries.
Department of Energy, Mines, Industry Regulation and Safety	Guidelines for Mining Proposals, Mine Closure Plans, and guidelines for preparing Mining Development and Closure Proposals for mining operations.
Department of Water, Environment Regulation – WPQN-15, Basic Raw Materials Extraction (2019)	WPQN-15 is a guideline, not a statutory requirement. It relates to general mining and water quality management and contains useful information.

6.4 Factors & Issues Affecting Supply

The supply of BRMs for coastal infrastructure projects is influenced by multiple factors. These issues are particularly significant in high-population and high-activity regions, including Perth Metropolitan, Peel and Southwest regions, coastal nodes such as Esperance, Geraldton and Albany, and high-development regions like the Pilbara.

Due to the pressing demand in the Perth Metropolitan, Peel and Southwest regions, this report examines supply issues in these regions in greater detail, although many of the same challenges apply to other areas.

6.4.1 Types of Resource

Geological materials vary significantly in their characteristics. Each development project requires specific geotechnical properties, but materials with the required specifications may not always be available at a given site.

Case Study 5.2 – Variability in Sand & Rock Types

There are several types of sand, including silica, calcareous and dredge sands, each with distinct geotechnical and compositional properties. The suitability of a particular sand type depends on the project's requirements, making it crucial to source materials that align with the specified criteria.

Similarly, different rock types such as granite, basalt and limestone have varying density, strength, and colour, which can influence their application in construction. Selecting the wrong material can affect durability, cost, and compliance with project specifications.

6.4.2 Quality of Resources

Each development requires materials with specific geotechnical properties. Even when the right geological material is available, it may not always meet the required density, strength, or durability. Typical requirements for coastal works were outlined in Section 3.

In some cases, alternative materials may need to be sourced, affecting project design and cost.

Case Study 5.3 – Sourcing Suitable Limestone & Granite

Tamala Limestone, which is widely used for coastal protection structures, is becoming more difficult to source at the required density and strength levels. As availability declines, alternative materials, such as granite, may be required. While granite provides similar strength, its different colour and limited supply may affect project feasibility.

In some regions, granite and gneiss formations share similar compositions, but gneiss may contain lines of weakness (gneissosity), reducing the size of extractable blocks. This can make it unsuitable for large-scale construction applications, such as breakwaters. Likewise, basalt, while extremely dense and strong, tends to have natural jointing that prevents the extraction of large blocks, limiting its use for specific applications.

Another challenge is presented by sandstone, which may meet the necessary density and block size requirements but is prone to weathering due to salt crystal expansion. This makes it unsuitable for marine environments, where materials are exposed to continuous wetting and drying cycles.

6.4.3 Distribution of Resources

Geological resources are not evenly distributed across the state. Even if a material is present in an area, transportation costs, time constraints and fossil fuel emissions may make it impractical to use.

Case Study 5.4 – Limited Availability of Key Resources

Bunbury Basalt is confined to a single deposit at Gelorup. Once this resource is depleted, it will no longer be available for construction projects.

A similar issue exists with Tamala Limestone, which has historically been the primary material for coastal protection, road construction and subdivision retaining walls in the south of the state. However, annual demand is in the order of 1 to 2 million tonnes and much of the remaining supply has been sterilised by urban development, conservation designations and environmental restrictions.

During the construction of Ocean Reef Marina, the demand for granite armour rock exceeded the available supply from metropolitan quarries, requiring the transportation of rock from over 200 km away.

In Broome, there is little suitable hard rock available for coastal works. While sandstone deposits exist 135 km east of Broome at Jowlaena, the nearest granite source is 370 km away, significantly increasing transport costs and environmental impacts.

6.4.4 Availability of Resources

Availability is influenced not only by geological distribution but also by regulatory approvals. Delays in obtaining necessary approvals can create uncertainty and hinder project timelines.

Case Study 5.5 – Regulatory Delays in Accessing Key Materials

Sourcing granite for coastal works in Albany and Esperance is difficult due to the limited number of approved quarries. Esperance has only one approved granite quarry, and if the material is unsuitable, securing approvals for a new site can take several years.

Similarly, the extraction of Tamala Limestone in Neerabup and Nowergup is limited to small, approved areas, while the remainder of the resource is located under native vegetation. Clearing permits for this resource are challenging to obtain, as they require State and Commonwealth approvals and must be paired with offset agreements. The approval process currently takes 2–3 years, delaying projects that depend on this material.

Any large-scale coastal development requiring Tamala Limestone rock could experience significant delays in securing approvals, leading to impacts on project planning, construction schedules and overall design feasibility.

6.5 Other Factors Affecting Coastal Infrastructure Projects

The sourcing and supply of BRMs are not the only factors that can impact coastal infrastructure projects. Other considerations, while indirectly related to BRM supply, can lead to significant cost escalations, sometimes to the extent that the Business Case no longer remains viable. This can result in project abandonment or postponement until sufficient funding can be secured. These challenges are particularly relevant to projects in the Perth Metropolitan, Peel, and Southwest regions, though many also apply to other areas.

Again, the examples detailed related to projects undertaken in the Perth / Peel and Bunbury regions.

6.5.1 Access Restrictions

To use BRMs in coastal infrastructure projects, the material must be transported from the extraction site to a designated laydown area before being utilised in construction. Site access restrictions can result in additional handling requirements, such as double or even triple handling of materials, or necessitate night works to comply with access limitations. These constraints inevitably drive-up capital costs and extend project timelines.

Case Study 5.6 – Site Access for the supply of BRMs

The Kwinana Freeway runs adjacent to the Swan and Canning Estuary between the Narrows Bridge in the north and the Mt Henry Bridge in the south. This area is known as the Kwinana Freeway Foreshore (KFF). This foreshore and the protection assets within it provide protection for critical infrastructure, including the Principal Shared Pathway (PSP), the Kwinana Freeway and other civil assets.

Due to the foreshore's significance, an annual maintenance program and capital works program, is regularly undertaken along the KFF. However, as access to the foreshore is limited to only a few locations and works must be carried out outside peak hours, projects in this area typically take longer and incur significantly higher costs than those in easily accessible locations.

Similarly, projects along Perth's coastline, between Hillarys Boat Harbour in the north and Trigg Point in the south, face similar challenges along West Coast Drive. In some cases, extensive traffic management has been required, including lane closures for access. Similar issues are common in heavily used or built up areas.

6.5.2 Principal's Project Requirements

The Principal's project requirements outline the necessary conditions and functions that a Contractor must deliver. These requirements may relate to construction methodology, project deliverables, management of impacts or business and technical specifications. Typically, they result in risks borne by the Contractor, which can lead to potential cost and time escalations.

Poor understanding of the full impacts of Project requirements on the works, construction methodologies and therefore total project costs can lead to significant cost escalations though the life of a project.

Case Study 5.7 – Principal's Project Requirements

Recent works along the Swan River foreshore, impacted a heavily used PSP and were adjacent to Mounts Bay Road. Initially, the City considered retaining access along the PSP while the works were completed, requiring Mounts Bay Road lane closure and increased Traffic Management. This was competitively costed by Tenderer's and shown to add approximately $1,000,000 to the cost of the project. This represented a 300% increase in the cost of the works compared to closing the PSP and diverting cyclists and pedestrians for the duration of the works.

Another example of how Principal's project requirements can impact costs is beach nourishment. While often undertaken to maintain social amenity rather than material performance, local communities frequently oppose the use of sand that differs in colour from the native beach material.

For instance, in the CoR, borrowed sand sourced from a nearby beach was placed on the beach as nourishment for coastal protection. However, community criticism regarding the physical properties, specifically its initial grey colour, led to the removal of all the placed material which was subsequently transported to landfill at increased cost.

Similarly, in the CoW, washed white sand is sourced from local quarries and placed on the foreshore to protect critical infrastructure. While washed sand typically has the same physical properties as unwashed sand, it is estimated to cost approximately ten times more to supply (ie $20 /tonne is lieu of $2–$4 /tonne) resulting in a significant increase to the cost of the works.

7. Task 6 – Recommendations

7.1 General

The purpose of Task 6 is to develop a set of recommendations based on MRA's review of BRMs suitable for coastal adaptation works within WA's coastal regions. These recommendations are expected to:

- Address the knowledge gaps.
- Address the barriers associated with increasing the supply of BMRs.
- Address the barriers associated with using alternative sources of material, including offshore sediment sources and alternative material types.

At this stage, the study has focused only on reviewing available information for the regions listed below, as well as statewide data expected to directly or indirectly relate to BRMs used in coastal infrastructure projects.

- Perth Metropolitan and Peel regions.
- Southwest region.

7.2 Recommendations to Address Knowledge Gaps

The review highlights the significant time and effort invested in developing a governing framework, supported by guidelines and resource mapping, to address the growing demand for BRMs in WA. As the state's population continues to rise, there is increasing demand from infrastructure and residential developments. This work is invaluable as it sheds light on key physical factors placing pressure on the extractive industry, such as the distance of BRMs from major development nodes, material quality, competing land uses, and environmental constraints.

Consultation with Local Governments and Coastal Managers, who are among the primary users of BRMs for coastal infrastructure projects, revealed that no formal consideration has been given to the quantity of material required for future works. Furthermore, there has been little assessment of whether the necessary materials are available near project sites. Under the current procurement approach, these responsibilities are delegated to Contractors.

On the other hand, Contractors and Suppliers, who are responsible for sourcing and delivering BRMs, are acutely aware of the industry's challenges and the inflationary pressures affecting supply. In some cases, land-use constraints have sterilised more than half of available resources. Some government organisations that rely heavily on BRMs for infrastructure projects have recognised resource limitations, particularly fill in the Southwest region and armour and core rock for the Westport project. These organisations have invested in resource studies to better understand and mitigate supply risks.

As detailed above, this study focused specifically on sand and rock used for coastal adaptation works but also highlighted broader challenges in the extractive industry, including the need to assess current and future BRM demand.

Given these challenges, a key recommendation is to undertake a comprehensive statewide assessment of the BRM industry. This assessment should involve collaboration between industry and government and consider all BRM applications across WA, including those used in

manufacturing (eg concrete, reconstituted limestone blocks and the like) and alternative or non-conforming materials.

The high-level project objectives should include:

- Development of a Live BRM Repository – Existing applications such as TENGRAPH and GeoVIEW provide information on mining tenement locations; however, they do not capture the full picture. Extractive industries also operate on private land under DAs or EILs. The repository should build on previous work, including this report, and include details for all extractive industry sites, covering site details (eg site name, tenement number, location, owner / operator, constraints) and material characteristics (eg material type, quantity, yield, production rate, cost, lifespan, historical testing).

- Development of a Live Repository for Alternative / Non-Conforming Materials – Similarly to how BRMs are proposed to be documented, alternative or nonconforming materials should also be catalogued. As constraints on BRMs increase, the importance of alternative materials will grow. While Task 2 of this report outlines several alternatives, further analysis is needed to assess their availability, quantity and characteristics.

- Quantification of Past and Future BRM Demand – Under current extractive industry reporting requirements, suppliers submit an Annual Environmental Report (AER) to DEMIRS, detailing site activity, extraction areas, environmental monitoring, incidents and future work programs. Much of the data needed to assess past and future BRM demand is likely provided to DEMIRS within these reports but is not readily accessible. To improve transparency and planning, an up-to-date, publicly available resource on BRM demand should be developed using information from AERs and industry consultation.

- Review of Regulatory Approvals and Reporting Processes – Task 5 highlights that approvals are governed by multiple regulatory frameworks, often resulting in conflicting conditions that make compliance difficult and unpredictable. Additionally, proponents must satisfy multiple regulatory reporting requirements that are often repetitive but formatted differently for each authority. A comprehensive review is needed to simplify and streamline approval and reporting processes.

This study should build on existing work to forecast material demand over key timeframes (eg 50 years from the present), identify regional supply shortfalls and enable targeted actions to address supply issues or manage demand. It is assumed that the assessment will generally follow the methodology of this report and be broken down into ten key regions.

Given the identified shortfalls in Tamala Limestone in the Perth Metropolitan and Peel regions and sand for fill in the Southwest region, a staged approach is recommended, prioritising these key regions before expanding to the rest of WA.

Based on the level of effort required for this study, which focused solely on sand and rock for coastal adaptation works, a comprehensive statewide assessment of the BRM industry is estimated to take five years to complete. The metropolitan regions (eg Perth Metropolitan, Peel, and the Southwest) are expected to require the most time due to the complexity of material supply and demand. MRA estimates the project's cost at approximately $1.5 million, based on the following assumptions:

- The development of a data storage system and associated resource mapping will be completed in-house rather than procured externally. The repository will be similar to the one developed for this study.

- Industry and government participation will be voluntary; therefore, no costs have been included for industry consultation.

In addition to the key recommendation of conducting a comprehensive statewide assessment of the BRM industry, the following recommendations are essential to bridge the knowledge gap until such work can be undertaken:

- Publish the Material Study (this report) and the supporting database to allow Local Governments and Coastal Managers to utilise them for future adaptation projects.

- Require LGA and Coastal Managers to consider information on the type, quantity, and material characteristics early in the design process and provide this information when applying for grant funding for coastal adaptation construction works. This will reduce the reliance on input from Local Governments and Coastal Managers, allowing the information to be sourced from an online repository instead.

7.3 Recommendations to Address Increasing the Supply of Basic Raw Materials (BRMs)

The following recommendations are considered essential to help increase the supply of BRMs. These have been presented as general recommendations as well as recommendations specifically related to environmental impacts, approvals required and legislative and governance.

7.3.1 General

Extend Mapping of Significant Geological Supplies to All Coastal Nodes & Regions

Current geological mapping is incomplete, leaving many potentially valuable resource locations unaccounted for in planning frameworks. Extending these efforts to all coastal nodes and regions will provide greater clarity on BRM availability, facilitating informed decision-making by industry and government stakeholders. This initiative will help identify and protect essential material sources while ensuring that future infrastructure and development projects have access to nearby, cost-effective supplies.

Review State Planning Policy 2.4 (SPP 2.4) "Exclusion" Areas

SPP 2.4 designates exclusion areas that restrict BRM extraction. However, some of these exclusions may no longer reflect the optimal balance between environmental protection and economic viability. Over time, certain materials have become nearly exhausted, while others remain inaccessible due to policy constraints. Given the evolving nature of resource availability and environmental considerations, a review of SPP 2.4 is warranted to reassess whether these exclusions continue to provide the best outcomes. Adjustments to the policy could help strike a fair balance between conservation and resource utilisation, particularly in areas where demand for materials has increased.

Release and Approve Tenements / Resources

The government should prioritise the release and approval of tenements and resources where BRMs have been identified as a *Significant Geological Supply* under *SPP 2.6*. For example, the Myalup Pine Plantations in the Southwest region have been designated as a “Significant Geological Supply” under SPP 2.4 but remain underutilised.

The situation at Myalup Pine Plantations is not unique and there are other cases where BRMs remain inaccessible due to government inaction in releasing and approving tenements and resources.

Review the Criteria for Listing a Significant Geological Supply

The current criteria for listing a "Significant Geological Supply" primarily focus on the volume of the resource, overlooking smaller but strategically valuable materials. For example, highly sought-after dense igneous rock, ideal for coastal construction, is not widely recognised under existing criteria.

In the Pilbara, such resources are available but lack formal recognition or protection, limiting their accessibility for marine infrastructure projects. A similar issue exists in Broome, where there is a shortage of hard rock. Nearby limestone marl, which could serve as a viable alternative, remains unrecognised despite its potential to reduce transport costs and environmental impact.

A review of the criteria is essential to ensure that smaller but highly valuable resources are adequately identified and safeguarded for future use.

Consider the Importance of BRMs When Nominating Conservation Areas

The designation of conservation areas often leads to the sterilisation of valuable BRMs, as resource extraction is generally prohibited once an area is earmarked for conservation. Unlike urban planning decisions, which consider material requirements, conservation nominations frequently overlook the potential long-term need for BRMs.

Once a site is proposed for conservation, decision-makers are often reluctant to approve any activity that contradicts the nomination, even when resource extraction could provide a better environmental and economic outcome. This approach has resulted in the near-total sterilisation of Tamala Limestone resources south of the Swan River and severely restricted access to similar deposits in the north.

To avoid unintended consequences, conservation planning should incorporate assessments of future BRM requirements, ensuring a balanced approach to resource management.

Consider Construction Materials at the Time of Development Approvals

Construction material requirements are often overlooked during the DA process, leading to supply shortages once construction begins. This issue was evident in the Ocean Reef Marina project, which depleted much of the available Tamala Limestone and granite armour rock from nearby quarries.

In southern Perth, the remaining supply of Tamala Limestone armour rock is now only sufficient for small-scale coastal projects. Additionally, many subdivisions in the Peel Region require large quantities of sand fill, but restrictions on extraction at Myalup Pine Plantations have left limited alternatives, forcing reliance on distant sources such as Gnangara and Myalup Pines.

Requiring the extraction of sand and limestone before land is developed could help mitigate these supply constraints, ensuring that developments are at least resource-neutral or even contribute positively to local BRM availability.

7.3.2 Environmental

Environmental approvals for BRM extraction are currently governed by multiple regulatory frameworks, including the *State Environmental Protection Act 1986*, the *Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act 1999*, and various local

government regulations. These overlapping requirements often result in inconsistencies, delays, and increased compliance costs.

In some cases, approvals from different authorities contain conflicting conditions, making compliance challenging and unpredictable. Additionally, the appeals process, managed by the Appeals Convenor and the Minister for the Environment, can be time-consuming and lacks consistency.

A more streamlined approach to environmental approvals, with clearer upfront certainty regarding accessible resources, would improve planning efficiency and enhance investment confidence.

7.3.3 Approvals

Accessing BRMs typically requires multiple approvals, including DA under LGA Town Planning Schemes, approvals under Region Schemes, and EIL or Mining Leases. These requirements can create unnecessary complexity, particularly when conflicting conditions arise between different levels of government. Delays in approval processes not only increase costs but can also lead to supply shortages that impact major infrastructure projects. Establishing a more consistent and predictable planning approval framework would reduce administrative burdens, improve certainty and facilitate timely access to BRMs.

7.3.4 Legislative & Governance

Amendment to the Current Mining Act (*Mining Act 1978)*

Under the current Mining Act, processing and manufacturing activities, such as concrete or asphalt production, are not permitted on a mining lease if the product is removed from the site. This restriction creates inefficiencies, as locating manufacturing facilities in nearby towns or coastal nodes is often unfeasible due to a lack of suitable industrial land. Offsite production increases costs, requires additional transport, and results in unnecessary double handling of materials.

Amending the Act to permit on-site manufacturing would improve operational efficiency, reduce costs and enhance supply chain resilience for construction and infrastructure projects.

Regulatory Reporting Requirements

The regulatory reporting requirements for BRM extraction are extensive and often repetitive, with multiple government agencies at state, local, and federal levels requiring separate reports in different formats. Key reporting obligations include:

- DWER Licences.
- Development Approvals (State and Local Government).
- Extractive Industries Licences (Local Government).
- Clearing Permits (State, Commonwealth, and Local Government).
- Mining Leases (State and Commonwealth Governments).
- Operational Licensing (State and Local Government).
- Greenhouse Gas Reporting (Commonwealth).

Each of these reports requires significant resources to prepare and maintain, creating inefficiencies and administrative burdens. Rationalising and standardising reporting requirements across agencies would significantly reduce duplication, save time and costs for industry operators, and improve overall regulatory compliance.

7.4 Recommendations to Address the use of Alternative Sources of Material

7.4.1 Potential Marine Sediment Sources

The review of potential marine sediment sources was conducted using available data from the regions listed above. This included existing studies, navigational and nautical charts, bathymetric surveys, aerial imagery, benthic habitat data, marine parks, and input from stakeholders.

For the Perth Metropolitan and Peel regions, most of this information was readily available and covered the entire study area, extending from the southernmost boundary of the SoW to the northernmost boundary of the CoW, capturing most of the Coastal Waters. However, data availability diminished significantly beyond the metropolitan area.

Similarly, in the Southwest Region, particularly beyond Cape Naturaliste, resources were so limited that reliable predictions of potential marine sediment sources could not be made. Notably, most of the Coastal Waters between Port Geographe and the southernmost extent of the SoH fall within the Ngari Capes Marine Park. As a result, identifying potential sediment sources was not required due to the expected limitations in obtaining a licence to extract sediment within a marine park under the *Conservation and Land Management Act 1984*.

The study also revealed a general lack of existing information on geomorphology and sedimentology across all regions. Of the publicly accessible data, the MARS database maintained by Geoscience Australia lacks quantitative data on sediment characteristics, and only a limited number of published reports detail surface sediments.

Based on this review, the following recommendations focus on potential marine sediment sources within the Perth Metropolitan and Peel regions, where available information is generally considered more reliable. For areas within the Southwest Region, where limited data currently hinders reliable predictions of potential marine sediment sources, expanding digital resources would be a prudent next step. This could involve conducting bathymetric surveys and aerial imagery analysis to support a more comprehensive assessment. While these recommendations are primarily tailored to the Perth Metropolitan and Peel regions, they may also be applicable to select metropolitan areas within the Southwest Region:

Geophysical Survey Coupled with Ground Truthing

Given the lack of quantitative data, further investigation should be undertaken at each site to determine the physical characteristics of the sediment. This should involve sediment sampling and a detailed review of existing published data.

More in-depth investigations should only be pursued if the initial review confirms the sediment as a viable source. Volume estimates have been derived using data from navigational and nautical charts, bathymetric surveys, and aerial imagery, assuming that shoals or banks could be dredged to an average depth of one metre. However, this is a preliminary assessment that, as outlined in Task 4 of CoW's *Sand Sourcing Feasibility Study*, may significantly overestimate the available sediment volume.

To refine these estimates and provide more accurate data, a geophysical survey coupled with ground truthing is recommended.

Viability of Dredging

Dredging for sand nourishment is increasingly being considered a cost-effective approach to foreshore maintenance. This follows the recent successful dredging campaign at Port Beach, which demonstrated that dredging could be up to 50% more cost-effective than trucking sand from terrestrial sources. However, the low unit cost of the Port Beach project was due to unique circumstances that may not apply elsewhere.

Therefore, an in-depth cost-benefit analysis should be undertaken to determine the distance from a project site at which dredging becomes more economically viable than trucking sand from terrestrial sources.

Environmental Approvals

Once a potential dredge site (or a shortlist of sites) has been identified, environmental approvals will generally be required, except in cases where existing approvals are already in place, such as for dredging at Deepwater Channel. While these factors are typically considered during the environmental approval process, the following aspects should be thoroughly investigated due to the reasons outlined below:

- Mapping of Benthic Habitats – The assessment of benthic habitats was conducted using available habitat mapping and aerial imagery. However, this data provides only a snapshot in time, while benthic communities, comprising marine flora and fauna, are typically transient. As such, a detailed seafloor habitat assessment should be conducted to support each proposed site.

- Onshore Sediment Effects – Research by Collins (1981, 1986, 1988) and Collins et al. (1999) indicates that rippled bedforms are present at depths of less than 60 metres, suggesting that sediment within these coastal waters remains active and is influenced by bottom currents. Therefore, before any dredging is undertaken, assessments should be undertaken to demonstrate that sediment removal would not create a deficit in onshore sand supply, potentially causing more harm than good.

- Coastal Processes and Hydrodynamics – An assessment should be conducted to determine whether dredging would alter metocean conditions or local hydrodynamics to the extent that the coastline becomes more exposed to wave energy.

7.4.2 Potential Dredging Sources

The study also identified several potential dredging sources within the Perth Metropolitan, Peel, and Southwest regions that undergo periodic maintenance to ensure the functionality of marine, port, and navigation channels. These dredging activities often involve the removal of large sediment volumes, with disposal sites typically located nearby.

Given the frequency of dredging at certain locations, it is recommended that appropriate testing be conducted on potential dredge sources near coastal hotspots or urban areas. This would allow dredged material to be assessed for suitability as beach nourishment, promoting its beneficial reuse where possible.

This could be achieved through spoil stockpiling or opportunistic renourishment, where maintenance or capital dredging scopes consider potential nourishment locations as disposal sites.

7.4.3 Alternative / Nonconforming Materials

Beyond the conventional materials used in coastal adaptation projects, there is a significant volume of alternative / nonconforming materials available near key development nodes in WA. However, these materials have not been widely considered for coastal projects or the broader construction industry, primarily due to a lack of necessity and the requirement for dispensations from standard technical specifications. As circumstances evolve, the consideration of alternative / nonconforming materials is likely to become necessary.

This shift is already evident in MRWA's efforts to explore the use of recycled and alternative materials for fill. These investigations have included technical reviews assessing the performance of such materials and the potential for blending them to meet MRWA's stringent road construction standards. Additionally, MRWA is in the process of developing and implementing a hard rock standard to facilitate the use of Granite or Basalt in areas where suitable soft rock, such as Tamala Limestone, is unavailable.

For sand used in beach nourishment, material selection is influenced not only by performance but also by appearance. The adoption of alternative or nonconforming materials will require stakeholder support, particularly from local communities. Given current trends, a shift in public perception regarding the aesthetic characteristics of beaches may be necessary, as alternative materials are often deemed unsuitable based on appearance alone. This may require extensive public information, consultation and education.

Similarly, in the Perth metropolitan region, Tamala Limestone remains the preferred material for coastal protection works due to its softer appearance compared to Granite. In many cases, such as along the Swan and Canning Rivers, approval authorities continue to mandate the use of Tamala Limestone, often requesting "biscuit rock," despite its near exhaustion.

Moving forward, the industry must work collectively to explore and adopt alternative and nonconforming materials where feasible, ensuring long-term sustainability in coastal adaptation and construction projects. To support this, the following recommendations have been made:

- Assess Suitability – Investigate the suitability of alternative and nonconforming materials and determine where they may be appropriately considered based on specific project requirements.
- Identify Key Locations – Conduct detailed investigations into where alternative and nonconforming materials are likely to be found around key development nodes, enabling their strategic consideration in future projects.
- Trial and Validate – Encourage pilot projects to test and validate the performance of alternative materials in real-world coastal environments.
- Develop Standards – Establish guidelines and standards that allow the use of nonconforming materials while still meeting the necessary design and performance requirements.

