Oakajee Industrial Estate

Structure Plan

Environmental Review Report

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LANDCORP

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Executive summary

The Oakajee Industrial Estate (OIE) Structure Plan identifies the changes in land uses from rural to heavy industry and general industry for the Strategic Industry Area (SIA) and General Industry Areas (GIAs) consistent with the zoning of the land. The areas identified for industrial land use are predominantly cleared of vegetation and have been used for grazing and cropping over the last 100 years.

This report reviews the environmental values and issues associated with the proposed industrial land use activities and puts forward environmental management measures to minimise potential impacts, including responsibilities for implementation, in the form of an environmental management framework.

The environmental factors associated with the OIE were assessed by the Environmental Protection Authority (EPA) in 1997 (Bulletin 848), with the EPA recommendations incorporated in Scheme Amendment 18 (Shire of Chapman Valley, 2001) and the Environmental Review (Quilty, 2000) to facilitate the rezoning of the site for industrial uses.

The OIE comprises 6,404 hectares of land designated for strategic industry, general industry, buffer and coastal zoned land located approximately 23 kilometres north of Geraldton, Western Australia. The dominant environmental features in the study area include the Oakajee and Buller Rivers to the north and south of the SIA respectively, coastal vegetation to the west of the SIA, and scattered remnant vegetation and watercourses in the buffer which extends north to Coronation Beach Road and east to the Moresby Ranges.

The environmental factors associated with the structure plan include flora and fauna, surface water and groundwater, liquid and solid waste, dust and particulates, noise and risk. The key environmental factors potentially or directly impacted by the land use activities proposed in the structure plan include the loss of remnant vegetation and related fauna habitat, surface water and ground water quality and quantity (including possible treated wastewater irrigation/infiltration), dust and noise. These impacts will be adequately managed through a range of environmental management measures that are typically applied to industrial developments through the approvals and licensing process.

Of the combined 1,330 hectares associated with the SIA and GIAs, 97.7 hectares (or 7%) contains remnant near coastal and sand plain vegetation that may require clearing to accommodate industrial uses. The near coastal and sand plain remnant vegetation contains a number of priority listed flora species and locally significant fauna species. However the adjacent coastal zone to the west and buffer to the north and east of the SIA contain the majority of the flora and fauna species which are recognised for their regional conservation significance. Portions of these areas are subject to separate environmental approvals processes associated with the Oakajee Port and Rail (OPR) Public Environmental Reviews (PERs).

It is relevant to note that the OPR Terrestrial Port PER identifies three species of stygofauna (groundwater dwelling fauna) that have not to date been found elsewhere in Western Australia and that may be new to science. These were located on sites adjacent to, or within, the SIA.

The SIA and GIAs are located on permeable deep sands and as a consequence drain internally, with stormwater infiltration recharging the underlying aquifer which is at a depth ranging between 10 and 60 metres below ground level. Management of surface drainage associated with future developments will aim to maintain or improve water quality infiltrating into groundwater. This is discussed in some detail in a separate District Water Management Strategy (DWMS).

Groundwater movement is predominantly towards the coast, with sub-surface discharge to the marine environment substantially restricted to an approximate 500 metre wide front in the south west of the SIA.

A granite aquaclude located along the western boundary of the SIA restricts discharge north and south of this front. The water quality of the underlying groundwater is brackish to saline. A desktop qualitative risk assessment has determined that industrial land use will have negligible impact on stygofauna habitat, providing groundwater quality and quantity is maintained.

It will be the responsibility of proponent industries to manage their own solid and liquid wastes, with solid wastes likely disposed primarily in off-site licensed landfills, and with disposal of liquid wastes subject to prior treatment, and control of subsequent disposal, through a licensing process.

The exposed nature of the SIA and GIAs to prevailing south-easterly to south- westerly winds will demand stringent dust controls to ensure dust levels are managed within designated limits. The SIA could also be impacted by dust coming from iron ore stockpiles proposed to be located immediately west of the SIA.

A combination of noise, air emissions and risk modelling served to define the estate buffer, with noise the prime determinant of the buffer boundary.

Management measures related to the environmental features of the estate have been identified in the environmental review and consolidated into an environmental management framework, which includes timeframes and responsibilities for implementation.

The environmental management framework will guide environmental activities for which the Estate Manager is responsible, and will assist future proponents of major industrial developments in determining requirements to meet industrial estate standards for water, air, risk and noise impacts.

1. Introduction

1.1 Context and environmental approvals pathway

Following completion of the site selection process, a Public Environmental Review (PER) of the selected site (Oakajee) was prepared during 1993-94 and released for public comment in April 1994 (LandCorp, 1994).

The Oakajee Industrial Estate PER was assessed by the EPA and its report was prepared. Following a request from the Minister for the Environment for consideration of further aspects of the proposal, the EPA report was suspended pending compilation of information on those aspects.

Key areas on which additional information was sought included:

- The site selection process and the suitability of Oakajee compared with possible alternative sites.
- The potential for marine pollution by contaminants exiting the site via groundwater.
- A future port development, its environmental impacts and their management.

With respect to the first point, a 1995 study by Mitchell McCotter (ERM Mitchell McCotter, 1995) confirmed the conclusions of previous site investigations in recommending reservation of land for a major industrial site and deep water port at Oakajee. The study acknowledged that Oakajee offered the only opportunity in the region for an industrial site linked directly to a port.

The possibility of marine pollution was addressed in a 1995-96 investigation by Rockwater of the hydrogeology of Oakajee and the associated potential for escape of pollutants to the ocean via groundwater (Rockwater, 1996). This study found no evidence of solution pipes or cavities which might rapidly transfer groundwater contaminants to the ocean. It concluded that the site offered a lower risk of marine contamination than many alternative coastal locations in the south-west.

The port development was dealt with by a feasibility study and a subsequent PER for the Oakajee Port completed in May 1997 (Alan Tingay & Associates, 1997b). The EPA subsequently released its assessment of the port PER, giving conditional approval to the proposal (Environmental Protection Authority, 1997c).

While the above investigations were progressing, planning for the first two industries on the estate, the An Feng Kingstream steel plant and the Mt Gibson hot briquetted iron plant, commenced. A Consultative Environmental Review (CER) for the Kingstream project was submitted in January 1997 (Alan Tingay & Associates, 1997a), and the EPA reported on this CER (Bulletin 860) in June 1997 (Environmental Protection Authority, 1997b).

Following the Mitchell McCotter, Rockwater and port feasibility studies, LandCorp referred the Oakajee concept together with the findings of these further studies to the EPA for advice under Section 16(e) of the *Environmental Protection Act 1986* (EP Act).

The EPA provided that advice in April 1997 (Bulletin 848), concluding that "*implementation of the Oakajee Industrial Estate Concept Plan is capable of being managed to meet the EPA's objectives*" (Environmental Protection Authority, 1997a).

According to EPA Bulletin 848, the relevant environmental factors were as follows:

- rare and priority listed flora and vegetation communities
- surface water
- groundwater
- liquid and solid wastes
- gaseous emissions
- dust and particulate emissions
- noise and vibration
- public health and safety
- heritage and
- visual impact.

The EPA made a number of recommendations in Bulletin 848 for the management of the estate and for future studies required to address environmental factors. These further studies identified related to investigations for the Estate Manager (LandCorp) and future proponents of the industrial estate as outlined in the table below.

Table 1.1 Estate Manager and Proponent recommendations for further investigation (EPA Bulletin 848)

Estate Manager	Future Proponents
Spring surveys for Rare and Priority Flora prior to removal of any remnant vegetation	Spring surveys for Rare and Priority Flora prior to removal of any remnant vegetation
Baseline and ongoing groundwater monitoring	Demonstrate that industry with potential to pollute will not have significant impact on surface water
Liquid waste management strategy	Appropriate management and monitoring of surface water
Air quality and cumulative monitoring, including impacts on vegetation	Individual groundwater monitoring and mitigation procedures
Baseline dust levels and cumulative dust monitoring	Resolution of solid and liquid wastes
Additional noise modelling and monitoring of cumulative noise	Air emissions and greenhouse gas monitoring
Ongoing determination of cumulative risk	Monitor fugitive dust and stack emissions
Develop and implement strategies for site screening	Assess noise from proposed railway and other transport infrastructure
	Risk and hazard (including societal risk analyses) for each industry
	Detailed ethnographic survey of development sites
	Smoke plume view shed analysis by individual industries

Bulletin 848 did not constitute an assessment under Part IV of the EP Act and therefore was non-binding on LandCorp. In 1998, the Shire of Chapman Valley prepared an amendment to its Town Planning Scheme No. 1 to rezone the Oakajee site for industrial use. Amendment 18 largely incorporated the recommendations made by the EPA in Bulletin 848 regarding further investigations and the role of the Estate Manager.

In October 1998, Amendment 18 was referred to the EPA in accordance with Part IV of the EP Act and the EPA subsequently advised the Shire of Chapman Valley that the

Amendment would not be subject to formal assessment. Amendment 18 was gazetted in June 2004.

LandCorp has since implemented the majority of EPA Bulletin 848 recommendations for further investigations relevant to the Estate Manager including:

- spring vegetation survey, subsequently reinforced by more recent vegetation surveys by Ecologia for OPR (Ecologia, 2010a) and by Ecoscape for the Geraldton Regional Flora and Vegetation Survey (Department of Planning, 2010)
- groundwater, surface water and rainfall monitoring
- sediment quality monitoring (Oakajee and Buller River)
- vegetation condition surveys
- air emissions, risk and noise modelling updates
- noise and dust monitoring.

LandCorp has also undertaken large scale revegetation activities associated with the establishment of a vegetated screen on the eastern side of the industrial estate and the establishment of sandalwood/acacia plantations, in partnership with the Forest Products Commission, to reinforce vegetation remnants and provide a substantial native plant community on all sides of the industrial precincts.

Amendment 18 requires the preparation of a Structure Plan to guide land uses within the OIE consistent with its zoning. This Environmental Review Report consolidates the environmental issues and identifies management measures for the proposed land uses.

The OIE study area is shown in Figure 1 (Appendix A). Key zones are the Strategic Industry Area (SIA), General Industry Areas 1 and 2, Special Control Area (referred to herein as the "Buffer") and the Coastal Area (which is predominantly required for port purposes and is thus not considered in detail in this review).

The structure of this review is based on the environmental factors previously identified by the EPA and outlined below. This review provides an overview of each environmental factor, outlines opportunities and constraints and identifies environmental management measures to mitigate potential impacts.

The relevant factors are:

- flora and vegetation
- fauna
- surface water
- groundwater
- liquid and solid waste
- gaseous emissions
- dust and particulate emissions
- noise emissions
- public health and safety
- heritage and
- visual impact.

Heritage and Visual Impacts are covered separately in Heritage Management Plans and a Landscape Report respectively, and are therefore not included in the Environmental Review Report. In addition, there are environmental management synergies with other studies accompanying the Structure Plan, including a Sustainability Report, an Industrial Ecology Strategy, a District Water Management Strategy and an Engineering Report.

The OIE Structure Plan is being prepared in the context of approvals process for other key infrastructure projects related to port, rail and servicing. These are listed below, with a brief outline of status.

- OPR Rail Development Public Environmental Review – public review period closed on 30 August 2010, with EPA Report and decision by Environment Minister pending.
- OPR Terrestrial Port Development Public Environmental Review – public review period closed on 30 August 2010, with EPA Report and decision by Environment Minister pending.
- Oakajee-Narngulu Infrastructure Corridor (ONIC) – the alignment for the service corridor connecting Oakajee to Narngulu is being finalised and is expected to be referred to the EPA in mid 2011.
- Oakajee Port Master Plan – the plan being prepared by the Geraldton Port Authority (GPA) is expected to be finalised in 2011.

Although these projects are subject to a separate environmental assessment and approvals processes, the outcomes will influence the OIE Structure Plan.

1.2 Overview and general description

A general description of the Oakajee Industrial Estate site is provided below based on extracts from the Environmental Review report prepared for the rezoning of the site (Quilty, 2000) and information gathered from investigations and studies post 2001.

The Oakajee site is situated on a sandy plateau between the North-West Coastal Highway and the coast, approximately 23 kilometres north of Geraldton. The location experiences a dry Mediterranean climate, with hot, dry summers and mild to cool winters. It is noted for its windy conditions, particularly the strong summer breezes from the south-east to south-west. Rainfall is low (mean 469 mm/year), with most rain falling between May and August. There are long periods without rain during the summer (a mean of two rain days per month). Rainfall at this time is sporadic, with thunderstorms sometimes causing heavy falls in small areas, and tropical cyclones occasionally bringing heavy rain to the region generally. Geraldton has an annual evaporation rate of 2,464 mm, with evaporation exceeding rainfall for every month except June and July. Net evaporation is 1,995 mm.

The Oakajee plateau falls from its maximum height of 100 metres Australian Height Datum (mAHD) in the north east of the SIA to 70 mAHD in the west. It is bounded in the west by a limestone escarpment which leads down to Quindalup dunes behind a narrow beach. In the north and south, the plateau drops into the valleys of the Oakajee and Buller Rivers.

A study of the site's hydrogeology (Rockwater, 1996) has indicated the limited nature of groundwater in the area. The groundwater forms a veneer within and above granulite bedrock and overlying sediments. Its movement westwards to the ocean is obstructed in the north by granulite projecting above the water table. Flow to the coast is restricted to an approximate 500 m wide band in the south, where it passes through Tamala sand and alluvial sand and silt.

The SIA and GIAs are predominantly cleared, apart from about 50 hectares of sandplain/near coastal vegetation in the north-west and just under 50 hectares of sandplain/near coastal/limestone ridge vegetation on the western boundary and in the south-west. The site has been used for cereal and lupin cropping and grazing sheep, with this

grazing extending into the remnant vegetation of the limestone escarpment and the valley slopes.

The buffer surrounding the SIA and GIAs is bounded generally by Coronation Beach Road in the north, the Moresby Range in the east and the Buller River in the south. The buffer contains pockets of remnant vegetation that generally correspond to areas not suitable for cropping and grazing such as rocky outcrops and watercourses. There are a number of conservation reserves and priority listed plant species located within, or adjacent to, the buffer which will need to be managed to protect identified conservation values.

1.3 Objectives

Objectives for environmental aspects associated with the OIE Structure Plan are listed below and cover the key environmental aspects related to:

- flora and fauna
- water quality
- emissions
- risk.

1.3.1 Flora and fauna

To protect and enhance important flora and fauna species and their habitat through conservation measures, revegetation, and active management of the buffer.

1.3.2 Water quality

To protect and manage surface water and groundwater resources of the OIE, consistent with pre-development baseline water quality and groundwater levels.

1.3.3 Emissions

To provide for industries that are able to meet acceptable air, dust and noise emissions at the buffer boundary in accordance with predicted levels determined through modelling.

1.3.4 Risk

To provide for industries that meet risk emission profiles and acceptable risk exposures at the buffer boundary in accordance with predicted levels determined through quantitative risk assessment and modelling.

The management measures identified in this review address these objectives and contribute toward the establishment of a high quality and sustainable industrial estate.

2. Environmental review

The environmental review is largely drawn from existing information and is presented as a descriptive overview of each environmental factor, discussion on opportunities and constraints, and identification of environmental management measures. The environmental management measures are consolidated in the form of environmental conditions and recommendations in Section 3, including timeframes and responsibilities for implementation. Section 5 contains a reference list.

2.1 Flora and vegetation

2.1.1 Overview

The vegetation and flora associated with the OIE have been described in a number of studies and at different scales. The more recent studies include the Oakajee Port and Rail (OPR) Public Environmental Reviews (PERs) and the Geraldton Regional Flora and Vegetation Study (GRFVS) prepared by the Department of Planning (DoP). These provide the most detailed and up to date information on plant communities within the estate.

For the purposes of the Structure Plan, the GRFVS (DoP, 2010) forms the primary reference document to describe vegetation and identify conservation values within the OIE and its buffer. The OPR PER Vegetation and Flora Survey (Ecologia, 2010a) provides supplementary information related to the SIA and GIAs.

It is also relevant to note that the calculations provided in this review consider vegetation impacts for all of the land zoned heavy industry (SIA) and general industry (GIAs), including land identified for iron ore rail (OPR) and multi-product rail (Oakajee Port Master Plan) and are subject to pending approvals. On this basis, the vegetation clearing calculations are very conservative and represent a worst case vegetation impact scenario.

Figure 2 (Appendix A) identifies the GRFVS vegetation communities described in this review.

Strategic Industrial Area (SIA) and General Industrial Areas (GIAs)

The SIA and GIAs are cleared, apart from 98 hectares of remnant vegetation in the north-west, western boundary and in the south-west of the SIA, and along the western boundary of the southern GIA. The site was previously used for cereal and lupin cropping and grazing by cattle and sheep, with this grazing extending into the remnant vegetation of the limestone escarpment and the valley slopes. It continues to be used for grazing by sheep and cattle.

The 98 hectares of remnant vegetation within the SIA and GIAs comprises three GRFVS plant communities, namely:

- Plant community 10: Near Coastal *Acacia rostellifera shrubland (ncAr)* comprising 43.6% (or 42.6 hectares).
- Plant community 12: Limestone Ridge *Melaleuca cardiophylla (rMc)* containing 34.7% (or 33.9 hectares).
- Plant community 13: Sandplain *Banksia prionotes/Acacia rostellifera (Bp/Ar)* – forming 21.7% (or 21.2 hectares) in the north eastern portion of the 50 hectare remnant.

The Near Coastal *Acacia rostellifera* shrubland is the most widespread of the GRFVS plant communities, with disturbed areas dominated by *Acacia rostellifera*.

The Limestone Ridge *Melaleuca cardiophylla* plant community is also one of the more widespread GRFVS plant communities and occurs in areas of limestone capping. Most of this plant community throughout the GRFVS area was grazed and degraded, with the exception of the remnants north and south of the Oakajee River which were classified as being very good to excellent condition. In addition, the Limestone Ridge vegetation is recognised for its connections with the adjacent coastal vegetation, which is of higher conservation significance

According to the GRFVS, the Sandplain *Banksia prionotes/Acacia rostellifera* plant community is one of the more widespread in the region and its condition within the remnant ranges from good to poor, with grazing and proliferation of annual weed species being key contributing factors to its degradation. This plant community is also considered to have conservation significance due to being largely degraded or under threat.

There are no Declared Rare Flora (DRF) species recorded in the SIA or GIAs, however there are three species of Priority listed flora: *Melaleuca huttensis* (P1), *Grevillea triloba* (P3) and *Lasiopetalum oppositifolium* (P3).

It is relevant to note that the recorded Priority 3 species *Grevillea triloba* and *Lasiopetalum oppositifolium* are likely to be cleared for the OPR rail alignment and are therefore unlikely to remain in the SIA following installation of this rail line. A significant proportion of recorded Priority 1 species *Melaleuca huttensis* are also likely to be impacted by the OPR rail alignment, although several specimens will most likely remain intact in the north western remnants of the SIA following the installation of the rail line.

Any clearing of remnant vegetation to accommodate industries and infrastructure within the SIA and GIAs will require a Vegetation Clearing Permit from the Department of Environment and Conservation (DEC). As part of the permit application process, the conservation significance of vegetation to be cleared will have to be defined and offsets may be required to replace conservation values compromised by the clearing activity.

Coastal Area

The Coastal Area west of the Oakajee Estate has been studied by both the GRFVS (DoP, 2010) and OPR PER Vegetation and Flora Survey (Ecologia, 2010a). The surveyed area was 4,743 ha extending for approximately 12 km along the coast and approximately 7 km inland at its widest point. Fourteen vegetation subassociations were mapped within the Study Area by Ecologia with the following four encountered within the Coastal Area:

- Acacia rostellifera – Stylobasium spathulatum – Tetragonia implexicoma Acanthocarpus preissii open to closed medium to low scrub.
- Acacia xanthina – Melaleuca cardiophylla (+/- Grevillea argyrophylla) closed scrub.
- Acacia xanthina mid to tall dense scrub.
- Acacia rostellifera tall dense scrub

Areas of bare sand and disturbed agricultural land were also mapped.

The majority of the area surveyed by Ecologia comprises areas of disturbed grazing and farmland, as well as large areas of remnant and regrown native vegetation. Most of the intact native vegetation at Oakajee occurs adjacent to the coastline and alongside the Oakajee and Buller Rivers. Smaller areas of fragmented native vegetation also occur within larger areas of cleared farmland. The majority of the sand plain area has been cleared in the past and is now used for pastoral purposes. Database searches indicate that no threatened ecological communities (TEC) or priority ecological communities (PEC) occur in the area.

