

OUTER HARBOUR DEVELOPMENT FLORA AND VEGETATION ASSESSMENT



Job 08.216

Report RP001



Australia

OUTER HARBOUR DEVELOPMENT FLORA AND VEGETATION ASSESSMENT

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EXECUTIVE SUMMARY

ENV.Australia Pty Ltd was commissioned in October 2007 to undertake a terrestrial flora and vegetation assessment of BHP Billiton Iron Ore's proposed Outer Harbour Development (the project area). The project area covers approximately 20,303 ha and is located west and south-west of Port Hedland in the Pilbara region of Western Australia.

The flora and vegetation assessment was conducted in accordance with Guidance Statement No. 51 *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* of the WA Environmental Protection Authority. The objectives of the assessment were to document and describe the plant species and plant species of conservation significance in the project area, describe the vegetation associations and vegetation associations of conservation significance in the project area and assess potential impacts of the proposed development.

This flora and vegetation assessment involved summer and winter season surveys. The summer survey took place from 1-9 October 2007, with 22.5 person-days invested in the survey. Winter surveys took place from 5-15 May and from 26-30 May 2008, with 60 person-days invested in the survey. One hundred and twenty-six quadrats were surveyed during the summer survey, with these same quadrats plus an additional 96 quadrats, covering an additional rail option, conducted during the winter survey. A total of three hundred and ninety-four taxa were recorded across all surveys, with 250 taxa recorded during the summer survey, 279 during the winter survey of the revisited sites and 212 from the additional winter survey areas.

No Threatened species listed under the *Environment Protection and Biodiversity Conservation Act 1999*, or species listed as Declared Rare Flora under the *Wildlife Conservation Act 1950*, were recorded during the summer and winter surveys. Two Priority Flora species, *Tephrosia rosea* var. *venulosa* (Priority 1) and *Gymnanthera cunninghamii* (Priority 3), were recorded during the summer survey in low numbers, 16 and five individuals each, respectively. Five Priority Flora species were recorded during the winter survey: *Heliotropium muticum* (Priority 1), *Tephrosia rosea* var. *venulosa* (Priority 1), *Pterocaulon* sp. A Kimberley Flora (B.J. Carter 599) (Priority 2), *Goodenia nuda* (Priority 3) and *Gymnanthera cunninghamii* (Priority 3). Again, these species were recorded in low numbers, one, 17, two, one and four individuals each, respectively. Three of the five Priority Flora species recorded, *Heliotropium muticum*, *Tephrosia rosea* var. *venulosa* and *Pterocaulon* sp. A Kimberley Flora (B.J. Carter 599) will be disturbed by the proposed Outer Harbour Development.

A total of 10 introduced species were recorded during the surveys, of which four species were recorded in the summer survey and nine species recorded in the winter survey. During both seasons, introduced species were recorded at sites which were previously disturbed, predominately by cattle. Introduced species were recorded with generally a low percentage cover (less than 2 %), with the exception of *Aerva javanica* (up to 5 % cover) and *Cenchrus ciliaris* (up to 80 % cover).

One phreatophytic species, *Melaleuca argentea* was recorded within the Major Drainage Line A community within the project area. One vadophytic flora species, *Eucalyptus victrix*, was recorded within eight vegetation communities within the project area. These species are unlikely to be impacted by groundwater abstraction or dewatering associated with the construction of the project, as permanent aquifer drawdown is unlikely to occur and these species are located at distance from such activities.

A total of 34 vegetation communities (excluding areas devoid of vegetation) were identified and mapped by ENV.Australia Pty Ltd within the Outer Harbour Development project area, the majority of which are well represented in the Port Hedland area (exceptions are discussed below). These vegetation communities were delineated using information gathered during both the winter and summer surveys. Most of the survey sites from both the summer and winter surveys were classified as in Very Good vegetation condition. No communities listed as Threatened Ecological Communities or Priority Ecological Communities were recorded during the surveys.

One vegetation community considered to be of conservation significance, the mangroves, was identified in the project area. Although mangroves also occur outside of the project area and along the Pilbara coastline, disturbance to this community should be minimised. A separate assessment has been undertaken (SKM 2009a) to determine the impacts of the Outer Harbour Development on mangroves.

Four vegetation communities were identified as uncommon within the project area, the billabong, quartz outcrops, limestone hill and rockpile. These communities are considered to be of local significance, however are not of conservation significance. The rockpile is the only community to support species which were not recorded within the rest of the project area. Only the quartz outcrops are located within the proposed disturbance envelope.

The proposed Outer Harbour Development will result in a loss of vegetation and will impact upon the Priority Flora species *Heliotropium muticum*, *Tephrosia rosea* var. *venulosa* and *Pterocaulon* sp. A Kimberley Flora (B.J. Carter 599). Secondary impacts associated with the Outer Harbour Development include the risk of introduction and spread of introduced species, an increase in dust, a change in fire regimes and possible drainage shadow effects.

Excluding the mangroves, which are being assessed separately, the regional representation of flora and vegetation will not be affected by the proposed Outer Harbour Development.

1 INTRODUCTION

ENV.Australia Pty Ltd (ENV) was commissioned in October 2007 to undertake a terrestrial flora and vegetation assessment of BHP Billiton Iron Ore's proposed Outer Harbour Development in Port Hedland, Western Australia. This report documents the findings of flora surveys conducted in summer and winter within the proposed Outer Harbour Development project area.

