

Appendix IX: GHD BSIA Industrial Ecology Strategy



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LandCorp

Report for
Boodarie Strategic Industrial Area
Industrial Ecology Strategy

29 August 2011



The estimates provided in this report are indicative estimates based on information to GHD at the time of release of this report (see cover page for date), which does not include specific market research on the types of industries locating to the Boodarie Strategic Industrial Area. The estimates presented here should only be used for the purpose of the Concept Design of the Boodarie Strategic Industrial Area. The data presented in this report should be updated as more detailed information becomes available through the structure plan development process and thereafter (e.g. lot sizes, net developable land, industries locating to Boodarie Strategic Industrial Area, industry locations, industry inputs and outputs).

Limitations and reliance of data provided in this report are presented Section 13 'Limitations and Reliance'.



Executive Summary

Overview

Industrial ecology is about smart(er) design and operation of industrial estates from an economic, environmental and community perspective, including optimisation of resource efficiencies through industry collaboration, and ensuring the short and long term viability of the estate from economic, environmental, and social perspective.

This report outlines the industrial ecology opportunities for the Boodarie Strategic Industrial Area (BSIA), and its implications for the BSIA Concept Plan. The work follows a customised industrial ecology methodology developed by GHD for the project.

In this report, GHD has addressed the industrial ecology of the BSIA by examining potential industry inputs and outputs, utility demand forecasting, industrial synergy opportunities, centralised facilities, industry precincts, industry clustering, anchor tenants, benchmarking with other industrial estates, and an implementation plan.

Industry Input / Output assessment

An industry input/output assessment was undertaken to guide transport (e.g. location and type of transport routes), engineering work (e.g. location and width of service corridors), and planning of the estate. Furthermore, the industry input/output assessment provides the foundation for the utility demand forecasting and the identification of industrial synergy opportunities for the estate.

Key indicative inputs (when estate is fully developed):

Table 1 Summary of BSIA Industry Input / Output Assessment

Resource	BSIA Excluding Total BHP Investigation Area (700 ha)	BSIA Excluding BHP Investigation Area North West of Estate (385 ha)	BSIA Including Total BHP Investigation Area (700 ha)
Net developable land for industry	2,230 ha	2,545 ha	2,930 ha
INPUTS:			
Power	1,207 MW	1,378 MW	1,586 MW
Gas	428 PJ/a	489 PJ/a	562 PJ/a
Domestic use potable water	257 ML/a	293 ML/a	337 ML/a
High quality industry feedwater	23,013 ML/a	26,264 ML/a	30,237 ML/a
Low(er) quality industry feedwater	36,792 ML/a	41,989 ML/a	48,341 ML/a
OUTPUTS:			
Effluent	63,306 ML/a	72,248 ML/a	83,177 ML/a
Products	93,711 ktpa	106,948 ktpa	123,127 ktpa
By-products	4,643 ktpa	5,299 ktpa	6,101 ktpa

Utility Demand Forecasting



Based on a set of high level assumptions developed from other industrial estates in WA, along with the industry input / output assessment, an utility demand forecasting (power, gas, water) for the BSIA was undertaken to assist utility providers, government, and future industry with the planning and on-time delivery of required infrastructure and services to the estate.

In consultation with LandCorp, the assumptions made in this report are based on heavy industries being established in the BSIA over period of approximately 50 years. The utility demands will develop to their ultimate levels (as summarised above) over this time frame.

The forecasted demands will vary and are approximate estimates only, subject to actual development of the estate and final industry mix that will establish in the BSIA over time.

Industrial Synergies

Based on the potential industry mix and industry input / output assessment (Section 3), the great potential for new synergies emerging from the development of Boodarie Strategic Industrial Area was confirmed. As confirmation, this report identified a total of 44 synergy opportunities for the BSIA at this stage, made up of 13 supply chain synergies, 11 utility synergies, 14 by-product synergies, and 6 service synergies.

The types of benefits from industrial synergies often go well beyond the conventional business case benefits. Security of water and energy supply, increased resource efficiency, lower operational costs for resource use, and reduced storage and landfill costs are key benefits from the synergies presented in this report.

The BSIA Concept Plan should allow for the development of promising industrial synergy opportunities identified. This report outlines the potential implications from the industrial synergy opportunities on the BSIA Concept Plan, and to what extent the Concept Plan will be able to facilitate the development of these synergies over time.

Centralised Water, Energy, By-Product Facilities

Securing water and energy supply, and storage and processing of large volume industrial by-products and wastes will be critical to the successful development of the Boodarie Strategic Industrial Area. Key industrial ecology initiatives proposed for the BSIA are:

- ▶ **Centralised industry feedwater facility:** The BSIA, when fully developed, will likely require between 60 and 80 GL/yr of industry feedwater (high and low(er) quality). The lack of access to appropriate, well priced industry feed water can be a potential show stopper for new heavy industry wanting to establish in the BSIA. In the BSIA Concept Plan, it is proposed to allocate sufficient land area (about 65 ha) in the Utility Precinct for a centralised facility to produce fit-for-purpose industry feedwater. Such a facility could feed from various sources, including groundwater, industrial effluents generated within the estate, effluent from nearby municipal WWTP, seawater, or a combination of these sources. At this point in time, the BSIA Concept Plan should not lock in one water resource, but rather allow for the use of any of these water resources over time (subject to future feasibility studies, developments, and water availability).
- ▶ **Centralised energy facility:** Given the significant potential energy requirements of the BSIA, it is proposed to allow for the development of a centralised and joint industry energy facility (about 60 ha) in the Utility Precinct of the estate creating economies of scale and potentially avoiding the need for multiple, smaller, and under-utilised facilities throughout the estate. Such facility could produce electricity, steam, chill, hot air to industries in its close proximity. Allowance should be made for the facility to feed from various energy sources, including gas, coal, renewable energy, and industry



waste heat. It is recommended to co-locate the centralised energy facility with the industry feedwater facility to enable the generation of feedwater or seawater desalination with industry waste heat.

- ▶ **Centralised by-product facility:** Significant amounts of industrial by-products (both inorganic and organic) will likely be generated in the BSIA. Rather than stockpiling the large volume industrial by-products in within the strategic core of the estate, there is potential to transfer these by-products to a centralised storage facility in the buffer zone of the estate (subject to environmental, town planning, and land assembly constraints). A centralised facility in the buffer would maximise industrial land use in the strategic core, but would also facilitate and encourage the (co-)processing industrial by-products into valuable materials.

For the proposed centralised facilities to be successful, sufficient corridor access to these facilities must be provided.

Precincts and Industry Clustering

The clustering of relevant industries (based on their services and resource inputs and outputs) is at the heart of industrial ecology. Industry clustering is a critical element to allow for the development of regional synergies within the BSIA and with its surrounding regions, as well as a mechanism to reduce the need for utility infrastructure and associated costs.

High level industry clustering is facilitated through the industry precincts identified and their positioning within the Boodarie Strategic Industrial Area. Based on the industry input/output assessment, previous reports on the BSIA, regional synergy opportunities, and discussions with the Concept Plan Design Team, the following precincts were identified and positioned within the estate according to set of defined precinct location criteria:

- ▶ Port Dependent and Material Intensive Industries
- ▶ Downstream Petroleum / Gas / Coal Processing
- ▶ Downstream Iron Ore Processing
- ▶ Resource Processing
- ▶ General industries
- ▶ Noxious industries

Industry clustering within the proposed precincts in the BSIA can be based on various parameters, including water and energy consumption, risk profile, services and support, processing of organic and/or inorganic materials. This report provides guidance on the types of industry clustering which can occur in Boodarie, rather than locking in clustering scenarios at this point in time with limited information on future industries to locate to the BSIA. As industries locate to the BSIA, specific industry clustering scenarios should be assessed.

Anchor Tenants

The development of the BSIA will significantly benefit from having anchor tenants to attract associated and synergic businesses and establish regional synergies in the area. These anchor tenants can be existing industries in surrounding areas (such as the Port Hedland port) or new businesses locating in the BSIA. A preliminary review of potential anchor tenants for the BSIA is provided in this report.

Benchmarking with Other Industrial Areas

This report includes benchmarking of the results from this BSIA study with the existing Kwinana Industrial Area and the proposed Oakajee Industrial Area in WA. The benchmarking shows that the BSIA may have similar characteristics as Kwinana and Oakajee in terms of water demand, raw materials inputs, products, and effluent discharges (quantities per ha and per industry). BSIA seems to have higher gas and power demands than Kwinana and Oakajee. This can be partly explained by the Petroleum / Gas



/ Coal Processing Precinct in Boodarie. Furthermore, it is recognised that each industrial estate is unique in terms of industry mix, land assembly, infrastructure, and transportation (e.g. access to port, rail, etc).

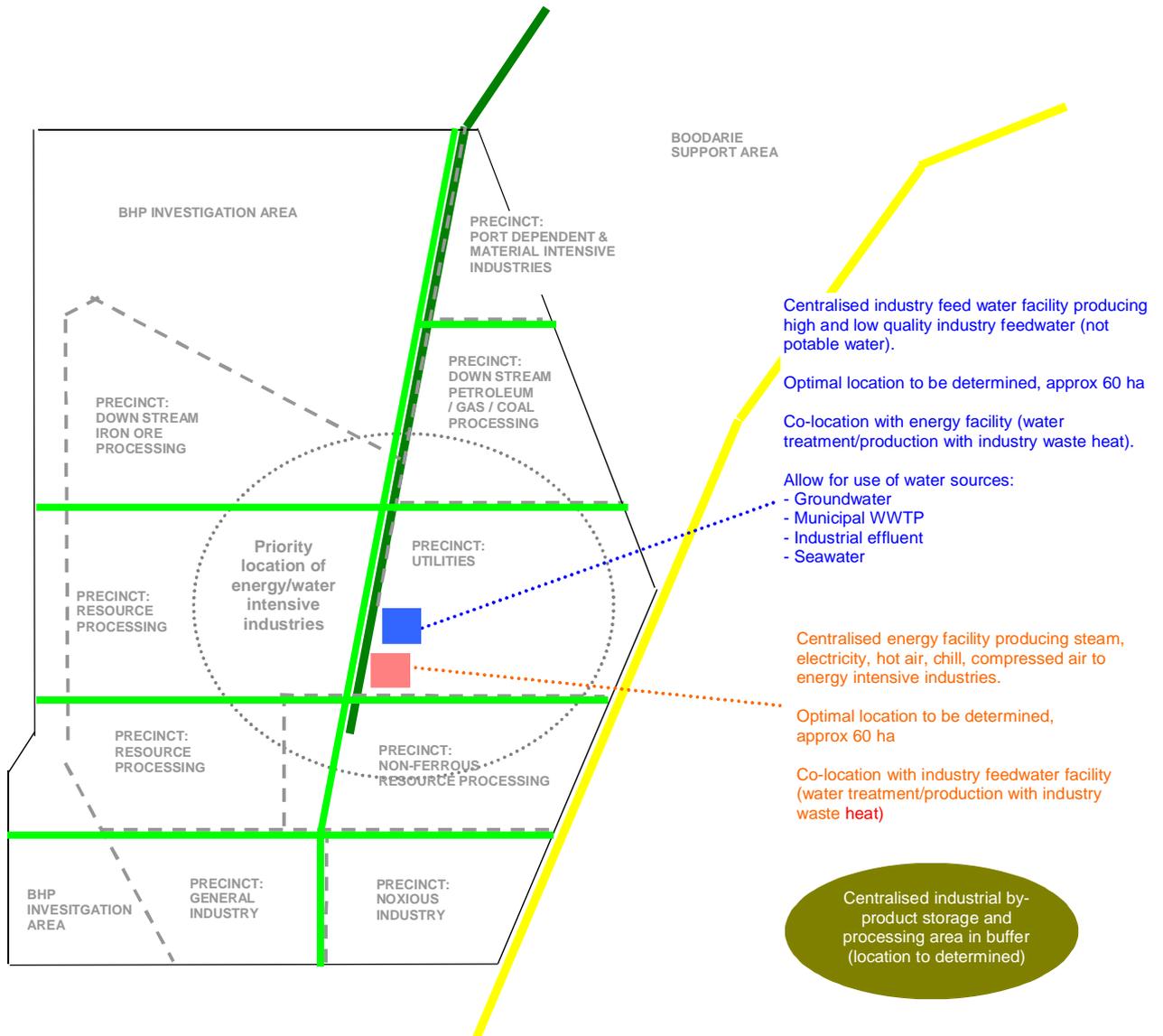
Implementation Plan

There is a need for an action plan and operational management model for the estate to assist with the further development and implementation of the industrial ecology (and other engineering and planning initiatives) post concept planning. It is recognised that otherwise key initiatives may not materialise because of a lack of a coordinated approach and upfront commitment from key stakeholders. The implementation plans listed in this report provide suggested leads for actions, listing of infrastructure components which are influenced by the industrial ecology initiatives, and a suggested timing.

Limitations and Reliance

Limitations and reliance of data provided in this report are presented Section 13 'Limitations and Reliance'.

Proposed Precinct Concept for Boodarie Strategic Industrial Area



Notes:

- ▶ Alignment shown are only indicative, and subject to assembly of base mapping;
- ▶ Plan subject to environmental, town planning, and land assembly constraints;
- ▶ Do not scale this plan; and
- ▶ Land size and location flexible, subject to industry demand.



Contents

Executive Summary

1.	Introduction	1
1.1	Boodarie Industrial Area	1
1.2	Industrial Ecology	2
1.3	Scope of Work	3
1.4	This Report	3
2.	Methodology	5
3.	Industry Input / Output Assessment	6
3.1	Notes and Limitations	6
3.2	Net Developable Areas	6
3.3	Summary of Estimated Industry Inputs and Outputs	8
3.4	Boodarie Strategic Industrial Area and Port	10
4.	Utility Demand Forecasting	13
4.1	Notes and Limitations	13
4.2	Assumptions	14
4.3	Gas	14
4.4	Power	15
4.5	Water	15
5.	Industrial Synergies	18
5.1	Introduction	18
5.2	Summary of Synergy Opportunities Identified	18
5.3	Benefits of Industrial Synergies	21
5.4	Success Factors on Industrial Synergies	22
5.5	Industrial Synergies and BSIA Concept Plan	22
6.	Centralised Water, Energy and By-Product Facilities	27
6.1	Centralised Industry Feedwater Facility	27
6.2	Centralised Energy Facility	28
6.3	Centralised Industrial By-Product Storage and Processing Facility	29
7.	Industrial Area Precincts	31
7.1	Identification of Precincts	31



7.2	Precincts Location Criteria	31
7.3	Precinct Concept	32
8.	Industry Clustering	34
8.1	Industry Clustering	34
8.2	Locating Industries within the Estate and Precincts	35
9.	Anchor Tenants	45
10.	Benchmarking with Other Industrial Areas	47
10.1	Introduction to Kwinana and Oakajee Industrial Areas	47
10.2	Industrial Area Base Data	49
10.3	Industrial Area Benchmarking	49
11.	Implementation Plan and Operational Management Model	51
11.1	Implementation Plan	51
11.2	Operational Management Model	55
12.	Recommendations	59
13.	Limitations and Reliance	61

Appendices

- A Industry Input / Output Assessment – Assumptions and References
- B Potable Water for Domestic Use – Assumptions
- C Potential Economic, Environmental, and Social Benefits of Industrial Synergy Opportunities



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1. Introduction

1.1 Boodarie Industrial Area

In line with the State Government's Heavy Use Industrial Land Strategy (HUILS), LandCorp is leading the conceptual design and structure planning for the Boodarie Strategic Industrial Area (BSIA).

The overarching vision for the BSIA is to create a benchmark industrial estate demonstrating an effective interface between general/noxious industry and strategic industry uses. This includes efficient use of land and infrastructure while incorporating flexibility to respond to changing market requirements to support a rapidly expanding resource sector.

The BSIA is well located in relation to social infrastructure and has large amounts of land available fronting Great Northern Highway. BSIA is approximately 25 km south west of Port Hedland township, and 5 km west of South Hedland.

An aerial map of the estate is provided below.

Figure 1 Aerial Map of Boodarie Strategic Industrial Area



BSIA provides approximately 4,000 ha of core heavy industry land zoned for Strategic Industry with an estimated minimum 2 km buffer in the Town of Port Hedland Planning Scheme No. 5.

The BSIA was established to provide opportunities for the development of downstream processing of local resources and waste planned with service corridor connections to the port. The types of industries likely to establish in the BSIA are those based on the local resources of iron ore, base metals, steel alloy, precious metals, salt, and gas. Land areas in the order of 45 ha to 150 ha would be likely be required for major processors.



There is a growing urgency in the Town of Port Hedland for the release of General Industry / Noxious Use land to accommodate new industries and to allow for inappropriately located existing industries to relocate into the BSIA. An indicative area within which to locate a 200 ha general industrial / noxious use area has been identified over the southern portion of the BSIA.

1.2 Industrial Ecology

Industrial Ecology is both 'industrial' and 'ecological'¹. It is industrial in that it focuses on product design and manufacturing processes. Industry is therefore viewed as the primary agent for environmental improvement, as it possesses the technological expertise, management capability and financial and other resources necessary for successful execution of environmentally informed design of products and processes. Industrial Ecology is ecological in at least two senses. Firstly, it looks to non-human 'natural' systems as models for industrial activity. Mature ecosystems are extremely effective in recycling of resources and therefore promoted as exemplary models for effective recycling in industry and society. Secondly, Industrial Ecology places industry – or technological activity – in the context of the larger ecosystems that support it. This focuses Industrial Ecology on examining the sources of resources used in industrial activity and the sinks that absorb and detoxify the wastes discharged by society.

In the context of industrial land planning and development of the Boodarie Strategic Industrial Area, an industrial ecology approach involves the following elements:

- ▶ Qualify and quantify industry inputs and outputs over time;
- ▶ Provide input into the identification and establishment of appropriate infrastructure to support the development of the industrial estate (e.g. service and utility corridors, transportation routes, facilities for water, energy, and waste processing and supply);
- ▶ Identify industrial synergy opportunities (supply chain, utility, by-product, and service synergies), and ensure that the industrial estate concept plan allows for the development of promising opportunities;
- ▶ Identify and locate appropriate industry precincts within the estate, and subsequent clustering of industries within these precincts based on their services, resource inputs and outputs, and potential synergy opportunities;
- ▶ Identify anchor tenants to attract further synergistic industries to the estate;
- ▶ Delivery of implementation plans to assist with the post concept plan development of the industrial ecology initiatives highlighted in this report.

In short, industrial ecology is about smart(er) design and operation of industrial estates from an economic, environmental and community perspective, including optimisation of resource efficiencies through industry collaboration, and ensuring the short and long term viability of the estate from economic, environmental, and social perspective.

¹ Lifset, R. and T. Graedel. 2002. Industrial Ecology: goals and definitions. In Handbook of Industrial Ecology, edited by R. Ayres and L. Ayres. Cheltenham, UK: Edward Elgar Publications.



1.3 Scope of Work

As part of the Engineering brief for the BSIA, LandCorp commissioned GHD to undertake the following industrial ecology study:

- ▶ Qualification and quantification of indicative inputs and outputs of potential industry types locating to the BSIA;
- ▶ Undertake high level and indicative utility demand forecasting;
- ▶ Review of potential industrial synergy opportunities;
- ▶ Identification of industry precincts and industry clustering opportunities;
- ▶ Development of implementation plans for promising industrial ecology opportunities.

The above items have been incorporated into the methodology presented in Section 2 'Methodology' of this report.

1.4 This Report

This report is structured as follows:

- ▶ Section 1 'Introduction' introduces the project and industrial ecology, including limitations and reliance of this report;
- ▶ The industrial ecology methodology applied as part of the BSIA Concept Planning process is provided in Section 2 'Methodology';
- ▶ Section 3 'Industry Input / Output Assessment' outlines the review of the inputs (e.g. power, gas, water, raw materials) and outputs (e.g. effluent, products, by-products, wastes) of potential industry types locating to the BSIA;
- ▶ The forecasting of utility demand (power, gas, water) is presented in Section 4 'Utility Demand Forecasting';
- ▶ Section 5 'Industrial Synergies' outlines the potential industrial synergy opportunities (supply chain, utility, by-product, and service synergies) for the estate, including implications for the BSIA Concept Plan;
- ▶ Introduction to the business case and the concepts of centralised facilities in the BSIA for industry feedwater, energy, and industrial by-products are provided in Section 6 'Centralised Water, Energy and By-Product Facilities';
- ▶ Based on the assessment of industry inputs and outputs and industrial synergies, Section 7 'Industrial Area Precincts' identifies appropriate industry precincts for the estate, including recommended locations of the precincts and a precinct concept plan;
- ▶ Potential location of industries within the precincts and potential opportunities for industry clustering are outlined in Section 8 'Industry Clustering';
- ▶ Section 9 'Anchor Tenants' provides a summary of potential industries to attract to BSIA. This information will assist LandCorp and DSD with the successful development of the estate;
- ▶ Benchmarking of the results from this BSIA study with the Kwinana and Oakajee Industrial Areas is provided in Section 10 'Benchmarking with Other Industrial Areas';



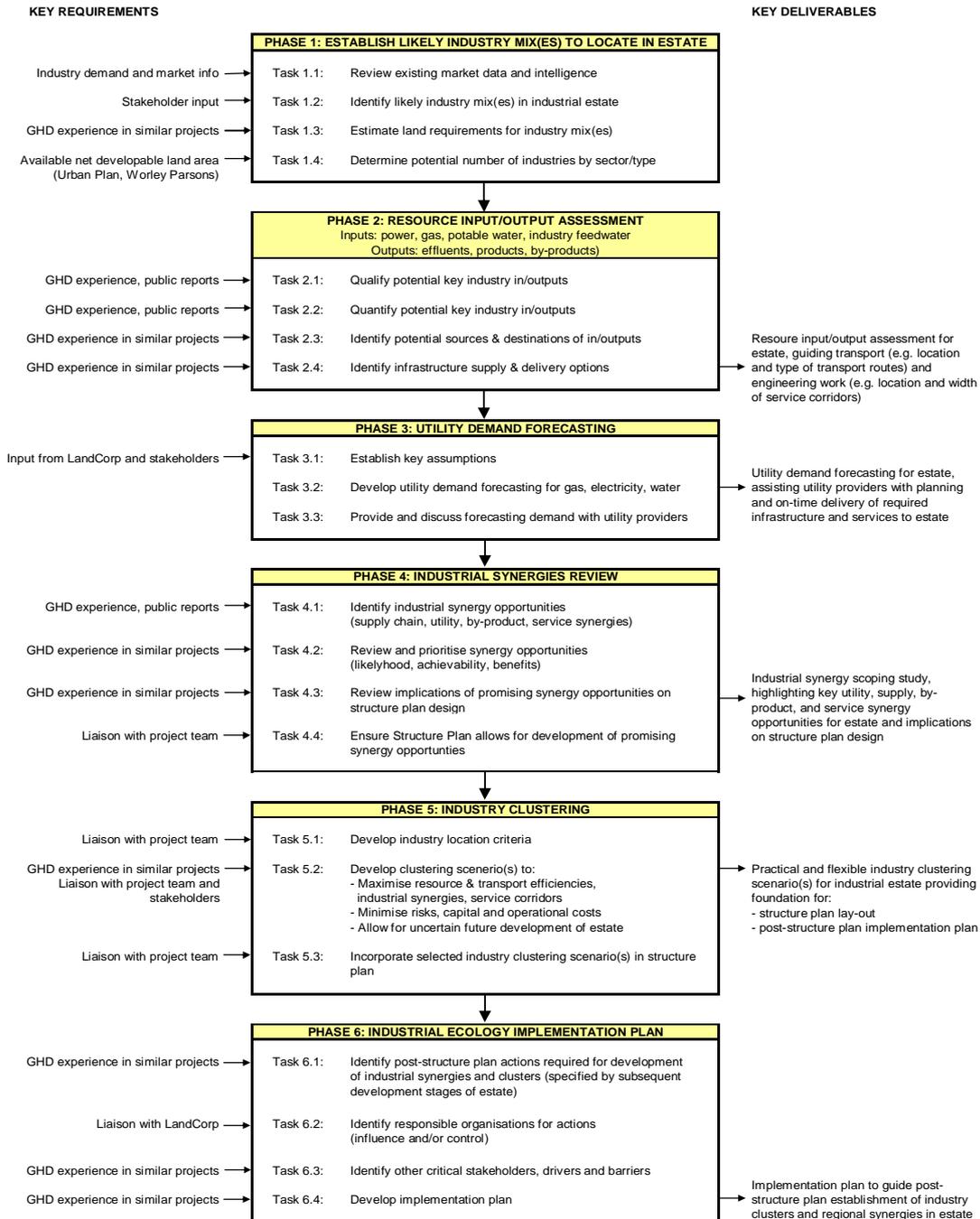
- ▶ Section 11 'Implementation Plan' presents an implementation and action plan to assist LandCorp, DSD and other stakeholders with the way forward towards implementation of promising industrial ecology initiatives post concept planning;
- ▶ Recommendations from this report are provided in Section 12 'Recommendations';
- ▶ Limitations and reliance of data provided in this report are presented in Section 13 'Limitations and Reliance'.