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9. Appendices

Appendix A **Knowledge Summary Review**

Appendix B **Stakeholder Engagement**

Appendix C **Extractive Industry Licence Sites (WAPC, 2012)**

Appendix D **Existing Sand & Rock Sources**

Appendix E **Potential Marine Sources**

Appendix F **MRWA's Potential Terrestrial Sand & Rock Sources**

Appendix A Knowledge Summary Review

K2108, Department of Transport (DoT) - Materials Study Sand & Rock Supply
Knowledge Summary

Region	Material Type	Year	Title	Relevance	Keywords	Summary/Comments
Perth Metro/Peel	Sand	2005	Physical characteristics of Perth Beaches, WA	High	Sediment composition, Sediment Transport, Beach Planform, Sediment Cells, Beach Sampling	Relevant however the report was prepared in 2009 for Perth beaches within the tertiary sediment cell (subject to seasonal variation). Information pertaining to Sediment characteristics (beach slope, beach type, breaker height, etc) are likely to vary therefore likely require review.
Perth Metro/Peel	Sand	2007	Sediment Cells along the Perth Metropolitan Coast	Medium	Sediment cells, Sediment Transport, Beach Planform, Planning consideration	Review of sediment cells within the Perth Metro area. Method to determine boundaries of sediment cells. Highlight planning considerations for
Perth Metro/Peel	Sand	2015	Coastal Sediment Cells for the Vlamingh Coast	Medium	Sediment cells, Sediment Database	Discussion on sediment dynamics for the Perth, peel and southwest coast. Criteria for determining sediment cells. KML database available
Perth Metro/Peel	Sand	2018	Ocean Reef Boat Harbour 2018 SAP Implementation Report	Low	Sediment Analysis, Sampling, Grain size, Site Specific	Sediment analysis was completed in prior to the construction of the breakwater. Sediment was collected within the marina prior to dredging. The report provides particle size distribution
Perth Metro/Peel	Sand	2013	Two Rocks Coastal Geomorphology Assessment	Medium	Site Specific, Metocean Conditions, Morphology, Sampling, Grain size	The report is for the Two Rocks Marina only to review the wrack accumulation and beach erosion of the south north side of the marina respectively. Loss of 14,000 m3/year which equates to 1.2m/year of shoreline recession on northside. Accretion of 13.000 m3/year southside..
Perth Metro/Peel	Sand	2016	Two Rocks Marina – Sediment Data Summary Report	Low	Sediment Analysis, Sampling, Grain size, Site Specific	Sediment was collected within the marina and surrounding beach's. The report provides particle size distribution
Perth Metro/Peel	Sand	2022	Beach Renourishment Sand Source Feasibility Study	High	Feasibility Assessment, Beach Nourishment, Target Grain Size, Quantities, Specifications	Recent investigation into the sand source for the Wanneroo area. Desktop review on sand nourishment sources, methods and approval requirements. Good source for information on guidelines, case studies, relevant literature. Report outline dredging operations in WA and Australia. Highlights current specifications and PSD within LGA.
Perth Metro/Peel	Sand	2013	Quinn's sediment analysis	Low	Sediment Analysis, Sampling, Grain size, Site Specific	Sediment was collected on Quinns Beach. The report provides particle size distribution
Perth Metro/Peel	Sand	2016	Joondalup Coastal Hazard Assessment	Low	Coastal Hazard Assessment	includes grain size information
Perth Metro/Peel	Sand	2020	Joondalup Coastal Monitoring 2019-2020	Low	Bypassing	Includes survey analysis and discussion on Hillary's bypassing. Discusses recent bypassing quantities.
Perth Metro/Peel	Sand	2010	Rottnest sediment PSDs	Low	Grain size	Sampling reports
Perth Metro/Peel	Sand	2019	Port Beach Coastal Adaptation Options	High	Coastal Hazard Assessment, Site Specific	Includes grain size information and estimated storm erosion. The report at a high level also explores the pros and cons of beach nourishment and sand nourishment sources.
Perth Metro/Peel	Sand	2020	Port Beach Adaptation Data Gathering and Site Visit	High	Sediment Analysis, Sampling, Grain size, Site Specific	Report is current and includes sampling at the following locations Port Beach, South Cottesloe, North Leighton, and offshore within Success, Parmelia and Deepwater Channels. The report assesses overfill ratios, aesthetics and environmental of the native and borrow material.
Perth Metro/Peel	Sand	2020	Port Beach Sand Nourishment via Dredging – Sediment Sampling and Analysis Plan and Implementation Report	High	Sediment Analysis, Sampling, Grain size, Site Specific	Sediment was collected within the Deepwater, Success and Parmelia Channels. The report provides particle size distribution.
Perth Metro/Peel	Sand	2021	Port Beach Sand Nourishment via Dredging – Sediment Colour Investigation	High	Sediment Analysis, Sampling, Grain size, Site Specific	Sediment was collected within the Deepwater, Success and Parmelia Channels. The report provides physical sediment characteristics (visual and odour characteristics).
Perth Metro/Peel	Sand	2021	Port Beach Detailed Design Report	High	Design Report, Beach Nourishment,	The report outlines the nourishment volumes required at port beach. It is noted that the long term coastal adaptation option is managed retreat however interim protection strategy is beach nourishment.
Perth Metro/Peel	Sand	2021	Port Beach Sand Nourishment via Dredging – Environmental Review Document	High	Environmental Considerations, Site Specific, Legislative Requirements, Environmental Protection Authority	Environmental Review Document designed to investigate environmental impacts associated with the dredging and beach nourishment operations. Insightful document as it is the environmental requirements for marine sand source.
Perth Metro/Peel	Sand	2022	Port Beach Sand Nourishment via Dredge EPA decision notice	Low	EPA Notice	EPA approval.
Perth Metro/Peel	Sand	2022	Port Beach Sand Nourishment EPA Public Advice	Low	EPA Notice	EPA community letter.
Perth Metro/Peel	Sand	2000	Long-Term Shell sand Dredging Owen Anchorage, Environmental Review and Management Programme	High	Environmental Considerations, Site Specific, Legislative Requirements, Environmental Protection Authority	Environmental management plans to support environmental management
Perth Metro/Peel	Sand	2001	Long-term shell sand dredging, Owen Anchorage	High	Environmental Considerations, Site Specific, Legislative Requirements, Environmental Protection Authority	Report and recommendations of EPA
Perth Metro/Peel	Sand	2002	Long-term shell sand dredging, Owen Anchorage	High	Environmental Considerations, Site Specific, Legislative Requirements, Environmental Protection Authority	Proponent conditions
Perth Metro/Peel	Sand	2017	Long-Term Shell sand Dredging Owen Anchorage Dredging and Environmental Management Plan—Stage 2 West Success Bank	High	Environmental Considerations, Site Specific, Legislative Requirements, Environmental Protection Authority	Dredging environmental management plan in response to EPA conditions
Perth Metro/Peel	Sand	2005	The Geomorphology and Sediments of Cockburn Sound	High	Sediment Analysis, Sampling, Grain size, Site Specific	Sampling was collected within the Cockburn Sound. Although the data was collected in 2005 it is within the Secondary/Primary cell boundary and therefore is more likely to be similar to current conditions. The review included grain size, calcium carbonate content, colour, texture and composition.
Perth Metro/Peel	Sand	2018	City of Rockingham, Coastal Hazard Risk Management and Adaptation Plan - Technical Assessment	Low	Coastal Hazard Risk Management and Adaptation Plan	Discussed further in the CHRMAPs tab.
Perth Metro/Peel	Sand	1987	Dawesville Channel Coastal Engineering Studies - Appendices C & D Volume 2	Low	Sediment Analysis, Sampling, Grain size, Site Specific	Relevant however the report was prepared in 1987 for Dawesville Channel within the tertiary sediment cell (subject to seasonal variation). Includes study - sediment sources, transport paths and sinks of the inner Rottnest shelf between Bunbury and Rockingham
Perth Metro/Peel	Sand	2007	Mandurah PSDs	Low	Grain size	Sampling reports
Perth Metro/Peel	Sand	2014	Mandurah Sediment Data Report Rev 0	Medium	Sediment Analysis, Sampling, Grain size, Site Specific	Relevant however the report was prepared in 2014 for Pyramids Beach sand trap within the tertiary sediment cell (subject to seasonal variation). Provides and analysis on contaminants and partial size.
Perth Metro/Peel	Sand	2021	Mandurah site specific scope and drawings	Low	Dredging, Technical Specification	Dredging Technical specification
Perth Metro/Peel	Sand	2021	Mandurah Northern Beaches CHRMAP Coastal Hazard Assessment (CHA)	Low	Coastal Hazard Assessment	Discussed further in the CHRMAPs tab.
Perth Metro/Peel	Sand	2013	Dawesville Sediment Data Report Rev 0	Medium	Sediment Analysis, Sampling, Grain size, Site Specific	Relevant however the report was prepared in 2014 for Halls Head sand trap within the tertiary sediment cell (subject to seasonal variation). Provides and analysis on contaminants and partial size.
Perth Metro/Peel	Sand	2021	Dawesville site specific scope and drawings	Low	Dredging, Technical Specification	Dredging Technical specification
Statewide	Sand	2021	Indicative dredging sites excel sheet	Medium	Dredging Campaigns, WA Sites	Living repository of dredge campaigns. Most recent entry relates to 2021. Provides indicative dredge volumes and the method by which the dredging is undertaken.
Statewide	Sand	2021	Department of Transport - Dredge Book 2021	Medium	Dredging Campaigns, WA Sites, Environmental Considerations, Approvals	High level report on dredging campaigns in WA for DoT. The document reports on location, contact, dredge method, frequency, dredge and disposal area, environmental considerations, etc.
Other	Sand	2010	Beach Sand Nourishment Scoping Study, Maintaining Sydney's Beach Amenity Against Climate Change Sea Level Rise	High	Sand Nourishment	The report is design for sand nourishment for Sydney beach utilising suitable offshore sand deposits. Provides insight on dredging campaigns overseas and interstate. Review of the compatibility of terrestrial and marine sand sources. The report includes case studies and approval process. Worth referring for dredging requirements.
Other	Sand	2013	Potentially Useful Beach Nourishment and Associated Studies/Projects – References	Medium	Sand Nourishment References	Sand Nourishment Forum – Sand Nourishment Reference list. Inclusive of WA projects.
Other	Rock & Sand	2016	Extractive Resources in Victoria: Demand and Supply Study 2015-2050	High	Basic raw materials	Supply, demand and issues analysis of extractive resources in Victoria. Worth referring to for structure of report, methods of reporting, etc.
Other	Sand	2017	Guidelines for Sand Nourishment Science and Synthesis for NSW	High	Sand Nourishment	The report provides an overview of the main considerations for beach nourishment projects in NSW. Discusses dredging options and limitations, costing, etc. Worth referring to for sand requirements.
Other	Sand		Marine Sediments Database	High	Marine Sediments ,Resource	Geoscience Australia: Marine Sediments (MARS) Database (ga.gov.au)
Perth Metro/Peel	Rock	2009	Perth Metropolitan Region Coastal Protection Structures Field Inspections & Condition Assessments	Medium	Coastal Protection Assessment, Maintenance	Coastal protection assessment for structures from Mandurah to Quinns Rocks. Included seawalls, groynes, headlands and other coastal protection structures. The report assessed the condition and function of the structures. The report also list repair priorities of structures along coast.
Perth Metro/Peel	Rock & Sand	2015	Perth and Peel @ 3.5 million Environmental impacts, risks and remedies - Interim strategic advice of the Environmental Protection Authority	High	Basic Raw Materials, Planning Requirements	High level report around basic raw materials and potential future planning requirements. Outlines the EPA's recommendation for the extraction of raw materials. Recommendation 25 to 28 have been made to the State Government regarding clearing, interagency master planning, sustainability and policy and regulatory regime for basic raw materials.
Perth Metro/Peel	Rock	2019	Millar Rd Limestone Armour rock test results	Low	Rock Analysis, Testing, Site specific	Limestone. Baldivis Quarry test results. Surface Saturated Dry (SSD) Density.
Perth Metro/Peel	Rock	2021	Letter re limestone supply for Ocean Reef Marina	Low	Certificate, Site specific	Dieback Free Certificate
Perth Metro/Peel	Rock	2021	Letter re bluemetal supply for Ocean Reef Marina	Low	Certificate, Site specific	Dieback Free Certificate
Perth Metro/Peel	Rock	2021	Doodlakine Quarry - Compliance Reports of Granite Armour Rock	Low	Rock Analysis, Testing, Site Specific	Doodlakine Quarry test results. Surface Saturated Dry (SSD) Density. Granite.

Perth Metro/Peel	Rock	2021	Dowerin Quarry - Compliance Reports of Granite Armour Rock	Low	Rock Analysis, Testing, Site Specific	Dowerin Quarry test results. Surface Saturated Dry (SSD) Density. Granite.
Perth Metro/Peel	Rock	2021	Morawa Quarry - Compliance Reports of Granite Armour Rock	Low	Rock Analysis, Testing, Site Specific	Morawa Quarry test results. Surface Saturated Dry (SSD) Density. Granite.
Perth Metro/Peel	Rock	2021	Narrogin Castle Quarry - Compliance Reports of Granite Armour Rock	Low	Rock Analysis, Testing, Site Specific	Narrogin Castle Quarry test results. Surface Saturated Dry (SSD) Density. Granite.
Perth Metro/Peel	Rock	2021	Voyager Quarry - Compliance Reports of Granite Armour Rock	Low	Rock Analysis, Testing, Site Specific	Voyager Quarry test results. Surface Saturated Dry (SSD) Density. Granite.
Perth Metro/Peel	Rock	2021	Watheroo Quarry - Compliance Reports of Granite Armour Rock	Low	Rock Analysis, Testing, Site Specific	Watheroo Quarry test results. Surface Saturated Dry (SSD) Density. Granite.
Perth Metro/Peel	Rock	2017	Two Rocks Boat Harbour - Preliminary Breakwater Design	Medium	Design Report, Site Specific	Concept design for Two Rocks Boat Harbour. In-depth review of the its current condition and the proposed works. Rock requirements determined based on design conditions for both granite and limestone.
Perth Metro/Peel	Rock	2017	Quinn's Beach - Detailed Design Report Stage 3	Medium	Design Report, Site Specific	Design report for Quinns Beach. In-depth review of the its current condition and the proposed works. Rock requirements determined based on design conditions for limestone.
Perth Metro/Peel	Rock	2018	Quinn's Beach - Stage 3 Design Drawings	Low	Design Drawings, Volumes, Site Specific	Design drawings for Quinns Beach.
Perth Metro/Peel	Rock	2021	South Thomson Bay Seawall Design Report	Medium	Design Report, Site Specific	Design report for Thomson Bay. In-depth review of the its current condition and the proposed works. Rock requirements determined based on design conditions for limestone.
Perth Metro/Peel	Rock	2021	South Thomson Bay Seawall Drawings	Low	Design Drawings, Volumes, Site Specific	Design drawings for Thomson Bay.
Perth Metro/Peel	Rock	2021	South Thomson Bay Seawall Technical Specification	Low	Technical Specification, Site Specific	Technical Specification for Thomson Bay.
Perth Metro/Peel	Rock	2020	Port Beach Temporary Seawall Design Report	Medium	Design Report, Site Specific	Design report for Port Beach. In-depth review of the its current condition and the proposed works. Rock requirements determined based on design conditions for limestone.
Perth Metro/Peel	Rock	2020	Port Beach Temporary Seawall Technical Specification	Low	Technical Specification, Site Specific	Technical Specification for Port Beach.
Perth Metro/Peel	Rock	2020	Port Beach Temporary Seawall IFC Drawings	Low		Design drawings for Port Beach.
Perth Metro/Peel	Rock & Sand	2018	South Metro Peel Sub Regional Planning Framework	Medium	Basic Raw Materials, Planning Requirements	Identifies Basic Raw Materials locations. This also can be found on interactive geological map (GeoVIEW.WA).
Perth Metro/Peel	Rock	2021	Point Peron Spur Groyne and Breakwater Design Report	Medium	Design Report, Site Specific	Design report for Point Peron. In-depth review of the its current condition and the proposed works. Rock requirements determined based on design conditions for limestone.
Perth Metro/Peel	Rock	2021	Point Peron Spur Groyne and Breakwater IFT Drawings	Low	Design Drawings, Volumes, Site Specific	Design drawings for Point Peron.
Perth Metro/Peel	Rock	2021	Point Peron Spur Groyne and Breakwater Technical Specification	Low	Technical Specification, Site Specific	Technical Specification for Point Peron.
Statewide	Rock	2014	Breakwater design criteria and features database	Low	Detailed Design, Site Specific	Database of breakwater design information including references to drawings, rock armour size and type. Includes Perth Metro / Peel Region.
Statewide	Rock	2014	Revetment design tables	Low	Detailed Design, Site Specific	Database of revetment design information including references to rock armour size and type. Includes Perth Metro / Peel Region.
Statewide	Rock	2015	Groyne and Offshore Breakwater Design Database	Low	Detailed Design, Site Specific	Database of groyne and offshore breakwater design information including references to rock armour size and type. Includes Perth Metro / Peel Region.
Statewide	Rock & Sand	2021	SPP2.4 - Planning for Basic Raw Materials	High	Basic Raw Materials, Planning Requirements	The information is more directed around proponent use. Details their requirements around management plans, relevant Legislation, access and checklist for BRM extraction. KML database available
Statewide	Rock & Sand	2021	Explanatory notes for SPP2.4 - Planning for Basic Raw Materials	High	Basic Raw Materials, Planning Requirements	The information is more directed around proponent use. Details their requirements around management plans, relevant Legislation, access and checklist for BRM extraction. KML database available
Statewide	Rock & Sand	2021	SPP2.4 - Planning for Basic Raw Materials Guidelines	High	Basic Raw Materials, Planning Requirements	The information is more directed around proponent use. Details their requirements around management plans, relevant Legislation, access and checklist for BRM extraction. KML database available
Statewide	Rock	2021	OPERATIONAL GUIDELINE 95 - EXTRACTING ROAD BUILDING MATERIALS FROM LAND IN WA	Low	Basic Raw Materials, Planning and Approval Requirements	Discusses approval requirements and process for extracting materials.
Statewide	Rock	2022	Minedex (Mines and Mineral Deposits)	High	Basic Raw Materials, Resource	https://minedex.dmirs.wa.gov.au/Web/home
Statewide	Rock	2022	Basic raw materials maps (Department of Mines, Industry Regulation and Safety - Geological Maps - Resource potential for land use planning)	High	Basic Raw Materials, Resource	https://dmpbookshop.eruditetechnologies.com.au/category/resource-potential-for-land-use-planning.do
Statewide	Rock	2022	Interactive geological map (GeoVIEW.WA)	High	Basic Raw Materials, Resource	https://www.dmp.wa.gov.au/GeoView-WA-Interactive-1467.aspx
Statewide	Rock	2022	Basic raw materials digital datasets	High	Basic Raw Materials, Resource	DMIRS Data and Software Centre (https://dasc.dmirs.wa.gov.au/) then scroll down and click on one of the Datasets tabs then click “Statewide spatial datasets” “Land use planning” Basic raw materials (50K or 200k) or Regionally significant basic raw materials 100k to download GIS data.
Statewide	Rock & Sand	2009	Multigrain seabed sediment transport modelling for the south-west Australian Shelf	Medium	Geomorphology, Sedimentology	Work relates to investigating the the long-term and large-scale seabed morphological changes on the southwest Australian continental shelf to gain a comprehensive understanding of the effects of climate change and sea level rise on sediment erosion, transport, and deposition across the continental shelf.
Statewide	Rock & Sand	2005	Geomorphology and Sedimentology of the South Western Planning Area of Australia: Review and synthesis of relevant literature in support of Regional Marine Planning.	Medium	Geomorphology, Sedimentology	An extensive investigation into the relevant literature on geomorphology and sedimentology for the South Western Planning Area (SWPA).
Other	Rock & Sand		Marine Sediments Database	High	Marine Sediments ,Resource	dbSEABED
Perth Metro/Peel	Sand	1986	Interpretation of Geological History from Dawesville, W.A.	Low	Site Specific, Coastal Erosion, Coastal Reserve	Works relates to determining the stratigraphy of the coastal zone around the Dawesville Cut. Determination was continued erosion will expose the underlying limestone which is likely to offer resistance.
Perth Metro/Peel	Sand	1992	Report on Drilling in Coastal Zone Adjacent to Dawesville Channel.	Low	Site Specific, Coastal Erosion, Coastal Reserve	Works relates to determining the stratigraphy of the coastal zone around the Dawesville Cut. Determination was continued erosion will expose the underlying limestone which is likely to offer resistance.
Perth Metro/Peel	Sand	1981	Grey Calcareous Sand, Beach Colouration at Woodman Point.	Low	Site Specific, Dredging, Coastal Erosion	Report relates to Cockburn dredging campaign and the discolouration of the beach at Woodman Point. The report confirmed the relocation of the outlet pipe allowed for natural waves and current actions to remove the sand.
Perth Metro/Peel	Sand	1983	Appraisal of Lime Sand Dredging, Parmelia and Success Banks in Cockburn Sound, Western Australia - Phase 1 : Desk Study of the Regional Setting of the Natural System	High	Historic Analysis, Environmental Considerations, Provenance	Environmental review of Lime Sand dredging at Parmelia and Success Banks. Review of regional setting including the bathymetry and topography, wave and currents, biological assemblages, Holocene sediment and evolution, sediment provenance and budget, sediment transport and Sediments accretion.
Perth Metro/Peel	Sand	1993	Estimate of Shell Sand Resource Mewstone Area Western Australia	High	Site Specific, Dredging, Shell Sands	An estimate of Shell Sand resources in Mewstone area.
Perth Metro/Peel	Sand	1992	Estimate of Shell Sand Resource Parmelia and Success Banks Western Australia, June 1992	High	Site Specific, Dredging, Shell Sands	An estimate of Shell Sand resources in Parmelia and Success Banks.
Perth Metro/Peel	Sand	1993	Factual Report - 1993 Geotechnical Investigation Mewstone Area Dredging Management Programme DMP4 (1992)	Low	Site Specific, Geotechnical Investigations	Dredging Management Programme. Calcium carbonate content and available tonnage.
Perth Metro/Peel	Sand	1991	Factual Report - Geotechnical Investigation North-East of Success Bank - 1991 Dredging Management Programme - Cockburn Sound, Western Australia	Low	Site Specific, Geotechnical Investigations	Dredging Management Programme. Calcium carbonate content and available tonnage.
Perth Metro/Peel	Sand	1992	Factual Report - Geotechnical Investigation - 1992 Dredging Management Programme Cockburn Sound, Western Australia	Low	Site Specific, Geotechnical Investigations	Dredging Management Programme. Calcium carbonate content and available tonnage.
Perth Metro/Peel	Sand	1986	Compilation of Cockburn Cement Limited - Bore Hole, Lime and Shell Sand Data - Parmelia and Success Banks	Low	Site Specific, Geotechnical Investigations	Dredging Management Programme. Calcium carbonate content and available tonnage.
Perth Metro/Peel	Sand	1990	Geotechnical Investigation - Part A - Parmelia Bank & Success Bank 1991 Dredging Management Programme - Factual Report	Low	Site Specific, Geotechnical Investigations	Dredging Management Programme. Calcium carbonate content and available tonnage.
Perth Metro/Peel	Sand	1990	Geotechnical Investigation - Part B - Parmelia Bank & Success Bank 1991 Dredging Management Programme - Factual Report	Low	Site Specific, Geotechnical Investigations	Dredging Management Programme. Calcium carbonate content and available tonnage.
Perth Metro/Peel	Sand	1991	Geotechnical Investigation Parmelia Bank & Success Bank - 1991 Dredging Management Programme - Factual Report	Low	Site Specific, Geotechnical Investigations, Grain size	Dredging Management Programme. Calcium carbonate content and available tonnage.
Perth Metro/Peel	Sand	1991	New Estimate of Shell Sand Resource - Parmelia And Success Banks	High	Site Specific, Geotechnical Investigations, Grain size	Dredging Management Programme. Calcium carbonate content and available tonnage. The document also includes partial size distribution.
Perth Metro/Peel	Sand	1995	Owen Anchorage Area Success Bank Shell Sand Resources & Reserves	High	Site Specific, Geotechnical Investigations, Environmental Consideration	Dredging Management Programme. Calcium carbonate content and available tonnage.
Perth Metro/Peel	Sand	1978	The Sedimentology of Barrier and Fringing Banks in Cockburn Sound and the Effect of Industrial Development on Sedimentation	High	Site Specific, Geotechnical Investigations	Works relates to Owen Anchorage Area. Review of regional setting including the bathymetry and topography, wave and currents, biological assemblages, Holocene sediment and evolution, sediment provenance and budget, sediment transport and Sediments accretion.
Perth Metro/Peel	Sand	1994	Siltation of Success Channel in the Outer Fremantle Harbour	Medium	Sediment Analysis, Sampling, Grain size, Environmental Analysis, Wave Dynamics, Site Specific	Assessment of Cockburn Sound to understand sedimentation, effect of growth of banks and man-made changes and predict the change in sedimentation. This works was completed for Rockingham, Parmelia, Success Banks.
Perth Metro/Peel	Sand	1995	Mandurah Marina reinterpretation of subsurface conditions	Low	Siltation, Site Specific	Assessment of siltation within the Success Channel.
Perth Metro/Peel	Rock	1995	Mandurah Marina Geotechnical Investigation - Backhoe Test Pits	Low	Geotechnical Conditions, Site Specific	Geotechnical investigation of the Mandurah Marina.
Perth Metro/Peel	Rock	1995	Mandurah Marina - Soil Profile Treatment	Low	Geotechnical Conditions, Site Specific	Geotechnical investigation of the Mandurah Marina.
Perth Metro/Peel	Rock	1994	Mandurah Marina - Geotechnical Investigation	Low	Geotechnical Conditions, Site Specific	Geotechnical investigation of the Mandurah Marina.

