Oakajee Industrial Estate

Structure Plan

Industrial Ecology Strategy

LANDCORP

Curtin University of Technology

Ferart

PB 125 YEARS

Government of Western Australia
Department of State Development

Oakajee Industrial Estate Structure Plan

Industrial Ecology Strategy

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Control Group

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Acknowledgements

This Strategy builds upon relevant published works on industrial policy and industrial ecology as described in the Bibliography. Table A2 in Appendix A and Appendix B were prepared by GHD Pty Ltd. Figures 2, 3 and 4 were prepared by RPS.

The Strategy was prepared within the overarching framework of the Oakajee Industrial Estate (OIE) Sustainability Report, which is a technical report accompanying the OIE Structure Plan. The Industrial Ecology Strategy has received input from, and been reviewed by, the Project Team, an Expert Design Review Panel and the Technical Advisory Group.

The Project Team included:

- Client – LandCorp
- External Project Manager – John Quilty
- Planning Consultancy – RPS
- Engineering Consultancy – GHD
- Environmental Consultancy – Parsons Brinckerhoff (PB)
- Landscape Design Consultancy – Hassell & Strategen
- Sustainability and Industrial Ecology Consultancy – PB, Ferart Design and Professor Peter Newman – Director of Sustainability, Curtin University Sustainability Policy (CUSP) Institute

Table of contents

Appendices

Executive summary

The Oakajee Industrial Estate (OIE) aims to be globally competitive and, given that the OIE is a green field site, this presents a unique opportunity to build an internationally recognised and sustainable industrial estate. Fundamental to this vision is that the OIE is planned in such a way that it is possible for industries to work together to minimise energy and water use, lower carbon emissions and share by-products in order to reduce waste. In addition, industrial activities should be characterised by cleaner production technologies, renewable energy, smart technology and high levels of innovation.

To be sustainable, the OIE also needs to be integrated into the surrounding natural ecosystems and have good transport linkages to the Region, State, Nation and World, and appropriate spatial relationships with the surrounding communities. This design approach is referred to as Industrial Ecology.

This Industrial Ecology Strategy has been specifically developed to inform the Structure Plan with respect to:

- Industries that may locate into the OIE
- How land in the OIE should be allocated to industry to optimise efficiency
- Identifying how the industries can be linked to improve process efficiencies minimise energy, water and materials through the sharing of by-products
- Identifying strategic industries and activities that should be attracted to the OIE to increase its efficiency and minimise its energy, water and greenhouse gas emissions
- Providing recommendations on future work which should be considered for the future governance and development of the OIE

Innovations which could support the industrial ecology of the OIE include the following:

Water Factory - process multiple sources of water supply including bore water, sea water, industrial waste water and sewage/organic waste.

Power Station/Energy Factory - co/tri-generation or combined cycle facility, analogous to the Water Factory, to receive gas, hot waste gases and liquids and to supply electrical energy, steam, hot air, hot water, cool air and cool water.

Infrastructure Corridors – ensure that there are adequately sized infrastructure corridors that link the Port, industry within the Strategic Industry Area and General Industry Areas, uses within the Buffer (e.g. WWTP), the Oakajee-Narngulu Infrastructure Corridor and the wider Region.

Separating Inorganic and Organic Processes – users of the site have been broadly segregated to keep inorganic and organic industrial processes separate while providing strong linkages to enable them to interface with each other via an infrastructure corridor.

By-Product Management – creating a framework in which by-products can be used as inputs to other industrial processes.

Waste Water Treatment Facility – a facility that could treat domestic waste water from Geraldton and distribute via the infrastructure corridor to industry.

Industrialised Solid Waste Re-processing - a dedicated facility to re-process selected solid wastes from the region/state into useable materials

Solid By-product Storage Areas – identifying areas within the Buffer where industries can store by-products in anticipation of future reuse.

Renewable Energy and Carbon Management – identifying locations within the OIE where renewable energy can be generated and carbon can be sequestered through revegetation.

The Industrial Ecology Strategy also recognises that the initiatives in the Structure Plan for the layout of the site will have to be complemented by an appropriate governance, policy and administration framework. This governance structure will provide a forum where industries can develop partnerships, exchange information, develop collaborative projects and manage the interface with regional development and sustainability initiatives.

1. Introduction

1.1 Background

LandCorp is undertaking structure planning to guide the development of the Oakajee Industrial Estate (OIE). The OIE is approximately 23 kilometres north of Geraldton in the Shire of Chapman Valley. Rezoning for the site was obtained in 2004 and identifies a Strategic Industry Area (SIA) for heavy industry with supporting General Industry Areas (GIAs) and a Buffer Area.

The Industrial Ecology Strategy has been guided by the relevant sections of the *Guidelines for Industrial Development*[1]. The *Guidelines* provide a comprehensive overview of relevant documentation including the *Western Australian State Sustainability Strategy*[2] and the *National Strategy for Ecologically Sustainable Development*[3]. Where there is a correlation between this Strategy and the *Guidelines* it has been noted as a footnote.

1.2 What is Industrial Ecology

Industrial ecology is a way of designing and operating industrial activity where industries are linked to mimic ecological systems. By linking industries, energy, water use and carbon emissions are minimised. By-products from one industry become the inputs for another, thereby increasing efficiency and reducing waste. Industrial activities are integrated into the surrounding natural ecosystems and have appropriate transport linkages to, and spatial relationships with, the surrounding human communities.

Traditionally, within industrial estates following the Business as Usual (BAU) model of industrial development, individual industries organise their own supplies of materials, energy and water; and waste disposal is an industry by industry activity. In the BAU model, the natural environment is a receptor of diluted pollutants with an associated acceptable level of damage. The general assumption is that industry is dirty, noisy and presents high levels of risk to surrounding human communities. This assumption supports the perception that heavy industry is inefficient, wasteful of raw materials and increases overall emissions.

Industrial design using industrial ecology principles sees natural ecosystems as an integral part of the industrial design, rather than an impediment to development. Industry can be sited so that it does not impact on parts of the landscape that have high biodiversity and use of appropriate revegetation in buffer zones can provide smooth transitions between natural

[1] Sands, L; Shepherd, S; *Guidelines for Industrial Development,* Perth NRM Region, Australian Government, Kwinana Industries Council and others, 2010
[2] Government of Western Australia 2003
[3] Government of Australia 1992

and industrial landscapes. Energy can be supplied from renewable resources and energy can be shared between industries. Discharges to the environment should create no damage and, ideally, improve and repair the natural environment. Human communities benefit from being close to, and integrated with, low impact industries, improved transport networks, stable supplies of energy and economic development opportunities.

Industrial ecology encourages the use of cleaner production technologies, renewable energy, smart technology and high levels of innovation to achieve these objectives.

1.3 Purpose

This Industrial Ecology Strategy has been specifically developed to inform the Structure Plan with respect to:

- Industries that may locate into the OIE
- How land in the OIE should be allocated to industry to optimise efficiency
- Identifying how the industries can be linked to minimise energy, water and materials through the sharing of by-products
- Identifying strategic industries and activities that should be attracted to the OIE to increase its efficiency and minimise its energy, water and greenhouse gas emissions
- Providing recommendations on future work which should be considered for the future governance and development of the OIE

1.4 Objectives

LandCorp recognises that if the OIE is to be globally competitive it has to be at the cutting edge of international trends in industrial development. In an internationally competitive environment, simply identifying a dedicated industrial area will not necessarily attract development. Trends in international industrial development that have been identified include[4]:

- High efficiency and minimum waste
- Innovation and technology development
- Low energy costs
- Low carbon footprint
- Water security and water use efficiency
- Easy access to flexible transport options
- Access to a sophisticated and well educated labour force

[4] see Bibliography

- Synergistic industries located close to each other
- Sophisticated management of by-products
- Integration into surrounding communities
- Protection and enhancement of, and positive integration into, natural ecosystems

1.5 Relationship to the Other Studies

The Structure Plan has been guided and informed by a range of studies dealing with transport, services, landscape, environment, heritage etc. There has been considerable consultation between members of the Project Team to inform each other's work and this has been particularly true of the Industrial Ecology Strategy. Of importance, was the work undertaken in the analysis of transport, water, energy, labour and land area needs for industries that could potentially locate into the OIE. This information was invaluable in informing the suggested land allocation.

Broader contexts for the development of the Industrial Ecology Strategy have also been provided by the State Heavy Use Industrial Land Strategy[5], the Guidelines for Industrial Development[6] and LandCorp's commitment to the vision of creating a sustainable industrial estate in Western Australia[7]. Regionally there are numerous policy frameworks for development of the OIE including the planning framework for the City of Geraldton-Greenough, Narngulu Industrial Estate, the Shire of Chapman Valley's Town Planning Scheme No 1 Amendment 18[8] and the Mid West Development Commission's active promotion of industrial development in the region.

[5] http://www.dsd.wa.gov.au/7029.aspx
[6] Sands, L; Shepherd, S; *Guidelines for Industrial Development,* Perth NRM Region, Australian Government, Kwinana Industries Council and others, 2010
[7] http://www.landcorp.com.au/sustainability/Our-framework/
[8] Western Australian Planning Commission *Narngulu Industrial Area Strategic Land Use Directions* May 2010

2. Methodology

The following methodology was used to develop the Industrial Ecology Strategy.