2. Methodology

The industrial ecology methodology developed by GHD and applied as part of the BSIA Concept Planning process is provided in the figure below, including key input requirements and deliverables.

Figure 2 BSIA – GHD’s Industrial Ecology Methodology





3. Industry Input / Output Assessment

The estimates provided in this report are indicative estimates based on information to GHD at the time of release of this report (see cover page for date), which does not include specific market research on the types of industries locating to the Boodarie Strategic Industrial Area. The estimates presented here should only be used for the purpose of the Concept Design of the Boodarie Strategic Industrial Area. The data presented in this report should be updated as more detailed information becomes available through the structure plan development process and thereafter (e.g. lot sizes, net developable land, industries locating to Boodarie Strategic Industrial Area, industry locations, industry inputs and outputs).

An industry input/output assessment is presented in this section to guide transport (e.g. location and type of transport routes), engineering work (e.g. location and width of service corridors), and concept planning of the estate.

Furthermore, the industry input/output assessment for the BSIA outlined in this section provides the foundation for the utility demand forecasting (Section 3.4.2), and the identification of industrial synergy opportunities for the estate (Section 5).

3.1 Notes and Limitations

The industry input and output assessment presented in this section is subject to following uncertainties and limitations:

- ▶ Underlying assumptions and references are included in Appendix A;
- ▶ These are indicative and high level estimates based on limited information available at this point in time, and therefore subject to change;
- ▶ Estimates are subject to the industry mix to be located in BSIA (still unknown);
- ▶ There is no certainty about date/year when the BSIA will be fully developed;
- ▶ Estimates do not take into account ongoing industry expansions and increasing efficiencies and technology developments over time;
- ▶ These estimates cover the operation of industries. Estimates do not cover potential higher demands during construction period.

3.2 Net Developable Areas

Table 2 shows the estimated total land areas and Net Developable Area (NDA) of the identified industry precincts of the Boodarie estate. As shown in the table, it is been estimated (by Urban Plan and Worley Parsons, May 2011) that about 490 ha and 80 ha will be consumed by service corridors and landscape drainage respectively.

It is likely that a proportion of the BSIA will be taken up by BHP Billiton for their future iron ore operations and facilities (this land area is referred to in this report as “BHP Investigation Area”). This report takes into account two land take scenarios for the BHP investigation area, namely 700 ha (total BHP investigation area) and 385 ha (BHP investigation area in the north west of the estate).



Table 2 BSIA – Land Uses and Estimated Net Developable Land

Land uses	ha
Total gross area of BSIA	3,500
Estimated area required for corridors	490
Estimated area required for landscape drainage	80
Total estimated net developable area BSIA - incl total BHP investigation area	2,930
BHP investigation area north west of estate	385
Total BHP investigation area	700
Total estimated net developable area BSIA - excl BHP investigation area north west of estate (385 ha)	2,545
Total estimated net developable area BSIA - excl total BHP investigation area (700 ha)	2,230

Net developable areas per land use	ha
Downstream iron ore processing	520
Downstream non-ferrous resource processing	600
Downstream petroleum / gas / coal processing	300
Port dependant (not specific to industry sector at this stage)	240
Utilities and resource recovery	310
General industry	160
Noxious industry	100
Total estimated net developable area BSIA - excl total BHP investigation area (700 ha)	2,230



3.3 Summary of Estimated Industry Inputs and Outputs

3.3.1 BSIA – Excluding Total BHP Investigation Area (700 Ha)

The table below provides the estimated industry inputs and outputs for the Boodarie Estate with a net developable land of 2,230 ha which excludes the total BHP investigation area (700 ha). The assessment is based on assumptions and references provided in Appendix A.

Table 3 Summary Indicative Industry Inputs and Outputs for BSIA - Excluding Total BHP Investigation Area

#	Potential industry types	Total area Ha	Direct employment			POTENTIAL KEY INPUTS						POTENTIAL KEY OUTPUTS		
			Total persons	'White collar' persons	'Blue Collar' persons	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
						MW	TJ/a	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ktpa	ML/a (ktpa)	ktpa	ktpa
DOWNSTREAM IRON ORE PROCESSING														
1	Sintered iron plant	80	400	120	280	25	200	11	2,600	0	6,210	2,340	5,000	311
1	Iron ore pelletising plant	80	400	120	280	10	2,000	11	1,050	1,950	5,250	2,408	5,000	250
1	DR1 / alternative smelting iron plant	140	400	120	280	60	50,000	11	2,100	3,900	5,250	4,815	2,000	726
1	Integrated steel making plant	120	400	120	280	80	50,000	11	3,500	6,500	6,072	8,025	2,000	730
1	Ferromanganese production plant	40	400	120	280	50	25,000	11	525	975	28	1,204	10	6
1	Ferrosilicon production plant	40	400	120	280	80	10,000	11	525	975	88	1,204	23	8
1	Iron carbide plant	20	400	120	280	20	10,000	11	1,400	1,100	2,000	2,085	1,000	500
	Subtotal	520	2,800	840	1,960	325	147,200	76	11,700	15,400	24,898	22,080	15,033	2,531
DOWNSTREAM NON-FERROUS RESOURCE PROCESSING														
1	Magnesium production plant	50	400	120	280	8	10,000	11	700	1,300	262	1,605	100	16
1	Titanium production plant	60	400	120	280	145	1,000	11	1,400	2,600	112	3,210	50	11
1	Copper smelter	120	400	120	280	50	10,000	11	525	975	624	1,204	150	474
1	Silicon manganese production plant	50	400	120	280	25	10,000	11	525	975	115	1,204	38	24
1	Silicon metal production plant	50	400	120	280	25	10,000	11	525	975	77	1,204	15	9
1	Chlor-alkali plant	50	100	30	70	90	0	3	70	130	400	161	460	39
1	Aluminium smelter	120	400	120	280	170	10,000	11	1,050	1,950	281	2,408	100	17
1	Chromite processing plant (ferro-chromium production)	100	400	120	280	80	10,000	11	525	975	630	1,204	315	144
	Subtotal	600	2,900	870	2,030	593	61,000	79	5,320	9,880	2,502	12,198	1,228	733
DOWNSTREAM PETROLEUM / GAS / COAL PROCESSING														
1	Methanol plant	50	100	30	70	1	28,000	3	875	1,625	595	2,006	800	125
1	Ammonia / urea plant	65	250	75	175	2	22,400	7	500	2,500	448	2,325	650	477
1	Ethane extraction	60	150	45	105	30	100,000	4	88	163	2,000	201	2,650	100
1	Ethane cracker	50	250	75	175	10	8,750	7	51	94	175	116	145	20
1	Ethylene dichloride (EDC) / Vinyl chloride monomer (VCM) plant	50	400	120	280	8	10,000	11	525	975	365	1,204	340	200
1	Sodium cyanide plant	25	100	30	70	1	10,000	3	525	975	34	1,204	15	2
	Subtotal	300	1,250	375	875	52	179,150	34	2,563	6,332	3,617	7,056	4,600	924
PORT DEPENDANT														
1	Large scale processing plant (liquids - not defined)	120	400	120	280	80	10,000	11	350	650	3,413	803	3,250	163
1	Large scale processing plant (conveyors - not defined)	120	400	120	280	80	10,000	11	350	650	2,100	803	2,000	100
	Subtotal	240	800	240	560	160	20,000	22	700	1,300	5,513	1,605	5,250	263
UTILITIES AND RESOURCE RECOVERY														
1	Gas fired power station (250 MW)	50	75	23	53	0	10,000	2	200	0	0	180	0	0
1	Gas fired power station (120MW)	25	50	15	35	0	5,000	1	100	0	0	90	0	0
1	Coal fired power station (800 MW)	100	200	60	140	0	0	5	450	2,000	802	1,905	0	30
1	Waste-to-energy and material recovery facility	10	25	8	18	0	2,500	1	100	0	252	90	Double counting	32
1	Industry feedwater facility	65	15	5	11	36	0	0.4	0	0	80,000	15,000	65,000	2
1	Energy facility (electricity, steam, heat, chill)	60	25	8	18	0	Double counting	1	Double counting	Double counting	0	Double counting	Double counting	0
	Subtotal	310	390	117	273	36	17,500	11	850	2,000	81,054	17,265	65,000	63
GENERAL INDUSTRY														
B4	General industries	160	960	288	672	26	2,080	26	1,280	1,280	1,680	2,112	1,600	80
	Subtotal	160	960	288	672	26	2,080	26	1,280	1,280	1,680	2,112	1,600	80
NOXIOUS INDUSTRY														
20	Noxious industries	100	300	90	210	16	1,300	8	600	600	1,050	990	1,000	50
	Subtotal	100	300	90	210	16	1,300	8	600	600	1,050	990	1,000	50
	Total Boodarie Strategic Industrial Area - excl total BHP area	2,230	9,400	2,820	6,580	1,207	428,230	257	23,013	36,792	120,313	63,306	93,711	4,643



3.3.2 BSIA - Excluding BHP Investigation Area North West of Estate (385 Ha)

The table below provides the estimated industry inputs and outputs for the Boodarie Estate with a total net developable area of 2,545 ha which excludes the BHP investigation area north west of the estate. The estimates are based on per ha proxies derived from the detailed input/output assessment undertaken for the BSIA excluding total BHP investigation area (Table 3).

Table 4 Summary Indicative Industry Inputs and Outputs for BSIA - Excluding BHP Investigation Area North West of Estate

	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
Total BSIA - excl total BHP investigation area	Ha 2,230	persons 9,400	persons 2,820	persons 6,580	MW 1,207	TJ/a 428,230	ML/a (ktpa) 257	ML/a (ktpa) 23,013	ML/a (ktpa) 36,792	ktpa 120,313	ML/a (ktpa) 63,306	ktpa 93,711	ktpa 4,643
Industry input/output proxy per ha based on detailed input/output assessment	Ha/ha 1.0	persons/ha 4.2	persons/ha 1.3	persons/ha 3.0	MW/ha 0.5	(TJ/a)/ha 192.0	(ML/a)/ha 0.1	(ML/a)/ha 10.3	(ML/a)/ha 16.5	ktpa/ha 54.0	(ML/a)/ha 28.4	ktpa/ha 42.0	ktpa/ha 2.1
Difference BHP investigation area to be added (700 ha - 385 ha)	Ha 315												
Total BSIA - excl BHP area (385 ha)	Ha 2,545	persons 10,728	persons 3,218	persons 7,509	MW 1,378	TJ/a 488,720	ML/a (ktpa) 293	ML/a (ktpa) 26,264	ML/a (ktpa) 41,989	ktpa 137,308	ML/a (ktpa) 72,248	ktpa 106,948	ktpa 5,299

3.3.1 BSIA - Including Total BHP Investigation Area North West of Estate (700 Ha)

The table below provides the estimated industry inputs and outputs for the Boodarie Estate with a total net developable area of 2,930 ha which includes the total BHP investigation area. The estimates are based on per ha proxies derived from the detailed input/output assessment undertaken for the BSIA excluding total BHP investigation area (Table 3).

Table 5 Summary Indicative Industry Inputs and Outputs for BSIA - Including Total BHP Investigation Area

	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
Total BSIA - excl total BHP investigation area	Ha 2,230	persons 9,400	persons 2,820	persons 6,580	MW 1,207	TJ/a 428,230	ML/a (ktpa) 257	ML/a (ktpa) 23,013	ML/a (ktpa) 36,792	ktpa 120,313	ML/a (ktpa) 63,306	ktpa 93,711	ktpa 4,643
Industry input/output proxy per ha based on detailed input/output assessment	Ha/ha 1.0	persons/ha 4.2	persons/ha 1.3	persons/ha 3.0	MW/ha 0.5	(TJ/a)/ha 192.0	(ML/a)/ha 0.1	(ML/a)/ha 10.3	(ML/a)/ha 16.5	ktpa/ha 54.0	(ML/a)/ha 28.4	ktpa/ha 42.0	ktpa/ha 2.1
Total BHP investigation area	Ha 700												
Total BSIA - incl BHP area (700 ha)	Ha 2,930	persons 12,351	persons 3,705	persons 8,645	MW 1,586	TJ/a 562,652	ML/a (ktpa) 337	ML/a (ktpa) 30,237	ML/a (ktpa) 48,341	ktpa 158,080	ML/a (ktpa) 83,177	ktpa 123,127	ktpa 6,101



3.4 Boodarie Strategic Industrial Area and Port

Sufficient and efficient access to the Port Hedland port is critical to the development of the BSIA. Based on the industry input / output assessment undertaken for the BSIA, the tables below provide a summary of the potential corridor and trade requirements between the industrial estate and the port.

3.4.1 BSIA – Excluding Total BHP Investigation Area (700 Ha)

Table 6 Potential Corridor and Trade Requirements between BSIA and Port - Excluding Total BHP Investigation Area (700 Ha)

Land uses	Potential industry types	BOODARIE STRATEGIC INDUSTRIAL AREA					PORT RELATED TRADE					
		Area [ha]	Resource type	Resource name	Bulk or break bulk	Total BSIA quantity [ktpa]	Import or export from port	Estimated trade quantity with port (import & export) [ktpa]	Transportation between port and estate	Number of corridors [number]	Comments / assumptions	
Downstream iron ore processing	Sintered iron plant	80	Raw material	Dolomite	Bulk	200	Import	200	Road		Assumed that 100% of total dolomite demand is imported from port	
			Raw material	Coke breeze	Bulk	350	Import	175	Road		Assumed that 50% of total coke breeze demand is imported from elsewhere	
			Product	Sintered products	Bulk	5,000	Export	3,750	Conveyor (or road)	1	Assumed that 75% of produced sintered products is exported through port	
	Iron ore pelletising plant	80	Product	Iron ore pellets	Bulk	5,000	Export	3,750	Conveyor (or road)	1	Assumed that 75% of produced iron ore pellets is exported through port	
			Raw material	Dolomite	Bulk	175	Import	175	Road		Assumed that 100% of total dolomite demand is imported through port	
	DRI / alternative smelting iron plant	140	Raw material	Coal (reductant)	Bulk	700	Import	700	Conveyor	1	Assumed that 100% of total coal demand is imported through port	
			Product	Direct reduced iron	Breakbulk	2,000	Export	2,000	Road		Assumed that all products are exported	
			Raw material	Coal	Bulk	940	Import	940	Conveyor	1	Assumed that 100% of total coal demand is imported through port	
	Integrated steel making plant	120	Product	Steel products	Breakbulk	2,000	Export	2,000	Road		Assumed that all products are exported through port	
			Raw material	Coke	Bulk	4	Import	2	Road		Assumed that 50% of total coke demand is imported from elsewhere	
	Ferromanganese production plant	40	Raw material	Coal	Bulk	2	Import	2	Road		Assumed that 100% of total coal demand is imported through port	
			Product	Fe/Mn HC/LS	Breakbulk	10	Export	10	Road		Assumed that all products are exported through port	
			Raw material	Coke	Bulk	9	Import	4	Road		Assumed that 100% of total coke demand is imported through port	
	Ferrosilicon production plant	40	Raw material	Coal	Bulk	13	Import	13	Road		Assumed that 100% of total coal demand is imported through port	
			Product	FeSi	Breakbulk	23	Export	23	Road		Assumed that all products are exported through port	
			Raw material	Iron carbide	Bulk	1,000	Export	1,000	Road		Assumed that all products are exported through port	
	Downstream non-ferrous resource processing	Iron carbide plant	20	Product	Iron carbide	Bulk	1,000	Export	1,000	Road		Assumed that all products are exported through port
				Raw material	Petcoke	Bulk	2	Import	1	Road		Assumed that 50% of total petcoke demand is imported from elsewhere
Product				Deodorised MgO	Breakbulk	80	Export	80	Road		Assumed that all products are exported through port	
Magnesium production plant		50	Product	Electrofused MgO	Breakbulk	20	Export	20	Road		Assumed that all products are exported through port	
			Product	Titanium sponge	Breakbulk	50	Export	50	Road		Assumed that all products are exported through port	
Titanium production plant		60	Product	Titanium sponge	Breakbulk	50	Export	20	Road		Assumed that all products are exported through port	
Copper smelter		120	Raw material	Copper concentrate	Bulk	624	Import	624	Conveyor	1	Assumed that all copper concentrate is imported through port	
			Product	Bilister copper	Breakbulk	150	Export	150	Road		Assumed that all products are exported through port	
Silicon manganese production plant		50	Raw material	Coke	Bulk	16	Import	8	Road		Assumed that 50% of total coke demand is imported from elsewhere	
			Raw material	Coal	Bulk	10	Import	10	Road		Assumed that 100% of total coal demand is imported through port	
			Product	SiMn	Breakbulk	38	Export	38	Road		Assumed that all products are exported through port	
Silicon metal production plant		50	Raw material	Coke	Bulk	2	Import	1	Road		Assumed that 50% of total coke demand is imported from elsewhere	
			Raw material	Coal	Bulk	20	Import	20	Road		Assumed that 100% of total coal demand is imported through port	
			Product	Silicon metal	Breakbulk	15	Export	15	Road		Assumed that all products are exported through port	
Chlor-alkali plant		50	Raw material	Sodium chloride	Breakbulk	400	Import	400	Pipeline	1	Assumed that all sodium chloride is imported through port	
Aluminium smelter		120	Raw material	Alumina	Bulk	190	Import	95	Road		Assumed that 50% of total alumina demand is imported through port	
			Raw material	Petcoke	Bulk	75	Import	38	Road		Assumed that 50% of total coke demand is imported from elsewhere	
			Raw material	Fluorides	Breakbulk	3	Import	3	Road		Assumed that all fluorides are imported through port	
Chromite processing plant (ferro-chromium production)	100	Product	Aluminium ingots	Breakbulk	100	Export	100	Road		Assumed that all products are exported through port		
		Raw material	Coke	Bulk	90	Import	45	Road		Assumed that 50% of total coke demand is imported from elsewhere		
		Raw material	Coal	Bulk	90	Import	90	Road		Assumed that 100% of total coal demand is imported through port		
Product	Ferro-chromium	Breakbulk	315	Export	315	Road		Assumed that all products are exported through port				



BOODARIE STRATEGIC INDUSTRIAL AREA							PORT RELATED TRADE				
Land uses	Potential industry types	Area [ha]	Resource type	Resource name	Bulk or break bulk	Total BSIA quantity [ktpa]	Import or export from port	Estimated trade quantity with port (import & export) [ktpa]	Transportation between port and estate	Number of corridors [number]	Comments / assumptions
Downstream petroleum / gas / coal processing	Methanol plant	50	Raw material	Natural gas	Bulk	595	Import	595	Pipeline	1	Assumed that methanol plant will process natural gas from North West Shelf, imported through port
			Product	Methanol	Bulk	800	Export	400	Pipeline	1	Assumed that 50% of methanol product will be exported through port
	Ammonia / urea plant	65	Raw material	Natural gas	Bulk	448	Import	448	Pipeline	1	Assumed that ammonium/urea plant will process natural gas from North West Shelf, imported through port
			Product	Ammonia	Bulk	250	Export	125	Pipeline	1	Assumed that 50% of ammonia product will be exported through port
	Ethane extraction	60	Raw material	Natural gas	Bulk	2,000	Import	2,000	Pipeline	1	Assumed that ethane extraction plant will process natural gas from North West Shelf, imported through port
			Product	Ethane	Bulk	200	Export	100	Pipeline	1	Assumed that 50% of ethane product will be exported through port
			Product	LPG	Bulk	2,450	Export	1,225	Pipeline	1	Assumed that 50% of LPG product will be exported through port
	Ethane cracker	50	Product	Ethylene	Bulk	145	Export	73	Pipeline (or road)	1	Assumed that 50% of ethylene product will be exported through port
			Product	Ethylene dichloride (EDC)	Bulk	100	Export	50	Pipeline (or road)	1	Assumed that 50% of EDC product will be exported through port
	Ethylene dichloride (EDC) / Vinyl chloride monomer (VCM) plant	50	Product	Vinyl chloride monomer (VCM)	Bulk	240	Export	120	Pipeline	1	Assumed that 50% of VCM product will be exported through port
Product			Sodium cyanide	Breakbulk	15	Export	8	Road	1	Assumed that 50% of sodium cyanide product will be exported through port	
Port dependant	Large scale processing plant (liquids - not defined)	120	Raw material	Raw materials	Bulk	3,313	Import	3,313	Pipeline	1	Assumed that 100% of raw materials are imported through port
			Raw material	Process chemicals	Breakbulk	100	Import	50	Road	1	Assumed that 50% of process chemicals are imported through port
			Product	Liquid product 1	Bulk	2,500	Export	1,250	Pipeline	1	Assumed that 50% of products are exported through port
			Product	Liquid product 2	Bulk	500	Export	250	Pipeline	1	Assumed that 50% of products are exported through port
	Large scale processing plant (conveyors - not defined)	120	Product	Liquid product 3	Bulk	250	Export	125	Pipeline	1	Assumed that 50% of products are exported through port
			Raw material	Raw materials	Bulk	2,000	Import	2,000	Pipeline	1	Assumed that 100% of raw materials are imported through port
			Raw material	Process chemicals	Breakbulk	100	Import	50	Road	1	Assumed that 50% of process chemicals are imported through port
			Product	Solid product 1	Bulk	1,500	Export	1,500	Conveyor	1	Assumed that 100% of product 1 will be exported
			Product	Solid product 2	Bulk	500	Export	500	Conveyor	1	Assumed that 100% of product 2 will be exported
			Product	No imports/exports for port	N/A	N/A	N/A	N/A	N/A	N/A	
Utilities and resource recovery	Gas fired power station (250 MW)	50	No imports/exports for port	N/A	N/A	N/A	N/A	N/A	N/A		
	Gas fired power station (120MW)	25	No imports/exports for port	N/A	N/A	N/A	N/A	N/A	N/A		
	Coal fired power station (800 MW)	100	Raw material	Coal	Bulk	800	Import	400	Conveyor	1	Assumed that 50% of coal will be imported through the port
	Waste-to-energy and material recovery facility	10	No imports/exports for port	N/A	N/A	N/A	N/A	N/A	N/A		
	Industry feedwater facility	65	Raw material	Groundwater or seawater	Bulk	40,000	Import	0	Pipeline	1	Assumed that industry feedwater facility will take seawater as a water source
			Water discharge	Brine	Bulk	15,000	Export	0	Pipeline	1	Assumed that brine from facility will discharged back to port area for ocean disposal
	Energy facility (electricity, steam, heat, chill)	60	No imports/exports for port	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
General industry	General industries	160	Raw material	Various	Breakbulk	1,680	Import	554	Road	1	Assumed that 33% of all raw materials are imported through port
			Product	Various products	Breakbulk	1,000	Export	528	Road	1	Assumed that 33% of all products are exported through port
Noxious industry	Noxious industries	100	Raw material	Various	Breakbulk	1,050	Import	347	Road	1	Assumed that 33% of all raw materials are imported through port
			Product	Various products	Breakbulk	1,000	Export	330	Road	1	Assumed that 33% of all products are exported through port
Total		2,230						33,387		26	



3.4.2 BSIA - Excluding BHP Investigation Area North West of Estate (385 Ha)

The service corridor and trade forecast between port and BSIA excluding BHP investigation area north west of estate is presented in table below. The indicative estimates are based on per ha proxies derived from the detailed input/output assessment undertaken for the BSIA excluding total BHP investigation area (Table 3).