The GRFVS and Ecologia 2010a reports have identified the coastal and limestone ridge vegetation as having conservation significance due to the threat of clearing and poor representation in the conservation estate along the coastal area in the region. At the same time they are recognised in the GRFVS as two of the more widespread communities in the region. It was noted in the OPR PER (Ecologia, 2010a) that no coastal conservation reserves exist along approximately 170 km of coastline between Kalbarri National Park to the north of the study area and Beekeepers Nature Reserve to the south (south of Dongara).

The OPR and GPA developments are located adjacent the OIE in the Coastal Area. There are three management plans that will guide the management of the Coastal Area. These are the:

- Shoreline Stability Management Plan (Operations plan) - Shoreline monitoring (alignment and profile) and Sand bypassing requirements
- Recreation and Fishing Access Management Plan (Construction and Operations plan) – Plan covers the area from Buller River to Coronation Beach and outlines accessibility areas for different purposes and safety/security controls and conditions.
- Wrack Management Plan – monitoring and management of wrack between Oakajee and Buller Rivers.

Buffer

The buffer surrounding the SIA and GIAs is bounded generally by Coronation Beach Road in the north, the foothills of the Moresby Range in the east and the Buller River in the south. The buffer contains pockets of remnant vegetation that generally correspond to areas not suitable for cropping and grazing such as rocky outcrops and watercourses. There are areas of vegetation within the buffer which will need to be managed to protect identified conservation values related to priority listed flora species.

The vegetation in the buffer has been described in the GRFVS (Department of Planning, 2010) and the relevant plant communities are listed below, with reference to location on Figure 2 (Appendix A).

- Plant community 2 (Riparian: *Eucalyptus camaldulensis/Casuarina obesa/Melaleuca rhaphiophylla*) – located on the banks of the Oakajee River, Buller River and tributaries. The riparian plant community represents 6.3% of the native vegetation in the GRFVS area and is recognised for its importance in maintaining ecological functions and linkages in the landscape.
- Plant community 3 (Foredune: *Atriplex isatidea/Spinifex longifolius*) – located on the western coastal dune fringe north of Oakajee River and south of the Buller River. This plant community occupies 1.57% of the native vegetation in the GRFVS area and is

likely to be more widespread outside the GRFVS area. The foredune plant community is threatened by degradation from recreational vehicle use and potentially by clearing for Oakajee port development.

- Plant community 8 (Coastal: *Acacia rostellifera* low shrubland) – located in the western fringe, immediately behind plant community 3, north of Oakajee River and south of the Buller River. This coastal community occupies 8.86% of the native vegetation in the GRFVS area and is widespread outside the GRFVS area as far south as Perth.

- Plant community 10 (Near Coastal: *Acacia rostellifera* shrubland – located east of plant community 8 the coastal vegetation to the north of Oakajee River, as well as either side of the Oakajee River. Pockets also occur to the west and south of General Industry Area 2, and east of the highway near General Industry Area 2. This plant community occupies 36.63% of the native vegetation in the GRFVS area and is the most widespread of the GRFVS plant communities.

- Plant community 12 (Limestone Ridge: *Melaleuca cardiophylla*) – located on the limestone ridge north and south of Oakajee River. This plant community occupies 14.04% of the native vegetation in the GRFVS area and is one of the more widespread GRFVS plant communities.

- Plant community 13 (Sandplain: *Banksia prionotes/Accacia rostellifera*) – located in various remnants in the northern buffer west of the highway. This plant community occupies 12.23% of the native vegetation in the GRFVS area and is one of the more widespread GRFVS plant communities. The Sandplain vegetation is at risk of clearing associated with industrial development and threatened by grazing, weed invasion and dieback.

- Plant community 15 (Thicket: *Melaleuca spp*/mixed spp) – remnants are located in the highway reserve, as well as comprising the most dominant remnant vegetation throughout the eastern buffer. This plant community occupies 7.61% of the native vegetation in the GRFVS area and is one of the more widespread GRFVS plant communities, with 22% of the remaining plant community contained in the Moresby Ranges and Wokatherra nature reserves. The plant community near the highway in Oakajee exhibited the greatest species richness of other areas surveyed for this plant community.

- Plant community 16 (Woodland: *Acacia acuminata/A. tetragonophylla/Hakea preissii* – widespread in the northern and north-eastern buffer This plant community occupies 7.33% of the native vegetation in the GRFVS area and is one of the more widespread GRFVS plant communities, with 3% of the remnants contained in the Oakajee Nature Reserve.

- Plant community 17 (Woodland: *Eucalyptus loxophleba*) – isolated pockets interspersed in the north-eastern buffer. This plant community occupies 0.28% of the native vegetation in the GRFVS area and is one of the most restricted GRFVS plant communities.

According to local surveys undertaken for the OPR PER (Ecologia, 2010a), there are 30 Priority listed flora species recorded in the buffer with many located along the proposed OPR rail alignment or within a small conservation area (Reserve 18200). Reserve 18200 is vested in the Department of Water for the purpose of conservation and water supply and contains a concentration of Priority listed flora species. Those species impacted by the OPR port and rail proposal are subject to a separate assessment process. The location of the

Priority flora species is shown on Figure 3 (Appendix A) and Appendix B provides a list of priority flora species recorded in the study area.

There are no recorded Declared Rare Flora (DRF) species located in the buffer. It is relevant to note that one previously recorded DRF species (*Eucalyptus blaxelii*) located in the eastern buffer adjacent to the Moresby Range Nature Reserve has since been re-classified as a Priority 4 species and is no longer a threatened flora species.

The remnant vegetation in the buffer is largely vegetation that is widespread in the region, although conservation significance is recognized for selected plant communities due to their restricted distribution (Plant community15: Thicket: *Melaleuca spp*/mixed spp and 17 (Woodland: *Eucalyptus loxophleba*) or degraded condition/threats (Plant community 12 (Limestone Ridge: *Melaleuca cardiophylla* and 13 Sandplain: *Banksia prionotes/Accacia rostellifera*).

The riparian vegetation, which contains habitat areas and is recognized for its important ecological functions, provides a framework for vegetated corridors linking the coastal areas with larger remnants and the Moresby Ranges to the east.

Vegetation management will need to include measures to protect and enhance the conservation values of these remnants, including the establishment of vegetation corridors to link the coast with the Moresby Ranges using the riparian zones as a framework for such corridors. Figure 4 (Appendix A) identifies the corridor linkages between the riparian network and the remnant vegetation throughout the buffer, connecting the Coastal Area to the Moresby Ranges to the east, together with possible priority locations for revegetation activities.

The Coastal Area to the west and north is to be vested with the Geraldton Port Authority and much of it will be impacted by proposed port activities. The conservation value of coastal vegetation is likely to increase over time as a result of clearing to accommodate port and rail infrastructure.

The Coastal Area to the south of the port development will be managed for conservation and recreation purposes and there are opportunities to protect and rehabilitate mobile dunes subject to impacts from uncontrolled access by recreational and four wheel drive (4WD) vehicles. A Coastal Management Strategy for this section of coastline has been prepared by the Shire of Chapman Valley and provides guidance on coastal management activities (Koltasz Smith, 2007). Figure 4 also includes key recreational features related to the Coastal Area, with further information provided in the Landscape Report.

2.1.2 Opportunities and constraints

Opportunities

The SIA and GIAs are substantially clear of vegetation and fauna habitat, allowing distribution of industry across >90% without impact on remnant vegetation.

The availability of large areas of the Coastal Area and buffer, particularly associated with the Oakajee and Buller River to the north and south respectively and along foothills of the Moresby Range to the east, affords the opportunity for revegetation offsets and the creation of vegetated corridors and fauna habitat to compensate for clearing which may be required elsewhere in OIE. A strategy will be prepared that identifies areas suitable for the establishment of biodiversity conservation and offsets. This strategy will provide supporting

information for any vegetation clearing permit applications. The biodiversity conservation and strategy will be prepared after OPR's offset strategy has been finalised and implemented.

As identified in the Terrestrial Port PER, opportunities exist for revegetation of the Oakajee and Buller Rivers. This potential opportunity has been investigated by OPR in development of their offsets strategy and will be complimented by LandCorp's work.

Constraints

The GRVFS (DoP, 2010) has identified that some of the remnant vegetation associations within the OIE and buffer have regional conservation significance, particularly the coastal areas which are poorly represented in the conservation estate and the isolated *Eucalyptus loxophleba* woodland remnants to the east.

Remnant vegetation totalling 98 hectares within SIA and GIAs will require clearing under a fully developed industrial estate scenario. This includes 33.9 hectares of limestone ridge vegetation and 22.2 hectares of sandplain vegetation recognised in the GRFVS as having conservation significance due to their restricted nature or risk of further threats of disturbance and/or clearing. The near coastal vegetation is well represented in the region.

Flora surveys have identified 30 species of Priority listed flora (Ecologia, 2010a), which are concentrated along the limestone ridge to the west and north of the SIA, in and around Reserve 18200, in the North West Coastal Highway reserve east of the SIA and extending further east to the Moresby Ranges.

Areas of remnant vegetation within the SIA, GIAs and buffer include Priority listed flora species, which may restrict development in proximity to identified species locations.

Any clearing of vegetation will require a vegetation clearing permit from the Department of Environment and Conservation (DEC).

2.1.3 Environmental management measures

The key environmental management measures relevant to flora and vegetation are outlined below. It is also relevant to note that the Landscape Report also incorporates the establishment of vegetated landscape corridors, which complements the flora and vegetation related environmental management measures identified in this review.

Prepare vegetation clearing permit applications

Vegetation clearing will be required within the industrial estate and in the buffer to accommodate road and rail infrastructure and associated services. Clearing will also be required in the SIA and GIAs for industrial activities and services. Prior to any clearing of vegetation, the proponent will need to obtain vegetation clearing permits from the DEC and identify offsets to compensate for cleared vegetation. A clearing control system will be implemented to restrict the number and extent of cleared areas to the minimum needed for safe and efficient development of the proposal.

Protect vegetation with conservation significance in the buffer

Native vegetation in the buffer consists of remnants of varying size and condition, with some areas containing priority listed flora species and restricted plant communities recognised for their conservation significance. Some of these remnants are presently fenced to exclude

stock. Measures to protect the remnant vegetation of conservation significance in the buffer include additional fencing, revegetation and weed control. There are also opportunities to undertake supplementary planting to increase biodiversity values and establish vegetated corridors in the buffer.

Prepare Flora and Vegetation Management Plans

A Flora and Vegetation Management Plan will be prepared followed by a conceptual Closure and Rehabilitation Management Plan. These plans will form the bases and provide guidance to the management and conservation of significant vegetation and wildlife within the OIE.

Prepare biodiversity conservation offsets strategy

Specific areas suitable for providing offsets will be identified based on potential to achieve a net environmental benefit in line with the EPA's offsets bulletin (September 2008). A strategy will be prepared identifying suitable areas for the establishment of biodiversity offsets.

LandCorp will assist proponents through the identification of areas suitable for the provision of biodiversity offsets to compensate for the loss of vegetation from clearing activities. Initial investigations have identified the riparian zones and sandplain vegetation areas as priority biodiversity offsets through either vegetation protection measures or revegetation. The biodiversity offsets strategy will provide supporting information to accompany any vegetation clearing permit applications related to the SIA, GIAs or buffer. The biodiversity conservation and offsets strategy would be finalised once confirmation of the pioneer industries establishing in the SIA and requiring vegetation clearing permits.

Minimise vegetation clearing and disturbance of priority listed flora species

Clearing within the buffer will be restricted to areas essential to development of services and infrastructure to support the industrial estate. All vegetation clearing will require a vegetation clearing permit from the DEC. Areas known to contain priority listed flora to be retained will be identified, marked and fenced prior to the commencement of vegetation clearing works. A conservation Significant Flora Register will be maintained throughout project activities.

Develop and implement dieback hygiene control measures

Dieback hygiene measures for construction activities with the potential to impact on retained and susceptible vegetation of conservation significance will be developed and implemented during the construction period. Hygiene measures include the working during dry soil conditions, washing down of machinery before and after clearing work, restricting work to construction zones and only importing clean fill and other materials for use in close proximity to remnant vegetation.

Prepare Weed Control Program

A weed control program will be developed and implemented to minimise the spread of weeds into unaffected areas.

Establish vegetation corridors linking coastal area to Moresby Ranges

The Oakajee and Buller riverine environments, larger areas of remnant vegetation north and east of the SIA and remnants containing Priority listed flora species and restricted plant communities provide a framework for the establishment of vegetation corridors linking the

coast to the Moresby Range. The vegetation corridors will also integrate with existing revegetation areas and sandalwood plantations.

Actively manage buffer to ensure conservation measures are implemented

The buffer will require active management to retain and enhance conservation values and to implement management measures over time, including fencing, revegetation and weed control, together with appropriate conditions on leases in the buffer. The management activities will also include securing approval for and supervising implementation of biodiversity offsets, and coordination of any community activities aimed at maintaining and improving environmental outcomes.

2.2 Fauna

2.2.1 Overview

The OIE has been subject to numerous fauna database searches and surveys indicating that the area supports a range of fauna species across the main habitats associated with the coastal sand dunes, limestone hills, sandplain, riverine habitats and lateritic hills and breakaways (Ecologia, 2010b).

Although predominantly cleared, apart from the vegetated remnants in the northwest and south west, the SIA and GIAs corresponds to sandplain habitat. The buffer contains mainly riverine habitats associated with the Oakajee and Buller rivers and their tributaries and lateritic hills and breakaway, with cleared sandplain habitat west of the North West Coastal Highway. The coastal zone, which is not part of this review, consists of coastal sand dunes and limestone scarps.

A species list of fauna recorded or expected to occur on the site is provided in the fauna assessment prepared for the OPR PER (Ecologia Environmental, 2010b). Figure 5 (Appendix A) shows the distribution of recorded fauna species of known conservation significance relevant to the OIE. The opportunities and constraints presented at 2.2.2 relate to those species most relevant to the SIA, GIAs and buffer.

Fauna species with recognised conservation significance can be listed as matters of national environmental significance under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and protected species under the Western Australian *Wildlife Conservation Act 1950*.

This review focuses on three key elements of the fauna work completed to date associated with terrestrial fauna, (Ecologia, 2010b), short range endemic invertebrates (Ecologia, 2010c) and stygofauna (Ecologia, 2010d).

Graceful sun-moth

Lomandra maritina was recorded during the vegetation survey conducted by Ecologia (2010). This herb is a host plant for the Graceful sun-moth and was recorded in different locations of the Oakajee Terrestrial Port Development area. The Graceful sun-moth is listed as a conservation significant species under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 and the Western Australia Wildlife Conservation Act 1950.

Terrestrial fauna

Vegetated areas on the western fringes of the SIA and the southern GIA and the plant communities beyond the industrial precincts have the potential to contain native fauna habitat. A total of 22 mammals, 161 birds, 105 reptiles and 15 frog species are expected or known to utilise the wider OIE area. Of these 32 are species with recognised conservation significance including:

- four EPBC Act listed migratory bird species – Fork-tailed Swift, Eastern Osprey, White-bellied Sea-eagle and Rainbow Bee-eater;
- two Priority 4 bird species listed by DEC – White-browed Babbler and Australian Bustard;
- one Priority 4 species listed by the DEC – Western Carpet Python, which is also listed as a Schedule 4 species under the Wildlife Conservation Act;
- northern and southern forms of the Fossorial skink, an undescribed worm lizard currently awaiting taxonomic classification, and several fauna species at or near the northern limit of their range.

It is relevant to note that Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*) has been previously sighted in the region, however there is limited suitable feeding habitat and the Oakajee area is unlikely to be a major source of food for local populations, with no nesting or breeding habitat available (Ecologia Environment 2010b). OPR is undertaking further assessment on the significance of habitat to support Carnaby's Black-Cockatoo and potential offsets related to habitat loss as part of the outcomes of EPBC Act referrals to the Federal Department of Sustainability, Environment, Water, Population and Communities.

The coastal sand dune and limestone hills habitat are considered to have local or possibly regional significance, as little native vegetation of similar size and structure exists in the Geraldton area or within conservation reserves (Ecologia, 2010b).

Short range endemic invertebrates

Short range endemics are species with ranges of 10,000km^2 or less. Remnant vegetation associations on the sandplain plateau, coastal limestone ridge, river margins, southern valley slopes and stable dunes on the western slope of the coastal zone may be suitable habitat for invertebrate SREs (Ecologia, 2010c). A survey of this area undertaken by Ecologia collected 500 specimens from 11 orders, 21 families, 30 genera and 36 species of invertebrates including trap door spiders (9), centipedes (7), slaters (6), snail (5), false scorpions (4), millipede (3) and scorpions (2).

Of the SRE species identified, 2 millipede species (*Antichiropus* 'Geraldton' and *Podykipus* sp. 1) occur on the north western and lower south western boundary of the SIA and in the vegetated portion of the southern GIA. In addition a trapdoor spider species (*Aname* sp. 1) was recorded in remnant vegetation in the north western portion of the SIA and the same species of trapdoor spider and a land snail (*Bothriembryon* sp.) were collected from the remnant vegetation in the north western section of the southern GIA.

A regional survey undertaken outside the Oakajee SRE study area (Ecologia 2010d) recorded most of the SRE species found at Oakajee, except the spider *Aname* sp 1 and a slater species collected from the Oakajee River.

Stygofauna

Stygofauna are groundwater dwelling fauna known to be present in a variety of rock types including karst limestones, fissures and porous rocks. They are typically adapted to a subterranean environment with features including lack of pigmentation, elongated appendages, worm like body shapes and reduced or no eyes. Many of these fauna have primitive features that link them to geological periods when Australia was covered by tropical forests and are therefore regarded as 'relict' fauna.

A stygofauna survey, undertaken in 2006 (Ecologia, 2010e), involved sampling of 17 of the 22 groundwater bores established throughout the OIE. The survey identified three species of stygofauna comprising one species of syncarid new to science and not found elsewhere in Western Australia and two copepod species which were not identified to species level due to damaged or juvenile specimens. These may also be new to science (Ecologia, 2010e).

Of the three bores that recorded the stygofauna species, one bore (OK11) is located in the central southern part of the SIA and the other two bores (OK15 and OK 18) are located on the northern and western boundary of the SIA respectively (see Figures 7, Appendix A).

A desktop qualitative risk assessment on the impact of stygofauna habitat from future industrial activities in the SIA and GIAs was undertaken (refer to Appendix C). Residual risks for all potential impacts were assessed to be 'low' or 'very low' as a consequence of either low initial risk or effectiveness of proposed management measures to address potential impacts. The risk assessment proposed several mitigation measures that have been incorporated into the objectives of the District Water Management Strategy (DWMS) for the site. This review concluded that the proposed development will cause no significant change to stygofauna habitat that may contain subterranean fauna.

If in the future a specific industry chooses to deviate from groundwater quality and quantity mitigation measures identified in the DWMS, it may elect to undertake a more detailed site specific investigation for presence or otherwise of stygofauna and, if found to be present, follow-on with a quantitative risk assessment for their specific requirements.

2.2.2 Opportunities and constraints

Opportunities

The SIA and GIAs are substantially clear of vegetation and fauna habitat, allowing distribution of industry across >90% without impacting on fauna habitat.

The buffer contains large areas of remnant vegetation and the vegetated corridors along the Oakajee and Buller Rivers. These areas provide a logical framework to maintain and enhance wildlife corridors linking the coast to the Moresby Ranges to the east. The buffer also offers considerable opportunities for biodiversity offsets through the creation of vegetated corridors and fauna habitat to compensate for clearing which may be required elsewhere in OIE. A strategy will be prepared that identifies areas suitable for the establishment of biodiversity conservation and offsets. This strategy will provide supporting information for any vegetation clearing permit applications. The biodiversity conservation and strategy will be prepared after OPR's offset strategy has been finalised and implemented.

The depth to groundwater, ranging from 10 to 60 metres below ground level, provides a significant separation between industrial estate activities and stygofauna species likely to utilise the area beneath the sandplain plateau. This separation distance, combined with the

existing groundwater condition associated with agricultural land use activities, minimises the risks of the industrial development adversely affecting stygofauna habitat.

Constraints

A number of fauna species of conservation significance (5 bird species) are likely to occur in, or utilise, remnant vegetation within the SIA. These species will require consideration in seeking vegetation clearing permits and in proposing any biodiversity offsets.

The presence of newly discovered stygofauna species in bores located within the SIA requires maintaining current groundwater quality, recharge volumes and levels to meet environmental requirements. Further details on the management of hydrology are provided in the District Water Management Strategy. The Federal Department of Environment, Water, Heritage and Arts (DEWHA), now Department of Sustainability, Environment, Water, Population and Communities were notified of the presence of these newly discovered species at the site as part of the OPR PER referral process.