1 Conduct a literature review to guide development of the industrial ecology strategy and related design principles (see Bibliography).

2 Review the Shire of Chapman Valley's Town Planning Scheme and the constraints and opportunities of this formal planning framework.

3 Review the ecology and geomorphology of the site, particularly in the Buffer that would guide location of future industries.

4 Review the other proposed uses of the site including infrastructure corridors, port and related facilities and how this might guide the location of future industries.

5 Develop and analyse a list of industries that may locate in the OIE and use this as a framework to develop generic clusters of similar types of industries. Based on this list:

- Develop locational principles including risk, proximity to transport (port, rail, road), operational synergies and land area required for each of these clusters[9]
- Identify key inputs (power, water, land) and outputs (waste, by-products), transport needs (rail, road, pipeline, conveyor) for the generic industry clusters and identify the types and sizes of infrastructure and service corridors required to link them[10]
- Identify specific industries (e.g. power, water supply and by-products reprocessing) that support the inter-industry linkages needed to foster industrial ecology

6 Determine the size, shape and best location of these generic industry clusters and linkages required within the OIE as recommendations for inclusion in the Structure Plan[11]

7 Identify a suite of issues relating to governance, future implementation and integration into the surrounding human community that should be addressed but are beyond the scope of the structure planning process.

8 Prepare a report of the above information.

[9] GIDr A1, B42
[10] GIDr A16, A17, A19, A21, A26
[11] GIDr A7 – A10

3. Design Principles

3.1 Development of Design Principles

The Industrial Ecology Strategy seeks to move the OIE beyond the *BAU* model. The long term objective for the OIE is that it will operate as a fully *Sustainable Industrial Estate (SIE)* based on industrial ecology principles. This objective does, however, require a large number of diverse industries to be established (Figure 1).

In the short to medium term a *Transition Phase (TP)* will be needed. Initially, only a few industries will be located in the OIE and it will take some time before synergistic industries can utilise all available by-products. Consequently by-products will need to be stored and there will be some discharges to the environment within limits set by the Environmental Protection Authority (EPA).

A review of the research literature shows that the discussion around design principles for industrial ecology can be considered in two broad areas:

- Principles developed for how industries relate and interface within a specific geographic area[12] [13]
- Principles developed to guide how governance of a group of industries (e.g. an industrial estate) is organised and how these industries integrate into the surrounding human community and environmental systems[14] [15].

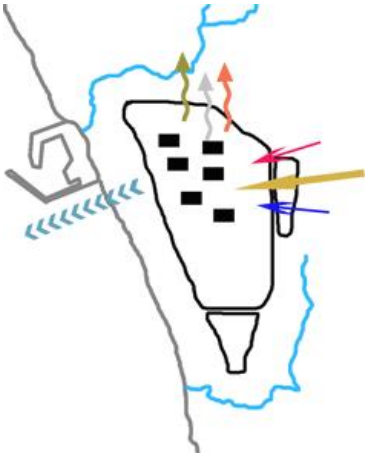
The Structure Plan provides the next level of detail, after the Town Planning Scheme, in describing how the site should be used and organised. Consequently, this Industrial Ecology Strategy has a strong emphasis on developing and applying principles that guide where industry should be located and how they should be linked.

[12] particularly Ashford and Cote (1997), Roberts (2004), Chertow (2000), Yang and Boon Lay (2004)
[13] GIDr A3, A4, A5, A20, A25
[14] particularly Korhonena and Juha-Pekka (2005), Faucheux and Nicolaı (1998), Raymond Smolenaars (1997)
[15] GIDR B1, B4 – B6

FIGURE 1 Evolution of Industrial Ecology at the Oakajee Industrial Estate

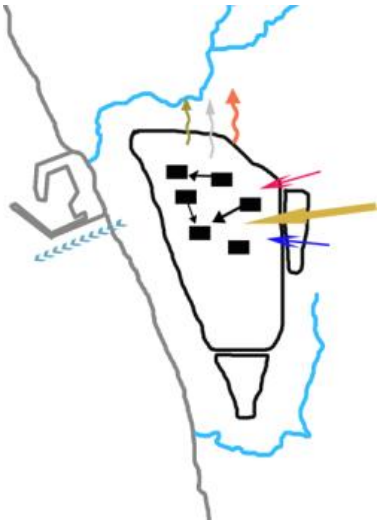
BUSINESS AS USUAL

- Based around complete through-put of energy, water and materials by individual industries
- High inputs of materials, water and energy per unit of production
- Emissions from individual industries within EPA standards
- Significant emissions of CO_2
- High levels of treated water discharged to ocean or infiltrated to ground within EPA standards
- No linkages between industries
- Solid by-products are treated as wastes



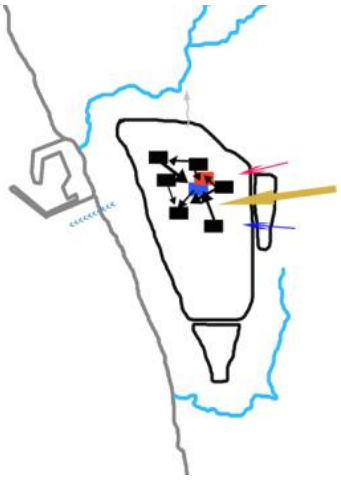
TRANSITION PHASE

- Some linkages between industries
- Still some throughput by individual industries
- Reduced input of water and energy per unit of production
- Reduced emissions from individual industries, within EPA standards
- Some reduction of emissions of CO_2
- Moderate levels of treated water discharged to ocean or infiltrated to ground
- Some solid by-products re-used, the rest stored for future use
- Efficiency of individual industries and the OIE as a whole is increasing



SUSTAINABLE INDUSTRIAL ESTATE

- Strong synergistic linkages between industries
- Minimal wastage of materials, energy and water
- Significantly reduced input of water and energy per unit of production
- Reduced materials input
- Reduced emissions below EPA standards
- Well established carbon management in place
- Low levels of treated water discharged to ocean or infiltrated to ground
- Most solid by-products re-used, the rest stored for future use
- High levels of efficiency of both individual industries and the OIE



Given the predominant focus of structure planning on activities within the OIE boundary, the following design principles have been derived from the research and the above discussion for the design of the Estate:

Principle 1 ***Integration into the Site*** *- Match the locational criteria of the industries to the geology, ecosystems and topography of the site. Take advantage of natural features provided by the landscape and ensure natural ecosystems are enhanced by the presence of industry*[16]

Principle 2 ***Diversity of Industries*** *- Include a diversity of industries in the industrial mix to maximise the opportunities to develop synergies between industries. Provide sufficient land area for each of these industries and identify key "linking" industries (e.g. energy and water supply, by-product processing etc, that will facilitate Industrial ecology).*

Principle 3 ***Design for Overall Efficiency*** *- Locate and orientate synergistic industries in relation to each other to optimise the shared use of by-products, energy, water and transport. Design industries to be highly efficient to minimise materials, energy and water requirements.*[17]

Principle 4 ***Interfaces between Industries*** *- Provide ample shared corridors for easy transfer of materials, liquids and energy between industries. Provide "smart" infrastructure (e.g. fibre optic communication links, common process control protocols, common sizing of infrastructure) that enables industries to "talk" to each other and to easily interface with each other*

Given that industrial ecology requires a broader view outside the planning boundary, the issues of governance of industry and integration into surrounding human community and environmental systems of the OIE are discussed in the Implementation section of this report and the related Sustainability Report. The following design principle has been developed to guide this discussion but details of how this will unfold will be the subject of further work.

Principle 5 ***Governance, policy and administration framework*** *- provide a policy and administration framework that*[18]*:*

- *Encourages investment in innovative processes, cleaner production and waste management*

[16] GIDr A3, A6, A22, A4, A5, A20, A25
[17] GIDR B14-19, B33, B36,B37,B43-46, B51, B54
[18] GIDr B1

- *Creates and capitalises on opportunities to value-add through reprocessing waste and energy recovery*
- *Provides linkages into regional sustainability initiatives (e.g. transport strategies, carbon sequestration opportunities, workforce education and training, community and cultural development)*
- *Provides a forum where industries can develop partnerships, exchange information and develop collaborative projects*
- *Markets the benefits of the OIE and has a well developed Industry Attraction Strategy*
- *Reports on overall performance and what individual industries are contributing to that performance*