Table 7 Potential Corridor and Trade Requirements between BSIA and Port - Excluding BHP Investigation Area North West of Estate (385 Ha)

	Area	Estimated Trade Quantity with Port	Number of Corridors
Total BSIA - excl total BHP investigation area	2,230 ha	33,387 ktpa	26
Trade/corridor proxy per ha based on detailed input/output assessment (Table 6)	1.0 ha/ha	15.0 ktpa/ha	0.0117 corridors/ha
Difference BHP investigation area to be added (700 ha - 385 ha)	315 ha		
Total BSIA - excl BHP area (385 ha)	2,545 ha	38,103 ktpa	30

3.4.1 BSIA - Including Total BHP Investigation Area (700 Ha)

The service corridor and trade forecast between port and BSIA including total BHP investigation area is presented in table below. The indicative estimates are based on per ha proxies derived from the detailed input/output assessment undertaken for the BSIA excluding total BHP investigation area (Table 3).

Table 8 Potential Corridor and Trade Requirements between BSIA and Port - Including Total BHP Investigation Area

	Area	Estimated Trade Quantity with Port	Number of Corridors
Total BSIA - excl total BHP investigation area	2,230 ha	33,387 ktpa	26
Trade/corridor proxy per ha based on detailed input/output assessment (Table 6)	1.0 ha/ha	15.0 ktpa/ha	0.0117 corridors/ha
Difference BHP investigation area to be added (700 ha)	700 ha		
Total BSIA - incl total BHP area (700 ha)	2,930 ha	43,867 ktpa	34



4. Utility Demand Forecasting

The estimates provided in this report are indicative estimates based on information to GHD at the time of release of this report (see cover page for date), which does not include specific market research on the types of industries locating to the Boodarie Strategic Industrial Area. The estimates presented here should only be used for the purpose of the Concept Design of the Boodarie Strategic Industrial Area. The data presented in this report should be updated as more detailed information becomes available through the structure plan development process and thereafter (e.g. lot sizes, net developable land, industries locating to Boodarie Strategic Industrial Area, industry locations, industry inputs and outputs).

The purpose of the utility demand forecasting for estate is to assist utility providers with the planning and on-time delivery of required infrastructure and services to the Boodarie Strategic Industrial Area.

Based on a set of high level assumptions developed from other industrial estates in WA, along with the industry input / output assessment, an utility demand forecasting (power, gas, water) for the BSIA was undertaken to assist utility providers, government, and future industry with the planning and on-time delivery of required infrastructure and services to the estate.

4.1 Notes and Limitations

The utility demand forecasting presented in this section is subject to following uncertainties and limitations:

- ▶ In consultation with LandCorp, the assumptions made in this report are based on heavy industries being established in the BSIA over period of approximately 50 to 60 years. The utility demands will develop to their ultimate levels over this time frame.
- ▶ Forecasting demands have been provided for the BSIA with a net developable land of 2,230 ha which excludes total BHP investigation (700 ha);
- ▶ The forecasted demands will vary and are approximate estimates only, subject to actual development of the estate and final industry mix that will establish in the BSIA over time.
- ▶ Information on estimated industry mix, industry specific utility demands is provided in Section 3 of this report;
- ▶ These are indicative and high level estimates based on limited information available at this point in time, and therefore subject to change;
- ▶ Estimates are subject to industry mix to be located in BSIA (still unknown);
- ▶ There is no certainty about date/year when the BSIA will be fully developed;
- ▶ Estimates do not take into account ongoing industry expansions and increasing efficiencies and technology developments over time;
- ▶ These estimates cover operation of industries. Estimates do not cover potential higher demands during construction period.



4.2 Assumptions

Table 9 BSIA Utility Demand Forecasting – Key Assumptions

Industry Type	Assumptions
Heavy industry	<ul style="list-style-type: none"> ▶ First heavy industry establishes in 2015 ▶ One heavy industry establishes every 2 years thereafter (average estimate based on historical development in the Kwinana Industrial Area) ▶ Estimated total of 30 potential heavy industries in BSIA ▶ Above assumptions imply that heavy industries establish in BSIA over period of approximately 60 years (by 2075) ▶ Utility demands averaged over total 30 heavy industries ▶ Sequence of industries establishing in BSIA is not known, but it is likely that a ferrous processing company will be first to establish in BSIA
General and noxious industry	<ul style="list-style-type: none"> ▶ First general industry establishes in 2014 ▶ Estimated Net Developable Area (NDA) for General and Noxious Industries = 260 ha ▶ General and noxious industries establish in BSIA over period of approximately 50 years (by 2064) ▶ Above assumptions imply development of 5.2 ha per annum for General and Noxious Industries Precincts
Iron ore stockpiling areas	<ul style="list-style-type: none"> ▶ Assumed that iron stockpiling areas (e.g. BHPB, Hancock) will be outside of Boodarie Strategic Industrial Area. Therefore, utility forecasting for iron ore stockpiling areas have not been included in this forecasting.

4.3 Gas

Table 10 BSIA Gas Demand Forecasting – Proxy Indicators

Industry Type	Proxy Indicator	Value
Heavy industry	Total estimated heavy industries in BSIA	30
	Total estimated gas use heavy industries	425 PJ/a
	Average gas use per heavy industry	14.2 PJ/a
General and noxious industry	Estimated NDA general and noxious industries	260 ha
	Total estimated gas use general and noxious industries	3.4 PJ/a
	Average gas use per ha	0.013 PJ/ha



Table 11 BSIA Gas Demand Forecast

Industry Types	Indicative Forecast - Gas Demand (PJ/a)												
	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
Heavy industry	14	50	85	120	156	191	227	262	297	326	354	389	425
General & noxious industry	0.1	0.5	0.8	1.1	1.5	1.8	2.2	2.5	2.8	3.2	3.4	3.4	3.4
Total – Excl BHP Investigation Area (700 ha)	14	50	86	122	157	193	229	264	300	329	357	393	428

4.4 Power

Table 12 BSIA Power Demand Forecasting – Proxy Indicators

Industry Type	Proxy Indicator	Value
Heavy industry	Total estimated heavy industries in BSIA	30
	Total estimated electricity use heavy industries	1,166 MW
	Average electricity use per heavy industry	39 MW/ha
General and noxious industry	Estimated NDA general and noxious industries	260 ha
	Total estimated electricity use general and noxious industries	42 MW
	Average electricity use per ha	0.16 MW/ha

Table 13 BSIA Power Demand Forecast

Industry Types	Indicative Forecast - Power Demand (MW)												
	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
Heavy industry	39	136	233	330	427	525	622	719	816	894	971	1,068	1,166
General & noxious industry	2	6	10	14	18	22	27	31	35	39	42	41.6	42
Total – Excl BHP Investigation Area (700 ha)	41	142	243	344	446	547	648	750	851	933	1,013	1,110	1,207

4.5 Water

4.5.1 High Quality Industry Feedwater

Quality: ~ 100 to 200 mg/L TDS (subject to detailed options / pre-feasibility studies)

Targeted to be suitable for following applications:

- ▶ Boiler feedwater / steam production;
- ▶ High quality process water.

Table 14 BSIA High Quality Industry Feedwater Demand Forecasting – Proxy Indicators

Industry Type	Proxy Indicator	Value
Heavy industry	Total estimated heavy industries in BSIA	30



Industry Type	Proxy Indicator	Value
	Total estimated high quality industry feedwater use heavy industries	21 GL/a
	Average high quality industry feedwater use per heavy industry	0.70 GL/a
	Estimated NDA general and noxious industries	260 ha
General and noxious industry	Total estimated high quality industry feedwater use general and noxious industries	1.88 GL/a
	Average high quality industry feedwater use per ha	0.0072 GL/ha

Table 15 BSIA High Quality Industry Feedwater Demand Forecast

Industry Types	Indicative Forecast - High Quality Industry Feedwater Demand (GL/a)												
	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
Heavy industry	0.7	2.5	4.2	6.0	7.7	9.5	11.3	13.0	14.8	16.2	17.6	19.4	21.1
General & noxious industry	0.1	0.3	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	1.9	1.9	1.9
Total – Excl BHP Investigation Area (700 ha)	0.8	2.7	4.7	6.6	8.6	10.5	12.5	14.4	16.4	18.0	19.5	21.3	23.0

4.5.2 Low(er) Quality Industry Feedwater

Quality: ~ 800 to 1000 mg/L TDS (subject to detailed options / pre-feasibility studies)

Targeted to be suitable for following applications:

- ▶ Cooling water
- ▶ Process water
- ▶ Dust suppression
- ▶ Wash water
- ▶ Slurry water
- ▶ Irrigation

Table 16 BSIA Low(er) Quality Industry Feedwater Demand Forecasting – Proxy Indicators

Industry Type	Proxy Indicator	Value
Heavy industry	Total estimated heavy industries in BSIA	30
	Total estimated low quality industry feedwater heavy industries	35 GL/a
	Average low quality industry feedwater use per heavy industry	1.2 GL/a
General and noxious industry	Estimated NDA general and noxious industries	260 ha
	Total estimated low quality industry feedwater use general and noxious industries	1.88 GL/a
	Average low quality industry feedwater use per ha	0.0072 GL/ha

Table 17 BSIA Low(er) Quality Industry Feedwater Demand Forecast

Industry Types	Indicative Forecast – Low(er) Quality Industry Feedwater Demand (GL/a)												
	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
Heavy industry	1.2	4.1	7.0	9.9	12.8	15.7	18.6	21.5	24.4	26.8	29.1	32.0	34.9
General & noxious industry	0.1	0.3	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	1.9	1.9	1.9
Total – Excl BHP Investigation	1.2	4.3	7.4	10.5	13.6	16.7	19.8	22.9	26.0	28.5	31.0	33.9	36.8



Industry Types Indicative Forecast – Low(er) Quality Industry Feedwater Demand (GL/a)

Area (700 ha)

4.5.3 Industry Feedwater – Total

Table 18 BSIA Total Industry Feedwater Demand Forecast (High and Low Quality)

Industry Types	Indicative Forecast - Total Industry Feedwater Demand (GL/a)												
	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
Heavy industry	1.9	6.5	11.2	15.9	20.5	25.2	29.9	34.6	39.2	43.0	46.7	51.4	56.0
General & noxious industry	0.2	0.5	0.9	1.3	1.7	2.0	2.4	2.8	3.2	3.5	3.8	3.8	3.8
Total – Excl BHP Investigation Area (700 ha)	2.0	7.1	12.1	17.2	22.2	27.3	32.3	37.3	42.4	46.5	50.5	55.1	59.8

4.5.4 Potable Water for Domestic Use

Assessment includes domestic use of potable water in:

- ▶ Toilets;
- ▶ Hand basins;
- ▶ Showers;
- ▶ Commercial kitchens;
- ▶ 10% for other various.

Water demand for irrigation and industry feedwater are not included.

Assumptions and calculations for estimating potable water use for domestic purposes in the Boodarie Industrial Area are provided in Appendix B.

Table 19 BSIA Potable Water for Domestic Use Forecasting – Proxy Indicators

Industry Type	Proxy Indicator	Value
Heavy industry	Total estimated heavy industries in BSIA	25
	Total estimated domestic use of potable water	222 ML/a
	Average domestic use of potable water per heavy industry	7.4 ML/a
General and noxious industry	Estimated NDA general and noxious industries	260 ha
	Total estimated domestic use of potable water general and noxious industries	34 ML/a
	Average domestic use of potable water per ha	0.13 ML/ha

Table 20 BSIA Potable Water for Domestic Use Forecast

Industry Types	Indicative Forecast Potable Water for Domestic Use (ML/a)												
	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075
Heavy industry	7	26	44	63	81	100	119	137	156	170	185	204	222
General & noxious industry	1.4	4.8	8.3	11.7	15.1	18.6	22.0	25.5	28.9	32.3	34.4	34.4	34.4
Total – Excl BHP Investigation Area (700 ha)	9	31	53	75	97	119	141	162	184	203	220	238	257



5. Industrial Synergies

5.1 Introduction

Regional synergies are perhaps the best-known application of the principles of industrial ecology. They deal with the exchange of by-products, energy, and water, and sharing of services between closely situated firms. Because of the links between the firms, an industrial area is transformed into an ‘industrial ecosystem’ through ‘industrial symbiosis’. Chertow (2000) defines industrial symbiosis as a process that “engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity”.

As part of the project, GHD explored the following types of regional synergies for the Boodarie Industrial Area:

- ▶ **Supply synergies:** featuring local manufacturers and dedicated suppliers of principal reagents for core process industries (e.g. production of ammonia and chlorine for industrial use);
- ▶ **Utility synergies:** shared use of utility infrastructure, and mainly revolving around water and energy (e.g. water recovery and energy cogeneration);
- ▶ **By-product synergies:** the use of a previously disposed by-product (as solid, liquid, or gas) from one facility by another facility to produce a valuable by-product; and
- ▶ **Service synergies:** sharing of services and activities between industries in an industrial area (e.g. joint training of staff and sharing of maintenance contractors).

5.2 Summary of Synergy Opportunities Identified

Based on the identified industry mix and industry input / output assessment (Section 3), a total of 44 synergy opportunities have been identified for the BSIA at this stage, including 13 supply chain synergies, 11 utility synergies, 14 by-product synergies, and 6 service synergies. A summary of the industrial synergy opportunities identified for the potential types of industries to be located in the BSIA are presented in Table 21.

A high level assessment of their overall benefits and achievability (low, medium, high) has been included in the table below. A more detailed analysis of the benefits and achievability can be undertaken if required.

Table 21 Summary of Synergy Opportunities for Boodarie Strategic Industrial Area

Potential Synergies	Overall Benefits	Overall Achievability	Overall Priority
SUPPLY SYNERGIES:			
1 Supply of stockpiled iron ore to ferrous processing plants	High	High	High
2 Supply of produced steel products (e.g. finished shapes) from BSIA steel plant to local heavy construction companies	High	Medium	Medium
3 Supply of logistical and transportation services by transport companies and warehouses to BSIA industries (e.g. road, rail, port)	High	High	High
4 Supply of beneficiated iron fines from pelletising and/or sinter plant to iron carbide plant	High	High	High



Potential Synergies		Overall Benefits	Overall Achievability	Overall Priority
5	Supply of Fe-chips to ferrosilicon plant by steel plant	Medium	Medium	Medium
6	Supply of chlorine from chlor-alkali plant to resource processing plants	High	High	High
7	Supply of caustic soda from chlor-alkali plant to resource processing plants	High	High	High
8	Supply of magnesium by magnesium production plant to titanium production plant	Medium	Medium	Medium
9	Supply of sodium chloride from salt mine to chlor-alkali plant	High	High	High
10	Supply of ethane from ethane extraction to ethane cracker	High	High	High
11	Supply of ethylene from ethane cracker to EDC / VCM plant	High	High	High
12	Supply of ammonia from ammonia/urea plant to sodium cyanide plant and fertiliser production plant	High	High	High
13	BSIA non-ferrous smelter (e.g. nickel, aluminium, copper, zinc, lead) supplying intermediate product (e.g. nickel-in-matte, alumina, blister copper, zinc, lead) to non-ferrous refinery in BSIA	High	High	High
UTILITY SYNERGIES:				
1	Energy factory supplying electricity, steam, and hot/cold air to surrounding BSIA industries. Potential feeds: <ul style="list-style-type: none"> ▶ Gas ▶ Electricity ▶ Biofuels ▶ Renewables ▶ Off-gases and waste heat from BSIA industries 	High	Medium	Medium
2	Water factory supplying high and low quality industry feedwater to BSIA industries. Potential feeds: <ul style="list-style-type: none"> ▶ Groundwater ▶ Industrial effluents ▶ WWTP effluent ▶ Seawater ▶ Waste heat from BSIA industries 	High	High	High
3	Direct use of WWTP treated effluent by selected BSIA industries (potential for on-site treatment to suit requirements)	High	High	High
4	Reuse of effluent stream (segregated or not) from one BSIA industry by other BSIA industry	Medium	Medium	Medium
5	Centralised production and supply of pressurised air to BSIA industries	Medium	Low / medium	Low
6	Centralised production, supply, and recovery of utility gases to BSIA industries (nitrogen, hydrogen, oxygen)	High	Medium	Medium
7	Managed aquifer recharge of treated effluents, and indirect industrial reuse	Medium	Low	Low
8	Centralised storage and processing facility for large volume inorganic by-products produced in BSIA	High	High	High
9	Centralised treatment facility for industry off-gases (e.g. SO _x , NO _x)	Medium	Medium	Medium
10	Joint industry production of demineralised water for specialised applications (boiler feedwater)	Medium	Medium	Medium



Potential Synergies		Overall Benefits	Overall Achievability	Overall Priority
11	Centralised storage and processing facility for selected (smaller volume) waste streams (e.g. hazardous wastes, oils, pallets, metals)	Medium	High	Medium
BY-PRODUCT SYNERGIES:				
1	Use of industry waste heat for drying or concentrating wet products and by-products. Potential products: <ul style="list-style-type: none"> ▶ Sludges ▶ Filtercakes ▶ Acids 	Medium	Medium	Medium
2	Use of pelletising wastes from iron ore pelletising plant (e.g. cement plant)	Medium	Medium	Medium
3	Use of ammonium sulphate from nickel processing in fertiliser production	High	High	High
4	Processing and use of slag from ferrous mineral processing. Potential uses: <ul style="list-style-type: none"> ▶ Aggregate in construction ▶ Substitute for clinker in cement manufacturing ▶ Soil conditioning 	High	Medium	Medium
5	Processing and use of gypsum from resource processing. Potential uses: <ul style="list-style-type: none"> ▶ Use in construction materials (e.g. plasterboard and blended in bricks) ▶ As feedstock for chemical processing (e.g. ammonium sulphate, sulphuric acid, nitric fertiliser, and lime) 	Medium	Medium	Medium
6	Re-processing of scrap steel from BSIA industries by BSIA steel plant	Medium	High	Medium
7	Co-processing of organic by-products from BSIA industries at large scale organic processing plant (e.g. ethanol, biofuels). Potential feeds: <ul style="list-style-type: none"> ▶ Biosolids from WWTP ▶ Residues from organic based processing plants ▶ Waste grain ▶ Organic residues from alternative waste technologies 	High	Medium	Medium
8	Co-processing of inorganic by-products from BSIA industries and other alternative materials. Potential feeds: <ul style="list-style-type: none"> ▶ Slags from ferrous mineral processing ▶ Process residues from non-ferrous mineral processing (e.g. nickel) ▶ Process residues from industrial processing (manufacturing) ▶ Inorganic residues from alternative waste technologies ▶ Tyres ▶ Gypsum 	High	Medium	Medium
9	Use of alternative fuels at selected BSIA industries (e.g. waste oils, tyres, shredded wood, coke dust from steel making)	High	Medium	Medium
10	Use of alternative lime sources in ferrous and non-ferrous mineral processing. Potential alternatives: <ul style="list-style-type: none"> ▶ Lime kiln dust from cement manufacturing ▶ Lime dust from steel making 	High	High	High



Potential Synergies		Overall Benefits	Overall Achievability	Overall Priority
11	Conversion of process carbon dioxide in commercial gases by utility gas company	High	Medium	Medium
12	Conversion of process by-product hydrogen into commercial gases by utility gas company	High	High	High
13	Conversion of process by-product nitrogen into commercial gases by utility gas company	High	High	High
14	Use of charcoal (from plantations) as alternative to (petroleum) coke as reductant in steel sintering and mineral processing	High	Medium	Medium
SERVICE SYNERGIES:				
1	Joint industry training and education facilities (regional industry training centre), including shared staffing (e.g. maintenance support)	High	High	High
2	Joint logistic and transportation facilities covering: <ul style="list-style-type: none"> ▶ Centralised storage ▶ Shared transportation of incoming and outgoing goods ▶ Common vehicle maintenance 	High	Medium	Medium
3	Joint industry agreement for collection and handling of selected industry wastes. Potential waste streams: <ul style="list-style-type: none"> ▶ Waste metals ▶ Waste oil and greases ▶ Packaging materials (e.g. pallets, cardboard, plastics, drums) ▶ Construction and demolition wastes ▶ "Small volume" process residues 	Medium	Medium	Medium
4	BSIA interpretive centre which aims: <ul style="list-style-type: none"> ▶ Communication, education, and awareness of industry processes, resource recovery ▶ Facilitate stakeholder discussions re BSIA (e.g. industries, government, community) ▶ Facilitate community involvement in BSIA 	Medium	Medium	Medium
5	Joint industry monitoring and control of odour and air quality footprint	Medium	High	Medium
6	Joint industry incident and accident prevention and response	High	High	High

5.3 Benefits of Industrial Synergies

The potential synergies for the BSIA, if implemented, can provide a range of economic, environmental, and social benefits to the companies involved, the region as a whole, and the local community. Appendix C shows that the types of benefits can vary greatly and often go well beyond the conventional business case benefits. Security of water and energy supply, increased resource efficiency, lower operational costs for resource use, and reduced storage and landfill costs are key benefits from the synergies presented here. In addition, all of these synergies had environmental and community benefits. The benefits from regional synergies are not just commercial but also strategic, leading to reduced exposure to risk and improved reputation. The full range of benefits needs to be communicated clearly to the stakeholders (industries, government, community) involved in the synergy development process.

The information on synergy benefits allows for the selection of opportunities that target specific benefits or outcomes (e.g. creation of employment or search for cheaper raw materials).

5.4 Success Factors on Industrial Synergies

The realisation of successful synergies is dependent on three main aspects: proven technology, convincing business case, and license to operate (see Figure 3)². For a synergy to be successful all involved parties must benefit in one way or another. In fact, it is unlikely that a synergy would be implemented unless all involved parties at least perceive some business benefit (direct or indirect). When developing synergy opportunities for the Boodarie Strategic Industrial Area, it is most important to maintain a focus on these three key success factors.