2.2.3 Environmental management measures

The key environmental management measures relevant to fauna are outlined below and complement those already captured as part of the management measures for flora and vegetation. For example, the preparation of a biodiversity offsets strategy will include the consideration of fauna habitat offsets for protected species such as Carnaby's Black-Cockatoo. It is also relevant to note that the Landscape Report incorporates the establishment of vegetated landscape corridors, which complements the fauna habitat environmental management measures identified in this report.

Protect vegetation with conservation significance in the buffer

Native vegetation in the buffer consists of remnants of varying size and condition, with some areas containing Priority listed flora species and restricted plant communities recognised for their conservation significance. Some of these remnants are presently fenced to exclude stock. Measures to protect the remnant vegetation of conservation significance in the buffer include additional fencing, revegetation and weed control. There are also opportunities to undertake supplementary planting to increase biodiversity values, extend fauna habitat areas and establish vegetated corridors in the buffer.

Establish vegetation corridors linking coastal area to Moresby Ranges

The Oakajee and Buller riverine environments and larger areas of remnant vegetation north and east of the SIA provide a framework for the establishment of vegetation corridors linking the coast to the Moresby Ranges. The vegetation corridors will provide additional fauna habitat and also integrate with existing revegetation areas and sandalwood plantations.

Actively manage buffer to ensure conservation measures are implemented

The buffer will require active management to retain and enhance conservations values and to implement management measures over time. Revegetation and weed control, together with appropriate conditions on leases in the buffer, will ensure that fauna habitat areas are maintained and extended where practicable.

Maintain groundwater recharge and quality to protect stygofauna habitat

Maintaining current groundwater levels and quality is the key management measure for maintaining stygofauna habitat. The District Water Management Strategy has identified recharge and water quality requirements for infiltration of stormwater to maintain pre-development hydrological conditions.

Prepare biodiversity conservation offsets strategy

Specific areas suitable for providing offsets will be identified based on potential to achieve a net environmental benefit in line with the EPA's offsets bulletin (September 2008). A strategy will be prepared identifying suitable areas for the establishment of biodiversity offsets.

LandCorp will assist proponents through the identification of areas suitable for the provision of biodiversity offsets to compensate for the loss of vegetation from clearing activities. Initial investigations have identified the riparian zones and sandplain vegetation areas as priority biodiversity offsets through either vegetation protection measures or revegetation which will provide further fauna habitats. The biodiversity offsets strategy will provide supporting information to accompany any vegetation clearing permit applications related to the SIA, GIAs or buffer. The biodiversity conservation and offsets strategy would be finalised once confirmation of the pioneer industries establishing in the SIA and requiring vegetation clearing permits.

2.3 Surface water

2.3.1 Overview

The main surface drainages in the vicinity of OIE are the Oakajee River, 0.5 - 1 km north of the estate, and the Buller River, 0.5 - 1 kilometre east and south of the estate.

The rivers are ephemeral and drain farmland and remnant vegetation within the catchment. They receive little or no surface water and limited groundwater flows from the SIA or GIAs. Based on the detailed hydro-geological study of the site (Rockwater, 1996), it is estimated that 80% of the rainfall over the SIA and GIAs drains internally, with the remainder draining to the riverine environment via surface and sub-surface flows.

Baseline water quality has been measured to evaluate surface water quality (Rockwater, 2003) based on data gathered in 1999 and 2000 (Rockwater 2001).

Surface water and streambed sediments were collected at established gauging stations located on the lower Buller River and the lower Oakajee River. In addition, the then Department of Environment (DoE) undertook rainfall and surface water monitoring for the Buller River catchment from May 2001 to June 2003 (DoE, 2004).

The synthesis of the information gathered in these investigations for key water quality parameters is presented in Table 2.1 below, with reference to the Australia and New Zealand Environment and Conservation Council Guidelines for Fresh and Marine Water Quality (ANZECC, 2000) and the Environmental Protection Authority Draft Western Australian Water Quality Guidelines for Fresh and Marine Waters – Protection of Aquatic Ecosystems (EPA, 1993).

Table 2.1 Water quality data summary for Rainfall, Oakajee River and Buller River

	pH (units)	TDS (mg/L)	TN (mg/L)	TP (mg/L)
Oakajee River	7 – 8.8	1,700 – 9,000	0.8 – 7.8	<0.01 – 0.59
Buller River	6.0 – 9.3	700 – 14,000	<0.1 – 11.0	<0.01 – 5.35
Rainfall	6.0 – 8.5	10 – 240	<0.1 – 2.1*	<0.01 – 0.3
ANZECC (2000)	*6.5 – 8.0*	*150 – 375*	*1.2*	*0.65*
EPA (1993)a	*6.5 – 9.0*	*<1,000*	*0.1 – 0.75*	*0.01 – 0.10*

TDS = Total Dissolved Solids, TN = Total Nitrogen, TP = Total Phosphorus
* following removal of contamination source

The results from both river catchments are considered typical of agricultural environments. The surface water quality for the rivers is largely influenced by seasonal water flows during winter and evapo-concentration during summer months, with elevated levels of key water quality parameters occurring in summer when flows are usually low.

The water quality can be generally described as:

- neutral to alkaline
- brackish to saline
- nutrient enriched at certain times of the year.

Levels of heavy metals recorded during the above studies also showed seasonal trends, with the highest concentrations occurring during the summer months. It is relevant to note the presence of zinc, lead and chromium consistent with the presence of mineralization within the catchment area, and the accumulation of trace elements on sediments from some fertilizers (Greenbase, 2001).

Rainfall quality data gathered by the DoE indicates that the rainwater quality is fresh and neutral, with low nutrient levels, although unexpectedly high levels of some metals were recorded and traced back to high dust levels in rain gauging equipment.

With regard to sediments, nitrate levels were measured at 65 and 78 mg/kg for the lower Oakajee and Buller Rivers, respectively. These levels are above water quality guideline values for aquatic ecosystems (Total Nitrogen 1.2 mg/kg) in undisturbed lowland rivers, but are well within the guideline limit of 400 mg/kg for livestock drinking water (ANZECC, 2000). Elevated nitrogen concentrations are common in agricultural areas and may result from nitrogen fixation by lupins and application of fertilizers (Rockwater, 2003).

Total phosphorus concentrations in sediments were high at 840 mg/kg for the Oakajee River and 610 mg/kg for the Buller River. The elevated levels are probably due to agricultural activities, but there may also be some contribution from local soils and weathered bedrock (Rockwater, 2003).

Water quality, during periods of outflow into the marine environment is expected to be superior due to dilution of any contaminants by winter runoff.

Development within the OIE is well removed from both rivers and is unlikely to impact on either, although the Oakajee-Narngulu Infrastructure Corridor bringing infrastructure and services to the estate is required to cross the Buller River. This crossing will require erosion and sediment controls on earthworks, and containment/treatment of any run-off which might discharge from the corridor to the river. An environmental impact assessment for the

Oakajee-Narngulu Infrastructure Corridor is being managed separately through the Department of Planning.

There is also a requirement to prepare a District Water Management Strategy (DWMS) for the estate as part of the Structure Plan. The DWMS incorporates a range of objectives related to the management of surface water and groundwater resources including:

- Water quantity management – maintaining pre-development hydrological conditions and providing for ecological water requirements for sensitive environment.
- Water quality management – maintaining and if possible improving water quality leaving the development area to meet relevant water quality guidelines (ANZECC, 2000), and managing stormwater in accordance with the Stormwater Management Manual for Western Australia (DoW, 2007).
- Stormwater modelling – achieving compliance with design parameters for reductions of at least 80 per cent total suspended solids, 60 per cent total phosphorus, 45 per cent of total nitrogen and 70 per cent of gross pollutants.
- Water conservation and efficiency – no potable water should be used outside buildings, consumption target of 100 kL/person/yr including not more than 40-60 kL/person/yr scheme water, meeting 5 Star Plus provisions for all new fittings, and use of native plants in landscaping.

2.3.2 Opportunities and constraints

Opportunities

The SIA and GIAs are located on deep, freely draining, sandy soils. The presence of these deep sandy soils affords the opportunity for on-site infiltration of clean surface runoff and/or of suitable quality waste water.

Constraints

Clay and loam soils east of the North West Coastal Highway afford less opportunity for infiltration compared with the deep, sandy soils west of the highway and this may influence selection of any future areas for waste water infiltration and other activities requiring well drained soils.

The Oakajee-Narngulu Infrastructure Corridor will cross the Buller River and appropriate management measures will be required to minimise erosion and water quality impacts.

2.3.3 Environmental management measures

The management of surface waters focuses on measures to treat and infiltrate stormwater drainage to improve water quality and to maintain adequate recharge of the underlying groundwater.

The key environmental management measures relevant to surface water are outlined below.

Infiltrate surface waters at source following adequate treatment to achieve required water quality standards

Drainage from impermeable surfaces should be directed into vegetated swales or treatment ponds before discharge to infiltration basins. Runoff from industrial premises may require a higher standard of treatment to remove pollutants depending on materials involved in processing and/or storage. These facilities will attract approval conditions through the impact assessment process and through licensing provisions under Part V of the Environmental Protection Act.

Implement surface water and stormwater drainage best management practices in accordance with the District Water Management Strategy (DWMS)

A DWMS will establish water quality objectives for the industrial estate and will include specific measures to manage water quality, water quantity and water efficiency.

Undertake pre-development surface water and rain water quality monitoring for 2 years prior to the establishment of the first industry in the Oakajee Industrial Estate

Baseline surface water quality data gathered to date characterises water quality in the Oakajee and Buller Rivers and in local rainfall. Additional monitoring will be undertaken to provide more current data on baseline water quality prior to industrial development activities.

2.4 Groundwater

2.4.1 Overview

The groundwater overview is based on a comprehensive hydrogeological investigation of the site was carried out in 1996 (Rockwater, 1996) and the Environmental Review prepared for the rezoning of the site (Quilty, 2000).

The Rockwater 1996 study was a response to one of the primary concerns expressed by the EPA in their assessment of the Oakajee PER prepared by LandCorp in 1994, namely the possible transport of industrial pollutants to the marine environment via groundwater. The investigation found that groundwater in the area forms a veneer within and above the contact between granulite bedrock and overlying sediments. Beneath the escarpment and the adjacent coastal dunes these groundwater-bearing sediments are variously alluvial sand and silt, Tamala sand and limestone, and the Safety Bay sand of the Quindalup dunes.

There was no evidence of rapid flow of groundwater towards the ocean via cavities or solution pipes, and the site was found to have favourable characteristics for retardation of contaminant movement, should contamination occur.

Groundwater moving westwards beneath the Oakajee plateau is obstructed in the northern 70% of the site by a granulite bedrock ridge which rises above the watertable, separating the aquifer beneath the proposed industrial area from that beneath the coastal dunes to the west. The granulite has an extremely low permeability, so that groundwater movement through it is likely to be restricted.

For the southern 30% of the site, this separation does not apply. Rather, groundwater beneath the coastal dunes receives inflow from thin sand and siltstone aquifers beneath the Oakajee plateau to the east. It is therefore likely that the flow of groundwater from beneath the proposed industrial estate to the coastal dunes and the sea is concentrated in this

southern section of the site. More specifically, the Rockwater investigation suggested that groundwater flow is concentrated in an approximate 500-metre wide band comprising Tamala sand beneath the escarpment and alluvial sand and silt beneath the adjacent coastal dunes.

Because of the expected concentration of groundwater discharge to the ocean in this locality, a series of groundwater monitoring bores are suitably located to maintain a check on the quality of groundwater passing from the industrial site to the ocean.

There is a network of 26 groundwater monitoring bores established across the OIE site. Groundwater level data has been recorded on 11 occasions for all bores between February 1996 and April 2003, and groundwater quality has been measured on up to 9 occasions for 6 bores (Rockwater, 2003). The groundwater quality data covered a range of water quality parameters including major anions/cations, salinity, field parameters, metals, nutrients, hydrocarbons, volatile organic compounds, and organochlorides for selected bores.

The groundwater quality can be generally described as brackish to saline (Total Dissolved Salts (TDS) ranging from 500 – 3,000 ppm) and within water quality guidelines for fresh and marine waters in lowland rivers (ANZECC, 2000), apart from elevated nitrate throughout the site and minor exceedance of arsenic in two bores. The elevated nitrate may result from nitrogen fixation by lupins and application of fertilizers (Rockwater, 2003). The arsenic may stem from historic use of arsenic dips for livestock management (Rockwater, 2003) or relate to naturally occurring arsenic released during the mineralisation process (O'Shea et al, 2007).

Groundwater depth in the SIA ranges from 10 to 60 metres below ground level, with groundwater availability restricted due to lack of resource availability and saline water quality. Figure 6 (Appendix A) shows the groundwater contours for the site.

A review of the groundwater monitoring bore network was undertaken in June 2010 (PB, 2010a) and identified 2 new sites for the installation of 3 new up-gradient monitoring bores to gather baseline data as part of the pre-development monitoring program. The 2 bores have been installed to the north east area of the SIA and eastern GIA, to coincide with the Chapman Group silts, where a key sub-surface recharge area in the form of a "paleo-channel" is apparent. Another groundwater bore has been installed on the eastern boundary of the southern GIA located to the south of the SIA to cover an identified gap in the monitoring network coverage.

The monitoring bore network (see Figure 7, Appendix A) provides suitable coverage of the OIE and has bores well positioned to gather ongoing background water quality data and detect any potential groundwater contamination well before subsurface discharge toward the marine environment.

2.4.2 Opportunities and constraints

Opportunities

The depth to groundwater, ranging from 10 to 60 metres below ground level, provides a significant separation between industrial estate activities and groundwater.

The deep sandy soils provide the opportunity for infiltration and further treatment of stormwater to achieve required recharge and water quality standards.

The presence of the granite aquaclude in the north western area of the industrial estate limits groundwater discharges to the ocean to a narrow front beneath the south-western sector of the SIA. This feature restricts the discharge area and enables effective monitoring of groundwater quality prior to entering the marine environment.

The above characteristics place negligible restrictions on distribution of services/utilities or various types of industry within the SIA, subject to appropriate requirements for containment and treatment of pollutants such that neither surface water nor groundwater are at risk of contamination.

A desktop qualitative risk assessment report on the impacts of stygofauna identified that there is minimal risks of industrial development adversely affecting stygofauna habitat at the site.

Constraints

Groundwater beneath the Strategic Industrial Core is generally:

- brackish to saline
- used only for stock water within the site itself, with no downstream users.

There is negligible groundwater available for industrial uses.

Discharge of groundwater to the ocean from the south-western sector of the SIA presents a slight risk of ocean pollution in event of uncontained pollutant spill.

Groundwater monitoring at the individual lot level and along the boundary of the SIA will therefore be essential to ensure any spills are detected, with an appropriate recovery mechanism installed in the event there is any risk of polluted groundwater reaching the ocean.

Stygofauna species may utilise the area beneath the sandplain plateau. Given the limited availability of groundwater resources and the need to protect stygofauna habitat, it is unlikely abstraction licences would be issued for groundwater beneath the site.

2.4.3 Environmental management measures

The management of groundwater is closely linked to surface water management measures previously described, given the internal and rapid draining properties of the SIA and GIAs. Groundwater management measures focus on measures to treat and infiltrate stormwater drainage to improve water quality and maintain adequate groundwater recharge quality and quantity.

The key environmental management measures relevant to groundwater are outlined below.

Undertake pre-development groundwater level and quality monitoring for 2 years prior to the establishment of the first industry in the Oakajee Industrial Estate

Following initial groundwater monitoring between 1999 and 2003, a further round of pre-development groundwater monitoring was undertaken in September 2010, with a second round due in August/September 2011. The monitoring program includes groundwater level measurements and standard inorganic/organic water quality measurements for selected bores as undertaken previously.

Establish groundwater monitoring programs and develop mitigation procedures for industries with the potential to pollute groundwater resources

Any proponents intending to establish facilities with the potential to pollute groundwater resources will be required to develop groundwater monitoring programs and mitigation procedures specific to their process and pollutants of concern.

2.5 Liquid and solid waste

2.5.1 Overview

Solid and liquid wastes associated with a fully developed OIE have been estimated and are presented in the industrial ecology strategy. A summary of potential key outputs for the respective industrial areas is provide below, noting that this does not include port and rail related waste materials.

Table 2.2 Estimated outputs and by-products/waste (ktpa) for the Oakajee Industrial Estate

Industry Area	Water Discharge	Products	By-products/wastes
Strategic Industry Area	40,266	49,750	1,669
General Industry Areas	396	400	24
Coastal Area	512	918	18
Buffer	2,053	1,290	366
Totals	**43,222**	**52,178**	**2,077**

Source – Industrial Ecology Strategy (PB, 2010b)

The nearest solid waste facility is the Shire of Chapman Valley's Nabawa transfer station, located approximately 15 kilometres to the east of the industrial estate, however this facility is not suitable to receive large quantities of waste materials. The City of Geraldton-Greenough's Meru waste disposal facility is located south-east of Geraldton townsite and is able to accept Class 1, 2 and 3 wastes, including septage waste from onsite effluent disposal systems.

Liquid wastes fall into two main categories - domestic and industrial liquid waste. The domestic waste relates to onsite effluent disposal systems for the management of black water and grey water from toilets, showers and sinks. This waste can be managed through alternative treatment units (ATUs) that treat wastewater to a required standard for onsite irrigation.

The Water Corporation has a longer term objective to establish a wastewater treatment plant within the OIE buffer. The proposed wastewater treatment plant would primarily service the expanding urban corridor currently serviced by the Geraldton North wastewater treatment plant in Glenfield. The Industrial Ecology (IE) strategy has identified opportunities for re-use of treated wastewater from this plant for industrial water supply purposes.

Industrial liquid wastes will be managed by proponent industries through the approvals and licensing process. There is the potential for re-use synergies for wastes generated in the estate, as identified in the industrial ecology strategy, or for treatment in the proposed wastewater treatment plant, subject to meeting acceptance criteria.

2.5.2 Opportunities and constraints

Opportunities

Liquid wastes will be managed by industry proponents through the approvals and licensing process.

Liquid waste associated with on-site effluent disposal systems can be adequately managed in the short term through the use of higher standard effluent disposal systems or alternative treatment units.

The proposed wastewater treatment plant to be established within the buffer will be required to adequately treat wastewater to a standard suitable for woodlot irrigation or infiltration. In the longer term, treated wastewater may be recycled and re-used by industries as a process input, as described by the IE strategy.

The Meru waste disposal facility is located south-east of Geraldton townsite and is able to accept Class 1, 2 and 3 wastes. The Shire of Chapman Valley operates a waste transfer station at Nabawa, which may be suitable for receiving small quantities of domestic waste in the short term.

Recycling and re-use of industrial process waste materials and green waste has been considered as part of the IE strategy, particularly opportunities for beneficiation of industry by-products through temporary storage and treatment.

The IE waste re-use and wastewater treatment facility proposals essentially satisfy the requirements for the liquid waste management strategy for the OIE.

Constraints

Any site selected for disposal (interim or otherwise) of treated effluent from the proposed wastewater treatment plant may be constrained by soil types and by setbacks required from water courses.

Infiltration of large quantities of treated wastewater to groundwater will need to be carefully managed to minimise impacts on groundwater and marine environments.

The nearest solid waste facility is the Nabawa transfer station, located approximately 15 kilometres east of the industrial estate. This facility is not suitable to receive large quantities of waste materials.

2.5.3 Environmental management measures

The management of solid and liquid wastes will be through existing or proposed licensed facilities associated with landfills (solid waste, septage) and wastewater treatment plants (sewage, suitable quality industrial process water). Opportunities to recycle and re-use solid waste from industrial processes have been considered in the IE strategy.

The key environmental management measures relevant to solid and liquid wastes are outlined below.

2.5.3.1 Short term

Disposal of all solid waste (including construction and process waste) and septage to licensed waste disposal facilities located at Nabawa and Meru

During the first few years of the estate development, it will be necessary to utilise licensed waste disposal facilities in the region and to manage domestic wastewater using onsite effluent disposal systems to the satisfaction of the Local Government.

2.5.3.2 Medium term

Re-use and beneficiate solid waste by-products from industry processes based on synergies and feasibility

In the medium term, dependent upon the types of industries established, it is likely that there will be opportunities for re-use, beneficiation and recycling of waste by-products between industries. Appropriate safeguards will need to be put in place to ensure that by-product materials, reprocessing and any potentially contaminated leachates are contained and treated or disposed appropriately.