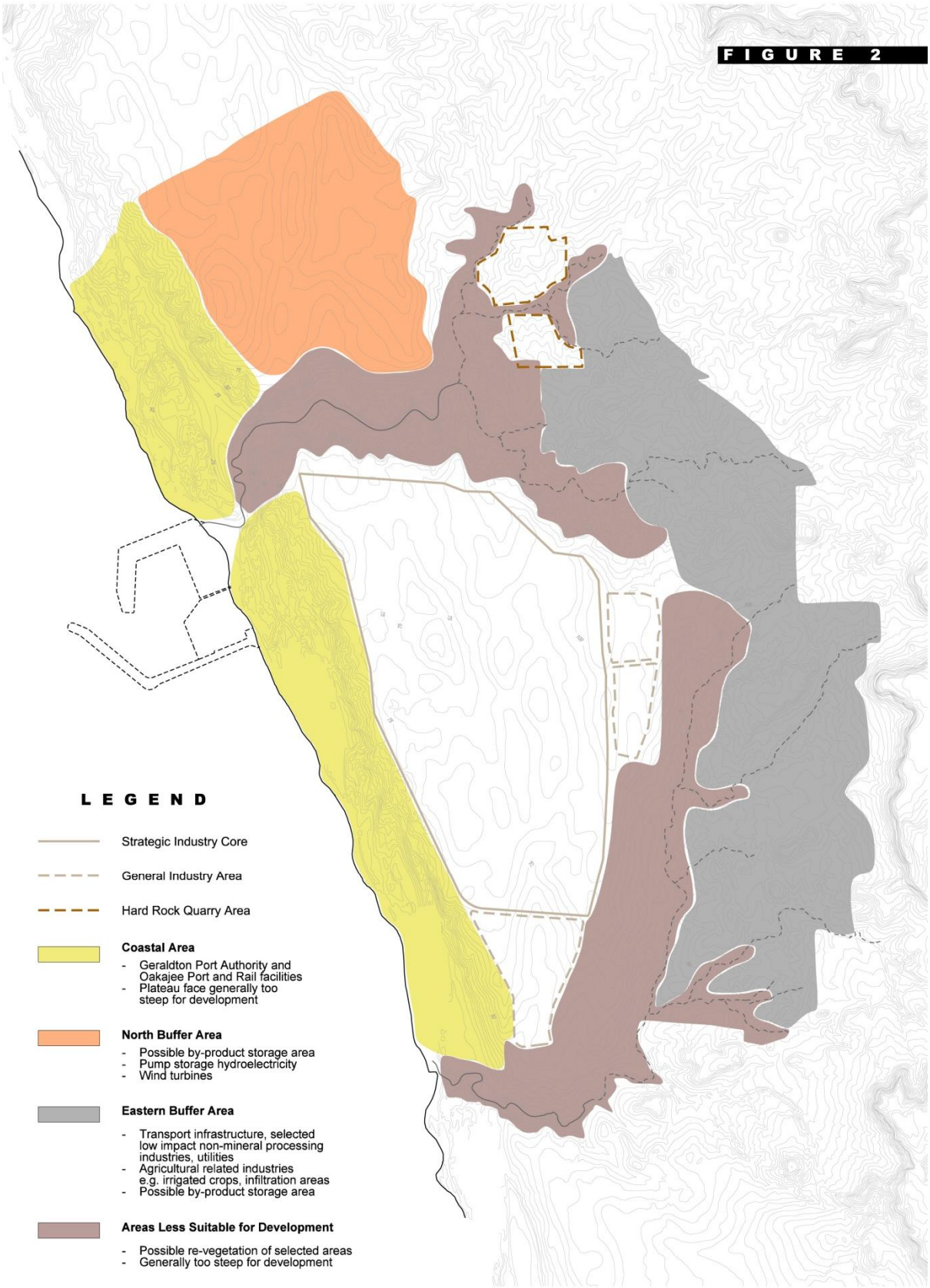
3.2 Implications for the Structure Plan: Principle 1 – Integration into the Site

Match the location criteria of the industries to the geology, ecosystems and topography of the site. Take advantage of natural features provided by the landscape and ensure natural ecosystems are enhanced by the presence of industry

The Shire of Chapman Valley Town Planning Scheme No 1, Amendment 18 (TPS) identifies four areas within the OIE:

- Strategic Industry Area (SIA) - is the 'core' of the OIE where heavy industry will locate. The area is characterised by a large, gently undulating sand plain. Within the SIA the Industrial Ecology Strategy identifies a range of areas linked to specific characteristics relating to risk, access to transport, land area required etc. This is discussed further in Section 3.3.
- General Industry Areas (GIAs) - support industry will be located in the two General Industry Areas. Geographically, the GIAs are similar to the SIA.
- Buffer - A large zone around the SIA and GIAs to provide a buffer to contain noise, risk and air emissions from industries in the SIA.
- Coastal Area - A strip of coastal land extending north and south from the proposed port and will be used for port related activities such as stockpiles.

FIGURE 2 Geographic land areas in the Oakajee Industrial Estate



The TPS allows a range of compatible land uses within the Buffer including uses that may support the SIA/GIAs and rural industry. The Buffer divides into three broad geographic areas:

- A large, gently undulating sand plain area north of the Oakajee River similar to the SIA.
- The valleys of the Oakajee and Buller Rivers.
- More undulating land on lateritic soils north-east of the SIA and east to the Moresby Ranges.

The coastal zone is also part of the geography of the site but is the subject of separate planning studies and consequently is not discussed in this report. The locations of these areas are shown in Figure 2, while potential uses are discussed in Section 3.3.

3.3 Implications for the Structure Plan: Principle 2 – Diversity of Industries

Include a diversity of industries in the industrial mix to maximise the opportunities to develop synergies between industries. Provide sufficient land area for each of these industries. Identify key "linking" industries (e.g. energy and water supply, by-product processing etc) that will facilitate industrial ecology.

The Mid West Region of Western Australia is widely identified as having significant development potential, particularly for mineral processing. There is, however, considerable uncertainty about what industries will locate in the OIE and when they will be established. Identification of industries that will support a fully developed industrial ecology strategy has to be balanced by a realistic assessment of the likelihood of specific industries locating in the OIE[19]. Consequently, with all the uncertainties associated with a "green field" estate, a generic approach was developed to assist locating industry clusters. This approach sought to identify appropriately sized areas to accommodate industry clusters that share similar characteristics. There were four stages in this process.

- *Stage 1* – A general assessment, drawing on a number of sources, of industries that may locate in the Estate. This list of potential industries was then refined to identify industries considered more likely than others to locate in the OIE (Table 1).
- *Stage 2* – This list of "likely" industries was used to develop a matrix (refer to Appendix A, Table A1) detailing transport, water, energy, labour and land area needs. This matrix was also used to inform potential water, energy and gas needs of the OIE (refer to Appendix A, Table A2).

[19] Marian R. Chertow *Uncovering Industrial Symbiosis* Journal of Industrial Ecology (2007)

- *Stage 3* – Based on this list, industry location criteria were identified and prioritised. The list of location criteria is shown in Table 2.
- *Stage 4* – Clusters of industries with similar criteria were identified, located and oriented to maximise industrial ecology benefits. The output from this analysis is shown in Figure 3.

It should be noted that the location and area requirements for some industry types has yet to be determined and will require more detailed investigation and a feasibility assessment against Town Planning Scheme requirements.

In addition, some of the industry types such as grain handling, infrastructure hub/port related services, marine construction etc would ideally be located within the port precinct, however this will be dependent upon the land use allocations associated with the Oakajee Port Master Plan, which is in preparation.

TABLE 1 Generic types of industries that potentially may locate in the Oakajee Industrial Estate

Industry Type	Description
Ferrous mineral processing	When fully developed, these will typically include stockpiling, pelletising, HDI/blast furnace production of iron, creation of specialised steels for export. These processes are typically high energy use/production and high water use.
Large non-ferrous mineral processing/manufacturing	Covers a range of possible mineral groups. When fully developed, will involve concentrate delivery, pyrometallurgical/hydrometallurgical processing, refining, export. These processes are typically high energy use/production, high water use. (e.g. nickel refinery).
Medium size non-ferrous mineral processing/manufacturing -high energy and water use	Covers a range of possible mineral groups, when fully developed, will involve concentrate delivery, pyrometallurgical, hydrometallurgical, refining and export. These processes are typically moderate energy use/production and high water use. (e.g. synthetic rutile plant or vanadium production).
Mineral processing/manufacturing with high impact if catastrophic failure occurs	Similar to the other non-ferrous mineral processing but presenting a high risk from emissions if a catastrophic plant failure occurred (e.g. chloride route pigment plant).
Non-ferrous mineral processing/manufacturing low - moderate energy and water use	Covers a range of possible activities principally using crushing/grinding / hydrometallurgical /drying/coating processes. Typically this would be low – moderate energy and water use (e.g. production of abrasives).
Water Factory	A facility to process multiple sources of water for the OIE. Sources of water include bore water, sea water, industrial by-product water, and discharge water from the sewage/organic by-product treatment plant. The Water Factory can supply a variety of qualities and volumes of water to users in the OIE and should also have the capacity to discharge to ocean outfall.
Power Station/Energy Factory	A co/tri-generation or combined cycle facility, analogous to the Water Factory, to receive natural gas, hot waste process gases, liquids etc and supply electrical energy, steam, hot air, hot water, cool air, cool water back to industries. It is anticipated that the Energy Factory could be built in modules to expand its range of services as the OIE expands.
Industrialised Solid Waste Re-processing (ISWR)	A processing facility that uses industrial processes to convert selected solid wastes from the Region/State into useful products (e.g. a cement kiln to burn tyres and utilise slags from steel works, pyrolysis production of fuels etc).