The flora and vegetation assessment was conducted in accordance with the Environmental Protection Authority's *Guidance Statement No. 51 Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (Environmental Protection Authority (EPA) 2004). The objectives of the flora and vegetation assessment were to:

- document plant species in the project area;
- document and describe plant species of conservation significance in the project area;
- document and describe the vegetation associations in the project area;
- describe the conservation significance of vegetation associations in the project area;
- comment on seasonal differences in flora and vegetation within the project area; and
- undertake an impact assessment with reference to the proposed disturbance envelope.

1.1 LOCATION

The project area lies west and south-west of the towns of Port Hedland and South Hedland, and covers an area of 20,303 ha from Finucane Island to the decommissioned Boodarie Hot Briquette Iron (HBI) Plant and inland to the Newman to Port Hedland rail line in the south-east (Figure 1).

1.2 PROPOSED INFRASTRUCTURE

The proposed Outer Harbour Development terrestrial infrastructure is shown on Figure 2 and includes:

- three rail options, 2007 Rail Options A and B, and 2008 Rail Option C (the preferred rail option otherwise known as 'the proposed Western Spur

Railway') which originate from the area of the decommissioned Boodarie HBI Plant and connect with the existing Newman to Port Hedland rail line;

- stockyards to the north of the decommissioned Boodarie HBI Plant;
- four car dumpers and associated conveyor tunnels within the area of the decommissioned Boodarie HBI Plant;
- a transfer pad on Finucane Island; and
- an infrastructure corridor (including conveyors, access roadway and utilities) from the stockyards to the transfer pad.

To allow for the location of potential construction laydown areas, a liberal disturbance envelope surrounds the above proposed infrastructure (Figure 2), although it is unlikely that all of this area will be disturbed by the project.

1.3 PHYSICAL ENVIRONMENT

1.3.1 Climate

The Pilbara region has an arid-tropical climate with two distinct seasons, a hot summer from October to April and a mild winter from May to September. The Port Hedland area experiences a wide range of temperatures throughout the year, with an average temperature of 33.2 °C. During summer, maximum temperatures may reach 49.0 °C, whilst in winter, minimum temperatures may reach 3.2 °C (Bureau of Meteorology 2009).

Rainfall in the Pilbara is often sporadic, and can occur year-round. Port Hedland has average annual rainfall of 313.9 mm (Figure 3). Summer rainfall is a result either of tropical storms or of tropical cyclones that cross the coast and move inland. Winter rainfall is generally lighter, and is the result of cold fronts moving across the State.

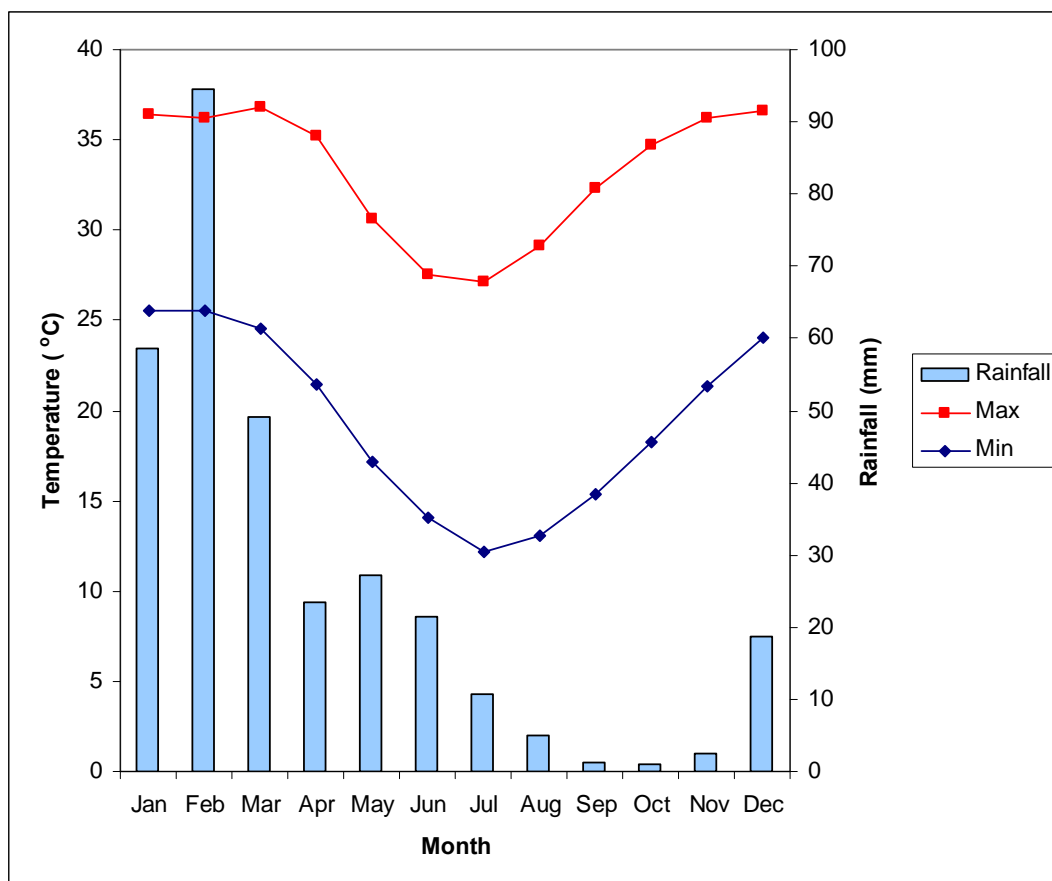


Figure 3: Average monthly rainfall and maximum and minimum temperatures for the Port Hedland area (Bureau of Meteorology 2009).