Establish a fully integrated wastewater treatment facility that is capable of providing treated wastewater for industry purposes

The proposed establishment of the wastewater treatment plant within the estate buffer provides the opportunity to treat and recycle large quantities of treated wastewater at source. The treated wastewater can be combined with other potentially re-useable water resources through a centralised “water factory”. This approach will minimise the demands on regional groundwater resources and potentially reduce the reliance on desalinated water as the key local water resource for the estate.

2.5.3.3 Long term

Establish closed loop re-use and recycling of solid waste and treated wastewater throughout the industrial estate

Longer term measures are similarly dependent upon the types of industries that establish in the estate, potential synergies between industries, and the technologies available to maximise recycling and re-use opportunities.

Further details on the waste management and re-use initiatives are provided in the IE strategy.

2.6 Gaseous emissions

2.6.1 Overview

The OIE has been subject to numerous modelling studies since 1993 for gaseous emissions, dust and particulates, noise and risk. The earlier modelling work was used to define and establish the buffer boundary, with noise being the main determinant (refer to Section 2.8). The buffer boundary was accepted by the then Department of Environmental Protection (DEP) and the EPA and was subsequently endorsed by the State Government for the rezoning of the estate and buffer.

In terms of gaseous emissions, the key parameters modelled include NO_2, SO_2 and odours based on emissions profiles from a fully developed industrial estate. Particulates (PM_{10}) were also modelled and are presented in Section 2.7. The modelled air dispersion results were compared against relevant standards which showed that acceptable emission standards would be achieved inside the buffer boundary. The original modelling did however indicate that the more polluting industries should preferably be located in the northern portion of the SIA.

The air dispersion modelling was updated in 2009 (Air Assessments, 2009) and this confirmed the adequacy of the buffer.

The updated modelling confirmed that the OIE site demonstrates good atmospheric dispersion characteristics and can accommodate a variety of industries discharging gaseous emissions without exceedance of relevant standards at the buffer zone boundary. Figures 8 and 9 (Appendix A) show the key modelled emission contours for NO_2 and odour respectively (Air Emissions, 2009).

LandCorp has also undertaken vegetation condition assessment, including foliar sampling, to gather baseline data on the levels of key inorganic elements that could occur in air emissions such as sulphur, nitrogen, calcium, sodium, manganese, zinc, iron, copper, lead and arsenic (Mattiske, 2000). The results of the vegetation condition assessment provide useful background data to compare with any future vegetation assessments.

Individual industries seeking to establish facilities in the OIE will be required to verify their emissions profile via modelling and undertake air emissions monitoring as part of the environmental impact assessment and licensing process respectively. LandCorp will have an ongoing role in reviewing the consistency of proponent industry air emissions modelling results against the air emission profiles used to establish the OIE buffer.

Consistent with the recommendations within the Sustainability Report, in the future it is proposed to establish an industry advisory committee or board similar to the Kwinana Industry Council (KIC) to oversee industry establishment and to coordinate common industry activities such as air quality monitoring and reporting. The industry advisory board could also play a role in overseeing other common industry environmental management activities such as groundwater monitoring, establishment of carbon offsets, and estate-wide procedures for achieving waste management and industrial ecology objectives.

2.6.2 Opportunities and constraints

Opportunities

The OIE site demonstrates good atmospheric dispersion characteristics for gaseous emissions and recent modelling has re-confirmed the adequacy of the buffer to contain a variety of industries with air, noise and/or risk profiles

Baseline vegetation condition assessment results provide useful background data for assessing the impacts of future emissions on susceptible plant species.

The future establishment of an industry body would assist in the coordination and implementation of common industry environmental management and monitoring activities throughout the estate.

Constraints

Although the modelling work has confirmed adequacy of the adopted buffer, the trend for higher gaseous emission and odour concentrations to the north-east through north-west suggests it may be prudent not to locate industry with significant gaseous or odour discharge close to the northern boundary of the SIA.

2.6.3 Environmental management measures

The management of gaseous emissions is largely associated with the operational phase of the estate and will be managed by future proponents seeking to locate in the OIE.

The key environmental management measures relevant to gaseous emissions are outlined below.

Develop air emission dispersion models and air quality monitoring programs, including greenhouse gases

Any proposals to establish industry in the SIA and possibly the GIAs will be referred to the EPA to determine environmental assessment requirements. The consideration of air emissions, including greenhouse gases, will be a key component of the assessment process.

Investigate the establishment of an industry body to oversee implementation and coordination of common industry environmental management and monitoring activities

The industry body could be administered by the Estate Manager and include representation from industry, government agencies and community stakeholders. The centralised coordination of common industry environmental management and monitoring activities is capable of achieving efficiencies and avoiding duplication of effort from industry proponents. The industry body could be established through a shared funding structure supported by industry and government agencies.

Establish a programme to monitor cumulative gaseous emissions

Once the industrial estate has been developed to a point where there are multiple emissions from a range of industries, it will be necessary to monitor cumulative gaseous emissions to ensure that limits set for the buffer are being achieved. The establishment of a cumulative monitoring program will be a joint responsibility between estate management and industry proponents and is an activity that the proposed industry body could coordinate centrally.

2.7 Dust and particulate emissions

2.7.1 Overview

Dust and particulates can be generated during the construction phase of the estate, primarily through fugitive dust generation, and during the operational phase of the estate associated with particulate emissions from industry stacks and fugitive dust from stockpiles and materials handling facilities.

Meteorological data indicates that the Geraldton area experiences average annual wind speeds of between 5 and 6 metres per second (m/s), which corresponds to between 18 and 22 kilometres/hour. The OIE area is quite exposed to prevailing south easterly and south westerly winds, which reach up to 20 m/s (or 72 kilometres/hour) during the afternoon and evenings, as well as fresh easterly winds (around 10 to 15 m/s or 36 to 54 kilometres/hour), during the summer period. The OIE site is exposed and susceptible to the generation of fugitive dust following the disturbance of the sandy surface soils.

The most common measure for particulates from fugitive and particulate stack emissions is PM_{10}. The typical background concentrations in the region for PM_{10} are approximately 25 $\mu g/m^3$ (based on 75th percentile value) compared to the NEPM standard of 50 $\mu g/m^3$ (Air Assessments, 2009). Background data for PM_{10} is presently being gathered by LandCorp from three sites located in the Oakajee buffer. The monitoring data recorded average daily concentrations ranging from 5 to 25 $\mu g/m^3$, with mean average concentrations of background PM_{10} levels around 15 to 20 $\mu g/m^3$ for the March/April 2010 period and 10 $\mu g/m^3$ for the June 2010 period.

The original and recently updated modelling confirms that the OIE site demonstrates good atmospheric dispersion characteristics and can accommodate a variety of industries discharging gaseous and particulate emissions. The most recent modelling work for PM_{10} included consideration of iron ore stockpiles proposed in the Coastal Area adjacent to the port (refer to Figure 10, Appendix A).

Wind erosion is predicted to be the highest generator of particulates, with higher concentrations extending further to the west and a lesser lobe extending north and north east due to strong sea breezes, although impacts are contained well within the buffer (Air Assessments, 2009). This result is largely due to the proposed iron ore stockpile locations, which are being assessed separately as part of the OPR PER.

It is expected that fugitive dust emissions generated through the construction phase on the OIE can be adequately managed through standard dust suppression measures aimed at stabilising disturbed ground and the use of water carts to maintain appropriate surface moisture levels.

It will be the responsibility of industry proponents and relevant service providers to ensure that dust and particulate emissions are managed within required standards as applied by the EPA through environmental impact assessment, works approval and licensing processes. LandCorp will have an ongoing role in reviewing the consistency of proponent industry particulate modelling results against the particulate emission profiles used to establish the OIE buffer.

2.7.2 Opportunities and constraints

Opportunities

The OIE site demonstrates good atmospheric dispersion characteristics for particulate emissions.

Recent modelling demonstrates that the buffer is adequate to contain a variety of industries with particulate emissions, such that acceptable standards are achieved at the buffer boundary.

Existing reports by GPA and OPR including a Materials Handling Environmental Requirements Specification for the port operations and Construction and Operation EMPs for Air Quality and Noise Management will guide the management of noise and dust impacts in the coastal zone.

Constraints

The OIE site is exposed and susceptible to generation of dust following disturbance of the sandy surface soils.

The iron ore stockpiles proposed in the Coastal Area adjacent to the port may result in elevated fugitive dust particulate levels in a small area in the north western part of the SIA, based on modelling completed to date. This will be a key compliance issue for managers of the stockpiles that will require review and monitoring of actual conditions once stockpiles are established.

2.7.3 Environmental management measures

The management of dust mainly relates to the construction phase and dust impacts associated with the proposed iron ore stockpiles. The latter is being assessed as part of the OPR PER. Particulate emissions from facilities will largely be an issue to be managed by future proponents seeking to locate in the OIE.

The key environmental management measures relevant to dust and particulate emissions are outlined below.

Undertake monitoring of background dust levels to provide baseline information for the assessment of future particulate emissions

LandCorp has established a dust monitoring program to determine baseline concentrations of PM_{10}. The monitoring requires a full year of data to determine seasonal characteristics and trends.

Prepare dust management plans for construction activities involving the disturbance of surface soils

Dust management plans should ensure that dust impacts are accurately determined and that appropriate management measures are put in place to achieve required particulate standards during the construction phase. Their preparation will be the responsibility of infrastructure related service providers (road, rail, power, water, service corridors) and industry proponents. For large scale disturbance, there is likely to be a requirement to undertake dust monitoring.

Monitoring of stack and fugitive particulate emissions

Monitoring stack and fugitive emissions will be the responsibility of industry proponents during and following establishment of their industrial facilities. This requirement is usually applied during the environmental approvals and licensing process.

Establish a programme to monitor cumulative particulate emissions

As with gaseous emissions, it will be necessary to monitor cumulative particulate emissions to ensure limits set for the buffer are being met. The establishment of a cumulative

monitoring program will be a joint responsibility between estate management and industry proponents and is an activity that the proposed industry body could coordinate.

2.8 Noise emissions

2.8.1 Overview

Oakajee is situated in a rural environment with relatively low background noise levels, the most significant being that from traffic along the North-West Coastal Highway and coastal wave and wind sources. Previous noise modelling studies undertaken in 1993 (Dames & Moore, 1993) and 1996/97 (Herring Storer, 1997) predicted noise levels associated with a fully developed industrial estate, with the latter used to define the final buffer boundary.

Of all the parameters used to establish the buffer boundary (noise, air emissions, odour, risk), noise was the primary determinant that set the buffer boundary to meet noise criteria at the nearest sensitive receptor.

LandCorp revisited the noise modelling in 2009 and 2010 (Herring Storer, 2009 and 2010a), based on fifteen typical industries under a fully developed industrial estate and operational port (including the southwards extension to the iron ore stockpiles). Under the *Environmental Protection (Noise) Regulations 1997*, individual industries are required to comply with a night-time assigned level of 30 dB LA10 at the nearest sensitive premises. The outcome of the 2009 and 2010 modelling (Figure 11, Appendix A) confirmed that the defined buffer is adequate, although for the southern extension to the iron ore stockpiles, a 10 metre high noise bund is required to the south of the stockpiles to ensure compliance beyond the southern buffer with the requirements of the *Environmental Protection (Noise) Regulations 1997.*

With respect to background levels, noise monitoring undertaken during April and May 2010 (Herring Storer, 2010b) involved the establishment of noise loggers at four sites around Oakajee. The results of the noise monitoring are as follows:

- Locations 1 (south east of SIA) and 3 (east of the SIA) are dominated by background noise expected for a rural setting with typically lower background noise levels of 25 to 26 dB(A) during the night and 29 to 31 dB(A) during the day.

- Locations 5 (south west of SIA) and 6 (north of SIA) on the western edge of the coastal plateau were typically between 31 and 32 dB(A), with little variation between night and day and with the slightly elevated noise levels likely due to waves and wind.

It will be the responsibility of industry proponents and relevant service providers to ensure that noise emissions are managed in accordance with the *Environmental Protection (Noise) Regulations 1997* through the environmental impact assessment, works approval and licensing processes. The noise assessment and management requirements for service providers includes activities associated with the establishment of roads, rail, service corridors, energy, wastewater treatment plants and other services.

LandCorp will have an ongoing role in reviewing the consistency of proponent industry noise modelling results against the noise emission profiles used to establish the OIE buffer. In summary, earlier and more recent noise modelling have affirmed the adequacy of the buffer for the OIE, while noise monitoring has confirmed background noise levels being consistent with a rural setting and largely influenced by road traffic and coastal noise sources.

2.8.2 Opportunities and constraints

Opportunities

Recent modelling demonstrates the buffer is adequate to contain variety of industries with air, noise and/or risk profiles

Existing reports by GPA and OPR including a Materials Handling Environmental Requirements Specification for the port operations and Construction and Operation EMPs for Air Quality and Noise Management will guide the management of noise and dust impacts in the coastal zone.

Constraints

Although the noise modelling work has confirmed adequacy of the adopted buffer, as a result of advancing residential land use from the south, it is considered prudent not to locate particularly noisy industries close to the southern boundary of the SIA.

2.8.3 Environmental management measures

The management of noise (and vibration) relates to the construction phase for infrastructure (roads, rail, service corridors) and operational phase for industries.

The key environmental management measures relevant to noise emissions are outlined below.

Prepare Noise Management Plan

Noise impacts expected to occur, particularly in the southern portion of the buffer area, will be addressed in a Noise Management Plan which will include impacts generated during construction and operation of the OIE.

Undertake monitoring of background noise levels to provide baseline information for the assessment of future noise emissions

LandCorp has undertaken recent noise monitoring to determine background noise levels, adding to findings from earlier noise monitoring carried out for Kingstream in the late 1990's.

Establish a programme to monitor cumulative noise emissions

It will be necessary to monitor cumulative noise emissions to ensure criteria are met at the nearest noise sensitive premises. The establishment of a cumulative noise monitoring program will be a joint responsibility between the Estate Manager and industry proponents and is an activity that the proposed industry body could coordinate.

2.9 Public health and safety

2.9.1 Overview

The establishment of a SIA at Oakajee is likely to attract industries involving hazardous substances and risk. The EPA criteria for risk levels in residential areas is 1×10^{-6} (one in a million per year) based on EPA guidelines (EPA, 2000) as determined through the industry

recognised quantitative risk assessment methodology outlined in AS/NZS 4360 Risk Management Standard.

A quantitative risk assessment was undertaken by Environmental Risk Solutions (ERS, 1998) which defined the risk contours likely to be associated with future hazardous industries. Using Oakajee meteorological data, the 1998 ERS study derived cumulative risk contours for up to five high risk, three medium risk and seven low risk industries dispersed across the estate. The study established that, with this combination of hazardous industries, the one in one million cumulative risk contour fell well inside the proposed buffer, while the ten in one million contour is contained within the boundary of the proposed Strategic Industry Core.

More recently, LandCorp commissioned ERS to undertake an updated quantitative risk assessment and model based on industries similar to the Kwinana Industrial Area (ERS, 2010). This represents a high industrial loading case associated with a fully developed estate

The study concluded that the $1x10^{-6}$ risk contour (blue line) for the high industrial loading case falls well within the buffer boundary (Figure 12, Appendix A). The 50×10^{-6} contour (yellow line), which is the EPA criteria for risk levels at industry site boundaries, is well within the SIA for the high industrial loading case.

It will be the responsibility of industry proponents to undertake quantitative risk assessment studies of their own facilities seeking to establish at the OIE. LandCorp will have an ongoing role in assessing the results of proponent industry quantitative risk assessment studies against the risk profiles used to establish the OIE buffer.

2.9.2 Opportunities and constraints

Opportunities

Recent quantitative risk assessment modelling demonstrates the buffer is adequate to contain risk impacts of a variety of industries with risk profiles, with no apparent need to preferentially locate high/medium/low risk industries in particular sector(s) of the estate.

Constraints

Although the quantitative risk assessment modelling work has confirmed adequacy of the adopted buffer, as a result of the advancing residential land use from the south, it is considered prudent not to locate particularly high risk industry types close to the southern boundary of the SIA.

2.9.3 Environmental management measures

Undertake quantitative risk assessments for individual industrial facilities

LandCorp has recently updated the quantitative risk assessment model based on high risk industrial loading similar to Kwinana Industrial Area. Individual proponents will be required to undertake their own quantitative risk assessments of their proposed facilities as required under the environmental assessment process.

3. Environmental management plan framework

The environmental management measures identified in Section 2 are consolidated into recommendations in the framework below, which identifies timeframes and responsibility.

The “Pre-Construction” period refers to activities to be completed prior to construction of industrial facilities by proponents.

The “During Construction” period refers to the construction phase for industrial facilities and may extend over a number of years.

The “Post Construction” period covers the operational phase for industrial facilities.

“Ongoing” activities refer to those required over the construction phases and into the future.

Broad environmental management obligations for the Estate Manager and industry proponents are also outlined.

3.1 Estate manager

The Estate Manager is responsible for the coordination of activities related to the industrial estate, including the General Industry Areas and buffer areas under its control. LandCorp currently undertakes the role of Estate Manager and is supported by State Government agencies with statutory responsibilities for environmental impact assessment and environmental regulation/licensing (EPA and DEC respectively) and risk (Department of Mines and Petroleum). This role is expected to continue in the short to medium term to ensure that proponent industries meet environmental (and other) objectives established for the industrial estate. This will include reviewing the consistency of proponent industry emissions modelling results against industry profiles used to establish in the Oakajee Industrial Estate buffer and providing advice to the EPA in this regard.

It is expected that the Estate Manager role will evolve over time, with industry taking an increasing role in the identification and coordination of environmental management activities common to the estate. This role and collaborative style model is similar to that undertaken by the Kwinana Industry Council for the Kwinana Industrial Area. Further information on the proposed governance structure for the OIE is provided in the Sustainability Report.

3.2 Future proponents

Future proponents have a major role in environmental management measures at an individual facility level and collectively represent the larger share of environmental management activities of the estate. This is particularly relevant over time as the estate becomes more established with industrial facilities.

The tasks to be undertaken by industry proponents are determined during the environmental impact assessment process and environmental regulation process under Parts IV and V of the *Environmental Protection Act 1986* respectively. Under these processes, proponents are required to identify impacts, assess their significance and develop management measures to

mitigate impacts. This process usually requires the preparation of construction environmental management plans (CEMP) and operational environmental management plans (OEMP). These are translated into environmental commitments and Ministerial conditions, with relevant requirements incorporated into Works Approval conditions and license conditions. Collectively, these conditions require the proponent to undertake certain environmental management activities prior to construction, during construction and post construction.

The list of recommendations below considers estate wide environmental management requirements and includes proponent environmental management requirements for individual industrial facilities.

3.3 Consolidated environmental management recommendations

The following tables provide a consolidated list of environmental management measures for the respective environmental factors addressed in this environmental review. The environmental management measures are presented below as recommendations with timelines and responsibilities.