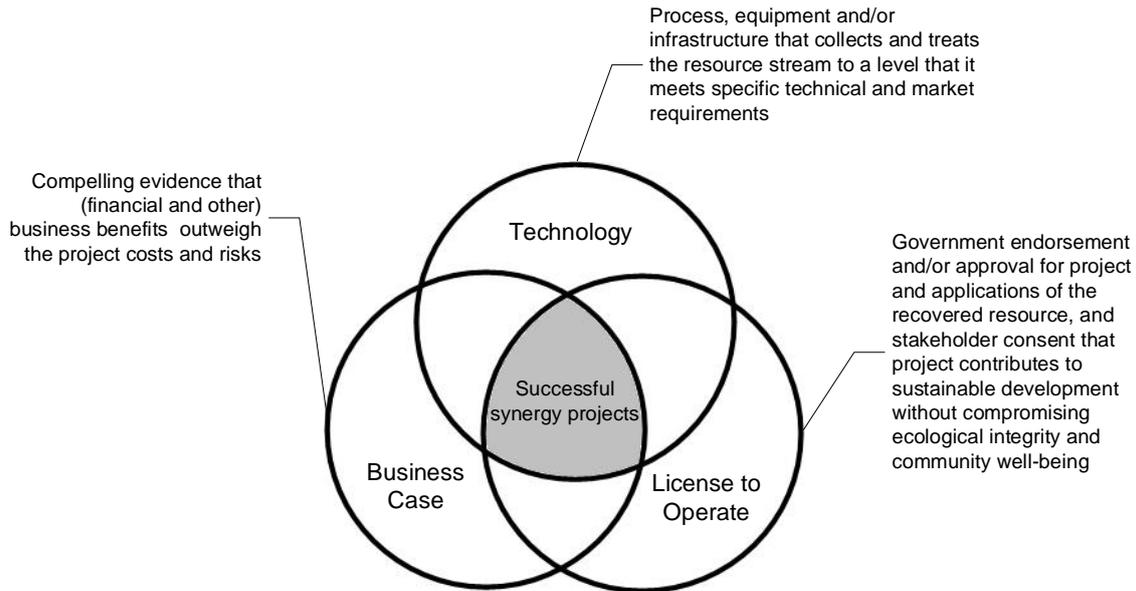


Figure 3 Success Factors for Regional Resource Synergies (van Berkel 2006)

5.5 Industrial Synergies and BSIA Concept Plan

The BSIA Concept Plan should allow for the development of promising industrial synergy opportunities identified. The table below outlines the potential implications from the industrial synergy opportunities on the BSIA Concept Plan, and to what extent the Concept Plan will be able to facilitate the development of these synergies over time.

² van Berkel, R. 2006. Regional Resource Synergies for Sustainable Development in Heavy Industrial Areas: An Overview of Opportunities and Experiences. Perth, WA, Australia: Curtin University of Technology.



Table 22 Potential Implication of Industrial Synergies on BSIA Concept Plan

#	Industrial Synergy Opportunity	Implications for BSIA Concept Design Plan
SUPPLY SYNERGIES:		
1	Supply of stockpiled iron ore to ferrous processing plants	<ul style="list-style-type: none"> ▶ Allow for location ferrous processing plants adjacent to iron ore stockpiling areas ▶ Service corridors and transportation nodes to allow for potential material movements between estate and iron ore stockpiling area west of estate
2	Supply of produced steel products (e.g. finished shapes) from BSIA steel plant to local heavy construction companies	<ul style="list-style-type: none"> ▶ Allow for location of heavy construction companies in General Industry Precincts, and possibly in strategic core of estate ▶ Transportation nodes to allow for potential steel products movements within strategic core of estate and General Industry Precinct
3	Supply of logistical and transportation services by transport companies and warehouses to BSIA industries (e.g. road, rail, port)	<ul style="list-style-type: none"> ▶ Allow for location of logistical and transportation industries in General Industry Precincts and areas adjacent to BSIA ▶ Transportation nodes to allow for potential material movements between and within strategic core, General Industry Precinct, Port, and BSIA surrounding regions
4	Supply of beneficiated iron fines from pelletising and/or sinter plant to iron carbide plant	<ul style="list-style-type: none"> ▶ Allow for co-location of iron pelletising plant, sinter plant, and iron carbide plant ▶ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries
5	Supply of Fe-chips to ferrosilicon plant by steel plant	<ul style="list-style-type: none"> ▶ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries
6	Supply of chlorine from chlor-alkali plant to resource processing plants	<ul style="list-style-type: none"> ▶ Allow for co-location of chlor-alkali plant and resource processing plants ▶ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries
7	Supply of caustic soda from chlor-alkali plant to resource processing plants	<ul style="list-style-type: none"> ▶ Allow for co-location of chlor-alkali plant and resource processing plants ▶ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries
8	Supply of magnesium by magnesium production plant to titanium production plant	<ul style="list-style-type: none"> ▶ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries
9	Supply of sodium chloride from salt mine to chlor-alkali plant	<ul style="list-style-type: none"> ▶ Allow for location of chlor-alkaline plant in Port Dependent and Material Intensive Industries Precinct ▶ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries
10	Supply of ethane from ethane extraction to ethane cracker	<ul style="list-style-type: none"> ▶ Allow for location of ethane extraction and ethane cracker ▶ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries
11	Supply of ethylene from ethane cracker to EDC / VCM plant	<ul style="list-style-type: none"> ▶ Allow for location of ethane cracker and EDC / VCM plant ▶ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries
12	Supply of ammonia from ammonia/urea plant to sodium cyanide plant and fertiliser production plant	<ul style="list-style-type: none"> ▶ Allow for location of ammonia/urea plant, sodium cyanide plant and/or fertiliser plant ▶ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries



#	Industrial Synergy Opportunity	Implications for BSIA Concept Design Plan
13	BSIA non-ferrous smelter supplying intermediate product to non-ferrous refinery in BSIA	<ul style="list-style-type: none"> ▶ Allow for co-location of non-ferrous smelter and refinery ▶ Service corridors and transportation nodes to allow for potential material movements between non-ferrous smelter and refinery
UTILITY SYNERGIES:		
1	Energy factory supplying electricity, steam, and hot/cold air to surrounding BSIA industries.	<ul style="list-style-type: none"> ▶ Allow for location of energy facility in Utility Precinct ▶ Allow for co-location of energy intensive industries in close proximity of energy facility ▶ Service corridors to allow for potential energy exchanges between energy facility and energy intensive industries
2	Water factory supplying high and low quality industry feedwater to BSIA industries.	<ul style="list-style-type: none"> ▶ Allow for location of industry feedwater facility in Utility Precinct ▶ Allow for co-location of water intensive industries in close proximity of water facility ▶ Allow for co-location of energy facility with industry feedwater facility ▶ Service corridors to allow for potential water exchanges between industry feedwater facility, water/energy intensive industries, ocean, municipal WWTP, groundwater access point
3	Direct use of WWTP treated effluent by selected BSIA industries (potential for on-site treatment to suit requirements)	<ul style="list-style-type: none"> ▶ Service corridors to allow for potential water exchanges between water intensive industries and municipal WWTP
4	Reuse of effluent stream (segregated or not) from one BSIA industry by other BSIA industry	<ul style="list-style-type: none"> ▶ Allow for co-location of water intensive industries ▶ Service corridors to allow for potential water exchanges between water intensive industries
5	Centralised production and supply of pressurised air to BSIA industries	<ul style="list-style-type: none"> ▶ Allow for location of centralised pressurised air facility in Utility Precinct ▶ Service corridors to allow for potential pressurised air supply from facility to key industries in strategic core
6	Centralised production, supply, and recovery of utility gases to BSIA industries (nitrogen, hydrogen, oxygen)	<ul style="list-style-type: none"> ▶ Allow for location of centralised utility gas facility in Utility Precinct ▶ Service corridors to allow for potential utility gas movements between facility and key industries in strategic core
7	Managed aquifer recharge of treated effluents, and indirect industrial reuse	<ul style="list-style-type: none"> ▶ To be confirmed in later studies
8	Centralised storage and processing facility for large volume inorganic by-products produced in BSIA	<ul style="list-style-type: none"> ▶ Allow for location of centralised storage and processing facility for large volume inorganic by-products (if possible in buffer zone) ▶ Service corridors and transportation nodes to allow potential material movements between centralised storage and processing facility and industries in strategic core of BSIA
9	Centralised treatment facility for industry off-gases (e.g. SO _x , NO _x)	<ul style="list-style-type: none"> ▶ Allow for location of centralised treatment facility for industry off-gases in Utility Precinct ▶ Service corridors to allow for potential off-gas movements between facility and key industries in Utility Precinct
10	Joint industry production of demineralised water for specialised applications (boiler feedwater)	<ul style="list-style-type: none"> ▶ Allow for location of joint industry demin plant in Utility Precinct ▶ Service corridors to allow for potential demin water exchanges between key industries in Utility Precinct



#	Industrial Synergy Opportunity	Implications for BSIA Concept Design Plan
11	Centralised storage and processing facility for selected (smaller volume) waste streams (e.g. hazardous wastes, oils, pallets, metals)	<ul style="list-style-type: none"> ▶ Allow for location of centralised storage and processing facility for smaller volume wastes in BSIA ▶ Transportation nodes to allow for potential waste movements within BSIA Precincts and surrounding regions
BY-PRODUCT SYNERGIES:		
1	Use of industry waste heat for drying or concentrating wet products and by-products.	<ul style="list-style-type: none"> ▶ Allow for co-location of energy intensive industries and potential users of waste heat ▶ Service corridors to allow for potential waste heat exchanges industries in close proximity
2	Use of pelletising wastes from iron ore pelletising plant (e.g. cement plant)	<ul style="list-style-type: none"> ▶ Transportation nodes to allow for potential pelletising waste movements between pelletising plant and industrial/commercial users
3	Use of ammonium sulphate from nickel processing in fertiliser production	<ul style="list-style-type: none"> ▶ Allow for co-location of fertiliser plant with nickel refinery in Resource Processing Precincts ▶ Service corridors and transportation nodes to allow for potential material movements
4	Processing and use of slag from ferrous mineral processing	<ul style="list-style-type: none"> ▶ Transportation nodes to allow for potential material movements
5	Processing and use of gypsum from resource processing	<ul style="list-style-type: none"> ▶ Transportation nodes to allow for potential material movements
6	Re-processing of scrap steel from BSIA industries by BSIA steel plant	<ul style="list-style-type: none"> ▶ Transportation nodes to allow for potential material movements
7	Co-processing of organic by-products from BSIA industries at large scale organic processing plant (e.g. ethanol, biofuels)	<ul style="list-style-type: none"> ▶ Transportation nodes to allow for potential material movements
8	Co-processing of inorganic by-products from BSIA industries and other alternative materials.	<ul style="list-style-type: none"> ▶ Transportation nodes to allow for potential material movements
9	Use of alternative fuels at selected BSIA industries (e.g. waste oils, tyres, shredded wood, coke dust from steel making)	<ul style="list-style-type: none"> ▶ Transportation nodes to allow for potential material movements
10	Use of alternative lime sources in ferrous and non-ferrous mineral processing.	<ul style="list-style-type: none"> ▶ Transportation nodes to allow for potential material movements
11	Conversion of process carbon dioxide in commercial gases by utility gas company	<ul style="list-style-type: none"> ▶ Allow for co-location of utility gas plant with key industries ▶ Service corridors to allow for potential utility gas movements between facility and key industries in strategic core of BSIA
12	Conversion of process by-product hydrogen into commercial gases by utility gas company	<ul style="list-style-type: none"> ▶ Allow for co-location of utility gas plant with key industries ▶ Service corridors to allow for potential utility gas movements between facility and key industries in strategic core of BSIA



#	Industrial Synergy Opportunity	Implications for BSIA Concept Design Plan
13	Conversion of process by-product nitrogen into commercial gases by utility gas company	<ul style="list-style-type: none"> ▶ Allow for co-location of utility gas plant with key industries ▶ Service corridors to allow for potential utility gas movements between facility and key industries in strategic core of BSIA
14	Use of charcoal (from plantations) as alternative to (petroleum) coke as reductant in steel sintering and mineral processing	<ul style="list-style-type: none"> ▶ Transportation nodes to allow for potential material movements
SERVICE SYNERGIES:		
1	Joint industry training and education facilities (regional industry training centre), including shared staffing (e.g. maintenance support)	<ul style="list-style-type: none"> ▶ Identify potential location(s) of training and education facility in BSIA
2	Joint logistic and transportation facilities	<ul style="list-style-type: none"> ▶ Allow for location of logistic and transportation companies in General Industry Precinct or BSIA surrounding areas ▶ Transportation nodes to allow for potential material movements between BSIE strategic core, General Industry Precinct, Port, and BSIA surrounding regions
3	Joint industry agreement for collection and handling of selected industry wastes	<ul style="list-style-type: none"> ▶ Transportation nodes to allow for potential material movements
4	BSIA interpretive centre	<ul style="list-style-type: none"> ▶ Identify potential location(s) of BSIA interpretive centre (e.g. in General Industry Precinct or BSIA surrounding area)
5	Joint industry monitoring and control of odour and air quality footprint	<ul style="list-style-type: none"> ▶ Identify optimal locations for odour intensive industries ▶ Allow for co-location of odour intensive industries with minimum impact on community (e.g. close to BSIA Buffer Zone)
6	Joint industry incident and accident prevention and response	<ul style="list-style-type: none"> ▶ Identify optimal locations for high(er) risk industries ▶ Allow for co-location of high(er) risk industries (e.g. close to BSIA Buffer Zone)



6. Centralised Water, Energy and By-Product Facilities

Industrial ecology focuses on industry collaboration to address common needs and to increase resource efficiencies. Securing water and energy supply, and efficient and effective storage and processing of large volume industrial by-products and wastes are critical to the successful development of the Boodarie Strategic Industrial Area. Each item is discussed below from an industrial ecology perspective.

6.1 Centralised Industry Feedwater Facility

6.1.1 Business Case

Over the past 30 years Australia, including Western Australia, has experienced significantly decreased rainfall, most probably as a result of climate change. Due to declining levels of stored water in dams and underground aquifers, fresh water will be a more scarce resource over the next decades and the cost of water is likely to increase over time. Runoff into dams has reduced by 40-50 percent since 1975 due to decreased rainfall. This has impacted industrial water users by directly reducing the available fresh water resources and indirectly restricting potable scheme water available to industry. This trend is most likely to increase in the future.

The industry input / output assessment (Section 3) indicated that the BSIA, when fully developed, will potentially require between 60 and 80 GL/yr of industry feedwater, including 23 to 30 GL/yr of high quality feedwater (e.g. boilers, process), and about 36 to 48 GL/yr of lower quality feedwater (e.g. cooling, dust suppression). The lack of access to appropriate, well priced (industry feed) water can be a potential show stopper for new heavy industry wanting to establish in the BSIA.

The Water Corporation plan (Water Forever - Towards Climate Resilience, October 2009) has set a target of 30% for recycling of wastewater by 2030, with recycling to industry being a focus area. Of relevance to the Boodarie Strategic Industrial Area, the plan also refers to the need to influence land planning and development by initiatives such as planning for use of recycled water, increasing the application of water sensitive urban design, and helping business and industry to make better use of fit for purpose water.

6.1.2 Proposed Concept

In the BSIA Concept Plan, it is proposed to allocate sufficient land area (about 65 ha) in the Utility Precinct for a centralised facility to produce fit-for-purpose industry feedwater. Proposed approximate location of the facility is shown in Figure 4 in Section 7.

Such a facility could feed from various sources, including groundwater, industrial effluents generated within the estate, effluent from nearby municipal WWTP, seawater, or a combination of these sources. At this point in time, the BSIA Concept Plan should not lock in one water resource, but rather allow for the use of any of these water resources over time (subject to future feasibility studies, developments, and water availability).

It may be that an alternative industry feedwater arrangement and/or system is set up outside the boundaries of the BSIA. This is subject to future feasibility studies, and initiatives undertaken by other



organisations and/or utility providers in the region. In this case, the allocated land use for feedwater facility can be used for alternative land uses.

Overall, it is aimed to produce a fit-for-purpose industry feedwater for the BSIA at a cost competitive with potable water, given the likely price increases for potable water in the future. It is recognised that the development of an alternative industry feedwater system in the BSIA may occur additional capital costs over and above a business-as-usual approach (e.g. third pipe, recycling and storage facility). However, anticipated increasing price of potable water and government/community pressures will have positive effect on the economic feasibility of alternative industry feedwater concept. Having an alternative industry feedwater system in BSIA has the potential to attract water intensive industries to the area. Furthermore, it is important to consider the environmental cost of potable water (e.g. from seawater desalination plant) when evaluating the business case of an alternative water supply for industry.

A modular approach to the design of the water facility is recommended to allow the facility to expand over time as more industries require their services.

Future industries in the BSIA will likely generate significant amounts of waste heat, in particular flue gases. For example, the total energy release from flue gases in the Kwinana Industrial Area is estimated at approximate 6,300 TJ/yr, with up to 3,000 TJ/yr over 300°C³. The industry feedwater facility has potential to feed from the waste heat generated in the BSIA. Evaporative water treatment or desalination systems (e.g. multi-effect distillation) are proven technologies for regions and industries without readily access to fresh water. These technologies are normally driven by fossil fuels, but could be driven by industry waste heat as well. As a result, it is recommended to co-locate the feedwater facility with an energy facility (discussed in Subsection 6.2). The co-location of these two facilities is shown in Figure 4 in Section 7.

6.2 Centralised Energy Facility

6.2.1 Business Case

The industries in the BSIA will have significant energy requirements. The industry input / output assessment (Section 3) estimated, when estate is fully developed, power requirements between 1,200 to 1,500 MW and gas requirements between 425 and 560 PJ/yr. On the other hand, significant amounts of waste heat will likely be generated by the future BSIA industries resulting in opportunities for energy recovery and efficiencies.

There are numerous ways in which the industry can source these energy requirements, including conventional power stations, gas pipeline, co and/or trigeneration facilities, and renewable energy (e.g. wind, solar, wave, geothermal). Their application to power the BSIA over time will depend on specific industry energy demands, economic and technical feasibility, government (dis)incentives (e.g. carbon tax), community pressures, energy source availability, land assembly, and environmental constraints. The BSIA will most likely be driven by a combination of various energy supply options.

³ Van Beers (2008). 2008 Status Report of the CSRP Kwinana Synergies Project, Report for Centre for Sustainable Resource Processing.



Given the current uncertainties impacting of the estate development, it is key for the BSIA Concept Plan to allow for the development of multiple energy supply options over time.

6.2.2 Proposed Concept

It is proposed to allow for the development of a centralised and joint industry energy facility (about 60 ha) in the Utility Precinct of the estate creating economies of scale and potentially avoiding the need for multiple, smaller, and under-utilised facilities throughout the estate. Such facility could produce electricity, steam, chill, hot air to industries in its close proximity. Allowance should be made for the facility to feed from various energy sources, including gas, coal, renewable energy, and industry waste heat.

As for the industry feedwater facility, a modular approach to the design of the energy facility is recommended to allow the facility to expand over time as more industries require their services.

It is noted that heat losses over longer distances (e.g. over 500 meters) can be significant. Therefore it is recommended to locate the energy facility in the strategic core of the estate, close to industries producing significant amounts of waste heat.

Furthermore, as noted in Subsection 6.1, it is recommended to co-locate the centralised energy facility with the industry feedwater facility to enable the generation of feedwater or seawater desalination with industry waste heat. The co-location of these two facilities is shown in Figure 4 in Section 7.

6.3 Centralised Industrial By-Product Storage and Processing Facility

6.3.1 Business Case

Significant amounts of industrial by-products (both inorganic and organic) will likely be generated in the BSIA. Subject to specific types of industries locating to the BSIA, these could include slags, tailings, gypsum, cement, ashes, lime and cement kiln dusts.

The industry input / output assessment undertaken (Section 3) estimates that a total between 4.6 and 6.1 Mtpa (4,600,000 tpa to 6,100,000 tpa) of industrial by-products could be generated in the estate once fully developed. It is noted that the quantities could be significant higher if, for example, an alumina refinery would establish in the estate.

Many industrial by-products have significant potential to be reused in building and construction materials, sustainable agriculture, minerals and metals production and other applications. The opportunity exists to replace virgin materials with recovered inorganic by-products from industrial operations in BSIA, either directly or after beneficiation to improve properties. Their utilisation as valuable by-products have the potential to reduce liabilities associated with current management and storage practices. Overall, the reuse of industrial by-products can make a significant contribution to the sustainability of the Boodarie Strategic Industrial Area.

6.3.2 Proposed Concept

Rather than stockpiling the large volume industrial by-products within the strategic core of the estate, there is potential to transfer these by-products to a centralised storage facility in the buffer zone of the estate (subject to environmental, town planning, and land assembly constraints). A centralised facility in the buffer would maximise industrial land use in the strategic core, but would also facilitate and encourage the (co-)processing industrial by-products into valuable materials.



The concept of inorganic by-product storage and processing facility is shown in Figure 4 in Section 7.

It is noted that industry will need to ensure that their by-products are of suitable standard for long-term storage and re-processing. Quality standards and protocols should be developed for the facility, including commercial reprocessing agreements between industries to enable co-processing of different by-products into material with enhanced properties (e.g. mixing of gypsum and cement kiln dust as sustainable agricultural product).

It is envisaged that the different industrial by-products will be stored in separate areas to avoid cross contamination, and enable re- and co-processing of by-products into valuable products over time.

The preferred location and size of the centralised industrial by-product facility are yet to be determined.

Key criteria for the determining the location of the facility:

- ▶ Service corridor and road access (e.g. transferring materials in and out of storage facility);
- ▶ Town planning approval;
- ▶ Environmental constraints (e.g. flora, fauna, water bodies, soil type); and
- ▶ Land assembly (e.g. other planned uses and existing infrastructure and facilities in the buffer).

7. Industrial Area Precincts

In the first instance and at a high order, industry clustering is facilitated through the development of appropriate industry precincts within the BSIA. This section outlines the precincts identified, their preferred location, and proposed precinct concept for the estate.

Industry location and clustering within the precincts are discussed in Section 8.

7.1 Identification of Precincts

Based on the industry input/output assessment (Section 3), previous reports on the BSIA, and discussions with the Concept Plan Design Team (LandCorp, DSD, and appointed consultants), the following precincts were identified:

- ▶ Port Dependent and Material Intensive Industries;
- ▶ Downstream Petroleum / Gas / Coal Processing;
- ▶ Downstream Iron Ore Processing;
- ▶ Resource Processing;
- ▶ General industries;
- ▶ Noxious industries.

7.2 Precincts Location Criteria

Based on industry input/output assessment and industrial synergy opportunities identified, appropriate and relevant location criteria (requirements) for each precinct are summarised in Table 23.