The summer season survey was completed in October 2007, while the winter season survey was completed in May 2008. The Port Hedland area had received relatively low amounts of rainfall preceding both surveys, with only 9.4 mm falling in the three months before the summer survey and 103.6 mm in the three months before the winter survey (Figure 4). The area received very little rainfall during the summer months, as few cyclones crossed the Western Australian coast in the 2007-2008 cyclone season (Bureau of Meteorology 2009). On average, the area receives 225.7 mm from January to April, but it received only 110 mm for this period in 2008.

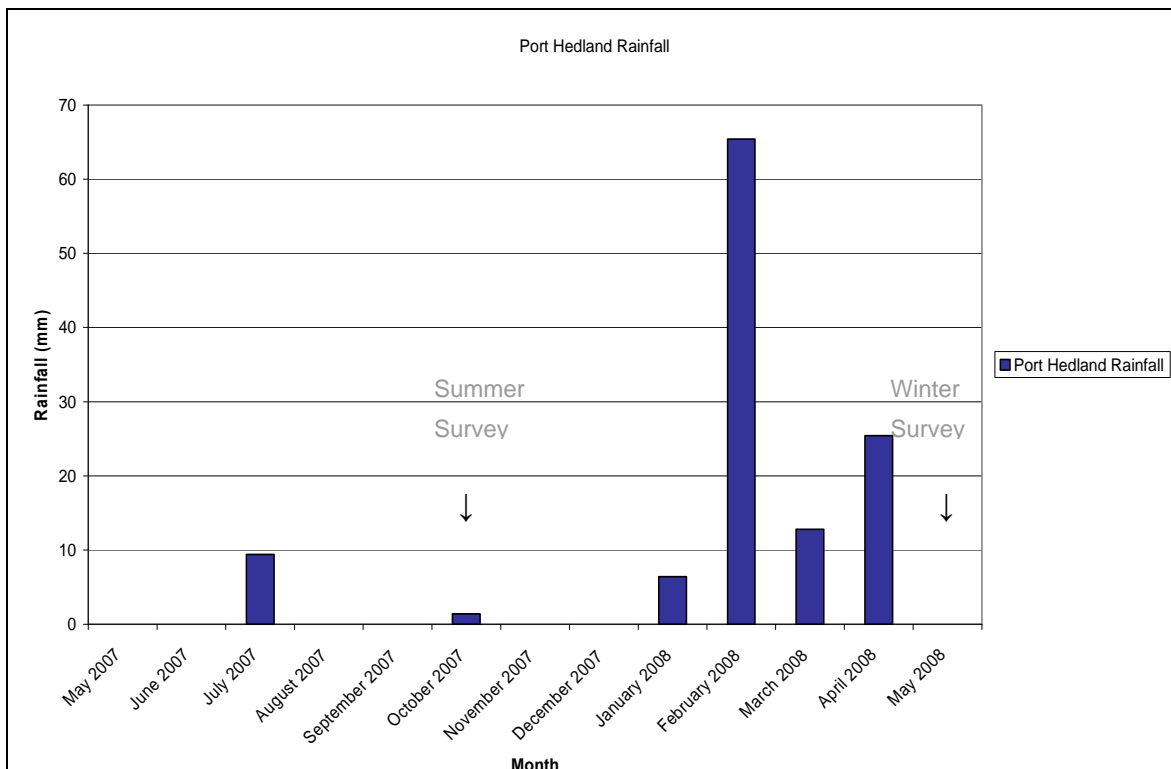


Figure 4: Rainfall received by the Port Hedland area from May 2007 to May 2008 (Bureau of Meteorology 2009).

1.3.2 Geology

The geology of the project area was mapped as consisting of the following nine units as per Geological Survey of Western Australia (1983) (Figure 5):

- Qhm: Mud and silt
- Qhs: Silty sand, red brown, containing *Anadara granosa*
- Qny: Younger beach and dune shelly sand
- Qr: Residual Sand
- Qp: Dune Limestone
- Ql: Lime cemented beach conglomerate
- Qc: Clayey sand, abundant claypans
- Qps: Silty sand, red brown
- Qs: High-level sands.

The geology of the far southern extent of project area is also mapped as consisting of the following four units as per Geological Survey of Western Australia (2001) (Figure 5):

Qao: Alluvial sand, silt and clay on floodplains.

Qaac: Mixed floodplain deposits with numerous small claypans.

Qaa: Alluvial sand and gravel in rivers and creeks; clay, silt, and sand in channels on floodplains.

AgLpe: Pegmatite; metamorphosed.

1.4 BIOLOGICAL ENVIRONMENT

The Interim Biogeographic Regionalisation for Australia (IBRA) divides Australia into 85 bioregions based on major biological and geographical/geological attributes (Thackway & Cresswell 1995). These bioregions are subdivided into 404 subregions, as part of a refinement of the IBRA framework (Department of Environment, Water, Heritage & the Arts ('DEWHA') 2005).