Perth Metro/Peel	Sand	1995	Sedimentology of Success & Parmelia Banks , Owen Anchorage, WA	High	Sediment Analysis, Sampling, Grain size, Site Specific	Works relates to sedimentology of Success and Parmelia banks and Owen Anchorage. The report includes grain size, chemical composition, grain characteristics and radiocarbon dating.
Perth Metro/Peel	Sand	1995	Sedimentology of Success and Parmelia Banks, Owen Anchorage, Western Australia	High	Sediment Analysis, Sampling, Grain size, Site Specific	Works relates to sedimentology of Success and Parmelia banks and Owen Anchorage. The report includes grain size, chemical composition, grain characteristics and radiocarbon dating.
Perth Metro/Peel	Sand	1989	Mandurah - San Remo Review of Sedimentological Setting	High	Historic Analysis, Provenance, Sediment Analysis, Site Specific, Regional Setting	Works relates to sedimentology of Mandurah, Robert Point to San Remo. The report includes regional Analysis of Perth Metro / Peel Coastline. Provides an interesting way to analyse the beach material along the coast both alongshore and offshore.
Perth Metro/Peel	sand	2004	Sediment Colour of Southern Perth Beaches - Field Observations and Data Report	High	Sampling, Grain size, Sediment Colour	Works involved reviewing the sand discolouration within Owen anchorage. The report in includes reviewing sediment movement, wave climate and sampling. Sand was collected between Swanbourne Beach and Point Peron Beach and was assessed for colour and grain size.
Perth Metro/Peel	Rock	2005	Seascapes Coastal Stability Study Report on Geotechnical Investigation	Low	Geotechnical Conditions, Site Specific	Geotechnical investigation of the Mandurah Marina.
Perth Metro/Peel	Rock	1998	Mandurah Marina Geotechnical Investigation	Low	Geotechnical Conditions, Site Specific	Geotechnical investigation of the Mandurah Marina.
Perth Metro/Peel	Rock	2007	Geology and Landform of the Perth Region	High	Geotechnical Conditions	Geology ad Landforms surrounding Perth. The report is prepared for multiple areas from Two Rocks to Mandurah.
Statewide	Sand	2001	An Overview of Gold Coast Coastal Monitoring	Medium	Sand Nourishment	Review of coastal management activities undertaken at the Gold Coast. The council has developed a number of management policies and procedures including the requirement for sand from developments to be used for beach nourishment.
Statewide	Sand	2013	History of the Implementation and Evolution of Sand Nourishment Methods on the Gold Coast.	Medium	Sand Nourishment	Review of sand sources for beach nourishment including terrestrial / building sites, river / estuarine, sand bypassing, sand bypassing and offshore.
Southwest	Sand & Rock	2012	Basic raw materials study	High	Basic raw materials	Supply and demand analysis for BRM in Bunbury-Busselton region. The review in involve a prediction of demand to 2030 and include multiple sectors including Coastal and Local Government Managers, Agriculture and Private.
Southwest	Sand	2015	Coastal Sediment Cells for the Vlamingh Coast	Medium	Sediment cells, Sediment Database	Discussion on sediment dynamics for the Perth, peel and southwest coast. Criteria for determining sediment cells. KML database available
Southwest	Sand	2001	Bunbury Coastal Enhancement Project: Sediment Analysis	Medium	Grain Size, Site Specific	Review of provenance for sand at Bunbury's Back Beach using sediment characteristics (PSD, Grain type characteristics and calcium carbonate content). The Study area extends approximately 5.5 km south of Casuarina Point.
Southwest	Sand	2009	Bunbury Sediment Samples	Medium	Grain Size, Site Specific	PSD for Hastle Street Beach, Rocky Beach, Near Breakwater Near Port and Koombana Bay.
Southwest	Sand	2010	Port Geographe Sand Management Busselton Sediment Sampling	Medium	Grain size, Sediment Dynamics, Site Specific	Busselton Sediment Sampling. Samples collected within Geographe Bay to predict sediment transport model. Samples were taken every 250 m intervals up to 2 km in both directions of Port Geographe developments and then at 1km for an extra 15 km to the west and 9 km in the east.
Southwest	Sand	2012	Sediment Transportation Processes in Geographe Bay, Western Australia: A Compositional Investigation of Subaqueous Dune and Bars	High	Grain size, Sediment Dynamics	Sampling of offshore sand bars within Geographe Bay. The assessment was undertaken to determine whether these sand formations play a primary role in onshore sediment transport.
Southwest	Sand	2015	Busselton Sand Nourishment Review	High	Sand nourishment	Includes discussion of nourishment activities with the CoB. Also reports on potential borrow sources including grain size and overfill ratios.
Southwest	Sand	2019	Port Geographe Sediment Sampling and Analysis Plan Implementation Report	Medium	Grain Size	Sediment samples taken for the coastline surrounding the marina at Port Geographe. Required as part of the Dredging Environmental Impact Assessment (DEIA).
Southwest	Sand	2020	City of Busselton Coastal Management Plan 2021 – 2031	High	Sand nourishment, coastal adaption	Outlines proposed nourishment quantities, existing and future coastal adaption projects for the City of Busselton.
Southwest	Sand	2021	Port Geographe site specific scope and drawings	High	Dredging, Technical Specification, Volumes	Dredging areas and historical dredge volumes for the marina within Port Geographe.
Southwest	Sand	2020	Gnarabup Sand Nourishment	Low	Sand nourishment	Discussion on sand sources and nourishment design
Southwest	Sand	2021	Gnarabup Sand Nourishment	Low	Sand nourishment	Review on nourishment performance
Southwest	Sand	2012	Augusta Sediment Samples	Low	Sediment Characteristics, Site Specific	PSDs and CaCO3
Southwest	Rock	2018	TBW Stage 2 Jetty Rd Causeway Revetment IFT drawings	Low	Design, Volumes, Site Specific	Bunbury Causeway Revetment Design.
Southwest	Rock	2018	TBW Stage 2 Jetty Rd Causeway Revetment design report	Low	Design, Site Specific	Bunbury Causeway Revetment Design.
Southwest	Rock	2018	TBW Stage 2 Jetty Rd Causeway Revetment technical specification	Medium	Technical Specification	Technical specification for Bunbury Causeway Revetment. Includes details on armour classes extracted from the onsite quarry.
Southwest	Rock	2019	Transforming Bunbury's Waterfront Stage 3 Business Case Development: Coastal Structures - Preliminary Design Report	High	Study	Includes discussion of rock armour sources and quantities of material required. Works is expected to occur within the next 10 years therefore good document to determine quantities and mateiral charecteristics.
Southwest	Rock	2013	Port Geographe Reconfiguration of Coastal Structures IFC Design Report	Low	Design, Site Specific	Port Geograophe re-configuration design.
Southwest	Rock	2015	Busselton Coastal Management Program: Coastal Structures Review Report on Sources of Rock for Armour Stone	High	Study	Desktop review of rock sources including five potential sites in close proximity of City of Bunbury.
Southwest	Rock	2015	RFQ - reconstruction of 2 timber groynes	Low	Alternatives	Relates to the procurement of timber groyne structures for west Busselton.
Southwest	Rock	2011	Geotech Investigation for Augusta Boat Harbour	Medium	Geological Assessment, Site Specific	Geotechnical test results for the onsite quarry for the Augusta Boat Harbour.
Southwest	Rock	2011	Augusta Boat Harbour Marine Noise Management Plan	Low	Environmental, Site Specific	Includes management of quarry noise for the Augusta Boat Harbour.
Southwest	Rock	2012	Augusta Boat Harbour Environmental Management and Monitoring Plan	Low	Environmental, Site Specific	Environmental management for the onsite quarry used to construct the Augusta Boat Harbour.
Southwest	Rock	2012	AUGUSTA BOAT HARBOUR BREAKWATERS AND BULK EARTHWORKS Technical Specification	Medium	Technical Specification, Site Specific	Technical specification for Augusta Boat Harbour. Includes details on armour classes extracted from the onsite quarry.
Southwest	Rock	2015	Augusta Boat Harbour Breakwaters	Medium	Study, Site Specific	Includes information on Augusta rock density and armour rock size. Alternative methods for dealing with rock supply. Rock sourced from an onsite quarry to construct the Augusta Boat Harbour.
Southwest	Sand	1989	Port Geographe - Beach Stabilisation	Medium	Shoreline movement, Site Specific	Investigation into the change in beach alignment and the patterns of accretion and erosion at Port Geographe.
Southwest	Rock & Sand	1985	Coastal Engineering Studies for Notice of Intent - Port Geographe	Medium	Coastal processes, Sediment transport, Site specific	Investigation into the change in coastal processes as a result of the construction of Port Geographe. The investigation looked at sediment transport, appropriate lines and levels, and rock sizes for groynes and revetments.
Southwest	Sand	1990	Sand Bypassing and Coastal Management - Port Geographe	Medium	Sand bypassing, Sediment transport, Site specific	Investigation into sand bypassing requirements of Port Geographe. The report details the sand bypassing system including sand traps and deposition location, scheduling and cost of the dredging works.
Southwest	Sand	1983	Coastal Engineering Aspects - Geographe Harbour	Medium	Sand bypassing, Sediment transport, Water Quality, Site specific	Investigation into littoral drift and water quality of Port Geographe. The report detailed the sediment bypassing requirements due to littoral drift and offshore sandbars. The report also suggested that water quality within Port Geographe provided that nutrient sources are excluded from the development.
Southwest	Rock & Sand	1995	Port Geographe - Report on Sources of Sand for Fill and Rock for Groynes and Revetment	High	Material Investigation, Sand & Rock, Site Specific	Investigation into potential sand and rock supplies surrounding the Port Geographe area. Review included 10 potential sources of rock and 5 potential sources of sand.
Southwest	Rock	1996	Proposed Breakwater Armour Rock, Port Geographe. Assessment of materials	High	Rock Supply, Material characteristics, Site Specific	Assessment of rock required for the Port Geographe groynes. Samples were collected from 5 potential rock quarries surrounding the Port Geographe area. Tests included partial density and water absorption, point load index and sodium sulphate soundness.
Southwest	Sand	1987	Coastal Engineering Aspects Beach Sand Mining	Low	Mineral deposits, Site specific	Investigation into beach sand mining at Minninup, Western Australia. Assessment of the impact removing mineral sand may have on the coastline.
Southwest	Sand	2001	Bunbury Coastal Enhancement Project-Sediment Analysis	High	Grain size, Sediment Dynamics, Site Specific	Investigation into the coastal processes of Bunbury Back Beach. It included a sediment analysis to determine provinance, geological description and testing and grading of the calcium carbonate content.
Southwest	Rock	2024	Leschenault Inlet Training Wall Repairs Design Report	Low	Design Report, Site Specific	Design report for the repairs to the Leschenault Inlet training wall. In-depth review of the its current condition and the proposed works.
Perth Metro/Peel	Sand & Rock	Undated 1882?	Availability of Basic Raw Materials Perth Metropolitan Region	High	Basic Raw Material, Perth Metropolitan Region	Outdated and superseded by GSWA maps and later information. Provides a summary of basic raw materials in the Perth Metropolitan Area, with a large geological map.
Statewide	Sand & Rock	1991?	Basic Raw Materials	High	Basic Raw Material, Statewide, Quarry Operations	Superseded by later information. Presents a list of operating quarries at 1991
Statewide	Sand & Rock	1995	Managing Basic Raw Materials of Perth and the Outer Metropolitan Region. Part 1	Medium	Basic Raw Material, Statewide, Quarry Operations	The mapping and summary provides some basic information. Resource mapping is superseded by later and more current information but remains indicative.
Perth Metro/Peel	Sand & Rock	1996	Managing Basic Raw Materials of Perth and the Outer Metropolitan Region. Part 2	Medium	Basic Raw Material, Perth Metropolitan Region	The mapping and summary provides basic information on the key resources which remains a useful background. Resource mapping is superseded by later and more current information but remains indicative. Provides data on current and future requirements, the approval processes with maps and examples.
Perth Metro/Peel	Sand & Rock	1992	Basic Raw Materials Policy Statement for the Perth Metropolitan Region	Medium	Basic Raw Material, Perth Metropolitan Region	Provides and updated summary of basic raw materials in the Perth Metropolitan Area from MRPA and provides a very brief review of the issues related to extraction. Geological information is superseded by GWSA mapping, and State Planning Policy 2.4.
Statewide	Rock	1998	State Gravel Supply Strategy	Medium	Statewide, Gravel	Discusses the uses and sources of gravel state wide and provides a summary of the locations, maps and processes at a broad State wide scale. Provides a list of supplies at 1998 in shires but no detail on locations. Superseded by GSWA geological and BRM mapping, changes to legislation and the introduction of additional environmental requirements.
Perth Metro/Peel	Sand & Rock	2002	Peel Region Scheme, Strategic Minerals and Basic Raw Materials Resource Policy	High	Basic Raw Material, Peel Region, Planning Document, Mapping of resources.	Brief overview of the planning processes combined with a map of the Resources in the Peel Region. Remains a current document. Mapping is indicative, does not show all resources and is updated within this study.

Perth Metro/Peel	Sand & Rock	2007	Basic Raw Materials Access and Availability 1996 - 2008	Medium	Basic Raw Material, Perth Metropolitan Region	Summarises the status of basic raw materials at 2007 across the Perth Metropolitan Area. Provides data on current and future requirements, the approval processes with maps and examples. The data is now not relevant as many basic raw materials have been used and urban expansion has overrun some resources. The mapping has relevance in indicating the location of resources.
Statewide	Sand & Rock	2009	Basic Raw Materials Applicant Manual	Low	Planning Document, Statewide	The approvals data is partially relevant but is superseded. Supersedes the 1996 study.
Southwest	Sand & Rock	2012	Basic Raw Materials, Demand and Supply Study for the Bunbury – Busselton Region	High	Basic Raw Material, Southwest Region, Demand Study	Summaries the considerations required for applications for extraction of basic raw materials. Superseded by Planning for Basic Raw Materials Guidelines 2021
Perth Metro/Peel	Sand & Rock	2015	Perth and Peel Growth Plan for 3.5 Million. Strategic Assessment of the Perth and Peel Regions. Draft Action Plan Basic Raw Materials	High	Basic Raw Material, Perth Metropolitan & Peel Regions, Planning Document	Contains a summary of the projected requirements for basic raw materials in the Region to 2030 and lists of all pits within the Region. The mapping is indicative only as many pits and resources have now been consumed or overtaken by development. The Bunbury Outer Ring Road, Bussell Highway duplication and recent development has used almost all the available sand resource in the Bunbury Busselton Region. The mapping has been updated in this study.
Statewide	Sand & Rock	2015	Industry Submissions to the Green Growth Plan	High	Basic Raw Material, Statewide, Planning Document	Unpublished reports were submitted to Government in response to the publication of the draft Green Growth Plan. These are not available but would provide additional industry data. A review of the information may be useful to inform and review of the State Planning Policy 2.4 mapping even though some information is now ten years old.
Statewide	Sand & Rock	2021	State Planning Policy 2.4 Planning for Basic Raw Materials Guidelines	Medium	Basic Raw Material, Statewide, Planning Document	Provides guidance on the considerations required for applications for extraction of basic raw materials Current
Statewide	Sand & Rock	2023	Basic Raw Materials Policy 2.4 Basic Raw Materials	High	Basic Raw Material, Statewide, Planning Document	The mapping of Significant Geological Supplies are provided in Geoview (DEMIRS) as are nominated Exclusion Zones. Extraction Areas are listed but only include existing operating pits and do not include potential resources. Significant Geological Supplies are nominated for large resources but do not include smaller resources that could provide very important local supplies. No marine supplies are listed. Consultation with industry and end users may refine the mapping. Current
Statewide	Sand & Rock	1998	Abeysinghe P B, 1998, Limestone and Limesand Resources of Western Australia, Geological Survey of Western Australia, Mineral Resources Bulletin 18.	Medium	Limestone, Sand & Rock, Statewide	Abeysinghe 1998 (Lime) provides a general overview of all the lime and limestone resources across the State from a geological unit perspective. For some locations there are typical analyses of CaCO3 and other elements. In many locations there are descriptions or data from small local pits that were operating at the time of the study providing an appearance or greater volumes and availability of the materials in that location. No environmental, availability or other factors are considered. The report is a good starting summary when looking for lime and limestone resources in particular locations, but is not exhaustive and there are other locations where local resources are available.
Statewide	Sand	1998	Abeysinghe P B, 1998, Silica Resources of Western Australia, Geological Survey of Western Australia, Mineral Resources Bulletin 21.	Low	Sand, Statewide	Abeysinghe 1998 (Silica) provides a general overview of silica resources across the State including sands, quartzites and cherts, providing locations, operating pits at the time of the study and typical analyses. In many locations the data is old and the pits described have closed, but the report provides
Statewide	Sand	2017	Bruch J and M Freeman, 2017, Migration of limesand dunes in Western Australia and their impacts. Department of mines and Petroleum, Perth Western Australia report 2017.	Low	Sand, Statewide	Bruch and Freeman reviewed the mobile limesand dunes along the west coast, where they have the ability to impinge on infrastructure The report concentrates on the current movements of the limesands and the future movements. No consideration is given to the use of the limesand as resources apart from as a means of restricting the dune migrations, but the report remains a source of potential limesand resources particularly where infrastructure may be impacted.
Statewide	Sand & Rock	2007	Department of Agriculture Primary Industries and Regional Development 4660, 2007, Survey of Western Australia agricultural lime.	Medium	Basic Raw Material, Statewide, Geological Maps	Lists existing lime pits utilising calcareous sands and limestones. The data contains some pits which have closed and which are small and unlikely to provide significant basic raw materials for construction. Even though many locations do not have current approvals, the data is a useful starting source of construction rock information, but does not include geotechnical properties, but rather aesthetic and market considerations. It should be noted that blasting to use the rock for construction will destroy the ability of the rock for future dimension stone use.
Southwest	Sand & Rock	2007	Fetherston J M, 2007, Dimension Stone in Western Australia, Volume 1, Southwest, Mineral Resources Bulletin No 23, Department of Mines and Petroleum.	Medium	Basic Raw Material, Southwest Region, Resource Maps	Reviews granite and sandstones in the south west which are being used for dimension stone. The rock is chosen to be decorative and may not always be aesthetically compatible with rock in the construction area, but is also chosen as being capable of producing large blocks of up to 10 tonnes.
Statewide	Sand & Rock	2007	Fetherston J M, 2007, Dimension Stone in Western Australia, Volume 2, Southern Central Western and Northern Regions, Mineral Resources Bulletin No 24, Department of Mines and Petroleum.	Medium	Basic Raw Material, Statewide, Geological Supply	The report covers dimension stone sites in the remainder of the State. Many of the sites will be located on mining tenements and may not be available. The comments for the South West resources above apply. Being country and remote locations the report provides a good starting point in the search for suitable rock, armour and core. A number of resources are sandstones which are often not suitable for coastal work or constructions in wet and dry or saline conditions because salt and other crystal development breaks the grains apart.
Perth Metro/Peel	Sand & Rock	1987	Gozzard J R, 1987, Limesand and Limestone Resources between Lancelin and Bunbury, Western Australia. GSWA Record 187/5.	Low	Basic Raw Material, Perth Metropolitan Region, Quarry Information	Provides a brief overview of the limesand and limestone between Lancelin and Bunbury. Superseded by Abeysinghe P B, 1998, above.
Statewide	Rock	2015	Geological Survey of Western Australia, 2015, Limesand and Limestone Resources of Southern Western Australia	High	Basic Raw Material, Southwest Region, Quarry Information	Lists existing lime pits utilising calcareous sands and limestones along the south coast. The data contains some pits which have closed and which are small and unlikely to provide significant basic raw materials for construction. There have also been a new lime pit opened at Nullaki Denmark that can supply limited construction road bases, but not armour or core rock.
Statewide	Sand & Rock	1990	Geological Survey of Western Australia, 1990, Geology and Mineral Resources of Western Australia, Memoir 3.	High	Basic Raw Material, Statewide, Geological Maps	Provides an overview summary of the geological units in Western Australia with large scale and some smaller scale maps. A starting point when looking for construction resources.
Statewide	Sand & Rock	2024	Geoview 2024. See DEMIRS website.	High	Basic Raw Material, Statewide,Online Repository	Geoview provides an interactive digital summary of the geology across the State with digital mapping which can be zoomed to. Cadastre, aerial photography and mining tenements can be displayed and overlain. Planning and resource mapping such as State Planning Policy 2.4 and significant geological resource mapping is provided. At particular locations the system will link to MINDEX and other DEMIRS databases of existing and historic geological reporting. Excellent starting point when searching fore resource, particularly those which have not been developed in regional areas.
Statewide	Sand & Rock		Environmental and Basic Raw Material Mapping – Geological Survey of Western Australia	High	Basic Raw Material, Statewide, Geological Maps	GSWA through DEMIRS website has a suite of maps along the coasts of Western Australia, focussed on development nodes. The maps are at 1 : 100,000 scale and provide excellent locations of resources. There is no consideration of land use, availability of the resources or environmental factors or restrictions.

Appendix B Stakeholder Engagement

Consultation was undertaken with Local Government and Coastal Managers, Suppliers and Contractors within the relevant regions. These groups were chosen as they are indirectly or directly involved in the placement of sand and rock used for coastal adaptation works.

A list of those stakeholders contacted for the study is provided in Table B.1.

Table B.1 List of Stakeholders

Region	Questionnaire Tracking	Type	Questionnaire Response / Meeting Complete
Perth Metro/Peel	Wanneroo	LGA	YES
Perth Metro/Peel	Joondalup	LGA	YES
Perth Metro/Peel	Stirling	LGA	NO
Perth Metro/Peel	Cambridge	LGA	NOT APPLICABLE
Perth Metro/Peel	Nedlands	LGA	NO
Perth Metro/Peel	Cottesloe	LGA	NO
Perth Metro/Peel	Mosman Park	LGA	NOT APPLICABLE
Perth Metro/Peel	Fremantle	LGA	NO
Perth Metro/Peel	Cockburn	LGA	YES
Perth Metro/Peel	Kwinana	LGA	NOT APPLICABLE
Perth Metro/Peel	Rockingham	LGA	YES
Perth Metro/Peel	Mandurah	LGA	YES
Perth Metro/Peel	Shire of Waroona	LGA	NOT APPLICABLE
Perth Metro/Peel	MRWA(P&PR)	Government Body	YES
Perth Metro/Peel	DevWA	Government Body	NO
Perth Metro/Peel	Fremantle Ports	Government Body	YES
Perth Metro/Peel	DBCA - Riverine	Government Body	YES
Perth Metro/Peel	DoT(P&PR)	Government Body	NOT APPLICABLE
Perth Metro/Peel	Urban Resources	Supplier	YES
Perth Metro/Peel	Hanson	Supplier	NO
Perth Metro/Peel	Cockburn Cement	Supplier	YES
Perth Metro/Peel	WA Limestone	Supplier	YES
Perth Metro/Peel	Italia	Supplier	YES
Perth Metro/Peel	Advanteering	Contractor	YES
Perth Metro/Peel	Ertech	Contractor	YES
Perth Metro/Peel	Georgiou	Contractor	NO
Southwest	Harvey	LGA	YES
Southwest	Bunbury	LGA	YES
Southwest	Capel	LGA	NO
Southwest	Busselton	LGA	YES
Southwest	Augusta/Margret River	LGA	YES
Southwest	Nannup	LGA	NOT APPLICABLE
Southwest	Manjimup	LGA	NOT APPLICABLE
Southwest	Southern Ports Authority(SWR)	Government Body	NO
Southwest	MRWA(SWR)	Government Body	YES
Southwest	DoT(SWR)	Government Body	NO
Southwest	SWDC	Government Body	NOT APPLICABLE
Southwest	DWER(SWR)	Government Body	NOT APPLICABLE
Southwest	BCP Group	Contractor	YES
Southwest	APH Contractors	Contractor	YES
Southwest	Geographe Civil	Contractor	NO
Southwest	B & J Catalano	Supplier	NO
Southwest	MGM Bulk	Supplier	YES
Southwest	Alcoa	Supplier	YES

Table B.2 to B.4 outline the questions / prompts sent to the stakeholders. Coastal and Local Government Managers were sent a questionnaire (refer to Table B.2) which they were asked to respond to and return, or for those Managers who preferred to talk through their responses, meetings were organised.

Suppliers and Contractors were issued with prompt questions to discuss during a subsequent meeting. These prompt questions are displayed in Tables B.3 and B.4 respectively. Some

Suppliers / Contractors preferred to respond to the questions directly, rather than trying to provide the information during the meeting.

Table B.2 Questionnaire – Coastal & Local Government Managers

1. Please provide a list of significant coastal projects within your LGA requiring sand and rock materials for the past 5 years?		
Project	**Location**	**Date**

2. For those projects listed above, please provide the following:	
What was the project (eg breakwater, groyne, beach nourishment)?	
What materials were used (eg Limestone, Granite, sand)?	
What size (eg grain size or rock size) and volume were required (indicative)?	
What was the cost (indicative)?	
Who was the Contractor engaged?	
Where was the material sourced from (eg Supplier, quarry, crown / private land)?	
Why was this source chosen (eg proximity, material type, project requirements)?	
What approvals were required (if any)?	

3. Please provide a list of coastal projects requiring sand and rock in the pipeline for your LGA over the next 5 years?		
Project	**Location**	**Date**

4. For those projects listed above, please provide the following:
What is the project (eg breakwater, groyne, beach nourishment)?
Has there been a study or underlying work completed to support these works, and if so what?

What is the level of project development (eg CHRMAP, concept, detailed design)?

What material(s) are proposed for use (eg Limestone, Granite, sand)?

What size (eg grain size or rock size) and volume may be required (indicative)?

What is the proposed the cost (indicative)?

5. **Please estimate the amount allocated by the LGA for coastal adaption projects for the next 5 years?**

6. **Has your LGA put any measures in place to ensure there is enough sand and rock available for future coastal adaptation projects?**

7. **What do you see as the main issues, challenges and constraints for sand and rock sources?**

8. **Please provide any other feedback relating to the sand and rock supply for coastal adaption projects?**

Table B.3 Prompt Questions – Contractors

1. Where are the primary sources of sand and rock material you use (supplier, quarry, crown land, private land, etc.) and why (proximity, material type, project requirements, etc.)?	
Contact Details	
Source	**Name / Number**

2. What is the cost of basic raw materials (indicative)?	
Material	**Cost**

3. What are the key factors leading to cost escalation in coastal projects?

4. What do you see as the main issues, challenges and constraints for sand and rock sources (eg approvals, material type, project requirements, proximity, etc.)?

5. Please provide any other feedback relating to the sand and rock supply for coastal projects?

Table B.4 Prompt Questions – Suppliers

1. Please provide the following information for quarries used to supply sand and rock for coastal projects (eg. beach nourishment, coastal structures, etc.)?

Site Name:	
Address:	address
Location:	latitude and longitude.
Current Status:	operational of under development.
Commodity(s):	for example: sand, rock (granite, limestone, ferricrete, etc.) or combination.
Description:	for example: general description.
Material Availability:	for example: cost, volume and yield of raw material(s).
Constraints/issues:	for example: flora, fauna, land use, approvals, material type, project requirements, proximity, resource sterilisation, demands for resource, life of the resource, etc

2. What measures have been or could be put in place to continuously supply sand and rock for future coastal projects?

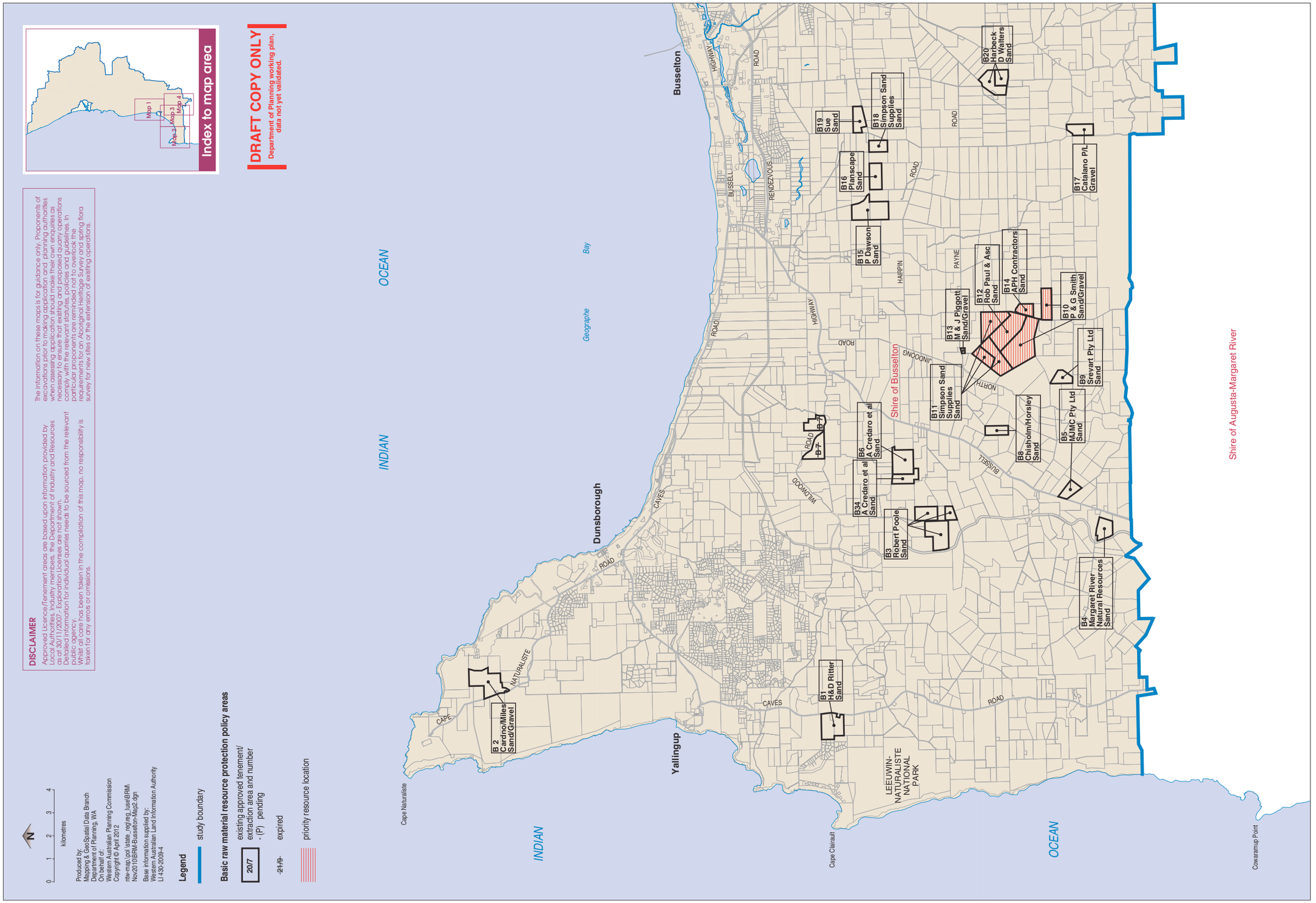
3. What are the key factors leading to cost escalation in coastal projects and the supply of raw materials?

4. What do you see as the main issues, challenges and constraints for sand and rock sources (eg approvals, material type, project requirements, proximity, resource sterilisation, clearing approvals, demands for resource, life of the resource, etc.)?