Industry Type	Description
Organic based industrial processing plant	Industrial scale processes that are based on organic chemicals (e.g. specialised oil refining, gas production).
Warehousing, service centre	Areas dedicated to low impact activities that support the operation of the OIE. These industry types would be well suited to locating within the GIAs.
Agricultural Industrial Processing (AIP)	A facility for processing of grain and other agricultural products (e.g. industrial starch production, biofuels).
Heavy Construction	Area dedicated to large industrial construction, predominantly ferrous but may include coatings, concrete casting. Some construction industries will be associated with large modular constructions and will require access to high wide load routes.
Solid By-product Storage (SBS)	Area dedicated to storage of solid mineral processing (inorganic) by-products. These are typically by-products from the mineral processing/manufacturing that are not immediately useable during the Transition Phase of the OIE. It is anticipated that these materials will be stored to be recovered at a later stage when an appropriate use is identified or a market is developed.
Grain handling	Storage and handling of bulk grain for export.
Infrastructure hub, port related services	A multi-modal facility designed to manage containers and other imports and exports. Also facilities for port and shipping related services.
Marine Construction	Facility to deploy marine related construction facilities. This will link with the heavy construction areas in the SIA via a high wide load road.
Organic Waste Water Treatment (OWWT)	An integrated Organic Waste Water Treatment Facility to treat domestic sewage from Geraldton, industrial agricultural processing wastes etc. Liquid from this facility will be further processed by the Water Factory if required. Solids will generally be suitable for an organic fertiliser, biogas production, pyrolysis production of fuels etc.
Agriculturally related land uses	Temporary holding paddocks and stock export facilities that support the regional agricultural industries, fodder crops, tree crops etc. These uses would most likely be located in the buffer.
Hard rock quarry	Area from which hard rock is removed for the construction and ongoing maintenance of the Port.
Renewable Energy	Suitable locations for renewable energy generation systems (e.g. wind turbines, wave energy generation systems, salt water pumped storage hydro-electricity).

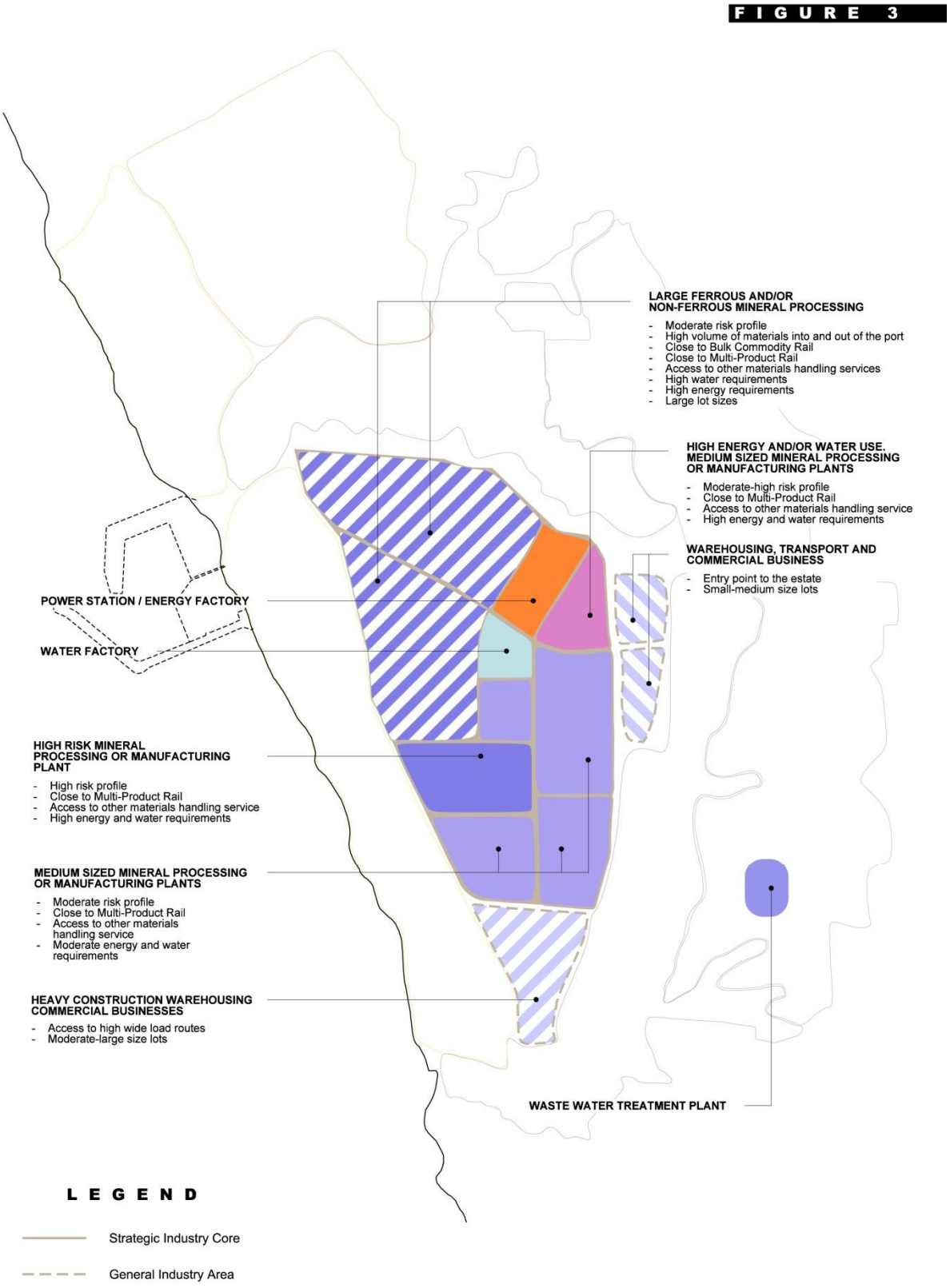
TABLE 2 Themes, Priorities and Location Criteria for Industry Clusters within the Oakajee Industrial Estate

Theme in order of priority	Rationale for Priority of Theme	Location Criteria	Description
Risk	Ongoing operations or catastrophic failure of plant and equipment may have unacceptable impacts on human life, community and the environment. Risk of damage or injury from the failure of critical components of industries operating in the OIE[20], impacts on neighbours from noise, odour etc, should be minimised by selecting locations adequately separated from neighbouring sensitive uses (notably residential)	High risk profile	Locate industries with a high risk profile towards the west of the SIA and approximately central to the whole of the OIE.
		Reduce risk between industries	Separate industries that may increase the risk profile within the SIA if they were located next to each other
Transport	The site is constrained by its topography and suitable locations for transport routes are limited. These should not be compromised by inappropriate location of other facilities. Different industries require different levels of access to a range of modes of transport (e.g. Bulk Commodity Rail, Port, roads, conveyors etc)	High volume materials into and out of the Port	Place industries with high volume, heavy material import and export requirements close to the Port (generally this would be via conveyors, road or pipeline)
		Bulk Commodity Rail	Place industries with high volume, heavy materials inputs close to the bulk commodity rail line
		Multi Product Rail	Provide good access to the multi product rail line
		High wide / wide loads	Industries that import or export high wide loads should be located adjacent to roads that are designed for this purpose
		Access to other material handling services	Industries that require access to conveyors, pipelines

[20] Environmental Risk Solutions Pty Ltd *Landcorp Oakajee Proposed Industrial Estate – Quantitative Risk Assessment 2009*, May 2009

Theme in order of priority	Rationale for Priority of Theme	Location Criteria	Description
Energy/Water	Making it easy to interchange energy and water between industries is a major component of industrial ecology. Industries should be located to achieve this objective wherever possible. Orient industries and corridors to maximise the efficiency of energy and water use and to permit sharing of energy and water between industries	High water requirements	Locate industries with high water uses around the Water Factory
		High energy requirements	Locate industries with high, non-electrical, energy requirements (gas, water, steam) around the Energy Factory
Land Use	Match the locations of industries to the statutory requirements, geography, size of area available, industrial synergies etc	Separate significantly different uses	Wherever possible reduce risks of contamination and interference between industries by geographically separating mineral processing / manufacturing and heavy construction from significantly different uses e.g. organic material processes (stock, grain, domestic and organic waste water treatment), infrastructure hub etc
		Specific Areas	Recognise that the site has constraints and opportunities dictated by its topography, geology and ecology. Four landform areas are identified • SIA/GIA • large flat area north of the Oakajee River, • undulating land to the north-east and east of the SIA/GIA • coastal zone
		Large size lots	Industries that require large, generally flat areas for their operations

FIGURE 3 Locations of types of industry clusters in the Oakajee Industrial Estate



3.4 Implications for the Structure Plan: Principle 3 – Design for Overall Efficiency

Locate and orient synergistic industries in relation to each other to optimise the shared use of by-products, energy, water and transport. Design industries to be highly efficient and to minimise materials, energy and water requirements.

While it is important to have a broad suite of industries to support industrial ecology, specific innovations were identified to support the industrial ecology of the OIE. These innovations represent the “glue” needed to join the proposed industries to make the OIE more sustainable and reduce reliance on extracting energy and water from non-sustainable sources.