The project area is located within the Pilbara bioregion and Roebourne subregion (Thackway & Cresswell 1995). Coastal areas in the subregion typically contain alluvial and colluvial coastal and subcoastal plains with a grass savannah of mixed bunch and hummock grasses, and dwarf shrub steppe of *Acacia stellaticeps* or *Acacia pyrifolia* and *Acacia inaequilatera*. The subregion also contains areas of Samphire, *Sporobolus* and mangal on marine alluvial flats and river deltas.

The project area is located within the Abydos Plain, which forms part of the Fortescue Botanical District in the Eremaean Botanical Province of Western Australia, as per Beard (1975).

1.4.1 Land System

Land system mapping is based on regional patterns in topography, soils and vegetation. The most recent land system mapping of the Pilbara bioregion was completed by van Vreeswyk *et al.* (2004). The mapping divides the Pilbara region into 102 land systems. The project area includes four main land systems (Figure 6), which are:

Lit: Littoral: Bare coastal mudflats with mangroves on seaward fringes, samphire flats, sandy islands, coastal dunes and beaches; forms 0.9 % (1,577 km²) of the Pilbara bioregion.

- Uar: Uaroo: Broad sandy plains; supporting shrubby hard and soft Spinifex grasslands; forms 4.2 % (7,681 km²) of the Pilbara bioregion.
- Riv: Active flood plains and major rivers supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands; forms 2.3 % (4,088 km²) of the Pilbara bioregion.
- Mac: Stony plains and occasional tor fields based on granite supporting hard and soft spinifex grasslands; forms 7.2 % (13,095 km²) of the Pilbara bioregion.

1.4.2 Vegetation Mapping

Beard (1975) broadly mapped the project area as Spinifex with no shrubs or trees and Mangroves on Finucane Island, dwarf shrub steppe and grass savanna mixed with Spinifex near the Decommissioned Boodarie HBI Plant and through the middle of the project area, and granite plains near the BHPBIO Newman to Port Hedland railway in the south-east of the project area. Beard (1975) vegetation mapping has been incorporated into mapping undertaken by the Department of Agriculture (Shepherd *et al.* 2002), and is illustrated in Figure 7. The corresponding Shepherd *et al.* (2002) codes as shown on Figure 7 are presented in brackets below. The six vegetation associations mapped for the area are:

- t₁Hi: Hummock grasslands, grass steppe; soft Spinifex (AP117);
- Mud: Bare areas; mud flats (AP127);
- Mangroves: Thicket; mangroves (AP43);
- a₁₈Zr.t₁Hi: Hummock grasslands, dwarf-shrub steppe; Acacia over Spinifex (AP647);
- xGc/t₁Hi: Mosaic: short bunch grassland – savanna/grass plain (AP589); and
- a₂Sr.t₁Hi: Hummock grasslands, shrub steppe; kanji over soft Spinifex (APC93).

Under the Environmental Protection Authority's (EPA) *Position Statement 2* (EPA 2000), proposals should not take vegetation below the 'threshold level' of 30 % of the pre-European settlement extent of the vegetation association. Shepherd *et al.* (2002) give an estimate of the percentage of each of Beard's vegetation associations that remains compared to its pre-European settlement extent, so an estimate of the scarcity of each association can be determined. For the

vegetation association's $t_1\text{Hi}$, $a_{18}\text{Zr.t}_1\text{Hi}$, $x\text{Gc/t}_1\text{Hi}$ and $a_2\text{Sr.t}_1\text{Hi}$, it is estimated that 100 % of their pre-European settlement extent remains, and therefore the project will not cause the threshold to fall below the 30 % level.

1.5 PREVIOUS BIOLOGICAL SURVEYS

The flora and fauna of the Pilbara has historically been disparately recorded, with the significant exceptions of flora studies by Burbidge (1959) and Beard (1975). More recently, the Western Australian Department of Agriculture and Food (van Vreeswyk *et al.* 2004) conducted an inventory and condition survey of the Pilbara region. This report provides a regional inventory of flora species and a description of land resources. In addition, the results of a comprehensive and systematic field review by the Department of Environment and Conservation (DEC) of Pilbara regional flora is being prepared (DEC Pilbara Biological Survey 2002-2007), and is due for public release shortly.

In recent decades, a boom in large-scale regional resource development projects has resulted in a significant amount of site-specific biological survey work being carried out in the Pilbara, mostly for formal environmental approvals. Within 10km of the project area, various biological surveys have been conducted over the last 10 years. Those most relevant to the current survey are as follows:

- Hedland HBI Project – Boodarie Site – Flora, Vegetation and Vertebrate Fauna Survey (Mattiske Consulting 1994);
- Biodiversity Assessment of the Utah Point Berth Project (Biota 2007).
- Flora and Fauna Assessment of RGP5 Spoil Area A, Port Hedland Harbour (Biota 2008);
- Flora and Fauna Review of DMMA H (Biota 2009); and
- Flora and Vegetation Assessment for Port Hedland Nelson Point Dredging Approvals (ENV 2009a).

Those surveys conducted further afield from the project area (i.e. greater than 50km), include:

- Hope Downs Iron Ore Project (Hope Downs Management Services Pty Ltd 2000, 2002); and
- Fortescue Metals Group (Biota 2004).