3.3.1 Flora and vegetation

Recommendation	Timeframe	Responsibility
Prepare vegetation clearing permit applications.	Pre-construction	Estate Manager
Protect vegetation of conservation significance in the buffer.	Ongoing	Estate Manager
Conduct Caladenia hoffmanii and other Declared Rare Flora species during October.	Pre-construction	Estate Manager
Conduct a Graceful sun-moth survey.	Pre-construction	Estate Manager
Prepare biodiversity offsets strategy.	Pre-construction	Estate Manager
Minimise vegetation clearing and disturbance of Priority listed flora species.	During construction	Proponents, Estate Manager
Develop and implement dieback hygiene control measures.	During construction	Proponents
Establish vegetation corridors linking coastal area to Moresby Ranges.	Post construction	Estate Manager
Actively manage buffer to ensure conservation measures are implemented.	Post construction	Estate Manager

3.3.2 Fauna

Recommendation	Timeframe	Responsibility
Protect vegetation of conservation significance in the buffer.	Ongoing	Estate Manager
Establish vegetation corridors linking coastal area to Moresby Ranges.	Ongoing	Estate Manager
Actively manage buffer to ensure conservation measures are implemented.	Ongoing	Estate Manager

Recommendation	Timeframe	Responsibility
Maintain groundwater recharge and quality to protect stygofauna habitat.	During and Post construction	Estate Manager, Proponents

3.3.3 Surface water

Recommendation	Timeframe	Responsibility
Undertake pre-development surface water and rain water quality monitoring for 2 years prior to establishment of the first industry in the Oakajee Industrial Estate.	Pre-construction	Estate Manager
Infiltrate surface waters at source following adequate treatment to achieve required water quality standards.	During and Post construction	Estate Manager, Proponents
Implement surface water and stormwater best management practices in accordance with the District Water Management Strategy (DWMS).	During and Post construction	Estate Manager, Proponents

3.3.4 Groundwater

Recommendation	Timeframe	Responsibility
Undertake pre-development groundwater level and quality monitoring for 2 years prior to the establishment of the first industry in the Oakajee Industrial Estate.	Pre-construction	Estate Manager
Establish groundwater monitoring programs and develop mitigation procedures for industries with the potential to pollute groundwater resources.	During and Post construction	Estate Manager, Proponents

3.3.5 Liquid and solid waste

Recommendation	Timeframe	Responsibility
Disposal of all solid waste (including construction and process waste) and septage to licensed waste disposal facilities located at Nabawa and Meru.	During and Post construction (Short term)	Proponents
Re-use and beneficiate solid waste by-products from industry processes based on synergies and feasibility.	During and Post construction (Medium term)	Proponents
Establish a fully integrated wastewater treatment facility that is capable of providing treated wastewater for industry purposes.	Post–construction (Medium term)	Water Corporation
Establish closed loop re-use and recycling of solid waste and treated wastewater throughout the industrial estate.	Post–construction (Long term)	Water Corporation, Proponents

3.3.6 Gaseous emissions

Recommendation	Timeframe	Responsibility
Carry out air emission dispersion modelling, and consider greenhouse gases.	Pre-construction	Proponents
Undertake air quality monitoring.	Pre and Post-construction	Proponents
Investigate the establishment of an industry body to oversee the implementation and coordination of common industry environmental management and monitoring activities.	Post construction	Estate Manager
Establish a programme to monitor cumulative gaseous emissions.	Post- construction	Estate Manager

3.3.7 Dust and particulate emissions

Recommendation	Timeframe	Responsibility
Undertake monitoring of background dust levels to provide baseline for the assessment of future particulate emissions.	Pre-construction	Estate Manager
Prepare dust management plans for construction activities involving the disturbance of surface soils.	Pre-construction	Proponents
Monitor stack and fugitive particulate emissions.	Post-construction	Proponents
Establish a programme to monitor cumulative particulate emissions.	Post-construction	Estate Manager

3.3.8 Noise emissions

Recommendation	Timeframe	Responsibility
Undertake monitoring of background noise levels to provide baseline information for the assessment of future noise emissions.	Pre-construction	Estate Manager
Monitor industrial noise.	Post construction	Proponents
Establish a programme to monitor cumulative noise emissions.	During and Post construction	Estate Manager

3.3.9 Public health and safety

Recommendation	Timeframe	Responsibility
Undertake quantitative risk assessments for individual industrial facilities	Pre-construction	Proponents

4. Conclusion and recommendations

The Oakajee Industrial Estate has been rezoned and approved for industrial development.

This Environmental Review is a key input to development of an Oakajee Industrial Estate Structure Plan to guide land use activities into the future.

The Oakajee site is well suited to development for heavy industry uses from an environmental perspective due to a number of factors, including:

- Favourable characteristics for industrial development (largely cleared, relatively flat topography, internally drained, deep sandy soils, depth to groundwater).
- Minimal environmental constraints.
- Ability to manage risks through existing conditions (Amendment 18), and through environmental measures identified in the review and approvals/licensing of proponent industries.
- Adequate buffer, as re-confirmed through recently updated air, risk and noise modelling, which is largely owned by the State Government.
- Opportunities for direct enhancement of environmental values - protection and management of remnant vegetation in the buffer, vegetated corridors and fauna habitat, biodiversity/carbon offsets through revegetation, retained rural use and improved land management in the buffer, increase in vegetation in SIA and GIAs through landscaping.
- Opportunities for indirect enhancement of environmental values – managed access and minimized 4WD impacts in coastal zone, rehabilitation of southern sand sheet, off-site biodiversity/carbon offsets.
- Preparation of a consolidated framework that provides environmental measures and timelines for the Estate Manager and future industry proponents.

4.1 Recommendations

1. That the Environmental Management framework outlined in this Environmental Review Report guide environmental management measures for the Estate Manager and future industrial proponents.
2. That all major industrial development proposals for the Strategic Industry Area are referred to the Estate Manager to determine compatibility with modelled emissions profiles and the Environmental Protection Authority (EPA) to determine level of environmental impact assessment.

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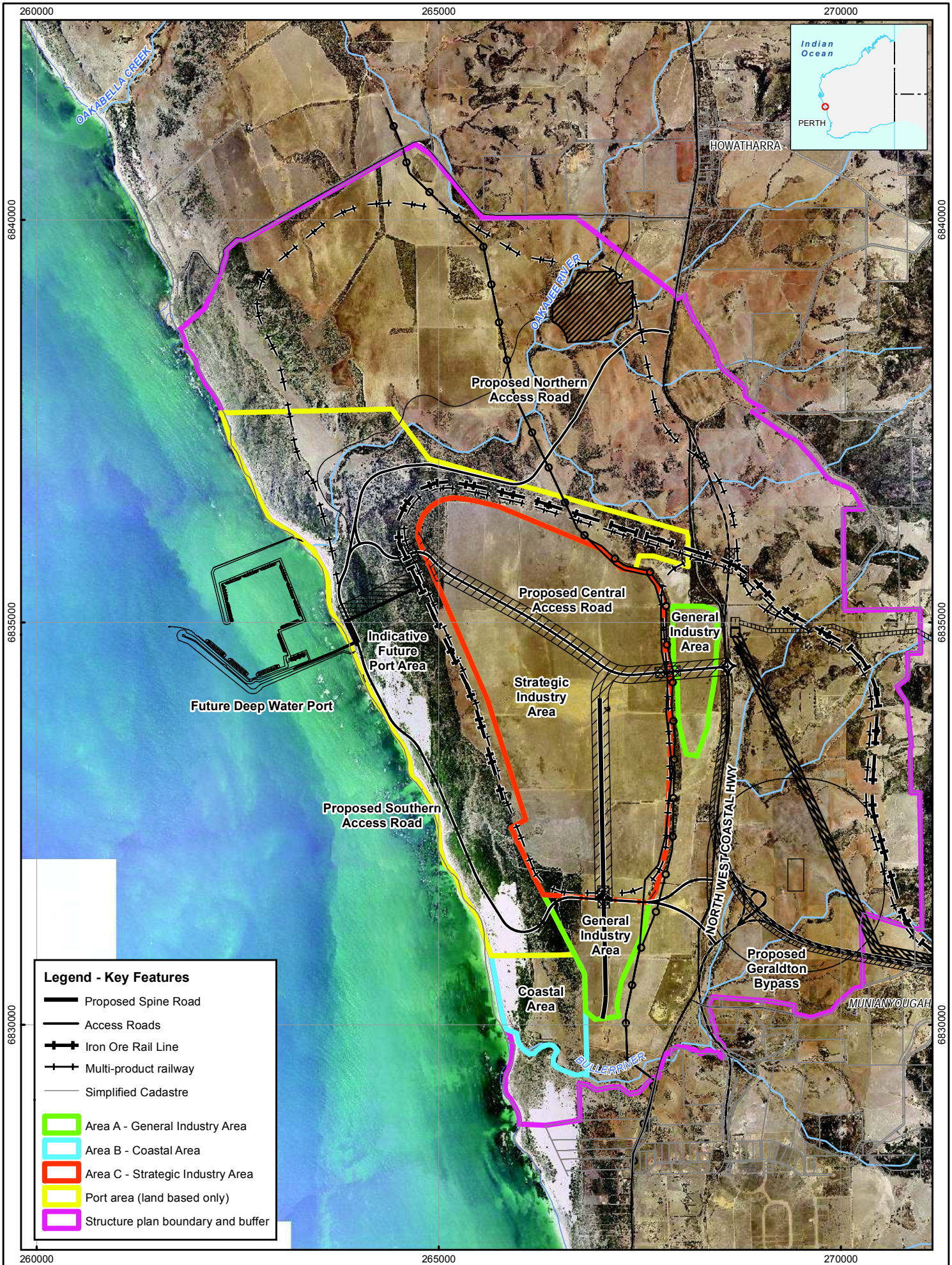
Appendix A

Figures



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LandCorp

Oakajee Environmental Review

Location plan - base plan plus zoning

Figure 1

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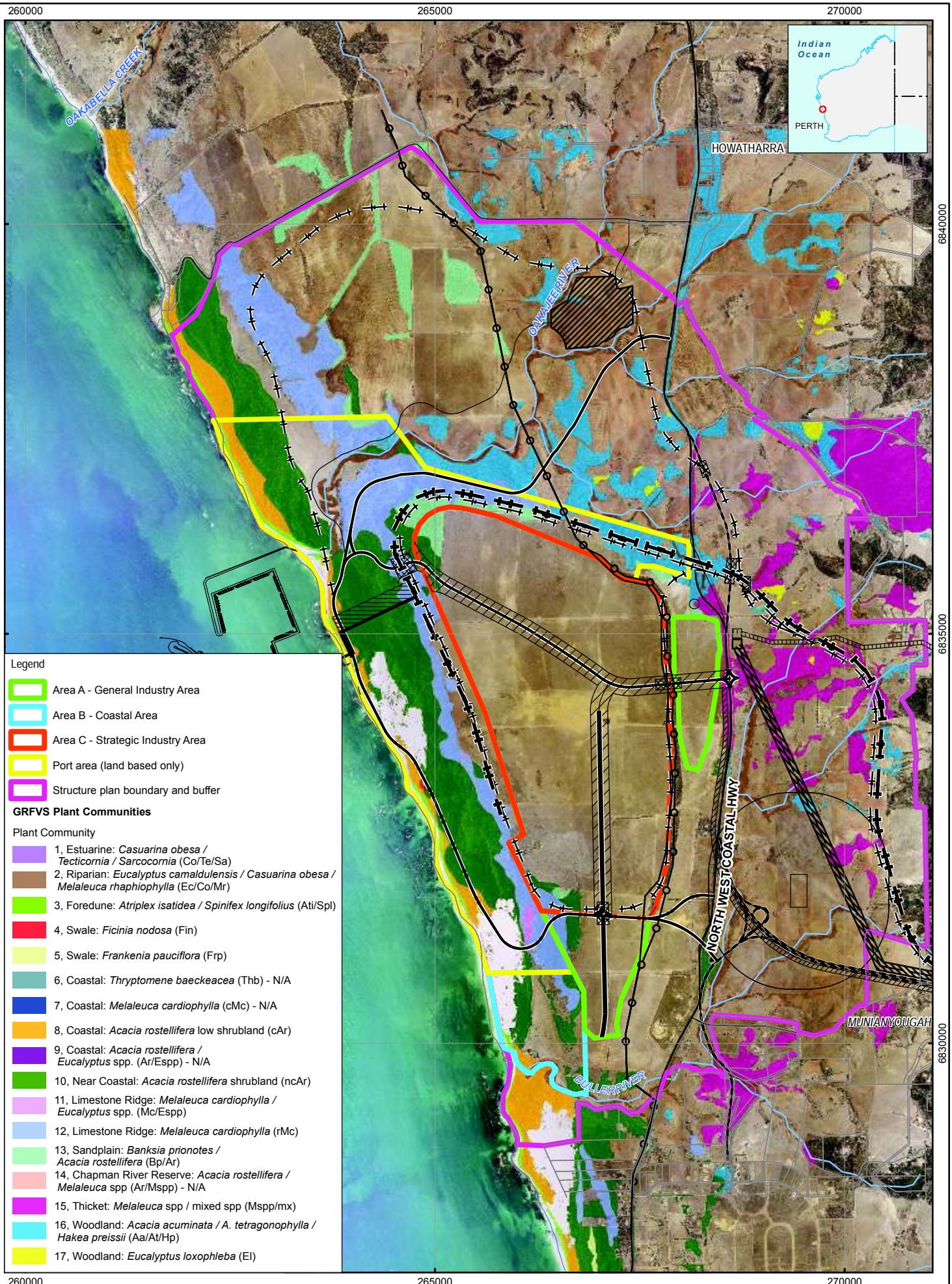

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LandCorp

Oakajee Environmental Review

Flora and Vegetation - GRFVS vegetation communities

Figure 2

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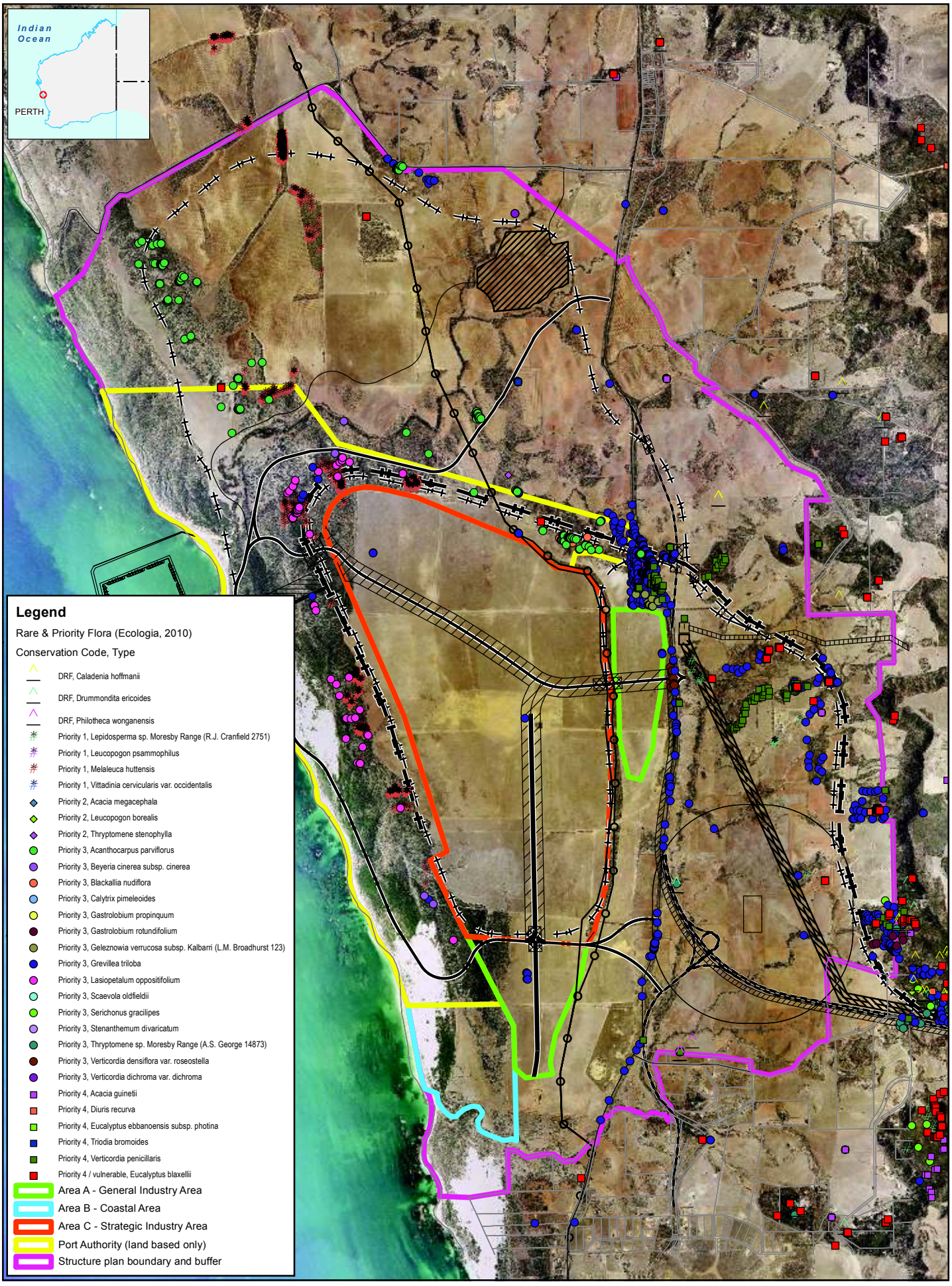

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Revision: A	Date: 26/11/2010
Drawn By: SH	Checked by: MM

Source: Ecologia (2010)

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Oakajee Environmental Review

Priority flora species
Figure 3

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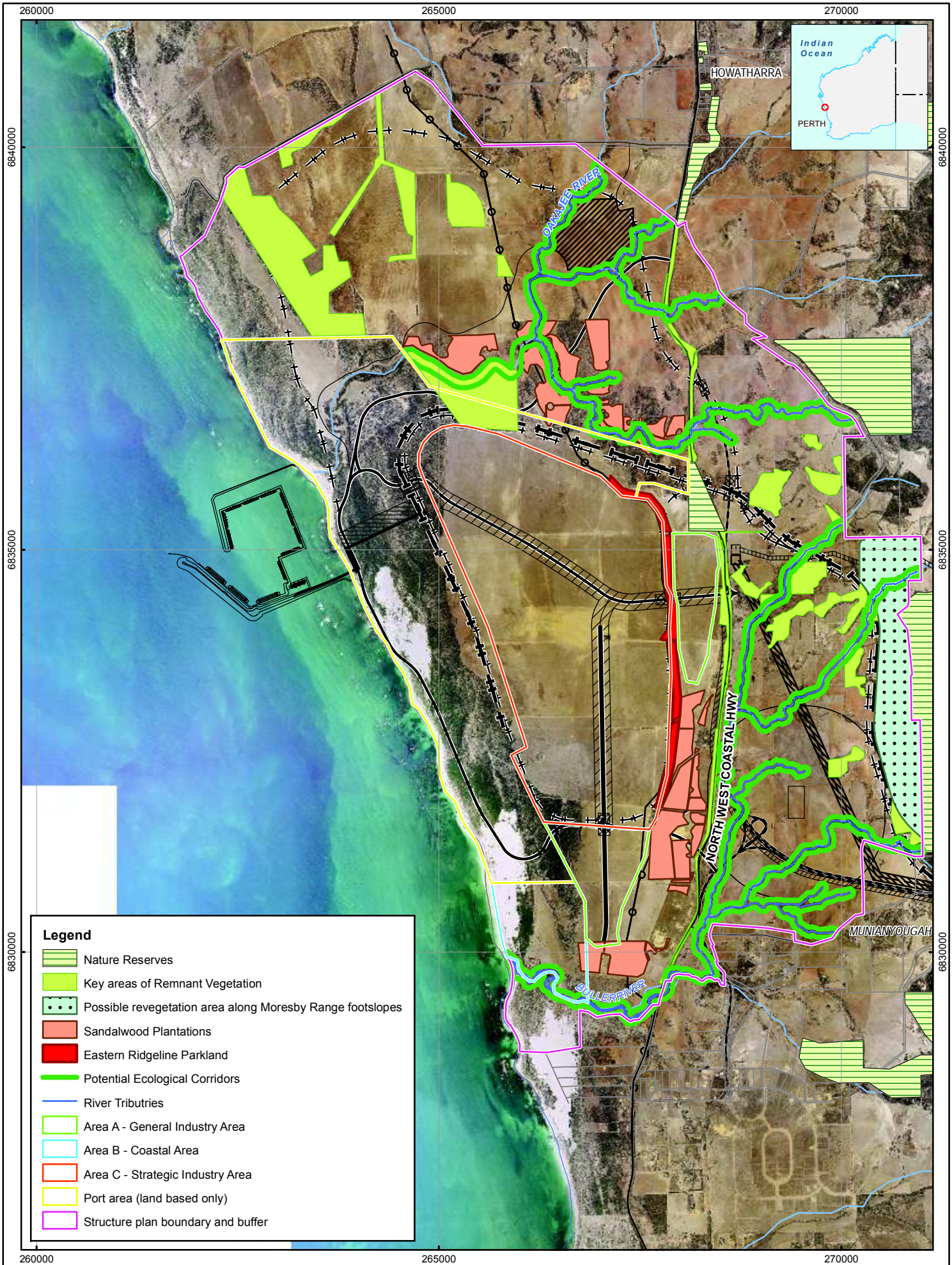

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Source: Hassell (2010)	

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Oakajee Environmental Review