Water Factory and Power Station / Energy Factory

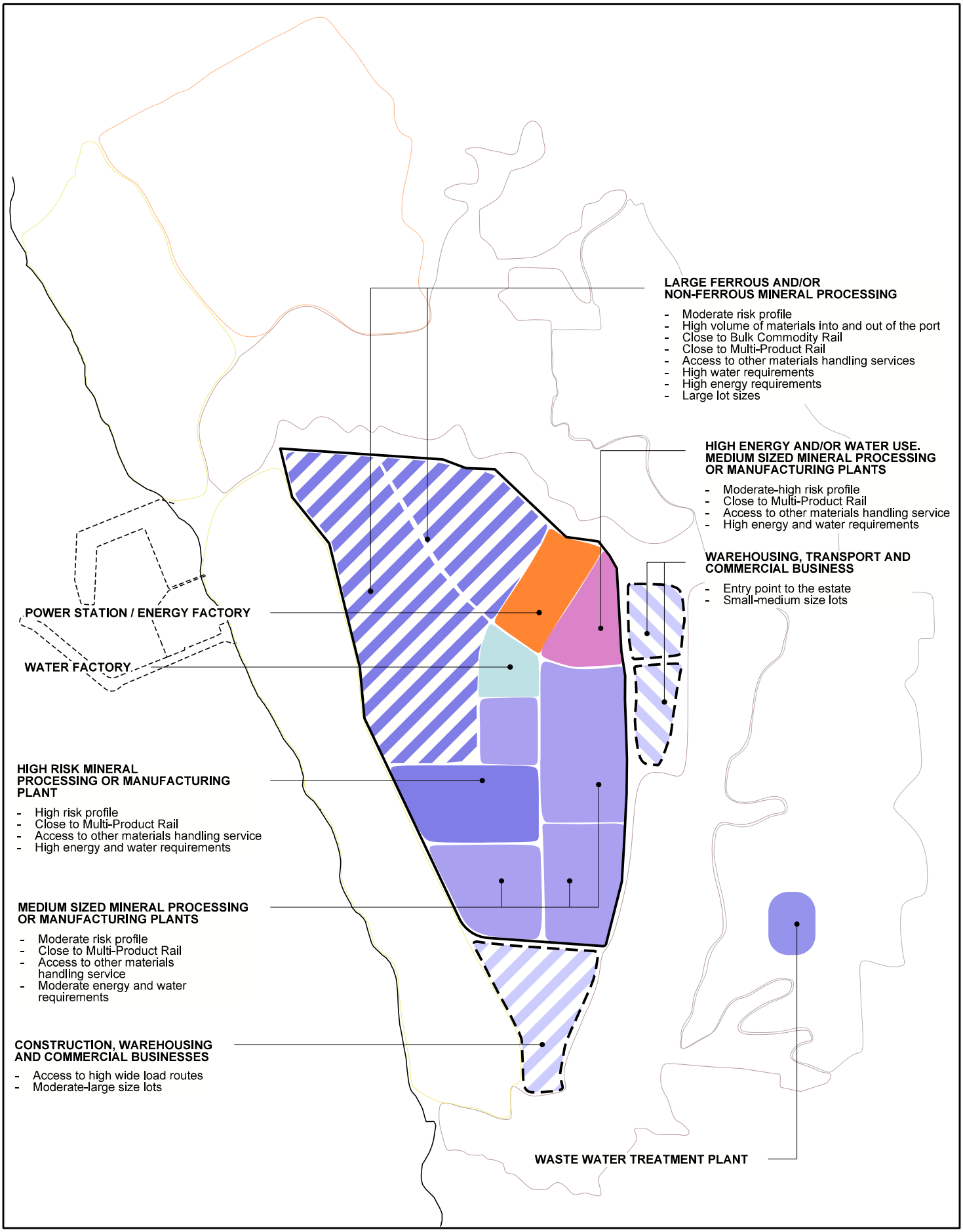
The Water Factory as described in Table 1 would have water processing systems designed to best meet the needs of industries that are located in the OIE. It should be modular and easily expandable, with room for interconnections, process modifications and entire new process trains to match capacity with future developments and changes.

The Power Station / Energy Factory described in Table 1 should also be modular in design to allow it to expand as more industries require its power. It will be located in the heart of the OIE, close to the proposed Dampier to Bunbury Pipeline gas lateral and will be surrounded by energy intensive industries.

Additional characteristics that will help the Water and Energy factories become more efficient include:

- Placing the Water and Energy Factories in close proximity will allow them to work synergistically (e.g. using waste heat in an evaporator to produce high quality water).
- Energy and water supply facilities to meet short term requirements of the pioneer industries of the OIE should locate on the sites of the Energy and Water Factories to allow their integration into the future Factories.
- The Estate Manager may contract the management of the Energy and Water Factories to businesses that specialise in such operations as a cost effective approach to their development and operation.

An indicative illustration of the management of energy and water is shown in Figure 4.



LEGEND

Strategic Industry Area

General Industry Area

NORTH

0 1 2 3km

1:50,000@A4 3570-5-009a.dgn 16 March 2012

Source: Landgate Slip Enabler Dated: June 2005 Checked : NT

FIGURE 4

INDICATIVE INDUSTRIAL ECOLOGY PLAN

Oakajee Industrial Estate, OAKAJEE

RPS

Interface between Inorganic and Organic Processes

While there are considerable synergies created by linking inorganic and organic industrial processes, there is some risk that these processes may interfere with each other. For example, dust from a mineral process may negatively impact on the operation of the waste water treatment plant. Consequently the location criteria require that, as far as possible, such processes are separate. Achieving the appropriate balance of separation and linkage will be achieved by:

- Inorganic (mineral) industrial processes will largely be located in the SIA, while Organic (sewage treatment, holding yards etc) industrial processes will be located in the Buffer.
- The infrastructure corridors that pass through the centre of the SIA and into the Buffer will provide the major linkage between the inorganic and organic industrial processes

By-Product Management

Traditionally BAU industries viewed all by-products as wastes to be made environmentally stable and disposed of. In the OIE, it is recommended that a different approach is taken to by-products, including:

- It would be preferred for each industry to treat their by-products to a “re-processing” or “storage ready” state, according to protocols, and relevant regulatory standards, developed by the Estate Manager. These standards may include commercial reprocessing agreements between industries (e.g. there may be an agreement between a cement producer, a construction aggregate recycler and a steel maker to combine steel slags and crushed aggregates to produce building products).
- It would be preferred if inorganic (mineral) by-products are transferred to the Solid By-product Storage Areas and stored under protocols developed by Estate Manager.
- The Solid By-product Storage Areas may be managed as a separate business under contract to the Estate Manager.

Organic Waste Water Treatment (OWWT) Facility

There is a proposal from the Water Corporation to locate a sewage treatment plant in the Buffer to treat domestic waste water from Geraldton. Organic wastes will be treated in the OWWT Facility. A major objective of the OWWTP should be the production of useable bio-solids. These may be used as fertilisers / soil conditioners, or in some form of downstream processing such as the pyrolysis production of fuels. In the short term, it is hoped that treated discharge water from the OWWT Facility can be used by industry for feedwater. The

suggested location of the OWWT Facility is strategically placed near a key infrastructure corridor which will allow the movement of by-products between the SIA and Buffer.

Industrialised Solid Waste Re-processing (ISWR) Facility

A facility may be developed in the OIE that can re-process selected solid wastes from the region/state into useable materials (e.g. a cement kiln to burn tyres and utilise slags from inorganic industries, pyrolysis production of fuels, etc.). If possible, this Facility could integrate with the operation of the Energy Factory.

Solid By-product Storage Areas (SBS)

All industries, and particularly those associated with mineral processing, will require dedicated areas to store by-products. This will be particularly relevant during the Transition Phase of the OIE, where some industrial ecology options may not be possible and it would be desirable for by-products to be stored and recovered at a later stage or when markets are identified.

Characteristics of the SBS areas will be:

- Characterise and store different by-product streams separately and secure them to minimise environmental impacts.
- Design storage areas such that materials can be easily recovered in the future for reprocessing or use.
- Storage areas should be in locations that are expansive, flat, and geologically suitable with adequate separation from groundwater.
- The Estate Manager may consider contracting the management of the SBS to a business that specialises in such operations and thereby providing a more cost effective outcome for industries in the OIE.

Sizing of Industry

Traditionally United States and Australian industrial plant design assumes large amounts of available space and expansive design. This can lead to significant inefficiencies and losses, particularly in an industrial ecology context where energy, water and materials have to be passed between industries. In addition, while the OIE is a reasonable size, expansion opportunities outside the SIA may be limited and consequently land should be preserved for essential industrial development. Because of this requirement, compact design of industrial plants is supported for the OIE, subject to meeting EPA criteria at their boundaries.

Renewable Energy and Carbon

In addition to the Energy Factory, the OIE can be supported by renewable energy generating capacity. Wind turbines can be located within the OIE, particularly in the northern section of the Buffer which already has planning approval for such development. The high energy coast is also prospective for wave power that could provide a very significant energy resource and pressurised sea water for the Water Factory.