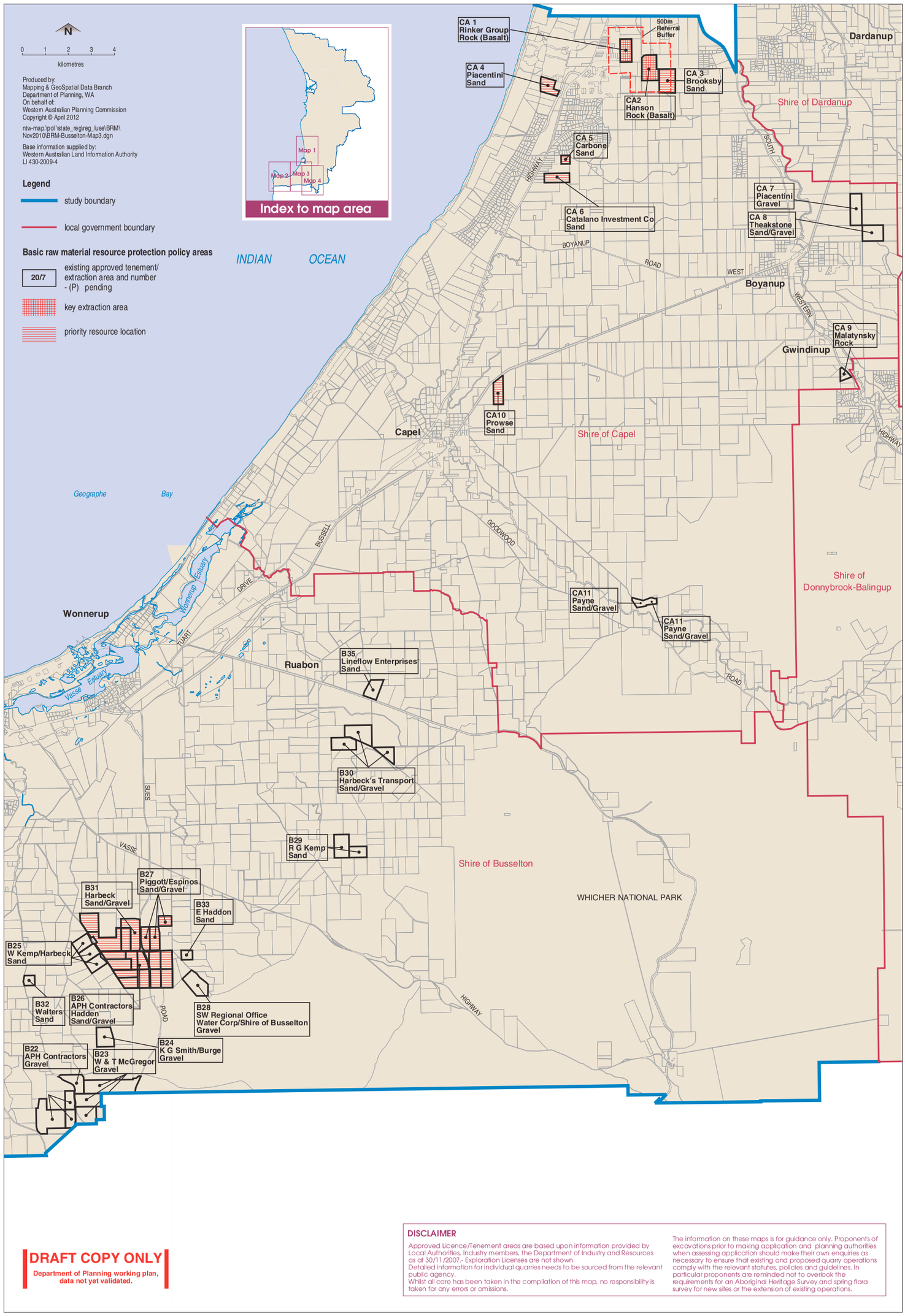
5. Please provide any other feedback relating to the sand and rock supply for future coastal projects?

Appendix C Extractive Industry Licence Sites (WAPC, 2012)

Map 1 2008 extractive industry licence sites in study area (Shire of Busselton)



Map 2 2008 extractive industry licence sites in study area (Shire of Busselton, Shire of Capel)



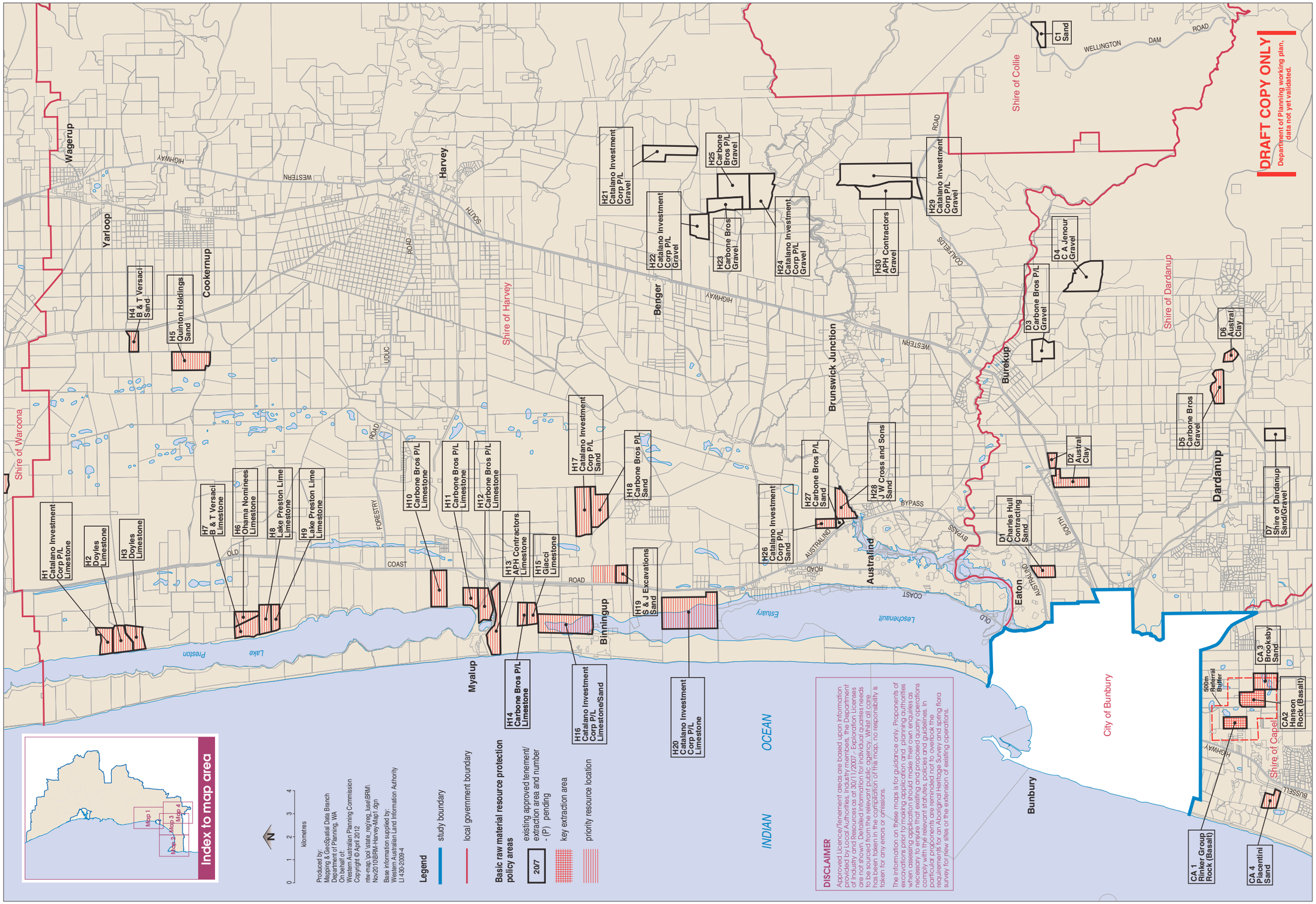
DRAFT COPY ONLY
Department of Planning working plan, data not yet validated.

DISCLAIMER

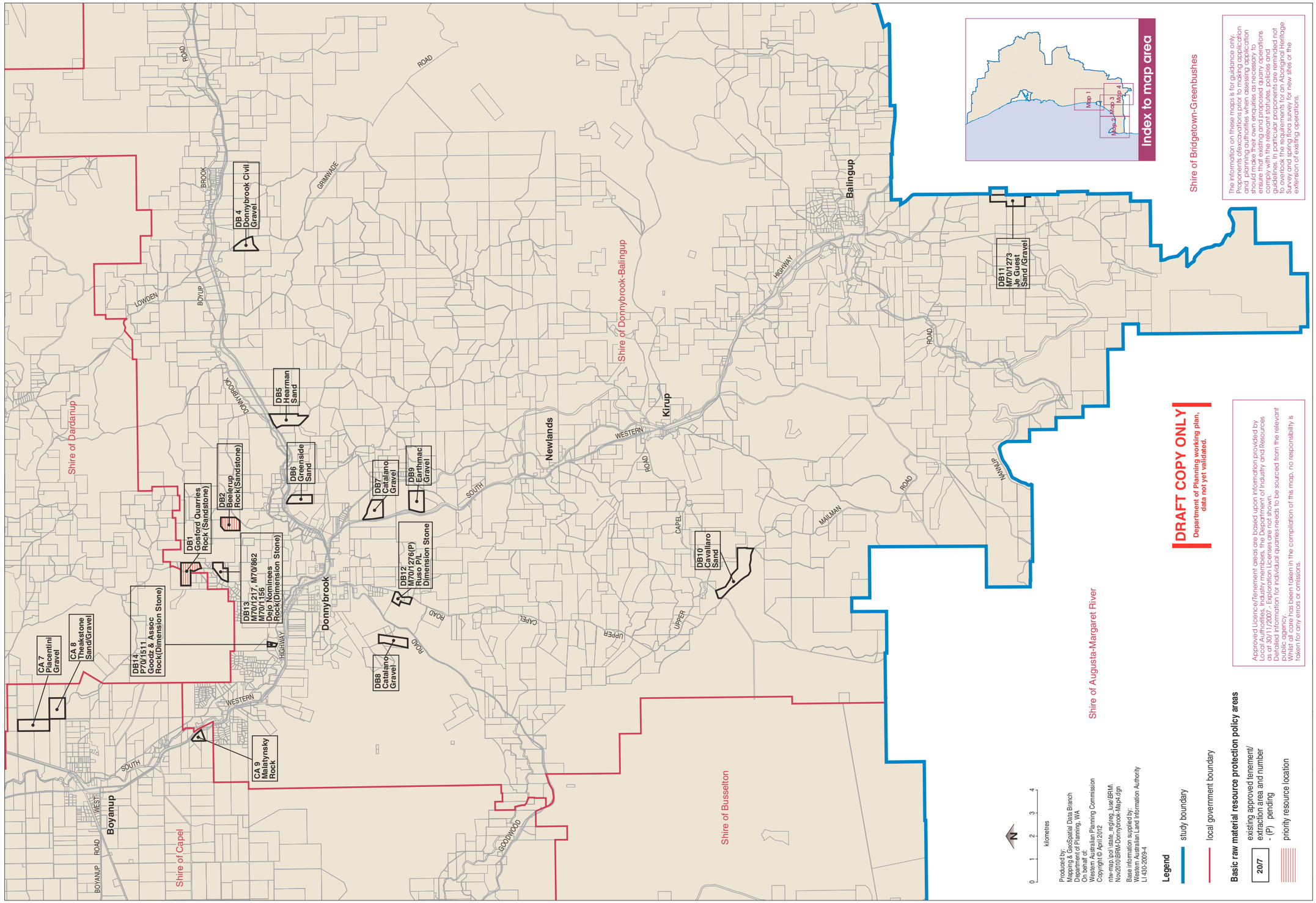
Approved Licence/Tenement areas are based upon information provided by Local Authorities, Industry members, the Department of Industry and Resources as at 30/11/2007.- Exploration Licenses are not shown.
Detailed information for individual quarries needs to be sourced from the relevant public agency.
Whilst all care has been taken in the compilation of this map, no responsibility is taken for any errors or omissions.

The information on these maps is for guidance only. Proponents of excavations prior to making application and planning authorities when assessing application should make their own enquiries as necessary to ensure that existing and proposed quarry operations comply with the relevant statutes, policies and guidelines. In particular proponents are reminded not to overlook the requirements for an Aboriginal Heritage Survey and spring flora survey for new sites or the extension of existing operations.

Map 3 2008 extractive industry licence sites in study area (Shire of Harvey, Shire of Dardanup)



Map 4 2008 extractive industry licence sites in study area (Shire of Capel, Shire of Dardanup)



Appendix D Existing Sand & Rock Sources

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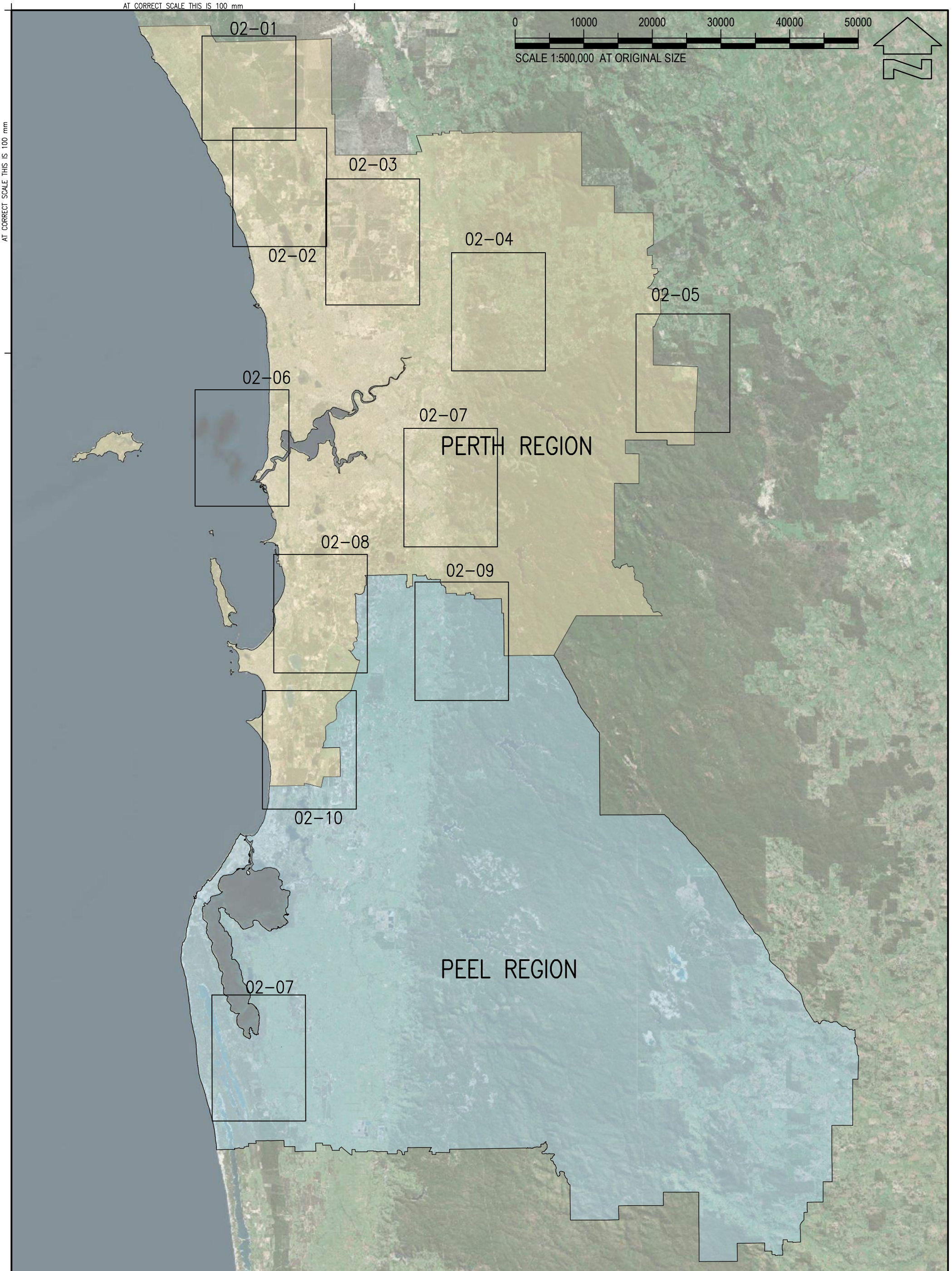

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LOCALITY PLAN

MATERIALS STUDY

SCALE AT A3 1:500,000

FEBRUARY 2025

SK2108–02–00B

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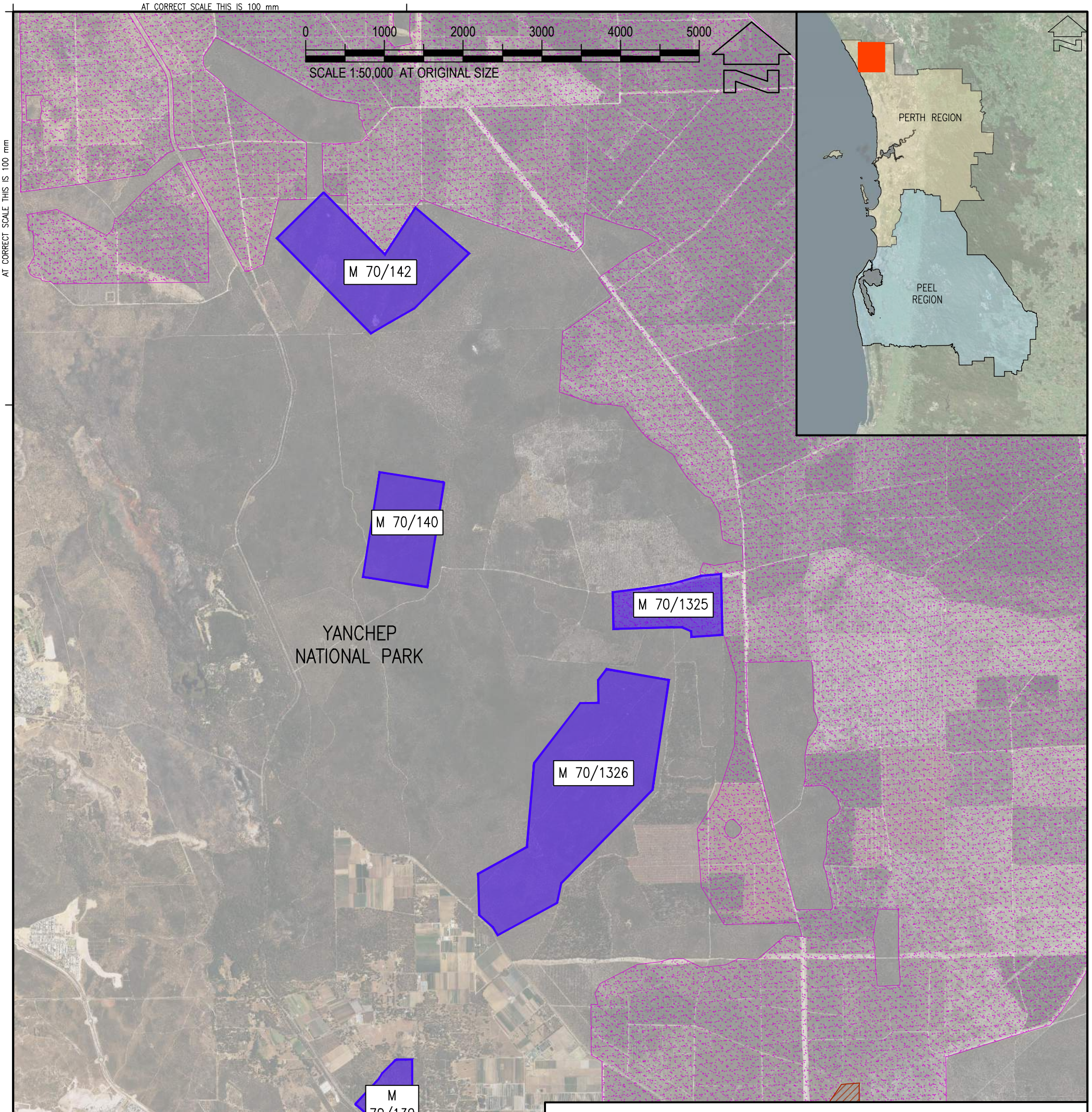

LEGEND:

- SAND
- LIMESTONE
- LOT/TENEMENT BOUNDARY

LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
M 70/139		ADELAIDE BRIGHTON	LIMESTONE
M 70/140			
M 70/142			
M 70/1325	HADDRILL ROAD, YANCHEP	WA LIMESTONE	SAND AND LIMESTONE
M 70/1326			

NOTES:

1. SIGNIFICANT GEOLOGICAL SUPPLIES AND TENEMENTS BOUNDARIES SOURCED FROM DEPARTMENT OF MINES, INDUSTRY, REGULATION AND SAFETY (DMIRS) INTERACTIVE GEOLOGICAL MAP (GEOVIEW.WA).
2. LOT LOCATION OF EXISTING SOURCES PROVIDED BY SUPPLIERS.

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EXISTING SOURCES - SHEET 1 OF 10

MATERIALS STUDY

SCALE AT A3 1:50,000

FEBRUARY 2025

SK2108-02-01B

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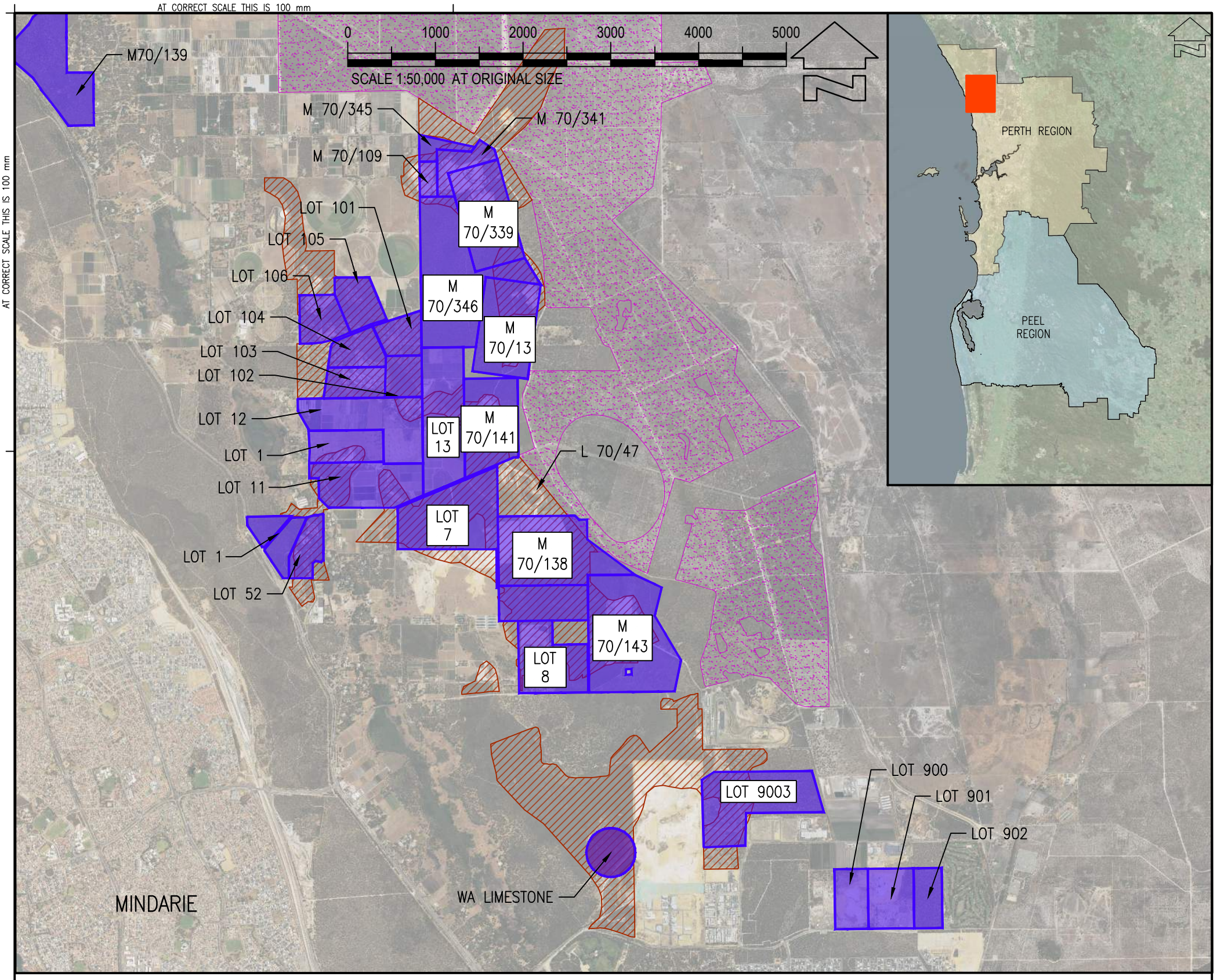

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LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
L 70/47		WA LIMESTONE	LIMESTONE
LOT 52	LOT 52 NOWERGUP ROAD, NOWERGUP	LIME INDUSTRIES	
LOT 105	KILN ROAD, NOWERGUP	URBAN RESOURCES	
LOT 106	KILN ROAD, NOWERGUP	ITALIA STONE GROUP	
LOT 7	LOT 7 WESCO ROAD, NOWERGUP	ADELAIDE BRIGHTON	
M 70/138	WATTLE AVENUE EAST, NOWERGUP		
M 70/141	WESCO ROAD NORTH, NOWERGUP		
M 70/143	WATTLE AVENUE EAST, NOWERGUP		
	410 FLYNN DRIVE, NEERABUP	DEVELOPMENT WA OPERATED BY WA LIMESTONE/ITALIA STONE GROUP	SAND AND LIMESTONE
LOT 1	LOT 1 NOWERGUP ROAD, NOWERGUP	WA LIMESTONE	LIMESTONE
LOT 8	WATTLE AVENUE WEST, NOWERGUP		
M 70/13			
M 70/109			
M 70/339			
M 70/341			

LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
M 70/345		WA LIMESTONE	LIMESTONE
M 70/346			
LOT 900-902	FLYNN DRIVE, NEERABUP	CARAMAR SANDS	SAND
LOT 1, 11-12	GIBBS ROAD, NOWERGUP	CARLOTTA	LIMESTONE
LOT 13	LOT 13 WESCO ROAD, NOWERGUP		
LOT 101-104	McLENNAN ROAD, NOWERGUP	ITALIA STONE GROUP	
LOT 9003	MATHER RD, NEERABUP	CITY OF WANEROO/URBAN RESOURCES	SAND AND LIMESTONE

LEGEND:

- SAND
- LIMESTONE
- LOT/TENEMENT BOUNDARY

NOTES:

1. SIGNIFICANT GEOLOGICAL SUPPLIES AND TENEMENTS BOUNDARIES SOURCED FROM DEPARTMENT OF MINES, INDUSTRY, REGULATION AND SAFETY (DMIRS) INTERACTIVE GEOLOGICAL MAP (GEOVIEW.WA).
2. LOT LOCATION OF EXISTING SOURCES PROVIDED BY SUPPLIERS.

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EXISTING SOURCES - SHEET 2 OF 10

MATERIALS STUDY

SCALE AT A3 1:50,000

FEBRUARY 2025

SK2108-02-02B

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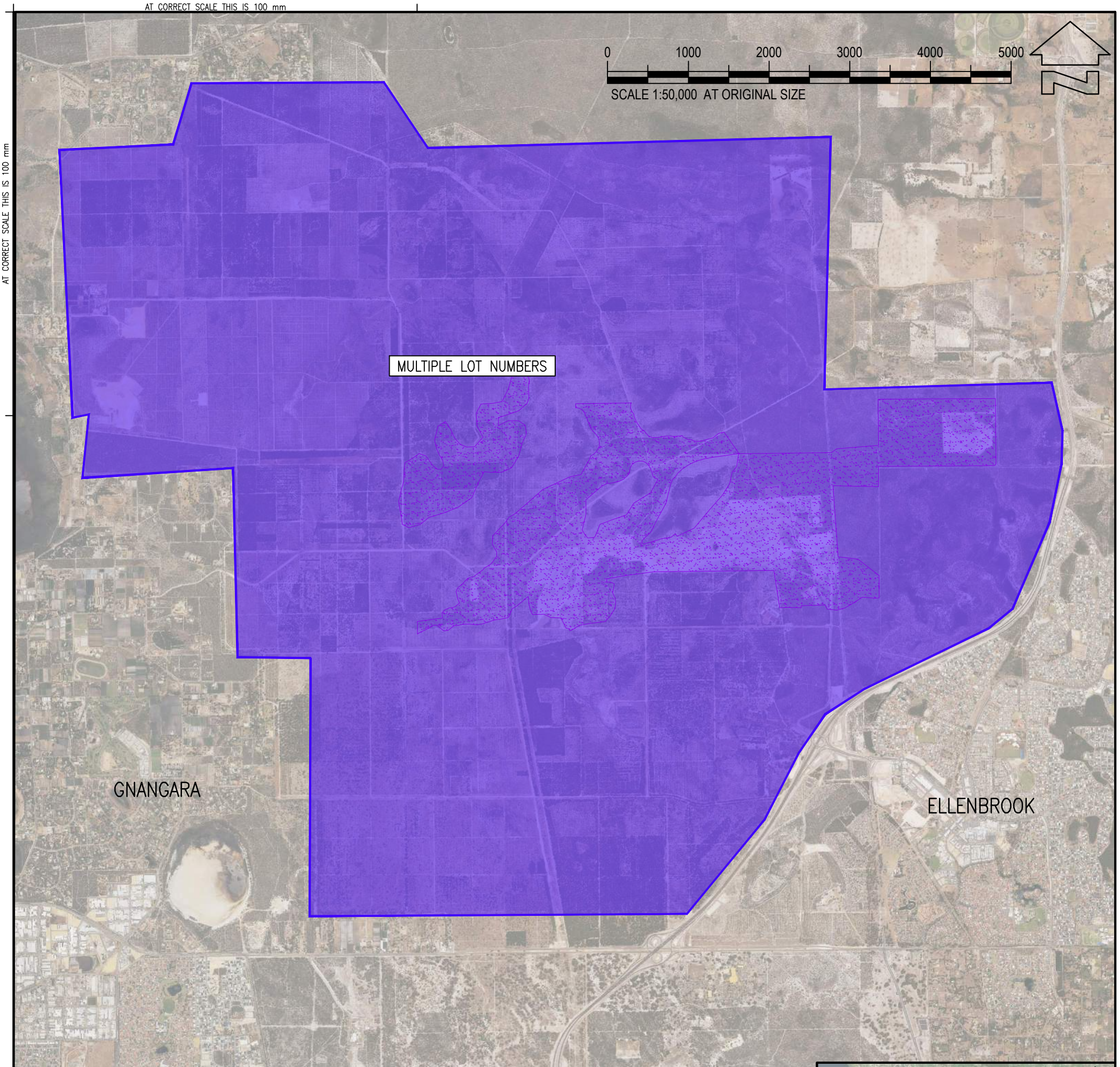

LOT/TENEMENT DETAILS			
NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
MULTIPLE LOT NUMBERS	GANANGARA PINE PLANTATIONS	VARIOUS MINING LEASES	SAND

LEGEND:

- SAND
- LOT/TENEMENT BOUNDARY

NOTES:

1. SIGNIFICANT GEOLOGICAL SUPPLIES AND TENEMENTS BOUNDARIES SOURCED FROM DEPARTMENT OF MINES, INDUSTRY, REGULATION AND SAFETY (DMIRS) INTERACTIVE GEOLOGICAL MAP (GEOVIEW.WA).
2. LOT LOCATION OF EXISTING SOURCES PROVIDED BY SUPPLIERS.