A more comprehensive bibliography of biological survey work undertaken in the Pilbara is available at <http://science.dec.wa.gov.au/projects/pilbaradb/>.

2 METHODOLOGY

2.1 BACKGROUND TO SURVEY METHODOLOGY

All surveys undertaken by ENV are designed to meet the requirements of the following State and Federal legislation:

- *Environmental Protection Act 1986* (WA) ('EP Act 1986');
- *Wildlife Conservation Act 1950* (WA) ('WC Act 1950'); and
- *Environment Protection and Biodiversity Conservation Act 1999* (Cth) ('EPBC Act 1999').

The surveys were carried out in a manner designed to be compliant with the EPA requirements for the environmental surveying and reporting for flora and vegetation in Western Australia, as set out in the following documents:

- *Environmental Protection of Native Vegetation in Western Australia: Clearing of Native Vegetation with Particular Reference to Agricultural Areas. Position Statement No. 2* (EPA 2000);
- *Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3* (EPA 2002); and
- *EPA Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. Guidance Statement No. 51* (EPA 2004).

EPA Guidance Statement No. 51 (EPA 2004) outlines the expectations of the EPA and details the extent, design and intensity of field surveys for environmental assessments. Two formal levels of flora survey are defined by the EPA Guidance Statement No. 51:

- *Level One*: a 'desktop' study to collate historical knowledge conducted in conjunction with a reconnaissance survey (site inspection).
- *Level Two*: an intensive survey that incorporates a detailed and comprehensive survey to characterise the flora present, combined with a Level One survey.

Throughout most areas of the State where the scale and nature of the proposed impact is moderate to high, a Level Two survey will be required. This is typically the case for most resource development projects. As a high level of disturbance to flora is likely to be caused by the Outer Harbour Development project, a Level Two survey was developed.

2.2 PROTECTION OF FLORA AND VEGETATION

Flora species are protected formally and informally by various legislative and non-legislative measures, which are as follows:

Legislative Protection

EPBC Act 1999:

- Threatened Flora Species; and
- Threatened Ecological Communities (TECs).

WC Act 1950:

- Declared Rare Flora species.

EP Act 1986:

- offers protection to Declared Rare Flora species, TECs and other environmentally sensitive areas.

Non-Legislative Protection

DEC Priority lists:

- Priority Flora species; and
- Priority Ecological Communities (PECs).

Informal recognition by the DEC of locally significant populations:

- endemic species;
- range extensions; and
- previously undescribed taxa.

Conservation categories and definitions are presented in Appendix A for Declared Rare and Priority Flora species and Threatened and Priority Ecological Communities.

2.3 INTRODUCED SPECIES

The Environmental Weed Strategy for Western Australia (Department of Conservation & Land Management 1999) contains criteria for the assessment and ranking of weeds in terms of their environmental impact on biodiversity. The strategy defines environmental weeds as 'plants that establish themselves in

natural ecosystems and proceed to modify natural processes, usually adversely, resulting in the decline of the communities they invade.'

Plants may also be 'Declared' by the Agriculture Protection Board under the *Agriculture and Related Resources Protection Act 1979* (WA). Declared Plants are gazetted under five categories (P1-P5), which define the action required. Details of the definitions of these categories are provided in Appendix B. A declaration may apply to the whole State, to districts, individual properties or even to single paddocks. If a plant is Declared, landholders are obliged to control that plant on their properties (Department of Agriculture and Food ('DAFWA') 2007).

2.4 SURVEY METHODOLOGY

2.4.1 Desktop Review

The purpose of the desktop review was to gather background information on the project area and the flora species and vegetation it may support. This involved a search of literature, data, aerial photographs and maps for information pertaining to landforms likely to be found in the area.

A request for a database search was submitted to the DEC to ascertain whether any Declared Rare or Priority species have been recorded within the project and surrounding areas. A similar process was followed to establish whether there were any Threatened or Priority Ecological Communities in the project area. The search was conducted within coordinates 20° 17' 6"S, 118° 27' 13"E to 20° 33' 26"S, 118° 39' 40"E. Due to the duration of this project, a DEC database search was submitted in both 2007 and 2009. In addition, a literature review was conducted, along with a review of historical and current records of flora species for the project area. Collectively, these sources were used to compile a list of expected Declared Rare or Priority species, and TECs or PECs that could potentially occur within the project area.

2.4.2 Field Survey

The flora and vegetation assessment for the project area involved summer and winter season surveys. The summer survey took place from 1-9 October 2007, with 22.5 person-days invested in the survey, while the winter survey took place from 5-15 May 2008 and 26-30 May 2008, with 60 person-days invested in the survey.

The field survey consisted of two main parts:

- 'Summer Survey' – Establishment and survey of 126 quadrats in October 2007;

- 'Winter Survey' – Resurveying in May 2008 of the 126 quadrats (labelled 'QR') set up in October 2007 and establishment and survey of an additional 96 quadrats.

The location of quadrats ('sites'), were selected on the basis of being representative of the flora and vegetation of the project area. Sites visited in the summer survey are labelled QT with data collected at these sites when revisited in the winter survey labelled QR (in appendices). Additional sites completed in the winter survey are labelled QN (Figure 8).