There is also an opportunity for a pump seawater storage hydroelectricity system. This initiative is essentially a large "battery" to manage the peak energy requirements of the OIE and port. A large, elevated, water storage area would be filled with sea water with the pumps being powered from wind turbines, wave power or off-peak power from the grid. When peak load power is required, the water in the storage area would flow back to the ocean through a hydroelectric turbine. This system reduces the need for large generating capacity to meet peak load power requirements and can be brought on-line almost instantaneously.

3.5 Implications for the Structure Plan: Principle 4 – Interfaces between Industries

Provide ample shared corridors for easy transfer of materials, liquids and energy between industries. Provide a "smart" infrastructure (e.g. fibre optic communication links, common process control protocols, common sizing of infrastructure) that enables industries to "talk" to each other and to easily interface with each other

Whilst siting industries in appropriate locations facilitates Industrial Ecology, linkages between industries are essential. Linking criteria were developed to describe how the industry clusters should be joined and addresses issues such as future proofing, the sharing of by-products and co-location of infrastructure. The linkage criteria are listed in Table 3.

There are two main infrastructure corridors planned for the SIA. The most important is the central infrastructure corridor which runs from the Port, through the SIA and eastern GIA, and on to the Oakajee Narngulu Infrastructure Corridor. This corridor will contain the main road access to the Port and will also be the entry point for services (water, power, gas) to the SIA. Another infrastructure corridor will branch off the central corridor and will form the 'spine' of the SIA. Smaller infrastructure and service corridors servicing individual industries will be linked to the two main corridors.

An indicative illustration of a typical cross section of a corridor is shown in Appendix B.

TABLE 3 Criteria for linkage between industries

LINKAGE CRITERIA	Description of Criteria
Corridors – key infrastructure corridor	Create central and "spine' infrastructure corridors that forms a "spine" for the Estate. The infrastructure corridors should link the Organic Waste Water Treatment Plant, the industries in the SIA, Energy Factory, Water Factory, and the Port. Services (rail, pipe work, roads etc) will spur off into individual industries
Corridors – appropriate and adequate linkages	Ensure that there are adequate linkages between clusters that reflect the future proposed use of the cluster (e.g. roads, pipe work and conveyors may be needed to access a by-product storage area but rail is probably not necessary).
Corridors – more than one access point for materials handling	Wherever possible, ensure each industry has the opportunity to access materials handling services from more than one point (e.g. road and rail may be at one end of a site with conveyors and pipelines at the other end)
Corridors – hub off the energy and water factory	As energy and water factories will play a vital role in creating efficiencies across the Estate, locate them on the central spine of the Estate
Corridors – location of services	Where possible, locate electrical cabling below ground and pipe work above ground so leaks can be easily identified and repaired and contamination of the environment prevented.
Corridors – collocation of services	Where possible, collocate pipes, conveyors, road and rail within the same corridor and size the corridor to suit.
Corridors – future proofing	Ensure adequate space in the corridors to accommodate additional pipe work, conveyors as new industries locate into the SIA. Space will also need to be available for new by-product synergies.
Corridors – ocean water intake and outfall	Provide a corridor to the Port for ocean intake and outfall. This should be considered within the Oakajee Port Master Plan.
Dust	Contain dust within the boundaries of each industry lot to avoid cross-contamination of other industrial processes
Common interface standards	The Estate Manager should develop protocols and design standards for how each industry will interface with shared infrastructure including pipe work, conveyors, rail, road, the Energy and Water Factories, the solid inorganic and organic by-products storage areas etc
Common data protocols	The Estate Manager should develop protocols for how individual industries share information and process control data so water, energy, materials flows can be coordinated within and around the Industrial Ecology framework

4. Implementation

The Industrial Ecology Strategy provides a “road map” to take structure planning for the OIE beyond a “Business-as-Usual” approach to a design that will one day provide for a highly innovative industrial estate that minimises water and energy use and significantly reduces carbon emissions. By-products from industrial processes will increasingly become inputs for others, creating opportunities for innovative industries to provide these services and consequently reduce the demand on raw materials.

Features such as land availability to accommodate vertical integration of industries over time, opportunities for renewable energy and regional carbon sequestration, the Water and Energy Factories, By-product Storage Areas and ample infrastructure corridors will create a competitive advantage for the OIE.

Integral to the industrial ecology planning for theOIE is the infrastructure and service corridors linking the Port to linked industries within the SIA and GIA, and to the Region, State, Nation and world via the Oakajee-Narngulu Infrastructure Corridor. This approach aims to achieve mimicry of, and integration into, the natural ecology of the region.

While industrial ecology is about the physical location and arrangement between industries, it also requires an administrative and governance structure to create the appropriate context to enable such activities to evolve.

4.1 Implications for the Structure Plan: Principle 5 - Governance, Policy and Administrative Framework

Provide a policy and administration framework that:

- *encourages investment in innovative processes, cleaner production and waste management*
- *creates and capitalises on opportunities to value-add through reprocessing waste and energy recovery*
- *provides linkages into regional sustainability initiatives (e.g. transport strategies, carbon sequestration opportunities, workforce education and training, community and cultural development)*
- *provides a forum where industries can develop partnerships, exchange information and develop collaborative projects*
- *markets the benefits of the OIE and has a well developed industry attraction strategy*

- *reports on overall performance of the OIE and the role that individual industries are contributing to that performance*

The Estate Manager will assist in facilitating industrial ecology and sustainability initiatives through an industry attraction strategy, influencing orderly and appropriate land allocation to prospective industries, the development of key infrastructure corridors, and developing suitable lease agreements and design guidelines for future industries. These, and other issues to be addressed in the governance framework, are discussed below.

4.1.1 Industry Attraction Strategy

The Estate Manager will need to develop a strategy that promotes the sustainability advantages of the OIE and the efficiencies it will bring to industries. In addition, the industry attraction strategy should target specific opportunities for innovative industries such as those identified in Section 3.4 of this report that will act as the "glue" that builds the industrial ecology of the OIE. Particular opportunities in the short term may include:

- an independent power provider that has strengths in renewable energy and is interested in growing with the development of the OIE; and
- a water processing provider with strengths in desalination and industrial effluent treatment.

4.1.2 Development of Corridors

The Industrial Ecology Strategy identifies a broad site layout, general sizes of land allocated for industry types, and the location of the infrastructure corridors. Section 3.5 provides some design criteria for these infrastructure corridors, however these will need further detailed engineering design during the master planning phase of the OIE.

4.1.3 Relationships between Specific Industries

The Estate Manager should develop protocols to guide how an individual industry can link with the wider industrial ecology operation of the OIE. This would include the sizing of physical infrastructure as well as data standards to enable industries to communicate process information with each other.

4.1.4 Management of the Estate

To facilitate the management of the OIE, the Estate Manager should:

- Establish an oversight group, such as an advisory committee or board as is outlined in the 1998 State Heavy Industry Policy, to guide the development of the OIE. This committee or board would provide a forum where industries can work together, develop partnerships, resolve conflicts, exchange information and develop collaborative projects.
- Establish frameworks and protocols for interactions between the advisory committee/board and the State and Local Governments, and the surrounding community. This framework should address matters, such as social impact of the workforce on the surrounding community, and ensure the OIE makes an ongoing positive contribution to the wellbeing of the region. It is also particularly important that this advisory committee/board understands the social dynamics and aspirations of the local community.
- Facilitate the establishment of clusters of industries, as outlined above that may locate into the OIE. This should include identifying opportunities for estate wide assessments of emissions and opportunities for emissions trading between industries within the OIE.
- Work with regulatory agencies to develop a by-products processing, storage and management framework that address the regulatory standards and protocols applied to processing, handling and storage of by-products; and long term responsibilities for final use of sites within the OIE.

4.1.5 Estate Performance

It is important that the OIE can support its sustainability credentials by verifiable data. In this context the Estate Manager should:

- Develop a product, by-product and resource register of industries to assist in identifying synergies.
- Set Estate wide targets and strategies for energy, water, emissions and materials use.
- Provide an Estate wide sustainability reporting framework that enables long term improvements in efficiencies to be tracked and reported.
- Prepare plans and enlist industry funding and support to improve the biodiversity of the OIE and of the region

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The paper discusses five eco-industrial park models: through waste exchanges, within an organization, among collocated firms in a park, among local firms not collocated, among firms organized virtually in broader region; and addresses features gives examples for each model..

It also discusses various tools and approaches for designing industrial ecology including: input-output matching, stakeholder processes, materials budgeting, stream based or business based, etc and explores why and when these approaches may be useful. Questions of viability and usefulness of these approaches are examined and reasons given why they may or may not be advantageous for a company. Evolutionary approaches where industries evolve in concert with each other are discussed for the development of industrial symbiosis, particularly places in which development will be economically beneficial and likely to occur as more businesses become aware of the possibilities.

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The article continues to explain a few guidelines for the development of landscape design, in particular four indispensable special patterns that are claimed to be necessary for an ecologically sound environment: large natural vegetation patches, connectivity among patches, major vegetated stream corridors, and "bits of nature" as a stepping stone system between larger patches. They then try to apply these necessities to industrial ecosystems, creating the "nurtured environment", and describe how this might be applied to Jurong Island.