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EXISTING SOURCES - SHEET 3 OF 10

FEBRUARY 2025

MATERIALS STUDY

SCALE AT A3 1:50,000

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SCALE 1:50,000 AT ORIGINAL SIZE

N

MILLENDON

LOT 11

LOT 193

JANE BROOK

LOT/TENEMENT DETAILS			
NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 11	TOODYAY ROAD, RED HILL	HEIDELBERG MATERIALS AUSTRALIA	HARD ROCK AGGREGATE
LOT 193			

LEGEND:

- CLAY
- HARD ROCK AGGREGATE
- LOT/TENEMENT BOUNDARY

NOTES:

1. SIGNIFICANT GEOLOGICAL SUPPLIES AND TENEMENTS BOUNDARIES SOURCED FROM DEPARTMENT OF MINES, INDUSTRY, REGULATION AND SAFETY (DMIRS) INTERACTIVE GEOLOGICAL MAP (GEOVIEW.WA).
2. LOT LOCATION OF EXISTING SOURCES PROVIDED BY SUPPLIERS.

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EXISTING SOURCES - SHEET 4 OF 10

FEBRUARY 2025

MATERIALS STUDY

SCALE AT A3 1:50,000

SK2108–02–04C

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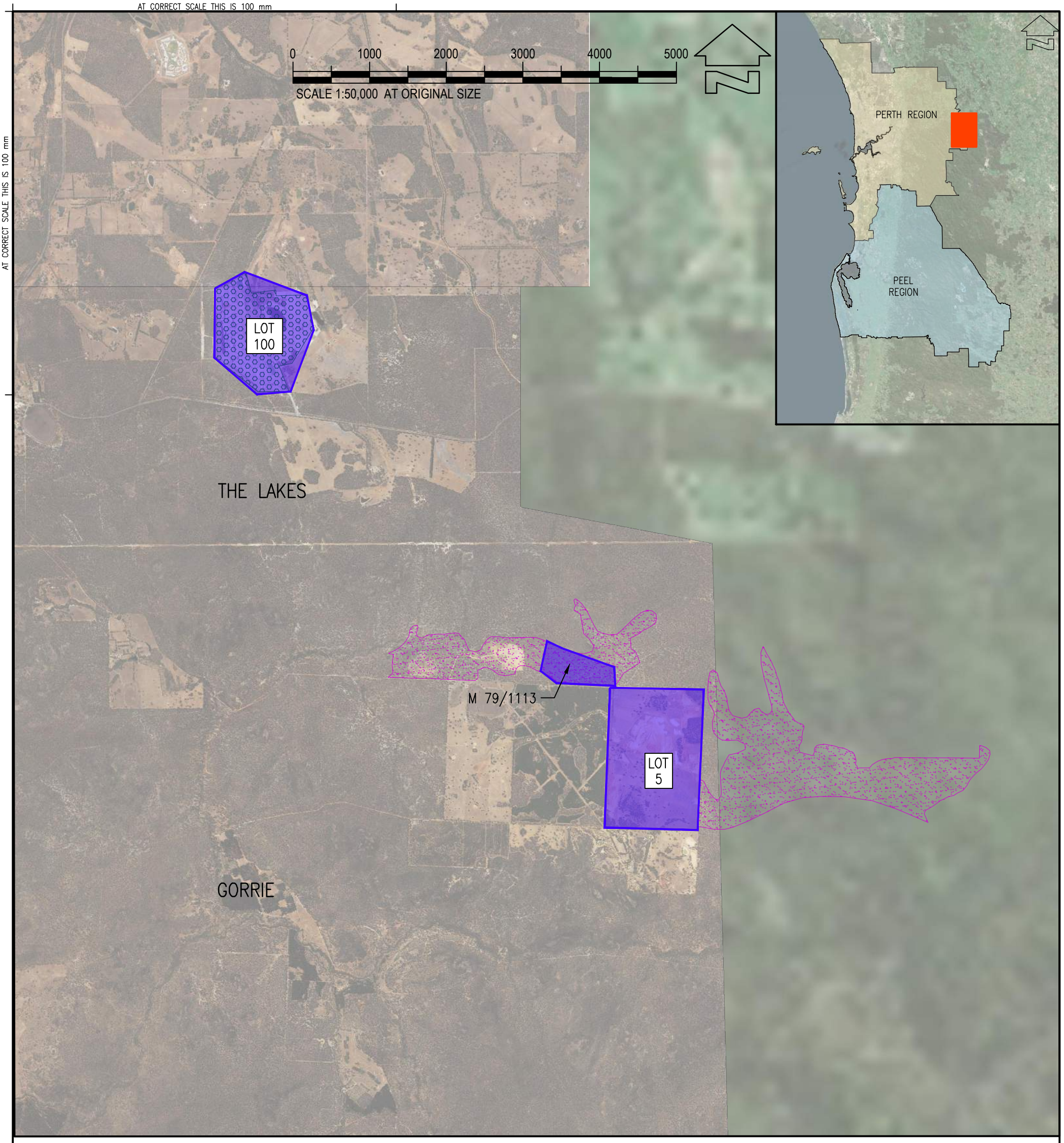

LOT/TENEMENT DETAILS			
NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 100	GREAT SOUTHERN HIGHWAY, KOOBEJA FARM	BGC PTY LTD	HARD ROCK AGGRAGATE
LOT 5	GOODS ROAD, THE LAKES	GREAT SAND SUPPLIES	SAND
M 79/1113		TUMA HOLDINGS PTY LTD/URBAN RESOURCES	SAND

LEGEND:

- SAND
- HARD ROCK AGGREGATE
- LOT/TENEMENT BOUNDARY

NOTES:

1. SIGNIFICANT GEOLOGICAL SUPPLIES AND TENEMENTS BOUNDARIES SOURCED FROM DEPARTMENT OF MINES, INDUSTRY, REGULATION AND SAFETY (DMIRS) INTERACTIVE GEOLOGICAL MAP (GEOVIEW.WA).
2. LOT LOCATION OF EXISTING SOURCES PROVIDED BY SUPPLIERS.

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EXISTING SOURCES - SHEET 5 OF 10

FEBRUARY 2025

MATERIALS STUDY

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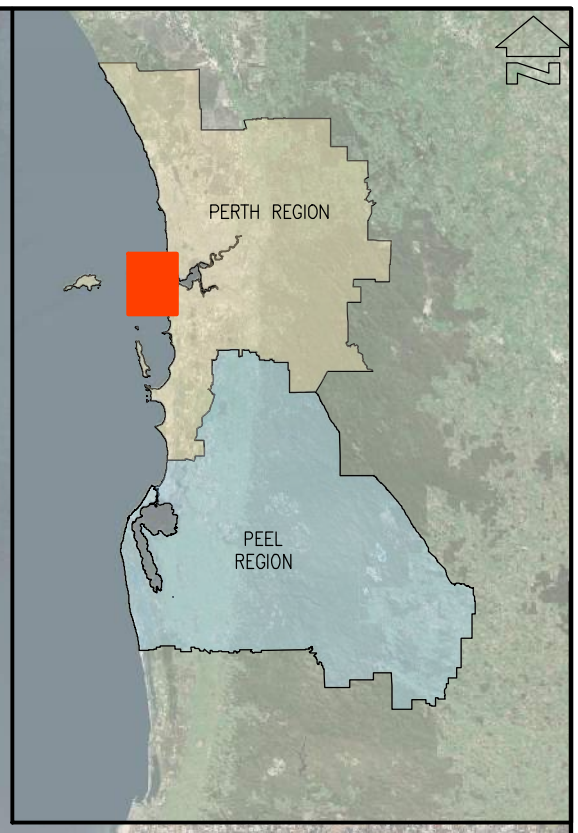

DEEPWATER CHANNEL
(STRAIGHT NORTH)

DEEPWATER
CHANNEL (BEND)

DEEPWATER CHANNEL
(STRAIGHT SOUTH)

FREMANTLE

LEGEND:

LOT/TENEMENT LOCATION

LOT/TENEMENT DETAILS			
NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
	DEEPWATER CHANNEL (STRAIGHT NORTH)	FREMANTLE PORTS AUTHORITY	SAND
	DEEPWATER CHANNEL (BEND)	FREMANTLE PORTS AUTHORITY	
	DEEPWATER CHANNEL (STRAIGHT SOUTH)	FREMANTLE PORTS AUTHORITY	

NOTES:

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2. LOT LOCATION OF RESOURCES PROVIDED BY SUPPLIERS.

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EXISTING SOURCES - SHEET 6 OF 10

MATERIALS STUDY

SCALE AT A3 1:100,000

FEBRUARY 2025

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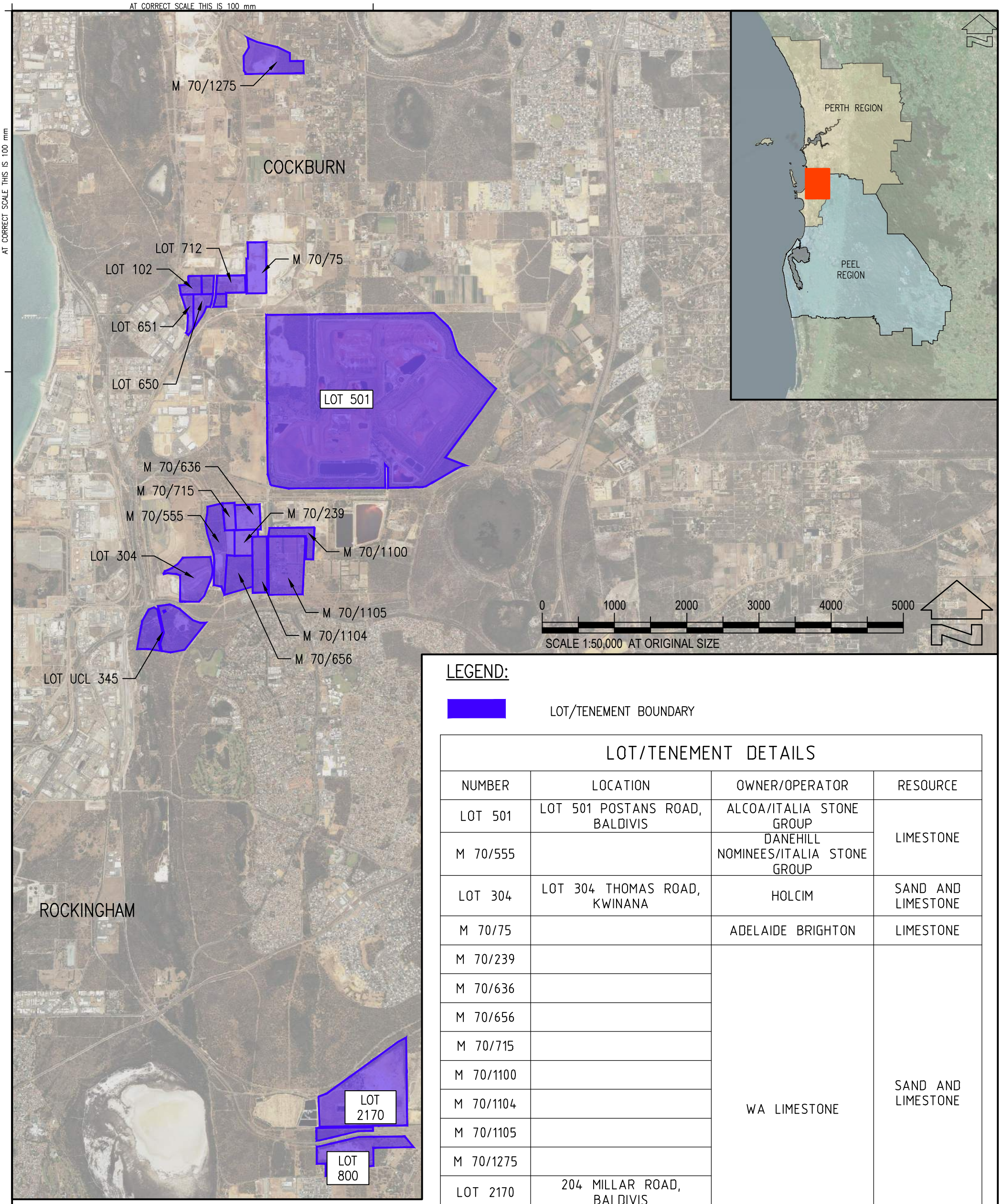

LEGEND:

LOT/TENEMENT BOUNDARY

LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 501	LOT 501 POSTANS ROAD, BALDIVIS	ALCOA/ITALIA STONE GROUP	LIMESTONE
M 70/555		DANEHILL NOMINEES/ITALIA STONE GROUP	
LOT 304	LOT 304 THOMAS ROAD, KWINANA	HOLCIM	SAND AND LIMESTONE
M 70/75		ADELAIDE BRIGHTON	LIMESTONE
M 70/239		WA LIMESTONE	SAND AND LIMESTONE
M 70/636			
M 70/656			
M 70/715			
M 70/1100			
M 70/1104			
M 70/1105			
M 70/1275			
LOT 2170	204 MILLAR ROAD, BALDIVIS		
LOT 800	LOT 800 KEROSENE LANE, BALDIVIS		
LOT 102, 650, 651, 721	LUSSKY ROAD, HOPE VALLEY		LIMESTONE
UCL 354	UCL 345 THOMAS ROAD, KWINANA	UNALLOCATED CROWN LAND	

NOTES:

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2. LOT LOCATION OF EXISTING SOURCES PROVIDED BY SUPPLIERS.

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EXISTING SOURCES - SHEET 7 OF 10

MATERIALS STUDY

SCALE AT A3 1:50,000

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BYFORD

WHITBY

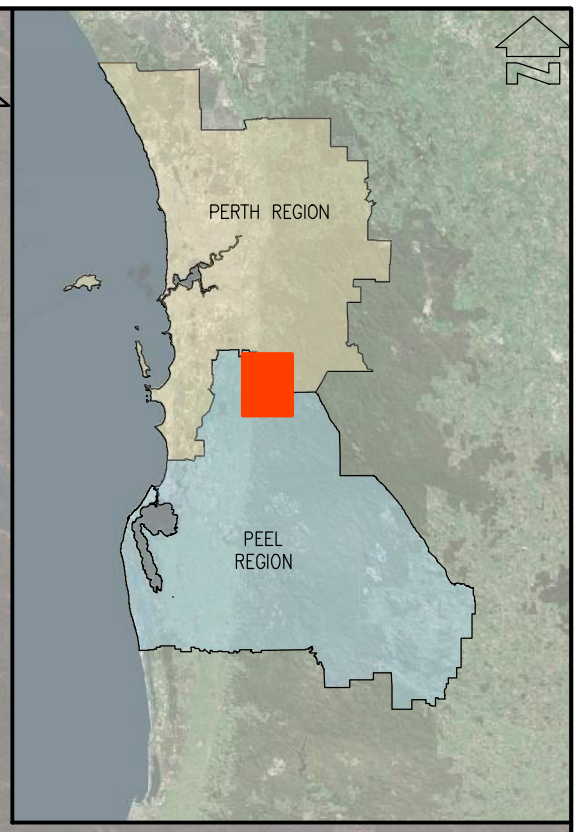
SERPENTINE

LOT 202

LOT 500

LOT 901

LOT 800



LEGEND:

- CLAY
- HARD ROCK AGGREGATE
- LOT/TENEMENT BOUNDARY

LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 901	1477 SOUTH WESTSERN HIGHWAY, WHITBY	WA LIMESTONE	HARD ROCK AGGREGATE
LOT 500	SOUTH WESTERN HIGHWAY, WHITBY		
LOT 800	PRUDEN ROAD, WHITBY	ITALIA STONE GROUP	
LOT 202	SOUTHWEST HIGHWAY, WHITBY	HEIDELBERG MATERIALS AUSTRALIA	

NOTES:

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2. LOT LOCATION OF EXISTING SOURCES PROVIDED BY SUPPLIERS.

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EXISTING SOURCES - SHEET 8 OF 10

MATERIALS STUDY

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FEBRUARY 2025

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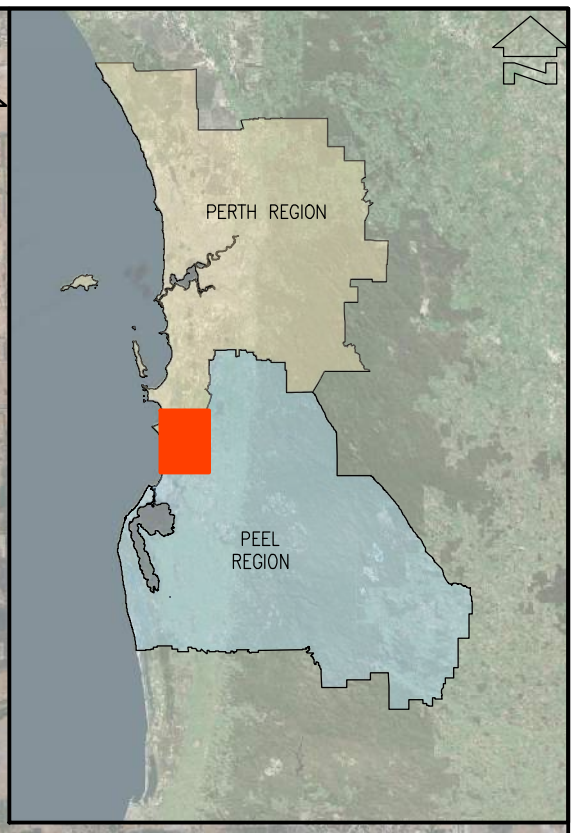

M 70/1046

ROCKINGHAM

M 70/1241

NAMBEELUP

LEGEND:

LOT/TENEMENT BOUNDARY

NOTES:

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2. LOT LOCATION OF SOURCES PROVIDED BY SUPPLIERS.

LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
M 70/1046	STAKEHILL ROAD, BALDIVIS	WA LIMESTONE	SAND
M 70/1241			

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EXISTING SOURCES - SHEET 9 OF 10

FEBRUARY 2025

MATERIALS STUDY

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AT CORRECT SCALE THIS IS 100 mm

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LEGEND:

SAND

LOT/TENEMENT BOUNDARY

LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
M 70/1319	PEPPERMINT GROVE ROAD, HERRON	WA LIMESTONE	SAND AND LIMESTONE
M 70/1320			
LOT 5	2711 OLD COAST ROAD, HERRON		
LOT 721	LOT 712 OLD COAST ROAD, HERRON	BUSHBEACH HOLDINGS	SAND
LOT 1001	LOT 1001 LAKE CLIFTON ROAD, CLIFTON	COUGAR SANDS	

NOTES:

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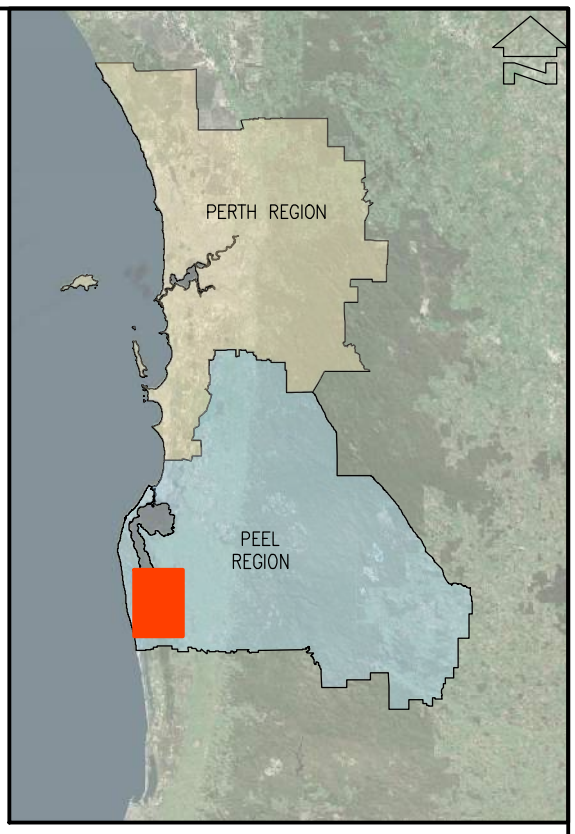
2. LOT LOCATION OF EXISTING SOURCES PROVIDED BY SUPPLIERS.



LOT 721

LOT 5

HERRON

LOT 1001

M 70/1320

M 70/1319

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SCALE 1:50,000 AT ORIGINAL SIZE

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EXISTING SOURCES - SHEET 10 OF 10

FEBRUARY 2025

MATERIALS STUDY

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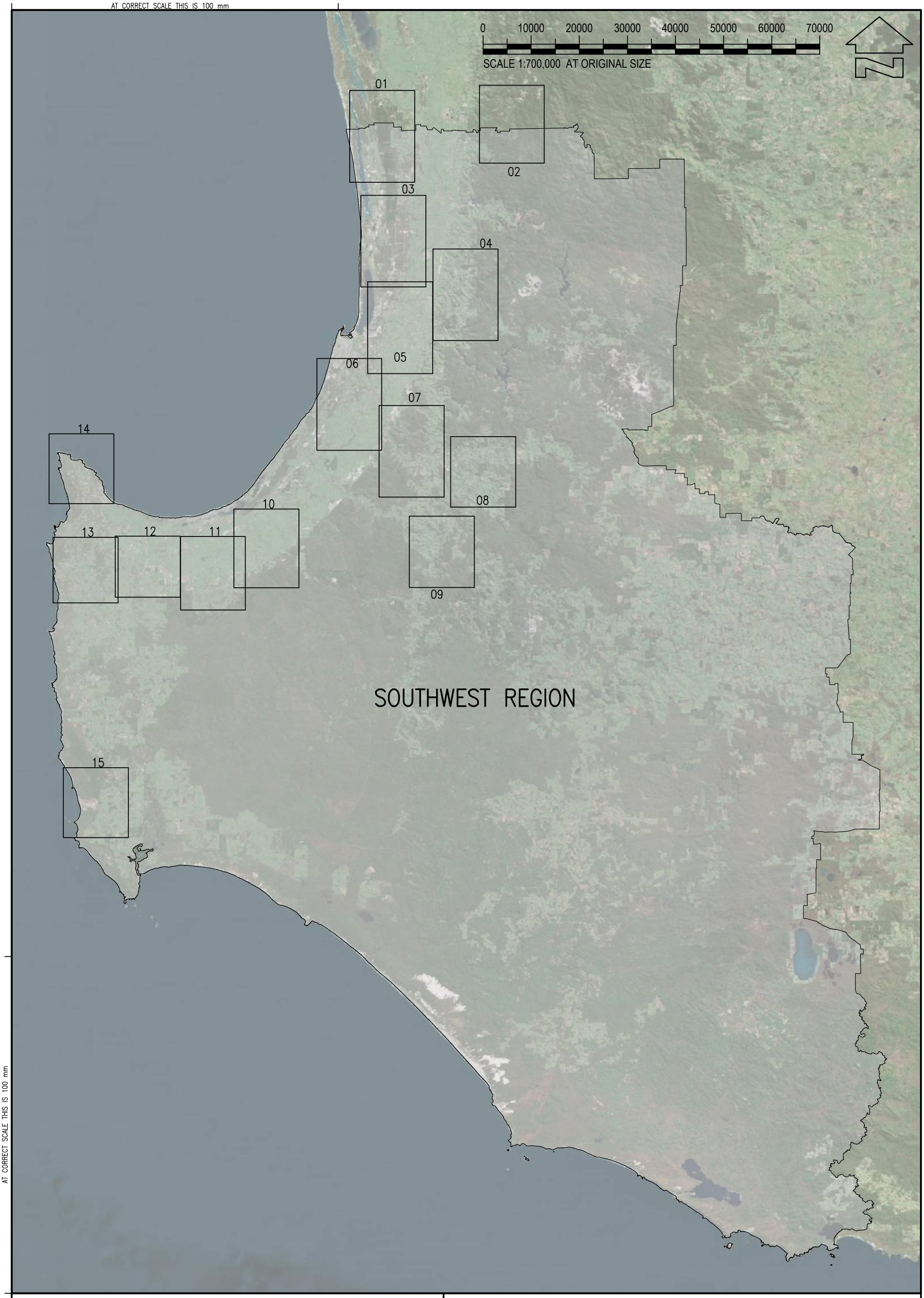

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LOCALITY PLAN

MATERIALS STUDY

SCALE AT A3 1:700,000

FEBRUARY 2025

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AT CORRECT SCALE THIS IS 100 mm

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SCALE 1:50,000 AT ORIGINAL SIZE

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M 70/1320

M 70/1319

M 70/1409

M 70/1408

M 70/1339

MYALUP

M 70/1383

LOT 2

LOT 4

LOT 5

LOT 1734

LOT 1794

LOT 3618

LOT 3671

AT CORRECT SCALE THIS IS 100 mm

LEGEND:

- SAND
- LIMESTONE
- LOT/TENEMENT BOUNDARY

NOTES:

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2. LOT LOCATIONS OF EXISTING SOURCES PROVIDED BY SUPPLIERS AND OTHER AVAILABLE INFORMATION.

LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
M 70/1319	PEPPERMINT GROVE RD, PRESTON BEACH	WA LIMESTONE	SAND AND LIMESTONE
M 70/1320			
M 70/1409	JOHNSTON RD, PRESTON BEACH	MGM BULK PTY LTD	SAND AND LIMESTONE
M 70/1339		CARBONE	SAND
M 70/1408	JOHNSTON RD, PRESTON BEACH	MGM BULK PTY LTD	SAND AND LIMESTONE
M 70/1383	BAGJEAU RD, MYALUP		LIMESTONE
LOT 2	LUDLOW RD, MYALUP	B&J CATALANO	
LOT 4			
LOT 5			
LOT 1734	FINN RD, MYALUP	B&T VERSACI	
LOT 1794		OHAMA NOMINEE LIMESTONE/MGM BULK PTY LTD	
LOT 3618	GILBERT RD, MYLAUP	LAKE PRESTONE LIME	
LOT 3671			

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EXISTING SOURCES - SHEET 1 OF 15

MATERIALS STUDY

SCALE AT A3 1:50,000

FEBRUARY 2025

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AT CORRECT SCALE THIS IS 100 mm

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SCALE 1:50,000 AT ORIGINAL SIZE

N

WAGERUP

LOT 2143

AT CORRECT SCALE THIS IS 100 mm

LEGEND:

GRAVEL

LOT/TENEMENT BOUNDARY

LOT/TENEMENT DETAILS			
NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 2143	WILLOWDALE RD, WAGERNUP	B&J CATALANO	GRAVEL

NOTES:

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2. LOT LOCATIONS OF EXISTING SOURCES PROVIDED BY SUPPLIERS AND OTHER AVAILABLE INFORMATION.