Table 23 Precinct Location Criteria for Boodarie Strategic Industrial Area

Precinct	Precinct Location Criteria	Recommended Precinct Location
Port Dependent and Material Intensive Industries	▶ Access to port (service corridor, road, rail)	Far north eastern part of estate (closest to port)
	▶ Access to bulk commodity rail	
	▶ Access to multi-product rail	Adjacent to main BSIA service corridor
	▶ Access to road	
	▶ Access to conveyor systems	
Downstream Iron Ore Processing	▶ Access to port (service corridor, road, rail)	Western part of estate
	▶ Access to bulk commodity rail	Adjacent east of Iron Ore Stockpiling Precinct
	▶ Access to multi-product rail	
	▶ Access to road	Proximity and access of General and Noxious Industries Precincts
	▶ Access to gas pipelines	
	▶ Access to conveyor systems	
	▶ Access to HV power supply	Adjacent to main BSIA service corridor
	▶ Access to industry feedwater supply	
	▶ Buffer zone	
	▶ Adjacent to Iron Ore Stockpiling Area (raw material supply)	
	▶ Adjacent to Resource Processing Precinct (industrial synergies)	

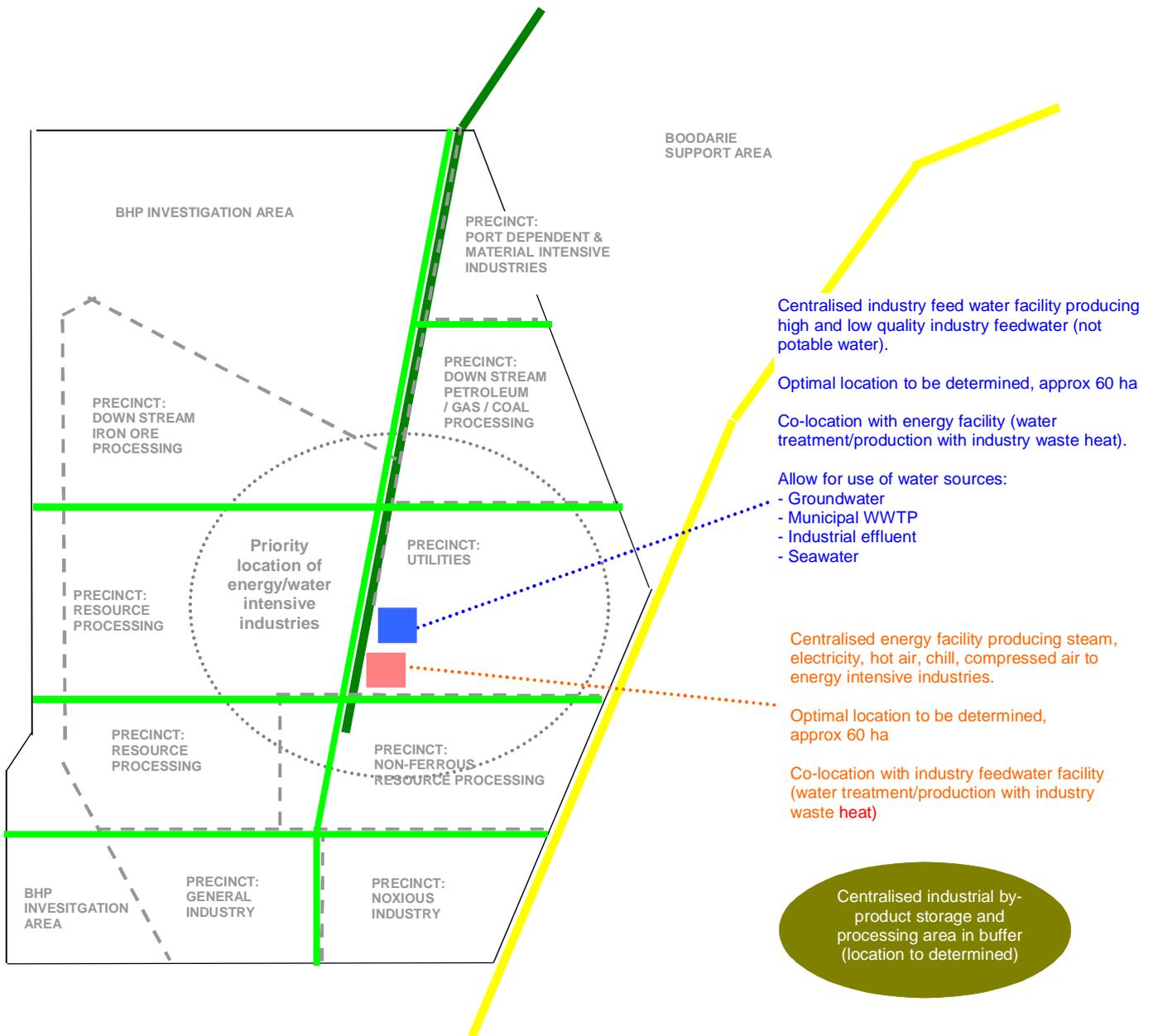


Precinct	Precinct Location Criteria	Recommended Precinct Location
	<ul style="list-style-type: none"> Proximity and access to Noxious Industries Precincts (support and synergies) 	
Downstream Petroleum / Gas / Coal Processing	<ul style="list-style-type: none"> Access to gas pipeline supply Access to port (service corridor, road, rail) Access to pipelines in service corridors Buffer zone Appropriate distance to Turner River Aquifer Groundwater Control Area south of BSIA (spillage risks) 	<p>North eastern part of estate (close access to port and away from Turner River Aquifer Groundwater Control Area)</p> <p>Adjacent to main BSIA service corridor</p>
Resource Processing	<ul style="list-style-type: none"> Access to port (service corridor, road, rail) Access to bulk commodity rail Access to multi-product rail Access to road Access to gas pipelines Access to HV power supply Access to industry feedwater supply Buffer zone Adjacent to Down Stream Iron Ore Processing Precinct (industrial synergies) Proximity and access to General and Noxious Industries Precincts (support and synergies) 	<p>North eastern part of estate</p> <p>Adjacent to Downstream Iron Ore Processing Precinct</p> <p>Proximity and access of General and Noxious Industries Precincts</p> <p>Adjacent to main BSIA service corridor</p>
General industries	<ul style="list-style-type: none"> Access to road Proximity and access to Resource Processing Precinct (industrial synergies) Proximity and access to Down Stream Iron Ore Processing Precinct (industrial synergies) 	<p>Subject to environmental assessment (e.g. Turner River Aquifer Groundwater Control Area of BSIA) and connection to sewer</p> <p>Southern part of estate</p> <p>Proximity and access to Resource Processing Precinct</p> <p>Proximity and access to Down Stream Iron Ore Processing Precinct</p>
Noxious industries	<ul style="list-style-type: none"> Buffer zone Access to road Adjacent to Resource Processing Precinct (industrial synergies) Adjacent to Down Stream Iron Ore Processing Precincts (industrial synergies) 	<p>Subject to environmental assessment (e.g. Turner River Aquifer Groundwater Control Area south of BSIA) and connection to sewer</p> <p>Southern part of estate</p> <p>Adjacent south of Resource Processing Precinct</p> <p>Adjacent south of Down Stream Iron Ore Processing Precinct</p>

7.3 Precinct Concept

Following the review of location criteria and subsequent recommended precinct location, Figure 4 presents a precinct concept for the Boodarie Strategic Industrial Area. This precinct plan will allow for the development of promising industry synergies identified and subsequent industry clustering.

Figure 4 Proposed Precinct Concept for Boodarie Strategic Industrial Area



Notes:

- ▶ Alignment shown are only indicative, and subject to assembly of base mapping;
- ▶ Plan subject to environmental, town planning, and land assembly constraints;
- ▶ Do not scale this plan; and
- ▶ Land size and location flexible, subject to industry demand.



8. Industry Clustering

High level industry clustering is facilitated through the industry precincts identified and their positioning within the Boodarie Strategic Industrial Area (Section 7). This section discusses the potential for industry clustering within the precincts.

It is noted that the specific industry types locating to the BSIA are still largely unknown. Therefore, this section provides guidance on the types of clustering which can occur in Boodarie, rather than locking in clustering scenarios at this point in time.

The implementation plans in Section 11 provide guidance on actions to be taken to facilitate industry clustering post concept planning.

8.1 Industry Clustering

The clustering of relevant industries (based on their services and resource inputs and outputs) is at the heart of industrial ecology. Industry clustering is a critical element to allow for the development of regional synergies within the BSIA and with its surrounding regions as well as a mechanism to reduce the need for utility infrastructure and associated costs.

Firms and organisations involved in clusters are able to achieve synergies and leverage economic advantage from shared access to information and knowledge networks, supplier and distribution chains, markets and marketing intelligence, special competencies, resources and support institutions available in a specific locality. The cluster concept focuses on the functional linkages and interdependencies among actors in value chains.

In summary, the benefits of industry clustering include⁴:

- ▶ Attracting businesses to the industrial estate because of the cost benefits associated with co-location and security of resource supply;
- ▶ Proximity generates externality savings and economies of scale, which reduce operational costs for companies sharing common suppliers or services;
- ▶ Encourages innovation, which leads to opportunities for the development of new industries especially firms capable of using wastes and by-products;
- ▶ The more intense the agglomeration, the greater are the prospects for innovation and synergies.

Table 24 presents a preliminary overview of industry clustering options for the Boodarie Industrial Area.

Table 24 Preliminary Review of Industry Clustering Options

Clustering Options	Comments / Illustrative Examples
Water cluster	Water intensive industries (demand and discharges)
Energy cluster	Energy intensive industries (demand and discharges)

⁴ Planning for Sustainable Industry' by Roberts and Wadley, Royal Australian Planning Institute. 2004.



Clustering Options	Comments / Illustrative Examples
Anchor tenant clusters	Clusters around power station, cement plant, chemical plant (see next section)
High risk industry cluster	Clusters of high risk industries to enhance accident prevention and emergency response
Service and support cluster	Logistics, maintenance, storage , buying, training
Inorganics cluster	Processing and recovery of inorganic materials, including acids, process chemicals, construction materials, industrial inorganic by-products
Organics cluster	Processing and recovery of organic materials, including grains, wood, food waste
By-product / waste exchange cluster	By-product / waste intensive and processing industries
"Green products" cluster	Manufacturers of water/energy saving products, business utilising semi-products from resource recovery operations
Post-consumer waste cluster	Processing and recovery of end-of-life household appliances, plastics, paper, glass, waste oil, tyres
Intermodal cluster	Industries servicing inter-modal facility
Industry type clusters	Engineering, manufacturing, chemical, utility providers
Industry size clusters	Locate small, medium, large enterprises in different clusters

8.2 Locating Industries within the Estate and Precincts

The tables on the next pages provide guidance on locating potential industry types within the BSIA precincts.

Given the uncertainties regarding potential industry types locating to BSIA and the need to incorporate maximum flexibility in the development of the industrial estate, the assessment is based on relevant industry groups from the Australian and New Zealand Standard Industry Codes (ANSZIC).

Each potential industry type is assessed against a set of industry location criteria. These location criteria provide the basis for determining preferred location of the industries within the identified precincts.

The industry location criteria cover the following:

► Risk:

- High risk profile: Industries with the risk of high impact (noise, odour, air emissions) industries;
- Industry co-location risk: Separate industries that may increase the risk profile within the estate if they were located next to each other;

► Transport:

- Access to port: Industries with high import/export volumes requiring access to port;
- Access to bulk commodity rail: Industries with high input/output volumes requiring access to bulk commodity rail;
- Access to multi-product rail: Industries with high input/output volumes requiring access to multi-product rail;
- High wide loads: Industries with high and/or wide inputs/outputs;



- Access to conveyors:
- Access to other materials handling services: Industries with other significant materials handling requirements needing access to multi-purpose corridors;
- ▶ Water:
 - High water requirements: Industries with significant industry feedwater requirements;
- ▶ Energy:
 - High energy requirements: Industries with high energy use requirements;
- ▶ Waste:
 - Access to by-product/waste storage and processing area;
- ▶ Lot size:
 - Large lots: Industries which require large, generally flat areas for their operations.



Table 25 Guidance for Locating Industries within the Estate and Precincts

ANZSIC - Short-listed industries		Potential to locate to BSIA (Low, Medium, High)	Industry location criteria										Recommended location within BSIA										
Code	Industry type		Risk		Transport				Water	Energy	Waste	Lot size	Port Related and Material Intensive	Downstream Iron Ore Processing Precinct	Downstream Petroleum / Coal / Gas Processing Precinct	Resource Processing Precinct	Utilities	Non-Ferrous Resource Processing	General Industry Precinct	Noxious Industry Precinct	Buffer zone	Boodarie Support Area (east of BSIE boundary)	Priority location in selected precinct (if applicable)
			High risk profile	Industry co-location risk	Access to port	Access to bulk commodity rail	Access to multi-product rail	High wide loads	Access to conveyors materials handling services	High water requirements	High energy requirements	Access to by-product/waste storage and processing											
Division A																							
Agriculture, Forestry and Fishing																							
011	Nursery and Floriculture Production	Low	X								X										O	Sufficient distance to nearest industry development	
013	Fruit and Tree Nut Growing	Low									X										O	Sufficient distance to nearest industry development	
014	Sheep, Beef Cattle and Grain Farming	Medium	X								X										O	Sufficient distance to nearest industry development	
0143	Beef Cattle Feedlots (Specialised)	Medium	X								X										O	Sufficient distance to nearest industry development	
016	Dairy Cattle Farming	Medium	X								X										O	Sufficient distance to nearest industry development	
017	Poultry Farming	Medium	X																		O	Sufficient distance to nearest industry development	
0203	Onshore Aquaculture	Low	X								X										O	Sufficient distance to nearest industry development	
051	Forestry Support Services	Low																			O	Sufficient distance to nearest industry development	
052	Agriculture and Fishing Support Services	Low																			O	Sufficient distance to nearest industry development	
Division B																							
Mining																							
091	Construction Material Mining	High									XX	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	Subject to mining/extraction leases
099	Other Non-Metallic Mineral Mining and Quarrying	High									XX	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	Subject to mining/extraction leases
109	Other Mining Support Services (includes ore stockpiling)	High			XX	XX				XX													As per current arrangements
Division C																							
Manufacturing																							
13	Textile, Leather, Clothing, and Footwear Manufacturing	Low							XX	X											O	Proximity / access to industry feedwater facility Synergistic industries close and/or good access to appropriate precinct	
14	Wood Product Manufacturing	Low	X						X	X											O	O	Synergistic industries close and/or good access to appropriate precinct
15	Pulp, Paper, and Converted Paper Product Manufacturing	Low	X						XX	X											O	Proximity / access to industry feedwater facility Synergistic industries close and/or good access to appropriate precinct	



ANZSIC - Short-listed industries		Potential to locate to BSIA (Low, Medium, High)	Industry location criteria											Recommended location within BSIA									
Code	Industry type		Risk		Transport				Water	Energy	Waste	Lot size	Port Related and Material Intensive	Downstream Iron Ore Processing Precinct	Downstream Petroleum / Coal / Gas Processing Precinct	Resource Processing Precinct	Utilities	Non-Ferrous Resource Processing	General Industry Precinct	Noxious Industry Precinct	Buffer zone	Boodarie Support Area (east of BSIE boundary)	Priority location in selected precinct (if applicable)
			High risk profile	Industry co-location risk	Access to port	Access to bulk commodity rail	Access to multi-product rail	High wide loads	Access to conveyors materials handling services	High water requirements	High energy requirements	Access to by-product/waste storage and processing	Large lots										
18	Basic Chemical and Chemical Product Manufacturing	High	XX	XX	XX	X	X			XX	XX	XX	X	XX	O								Proximity / access to water and energy facility
19	Polymer Product and Rubber Product Manufacturing	Medium	X	X			X			X	X	X							O	O		Co-location with synergistic industries Synergistic industries close and/or good access to appropriate precinct	
201	Glass and Glass Product Manufacturing	Low																				Synergistic industries close and/or good access to appropriate precinct	
202	Ceramic Product Manufacturing	Medium													O				O			Energy, water, material intensive companies in Resource Processing Precinct, in proximity to water and energy facility. Otherwise in General and Noxious Industry Precinct General or Noxious Industry Precincts: Synergistic industries close and/or good access to appropriate precinct Co-location with synergistic industries	
203	Cement, Lime, Plaster and Concrete Product Manufacturing	Medium		XX	X	X				X	XX	XX	X	XX	O			O	O	O		Energy, water, material intensive companies in Resource Processing Precinct, in proximity to water and energy facility. Otherwise in General or Noxious Industry Precincts General or Noxious Industry Precincts: Synergistic industries close and/or good access to appropriate precinct Co-location with synergistic industries If required: proximity to centralised industrial by-products storage and processing area	
209	Other Non-Metallic Mineral Product Manufacturing	High		X		X				X	X	X	X	X	O			O	O	O		Energy, water, material intensive companies in Resource Processing Precinct, in proximity to water and energy facility. Otherwise in General or Noxious Industry Precincts General or Noxious Industry Precincts: Synergistic industries close and/or good access to appropriate precinct Co-location with synergistic industries	
211	Basic Ferrous Metal Manufacturing	High	X	XX	XX	XX	XX			XX	XX	XX	XX	XX	O	O						Proximity / access to water and energy facility Co-location with synergistic industries Proximity to centralised industrial by-products storage and processing area	



ANZSIC - Short-listed industries		Potential to locate to BSIA (Low, Medium, High)	Industry location criteria											Recommended location within BSIA														
Code	Industry type		Risk		Transport				Water	Energy	Waste	Lot size																
			High risk profile	Industry co-location risk	Access to port	Access to bulk commodity rail	Access to multi-product rail	High wide loads	Access to conveyors materials handling services	High water requirements	High energy requirements	Access to by-product/waste storage and processing	Large lots	Port Related and Material Intensive	Downstream Iron Ore Processing Precinct	Downstream Petroleum / Coal / Gas Processing Precinct	Resource Processing Precinct	Utilities	Non-Ferrous Resource Processing	General Industry Precinct	Noxious Industry Precinct	Buffer zone	Boodarie Support Area (east of BSIE boundary)	Priority location in selected precinct (if applicable)				
212	Basic Ferrous Metal Product Manufacturing	High		X	XX			XX	XX		XX	X	X		X	O	O					O	O	O				Energy, water, material intensive companies in Resource Processing Precinct, in proximity to water and energy facility. Otherwise in General or Noxious Industry Precincts General or Noxious Industry Precincts: Synergistic industries close and/or good access to appropriate precinct Co-location with synergistic industries
2131	Alumina Production	Medium	X	XX	XX	XX	X			XX	XX	XX	XX	XX	XX	O												Proximity / access to water and energy facility Co-location with synergistic industries Proximity to centralised industrial by-products storage and processing area
2132	Aluminium Smelting	High	X	XX	XX	X	X			XX	XX	XX	X	XX	XX	O												Proximity / access to water and energy facility Co-location with synergistic industries Proximity to centralised industrial by-products storage and processing area
2133	Copper, Silver, Lead and Zinc Smelting and Refining	Medium	XX	XX	XX	XX	X			XX	XX	XX	XX	XX	XX	O												Access to water and energy facility Co-location with synergistic industries Access to centralised industrial by-products storage and processing area
2139	Other Basic Non-Ferrous Metal Manufacturing	High	X	XX	XX	XX	XX			XX	XX	XX	XX	XX	XX	O												Proximity / access to water and energy facility Co-location with synergistic industries Proximity to centralised industrial by-products storage and processing area
214	Basic Non-Ferrous Metal Product Manufacturing	Medium		X	X	X	X	XX		X	X	X		X	O							O	O	O				Energy, water, material intensive companies in Resource Processing Precinct, in proximity to water and energy facility. Otherwise in General and Noxious Industry Precinct General or Noxious Industry Precincts: Synergistic industries close and/or good access to appropriate precinct Co-location with synergistic industries



ANZSIC - Short-listed industries		Potential to locate to BSIA (Low, Medium, High)	Industry location criteria											Recommended location within BSIA														
Code	Industry type		Risk		Transport					Water	Energy	Waste	Lot size															
			High risk profile	Industry co-location risk	Access to port	Access to bulk commodity rail	Access to multi-product rail	High wide loads	Access to conveyors	materials handling services	High water requirements	High energy requirements	Access to by-product/waste storage and processing	Large lots	Port Related and Material Intensive	Downstream Iron Ore Processing Precinct	Downstream Petroleum / Coal / Gas Processing Precinct	Resource Processing Precinct	Utilities	Non-Ferrous Resource Processing	General Industry Precinct	Noxious Industry Precinct	Buffer zone	Boodarie Support Area (east of BSIE boundary)	Priority location in selected precinct (if applicable)			
22	Fabricated Metal Product Manufacturing	Medium		X	X	X	X	XX		X	X		X															Energy, water, material intensive companies in Resource Processing Precinct, in proximity to water and energy facility. Otherwise in General and Noxious Industry Precinct General or Noxious Industry Precincts: Synergistic industries close and/or good access to appropriate precinct Co-location with synergistic industries
23	Transport Equipment Manufacturing	Medium				X		X	X				X															Synergistic industries close and/or good access to appropriate precinct Co-location with synergistic industries
24	Machinery and Equipment Manufacturing	Medium				X		X	X				X															Synergistic industries close and/or good access to appropriate precinct Co-location with synergistic industries
25	Furniture and Other Manufacturing	Low																										Synergistic industries close and/or good access to appropriate precinct Co-location with synergistic industries
Division D	Electricity, Gas, Water, and Waste Services																											
2611	Fossil Fuel Electricity Generation	High		XX	XX	X				XX	XX	XX	X	X														Proximity / access to water and energy facility Co-location with synergistic industries If required: proximity to centralised industrial by-products storage and processing area
2612	Hydro-Electricity Generation	Low								X	XX	X		XX												O		Proximity to ocean Access to service corridor
2619	Other Electricity Generation	High		X							XX	XX		X														Proximity / access to water and energy facility Co-location with synergistic industries
2811	Water Supply	High		X						XX	XX	X		X														Proximity / access to water and energy facility Co-location with synergistic industries
2812	Sewerage and Drainage Services	High		X						XX				X												O	O	Proximity / access to water and energy facility Co-location with synergistic industries



ANZSIC - Short-listed industries		Potential to locate to BSIA (Low, Medium, High)	Industry location criteria											Recommended location within BSIA										
Code	Industry type		Risk		Transport				Water	Energy	Waste	Lot size	Port Related and Material Intensive	Downstream Iron Ore Processing Precinct	Downstream Petroleum / Coal / Gas Processing Precinct	Resource Processing Precinct	Utilities	Non-Ferrous Resource Processing	General Industry Precinct	Noxious Industry Precinct	Buffer zone	Boodarie Support Area (east of BSIE boundary)	Priority location in selected precinct (if applicable)	
			High risk profile	Industry co-location risk	Access to port	Access to bulk commodity rail	Access to multi-product rail	High wide loads	Access to conveyors materials handling services	High water requirements	High energy requirements	Access to by-product/waste storage and processing												Large lots
Division H Accommodation and Food Services																								
451	Cafes, Restaurants, and Takeaway Food Services	High																					As required to service BSIE Sufficient distance to industries with high(er) risk profile	
Division I Transport, Postal and Warehousing																								
461	Road Freight Transport	High	X		XX	XX			X														Proximity / access to road and rail Synergistic industries close and/or good access to appropriate precinct Co-location with synergistic industries	
471	Rail Freight Transport	High	X		XX	XX			X														Proximity/access to road and rail Synergistic industries close and/or good access to appropriate precinct Co-location with synergistic industries	
52	Transport Support Services	High																					Synergistic industries close and/or good access to appropriate precinct Co-location with synergistic industries	
53	Warehousing and Storage Services	High		X	X	X			X														Synergistic industries close and/or good access to appropriate precinct Co-location with synergistic industries	
Division J Information Media and Telecommunications																								
580	Telecommunications Services	High							X															
592	Data Processing, Web Hosting and Electronic Information Storage Services	High																						
602	Other Information Services	High																						
Division K Financial and Insurance Services																								
-	None are suitable for location in OIE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Division L Rental, Hiring, and Real Estate Services																								
-	None are suitable for location in OIE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Division M Professional, Scientific and Technical Services																								
691	Scientific Research Services	Medium																					Sufficient distance to industries with high(er) risk profile	
Division N Administrative and Support Services																								
721	Employment Services	Medium																					Sufficient distance to industries with high(er) risk profile	

9. Anchor Tenants

An anchor tenant can act as a central feature of an industrial estate and a step towards establishing regional synergies. Having an anchor tenant helps to define potential sources of exchanges (e.g. the use of steam from a power plant). Furthermore, the availability of a specific resource (e.g. inorganic and organic by-product, waste energy, wastewater stream) may serve as an attraction for potential tenants. The major inputs and outputs of an anchor will help define the search for the next round of companies, those capable of using its outputs or supplying it with theirs.

The development of Boodarie Strategic Industrial Area will significantly benefit from having anchor tenants to attract associated businesses and establish regional synergies in the area. These anchor tenants can be existing industries in surrounding areas (such as the Port Hedland port) or new businesses locating in the BSIA. A preliminary review of existing and potential new anchor tenants is provided in the table below.