Flora and vegetation assessment field staff collected flora information using 50 m x 50 m quadrats, as preferred by DEC (pers. comm., S. van Leeuwen, DEC). Relévés¹ and opportunistic collections were also undertaken in the additional winter survey areas. For areas in which a 50 m x 50 m quadrat was inappropriate, suitable quadrat dimensions were used whilst maintaining the same total search area.

The locations of the 126 quadrats from the summer survey, all of which were revisited in the winter survey, and the additional 96 quadrats from the winter survey are presented in Appendix C and in Figure 8. Site photographs are presented in Appendix D.

Data was recorded at all sites using standardised field sheets. The information noted at each site included landscape features, soils, bare ground and disturbance. Vegetation condition was also rated using the scale presented in Appendix E. Each species of plant at each site was recorded, including information on height and percentage cover (data sheets are presented in Appendix F). The opportunistic collections and relévés focussed mainly on the location of new flora taxa not recorded in the quadrats, and in particular on Priority Flora, and flora not well known or not currently described.

Access to the western side of the conveyor to Finucane Island was physically restricted by the presence of the existing Finucane Island causeway during the surveys, and an area of 4.5 km x 0.5 km was therefore not surveyed by ENV. Quadrats were therefore established on the eastern side of the conveyor in vegetation that was considered representative of the western side of the conveyor. Sites were chosen using aerial photographs to match vegetation types occurring on both sides of the conveyor. Part of the western side of the conveyor was surveyed in February 2008 by Biota (Biota 2008), with this information used to confirm vegetation mapping of the area.

¹ For the purposes of this flora and vegetation assessment, a **relévé** is defined as an unconfined survey area in which a general statement about the floristic composition of the location can be made.

2.4.3 Taxonomic Identification

Where field identification of plant taxa was not possible, specimens were collected systematically for later identification by expert taxonomists utilising the resources of the Western Australian Herbarium. Species were identified through comparison with the reference collection and the use of identification keys.

The project species list was checked against FloraBase (Western Australian Herbarium 2009) and Atkins (2008) Declared Rare and Priority Flora list to determine whether any of the identified species were listed as Rare or Priority species. Species were also checked against the EPBC Act 1999 listing of TECs or PECs.

2.4.4 Vegetation Association Mapping

Quadrat vegetation descriptions were used to delineate vegetation associations in the project area. These vegetation associations were then mapped using notes and maps created in the field. Once the vegetation associations were determined, they were also checked against the listing of State and Commonwealth Threatened or Priority Ecological Communities. Vegetation mapping focussed on areas in which proposed infrastructure was planned.

2.5 PERMITS

Specimens collected during the survey were taken by permit of and subject to the conditions of the following licences issued under sections 23C and 23F of the WC Act 1950:

- SL008004 to Emma Carroll;
- SL008015 to Ciaran Sgherza;
- SL008009 to Breanne Cook;
- SL008007 to Matthew Love;
- SL008010 to Todd Edwards; and
- SL008114 to Katherine Chuk.

3 FLORA SURVEY LIMITATIONS AND CONSTRAINTS

It is important to note the specific constraints imposed on individual surveys. Constraints are often difficult to predict, as is the extent to which they influence survey outcomes. Survey constraints of the Outer Harbour Development flora and vegetation survey are detailed in Table 1.

Table 1: Limitations and Constraints Associated with the Outer Harbour Development Flora and Vegetation Surveys

Variable	Impact on Survey Outcomes
Access Problems	Access to an area 4.5 km long on the western side of the conveyor to Finucane Island was restricted during both the summer and winter surveys. This area was therefore not surveyed, but representative quadrats were placed in similar vegetation to the east of the conveyor. This area has previously been surveyed by Biota (2008).
Experience levels	The biologists who executed these surveys were practitioners suitably qualified in their respective fields. <ul style="list-style-type: none"> • Ms Emma Carroll – Biologist • Ms Ciaran Sgherza – Biologist • Ms Breanne Cook – Biologist • Mr Mathew Love – Biologist • Mr Todd Edwards – Botanist • Ms Katherine Chuk – Field Assistant • Mr Malcolm Trudgen – Taxonomist
Timing ² , weather, season.	The summer survey was undertaken from 1-9 October 2007. During the three months preceding the survey (July-September) the area received 9.4 mm of rainfall, and a total of 504.8 mm in the year preceding the commencement of the survey (Bureau of Meteorology 2009). The winter survey was undertaken from 5-15 May 2008 and 26-30 May 2008. The area had received 110 mm of rain in the year to date (January-April). The area received very little rainfall during the summer months, as few cyclones crossed the WA coast in the 2007-2008

² EPA Guidance Statement 51 (2004) stipulates that flora and vegetation surveys should be undertaken following the season that contributes the greatest rainfall in the region. In the Eremaean Province, this is after summer. Short-term variations in normal weather patterns (e.g. drought) may necessitate supplementary survey work at other times of year or in later years to take into account temporal changes in diversity.