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EXISTING SOURCES - SHEET 2 OF 15

FEBRUARY 2025

MATERIALS STUDY

SCALE AT A3 1:50,000

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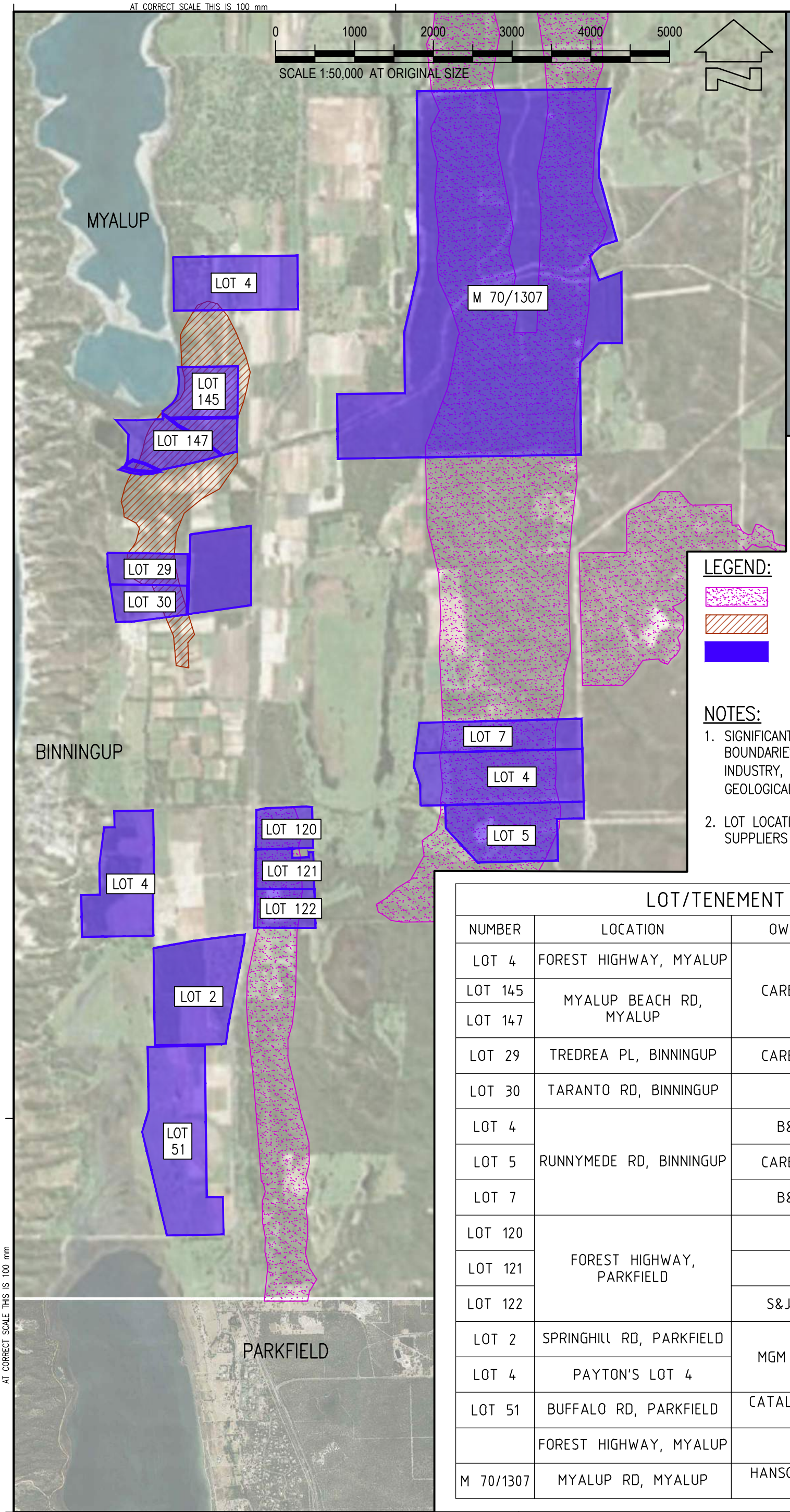

LEGEND:

- SAND
- LIMESTONE
- LOT/TENEMENT BOUNDARY

NOTES:

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2. LOT LOCATIONS OF EXISTING SOURCES PROVIDED BY SUPPLIERS AND OTHER AVAILABLE INFORMATION.

LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 4	FOREST HIGHWAY, MYALUP	CARBONE BROS P/L	LIMESTONE
LOT 145	MYALUP BEACH RD, MYALUP		
LOT 147			
LOT 29	TREDREA PL, BINNINGUP	CARBONE BROS P/L	
LOT 30	TARANTO RD, BINNINGUP	GIACCI	
LOT 4	RUNNYMEDE RD, BINNINGUP	B&J CATALANO	SAND
LOT 5		CARBONE BROS P/L	
LOT 7		B&J CATALANO	
LOT 120	FOREST HIGHWAY, PARKFIELD		
LOT 121			
LOT 122		S&J EXCAVATIONS	
LOT 2	SPRINGHILL RD, PARKFIELD	MGM BULK PTY LTD	SAND AND LIMESTONE
LOT 4	PAYTON'S LOT 4		LIMESTONE
LOT 51	BUFFALO RD, PARKFIELD	CATALANO INVESTMENT CORP P/L	
	FOREST HIGHWAY, MYALUP		
M 70/1307	MYALUP RD, MYALUP	HANSON CONSTRUCTION MATERIALS	SAND

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EXISTING SOURCES - SHEET 3 OF 15
MATERIALS STUDY
SCALE AT A3 1:50,000
FEBRUARY 2025
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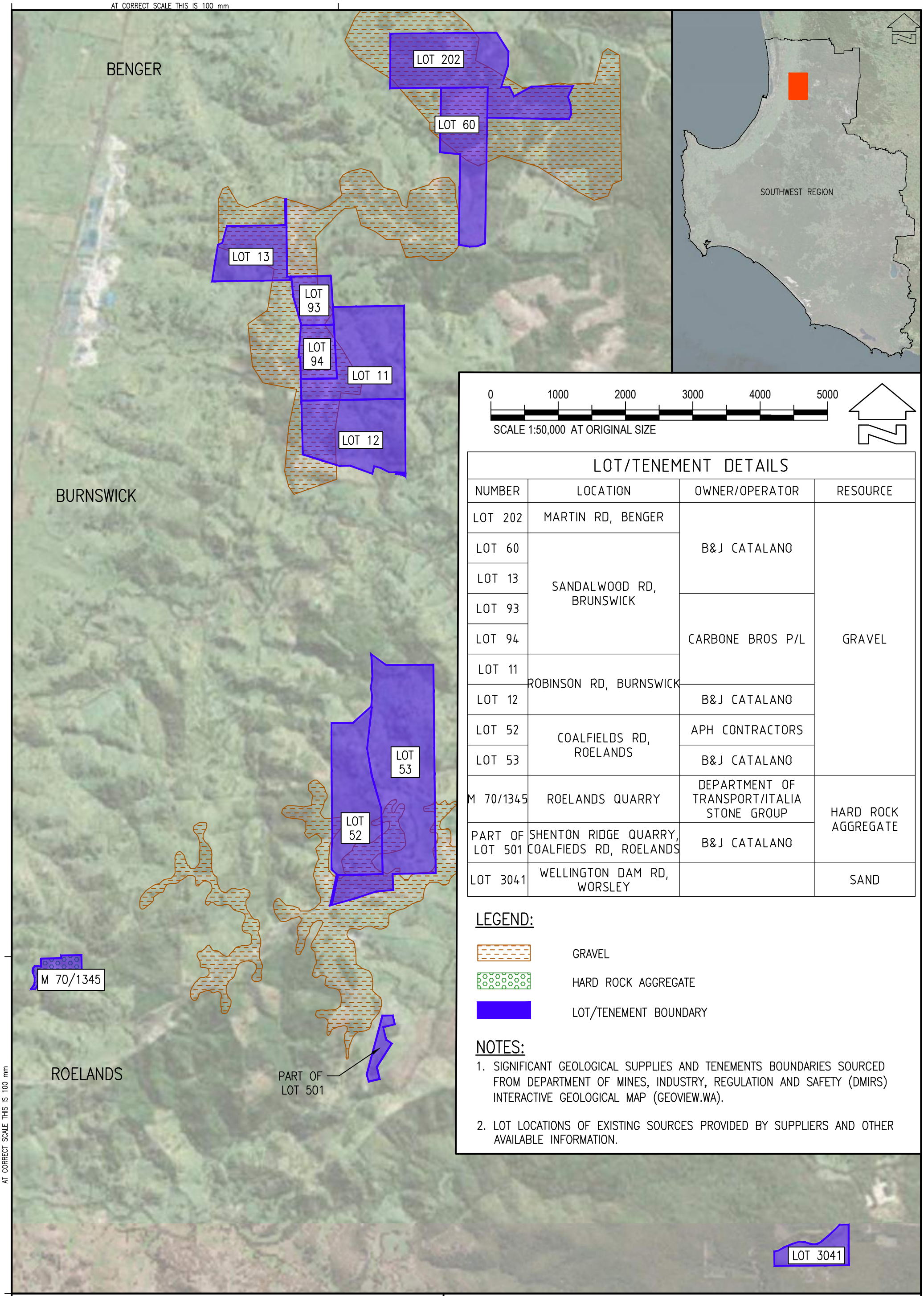

LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 202	MARTIN RD, BENGER	B&J CATALANO	GRAVEL
LOT 60	SANDALWOOD RD, BRUNSWICK		
LOT 13			
LOT 93		CARBONE BROS P/L	
LOT 94			
LOT 11	ROBINSON RD, BURNSWICK		
LOT 12		B&J CATALANO	
LOT 52	COALFIELDS RD, ROELANDS	APH CONTRACTORS	
LOT 53		B&J CATALANO	
M 70/1345	ROELANDS QUARRY	DEPARTMENT OF TRANSPORT/ITALIA STONE GROUP	HARD ROCK AGGREGATE
PART OF LOT 501	SHENTON RIDGE QUARRY, COALFIEDS RD, ROELANDS	B&J CATALANO	
LOT 3041	WELLINGTON DAM RD, WORSLEY		SAND

LEGEND:

- GRAVEL
- HARD ROCK AGGREGATE
- LOT/TENEMENT BOUNDARY

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2. LOT LOCATIONS OF EXISTING SOURCES PROVIDED BY SUPPLIERS AND OTHER AVAILABLE INFORMATION.

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EXISTING SOURCES - SHEET 4 OF 15

MATERIALS STUDY

SCALE AT A3 1:50,000

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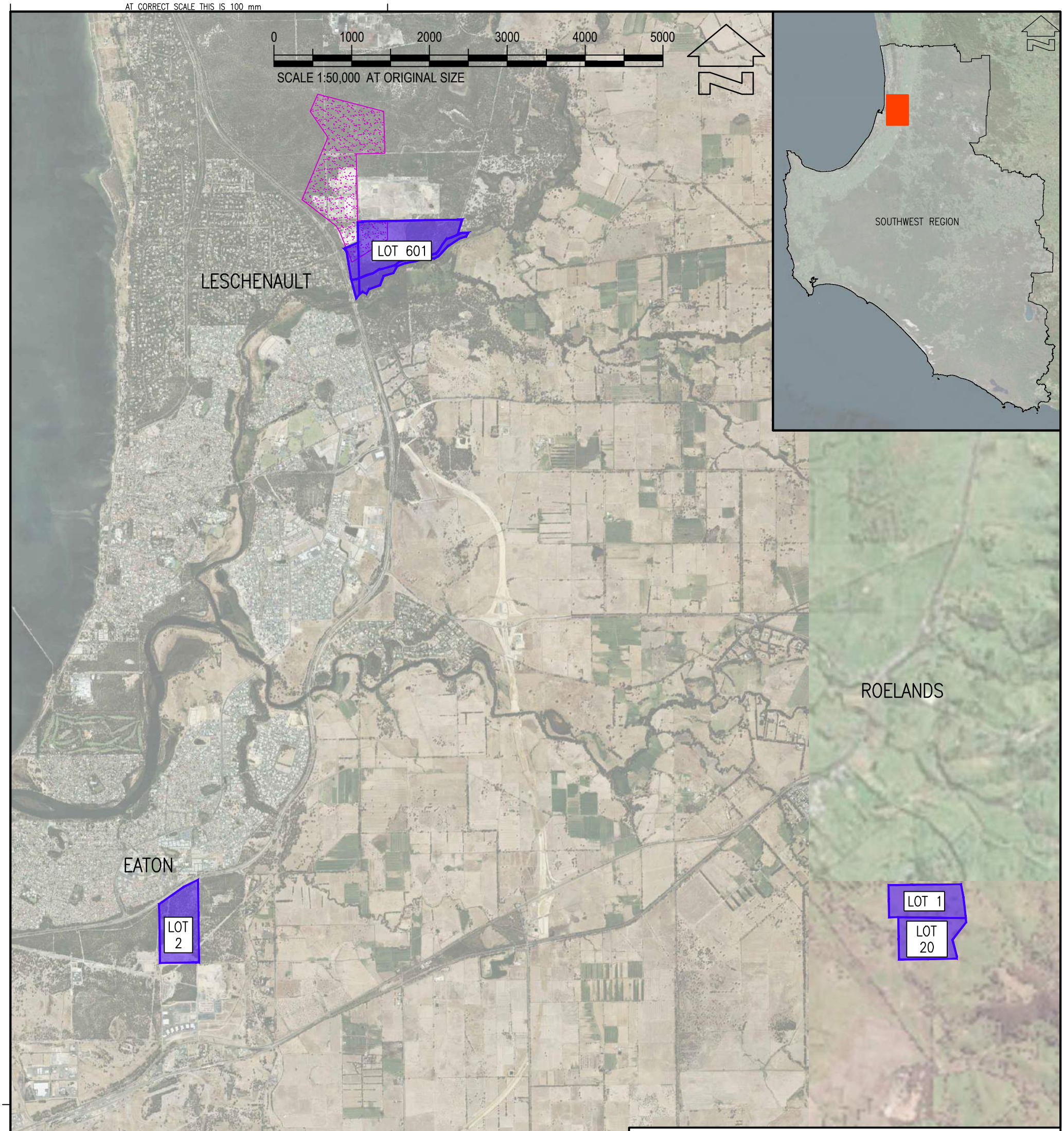

LEGEND:

SAND

LOT/TENEMENT BOUNDARY

LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 601		JW CORP	SAND
LOT 2	FOREST HIGHWAY, EATON	CHARLES HULL CONTRACTING	
LOT 1	SHENTON RD, BUREKUP	CARBONE BROS P/L	GRAVEL
LOT 20			

NOTES:

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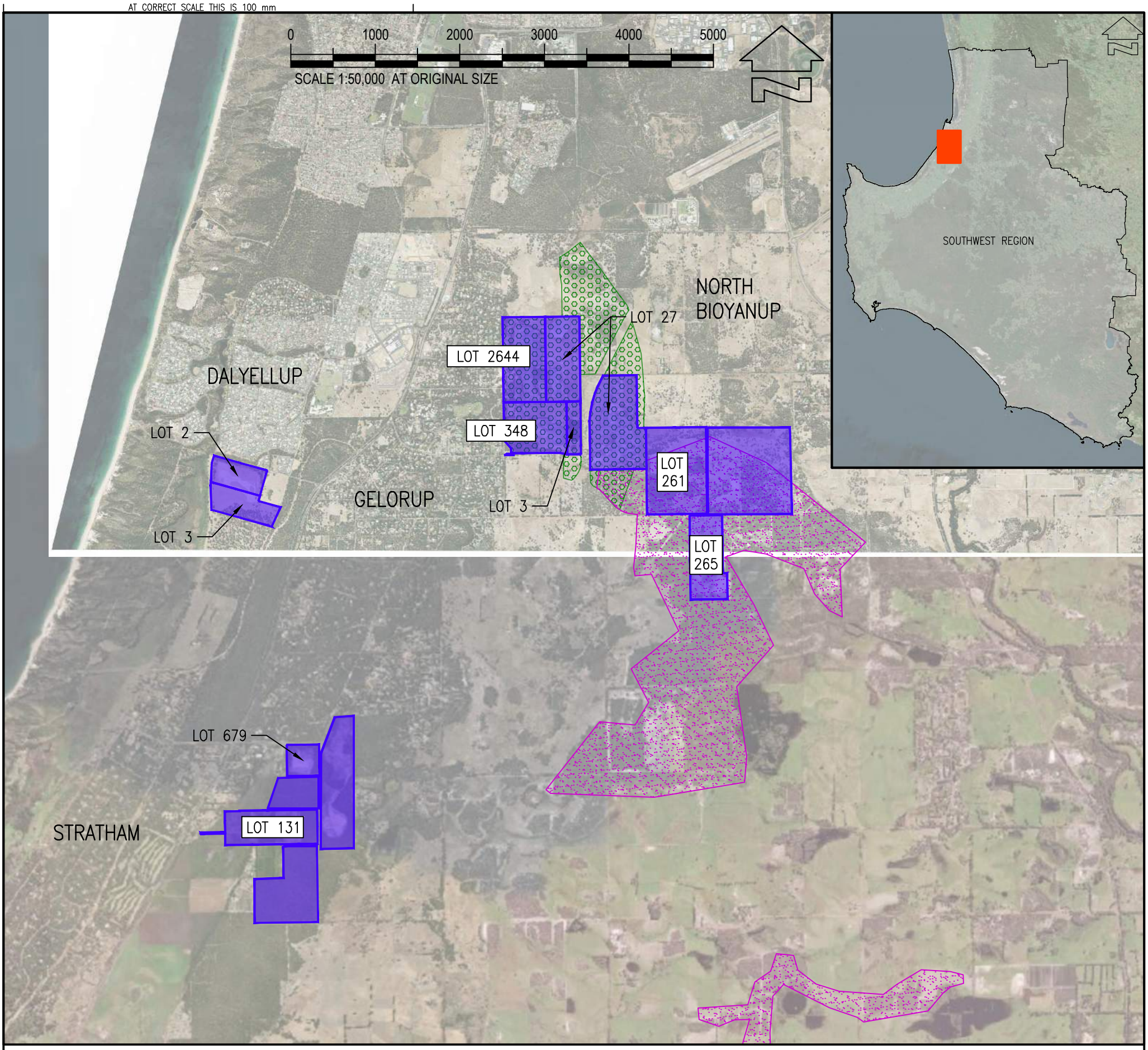

LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 2644	JULES RD, NORTH BOYANUP	HOLCIM	HARD ROCK AGGREGATE
LOT 348			
LOT 27	ALLENVILLE RD, NORTH BOYANUP	HEIDELBERG MATERIALS AUSTRALIA	
LOT 261	DUCANE RD, NORTH BOYANUP		SAND
LOT 265	QUEELUPRD, GELORU[P	MGM BULK PTY LTD	
LOT 2	HAREWOODS RD, DALYELLUP	PLACENTINI	
LOT 3			
LOT 679	CALINUP RD, STARTHAM	CARBONE BROS P/L	
LOT 131	BUSSELL RD, STARTHAM	B&J CATALANO	
	DUCANE ROAD, NORTH BOYANUP		
	CALINUP ROAD, STRATHAM		

LEGEND:

- SAND
- HARD ROCK AGGREGATE
- LOT/TENEMENT BOUNDARY

NOTES:

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EXISTING SOURCES - SHEET 6 OF 15

MATERIALS STUDY

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AT CORRECT SCALE THIS IS 100 mm

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SCALE 1:50,000 AT ORIGINAL SIZE

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LOT 26

LOT 359

BOYANUP

LOT 393

LOT 287

GWINDINUP

LOT 1000

M 70/1217

LOT 102

BEELERUP

DONNYBROOK

UPPER CAPEL

R17665 3668

R37474 5343

LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 393	LOWRIE RD, GWINDINUP	MGM BULK PTY LTD	SAND/GRAVEL
LOT 287	GWINDINUP EASTERN		GRAVEL
LOT 1000	MEOTTI RD, DONNYBROOK	GOSFORD QUARIES	HARD ROCK DIMENSION STONE
M 70/1217	UPPER CAPEL RD	ITALIA STONE GROUP	
LOT 102	BEELERUP RD, BEELERUP	DONNYBROOKE SANDSTONE	
R17665 3668	UPPER CAPEL RD	RUSO PL	
R37474 5343			
LOT 26	PERRY RD, BOYANUP	PLACENTINI	GRAVEL
LOT 359		THEAKSTONE	SAND/GRAVEL

LEGEND:

SAND

HARD ROCK DIMENSION STONE

LOT/TENEMENT BOUNDARY

NOTES:

1. SIGNIFICANT GEOLOGICAL SUPPLIES AND TENEMENTS BOUNDARIES SOURCED FROM DEPARTMENT OF MINES, INDUSTRY, REGULATION AND SAFETY (DMIRS) INTERACTIVE GEOLOGICAL MAP (GEOVIEW.WA).
2. LOT LOCATIONS OF EXISTING SOURCES PROVIDED BY SUPPLIERS AND OTHER AVAILABLE INFORMATION.

AT CORRECT SCALE THIS IS 100 mm

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t: +61 8 9254 6600
admin@coastsandports.com.au

EXISTING SOURCES - SHEET 7 OF 15

MATERIALS STUDY

SCALE AT A3 1:50,000

FEBRUARY 2025

SK2108-05-07B

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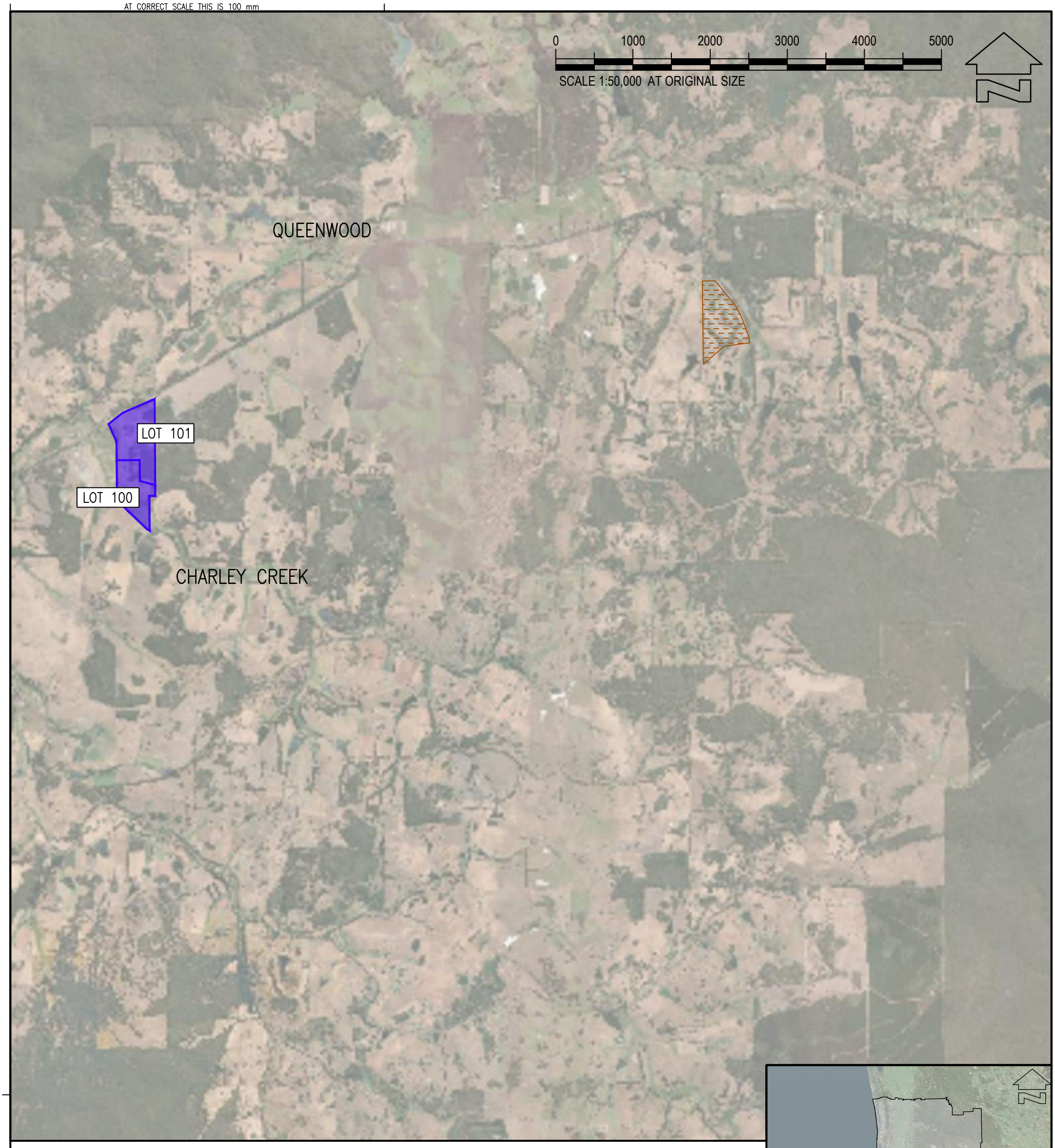
AT CORRECT SCALE THIS IS 100 mm



LOT/TENEMENT DETAILS			
NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 100	CHARLEY CREEK RD, CHARLEY CREEK	HEARMAN	SAND
LOT 101			

LEGEND:

GRAVEL

LOT/TENEMENT BOUNDARY

NOTES:

1. SIGNIFICANT GEOLOGICAL SUPPLIES AND TENEMENTS BOUNDARIES SOURCED FROM DEPARTMENT OF MINES, INDUSTRY, REGULATION AND SAFETY (DMIRS) INTERACTIVE GEOLOGICAL MAP (GEOVIEW.WA).
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EXISTING SOURCES - SHEET 8 OF 15

MATERIALS STUDY

SCALE AT A3 1:50,000

FEBRUARY 2025

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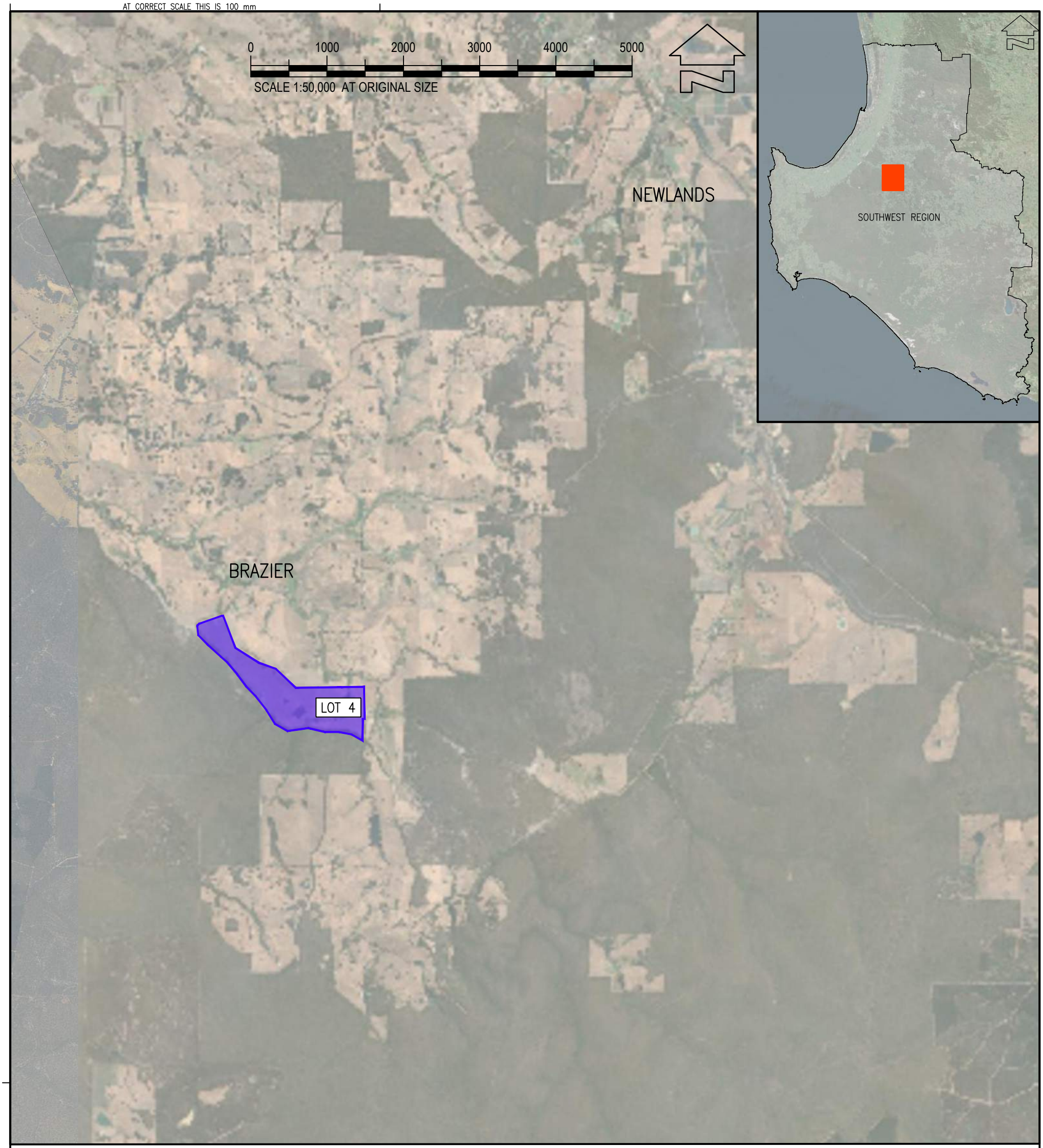