Landscape and Vegetation
Figure 4

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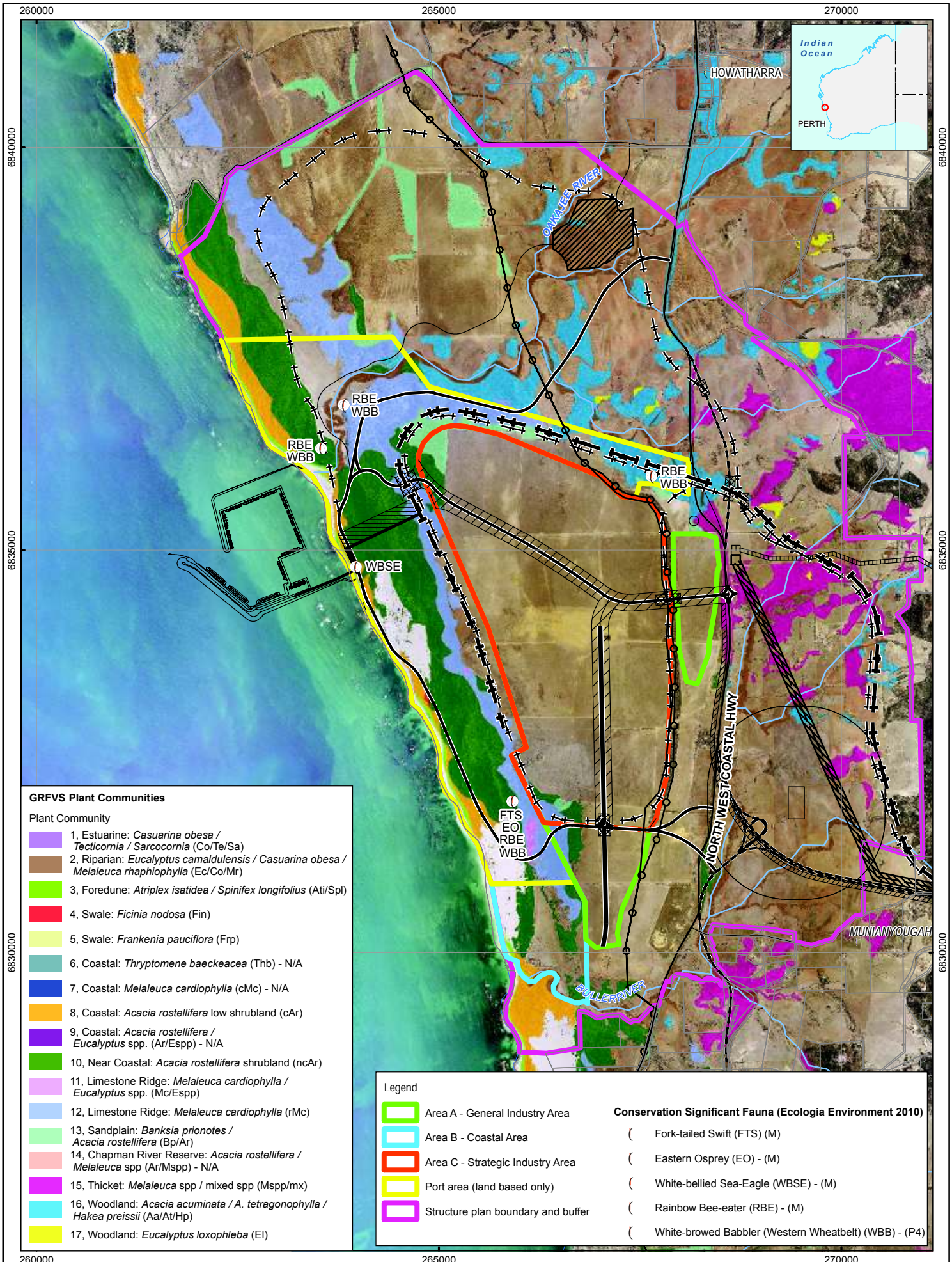

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Source: Ecologia (2010b)	

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Oakajee Environmental Review

Significant Fauna - GRFVS vegetation communities, plus location of conservation significant fauna species

Figure 5

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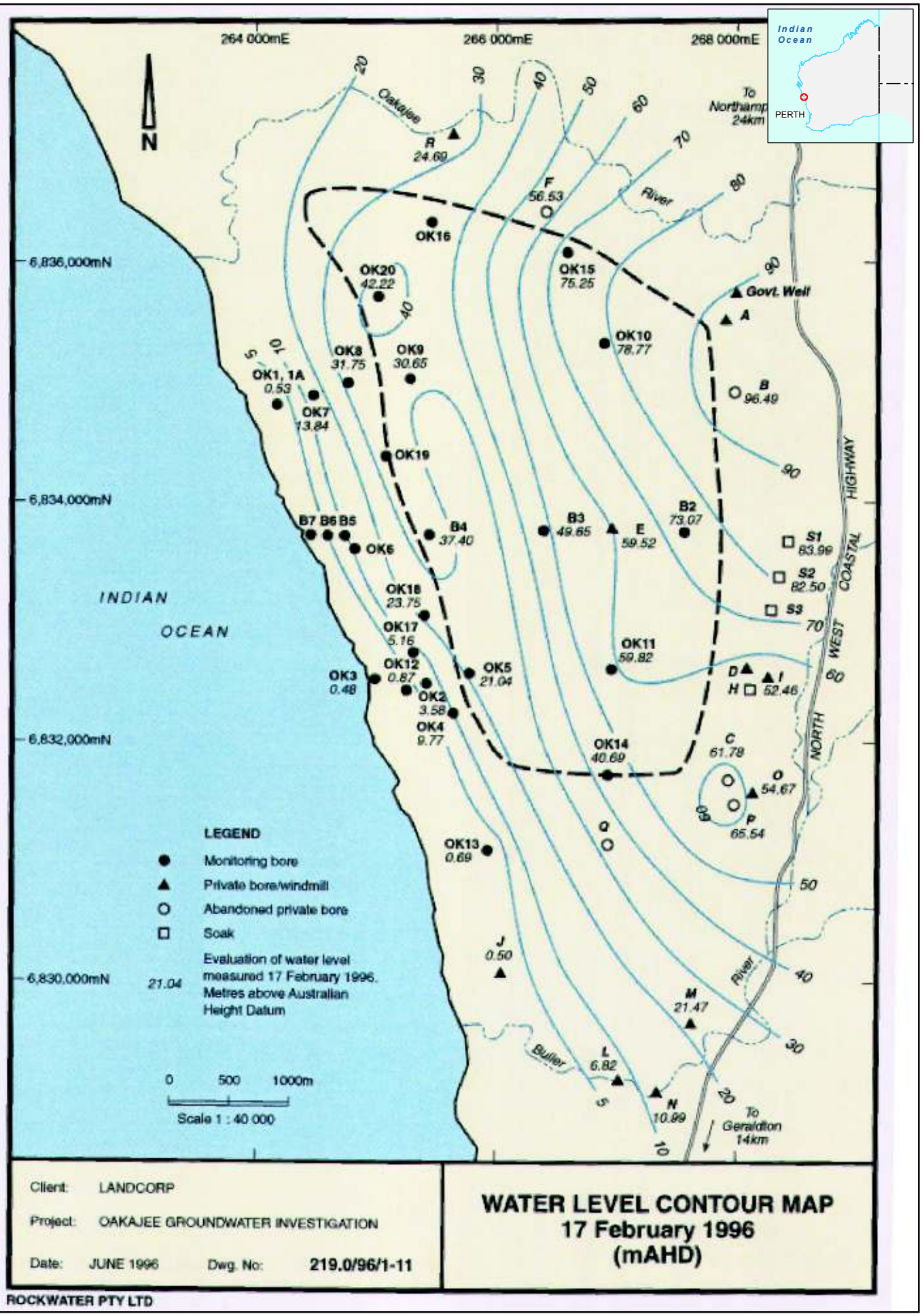

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		Revision: A / Date: 26/11/2010	Oakajee Environmental Review
		Drawn By: SH / Checked by: MM	**Surface water and groundwater**
		Source: Rockwater(1996)	**Figure 6**

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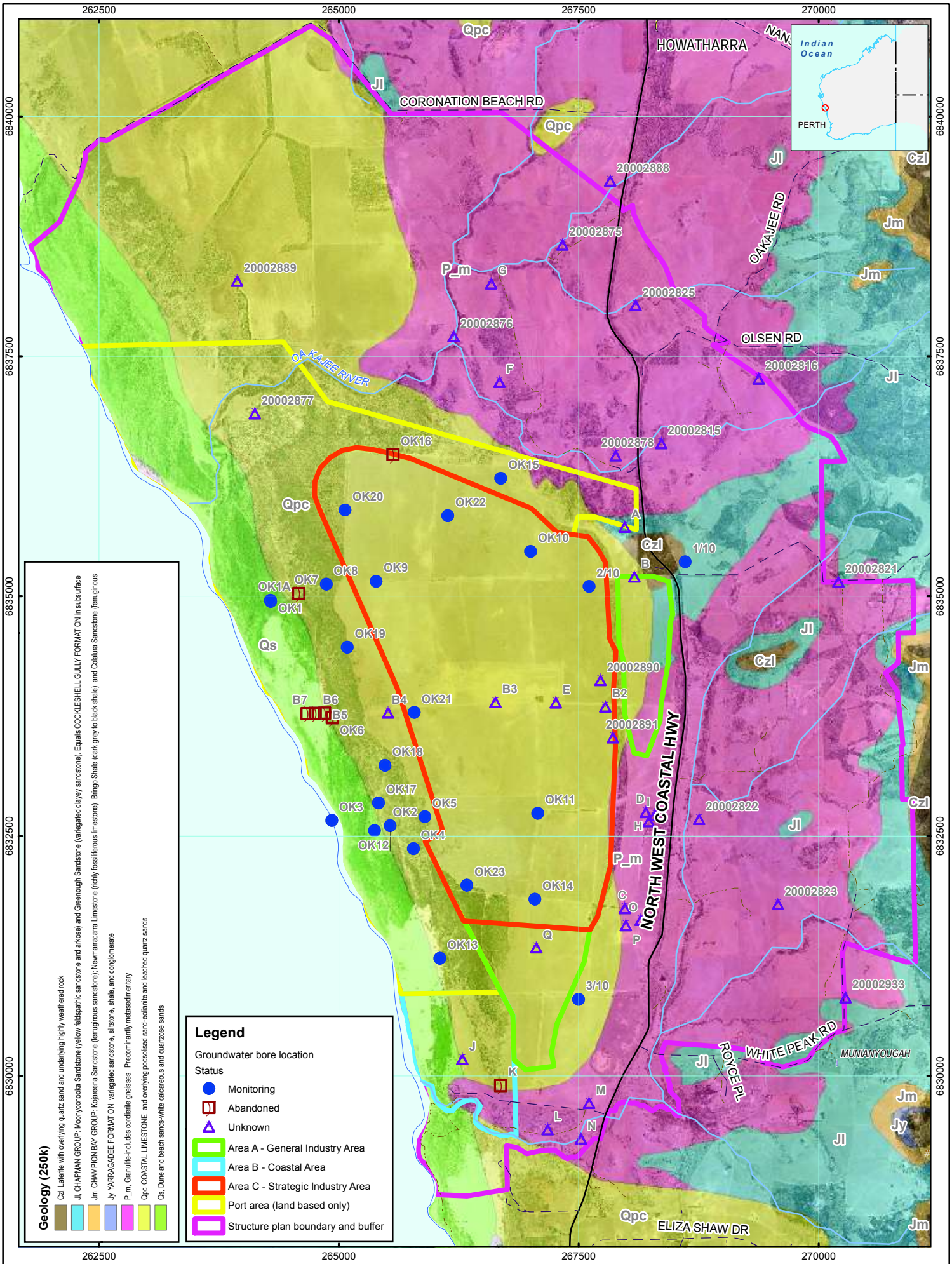

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Source: Landgate (2009), PB (2010a)	

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Oakajee Environmental Review

Groundwater monitoring bore locations
Figure 7

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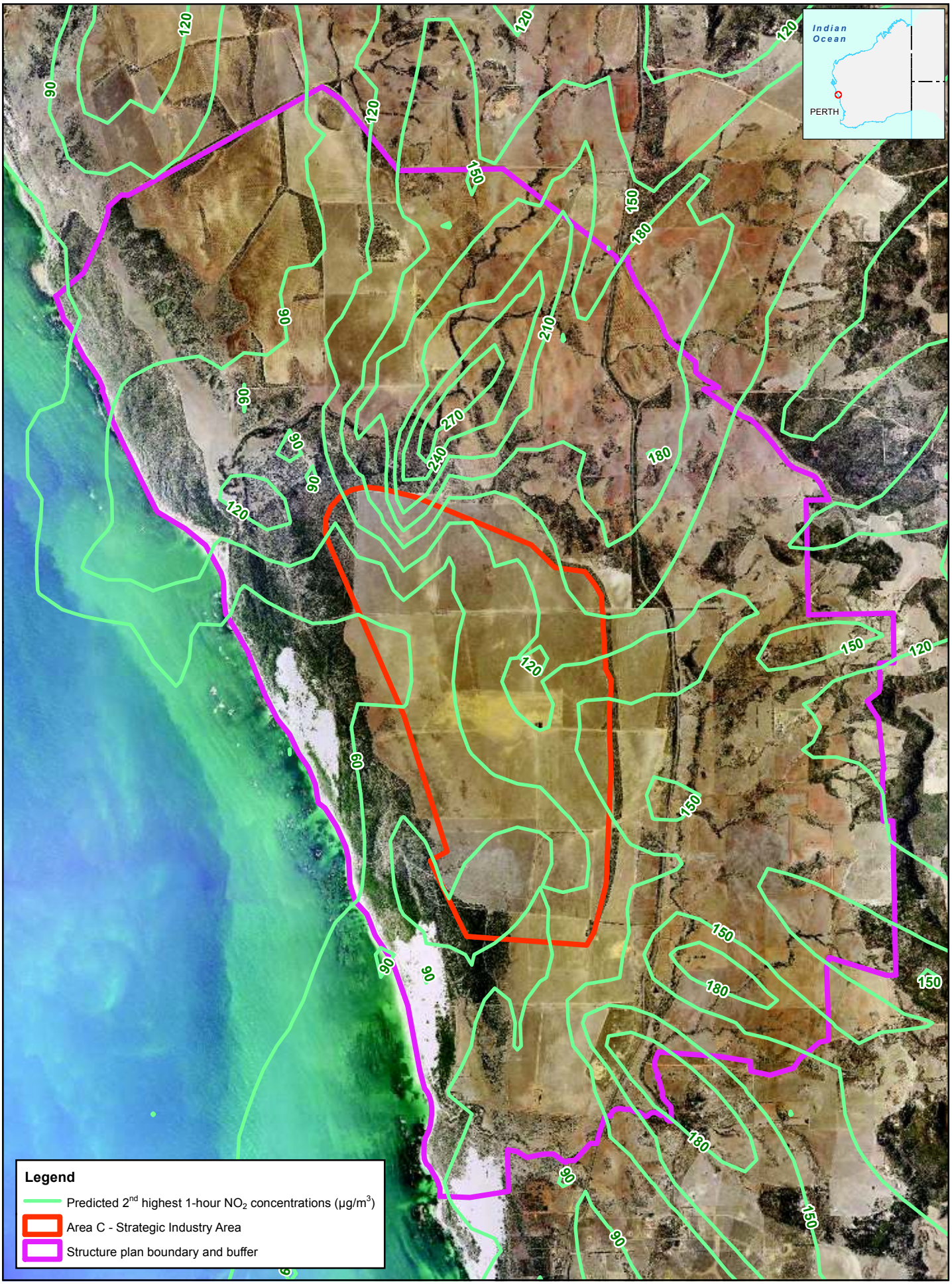

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Revision: A	Date: 26/11/2010
Drawn By: BS	Checked by: MM
Source: Air Assessments (2009)	

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Oakajee Environmental Review

Predicted 2nd highest 1-hour NO_2 concentrations (µg/m3) from multiple stacks. NEPM standard is equivalent to 246 µg/m3

Figure 8

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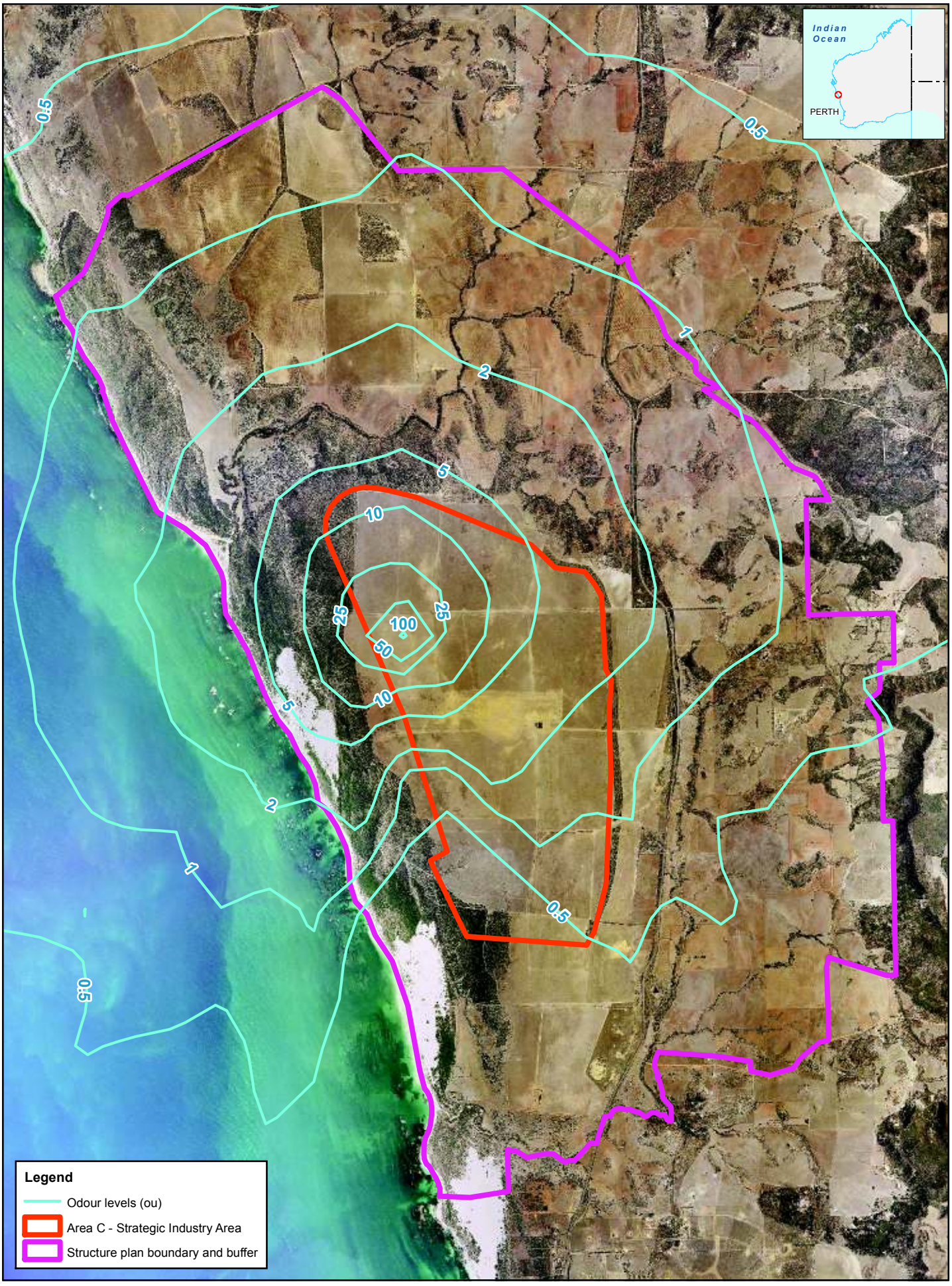

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Source: Air Assessments (2009)	

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Oakajee Environmental Review