Table 26 Preliminary Review of Anchor Tenants for BSIA

		Overall significance for development BIE			
		Most significant			Less significant
#	Potential Anchor Tenants	Trigger or Contribute to Attracting Industries			
		Supply Synergies	Utility Synergies	By-Product Synergies	Service Synergies
1	Steel plant	Iron ore pelletising plant	industry feedwater facility supplying low and/or high quality industry feedwater	Company processing and/or reusing slag (aggregate, soil conditioner, cement clinker)	Joint industry training and education facility
		Heavy construction companies	energy facility supplying steam, electricity, hot/cold air	Company processing and/or reusing gypsum (plasterboard, bricks, chemical processing)	Joint industry logistic and transportation facility
		Producers or local suppliers of process chemicals and raw materials	Producer of utility gases	Company co-processing large volume inorganic by-products from BIE industries into valuable products	Waste management company collecting small(er) volume wastes in BIE
		Warehouses	Treatment facility for industry off-gases	Company processing and supplying alternative fuels	
		Transport companies		Company processing and supplying lime sources (e.g. cement plant)	
		Commercial businesses	Utility company converting process CO ₂ , N ₂ , H ₂ into commercial gases		
2	Non-ferrous industries	Non-ferrous smelter or refinery	industry feedwater facility supplying low and/or high quality industry feedwater	Fertiliser company processing ammonium sulphate (from nickel refinery)	Joint industry training and education facility
		Producers or local suppliers of process chemicals and raw materials	energy facility supplying steam, electricity, hot/cold air	Company co-processing large volume inorganic by-products from BIE industries into valuable products	Joint industry logistic and transportation facility
		Warehouses	Producer of utility gases	Company processing and supplying alternative fuels	Waste management company collecting small(er) volume wastes in BIE
		Transport companies	Treatment facility for industry off-gases	Utility company converting process CO ₂ , N ₂ , H ₂ into commercial gases	
		Commercial businesses			
2	Chemical and/or commercial fertiliser plant	Nickel refinery supplying ammonium sulphate	industry feedwater facility supplying low and/or high quality industry feedwater	Company co-processing large volume organic materials (products, by-products, wastes) into valuable products	Joint industry training and education facility
		Producers or local suppliers of process chemicals and raw materials	energy facility supplying steam, electricity, hot/cold air	Company co-processing large volume inorganic by-products from BIE industries into valuable products	Joint industry logistic and transportation facility
		Warehouses	Producer of utility gases	Company processing and supplying alternative fuels	Waste management company collecting small(er) volume wastes in BIE
		Transport companies	Treatment facility for industry off-gases	Utility company converting process CO ₂ , N ₂ , H ₂ into commercial gases	
		Commercial businesses			



Most significant

Overall significance for development BIE

Less significant

#	Potential Anchor Tenants	Trigger or Contribute to Attracting Industries			
		Supply Synergies	Utility Synergies	By-Product Synergies	Service Synergies
3	Power station	Producers or local suppliers of process chemicals and raw materials	industry feedwater facility supplying low and/or high quality industry feedwater	Company co-processing large volume inorganic by-products from BIE industries into valuable products	Joint industry training and education facility
		Transport companies	Producer of utility gases	Company processing and supplying alternative fuels	Joint industry logistic and transportation facility
		Commercial businesses	Treatment facility for industry off-gases	Utility company converting process CO ₂ , N ₂ , H ₂ into commercial gases	Waste management company collecting small(er) volume wastes in BIE
4	Cement plant	Producers or local suppliers of process chemicals and raw materials	industry feedwater facility supplying low and/or high quality industry feedwater	Company co-processing large volume inorganic by-products from BIE industries into valuable products	Joint industry training and education facility
		Ferrous and non-ferrous mineral processing industries using lime as raw material	energy facility supplying steam, electricity, hot/cold air	Company processing and supplying alternative fuels	Joint industry logistic and transportation facility
		Ferrous and non-ferrous mineral processing industries supplying raw materials (e.g. iron oxide, gypsum, overburden, bauxite)	Treatment facility for industry off-gases	Utility company converting process CO ₂ , N ₂ , H ₂ into commercial gases	Waste management company collecting small(er) volume wastes in BIE
		Warehouses			
		Transport companies			
Commercial businesses					
5	Organic-based processing plant	Producers or local suppliers of process chemicals and raw materials	industry feedwater facility supplying low and/or high quality industry feedwater	Company co-processing large volume organic by-products into valuable products	Joint industry training and education facility
		Grain and other organic material handling facilities	energy facility supplying steam, electricity, hot/cold air	Company processing and supplying alternative fuels	Joint industry logistic and transportation facility
		Warehouses	Producer of utility gases	Utility company converting process CO ₂ , N ₂ , H ₂ into commercial gases	Waste management company collecting small(er) volume wastes in BIE
		Transport companies			
Commercial businesses					
6	Solid waste industrial processing plant	Pre-treatment and local suppliers of solid wastes	industry feedwater facility supplying low and/or high quality industry feedwater	Company co-processing large volume inorganic and organic by-products into valuable products	Joint industry training and education facility
		Producers or local suppliers of process chemicals	energy facility supplying steam, electricity, hot/cold air	Company processing and supplying alternative fuels	Joint industry logistic and transportation facility
		Warehouses	Producer of utility gases	Utility company converting process CO ₂ , N ₂ , H ₂ into commercial gases	Waste management company collecting small(er) volume wastes in BIE
		Transport companies			
Commercial businesses					
7	Municipal WWTP	industry feedwater facility supplying low and/or high quality industry feedwater (with Oakajee WWTP as one of more potential water sources)	energy facility supplying electricity, hot/cold air	Company co-processing large volume organic materials (e.g. biosolids) into valuable products	Waste management company collecting small(er) volume wastes in BIE
		BIE industries using Oakajee WWTP effluent as industry feedwater directly			
		Producer or local supplier of water treatment chemicals			
8	Industry feedwater facility	Water intensive industries requiring high and/or low quality industry feedwater	energy facility supplying electricity, hot/cold air	Company co-processing large volume organic materials (e.g. biosolids) into valuable products	Waste management company collecting small(er) volume wastes in BIE
		Oakajee WTP supplying source water	BIE industries supplying waste heat (for advanced treatment such as multi-effect evaporation)		
		Producer or local supplier of water treatment chemicals			
9	Energy facility	Energy intensive industries requiring steam, electricity, hot/cold air	industry feedwater facility supplying low and/or high quality industry feedwater	Company processing and supplying alternative fuels	Waste management company collecting small(er) volume wastes in BIE
		Producer or local supplier of process chemicals	Treatment facility for industry off-gases		
10	Centralised storage and processing facility for large volume inorganic by-	Large scale ferrous and non-ferrous minerals processing plants	None identified	Companies (co-)processing large volume inorganic by-products from BIE industries into valuable products	Waste management company servicing storage and processing facility, and associated handling of by-products
		Large scale industrial processing plants			

10. Benchmarking with Other Industrial Areas

The estimates provided in this report are indicative estimates based on information to GHD at the time of release of this report (see cover page for date), which does not include specific market research on the types of industries locating to the Boodarie Strategic Industrial Area. The estimates presented here should only be used for the purpose of the Concept Design of the Boodarie Strategic Industrial Area. The data presented in this report should be updated as more detailed information becomes available through the structure plan development process and thereafter (e.g. lot sizes, net developable land, industries locating to Boodarie Strategic Industrial Area, industry locations, industry inputs and outputs).

This section benchmarks of the results from this BSIA study with the existing Kwinana Industrial Area and the proposed Oakajee Industrial Area in WA. An introduction to both industrial estates is provided first.

10.1 Introduction to Kwinana and Oakajee Industrial Areas

10.1.1 Kwinana Industrial Area (Existing)

Heavy process industry is concentrated in a few industrial areas in WA, of which the Kwinana Industrial Area is by far the largest and most diverse. The industrial area was established in the 1950's following a special Act of Parliament, which secured an area of about 120 square km to accommodate the development of major resource processing industries in Western Australia. Kwinana is located 40 km south of the capital city of Perth on the shores of the Cockburn Sound, a sensitive marine environment. It has a deep-water port, and is therefore strategically placed for export markets in Asia. About 3,600 people work in the area's core industries, and many more in related sectors and service jobs. The total economic output of the area exceeds A\$4.3 billion annually. Overall, the Kwinana Industrial Area plays a very important role in the economy of Western Australia, and in the local community. The region has long been recognised as a cornerstone of the Western Australia's economy.

The Kwinana Industrial Area is dominated by heavy process industries. These include⁵: 2,000 kt/yr alumina refinery (Alcoa), 70 kt/yr nickel refinery (Kwinana Nickel Refinery), 105 kt/yr titanium dioxide pigment plant (Tiwest), 850 kt/yr lime and cement kilns (Cockburn Cement), 135,000 barrels/day oil refinery (BP), and 800 kt/yr pig iron plant (HIs melt). These are complemented with a variety of chemical producers, including CSBP (ammonia, ammonia nitrate, cyanide, chlor-alkali and fertiliser plants), Coogee Chemicals (inorganic chemicals), Nufarm (herbicides and other agricultural chemicals), Nufarm Coogee (chlor-alkali plant), Bayer (agricultural chemicals), Chemeq (veterinary products), and Ciba and Nalco (water treatment and process chemicals). Moreover, there are important utility operations, including two power stations (900 MW coal, oil and gas fired, and 240 MW combined cycle gas) both Verve Energy, two cogeneration plants (respectively 116 MW (Kwinana

⁵ SKM. 2002. Kwinana Industrial Area Economic Impact Study: an example of industrial interaction. Perth, Australia: Sinclair Knight and Merz for Kwinana Industries Council.



Cogeneration Plant) and 40 MW (Verve Energy)), two air separation plants (Air Liquide and BOC Gases), a grain handling and export terminal (CBH), port facilities (Fremantle Port Authority), and water and wastewater treatment and recycling plants (Water Corporation). There is historically considerable supply chain integration between these industries in the area. A number of companies produce essential raw materials for the manufacturing and refining processes or other nearby enterprises. Figure 1 provides an overview of the location of companies in Kwinana.

In 1991 the core industries established the Kwinana Industries Council (KIC, www.kic.org.au). Until then there was no formal industry association for the Kwinana Industrial Area. The original purpose of the KIC was to organise the required air and water monitoring collectively for the industries in the area. This was in response to increased government and community pressure to manage the air- and watersheds, and protect the sensitive marine environment in the adjacent Cockburn Sound. The KIC now addresses a broad range of issues common to Kwinana's major industries, and seeks to foster positive interactions between member companies, government, and the broader community.

10.1.2 Oakajee Industrial Area (Planned)⁶

Oakajee is currently farmland used for cropping and grazing. It was selected by the State Government in 1992 as a site for future processing industry and a deep water port. Over the ensuing years the State acquired and zoned approximately 6,400 ha of land for this purpose (approx 2,300 ha excluding buffer zones).

Early 2000, prospective mining developments in the Mid-West and Murchison began generating interest from various proponents in raiing iron ore to Oakajee for export through a deep water port. The ultimate outcome was the signing in March 2009 of a Development Agreement between the State Government and Oakajee Port and Rail (OPR) to construct a rail line from the mines to Oakajee and to develop a deep water port at the mouth of the Oakajee River. OPR has prepared and submitted concept plans for the port, rail and related infrastructure. These concept plans have taken account of LandCorp's requirements that the port and rail design do not constrain but instead complement the Oakajee Industrial Area.

The vision for the Oakajee Industrial Area is to be globally competitive with access to excellent local, national and international transport links by sea, road and rail. Access to skilled labour, support industries and competitively priced energy is also available. Renewable energy and commercial plantations help industry meet carbon management requirements and clusters of synergistic industries provide efficiencies which attract others. Streamlined approvals processes speed development and ensure timely service provision through ample service corridors.

Under LandCorp and DSD leadership, a Concept Plan for the BSIA is being developed which will:

- ▶ Fulfil the statutory requirements of the Shire of Chapman Valley Town Planning Scheme No 1 (Note that the gazettal of TPS No.2 is imminent);
- ▶ Take account of, and seek to maximise the benefit to the estate from OPR's planned port, rail and related infrastructure;
- ▶ Identify and take account of relevant features of the physical and social environment of the site;

⁶ Extracted from LandCorp documents

- ▶ Plan for long term servicing and infrastructure requirements of the estate beyond what will be provided by OPR in developing its port and rail;
- ▶ Provide a guide for locating and developing future industry within the estate, for bringing infrastructure and services to that industry, and for management and land use of the surrounding buffer; and
- ▶ Provide guidance on staging of development within the two support industry precincts and, to such extent as may be practical, within the strategic industry core.

10.2 Industrial Area Base Data

Table 27 presents the base data for the Boodarie Strategic Industrial Area, existing Kwinana Industrial Area, and the proposed Oakajee Industrial Area. These data provide the basis for the benchmarking in the following subsection.

Table 27 Industrial Areas – Base Data

Base Data	Unit	Boodarie Industrial Area (Planned) ⁷	Kwinana Industrial Area (Existing) ⁸	Oakajee Industrial Area (Planned) ⁹
Total area (excluding buffer zones)	ha	2,800 ¹⁰	2,400	2,333
Key heavy industries	No.	30	14	14
Total power demand	MW	1,207	-	365
Total gas/coal demand	TJ/yr	428,230	88,750	154,000
Total industry feedwater use	ML/yr	59,805	35,000	38,000
Total effluent	ML/yr	63,306	20,000	34,000
Total raw material input	ktpa	40,313	26,800	33,000
Total product output	ktpa	28,711	20,700	23,000
Total industrial by-products/wastes	ktpa	4,643	7,500	2,700
Existing industrial synergies	No.	0	47	0
Potential industrial synergies	No.	44	127	39
Direct employment	No.	9,400	4,804	5,500

10.3 Industrial Area Benchmarking

Table 28 presents the benchmarking of the results from this BSIA study with the existing Kwinana Industrial Area and the proposed Oakajee Industrial Area in WA. The benchmarking shows that the BSIA may have similar characteristics (quantities per ha and per industry) as Kwinana and Oakajee in

⁷ Values extracted from BSIA industry input and output assessment (Section 3 of this report).

⁸ Values extracted from: Van Beers (2008). 2008 Status Report of the Kwinana Synergies Project. Report for Centre for Sustainable Resource Processing.

⁹ Values extracted from industry input / output assessment for Oakajee Industrial Area (GHD, 2008).

¹⁰ BSIA excluding total BHP investigation area (700 Ha).



terms of water demand, raw materials inputs, products, and effluent discharges. BSIA seems to have high gas and power demands than Kwinana and Oakajee. This can be partly explained by the proposed Petroleum / Gas / Coal Processing Precinct in Boodarie. Furthermore, it is recognised that each industrial estate is unique in terms of industry mix, land assembly, infrastructure, and transportation (e.g. access to port, rail, etc).

Table 28 Industrial Areas – Benchmarking

Base Data	Unit	Boodarie Industrial Area (Planned)	Kwinana Industrial Area (Existing)	Oakajee Industrial Area (Planned)
PER HECTARE:				
Heavy industry	ha per industry	93	171	167
Power demand	MW per ha	0.43	-	0.16
Gas/coal demand	TJ/yr per ha	153	37	66
Industry feedwater	ML/yr per ha	21.4	14.6	16.3
Effluent	ML/yr per ha	22.6	8.3	14.6
Raw material input	ktpa per ha	14.4	11.2	14.1
Product output	ktpa per ha	10.3	8.6	9.9
Industrial by-products/wastes	ktpa per ha	1.7	3.1	1.2
Direct employment	No. per ha	3.4	2.0	2.4
PER HEAVY INDUSTRY:				
Power demand	MW per industry	40.2	-	26.1
Gas/coal demand	TJ/yr per industry	14,274	6,339	11,000
Industry feedwater	ML/yr per industry	1,994	2,500	2,714
Effluent	ML/yr per industry	2,110	1,429	2,429
Raw material input	ktpa per industry	1,344	1,914	2,357
Product output	ktpa per industry	957	1,479	1,643
Industrial by-products/wastes	ktpa per industry	155	536	193
Existing industrial synergies	No. per industry	0	3.4	0
Potential industrial synergies	No. per industry	1.5	9.1	2.8
Direct employment	No. per industry	313	343	393



11. Implementation Plan and Operational Management Model

11.1 Implementation Plan

There is a need for an action plan and operational management model for the estate to assist with the further development and implementation of the industrial ecology in the BSIA post concept planning. It is recognised that otherwise key initiatives may not materialise because of a lack of coordinated approach and upfront commitment from key stakeholders. Table 29 present the implementation plan for the industrial ecology initiatives with suggested leads for actions, listing of infrastructure components which are influenced by the industrial synergies, clustering and industrial ecology initiatives, and a suggested timing.

Table 29 Industrial Ecology Opportunities – Proposed Implementation Plans

Industrial Ecology Initiative	Suggested Actions / Studies	Suggested Lead for Action	Stakeholder Support Required	Infrastructure Components in BSIA which may be Influenced by Suggested Actions	Suggested Timing
Centralised industry feedwater facility	Engage with potential service providers and existing/proponent BSIA industries to build up the business case, including detailed technical review of industry feedwater concept	LandCorp	<ul style="list-style-type: none"> ▶ Water Corporation ▶ Service provider ▶ Existing/proponent industries 	<ul style="list-style-type: none"> ▶ Location and size of service corridors ▶ Land requirements for industry feed water production and storage 	Post concept / precinct planning
	Assess available financial incentive schemes with State and Federal Government	LandCorp	State and Federal Government Departments	Not applicable	Post concept / precinct planning
	Conduct key studies in conjunction with the service provider(s) and existing/proponent BSIE industries, including water balance calculations, water supply options (e.g. groundwater, seawater, municipal WWTP, industrial effluents)	Water Corporation and/or service provider	<ul style="list-style-type: none"> ▶ Existing/proponent industries ▶ Service provider ▶ Department of Water 	<ul style="list-style-type: none"> ▶ Location and size of service corridors ▶ Land requirements for industry feed water production and storage 	Post concept / precinct planning
	Secure water supply and disposal (e.g. groundwater, seawater, municipal WWTP, industrial effluents)	Water Corporation and/or service provider	<ul style="list-style-type: none"> ▶ Water Corporation ▶ Department of Water ▶ Existing/proponent industries 	<ul style="list-style-type: none"> ▶ Location and size of service corridors 	Post concept / precinct planning
	Require installation of third pipe infrastructure for land parcels with water intensive industries	LandCorp	<ul style="list-style-type: none"> ▶ DSD ▶ WAPC 	<ul style="list-style-type: none"> ▶ Location and size of service corridors 	Post concept / precinct planning



Industrial Ecology Initiative	Suggested Actions / Studies	Suggested Lead for Action	Stakeholder Support Required	Infrastructure Components in BSIA which may be Influenced by Suggested Actions	Suggested Timing
	Assess use of centralised industry feedwater facility for each new industry establishing in the BSIA	LandCorp	<ul style="list-style-type: none"> ▶ Water Corporation ▶ Service provider ▶ Proponent industries 	<ul style="list-style-type: none"> ▶ Location and size of service corridors ▶ Land requirements for industry feed water production and storage 	Subdivision design
	Develop and implement centralised industry feedwater facility as required	Water Corporation and/or service provider	<ul style="list-style-type: none"> ▶ Existing/proponent industries ▶ Department of Water ▶ LandCorp / DSD 	<ul style="list-style-type: none"> ▶ Location and size of service corridors ▶ Land requirements for industry feed water production and storage 	Subdivision design Lots/facilities design
Centralised energy facility	Engage with potential service providers and existing/proponent BSIA industries to build up the business case, including detailed technical review of centralised energy facility concept, including renewable energy opportunities	LandCorp	<ul style="list-style-type: none"> ▶ Service provider ▶ Existing/proponent industries 	<ul style="list-style-type: none"> ▶ Location and size of service corridors ▶ Land requirements for centralised energy facility 	Post concept / precinct planning
	Assess available financial incentive schemes with State and Federal government	LandCorp	State and Federal Government Departments	Not applicable	Post concept / precinct planning
	Conduct key studies in conjunction with the service provider(s) and existing/proponent BSIE industries, including energy balance calculations, energy supply and recovery options (e.g. gas, renewables, industry off-gases and waste heat)	LandCorp	<ul style="list-style-type: none"> ▶ Existing/proponent industries ▶ Service provider 	<ul style="list-style-type: none"> ▶ Location and size of service corridors ▶ Land requirements for centralised energy facility 	Post concept / precinct planning
	Secure energy supply and contracts	Service provider	<ul style="list-style-type: none"> ▶ Existing/proponent industries 	<ul style="list-style-type: none"> ▶ Location and size of service corridors 	Post concept / precinct planning
	Consider installation of energy supply/recovery infrastructure for land parcels with energy intensive industries	LandCorp	<ul style="list-style-type: none"> ▶ Existing/proponent industries 	<ul style="list-style-type: none"> ▶ Location and size of service corridors 	Post concept / precinct planning
	Assess use of centralised energy facility for each new industry establishing in the BSIA	LandCorp	<ul style="list-style-type: none"> ▶ Service provider ▶ Proponent industries 	<ul style="list-style-type: none"> ▶ Location and size of service corridors ▶ Land requirements for centralised energy facility 	Subdivision
	Develop and implement centralised energy facility as required	Service provider	<ul style="list-style-type: none"> ▶ Existing/proponent industries ▶ LandCorp / DSD 	<ul style="list-style-type: none"> ▶ Location and size of service corridors ▶ Land requirements for centralised energy facility 	Subdivision design Lots/facilities design



Industrial Ecology Initiative	Suggested Actions / Studies	Suggested Lead for Action	Stakeholder Support Required	Infrastructure Components in BSIA which may be Influenced by Suggested Actions	Suggested Timing
Centralised industrial by-product storage and processing facility	Confirm optimal location of centralised storage and processing facility, preferably outside boundaries of strategic core of estate (subject to environmental, town planning, and land assembly constraints)	LandCorp	<ul style="list-style-type: none"> ▶ Existing/proponent industries ▶ Service providers ▶ DEC and EPA 	<ul style="list-style-type: none"> ▶ Location and size of service corridors ▶ Land requirements for centralised industrial by-product facility 	Post concept / precinct planning
	Conduct key studies in conjunction with the existing/proponent BSIE industries and potential service provider(s), including by-product transportation to/from facility, storage and management options, environmental issues, and land assembly	LandCorp	<ul style="list-style-type: none"> ▶ Existing/proponent industries ▶ Service provider 	<ul style="list-style-type: none"> ▶ Location and size of service corridors ▶ Land requirements for centralised industrial by-product facility 	Post concept / precinct planning
	Identify and develop viable markets for (re- and/or co-processed) industrial by-products	Service provider	<ul style="list-style-type: none"> ▶ Existing/proponent industries 	Not applicable	Subdivision
	Assess use of centralised industrial by-product facility for each new industry establishing in the BSIA	LandCorp	<ul style="list-style-type: none"> ▶ Service provider ▶ Proponent industries 	<ul style="list-style-type: none"> ▶ Location and size of service corridors ▶ Land requirements for centralised industrial by-product facility 	Subdivision
	Develop and implement centralised industrial by-product storage/processing facility as required	Service provider	<ul style="list-style-type: none"> ▶ Existing/proponent industries ▶ LandCorp / DSD 	<ul style="list-style-type: none"> ▶ Location and size of service corridors ▶ Land requirements for centralised industrial by-product facility 	Subdivision design Lots/facilities design
Industrial synergies and industry clustering	Undertake detailed industrial synergy assessment for each new industry locating to BSIA, covering supply, utility, by-product, and service synergies	LandCorp	<ul style="list-style-type: none"> ▶ Existing/proponent industries ▶ Service provider 	<ul style="list-style-type: none"> ▶ Location and size of service corridors (subject to synergy opportunity) ▶ Transportation routes 	Subdivision design Lots/facilities design
	Assess preferred location with BSIA for industry proponent according to industry location criteria outlined in Table 25 (page 37), and synergy opportunities with existing industries	LandCorp	<ul style="list-style-type: none"> ▶ Existing/proponent industries 	<ul style="list-style-type: none"> ▶ Location and size of service corridors (subject to synergy opportunity) ▶ Transportation routes 	Subdivision design Lots/facilities design
	Undertake feasibility studies into promising synergy opportunities identified, including triple bottom line assessment and short/long-term benefits	Existing/proponent industries	<ul style="list-style-type: none"> ▶ Service provider ▶ LandCorp / DSD 	<ul style="list-style-type: none"> ▶ Location and size of service corridors (subject to synergy opportunity) ▶ Transportation routes 	Subdivision design Lots/facilities design
	Develop and implement feasible industrial synergies as required	Existing/proponent industries	<ul style="list-style-type: none"> ▶ Service provider ▶ LandCorp / DSD 	<ul style="list-style-type: none"> ▶ Location and size of service corridors (subject to synergy opportunity) ▶ Transportation routes 	Subdivision design Lots/facilities design



Industrial Ecology Initiative	Suggested Actions / Studies	Suggested Lead for Action	Stakeholder Support Required	Infrastructure Components in BSIA which may be Influenced by Suggested Actions	Suggested Timing
Anchor tenants	Develop economic development strategy for BSIA, including strategies to attract key anchor tenants to the estate	LandCorp / DSD	<ul style="list-style-type: none"> ▶ Existing/proponent industries ▶ Local, State and Federal Government Departments 	<ul style="list-style-type: none"> ▶ Location and size of service corridors (subject to synergy opportunity) ▶ Transportation routes ▶ Overall land assembly 	Post concept planning
	Implement economic development strategy as required	LandCorp / DSD	<ul style="list-style-type: none"> ▶ Existing/proponent industries ▶ Local, State and Federal Government Departments 	<ul style="list-style-type: none"> ▶ Location and size of service corridors (subject to synergy opportunity) ▶ Transportation routes ▶ Overall land assembly 	Post concept planning Subdivision planning

11.2 Operational Management Model

After completion of the the BSIA Concept Plan, there is a strong need for the establishment of an ongoing operational management model to ensure BSIA's ongoing viability, maximise resource efficiencies, and enable the development of industrial synergies (service, utility, supply, and by-products). This operational model would require the wide-spread support and participation from a range of stakeholders (industry, government, community).