LOT/TENEMENT DETAILS			
NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 4	RAVENSCLIFFE RD, BRAZIER	CAVALLARO	SAND

LEGEND:

LOT/TENEMENT BOUNDARY

NOTES:

1. SIGNIFICANT GEOLOGICAL SUPPLIES AND TENEMENTS BOUNDARIES SOURCED FROM DEPARTMENT OF MINES, INDUSTRY, REGULATION AND SAFETY (DMIRS) INTERACTIVE GEOLOGICAL MAP (GEOVIEW.WA).
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EXISTING SOURCES - SHEET 9 OF 15

MATERIALS STUDY

SCALE AT A3 1:50,000

FEBRUARY 2025

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AT CORRECT SCALE THIS IS 100 mm

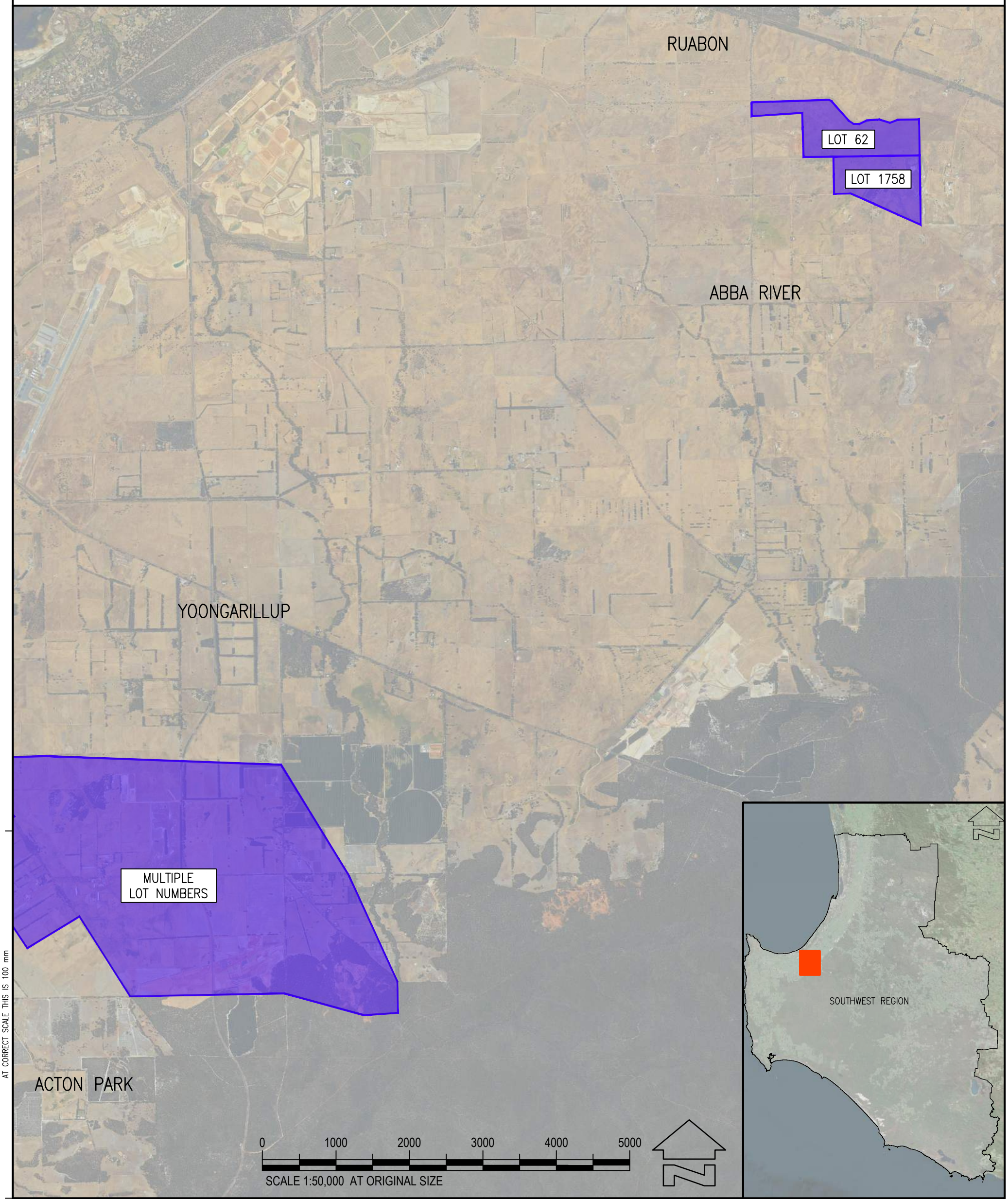
LOT/TENEMENT DETAILS			
NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
MULTIPLE LOT NUMBERS	YOONGARILLUP ROAD, SABINA RIVER	VARIOUS MINING LEASES	SAND AND GRAVEL
LOT 62	LUDLOW-HITHERGREEN RD	MGM BULK PTY LTD	GRAVEL
LOT 1758	GULBERTI RD, RUABON	HARBECK'S TRANSPORT	SAND/GRAVEL

LEGEND:

LOT/TENEMENT BOUNDARY

NOTES:

1. SIGNIFICANT GEOLOGICAL SUPPLIES AND TENEMENTS BOUNDARIES SOURCED FROM DEPARTMENT OF MINES, INDUSTRY, REGULATION AND SAFETY (DMIRS) INTERACTIVE GEOLOGICAL MAP (GEOVIEW.WA).
2. LOT LOCATIONS OF EXISTING SOURCES PROVIDED BY SUPPLIERS AND OTHER AVAILABLE INFORMATION.



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MATERIALS STUDY

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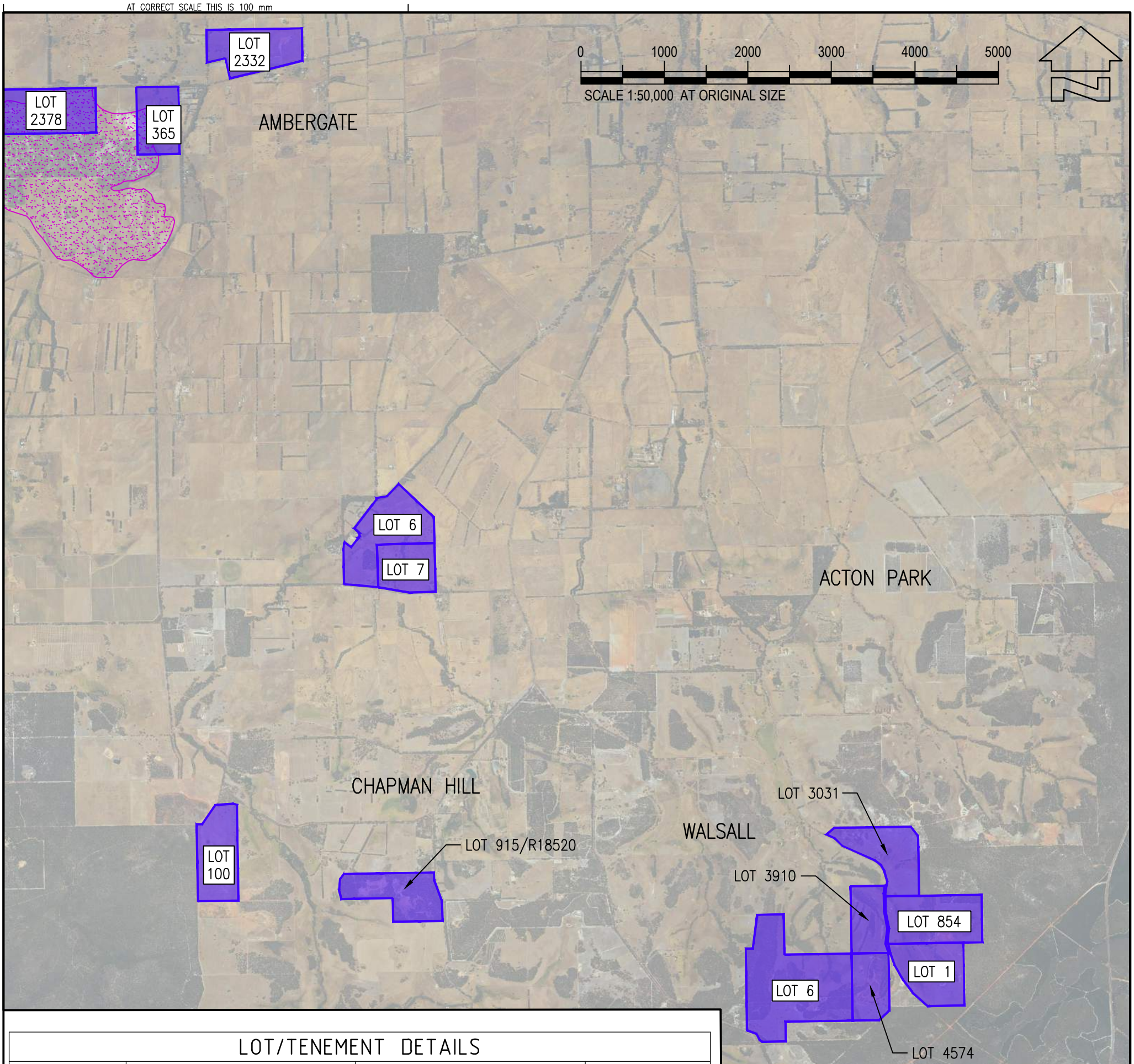

LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 2378	AMBERGATE RD, AMBERGATE	PLANSCAPE	SAND
LOT 2332		SUE	
LOT 365		SIMPSON SAND SUPPLIES	
LOT 3031	SIMPSON RD, WALSALL	APH CONTRACTORS	
LOT 3910	JALBARRAGUP RD, WALSALL		GRAVEL
LOT 854		W&T McGREGOR	SAND AND GRAVEL
LOT 1			
LOT 6		APH CONTRACTORS	
LOT 4574			
LOT 100	JAMINSONS RD, CHAPMAN HILL	B&J CATALANO	GRAVEL
LOT 915/R18520	CHAPMAN HILL RD, CHAPMAN HILL	CITY OF BUSSELTON	SAND AND GRAVEL
LOT 6	DON RD, CHAPMAN HILL	HARBECK D WALTERS	SAND
LOT 7			

LEGEND:

SAND

LOT/TENEMENT BOUNDARY

NOTES:

1. SIGNIFICANT GEOLOGICAL SUPPLIES AND TENEMENTS BOUNDARIES SOURCED FROM DEPARTMENT OF MINES, INDUSTRY, REGULATION AND SAFETY (DMIRS) INTERACTIVE GEOLOGICAL MAP (GEOVIEW.WA).
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EXISTING SOURCES - SHEET 11 OF 15

MATERIALS STUDY

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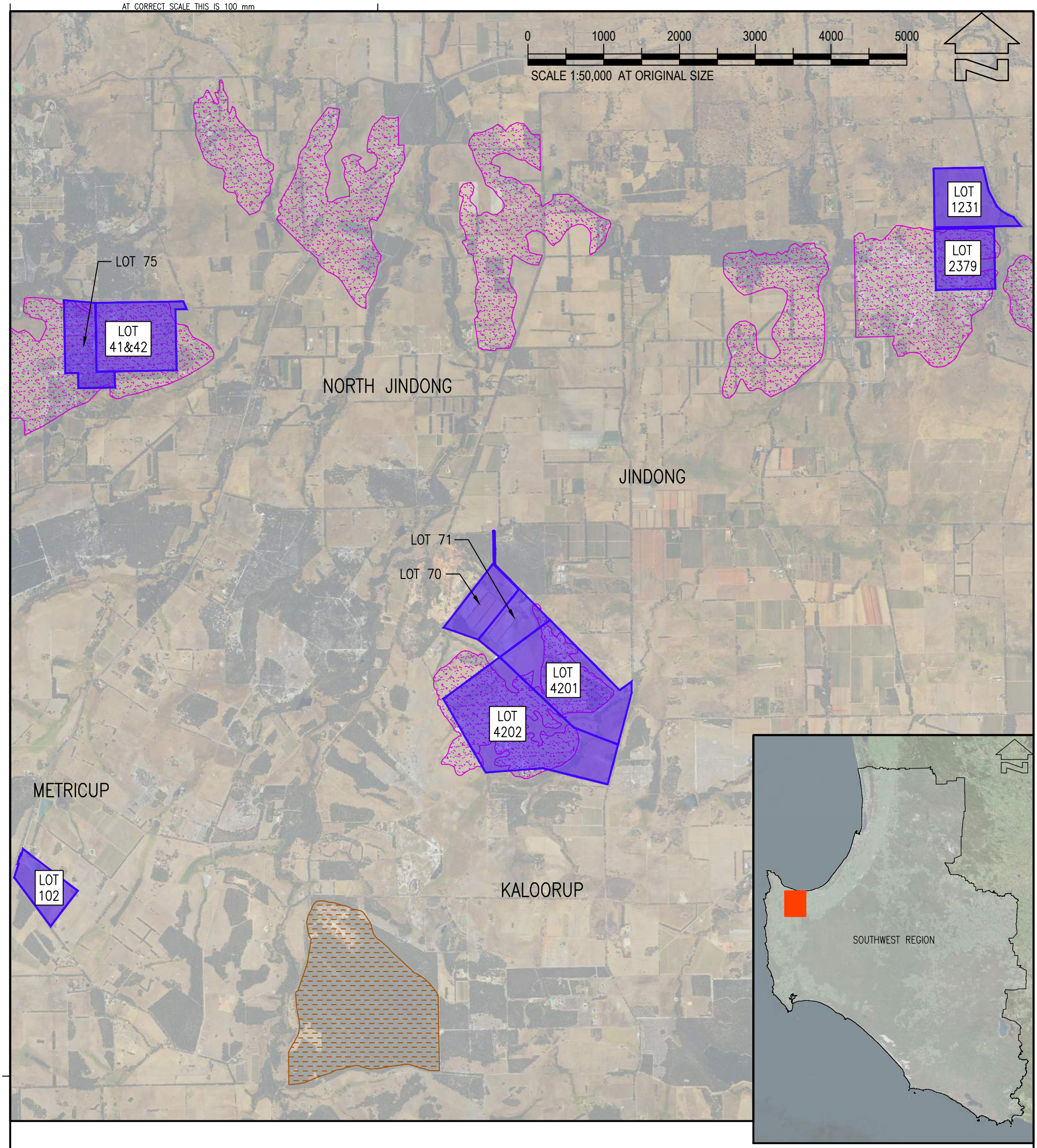

LOT/TENEMENT DETAILS

NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 1231	BOALLIA RD, VASSE	P DAWSON	SAND
LOT 2379			
LOT 75	HAAG RD, YELVERTON	A CREDARO ET AL	
LOT 41&42	CHAMBERS RD, YELVERTON		
LOT 4201	JINDONG-TREETON RD, KALOORUP	ROB PAUL & ASSOCIATES	SAND
LOT 4202		P&G SMITH	SAND/GRAVEL
LOT 102	WORGAN RD, METRICUP	MJC PTY LTD	SAND

LEGEND:

- SAND
- GRAVEL
- LOT/TENEMENT BOUNDARY

NOTES:

1. SIGNIFICANT GEOLOGICAL SUPPLIES AND TENEMENTS BOUNDARIES SOURCED FROM DEPARTMENT OF MINES, INDUSTRY, REGULATION AND SAFETY (DMIRS) INTERACTIVE GEOLOGICAL MAP (GEOVIEW.WA).
2. LOT LOCATIONS OF EXISTING SOURCES PROVIDED BY SUPPLIERS AND OTHER AVAILABLE INFORMATION.

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EXISTING SOURCES - SHEET 12 OF 15

MATERIALS STUDY

SCALE AT A3 1:50,000

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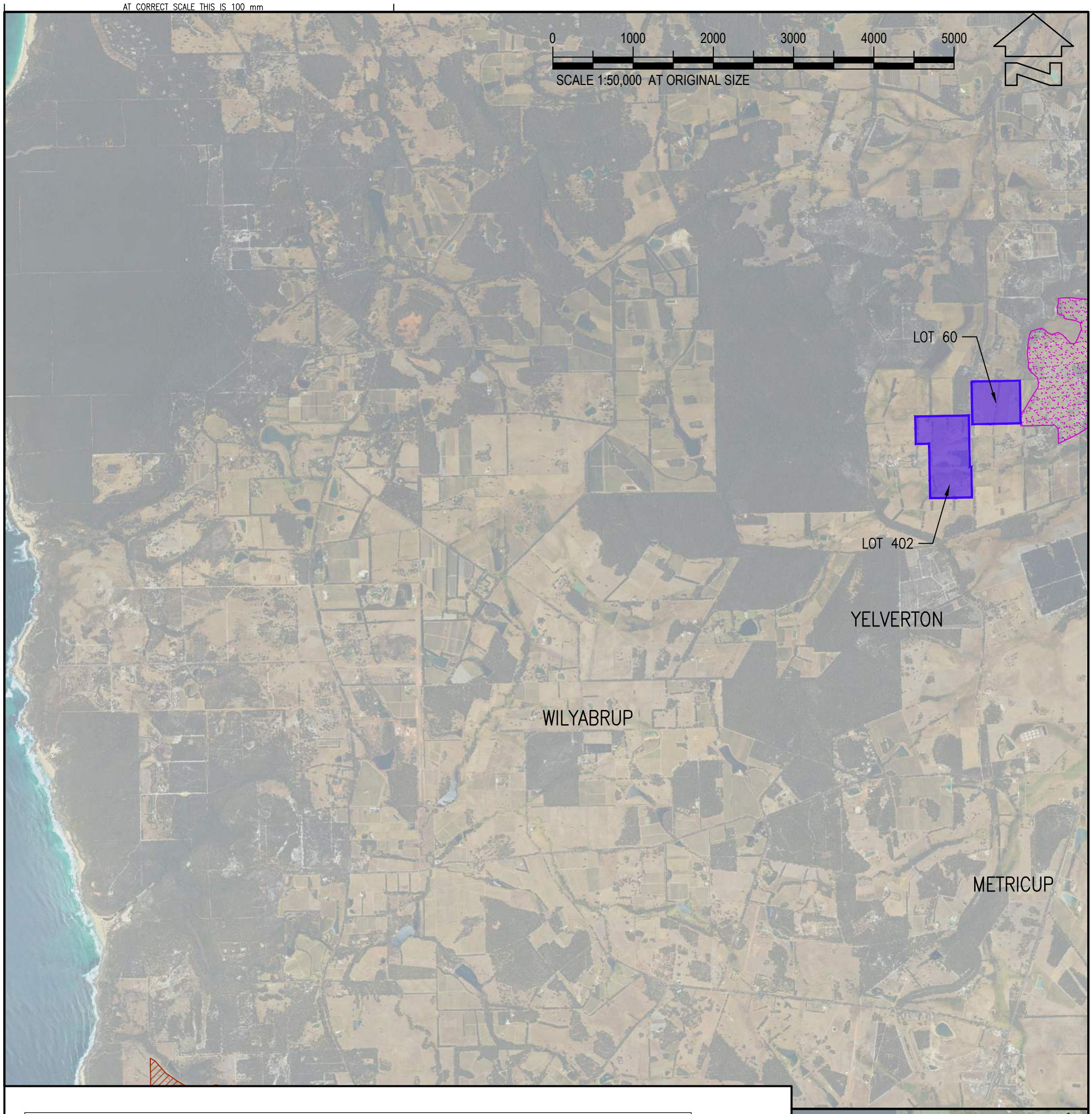
AT CORRECT SCALE THIS IS 100 mm



LOT/TENEMENT DETAILS			
NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 60	YELVERTON NORTH RD, YELVERTON	ROBERT POOLE	SAND
LOT 402			

LEGEND:

SAND

LOT/TENEMENT BOUNDARY

NOTES:

1. SIGNIFICANT GEOLOGICAL SUPPLIES AND TENEMENTS BOUNDARIES SOURCED FROM DEPARTMENT OF MINES, INDUSTRY, REGULATION AND SAFETY (DMIRS) INTERACTIVE GEOLOGICAL MAP (GEOVIEW.WA).
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EXISTING SOURCES - SHEET 13 OF 15

MATERIALS STUDY

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AT CORRECT SCALE THIS IS 100 mm

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SCALE 1:50,000 AT ORIGINAL SIZE

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CAPE NATURALISTE

EAGLE BAY

LOT 61

LOT 64

NATURALISTE

LOT/TENEMENT DETAILS			
NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
LOT 61 & 64	CAPE NATURALISTE RD, NATURALISTE	CARDNO/MILES	SAND AND GRAVEL

LEGEND:

LOT/TENEMENT BOUNDARY

NOTES:

1. SIGNIFICANT GEOLOGICAL SUPPLIES AND TENEMENTS BOUNDARIES SOURCED FROM DEPARTMENT OF MINES, INDUSTRY, REGULATION AND SAFETY (DMIRS) INTERACTIVE GEOLOGICAL MAP (GEOVIEW.WA).
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EXISTING SOURCES - SHEET 14 OF 15

MATERIALS STUDY

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AT CORRECT SCALE THIS IS 100 mm

LOT/TENEMENT DETAILS			
NUMBER	LOCATION	OWNER/OPERATOR	RESOURCE
M 70/1302	CAVES RD, BORANUP	ENMIC PTY LTD	SAND

LEGEND:

LOT/TENEMENT BOUNDARY

NOTES:

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EXISTING SOURCES - SHEET 15 OF 15

MATERIALS STUDY

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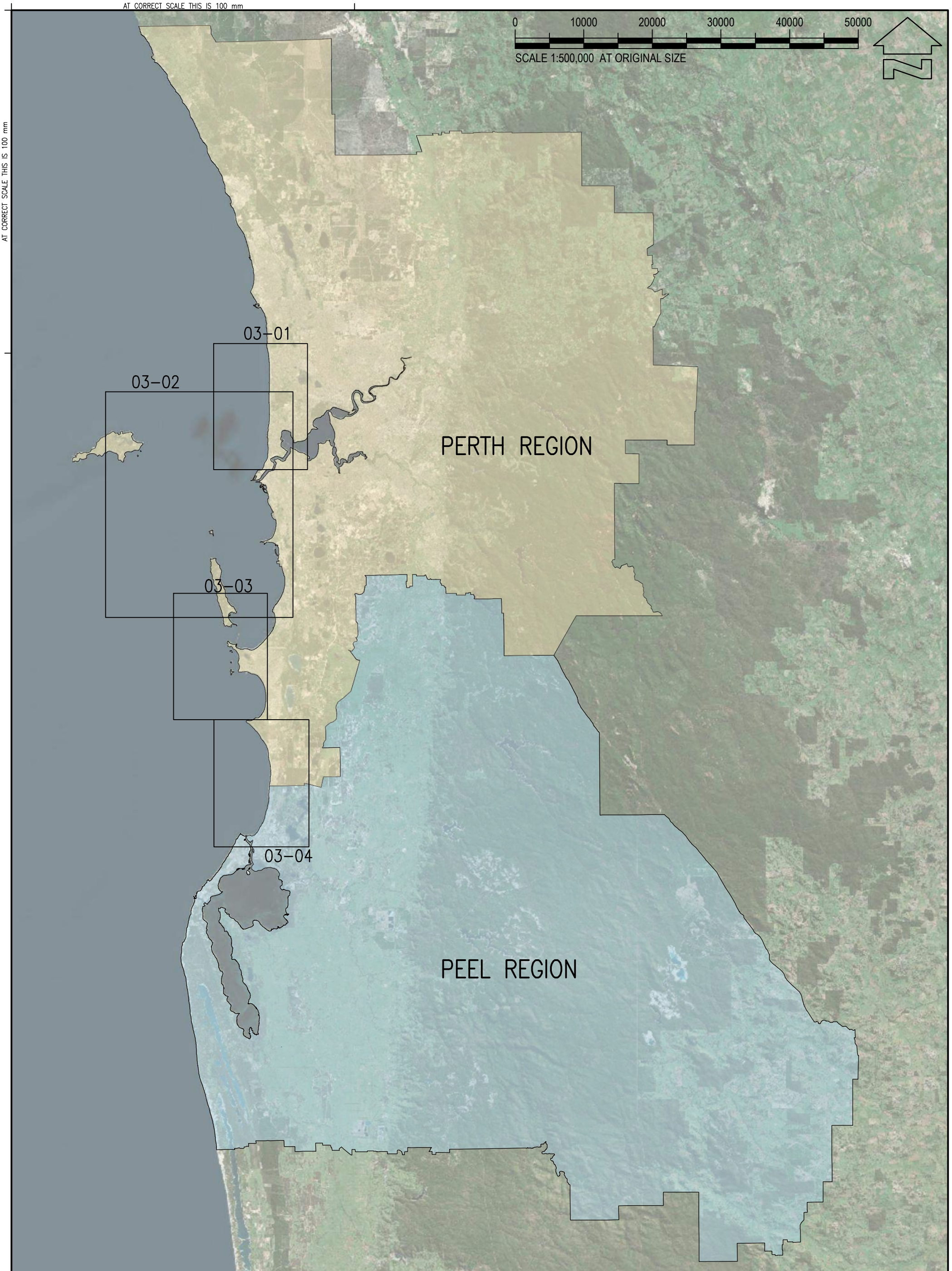
Appendix E Potential Marine Sources

AT CORRECT SCALE THIS IS 100 mm

AT CORRECT SCALE THIS IS 100 mm



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LOCALITY PLAN

MATERIALS STUDY

SCALE AT A3 1:500,000

FEBRUARY 2025

SK2108–03–00B

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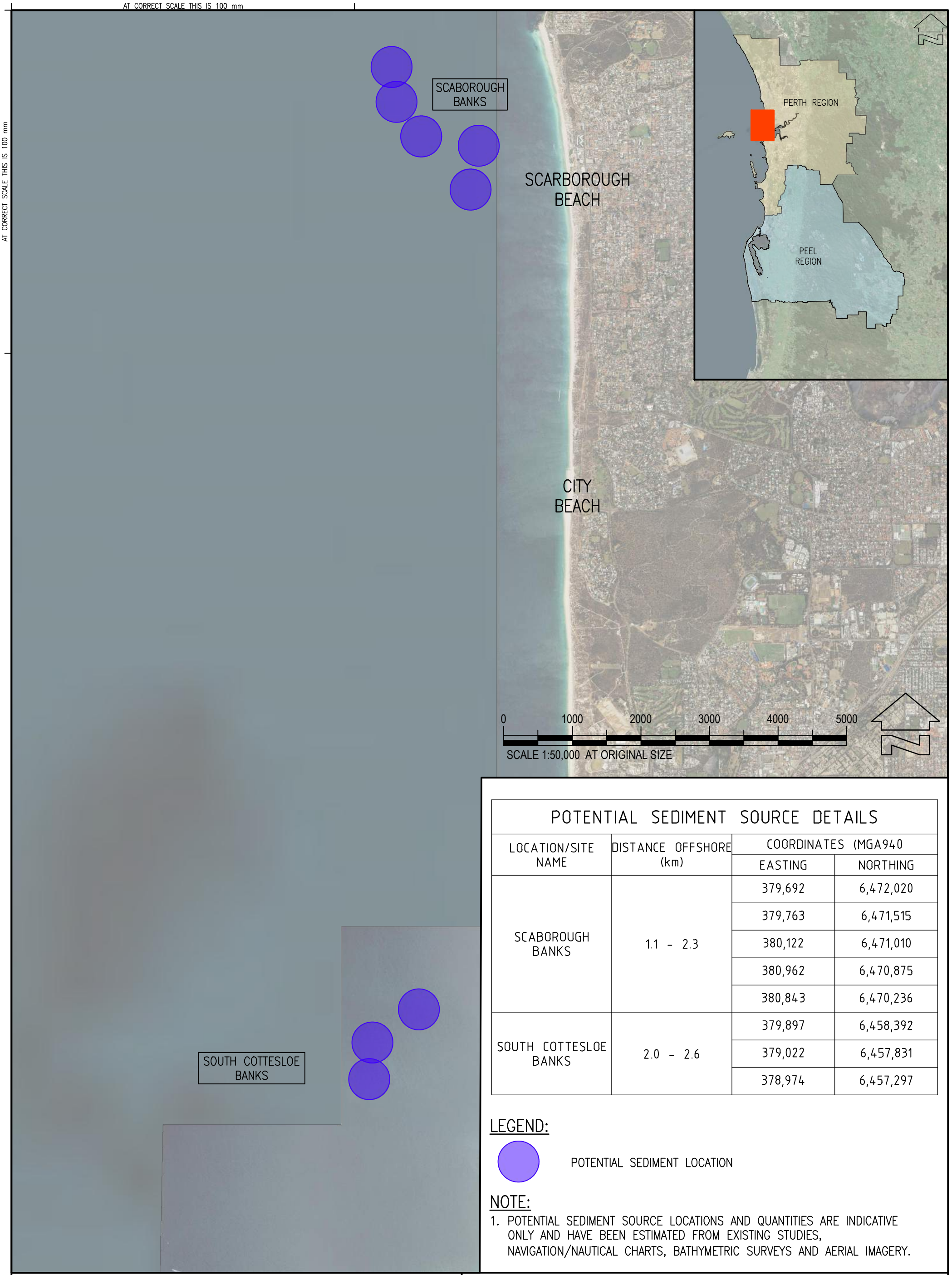
AT CORRECT SCALE THIS IS 100 mm

AT CORRECT SCALE THIS IS 100 mm



POTENTIAL SEDIMENT SOURCE DETAILS

LOCATION/SITE NAME	DISTANCE OFFSHORE (km)	COORDINATES (MGA940	
		EASTING	NORTHING
SCABOROUGH BANKS	1.1 - 2.3	379,692	6,472,020
		379,763	6,471,515
		380,122	6,471,010
		380,962	6,470,875
		380,843	6,470,236
SOUTH COTTESLOE BANKS	2.0 - 2.6	379,897	6,458,392
		379,022	6,457,831
		378,974	6,457,297

LEGEND:

POTENTIAL SEDIMENT LOCATION

NOTE:

1. POTENTIAL SEDIMENT SOURCE LOCATIONS AND QUANTITIES ARE INDICATIVE ONLY AND HAVE BEEN ESTIMATED FROM EXISTING STUDIES, NAVIGATION/NAUTICAL CHARTS, BATHYMETRIC SURVEYS AND AERIAL IMAGERY.