Predicted 99.5th 1-hour odour levels (ou) from a pond – variable emissions

Figure 9

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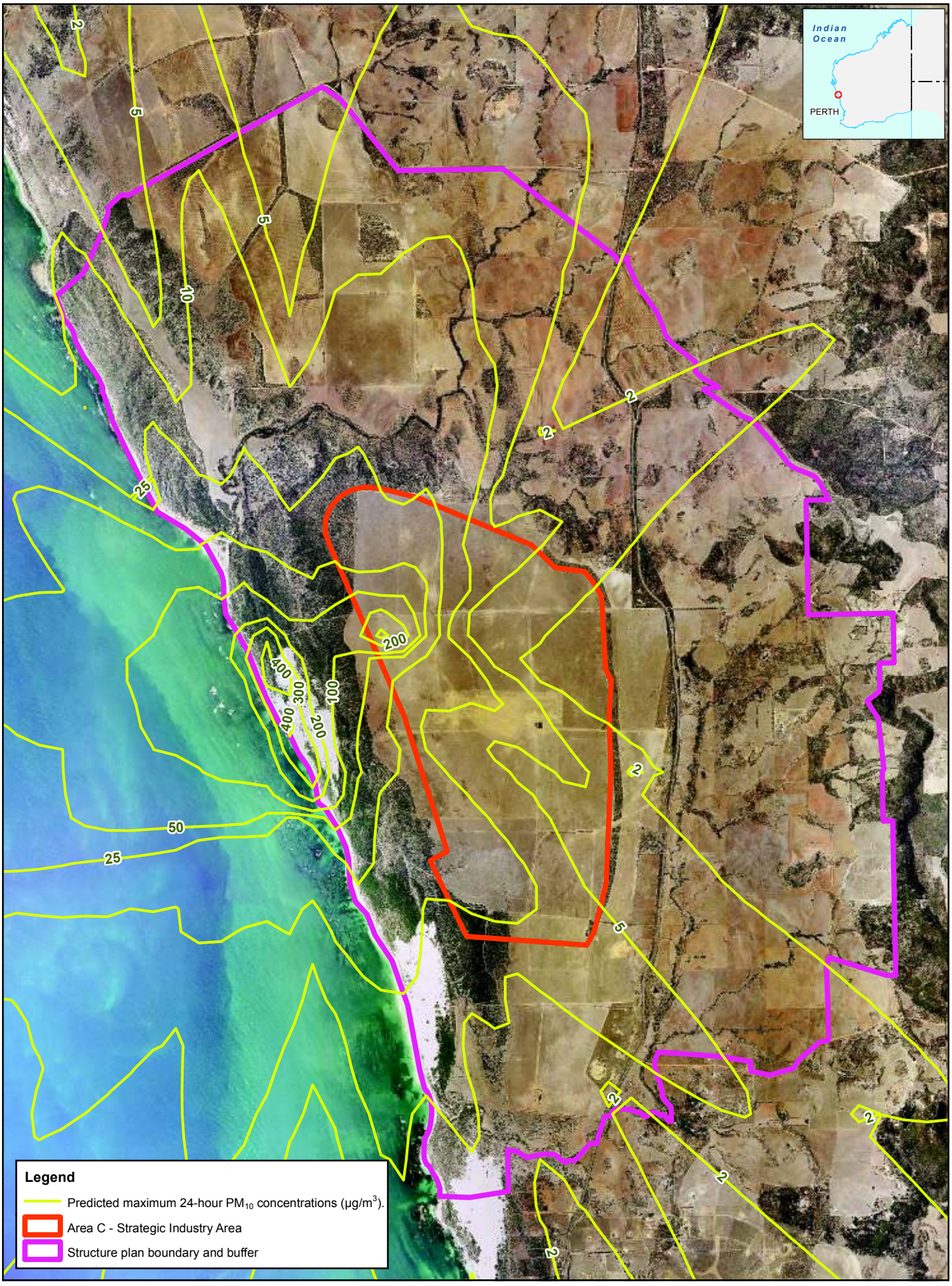

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Source: Air Assessments (2009)	

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Oakajee Environmental Review

Predicted maximum 24-hour PM_{10} concentrations (µg/m^3). NEPM standard is 50 µg/m^3 to be exceeded no more than 5 times per year. Note, the concentrations do not include background PM_{10}

Figure 10

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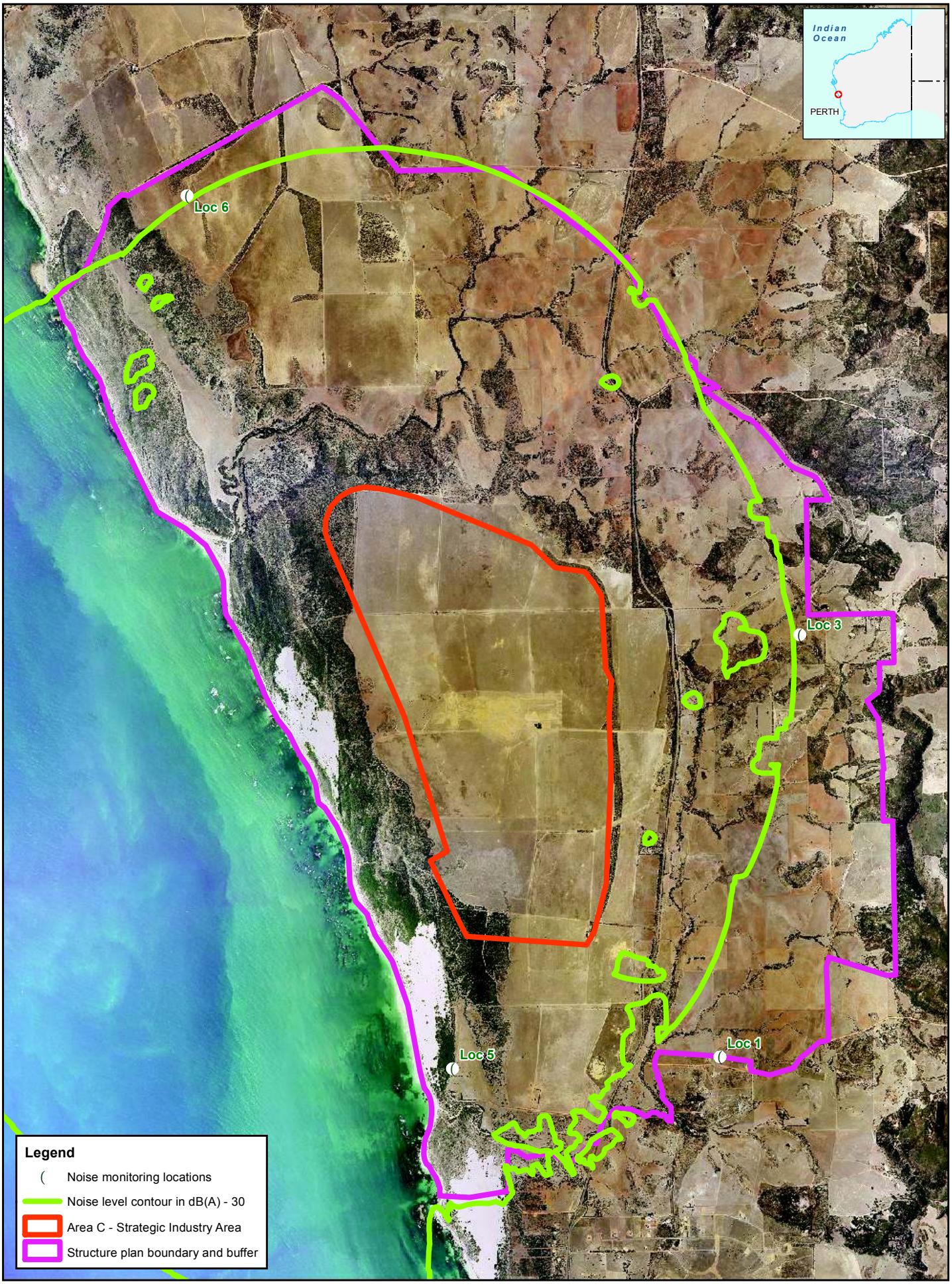

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Source: Air Assessments (2009)	

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Oakajee Environmental Review

Soundplan noise contours – 15 individual industries and developed port (including extended iron ore stockpiles and 10 m noise bund) and noise monitoring locations: Modelling conditions 3m/s and Pasquill Stability Class F

Figure 11

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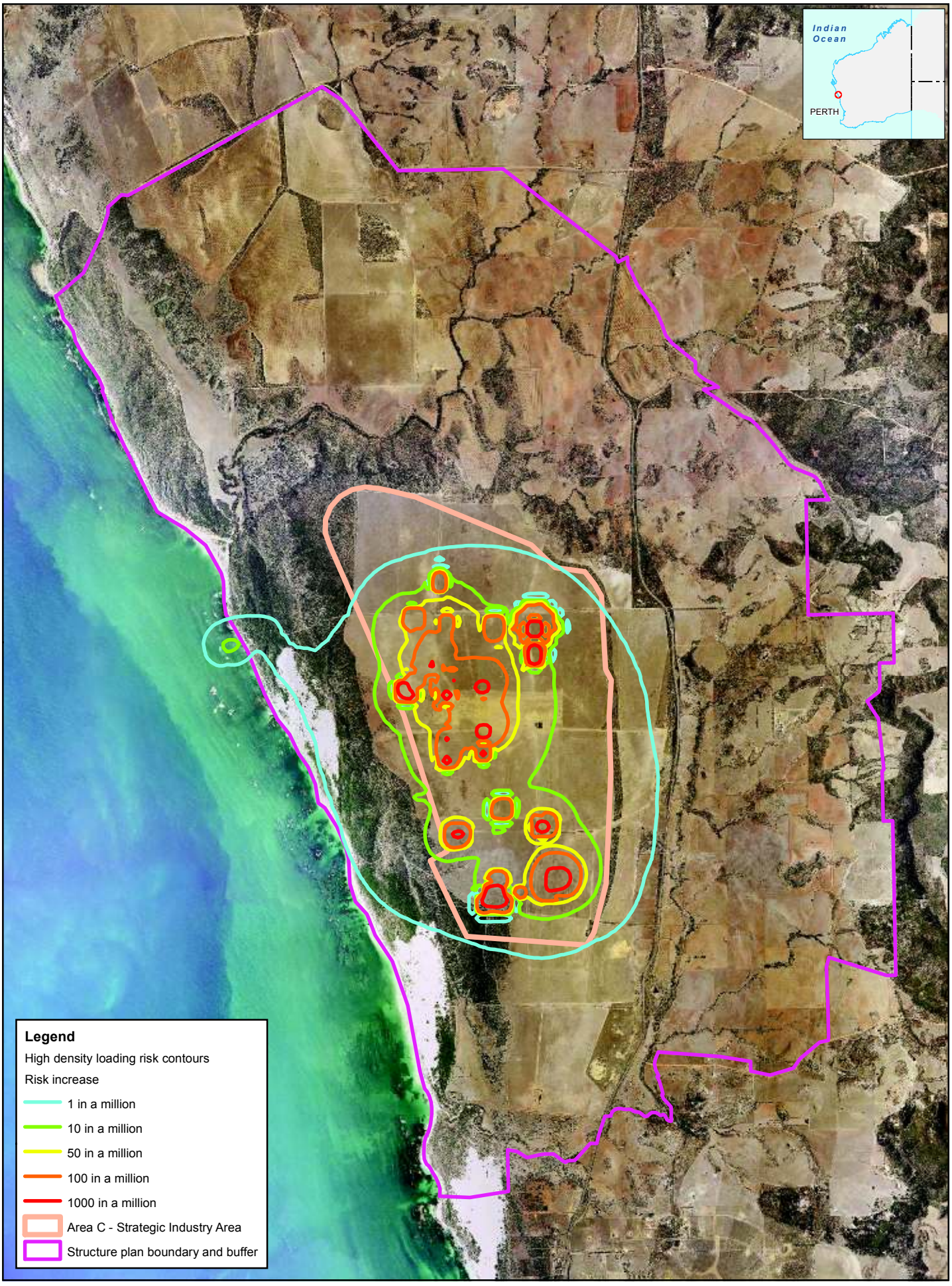

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Source: Air Assessments (2009)	

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Oakajee Environmental Review

High density loading risk contours
Figure 12

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Appendix B

Priority flora species

Priority Listed Flora Species Recorded in the Oakajee Study Area (Ecologia Environmental, 2010a)

Priority 1

Lepidosperma sp. Moresby Range

Melaleuca huttensis

Priority 2

Thyptomene stenophylla

Priority 3

Acanthocarpus parviflorus

Beyeria cinerea subsp *cinerea*

Blackellia nudiflora

Calytrix pimeleoides

Geleznowia verrucosa subsp Kalbarri

Grevillea triloba

Lasiopetalum oppositifolium

Verticordia densiflora var. *roseostella*

Verticordia dichroma var. *dichroma*

Leucopogan psammophilus

Priority 4

Eucalyptus blaxellii

Triodia bromoides

Verticorduia penicillaris

Appendix C

Stygofauna Qualitative Risk Assessment Report

Oakajee Industrial Estate — Stygofauna Qualitative Risk Assessment

18 January 2011

LandCorp

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A+ GRI Rating: Sustainability Report 2009

Revision	Details	Date	Amended By
00	Original	26 August 2010	J Safstrom
01	Comments from Landcorp	23 September 2010	J Safstrom
02	Final edits	18 January 2011	M McCarthy

Author: J Safstrom .....

Signed:  .....

Reviewer: A Parker .....

Signed:  .....

Approved by: M McCarthy .....

Signed:  .....

Date: 18 January 2011.....

Distribution: .....

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Contents

List of tables

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Executive summary

Stygofauna are groundwater dwelling fauna known to be present in a variety of rock types including karstic limestone, fissures and porous rocks. They are typically adapted for the subterranean environment with features including lack of pigmentation, elongated appendages, worm like body shapes and reduced or absent eyes. Many of these fauna have primitive features that link them to geological periods when Australia was covered by tropical forests and therefore they are regarded as 'relict' fauna.

Stygofauna and their habitat have been identified in specific locations beneath and in the vicinity of the areas proposed for industrial development associated with the Oakajee Industrial Estate (Ecologia, 2010). As part of a due diligence process for the structure plan, a study into the implications of these findings and likely impacts of any future industrial development was required. As such, a desktop qualitative risk assessment study on subterranean fauna has been undertaken, specifically stygofauna.

For the purpose of the assessment a conservative assumption was made in regard the extent of the habitat inside the Oakajee Industrial Estate (OIE) boundary, even though stygofauna species were only detected in two locations. It is assumed that stygofauna habitat is present across the entire site.

The greatest identified risk to habitat is from extreme changes in groundwater levels through abstraction or infiltration. These can be mitigated through strict controls on groundwater across the OIE and should be reflected in OIE's District Water Management Strategy (DWMS). With proposed mitigation measures, the risk assessment identified that all residual risks and potential impacts where assessed to be 'very low'.

A desktop risk assessment on the impact of stygofauna from industrial activities likely to occur in the Strategic Industry Area (SIA) and General Industry Areas (GIAs) concluded the risk to stygofauna species and habitat was "very low". The study proposed several mitigation measures that have been incorporated into the objectives of the District Water Management Strategy (DWMS) for the site.

In the event that future industrial proponents are not able to comply with the groundwater quality and quantity mitigation measures identified in the DWMS, it is recommended that proponents be required to undertake a more detailed site specific investigation, followed by a quantitative risk assessment, based on the potential impact of their proposal on subterranean species.

1. Introduction

This report provides information on the proposed industrial development at Oakajee and findings of a desktop qualitative risk assessment study undertaken on subterranean fauna, specifically stygofauna. The aim of the study is to understand the likely impacts of any future industrial development on stygofauna habitat, and to recommend mitigation and management measures to reduce the impact as far as reasonably practicable.

Stygofauna and their habitat have been identified in specific locations beneath the proposed development site (Ecologia, 2010). For the purposes of addressing the impacts and determining management measures, it is assumed that stygofauna habitat is present across the entire site and that the previous agricultural land use has been the key land use affecting groundwater quality in the area.

1.1 Background and proposal

The Oakajee Industrial Estate and proposed industrial zones are located approximately 23 kms north of Geraldton along the Western Australia coastline, in the Shire of Chapman Valley. The area occupies a coastal plateau at 70–100 m above sea level, bordered on the western side by an escarpment leading to a lower coastal dune zone, to the north and south by the Oakajee River and Buller River respectively, and to the east by the North West Coastal Highway.

Oakajee is currently farmland and has been used for cropping and grazing for at least the past 500 years. It was selected by the State Government in 1992 as a site for future processing industry and a deep water port. The proposed industrial development was referred to the EPA, resulting in a report of their assessment in 1997 (Bulletin 848).

The State has subsequently acquired and re-zoned approximately 6,400ha of land as part of an amendment to the Shire of Chapman Valley's Town Planning Scheme (TPS) No. 1. TPS 1, Amendment 18 was endorsed by the Western Australian Planning Commission (WAPC) in June 2000 and gazetted by the State Government in 2004.

In March 2009, a Development Agreement between the State Government and Oakajee Port and Rail (OPR) to construct a rail line from the mines in the Mid West region to Oakajee was signed. The agreement involves the development of a deep water port at the mouth of the Oakajee River and associated rail infrastructure to connect to selected iron ore mines. OPR has prepared and submitted concept plans for the port, rail and related infrastructure and prepared Public Environmental Reviews (PERs) for both the terrestrial port proposal and rail proposal. The PERs were subject to a public review period which closed on 30 August 2010 and it is expected that environmental approvals will be secured by mid 2011.

LandCorp is currently developing a Structure Plan for the OIE in support of orderly development of the industrial estate, as required by TPS Amendment 18.

A stygofauna survey undertaken in 2006 (Ecologia, 2010), as part of the OPR PER for the terrestrial port, involved the sampling of 17 of the 22 groundwater bores established throughout the OIE. The survey identified three species of stygofauna, with one species of syncarid being new to science and not found elsewhere in Western Australia and the two copepod species, unable to be identified to species level due to damaged or juvenile specimens, may also be new to science (Ecologia, 2010).

Of the three bores that recorded the sygofauna species, one bore (OK11) is located in the central southern part of the SIA and the other two bores (OK15 and OK 18) are located on the northern and western boundary of the SIA respectively (Figure 1).

1.2 Legislative framework

1.2.1 Western Australia

The *Environmental Protection Act 1986* is the primary legislation within Western Australia for the prevention, control and abatement of environmental pollution, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing

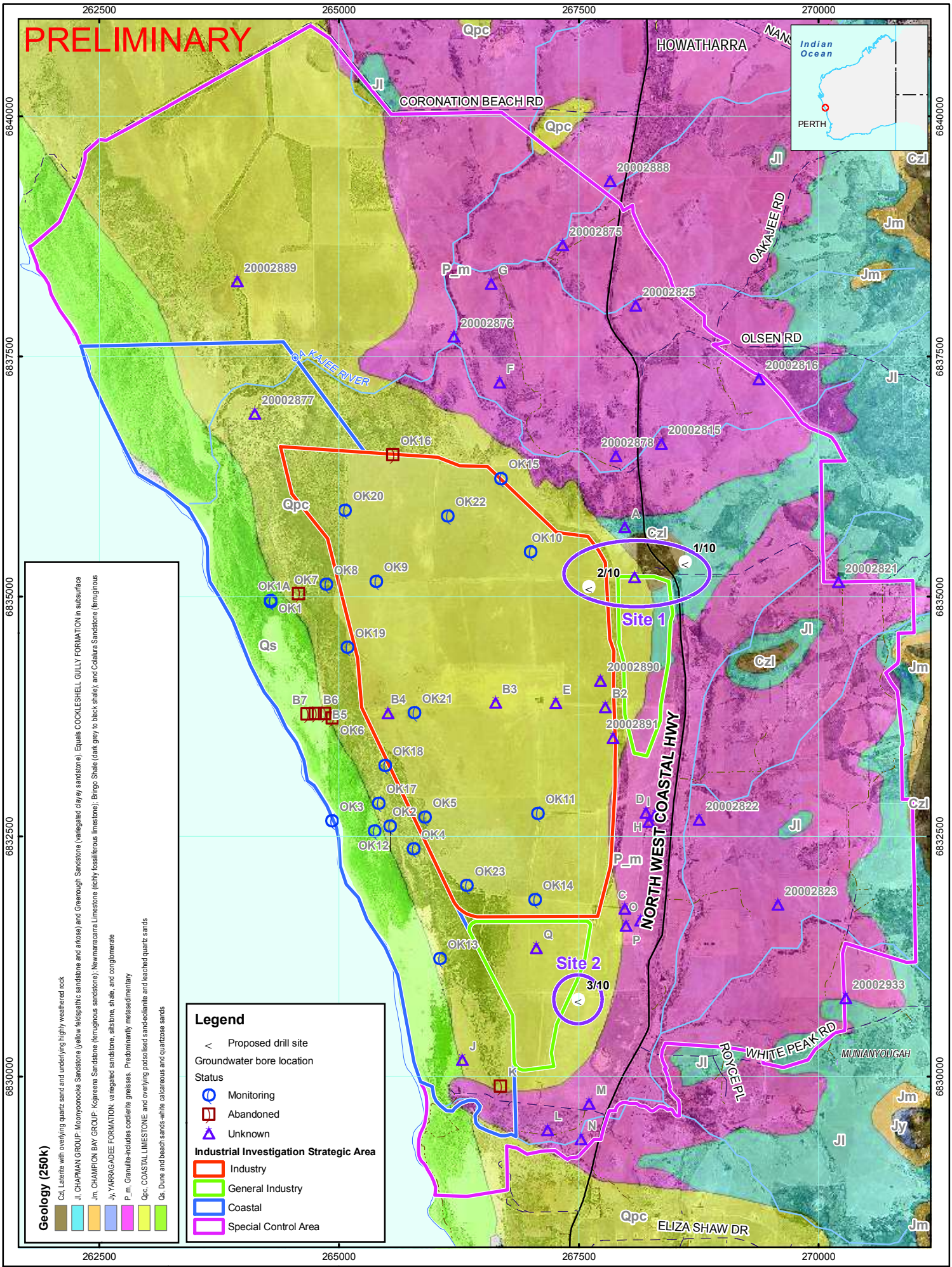
Native fauna in Western Australia are at a State level protected under the *Wildlife Conservation Act 1950* (WC Act). The WC Act was developed to provide for the conservation and protection of wildlife in Western Australia. Under Section 14 of this Act, all fauna and flora within Western Australia is protected; however, the Minister may, via a notice published in the Government Gazette, declare a list of fauna taxa identified as likely to become extinct, or is rare, or otherwise in need of special protection. The current listing was gazetted on 5 August 2008.