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Appendix A

Details of Identification of Industries

Details of Identification of Industries

1 Identifying potential industries

A generalised list was developed of industries that, potentially, could locate into the OIE. Sources used to develop this list included:

- The Australian and New Zealand Standard Industrial Classification (ANZSIC) [21] to provide an overview of types of industries that may be relevant to the region
- Mineral processing industries identified, from a market analysis by ACIL Tasman[22], as being economically feasible to locate in the Estate within a relatively short time frame.
- Using regional information sources[23] and discussions with individuals within the mining industry to identify mineral processing industries that may, given the mineralogy of the region and available mining/mineral processing technology etc, locate into the Estate at some stage.
- Regionally significant agriculture-related industries that could locate into the OIE to take advantage of the location and the facilities provided by the Port.
- Industries that are not directly related to heavy industrial processing, as would be located in the SIA, but would support regional economic activities and the Port (e.g. transport, marine related services).
- Other non-mineral processing industries that had been identified as potentially suitable for the Estate (e.g. domestic waste-water treatment plant, stock holding in the buffer).
- Industries relevant to the operation of the industrial ecology of the OIE such as renewable energy generation, water treatment, by-product processing/management and storage.
- Innovative industries that link into global trends in industrial development such as production of non-petroleum based fuels.

This list was refined using the criteria below:

- Had the industry been identified in other studies?
- Did the mineralogy of the region support the notion of down-stream processing?
- Were there any well established competitors to the industry elsewhere in the State that would make it unlikely that it would locate to the OIE?

[21] Australian Bureau of Statistics *Australian and New Zealand Standard Industrial Classification* (ANZSIC) 2006 (Revision 1.0)
[22] ACIL Tasman Oakajee Market Analysis – Market Analysis for the Oakajee Industrial Estate and Oakajee Port 2009
[23] for example Mid West Development Commission *MAJOR PROJECTS SUMMARY MID WEST REGION OF WA NOVEMBER 2009*

- Was there an existing industry that was being challenged in its existing location and may want to relocate to the OIE for a more favourable context?
- Were there indications either in government policy, or market comment, that a particular industry would be looking for a favourable location?
- Was an industry needed to make the Industrial Ecology Strategy work?
- Was there a significant potential for the industry to expand to downstream processing or provide raw materials for other industries?

Based on this assessment, a list of industries that potentially could locate into the OIE were identified (refer to Table 1 on pages 12 and 13 of main report).

2 Industry Details

The industries shown in Table 1 were analysed by GHD Pty Ltd to determine their individual transport, water, energy, labour, land area etc. needs. The industries were also grouped according to their general characteristics, for example those that typically have heavy materials handling requirements and should be located close to the port and bulk commodity rail, those with high water and energy use etc. This information is shown in Table 2 on pages 14 – 16 of main report.

3 Generic Criteria for Industrial Cluster Location

The information gathered in Tables 1 and 2 relating to transport, water, energy and land area needs etc, was used to develop generic criteria for locating industrial clusters within the OIE. Four overarching Themes emerged from this analysis, within these Themes specific location criteria were identified. This information is shown in Table 2. These generic location criteria were tested against the likely industry list from Table 1 and are shown in Table A1.

4 Locating Industry Clusters based on Location Criteria

The information in Table 2 above was combined with information about the sizes of land areas required by different industries to create a layout for the Estate that has been included in the report.

Table A1 Testing the industry clusters against location criteria

□ **X** Crucial location criteria **O** Potential location criteria

LOCATION CRITERIA > **INDUSTRY TYPE**	**RISK** High risk profile	**RISK** Reduce risk between industries	**TRANSPORT** High volume materials into and out of the Port	**TRANSPORT** Close to Bulk Commodity Rail	**TRANSPORT** Close to Multi Product Rail	**TRANSPORT** High wide / wide loads	**TRANSPORT** Access to other material handling services e.g. conveyors pipelines	**ENERGY / WATER** High water requirements	**ENERGY / WATER** High energy requirements	**LAND USE** Requires Large Lots	**LAND USE** Significantly separate from mineral processing / manufacturing	**LAND USE** Specific area - SIC	**LAND USE** Specific area - GIA 1	**LAND USE** Specific area - GIA 2	**LAND USE** Specific area - Buffer Large Area north of the Oakajee River	**LAND USE** Specific area - Buffer East and north-east of SIC/GIA	**LAND USE** Specific area - Coastal zone
Ferrous mineral processing		**O**	**X**	**X**	**X**		**X**	**X**	**X**	**X**		**X**					
Large non-ferrous mineral processing		**O**	**X**	**X**	**X**		**X**	**X**	**X**	**X**		**X**					
Medium size non-ferrous mineral processing		**O**	**X**		**X**		**X**	**X**	**X**			**X**					
Large scale mineral processing/manufacturing (high impact if catastrophic failure occurs)	**X**	**X**	**O**	**O**	**X**		**X**	**X**	**X**			**X**					
Medium size mineral processing/manufacturing with lower transport requirements		**O**			**X**			**O**	**O**			**X**					
Water Factory		**O**					**X**	**X**	**X**			**X**					
Power Station / Energy Factory		**O**					**X**	**X**	**X**			**X**					
Industrialised Solid Waste Re-processing (ISWR)		**O**			**X**		**X**	**O**	**O**			**X**					
Agricultural Industrial Processing (AIP)		**O**			**X**		**X**	**O**	**O**		**O**	**X**					

Organic based industrial processing plant		**O**			**X**		**X**	**O**	**O**			**X**					
Heavy construction					**X**								**X**	**X**			
Heavy construction (large scale fabrication and transport)					**X**	**X**				**X**				**X**			
Warehousing and service centres					**X**					**X**	**X**		**X**	**X**			
Commercial businesses											**X**		**X**	**X**			
Warehouses and transport companies														**X**			
Grain handling					**X**						**X**						**X**
Infrastructure hub, port related services					**X**	**X**					**X**						**X**
Marine Construction					**X**	**X**				**X**							**X**
Fuel Storage		**X**			**X**						**O**	**O**					**X**
Solid By-product Storage (SBS)							**X**			**X**	**X**				**X**		
Organic Waste Water Treatment (OWWT)							**O**				**X**					**X**	
Agriculturally related land uses							**O**			**X**	**X**					**X**	
Hard rock quarry	**O**	**O**									**X**					**X**	
Renewable Energy											**O**	**O**			**X**		**O**

Table A2 Estimated land area, energy, water, transport needs based on potential industry types – information supplied by GHD Pty Ltd

OAKAJEE INDUSTRIAL ESTATE: INDICATIVE INPUT/OUTPUT ASSESSMENT - SUMMARY

Update: 16-Aug-10

Land component	Indicative Area (Ha)
Strategic industries (~75%)	851
Road / rail reserves, service corridors (~25%)	284
Total Strategic Industrial Area	**1,135**
General industries (~80%)	64
Road / rail reserves (~20%)	16
Total General Industry Area 1	**80**
General industries (~80%)	93
Road / rail reserves (~20%)	23
Total General Industry Area 2	**116**
Coastal zone - OPR (~40%)	401
Coastal zone - non OPR (~20%)	200
Coastal zone - not utilised (~10%)	100
Road / rail reserves, service corridors (~30%)	301
Total Coastal Zone	**1,002**
Special Control Area available (~90%)	3,664
Road / rail reserves, service corridors (~10%)	407
Total Buffer Zone	**4,072**
TOTAL OAKAJEE INDUSTRIAL AREA	**6,324**

Red text = data to be refined

Notes and limitations:
- Underlying assumptions and references are included in worksheet 'Assumptions and References'
- These are indicative and high level estimates based on limited information available at this point in time, and therefor subject to change
- Estimates are subject to industry mix to be located in Oakajee Estate (still unknown)
- There is no certainty about date/year when the Oakajee industrial estate will be fully developed
- Estimates do not take into account ongoing industry expansions and increasing efficiencies and technology developments over time
- Inputs and outputs cover Oakajee Industrial Estate. Inputs and outputs from OPR are not included
- These estimates cover operation of industries. Estimates do not cover potential higher demands during construction period
- Disclaimer: GHD does not control its use therefore the content of the spreadsheet is not assured by GHD

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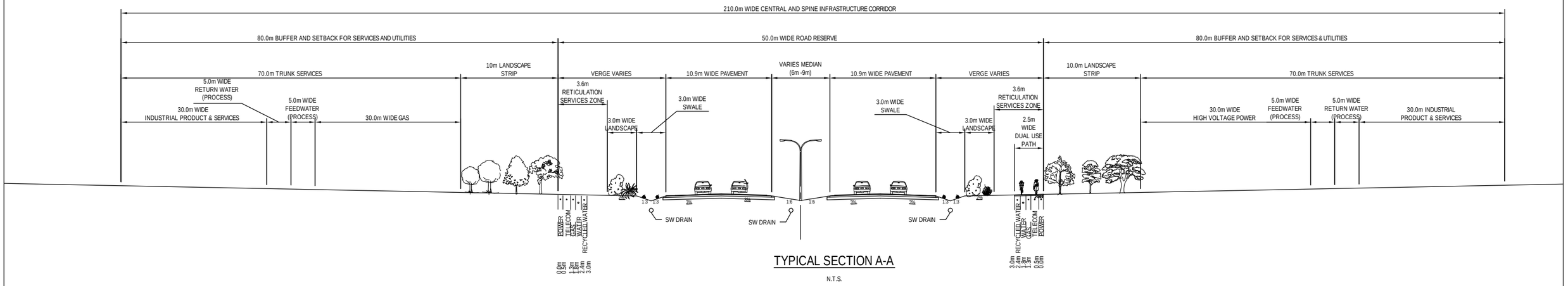
TDS ~ 100 to 200 mg/L