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POTENTIAL SEDIMENT SOURCES - SHEET 1 OF 4

FEBRUARY 2025

MATERIALS STUDY

SCALE AT A3 1:50,000

SK2108-03-01B

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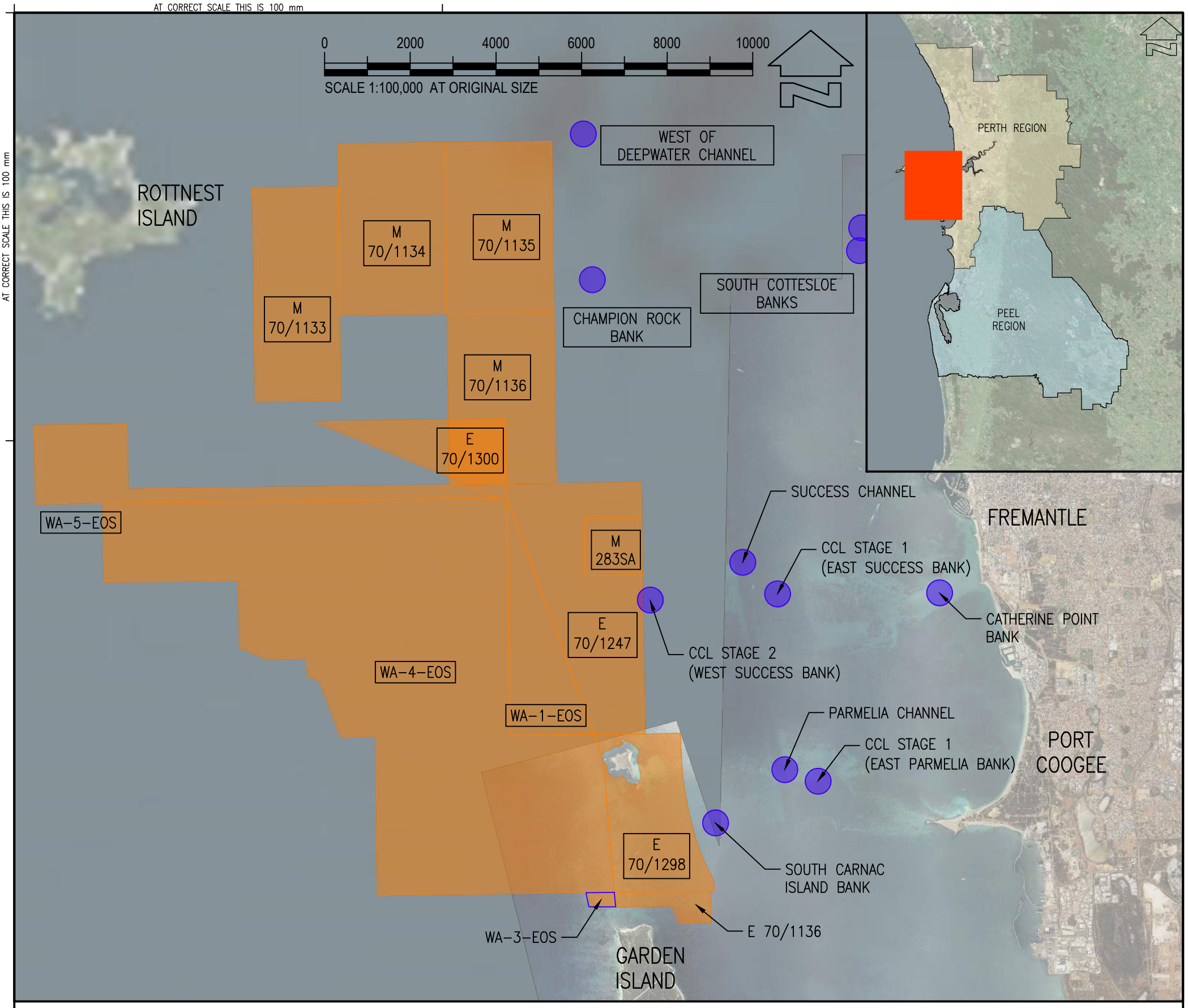

POTENTIAL SEDIMENT SOURCE DETAILS

LOCATION/SITE NAME	DISTANCE OFFSHORE (km)	COORDINATES (MGA94)	
		EASTING	NORTHING
WEST OF DEEPWATER CHANNEL	8.3	372,921	6,460,000
CHAMPION ROCK BANK	8.6	373,129	6,456,592
SUCCESS CHANNEL	5.5	376,640	6,449,991
CCL STAGE 1 (EAST SUCCESS BANK)	2.5	377,458	6,449,254
CCL STAGE 2 (WEST SUCCESS BANK)	2.5	374,482	6,449,109
CATHERINE POINT BANK	1.0	381,239	6,449,278
PARMELIA CHANNEL	5.3	377,623	6,445,147
CCL STAGE 1 (EAST PARMELIA BANK)	2.5	378,400	6,444,879
SOUTH CARNAC ISLAND BANK	3.8	376,003	6,443,908
E 70/1136	6.0	374,993	6,442,025
E 70/1247	6.0	373,044	6,449,206
E 70/1298	6.0	374,545	6,443,955
E 70/1300	10.0	369,623	6,452,680
M 283SA	6.0	373,626	6,450,359

POTENTIAL SEDIMENT SOURCE DETAILS

LOCATION/SITE NAME	DISTANCE OFFSHORE (km)	COORDINATES (MGA94)	
		EASTING	NORTHING
WA-1-EOS	6.5	371,839	6,447,813
WA-3-EOS	6.5	373,339	6,442,118
WA-4-EOS	14.0	368,647	6,447,377
WA-5-EOS	14.0	360,898	6,452,284
M 70/1133	15.5	366,233	6,456,255
M 70/1134	14.0	368,463	6,457,783
M 70/1135	10.5	370,962	6,457,816
M 70/1136	9.0	371,014	6,453,817

LEGEND:

EXPLORATION LICENCE BOUNDARY

POTENTIAL SEDIMENT LOCATION

NOTE:

1. POTENTIAL SEDIMENT SOURCE LOCATIONS AND QUANTITIES ARE INDICATIVE ONLY AND HAVE BEEN ESTIMATED FROM EXISTING STUDIES, NAVIGATION/NAUTICAL CHARTS, BATHYMETRIC SURVEYS AND AERIAL IMAGERY.

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POTENTIAL SEDIMENT SOURCES - SHEET 2 OF 4

FEBRUARY 2025

MATERIALS STUDY

SCALE AT A3 1:100,000

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SCALE 1:50,000 AT ORIGINAL SIZE

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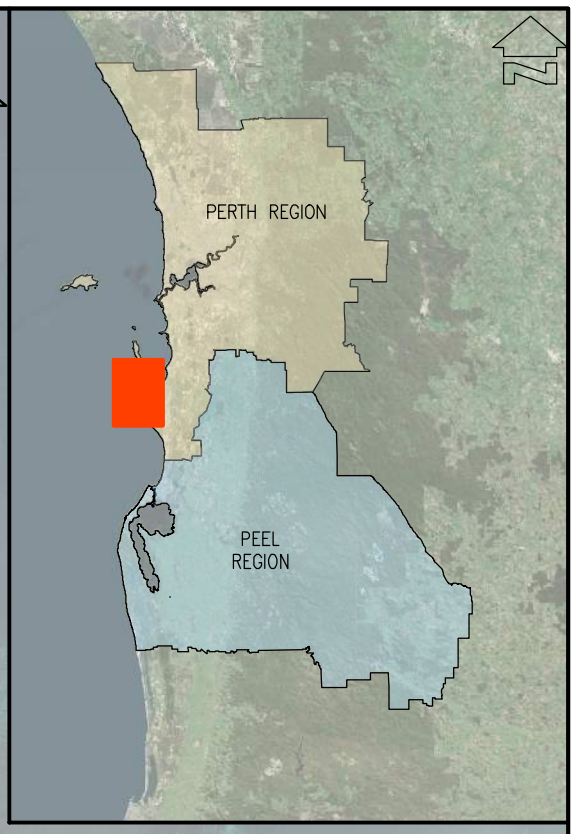

GARDEN ISLAND

SEPIA DEPRESSION BANK

SHOALWATER BAY BANK

SHOALWATER

COVENTRY REEF BANK

POTENTIAL SEDIMENT SOURCE DETAILS

LOCATION/SITE NAME	DISTANCE OFFSHORE (km)	COORDINATES (MGA94)	
		EASTING	NORTHING
SEPIA DEPRESSION BANK	11	372,071	6,432,613
SHOALWATER BAY BANK	4.5	373,275	6,427,105
CONVENTRY REEF BANK	8.3	373,317	6,421,443

LEGEND:

POTENTIAL SEDIMENT LOCATION

NOTE:

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POTENTIAL SEDIMENT SOURCES - SHEET 3 OF 4

FEBRUARY 2025

MATERIALS STUDY

SCALE AT A3 1:50,000

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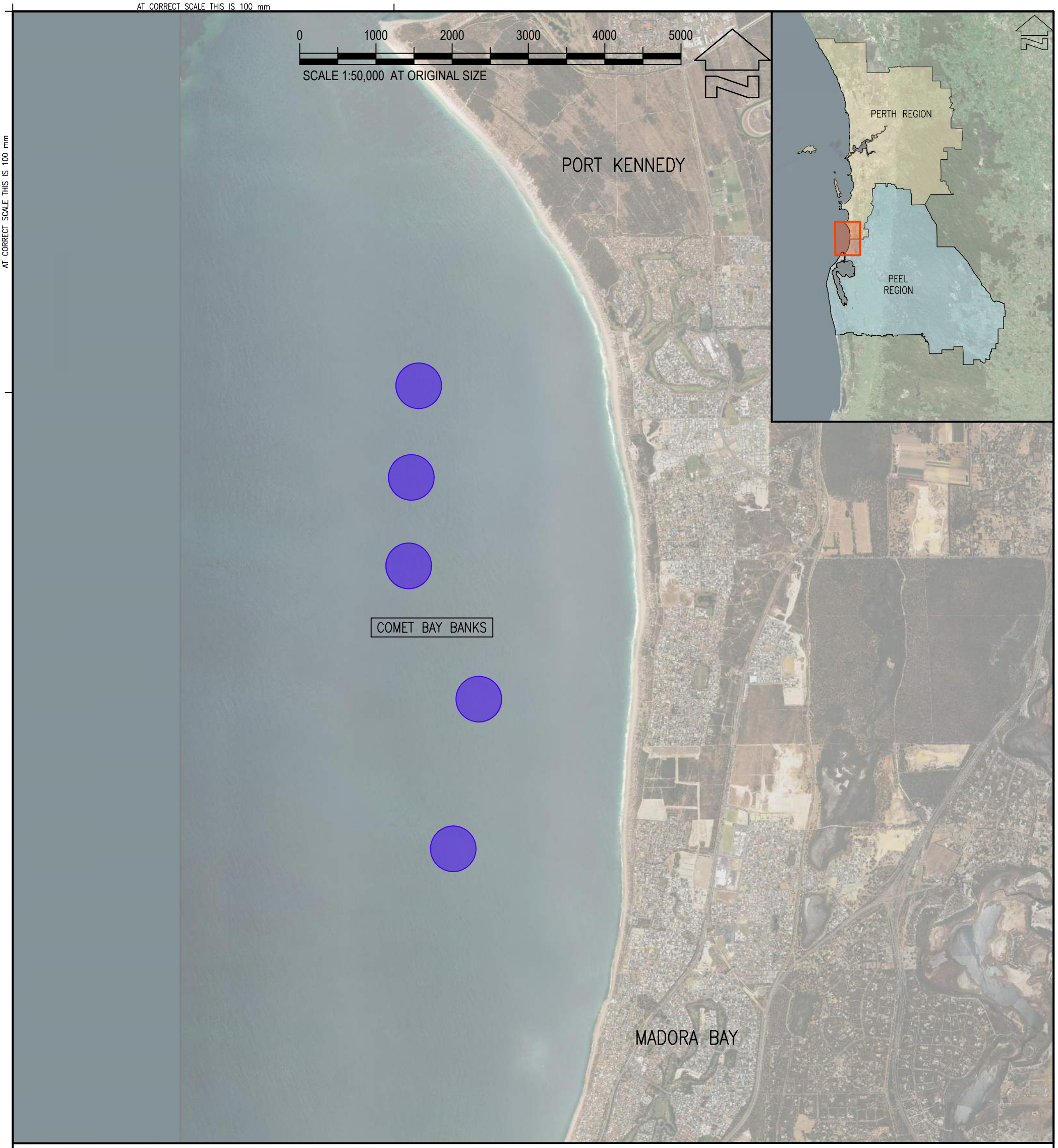

POTENTIAL SEDIMENT SOURCE DETAILS			
LOCATION/SITE NAME	DISTANCE OFFSHORE (km)	COORDINATES (MGA94)	
		EASTING	NORTHING
COMET BAY BANKS	2.5 - 2.8	379,501	6,413,094
		379,404	6,411,890
		379,370	6,410,730
		380,291	6,408,981
		379,953	6,407,018

LEGEND:

POTENTIAL SEDIMENT LOCATION

NOTE:

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POTENTIAL SEDIMENT SOURCES - SHEET 4 OF 4

MATERIALS STUDY

SCALE AT A3 1:50,000

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SCALE 1:700,000 AT ORIGINAL SIZE

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SOUTHWEST REGION

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LOCALITY PLAN

MATERIALS STUDY

SCALE AT A3 1:700,000

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SCALE 1:50,000 AT ORIGINAL SIZE

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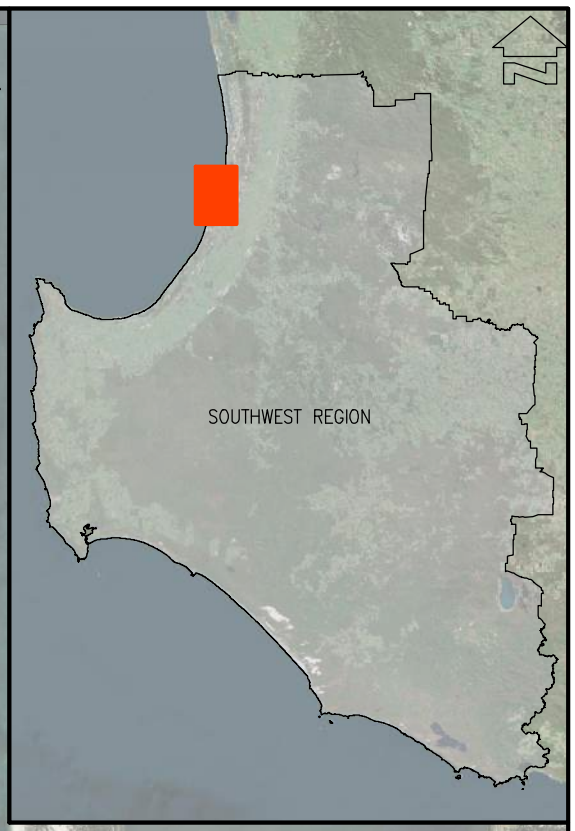

McKENNA POINT BANKS

BUNBURY SPOIL GROUND

BACK BEACH BANK

POTENTIAL SEDIMENT SOURCE DETAILS

LOCATION/SITE NAME	DISTANCE OFFSHORE (km)	COORDINATES (MGA94)	
		EASTING	NORTHING
BUNBURY POIL GROUND	2.0	374,963	6,317,040
McKENNA POINT BANKS	2.0 - 2.6	371,890	6,316,941
		371,046	6,316,835
BACK BEACH BANK	2.0	370,029	6,311,083

LEGEND:

POTENTIAL SEDIMENT LOCATION

NOTE:

1. MARINE SEDIMENT LOCATIONS AND QUANTITIES ARE INDICATIVE ONLY AND HAVE BEEN ESTIMATED FROM EXISTING STUDIES, NAVIGATION/NAUTICAL CHARTS, BATHYMETRIC SURVEYS AND AERIAL IMAGERY.

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POTENTIAL SEDIMENT SOURCES - SHEET 1 OF 2

FEBRUARY 2025

MATERIALS STUDY

SCALE AT A3 1:50,000

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AT CORRECT SCALE THIS IS 100 mm

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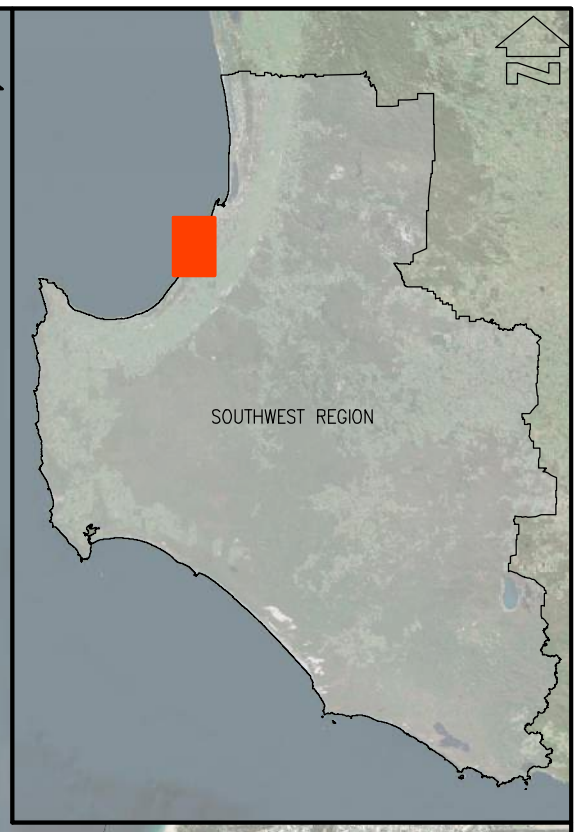
SCALE 1:50,000 AT ORIGINAL SIZE

N



STIRLING BEACH BANKS

AT CORRECT SCALE THIS IS 100 mm

POTENTIAL SEDIMENT SOURCE DETAILS

LOCATION/SITE NAME	DISTANCE OFFSHORE (km)	COORDINATES (MGA94)	
		EASTING	NORTHING
STIRLING BEACH BANKS	2.0 - 5.2	366,818	6,300,684
		363,007	6,300,544
		363,348	6,296,552

LEGEND:

POTENTIAL SEDIMENT LOCATION

NOTE:

1. MARINE SEDIMENT LOCATIONS AND QUANTITIES ARE INDICATIVE ONLY AND HAVE BEEN ESTIMATED FROM EXISTING STUDIES, NAVIGATION/NAUTICAL CHARTS, BATHYMETRIC SURVEYS AND AERIAL IMAGERY.

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POTENTIAL SEDIMENT SOURCES - SHEET 2 OF 2

FEBRUARY 2025

MATERIALS STUDY

SCALE AT A3 1:50,000

SK2108-06-02A

P:\MRA Paying Jobs\K2108 DoT - Material Study Sand & Rock Supply\5 MRA Dwgs\Sketches\SK2108-06 SWR PSS

Appendix F MRWA's Potential Terrestrial Sand & Rock Sources

AT CORRECT SCALE THIS IS 100 mm

0 10000 20000 30000 40000 50000 60000 70000

SCALE 1:700,000 AT ORIGINAL SIZE

N

01

02

03

SOUTHWEST REGION

AT CORRECT SCALE THIS IS 100 mm

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LOCALITY PLAN

MATERIALS STUDY

SCALE AT A3 1:700,000

JANUARY 2025

SK2108–07–00A

P:\MRA Paying Jobs\K2108 DoT – Material Study Sand & Rock Supply\5 MRA Dwgs\Sketches\SK2108–07 SWR Main Roads

AT CORRECT SCALE THIS IS 100 mm

0 5000 10,000 15,000 20,000 25,000

SCALE 1:250,000 AT ORIGINAL SIZE

N

LEGEND:

MATERIAL STATUS

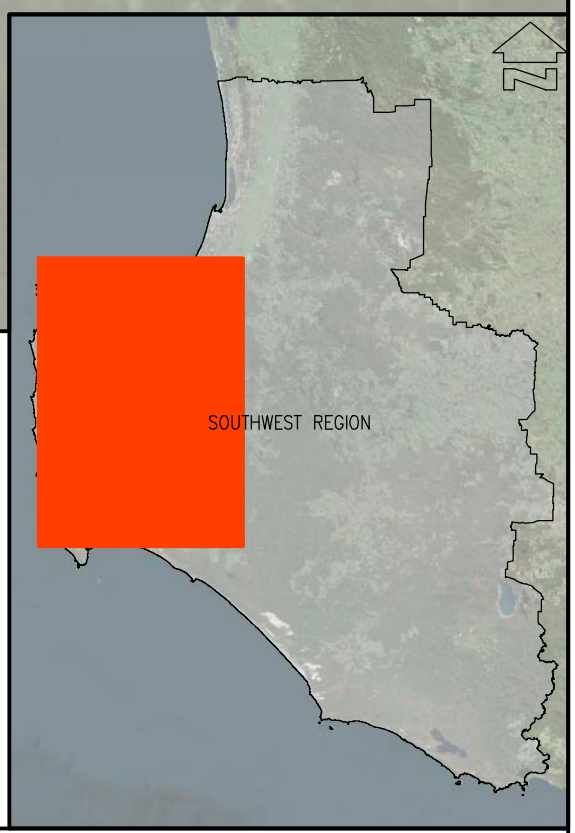
- MATERIAL PRESENT
- MATERIAL POTENTIAL
- MATERIAL TO BE INVESTIGATED
- MATERIAL WITH NO POTENTIAL

MATERIAL TYPE

- SAND
- ROCK
- UNKNOWN

NOTE:

1. POTENTIAL RESOURCE LOCATIONS ARE PROVIDED BY MAIN ROADS WESTERN AUSTRALIA (MRWA).



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MRWA'S POTENTIAL RESOURCE LOCATIONS - SHEET 1 OF 3

JANUARY 2025

MATERIALS STUDY

SCALE AT A3 1:250,000

SK2108–07–01A

AT CORRECT SCALE THIS IS 100 mm

P:\MRA Paying Jobs\K2108 DoT – Material Study Sand & Rock Supply\5 MRA Dwgs\Sketches\SK2108–07 SWR Main Roads

AT CORRECT SCALE THIS IS 100 mm

0 5000 10,000 15,000 20,000 25,000

SCALE 1:250,000 AT ORIGINAL SIZE

N

LEGEND:

MATERIAL STATUS

- MATERIAL PRESENT
- MATERIAL POTENTIAL
- MATERIAL TO BE INVESTIGATED
- MATERIAL WITH NO POTENTIAL

MATERIAL TYPE

- SAND
- ROCK
- UNKNOWN

NOTE:

1. POTENTIAL RESOURCE LOCATIONS ARE PROVIDED BY MAIN ROADS WESTERN AUSTRALIA (MRWA).

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MRWA'S POTENTIAL RESOURCE LOCATIONS - SHEET 2 OF 3

JANUARY 2025

MATERIALS STUDY

SCALE AT A3 1:250,000

SK2108–07–02A

AT CORRECT SCALE THIS IS 100 mm

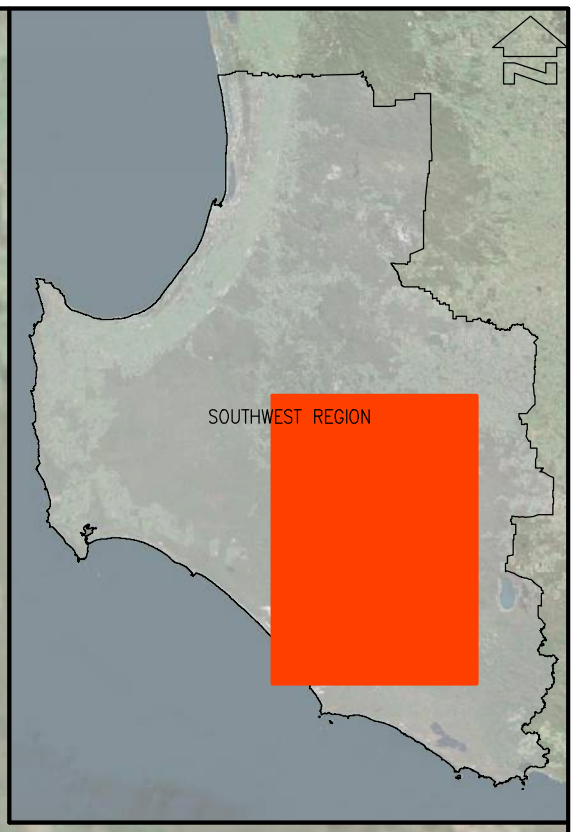
P:\MRA Paying Jobs\K2108 DoT – Material Study Sand & Rock Supply\5 MRA Dwgs\Sketches\SK2108–07 SWR Main Roads

AT CORRECT SCALE THIS IS 100 mm

0 5000 10,000 15,000 20,000 25,000

SCALE 1:250,000 AT ORIGINAL SIZE

N



LEGEND:

MATERIAL STATUS

- MATERIAL PRESENT
- MATERIAL POTENTIAL
- MATERIAL TO BE INVESTIGATED
- MATERIAL WITH NO POTENTIAL

MATERIAL TYPE

- SAND
- ROCK
- UNKNOWN

NOTE:

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MRWA'S POTENTIAL RESOURCE LOCATIONS - SHEET 3 OF 3

JANUARY 2025

MATERIALS STUDY

SCALE AT A3 1:250,000

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AT CORRECT SCALE THIS IS 100 mm

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