Variable	Impact on Survey Outcomes
	<p>cyclone season (Bureau of Meteorology 2009). On average, the area receives 224.6 mm during January to April.</p> <p>Flora composition changes over time, with flora species having specific growing periods, especially annuals and ephemerals (some plants lasting for a markedly brief time, some only a day or two). Therefore the results of future botanical surveys in this location may differ from the results of this survey (comparisons between surveys are discussed in Section 5.1).</p>
Completeness	<p>During the summer survey the relatively low level of rainfall meant that most plant species were not in fruit or in flower, and some annuals lacked sufficient foliage to allow identification.</p> <p>For the winter survey, the low level of rainfall received by the area over the summer months resulted in few annuals and ephemerals being present, and a number of species were not in flower. <i>Triodia</i> species were in flower in some areas.</p> <p>Species with insufficient material to be identified or those which were dead were either not collected or, where possible, were identified in the field to genus or family level only.</p> <p>A comprehensive species list has not been prepared for areas that do not constitute a natural vegetation area, such as areas that have been totally cleared.</p> <p>The summer survey recorded 250 taxa, including species, subspecies, and variants, while the winter survey recorded 279 taxa. A further 212 taxa were recorded from the additional winter survey areas.</p> <p>A total of 394 taxa were recorded from the proposed Outer Harbour Development project area across all surveys. This compares favorably with a survey undertaken in the area by Mattiske Consulting (1994) which recorded 107 taxa.</p>
Sources of information	<p>At the bioregion level, the Pilbara has been relatively well studied. Numerous flora and vegetation assessment surveys have been undertaken in the area as part of the environmental impact assessments. Previous studies completed in the vicinity of the project area include those completed for the Utah Point berth, RGP5 Spoil Area A and Area H and the Boodarie Iron Plant (Biota 2007, 2008, 2009; ENV 2009a; Mattiske Consulting 1994). Surveys completed further afield include those completed for the Hope Downs rail line, Fortescue Metals Group rail line (Hope Downs 2000, 2002; Biota 2004).</p> <p>An assessment of mangroves in the project area has been completed (SKM 2009a).</p>

Variable	Impact on Survey Outcomes
Determination	<p>This survey makes inferences about vegetation types that have the potential to be TECs. However, a decision as to the presence or absence of TECs in the project area remains the responsibility of the DEC's Species and Communities Branch.</p> <p>The taxonomy and conservation status of the Western Australian flora are dynamic. While this report was prepared in reliance on taxonomy and conservation current at the time of preparation, it should be noted this may change.</p>

4 RESULTS

4.1 DESKTOP REVIEW

The desktop review of the project area resulted in no EPBC Act 1999 listed species, no Declared Rare Flora species and 10 Priority Flora species being identified as potentially occurring in the project area (Table 2). The desktop review also determined that no TECs or PECs are known to occur in the project area.

Table 2: Priority Flora Species Potentially Occurring in the Project Area

Species	Code	Description (Western Australian Herbarium 2009)	Distribution (Atkins 2008)	Recorded in Previous Surveys
<i>Crotalaria spectabilis</i> subsp. <i>spectabilis</i>	P1	Annual herb.	Port Hedland	-
<i>Heliotropium muticum</i>	P1	Ascending to spreading perennial herb	Port Hedland	-
<i>Ptilotus appendiculatus</i> var. <i>minor</i>	P1	Prostrate or ascending perennial, herb or shrub.	Port Hedland, Boodarie	-
<i>Tephrosia rosea</i> var. <i>venulosa</i>	P1	Erect shrub to 1.7m. Red sands near creeks.	Port Hedland, Finucane Island.	Recorded south of Lumsden Point, Port Hedland (ENV 2009a)
<i>Euphorbia clementii</i>	P2	Erect herb, to 0.6 m high. Gravelly hillsides, stony grounds.	Port Hedland area, Yarrie.	-
<i>Gomphrena pusilla</i>	P2	Slender branching annual herb, to 0.2 m high. Fine beach sand, behind foredune, on limestone.	Dampier Peninsula, Port Hedland	-
<i>Pterocaulon</i> sp. A Kimberley Flora (B.J. Carter 599)	P2	Compact shrub, to 0.5 m high. Coastal areas and saline sandy flats.	West Kimberley, Anna Plains Homestead, Anjo Peninsula	Recorded south of Lumsden Point, Port Hedland (ENV 2009a)

Species	Code	Description (Western Australian Herbarium 2009)	Distribution (Atkins 2008)	Recorded in Previous Surveys
<i>Acacia glaucocaesia</i>	P3	Dense shrub or tree, 1.8–6 m high. Floodplains with red loam, sandy loam or clay.	Port Hedland, Mardie, Roebourne, De Grey	-
<i>Bulbostylis burbridgeae</i>	P3	Tufted annual herb, 0.03–0.25 m high. Granite outcrops and cliff bases.	Mount Edgar, Gorge Creek, Abydos-Woodstock	Recorded by Biota (2007) at Utah Point and within FMG rail line (Biota 2004)
<i>Gymnanthera cunninghamii</i>	P3	Erect shrub, 1–2 m high. Sandy soils.	Dampier Archipelago, Boodarie, 80 Mile Beach	Recorded within both the FMG and Hope Downs rail lines (Biota 2004; Hope Downs Management Services 2002)

4.2 FIELD SURVEY

4.2.1 Flora

A total of 394 taxa (including species, subspecies and variants) were identified within the project area across all surveys. These 394 taxa represented 58 families and 158 genera. The most commonly recorded families were Poaceae (57 taxa), Papilionaceae (45 taxa) and Malvaceae (25), while the most commonly recorded genera were *Acacia* (22 taxa) and *Sida* (12 taxa).