The possible functions and development process of such an operational model are presented in Subsections 11.2.1 and 11.2.2 respectively.

11.2.1 Potential Functions of Operational Management Model

The potential functions of an ongoing operational management model are summarised in the table below, including the key stakeholders that should be involved for the different functions of the management model.

Table 30 Operational Management Model – Possible Functions and Stakeholders

Possible Functions	Development Element	Key Stakeholder(s) ("Make or break" support)	Other Relevant Stakeholders
Enforcement	<ul style="list-style-type: none"> ▶ Design requirements (built form and civil works) ▶ Landscaping requirements 	<ul style="list-style-type: none"> ▶ DEC and EPA ▶ WAPC 	<ul style="list-style-type: none"> ▶ Industries/businesses ▶ LandCorp ▶ Land developers ▶ Local government
	Facilitate		
	<ul style="list-style-type: none"> ▶ Regional development options 	-	<ul style="list-style-type: none"> ▶ CCI and DSD ▶ Industries/businesses ▶ LandCorp and DoP ▶ Synergy facilitator
	<ul style="list-style-type: none"> ▶ Recruitment of new industries 	<ul style="list-style-type: none"> ▶ LandCorp and DSD ▶ Industries/businesses 	<ul style="list-style-type: none"> ▶ CCI ▶ Synergy facilitator
	<ul style="list-style-type: none"> ▶ Cogeneration and energy cascading developments 	<ul style="list-style-type: none"> ▶ Industries/businesses ▶ Service/technology provider 	<ul style="list-style-type: none"> ▶ CCI and DSD ▶ LandCorp ▶ Synergy facilitator
	<ul style="list-style-type: none"> ▶ Development of integrated and shared (waste)water systems 	<ul style="list-style-type: none"> ▶ Industries/businesses ▶ Water Corporation 	<ul style="list-style-type: none"> ▶ LandCorp and DSD ▶ DEC and EPA ▶ Synergy facilitator ▶ WAPC



Possible Functions	Development Element	Key Stakeholder(s) ("Make or break" support)	Other Relevant Stakeholders
	<ul style="list-style-type: none"> Development of waste management and recycling systems 	<ul style="list-style-type: none"> Industries/businesses LandCorp 	<ul style="list-style-type: none"> Local Government DEC and EPA Waste Authority
	<ul style="list-style-type: none"> Technology innovation, sharing and integration 	<ul style="list-style-type: none"> Industries/businesses 	<ul style="list-style-type: none"> CCI and DSD LandCorp and DoP
	<ul style="list-style-type: none"> Identification and development of by-product and supply synergies 	<ul style="list-style-type: none"> Industries/businesses 	<ul style="list-style-type: none"> Synergy facilitator LandCorp and DSD
	<ul style="list-style-type: none"> Identification and development of new markets 	<ul style="list-style-type: none"> Industries/businesses 	<ul style="list-style-type: none"> LandCorp CCI and DSD Synergy facilitator
	<ul style="list-style-type: none"> Identification and development of industry relocation opportunities 	<ul style="list-style-type: none"> Industries/businesses LandCorp and DSD 	<ul style="list-style-type: none"> CCI and DSD LandCorp Synergy facilitator
Manage	<ul style="list-style-type: none"> Estate wide management system 	<ul style="list-style-type: none"> Industries/businesses 	<ul style="list-style-type: none"> LandCorp DEC and EPA WAPC
Encourage and assist	<ul style="list-style-type: none"> Industry uptake of cleaner production practices 	<ul style="list-style-type: none"> Cleaner production experts/ practitioners Industries/businesses 	<ul style="list-style-type: none"> CCI and DSD DEC and EPA
	<ul style="list-style-type: none"> Development of regulatory framework to encourage reuse of alternative fuels 	<ul style="list-style-type: none"> DEC and EPA 	<ul style="list-style-type: none"> Industries/businesses
	<ul style="list-style-type: none"> Development of regulatory framework to encourage reuse of large volume inorganic by-products in infrastructure projects 	<ul style="list-style-type: none"> DEC and EPA 	<ul style="list-style-type: none"> Industries/businesses LandCorp / DoP Research providers
Coordinate	<ul style="list-style-type: none"> Shared buying 	<ul style="list-style-type: none"> Industries/businesses 	<ul style="list-style-type: none"> Synergy facilitator
	<ul style="list-style-type: none"> Shared logistics 	<ul style="list-style-type: none"> Industries/businesses 	<ul style="list-style-type: none"> Synergy facilitator
	<ul style="list-style-type: none"> Shared marketing 	<ul style="list-style-type: none"> Industries/businesses 	<ul style="list-style-type: none"> Synergy facilitator
	<ul style="list-style-type: none"> Benefit/wellness packages 	<ul style="list-style-type: none"> Industries/businesses 	<ul style="list-style-type: none"> Synergy facilitator
	<ul style="list-style-type: none"> Shared training 	<ul style="list-style-type: none"> CCI Industries/businesses 	<ul style="list-style-type: none"> Synergy facilitator
	<ul style="list-style-type: none"> Shared human resources 	<ul style="list-style-type: none"> Industries/businesses 	<ul style="list-style-type: none"> Synergy facilitator



Possible Functions	Development Element	Key Stakeholder(s) ("Make or break" support)	Other Relevant Stakeholders
	▶ Volunteer/community programs	▶ Industries/businesses	▶ Synergy facilitator
	▶ Emergency response	▶ DEC and EPA ▶ Industries/businesses	▶ Synergy facilitator
	▶ Common sub-contractors	▶ Industries/businesses	▶ Synergy facilitator

11.2.2 Development of Operational Management Model

A possible pathway for the development of the operational management model is presented in Figure 5. The figure shows that LandCorp and DSD could have a larger involvement in the initial stages of the operational management model, with their role declining over time as new occupiers and other interest groups increase their participation. LandCorp and DSD's involvement is expected to cease at the end of the development phases. By this stage the management model is expected to be self-sufficient and driven by the land occupants.

This pathway has not yet been discussed with any external stakeholders so there is not yet an indication for their level of support and commitment.

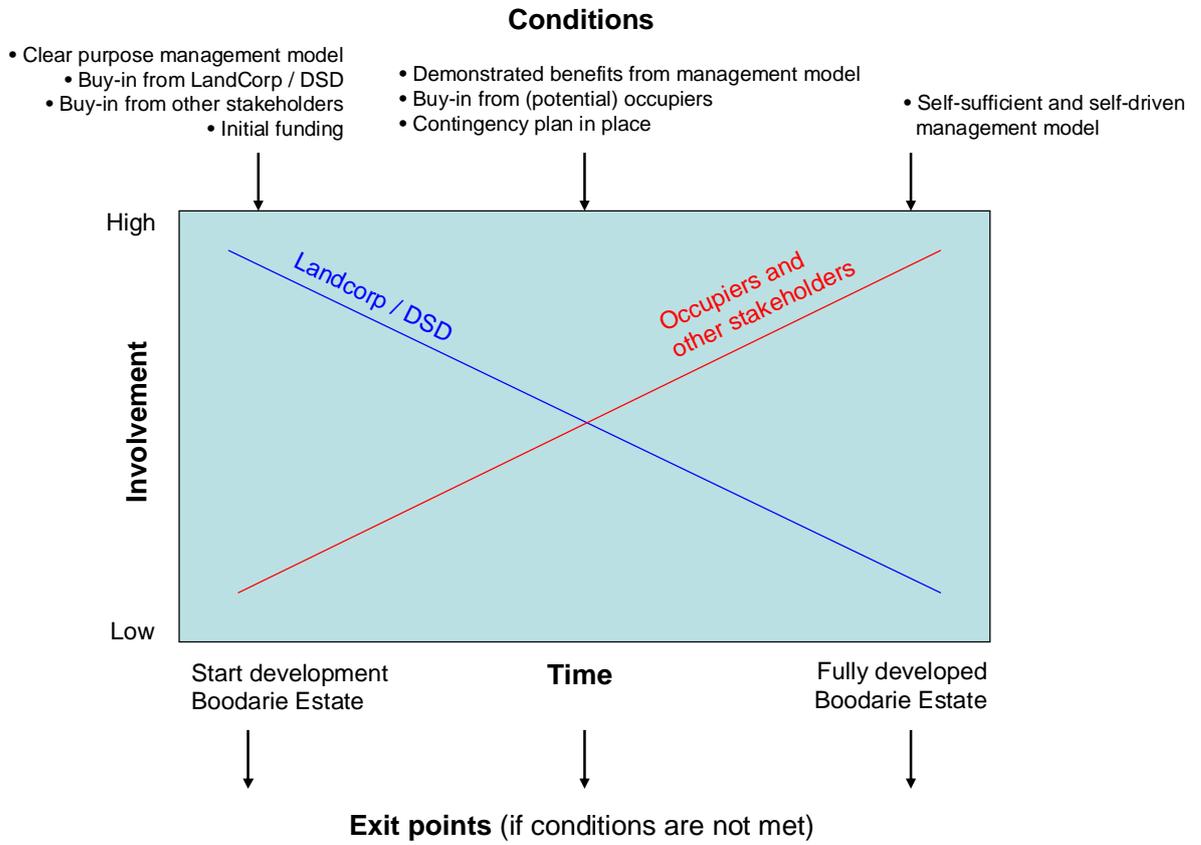
The development of the operational management model would be subject to a number of conditions, such as buy-in from LandCorp/DSD and other relevant key stakeholders, defined purpose, and demonstrated benefits. Exit points for LandCorp/DSD (and the other stakeholders) should be incorporated if these conditions are not met.

As expected, variations and different scenarios exist for Boodarie Estate's operational management model. It is envisaged that these will be subjected to further discussions with LandCorp, DSD and other stakeholders. Scenarios for discussion with LandCorp, DSD and other stakeholders include:

- ▶ Whether or not a management model becomes a part of the wider initiative for the Port Hedland industrial region;
- ▶ Structure of the Operational Management Model;
 - For example, Management Committee with (topic specific) sub-committees;
 - Expanding structure as development of the Boodarie Etstate progresses;
- ▶ Level of stakeholder involvement and engagement;
- ▶ The potential mentor role of the Kwinana Industries Council.

Given the success and experience of the Kwinana Industries Council (KIC), it is recommended to learn from KIC's practical experiences as a member based industry organisation. In the initial stages the KIC could have a mentor role to assist with setting up appropriate management structures (e.g. (sub)committees), stakeholder engagement, business networks, and achieving the desired outcomes.

Figure 5 Possible Pathway for Operational Management Model Development



12. Recommendations

It is suggested to review the recommendations made here with the detailed implementation plans provided in Section 11 'Implementation Plan'. In summary of the results and learnings of this study, the following recommendations are made to further develop industrial ecology in the Boodarie Strategic Industrial Area:

- ▶ The development of the BSIA is still subject to many uncertainties (e.g. potential industry mix, development timeframe, development front). As the BSIE develops and industries locate to the estate, it is recommended to review and update the content of this report on a period basis (e.g. every 5 years) to reflect estate developments into the industry input / output assessment and utility demand forecasting. This will assist with the efficient and effective roll-out of the estate over time.
- ▶ This study showcases that there is significant potential for the development of industrial synergies and industry clusters within the BSIA providing economic, environmental, and social benefits to the industries and region as a whole. Industry clustering within the proposed precincts in the BSIA can be based on various parameters, including water and energy consumption, risk profile, services and support, processing of organic and/or inorganic materials. This report provides guidance on the types of industry clustering and industrial synergies which can occur in Boodarie, and is reflected in the Precinct Concept Plan presented in this report (Figure 4, subject to environmental, town planning, and land assembly constraints). As industries locate to the BSIA, specific industry clustering and industrial synergy scenarios should be assessed on a case-by-case basis.
- ▶ Securing water and energy supply, and efficient and effective storage and processing of large volume industrial by-products and wastes are critical to the successful development of the Boodarie Strategic Industrial Area. There appears to be significant potential for the development of centralised facilities for industry feedwater, energy supply, and industrial by-product storage and processing. It is recommended to initiate detailed scoping and/or pre-feasibility studies into the proposed centralised industry feedwater, energy, and industrial by-product storage/processing facilities. It is strongly recommended to undertake these follow-up studies through a collaborative approach with state and local government, industry, and service providers. The follow-up work can involve follow-up discussions and/or additional studies with relevant parties to further evaluate the technical, economic, environmental, and social potential of these facilities.
- ▶ It is recommended to co-locate the proposed industry feedwater facility with an energy facility in the proposed Utility Precinct to enable synergies between these two facilities (e.g. use of waste heat for evaporative water treatment of desalination).
- ▶ Subject to environmental, town planning, and land assembly constraints, it is recommended to assess the feasibility of establishing a centralised storage facility in the buffer zone of the estate. A centralised facility in the buffer would maximise industrial land use in the strategic core, but would also facilitate and encourage the (co-)processing industrial by-products into valuable materials.
- ▶ There is significant potential for anchor tenants to locate to BSIA (e.g. power generation, cement plant, chemical producers, recycling facilities), and thereby attracting additional industries to Boodarie estate. Furthermore, existing anchor tenants in the region (e.g. power stations, iron ore facilities, port, Wedgefield) could attract synergistic industries to the BSIA. An industrial ecology



study for the entire Port Hedland region is recommended, taking into account the full range of existing and potential anchor tenants in region.

- ▶ Implementation of synergistic and industrial ecology opportunities in the BSIA requires long-term participation of various stakeholders (e.g. industry, government, and the community). There is a need for a coordinated effort and long-term operational management model to ensure and encourage:
 - Boodarie's ongoing and future economic, environment, and social viability;
 - Ensure that industrial synergies and key industrial ecology initiatives (such as the industry feedwater, energy, and industrial by-product storage and processing facilities) are incorporated into the development of the estate;
 - Boodarie will become a world class industrial development.



13. Limitations and Reliance

This Report:

- a) has been prepared by GHD for LandCorp and DSD;
- b) may only be used and relied on by LandCorp and DSD;
- c) may only be used for the specific purpose of the concept design of the Boodarie Strategic Industrial Area (and must not be used for any other purpose).

GHD and its servants, employees and officers expressly disclaim responsibility to any person other than LandCorp and DSD arising from or in connection with this Report.

This Report must not be altered, amended or abbreviated, issued in part or issued incomplete in any manner whatsoever without prior checking and approval by GHD which GHD may provide or withhold in its absolute discretion. GHD expressly disclaims responsibility for any liability which may arise from circumstances of issue of this Report in part or incomplete or its modification in any way whatsoever.

To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and this Report are expressly excluded.

The services undertaken by GHD in connection with preparing this Report were limited to those specifically detailed in Section 1.3 (Scope of Work) of this Report; and

GHD prepared this Report on the basis of information provided by external parties which GHD has not independently verified or checked (*Unverified Information*). GHD expressly disclaims responsibility in connection with the Unverified Information, including (but not limited to) errors in, or omissions from this Report which are caused or contributed to by errors in, or omissions from, the Unverified Information.

GHD accepts no obligation to update this Report for events subsequent to the date that this Report is signed by GHD.

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing this Report (*Assumptions*), including (but not limited to) those identified in this Report and GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with any of the Assumptions being incorrect.

GHD has prepared the Industry Input and Output Estimates set out in this Report:

- a) using information available to the GHD employee(s) who prepared this Report (as referenced and listed in this report); and
- b) based on assumptions made by GHD (as listed throughout report).

The Industry Input and Output Estimates have been prepared for the purpose of the concept design of the Boodarie Strategic Industrial Area, and assisting with the planning of required infrastructure to service the estate, and must not be used for any other purpose.

The industry inputs and outputs are estimates only. Actual industry inputs and outputs are dependent on, and directly affected by, many factors and may be different to those used to prepare the Industry Input and Output Estimates. The Industry Input and Output Estimates may need to be reviewed and revised if any of the assumptions made by GHD change. GHD does not represent, warrant or



guarantee that the development of the Boodarie Strategic Industrial Area over time can or will be undertaken according to the Industry Input and Output Estimate.

If LandCorp or DSD wishes to provide this Report to a third party recipient to use and rely upon, then GHD's prior written consent will be required. Before this Report is released to the third party recipient, the recipient will be required to execute a GHD prepared deed poll under which the recipient agrees:

- a) to acknowledge that the basis on which this Report may be relied upon is consistent with the above principles; and
- b) to the maximum extent permitted by law, GHD shall not have, and the recipient forever releases GHD from, any liability to the recipient for loss or damage howsoever in connection with, arising from or in respect of this Report whether such liability arises in contract, tort (including negligence), under statute or otherwise and whether arising from or in connection with one or more events.



Appendix A

Industry Input / Output Assessment – Assumptions and References



#	Potential industry types	Production process info	Total area Ha	Reference / comments / assumptions	Direct employment persons	Reference / comments / assumptions	POTENTIAL KEY INPUTS										POTENTIAL KEY OUTPUTS							
							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 / waste									
							Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions					
			ML/a (ktpa)	TJ/a	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ktpa	ktpa	ktpa									
DOWNSTREAM IRON ORE PROCESSING																								
1	Sintered iron plant	Thermal treatments, sintering furnace	80	Estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	400	- Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	25	Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	200	Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	11	- See estimated breakdown and assumptions in worksheet 'BIE Domestic Use Potable Water' - Estimated 78 /employee/day for domestic use of potable water in industrial operations	2,600	Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	0	Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	4,700	Iron ore fines (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) 900 Limestone (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) 200 Dolomite (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) 350 Coke breeze (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) 60 Other (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	2,340	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	5,000	Sinter (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	311	Assumed that process waste accounts for 5% of raw material input
1	Iron ore pellets plant	Grinding, concentration, and slurry transport, pellets furnace	80	Estimated based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	400	- Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	10	Oakajee Market Analysis (ACIL Tasman, 2009)	2,000	Oakajee Market Analysis (ACIL Tasman, 2009)	11	- See estimated breakdown and assumptions in worksheet 'BIE Domestic Use Potable Water' - Estimated 78 /employee/day for domestic use of potable water in industrial operations	1,050	- Total estimated water use taken from Oakajee Market Analysis (ACIL Tasman, 2009) - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	1,950	- Total estimated water use taken from Oakajee Market Analysis (ACIL Tasman, 2009) - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	5,250	- Assumed that material input (iron ore) accounts for 105% of product output - Raw material input includes product (95%) + waste (5%)	2,408	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	5,000	Iron ore pellets (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	250	- Pelletising wastes include scale, fines, off-spec products - Assumed that pelletising waste accounts for 5% of raw material input
1	DRI / alternative smelting iron plant	Alternative technologies include Hismelt, Corex, Finex, ITmk3 and gas based Direct Reduced Iron (DRI)	140	Average from Oakajee Market Analysis (ACIL Tasman, 2009) and Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	400	- Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	60	Oakajee Market Analysis (ACIL Tasman, 2009)	50,000	Oakajee Market Analysis (ACIL Tasman, 2009)	11	- See estimated breakdown and assumptions in worksheet 'BIE Domestic Use Potable Water' - Estimated 78 /employee/day for domestic use of potable water in industrial operations	2,100	- Total estimated water use taken from Oakajee Market Analysis (ACIL Tasman, 2009) - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	3,900	- Total estimated water use taken from Oakajee Market Analysis (ACIL Tasman, 2009) - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	175	Lime source: Assumed 5% of ore input (estimate based on CSRP Kwinana) 175 Dolomite: Assumed 5% of ore input (estimate based on CSRP Kwinana) 700 Coal (reductant): Assumed 20% of ore input (estimate based on CSRP Kwinana) 700 Utility gases (e.g. nitrogen, oxygen): Assumed 20% of ore input (estimate based on CSRP Kwinana) 3,500 Iron ore to product ratio (0.75) based on Hismelt plant in Kwinana	4,815	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	2,000	Assumed that similar capacity Hismelt plant in Kwinana	700	Slag to product ratio (0.35) based on Hismelt plant in Kwinana
1	Integrated steel making plant	Basic Oxygen Furnace or Electric Arc	120	CIL Tasman Oakajee Market Analysis and Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	400	- Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	80	Oakajee Market Analysis (ACIL Tasman, 2009)	50,000	Oakajee Market Analysis (ACIL Tasman, 2009)	11	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 78 /employee/day for domestic use of potable water in industrial operations	3,500	- Total estimated water use taken from Oakajee Market Analysis (ACIL Tasman, 2009) - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	6,500	- Total estimated water use taken from Oakajee Market Analysis (ACIL Tasman, 2009) - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	3,160	Iron ore: Assumed 1.58 kg iron ore to 1 kg steel product (Simapro LCA software) 1,340 Limestone: Assumed 0.67 kg limestone to 1 kg steel product (Simapro LCA software) 632 Utility gases (e.g. nitrogen, oxygen): Assumed 20% of ore 940 Coal: Assumed 0.47 kg coal to 1 kg steel product (Simapro LCA software)	8,025	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	2,000	Steel products: Assumed that similar capacity as a possible DRI plant	700	Slag: Assumed slag to product ratio (0.35) 30 Gypsum: Assumed gypsum to product ratio (0.015)
1	Ferromanganese production plant	Production of ferromanganese from iron-containing manganese ores (blast furnace)	40	Estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	400	- Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	50	- Assumed FeMg production through blast furnace - GHD guesstimate	25,000	- Assumed FeMg production through blast furnace - GHD guesstimate	11	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 78 /employee/day for domestic use of potable water in industrial operations	525	- Total estimated water use is GHD guesstimate - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	975	- Total estimated water use is GHD guesstimate - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	18.4	Manganese ore (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) 2.4 Limestone (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) 1.2 Quartz (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) 3.8 Coke (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) 2.4 Coal (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	1,204	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	10	Fe/Mn HCL/LS (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	5	Slag (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) 1.2 Dust (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))