TDS ~ 800 to 1000 mg/L

Potential industry types	Total area	Direct employment			POTENTIAL KEY INPUTS						POTENTIAL KEY OUTPUTS		
		Total	'White collar'	'Blue Collar'	Power	Gas	Domestic use of potable water	High quality industry feed water	Process & cooling water (lower quality)	Raw / source materials	Water discharge	Products	By-products / wastes
	Ha	persons	persons	persons	MW	TJ/a	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ktpa	ML/a (ktpa)	ktpa	ktpa
STRATEGIC INDUSTRY AREA													
Ferrous mineral stockpiling and pre-treatment													
Magnetite iron ore pelletising plant	60	400	120	280	10	2,000	11	1,050	1,950	4,725	2,408	4,500	225
Sub-total	**60**	**400**	**120**	**280**	**10**	**2,000**	**11**	**1,050**	**1,950**	**4,725**	**2,408**	**4,500**	**225**
Ferrous mineral processing													
DRI / alternative smelting iron plant	70	400	120	280	60	50,000	11	2,100	3,900	5,250	4,815	2,000	726
Integrated steel making plant	100	400	120	280	80	50,000	11	3,500	6,500	6,072	8,025	2,000	730
Sub-total	**170**	**800**	**240**	**560**	**140**	**100,000**	**22**	**5,600**	**10,400**	**11,322**	**12,840**	**4,000**	**1,456**
Large size non-ferrous mineral processing / manufacturing (high energy and water use)													
Large size nickel processing plant	200	400	120	280	15	20,000	11	1,750	3,250	222	4,013	60	99
Sub-total	**200**	**400**	**120**	**280**	**15**	**20,000**	**11**	**1,750**	**3,250**	**222**	**4,013**	**60**	**99**
Medium size non-ferrous mineral processing / manufacturing (high energy and water use)													
2 Medium size non-ferrous processing plants	80	400	120	280	15	20,000	11	1,750	3,250	222	4,013	60	39
Sub-total	**80**	**400**	**120**	**280**	**15**	**20,000**	**11**	**1,750**	**3,250**	**222**	**4,013**	**60**	**39**
Water supply													
Water factory	40	15	5	11	22	0	0.4	0.2	0	0	10,000	40,000	1.2
Sub-total	**40**	**15**	**5**	**11**	**22**	**0**	**0**	**0.2**	**0**	**0**	**10,000**	**40,000**	**1.2**
Energy supply													
Energy factory (steam, electricity, heat, chill)	40	25	8	18	Unknown	Unknown	0.7	Unknown	Unknown	0	Unknown	Unknown	0
Sub-total	**40**	**25**	**8**	**18**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
Non-ferrous mineral processing / manufacturing (high impact and risk)													
Large scale manufacturing plant	50	200	60	140	10	2,500	5	350	650	1,050	803	1,000	50
Sub-total	**50**	**200**	**60**	**140**	**10**	**2,500**	**5**	**350**	**650**	**1,050**	**803**	**1,000**	**50**
Non-ferrous mineral processing / manufacturing (low - moderate energy and water use)													
3 Medium scale manufacturing plants	60	300	90	210	12	3,000	8	525	975	1,575	1,204	1,500	75
Sub-total	**60**	**300**	**90**	**210**	**12**	**3,000**	**8**	**525**	**975**	**1,575**	**1,204**	**1,500**	**75**
Solid waste industrial processing (SWIP)													
Large scale processing plant	50	200	60	140	15	2,500	5	700	1,300	893	1,605	850	43
Sub-total	**50**	**200**	**60**	**140**	**15**	**2,500**	**5**	**700**	**1,300**	**893**	**1,605**	**850**	**43**
Agricultural industrial processing (AIP)													
2 Organic based processing plants	100	200	60	140	20	500	5	1,000	1,000	2,200	3,300	2,000	200
Sub-total	**100**	**200**	**60**	**140**	**20**	**500**	**5**	**1,000**	**1,000**	**2,200**	**3,300**	**2,000**	**200**
Heavy construction													
Heavy construction company	10	75	23	53	7	130	2	50	50	105	83	100	6
Sub-total	**10**	**75**	**23**	**53**	**7**	**130**	**2**	**50**	**50**	**105**	**83**	**100**	**6**
Total Strategic Industry Area	**860**	**3,015**	**905**	**2,111**	**266**	**150,630**	**82**	**12,775**	**22,825**	**22,314**	**40,266**	**54,070**	**2,194**
GENERAL INDUSTRIAL AREA 1													
6 Warehouses and transport companies	30	300	90	210	5	34	7	8	23	1,515	24	1,500	15
10 Commercial businesses	10	200	200	0	2	75	4	3	0	10	2	10	0
8 General industries	24	320	96	224	4	192	3	160	160	404	264	400	4
Total General Industry Area 1	**64**	**820**	**386**	**434**	**10**	**301**	**14**	**170**	**183**	**1,929**	**290**	**1,910**	**19**
GENERAL INDUSTRIAL AREA 2													
Heavy construction and general industry													
4 Heavy construction companies	40	300	90	210	6	520	8	200	200	315	330	400	24
8 General industries	24	320	96	224	4	312	9	160	160	404	264	400	4
Sub-total	**64**	**620**	**186**	**434**	**10**	**832**	**17**	**360**	**360**	**719**	**594**	**800**	**28**
Warehousing, service centre													
4 Warehouses and transport companies	20	200	60	140	3	23	4	5	15	1,010	16	1,000	10
10 Commercial businesses	10	200	200	0	2	75	4	3	0	10	2	10	0
Sub-total	**30**	**400**	**260**	**140**	**5**	**98**	**9**	**8**	**15**	**1,020**	**18**	**1,010**	**10**
Total General Industry Area 2	**94**	**1,020**	**446**	**574**	**15**	**930**	**26**	**368**	**375**	**1,739**	**612**	**1,810**	**38**
COASTAL ZONE													
Grain handling facility	25	50	15	35	6	29	1	1	4	18	4	18	0.2
Infrastructure hub, port related services	135	250	75	175	30	154	7	50	250	2,525	233	2,500	25
3 marine construction companies	30	225	68	158	21	390	6	150	150	315	248	300	18
Fuel storage	10	50	15	35	2	11	1	10	25	600	28	597	3
Total Coastal Zone	**200**	**575**	**173**	**403**	**59**	**584**	**15**	**211**	**429**	**3,458**	**512**	**3,415**	**46**
BUFFER ZONE													
Inorganic solid by-product storage and processing	550	40	8	32	15	2,000	1.1	0	1,000	1,490	750	1,118	373
Organic Waste Water Treatment (OWWT)	75	20	4	16	0	0	0.5	0	0	1,625	1,300	293	33
Agriculturally related land uses	366	25	5	20	0	0	0.6	0	11	19	3	18	1
Renewable energy	366	10	2	8	0	0	0.2	0	0	0	0	Unknown	0
Total Buffer Zone	**1,358**	**95**	**19**	**76**	**15**	**2,000**	**2**	**0**	**1,011**	**3,134**	**2,053**	**1,428**	**406**
Total Oakajee Industrial Estate	**2,576**	**5,525**	**1,928**	**3,597**	**366**	**154,445**	**140**	**13,524**	**24,822**	**32,574**	**43,733**	**62,633**	**2,703**

Appendix B

Typical Infrastructure Corridor



TYPICAL SECTION A-A

N.T.S.

NOTE:

TYPICAL INFRASTRUCTURE CORRIDORS ARE INDICATIVE AND BASED ON ULTIMATE DEVELOPMENT OF THE OIE. FINAL DEVELOPMENT OF THE PROPOSED INFRASTRUCTURE WILL BE STAGED AS REQUIRED TO MEET DEMAND AS INDUSTRIES LOCATE & EXPAND AT THE OIE

0 2 4 6 8 10m

SCALE 1:200 AT ORIGINAL SIZE

SKETCH

No	Revision	Note: * indicates signatures on original issue of drawing or last revision of drawing	Drawn	Job Manager	Project Director	Date
C	ISSUED FOR COMMENT		YV			20.01.11
B	ISSUED FOR COMMENT		YV			14.12.10
A	ISSUED FOR COMMENT		SL			24.11.10

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Drawn		Designer	
Drafting Check		Design Check	
Approved (Project Director)			
Date			
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

Client **LANDCORP**
Project **OIE STRUCTURE PLAN**
Title **TYPICAL INFRASTRUCTURE CORRIDOR**

Original Size **A1** **Drawing No: 61-24611-SK107** **Rev: C**

Plot Date: 20 January 2011 - 11:50 AM Plotted by: Yvonne Vermaak/Perth\GHD/AU Cad File No: G:\61\24611\CADD\Road Cross Sections\61-24611-SK107.dwg