1.2.1.1 Guidelines

Projects undertaken as part of the Environmental Impact Assessment (EIA) process are required to address the guidelines produced by the EPA. This assessment considers Guidance Statement 54: Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia (EPA 2003).

1.2.2 Commonwealth

The *Environment Protection Biodiversity and Conservation Act 1999* (EPBC Act) was developed to provide for the protection of the environment, especially those aspects of environment that are matter of national environmental significance; to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources and to promote the conservation of biodiversity. The EPBC Act includes provisions to protect native species (and in particular prevent the extinction, and promote the recovery, of threatened species) and ensures the conservation of migratory species. Section 3a of the EPBC Act includes a principle of ecologically sustainable development dictating that decision making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.



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Oakajee Stygofauna Qualitative Risk Assessment

Groundwater monitoring bore locations
Figure 1

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2. Existing environment

The land within the study area has been cleared for many decades and used for agricultural purposes. During assessment of the area, the OIE site has been found to have a combination of unusual geomorphology, ground water hydrology and newly discovered, locally endemic taxa of stygofauna. These factors are outlined in more detail below.

2.1 Geology, soils and geomorphology

Based on the 1:250,000 geological sheets 'Geraldton - Houtman Abrolhos' (DOIR, 1974), the geology consists of Quaternary age aeolian and quartz sands, overlaying Precambrian Granulite Bedrock and Quaternary Tamala Limestone. The Quaternary sand consists of moderate to well sorted quartz grains, that is cemented with calcium carbonate in areas. Quaternary Tamala limestone comprises of medium to coarse shell fragments and quartz sand. Precambrian granulite bedrock consists of highly metamorphosed rock of a granitic composition.

2.2 Hydrogeology

The hydrogeology of the proposed industrial site has been previously described in detail following hydro geological investigations (Rockwater, 1996, 2000, 2001 and 2003 and PB (internal documents). A synthesis of the site hydrogeology is described herein.

The Study Area is located on an elevated plateau (70-100 m AHD) underlain by a westward-dipping surface of granulite bedrock and 40 -50 m of sedimentary strata (Rockwater 2000). Groundwater occurs from about 15 to 65 m below ground level on the plateau and forms a veneer within and above the bedrock-sediment contact surfaces.

This veneer is recharged by rainfall and it flows predominantly westward towards the coast (Rockwater 2000). The unconfined groundwater aquifers comprise locally weathered bedrock and overlying siltstone (Chapman Group). Tamala Sand and superficial sand capped by Tamala Limestone at the western escarpment. Around the periphery of the development area there is a ring of impermeable granulite which rises above the water table in the north-west corner of the property and effectively acts as a diversion barrier to groundwater flow. Depth to groundwater varies between 10m and 50m, with a general increase from east to west (Rockwater, 1993)

Generally, the strata (excluding the granulite bedrock) are hydraulically connected and groundwater passes between them (Rockwater, 2000). Table 2.1 outlines the generalised stratigraphic column of the area.

Table 2.1 Generalised stratigraphy of the Oakajee area

Stratigraphy		Description
Tamala Limestone	Limestone	The Quaternary limestone consists of medium to coarse aeolian grains, comprising shell fragments and quartz sand, and caps the Tamala Sand aquifer at the western escarpment of the Oakajee Industrial Estate. The outcrop of limestone dominates the region west of the escarpment and predominately is unsaturated, lying ≤ 50 m above the water table (Rockwater, 1996). Whilst the limestone allows the passage of infiltrating rainwater, it is not likely to affect groundwater flow in the saturated zone.
	Sand	The Quaternary sand consists of moderate to well sorted grains of approximately 80% quartz, which is locally cemented with calcium carbonate cement. The sand extends beneath the water table in the central and north-western sectors of the site where the sand occupies a broad shallow trough leading south-southwest and extending across the western escarpment. The sand is between 10 to 15 m thick, exhibits high permeability (20 to 50 m/d), and is likely to act as a path of preferential groundwater flow over the site (Rockwater, 2000).
Chapman Group		The Mesozoic Chapman Group aquifer consists of siltstone overlying to a lesser extent sandstone, with occasional basal siltstone along the coastal escarpment. The formation is predominately saturated in the western region of the site, with a thickness of generally ≤ 40 m, and exhibiting relatively low permeability (Rockwater, 1996).
Bedrock		The Precambrian granulite bedrock consists of highly metamorphosed grained granulites of granite/mafic composition, is located 20 to 70 m below the site, and is observed to outcrop in the eastern region of the Oakajee Industrial Estate. Unweathered bedrock is considered relatively impermeable and is considered to exhibit a low permeability (Rockwater, 2000), however secondary porosity is likely provided by structure. The formation is saturated over the majority of the site, except where outcropping is observed. Permeability is assumed to increase in weathered sections of the bedrock, however generally water yields obtained from the formation are very small.

2.2.1 Groundwater flow

Groundwater is understood to flow westerly towards the coastline from the upslope areas to the east of the project area. There is a known deep palaeochannel between the granulite in the north east of the study area, which has recently been investigated. This palaeochannel appears to be draining the Moresby Range groundwater catchment.

It is noted that whilst the groundwater gradient in the study area is considered to be quite high, the seasonal variation in ground water table height is less than 0.4 of a metre. This reflects the low transmissivity of some of the sediments and modest rainfall of the area.

2.2.2 Physio-chemical and nutrient results

Ecologia Environment (Ecologia) undertook a physico-chemical study and nutrient study of the groundwater (Ecologia, 2010). Six physio-chemical parameters (temperature, pH, conductivity, total dissolved solids, oxidation reduction potential and dissolved oxygen) were measured from 14 bores. In addition, they measured seven physico-chemical parameters (conductivity, total suspended solids, total dissolved solids, turbidity, true colour, alkalinity and acidity) and four nutrient parameters namely Nitrate (NO_3), Nitrate (NO_2), Phosphate (PO_4-P) and Phosphorus (P).

Analysis of the physico-chemical data indicated that the groundwater environment was suitable for stygofauna habitat. Ecologia (2010) indicated that while higher levels of nitrite and phosphorus where found within the study area, and could be caused by the existing agricultural land use, this environment did not seem to affect stygofauna habitation.

2.3 Stygofauna

Ecologia also undertook a stygofauna survey of the Oakajee area in 2010 (Ecologia, 2010). The survey was carried out according to the requirements of the EPA guidance Statement 54 (EPA, 2003). It consisted of sampling of 17 bores, in three stages. This section is a summary of that report.

The stygofauna sampling program resulted in three species of sygofauna, representing two classes and three orders being recorded within three bores. The static waterlevel of these bores range from 24.01 mAHD to 76.33 mAHD within the Chapman Group sediments and Greenough Sandstone.

The stygofauna species identified comprised two syncarids, one calanoid copepod and one harpacticoid copepod. The syncaird specimens have not been recorded elsewhere in Western Australia. Of the copepods, one specimen was damaged and the other was a juvenile, thus both could not be identified to species level. Table 2.2 outlines a summary of the stygofauna findings to date.

Table 2.2 Summary of Stygofauna investigation

Class	Sub class	Super order	Order	Family	Genus Species	Description and Comments
Malacostraca	Eumalacostraca	Syncarida	Bathynellacea	Bathynellidae	Unidentified Genus	Two specimens were recorded; one adult and one juvenile. This species is currently unknown, and thus its conservation significance is unknown.
Maxillopoda	Copepoda	Gymnoplea	Calanoida	Unidentified family	Unknown	A partially damaged unknown single male individual was collected. Conservation significance of this species cannot be determined unless additional specimens are collected
Masillopoda	Copepoda	-	Harpaciticoida	Unidentified family	Unknown	A single juvenile species was collected. Conservation significance of this species cannot be determined unless additional specimens are collected

Source (Ecologia, 2010)

3. Potential impacts

For the purposes of the identification of potential impacts, it is assumed that stygofauna habitat which has been identified beneath part of the proposed development site at Oakajee in Section 2 is present over the entire site. It also assumes that the existing habitat has been degraded as a result of wholesale clearing of the original native plant cover and subsequent agricultural land use over many decades.

Based on the above, the key objective for the management of stygofauna is to maintain the current status of the habitat.

Future industrial land use may result in a varying amount of stygofauna habitat loss from:

- Changes in hydrology through the provision of impermeable surfaces to accommodate industrial development. Without the use at source controlled and treated infiltration of stormwater, this may reduce the quantity and quality of local groundwater recharge as a result of impervious surfaces (Buildings, roads, car parks etc).
- Pollution (e.g. chemical pollutants, accidental spills, sewage, direct discharge of wastes into the aquifer) resulting in potential changes to the quality and location of groundwater recharge areas.
- Nutrient enrichment of groundwater or changes in nutrient enrichment due to cessation of agricultural land use, may lead to proliferation of surface dwelling subterranean species that dominate stygofauna habitat.
- Groundwater drawdown from groundwater abstraction may lower the water table sufficiently to dry the zone that stygofauna inhabit and/or result in the alteration of the water balance and therefore impact on stygofauna habitat.

4. Risk assessment

To understand the potential risks the development of the OIE may have on the identified stygofauna habitat and the effect appropriate mitigation strategies will have in managing this risk, a desktop qualitative environmental risk assessment has been undertaken. The desktop qualitative environmental risk assessment has been undertaken in accordance with the principles and guidelines contained in the following:

- AS/NZ 4360:2004, Risk management
- SAA Handbook 203:2004, Environmental risk management – Principles and process
- AS/NZS 3931:1998, Risk analysis of technological systems – Application guide.

A high-level consequence table was constructed for stygofauna, containing five levels of consequence based on the level of severity of the potential impact (Table 4.1). The high level consequence table has been based on an inferred reduction of the extent of habitat and, where this reduction is 100%, inferred species extinction within the OIE.

Table 4.1 Definitions of consequence for subterranean fauna

Consequence rating		Environmental consequence
1	Catastrophic	Extinction of a species or total loss of habitat within the OIE
2	Massive	Habitat reduced to less than 30% of known extent
3	Major	Habitat reduced to 30–70% of known extent
4	Minor	Habitat reduced to 70–95% of known extent
5	Negligible/ slight	Habitat reduced to 95-100% of known extent

Five levels of likelihood were developed to determine the likelihood of the consequence occurring (Table 4.2). To ensure a consistent conservative approach to the risk assessment the consequences will be defined as localised impact from proposed industry development (at a lot scale) and not applied to the entire OIE.

Table 4.2 Definitions of likelihood levels

Likelihood rating		Likelihood definitions
1	Almost certain	Common repeating occurrence, ongoing
		Will occur most often
		Planned occurrence/action
2	Likely	Will probably occur in most circumstances
		There is at least 50% chance that it may happen
3	Possible/ occasionally	Might occur at some time
		Could occur but not often
		5% chance it could happen
4	Unlikely	Unusual occurrence
		Unexpected
5	Rare/ improbable	May occur only in exceptional circumstances
		Unheard of

A risk analysis matrix comprising likelihood and consequences was used to identify the inherent or residual risk (Table 4.3). A risk can be defined as the chance of something happening that will have an impact on an environmental factor.

Table 4.3 Risk Matrix

		Negligible	Minor	Major	Massive	Catastrophic
Likelihood	Almost certain	LOW	MEDIUM	HIGH	EXTREME	EXTREME
	Likely	LOW	LOW	MEDIUM	HIGH	EXTREME
	Possible/ occasionally	VERY LOW	LOW	MEDIUM	HIGH	HIGH
	Unlikely	VERY LOW	VERY LOW	LOW	MEDIUM	HIGH
	Rare/remote	VERY LOW	VERY LOW	LOW	LOW	MEDIUM

The risk assessment results for subterranean fauna are outlined below in Table 4.4. Each risk factor was assessed during a workshop, with officers experienced in industrial land development and stygofauna risk assessments. The risk assessment workshop was carried out in accordance with current risk assessment guidelines.

Table 4.4 Risk assessment results for subterranean fauna

Aspect (stressor)	Potential impacts	Likelihood	Consequence	Inherent risk	Assumptions/ Comments	Potential mitigation	Likelihood	Consequence	Residual risk	Assumptions/ Comments
Site disturbance / excavation	Direct loss of habitat	5	4	VERY LOW	Assumes stygofauna habitat is present across the entire site. The habitat is well below any earthworks required for construction or installation of services and present outside potential area of impact.					
Stormwater infiltration	Change in habitat suitability due to localised artificial infiltration of storm water. This could lead to localized mounding and flooding of the supporting habitat and minor habitat loss within OIE.	2	4	LOW	Assumes stygofauna habitat is present across the entire site. Low number of rainfall days.	Minimising impermeable surfaces. Recharge surface water close to catchment and equally distributed across OIE with local surface water infiltrated on site	2	5	VERY LOW	Mitigation to be incorporated into LWMS
Groundwater Abstraction	Reduction in habitat suitability due to abstraction of groundwater, leading to the drying out of the zone or zones where stygofauna may exist	4	4	VERY LOW	Assumes stygofauna habitat is present across the entire site. Low availability and quality of groundwater suggests that abstraction is unlikely, unless additional recharge to offset abstraction is achievable.					.

Aspect (stressor)	Potential impacts	Likelihood	Consequence	Inherent risk	Assumptions/ Comments	Potential mitigation	Likelihood	Consequence	Residual risk	Assumptions/ Comments
Physical presence of infrastructure	Reduction in habitat suitability due to partial sealing of recharge areas	2	4	LOW	Assumes stygofauna habitat is present across the entire site. Design mitigation includes minimising impermeable surfaces. Net recharge within the entire area is not likely to change however some areas may receive less or more recharge than before. Refer to the stormwater management DWMS.	Ensure each future industrial premise has upstream onsite infiltration of all hardstand areas, where these areas cannot be constructed of permeable materials.	3	5	VERY LOW	
Liquid waste disposal	Nutrient loading of subterranean habitats	2	4	LOW	Assumes stygofauna habitat is present across the entire site. Known plans for local wastewater treatment plant (LWTP) are proposed for the site. Nutrient loading from irrigation and/or infiltration of treated effluent. The LWTP in short term is proposing the infiltration of effluent.	Keep nutrient levels low in treated effluent. Use as feed water for water recycling (industry develops as outlined in Industrial Ecology Strategy) Irrigage/infiltrate on alternative sites within the buffer where stygofauna are not present	4	4	VERY LOW	Industry develops as outlined in Industrial Ecology Strategy

Aspect (stressor)	Potential impacts	Likelihood	Consequence	Inherent risk	Assumptions/ Comments	Potential mitigation	Likelihood	Consequence	Residual risk	Assumptions/ Comments
	Change in habitat by mounding of groundwater in the infiltration area	2	3	MED-IUM	Assumes stygofauna habitat is present across the entire site Other industries may require wet processing of minerals and waste water disposal on site	Short term lined evaporation ponds. Treat to use as feed for other industries or recycled onsite	4	4	VERY LOW	Industry develops as per IE strategy
Spills and leaks (acute / chronic / cumulative)	Contamination of subterranean habitats	5	6	VERY LOW	Assumes stygofauna habitat is present across the entire site. Bunded areas and spill management as per standard industrial licence requirements	No mitigation required.				
	Toxicity of subterranean habitat	5	6	VERY LOW	Assumes stygofauna habitat is present across the entire site. Bunded areas and spill management as per standard industrial licence requirements.	No mitigation required.				

5. Proposed mitigation measures

Stygofauna habitat is present beneath some areas of the proposed OIE, although the limited availability of information makes it difficult to delineate habitat areas. Therefore the mitigation and management measures identified within this section, to reduce the impacts on stygofauna habitat identified in Section 4, will be adopted for the entire estate.

There is also a requirement to prepare a District Water Management Strategy (DWMS) for the estate as part of the Structure Plan. The DWMS incorporates a range of objectives related to the management of surface water and groundwater resources including:

- Water quantity management – maintaining pre-development hydrological conditions and providing for ecological water requirements for sensitive environments
- Water quality management – maintaining and if possible improving water quality leaving the development area to meet relevant water quality guidelines (ANZECC, 2000) and managing stormwater in accordance with the Stormwater Management Manual for Western Australia (DoW, 2007)
- Stormwater modelling – achieving compliance with design parameters for reductions of at least 80 per cent total suspended solids, 60 per cent total phosphorus, 45 per cent of total nitrogen and 70 per cent of gross pollutants.
- Water conservation and efficiency – needs to capture the recycling and reuse opportunities by industry, detailed within the Industrial Ecology Strategy.

Potential impacts to subterranean fauna will be minimised through the following strategic design elements for development of the scheme amendment area. These elements are primarily designed to maintain and/or improve groundwater quality and quantity.

Pre construction

- Adoption of DWMS recommendations

During the construction phase

- **Contain spills**
  - Containment and cleanup of any hydrocarbon spills.
- **Provide permeable surfaces**
  - Use of permeable material for surfaces.
- **Treat stormwater/drainage from impermeable surfaces**
  - Ensure each future industrial premise has infiltration upstream of all hardstand areas, where these areas cannot be constructed of permeable materials.

Following the construction phase

- **Appropriate treatment of stormwater**
  - Maintain the effectiveness of swales and surface water drainage treatment measures for stormwater disposal.
- **Appropriate storage and treatment of wastewater**
  - Industries cannot inject or use local infiltration for waste water disposal which may increase groundwater levels artificially and risk flooding existing habitat.
  - Have appropriate waste water storage and treatment facilities to prevent release to the local environment.
- **Minimise groundwater abstraction**
  - No local abstraction of the groundwater so that the water table will only be subject to natural variations, avoiding drying of the zone or zones where these species may live.
- **Landscape Management**
  - Minimal use of fertilisers, with preference with slow release forms.
  - Predominantly native vegetation to be used in rehabilitation and landscaping therefore water demands unlikely to significantly change the hydrology of the area.

Because of the highly conservative assumptions regarding the extent of stygofauna habitat in the OIE, a specific industry may not be able to comply with these measures and may propose an alternative strategy. In the event future industrial proponents are not able to comply with the groundwater quality and quantity mitigation measures identified in the DWMS, they may choose to undertake a more detailed site specific investigation for presence or otherwise of stygofauna and, if stygofauna are found to be present, follow-up with a quantitative risk assessment.

6. Findings and recommendations

In considering the details presented for the above proposal, results from the stygofauna survey, other hydrogeological investigations and subsequent Qualitative Risk Assessment allow PB to conclude:

- Groundwater quality will not be changed as a result of this proposal.
- Other geomorphologic characteristics that may favour stygofauna habitat will not be affected by the proposal.
- The construction of hardstand areas as part of the Oakajee Industrial Estate (OIE) will result in only minor reductions to recharge which can readily be offset by stormwater infiltration
- The site has already been radically altered by wholesale clearing and agricultural land use over many decades, and future industrial use with attendant environmental controls will have far less impact on the groundwater regime than this historic unconstrained agricultural clearing and land use.

Stygofauna habitat and stygofauna species have been identified beneath some of the proposed development site at Oakajee, although the delineation of the habitat is uncertain. Against this background, estate-wide mitigation and management measures are proposed to remove any impact on potential stygofauna habitat

Residual risks for all potential impacts were assessed to be ‘low’ or ‘very low’ as a consequence of either low initial risk or effectiveness of proposed management measures to address potential impacts. This review therefore, concludes that the proposed development will cause no significant change to stygofauna habitat that may contain subterranean fauna

If in the future a specific industry chooses to deviate from groundwater quality and quantity mitigation measures identified in the DWMS, it may elect to undertake a more detailed site specific investigation for presence or otherwise of stygofauna and, if found to be present, follow-on with a quantitative risk assessment for their specific requirements.

7. References

AS/NZS ISO 31000:2009 'Risk management – Principles and guidelines'

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