#	Potential industry types	Production process info	Total area	Reference / comments / assumptions	Direct employment	Reference / comments / assumptions	POTENTIAL KEY INPUTS										POTENTIAL KEY OUTPUTS									
							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 / waste											
							Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions								
	Ha	persons	MW	TJ/a	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ktpa	ktpa											
1	Ferrosilicon production plant	Reduction of silica or sand with coke in presence of scrap iron, millscale, or other source of iron. Electric arc furnace	40	Estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	400	- Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	80	- Guestimate by GHD - Literature suggested 9 MW/ton product	10,000	GHD guestimate	11	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	525	- Total estimated water use is GHD guestimate - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	975	- Total estimated water use is GHD guestimate - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	45	Quartz (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	1,204	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	23	FeSi (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	0.9	Slag (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))		
																8.5	Coke (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))					6.9	Dust (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))			
																13.1	Coal (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))									
																5.5	Fe-chips (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))									
																16.1	Woodchips (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))									
1	Iron carbide plant	Reduction of iron oxide in the presence of carbon monoxide	20	Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	400	- Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	20	Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	10,000	GHD guestimate	11	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	1,400	Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	1,100	Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	2,000	Beneficiated iron ore fines (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	2,085	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	1,000	Iron carbide (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	500	Tailings (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))		
Subtotal			520		2,800			147,200			76		11,700		15,400		24,898		22,080		15,033		2,531			
DOWNSTREAM NON-FERROUS RESOURCE PROCESSING																										
1	Magnesium production plant	Electrowinning of magnesium or chemical reduction of magnesium compounds at high temperatures with carbon, calcium carbide, or ferrosilicon	50	Estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	400	- Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	8	Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	10,000	GHD guestimate	11	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	700	- Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	1,300	- Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	250	Magnesium ore (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	1,605	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	80	Deod burned MgO (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	13	Assumed that process waste accounts for 5% of raw material input		
																5.0	Chloride (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))				20	Electrofused MgO (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	3.2	Dust (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))		
																2.0	Petcoke (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))									
																5.4	Fuel oil/gas (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))									
1	Titanium production plant	Purification, sponge production	60	GHD estimate based on other projects	400	- Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	145	Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	1,000	GHD estimate based on other projects	11	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	1,400	- Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	2,600	- Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	105	Ilmenite (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	3,210	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	50	Titanium sponge (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	6	Assumed that process waste accounts for 5% of raw material input		
																4.5	Chlorine (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))									
																2.0	HCl (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))					5	Dust (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))			
																1.0	Magnesium (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))									
1	Copper smelter	Furnaces	120	Guestimate by GHD	400	- Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	50	GHD guestimate	10,000	GHD guestimate	11	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	525	- Total estimated water use is GHD guestimate - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	975	- Total estimated water use is GHD guestimate - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	624	Assumed raw material input (copper concentrate) is sum of product and slag	1,204	- Assumed discharge = 90% high quality water use + 75% of lower quality water use	150	- Assumed capacity by GHD - Olympic Dam production is about 175	474	Slag formula developed by Yale Stocks and Flows Project (2001)		
1	Silicon manganese production plant	Electric furnace	50	Estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	400	- Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	25	Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	10,000	GHD guestimate	11	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	525	- Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	975	- Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	63.5	Manganese ore (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	1,204	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	38	SiMn (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	19	Slag (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))		
																2.7	Limestone (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))									
																22.0	Quartz (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))									
																16.3	Coke (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))									
																10.3	Coal (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))									



#	Potential industry types	Production process info	Total area Ha	Reference / comments / assumptions	Direct employment persons	Reference / comments / assumptions	POTENTIAL KEY INPUTS										POTENTIAL KEY OUTPUTS						
							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 / waste								
							Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions	Reference / comments / assumptions			
			MW	TJ/a	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)	ML/a (ktpa)		
1	Ethane extraction	Isolation from natural gas, or as a byproduct of petroleum refining.	60	Increased estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	150	GHD guesstimate	30	100,000	- Natural gas estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) - Assumed conversion factor of 20 tonnes/TJ	4	- See estimated breakdown and assumptions in worksheet BSIA Domestic Use Potable Water - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	88	- Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	163	- Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	2,000	Natural gas (estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	201	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	200	Ethane (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	100	Assumed that process waste accounts for 5% of raw material input
1	Ethane cracker	Production of ethylene from ethane in steam cracking	50	Increased estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	250	GHD guesstimate	10	8,750	- Natural gas use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) - Assumed conversion factor of 20 tonnes/TJ	7	- See estimated breakdown and assumptions in worksheet BSIA Domestic Use Potable Water - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	51	- Assumed 1 kLton product based on http://sustainability.bhpbilliton.com/2003/additional/appendix_f.html - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	94	- Assumed 1 kLton product based on http://sustainability.bhpbilliton.com/2003/additional/appendix_f.html - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	175	Ethane (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	116	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	145	Ethylene (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	20	Various liquid wastes (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))
1	Ethylene dichloride (EDC) / Vinyl chloride monomer (VCM) plant	EDC = Iron(III) chloride-catalysed reaction of ethene (ethylene) and chlorine	50	Increased estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	400	- Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	8	10,000	GHD guesstimate	11	- See estimated breakdown and assumptions in worksheet BSIA Domestic Use Potable Water - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	525	- Total estimated water use is GHD guesstimate - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	975	- Total estimated water use is GHD guesstimate - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	145	Ethylene (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	1,204	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	100	Ethylene dichloride (EDC) (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	200	Various liquid wastes (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))
1	Sodium cyanide plant	Treating hydrogen cyanide with sodium hydroxide	25	Increased estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	100	GHD guesstimate	1	10,000	GHD guesstimate	3	- See estimated breakdown and assumptions in worksheet BSIA Domestic Use Potable Water - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	525	- Total estimated water use is GHD guesstimate - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	975	- Total estimated water use is GHD guesstimate - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	14	- Natural gas use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)	1,204	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	15	Sodium cyanide (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996))	2	Assumed that process waste accounts for 5% of raw material input
Subtotal			300		1,250		52	179,150		34		2,563		6,332		3,617		7,056		4,600		924	
PORT DEPENDANT																							
1	Large scale processing plant (liquids - not defined)	Subject to specific industry type	120	- Assumed average lot size of 1 large scale processing plant = 100 ha	400	- Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	80	10,000	- Guestimate based on CSRP Kwinana Industrial Area Regional Synergies Project (2007 Status Report, Van Beers)	10.9	- See estimated breakdown and assumptions in worksheet BSIA Domestic Use Potable Water - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	350	- Total water use estimated based on CSRP Kwinana Industrial Area Regional Synergies Project (2007 Status Report, Van Beers) - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	650	- Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers) - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	3,313	- Raw materials - Subject to specific types of large scale processing plant	803	- Assumed discharge = 90% potable water use + 75% of process/cooling water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	2,500	- Liquid product 1 - Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers)	163	- Assumed that process residues account to 5% of total product output - Various process wastes - Specific types of large scale manufacturing plants are unknown
															100	- Process chemicals - Subject to specific types of large scale processing plant			500	- Liquid product 2 - Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers)			
															250	- Liquid product 3 - Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers)			250	- Liquid product 3 - Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers)			
1	Large scale processing plant (conveyors - not defined)	Subject to specific industry type	120	- Assumed average lot size of 1 large scale processing plant = 100 ha	400	- Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	80	10,000	- Guestimate based on CSRP Kwinana Industrial Area Regional Synergies Project (2007 Status Report, Van Beers)	10.9	- See estimated breakdown and assumptions in worksheet BSIA Domestic Use Potable Water - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	350	- Total water use estimated based on CSRP Kwinana Industrial Area Regional Synergies Project (2007 Status Report, Van Beers) - Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))	650	- Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers) - Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))	2,000	- Raw materials - Subject to specific types of large scale processing plant	803	- Assumed discharge = 90% potable water use + 75% of process/cooling water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	1,500	- Solid product 1 - Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers)	100	- Assumed that process residues account to 5% of total product output - Various process wastes - Specific types of large scale manufacturing plants are unknown
															100	- Process chemicals - Subject to specific types of large scale processing plant			500	- Solid product 1 - Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers)			
Subtotal			240		800		160	20,000		22		700		1,300		5,513		1,605		5,250		263	



#	Potential industry types	Production process info	Total area	Reference / comments / assumptions	Direct employment	Reference / comments / assumptions	POTENTIAL KEY INPUTS										POTENTIAL KEY OUTPUTS							
							Power	Reference / comments / assumptions	Gas	Reference / comments / assumptions	Domestic use of potable water	Reference / comments / assumptions	High quality industry feed water	Reference / comments / assumptions	Process & cooling water (lower quality)	Reference / comments / assumptions	Raw / source materials	Reference / comments / assumptions	Water discharge	Reference / comments / assumptions	Products	Reference / comments / assumptions	By-products / waste	Reference / comments / assumptions
UTILITIES AND RESOURCE RECOVERY																								
1	Gas fired power station (250 MW)	Gas fired power generation (assumed 250 MW)	50	Guestimate by GHD	75	GHD guestimate	0	- Power requirements for power station will substitute power demands for industries listed above - Potential power requirements not included in here to avoid double counting	10,000	Estimate based on CSRP Kwinana Synergies Project	2.0	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	200	- Boiler feedwater - Estimate based on CSRP Kwinana Synergies Project	0	- Assumed that gas fired power generation does not need cooling water - Estimate based on CSRP Kwinana Synergies Project	0	Assumed that power station does not consume significant amounts of raw materials (other than fuel captured in gas demand)	180	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	0	Other than electricity, assumed no significant product outputs	0	- Assumed no significant by-products/waste from gas fired power generation - Waste heat will be significant but not quantified
1	Gas fired power station (120MW)	Gas fired power generation (120 MW)	25	Paul Schneider note at SRG workshop on 9-Nov-10, and preliminary plan Lots 600, 601 & Easement (Whelans)	50	GHD guestimate	0	- Power requirements for power station will substitute power demands for industries listed above - Power station will produce its own power - Potential power requirements not included in here to avoid double counting	5,000	Estimate based on CSRP Kwinana Synergies Project	1.4	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	100	- Boiler feedwater - Estimate based on CSRP Kwinana Synergies Project	0	- Assumed that gas fired power generation does not need cooling water - Estimate based on CSRP Kwinana Synergies Project	0	Assumed that power station does not consume significant amounts of raw materials (other than fuel captured in gas demand)	90	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	0	Other than electricity, assumed no significant product outputs	0	- Assumed no significant by-products/waste from gas fired power generation - Waste heat will be significant but not quantified
1	Coal fired power station (800 MW)	Coal fired power station (assumed 800 MW)	100	Guestimate based on GHD experience	200	GHD guestimate	0	- Power requirements for power station will substitute power demands for industries listed above - Power station will produce its own power - Potential power requirements not included in here to avoid double counting	0	Assumed no use of gas for coal-fired power station	5.5	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	450	- Boiler feedwater (approx 60 t/h of boiler feedwater) - Estimate based on CSRP Kwinana Synergies Project	2,000	- Ashing, dust suppression water - Assumed air cooling - Estimate based on CSRP Kwinana Synergies Project	800	Coal: estimate based on CSRP Kwinana Synergies Project	1,905	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	0	Other than electricity, assumed no significant product outputs	25	Fly ash: estimate based on CSRP Kwinana Synergies Project
1	Waste-to-energy and material recovery facility	Waste to gas thermal conversion technology, including material recovery facility (MRF)	10	Waste To Gas Renewable Energy proposal, New Energy, September 2010	25	- Guestimate - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	0	- Power requirements for energy factory will substitute power demands for industries listed above - Potential power requirements not included in here to avoid double counting	2,500	Guestimate for back-up gas use	0.7	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	100	- Boiler feedwater - Estimate based on Waste To Gas Renewable Energy proposal, New Energy, September 2010	0	- Assumed that waste to energy plant does not need cooling water - Estimate based on Waste To Gas Renewable Energy proposal, New Energy, September 2010	126	- Initial capacity of plant will be 360 tonnes/day - Waste To Gas Renewable Energy proposal, New Energy, September 2010	90	- Assumed discharge = 90% high quality water use + 75% of lower quality water use - Assumed that 25% of lower quality water use is lost (e.g. evaporation, product)	Double counting	Steam, electricity, heat/chill to selected industries	32	Slag production: assumed 25% of total raw material input into gasifier
1	Industry feedwater facility	Production of industry feedwater at different qualities, feeding from range of potential water sources (e.g. ground water, seawater, treated effluents)	65	Guestimate based on GHD experience and land area estimate for industry feedwater facility in Oakajee Industrial Estate	15	- Guestimate based on GHD experience - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	36	- Power requirement = 0.2 MW/(ML/day water production) (Proxy based on Kwinana Desalination Plant)	0	Water recycling plant is not likely to use significant amounts of gas	0.4	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	0	Assumed Water factory does not require significant amount of high quality industry feedwater	0	Assumed Water factory does not require significant amount of high quality industry feedwater	40,000	Processing of industrial effluents	15,000	Assumed that proportion of water (e.g. brine) needs to be discharged	25,000	- High quality industry feedwater - Sufficient capacity to supply water demand BIE industries	2.0	Sludge production = 0.03 tonnes/day per ML/day potable water production (Proxy based on Kwinana Desalination Plant)
1	Energy facility (electricity, steam, heat, chill)	Potential joint-industry cogen or tri-generation plant, potential to feed from industry waste heat	60	Guestimate based on GHD experience	25	- Guestimate based on GHD experience - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	0	- Power requirements for energy factory will substitute power demands for industries listed above - Potential power requirements not included in here to avoid double counting	Double counting	- Gas requirements for energy factory will substitute gas demands for industries listed above - Potential gas requirements not included in here to avoid double counting	0.7	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 78 l/employee/day for domestic use of potable water in industrial operations	Double counting	- Water requirements for energy factory will substitute water demands for industries listed above - Potential water requirements not included in here to avoid double counting	Double counting	- Water requirements for energy factory will substitute water demands for industries listed above - Potential water requirements not included in here to avoid double counting	0	Other than energy sources (e.g. gas, coal, waste heat) and water, energy factory is not likely to consume large large of raw materials	Double counting	- Water discharges from energy factory will substitute water discharges from industries listed above - Potential water requirements not included in here to avoid double counting	Double counting	Steam, electricity, heat/chill to selected industries	0	No significant solid or liquid by-products from energy factory
Subtotal			310		390		36		17,500		11		850		2,000		81,054		17,265		65,000		63	
GENERAL INDUSTRY																								
64	General industries	Subject to specific industry type	160	- Assumed average lot size of 1 general industry = 2.5 ha	960	- Assumed 15 employees per general industry - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	26	- Assumed 200 kVA per ha for general industrial area (Western Power standard) - Assumed that 200 kVA/ha = 160 kW/ha = 0.16 MW/ha	2,080	Estimated gas demand proxy general industry = 13 TJ/ha (based on Latitude 32 Alternative Energy Study (GHD))	26	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 64 l/employee/day for domestic use of potable water in non-industrial operations	1,280	- Estimated water use per general industry = 40 ML/yr (based on Latitude 32 Alternative Industry Feedwater Study (GHD)) - Assumed high quality water demand comprises 50% of total water use (based on Latitude 32 Alternative Industry Feedwater Study (GHD))	1,280	- Estimated water use per general industry = 40 ML/yr (based on Latitude 32 Alternative Industry Feedwater Study (GHD)) - Assumed lower quality water demand comprises 50% of total water use (based on Latitude 32 Alternative Industry Feedwater Study (GHD))	1,680	- Assumed that raw materials is sum of products + by-products/wastes - Specific types of general industries have not yet been identified	2,112	- Assumed discharge = 90% potable water use + 75% of lower quality water use - Assumed that 25% of process/cooling water use is lost (e.g. evaporation, product)	1,600	- Assumed 25 kpa of produced product per general industry - Specific types of general industries have not yet been identified	80	- Assumed that wastes from general industry accounts to 5% of total product output
Subtotal			160		960		26		2,080		26		1,280		1,280		1,680		2,112		1,600		80	
NOXIOUS INDUSTRY																								
20	Noxious industries	Subject to specific industry type	100	- Assumed average lot size of 1 noxious industry = 5 ha	300	- Assumed 25 employees per noxious industry - 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007))	16	- Assumed 200 kVA per ha for general industrial area (Western Power standard) - Assumed that 200 kVA/ha = 160 kW/ha = 0.16 MW/ha	1,300	Estimated gas demand proxy noxious industry = 13 TJ/ha (based on Latitude 32 Alternative Energy Study (GHD))	8	- See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water' - Estimated 64 l/employee/day for domestic use of potable water in non-industrial operations	600	- Estimated water use per noxious industry = 60 ML/yr - Assumed high quality water demand comprises 50% of total water use (based on Latitude 32 Alternative Industry Feedwater Study (GHD))	600	- Estimated water use per noxious industry = 60 ML/yr - Assumed lower quality water demand comprises 50% of total water use (based on Latitude 32 Alternative Industry Feedwater Study (GHD))	1,050	- Assumed that raw materials is sum of products + by-products/wastes - Specific types of general industries have not yet been identified	990	- Assumed discharge = 90% potable water use + 75% of lower quality water use - Assumed that 25% of process/cooling water use is lost (e.g. evaporation, product)	1,000	- Assumed 50 kpa of produced product per noxious industry - Specific types of general industries have not yet been identified	50	- Assumed that wastes from general industry accounts to 5% of total product output
Subtotal			100		300		16		1,300		8		600		600		1,050		990		1,000		50	
Total Boodarie Industrial Estate			2,230		9,400		1,207		428,230		257		23,013		36,792		120,313		63,306		93,711		4,643	



Appendix B
Potable Water for Domestic Use –
Assumptions



INDUSTRIAL OPERATIONS

Applications	Indicative water use (ltr/employee/day)	% of total water use	Assumptions	Comments / Data sources
Toilets	25.0	32%	5 * 3 ltr half flushes per employee per day 2 * 5 ltr full flushes per employee per day	
Hand basins	20.0	26%	Basin water use = 10 L/min Standard basin use per employee is 6 uses per day for 20 seconds.	
Showers	20.0	26%	Shower water use = avg 10 L/min Average time per shower = 10 min 20% of employees take one shower per day	
Commercial kitchen	5.0	6%	Kitchen water consumption: 10.0 L/meal 50% of employees consume 1 kitchen meal per day	
Other various	8.0	10%	Assume 10% of total domestic use of potable water	
Irrigation	0.0	0%	Assumed that irrigation will not be supplied by potable water	
Total	78.0	100%		

NON-INDUSTRIAL OPERATIONS

Applications	Indicative water use (ltr/employee/day)	% of total water use	Assumptions	Comments / Data sources
Toilets	25.0	39%	5 * 3 ltr half flushes per employee per day 2 * 5 ltr full flushes per employee per day	
Hand basins	20.0	31%	Basin water use = 10 L/min Standard basin use per employee is 6 uses per day for 20 seconds.	
Showers	10.0	16%	Shower water use = avg 10 L/min Average time per shower = 10 min 10% of employees take one shower per day	
Commercial kitchen	2.5	4%	Kitchen water consumption: 10.0 L/meal 25% of employees consume 1 kitchen meal per day	
Other various	6.5	10%	Assume 10% of total domestic use of potable water	
Irrigation	0.0	0%	Assumed that irrigation will not be supplied by potable water	
Total	64.0	100%		



Appendix C

Potential Economic, Environmental, and Social Benefits of Industrial Synergy Opportunities



#	Opportunity	Potential economic benefits					Potential environment and community benefits				
		Lower operational / capital costs	Increased business revenue	Increased transportation efficiencies	Increased resource security	Increased resource efficiency	Reduced impact of disposal	Reduced impact of extraction	Employment creation	Reduced risk	Improved living / work conditions
SUPPLY CHAIN SYNERGIES											
1	Supply of stockpiled iron ore to ferrous processing plants	X		X	X				X		
2	Supply of produced steel products (e.g. finished shapes) from BIE steel plant to local heavy construction companies	X		X	X				X		
3	Supply of logistical and transportation services by transport companies and warehouses to BIE industries (e.g. road, rail, port)	X		X		X			X		
4	Supply of beneficiated iron fines from pelletising and/or sinter plant to iron carbide plant	X		X	X				X		
5	Supply of Fe-chips to ferrosilicon plant by steel plant	X		X	X				X		
6	Supply of chlorine from chlor-alkali plant to resource processing plants	X		X	X				X	X	
7	Supply of caustic soda from chlor-alkali plant to resource processing plants	X		X	X				X	X	
8	Supply of magnesium by magnesium production plant to titanium production plant	X		X	X				X		
9	Supply of sodium chloride from salt mine to chlor-alkali plant	X		X	X				X		
10	Supply of ethane from ethane extraction to ethane cracker	X		X	X	X			X	X	
11	Supply of ethylene from ethane cracker to EDC / VCM plant	X		X	X	X			X	X	
12	Supply of ammonia from ammonia/urea plant to sodium cyanide plant and fertiliser production plant	X		X	X	X			X	X	
13	BIE non-ferrous smelter (e.g. nickel, aluminium, copper, zinc, lead) supplying intermediate product (e.g. nickel-in-matte, alumina, blister copper, zinc, lead) to non-ferrous refinery in BIE	X		X	X				X		
UTILITY SYNERGIES											
1	Energy factory supplying electricity, steam, and hot/cold air to surrounding BIE industries.	X			X	X		X	X		
2	Water factory supplying high and low quality industry feedwater to BIE industries	(X)			X	X		X	X		X
3	Direct use of WWTP treated effluent by selected BIE industries (potential for on-site treatment to suit requirements)	X			X						
4	Reuse of effluent stream (segregated or not) from one BIE industry by other BIE industry	(X)			X		X	X			
5	Centralised production and supply of pressurised air to BIE industries	X			(X)	X					
6	Centralised production, supply, and recovery of utility gases to BIE industries (nitrogen, hydrogen, oxygen)	(X)		X	(X)	X			X		
7	Managed aquifer recharge of treated effluents, and indirect industrial reuse				X	X					
8	Centralised storage and processing facility for large volume inorganic by-products produced in BIE	(X)		X			X			X	
9	Centralised treatment facility for industry off-gases (e.g. SO _x , NO _x)	(X)					X		X	X	X
10	Joint industry production of demineralised water for specialised applications (boiler feedwater)	X			X				X		
11	Centralised storage and processing facility for selected (smaller volume) waste streams (e.g. hazardous wastes, oils, pallets, metals)	X				X	X		X	X	
BY-PRODUCT SYNERGIES											
1	Use of industry waste heat for drying or concentrating wet products and by-products	(X)				X					
2	Use of pelletising wastes from iron ore pelletising plant (e.g. cement plant)	X			X		X				
3	Use of ammonium sulphate from nickel processing in fertiliser production	X				X	X		X		
4	Processing and use of slag from ferrous mineral processing	X	X			X	X		X		
5	Processing and use of gypsum from resource processing	X	X			X	X		X		
6	Re-processing of scrap steel from BIE industries by BIE steel plant	(X)	X			X	X	X			
7	Co-processing of organic by-products from BIE industries at large scale organic processing plant (e.g. ethanol, biofuels)	(X)			(X)	X	X		X		
8	Co-processing of inorganic by-products from BIE industries and other alternative materials	(X)			(X)	X	X		X		
9	Use of alternative fuels at selected BIE industries (e.g. waste oils, tyres, shredded wood, coke dust from steel making)	X			X	X		X			
10	Use of alternative lime sources in ferrous and non-ferrous mineral processing	X			X	X	X	X			
11	Conversion of process carbon dioxide in commercial gases by utility gas company	X				X	X	X	X		
12	Conversion of process by-product hydrogen into commercial gases by utility gas company	X				X	X	X	X		
13	Conversion of process by-product nitrogen into commercial gases by utility gas company	X				X	X	X	X		
14	Use of charcoal (from plantations) as alternative to (petroleum) coke as reductant in steel sintering and mineral processing	(X)				X		X			
SERVICE SYNERGIES											
1	Joint industry training and education facilities (regional industry training centre), including shared staffing (e.g. maintenance)	X				X			X	X	X
2	Joint logistic and transportation facilities	X				X					
3	Joint industry agreement for collection and handling of selected industry wastes	X		X		X	X		X	X	X
4	BIE interpretive centre								X		X
5	Joint industry monitoring and control of odour and air quality footprint						X			X	X
6	Joint industry incident and accident prevention and response									X	X



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