Summer Survey

Two hundred and fifty taxa (including species, subspecies and variants) were identified during the summer survey. These 250 taxa represented 51 families, 22 of which were represented by only one taxon, and 120 genera, 78 of which were represented by only one taxon (refer to Appendix G for the flora species inventory).

The plant families most frequently recorded from the summer survey were as follows:

- Poaceae (38 taxa);
- Papilionaceae (24 taxa); and
- Malvaceae (19 taxa).

The most frequently recorded genera from the survey were:

- *Acacia* (16 taxa); and
- *Sida* (eight taxa).

The most common taxon recorded in the summer survey was *Acacia stellaticeps*, which was recorded at 91 of the 126 sites, followed by *Triodia epactia*, which was recorded at 83 sites, and *Eriachne obtusa*, which was recorded at 70 sites. A flora species matrix is presented in Appendix H.

Winter Survey

Three hundred and thirty-four taxa (including species, subspecies and variants) were recorded during the winter survey, with 42 of these taxa recorded only within the additional areas. These represented 56 families, with 26 represented by only one taxon, and 149 genera, 93 of which only had one representative. The plant families most frequently recorded from the survey were:

- Poaceae (51 taxa);
- Papilionaceae (42 taxa);
- Malvaceae (20 taxa); and
- Amaranthaceae (20 taxa).

The most frequently recorded genera from the survey were:

- *Acacia* (17 taxa); and
- *Tephrosia*, *Sida* and *Euphorbia* (10 taxa).

The most common taxa recorded in the winter survey were *Triodia epactia*, which was recorded at 194 of the 236 sites, followed by *Acacia stellaticeps*, which was recorded at 173 sites.

Comparison of Summer Sites Revisited in Winter

One hundred and seventy-three taxa were recorded in both the summer and winter surveys at the revisited sites (i.e. excluding additional winter survey area), with 178 taxa recorded from only one survey. Of the 178 taxa recorded in only one survey, 74 taxa were recorded only in the summer survey and 104 taxa only in the winter survey.

4.2.2 Flora of Conservation Significance

A summary of all protected flora located during the surveys can be found in Appendix I, and the locations of these are mapped on Figure 9. The results are discussed below.

Summer Survey

No Threatened species listed under the EPBC Act 1999 were located during the summer survey.

No plant taxa listed as Declared Rare under the WC Act 1950 were located during the summer survey.

Two Priority Flora species, *Tephrosia rosea* var. *venulosa* (Priority 1) and *Gymnanthera cunninghamii* (Priority 3), were recorded during the summer survey. The Priority species *Tephrosia rosea* var. *venulosa* and *Gymnanthera cunninghamii* were recorded in low numbers (see Table 3). While the locations of *Gymnanthera cunninghamii* are outside the proposed disturbance envelope, one of the seven sites at which *Tephrosia rosea* var. *venulosa* was recorded (Site QT003) will be impacted by the proposed transfer pad on Finucane Island (see Figure 9).

Table 3: Priority Flora Species Recorded During the Summer Survey

Taxa	Conservation Code	Site	Number of Individuals	Habitat
<i>Tephrosia rosea</i> var. <i>venulosa</i>	Priority 1	QT003	One	Dune
		QT004	One	Dune
		QT005	Nine	Dune
		QT023	Two	Plain
		QT050	One	Sand Plain
		QT055	Two	Sand Plain
<i>Gymnanthera cunninghamii</i>	Priority 3	QT074	Four	Drainage Line
		QT087	One	Drainage Line

Winter Survey

No Threatened species pursuant to the EPBC Act 1999 were located during the winter surveys.

No plant taxa gazetted as Declared Rare pursuant to the WC Act 1950 were located in the project area.

Five Priority Flora species were recorded during the winter survey, the details of which are summarised in Table 4. No species of conservation significance were recorded in the additional winter areas only. Three of the five species, *Heliotropium muticum*, *Pterocaulon* sp. A Kimberley Flora (B.J. Carter 599) and *Tephrosia rosea* var. *venulosa*, occur within the proposed disturbance envelope. Two locations of the *Heliotropium muticum* will be impacted upon by the development. One *Pterocaulon* sp. A Kimberley Flora (B.J. Carter 599) individual is located within the proposed disturbance envelope of the 2008 rail loop (Figure 9). Two of the eight locations of *Tephrosia rosea* var. *venulosa* are within the disturbance envelope (see Figure 9).

All of the records of *Goodenia nuda* and *Gymnanthera cunninghamii* are located outside of the proposed disturbance envelope (Figure 9). Additional survey work was undertaken in October 2008 by ENV to map the extent of *Pterocaulon* sp. A Kimberley Flora (B.J. Carter 599) in the stockyard area, however no individuals were recorded during this work.

Comparison of Summer Sites Revisited in Winter

During both the summer and winter surveys of the original 126 sites, four individuals of *Gymnanthera cunninghamii* were recorded at site QT074. An individual of *Gymnanthera cunninghamii* was also recorded at site QT087 during the summer survey, but this species was not recorded at this site during the winter survey. Of the 12 sites at which *Tephrosia rosea* var. *venulosa* was recorded, only two sites recorded *Tephrosia rosea* var. *venulosa* during both the summer and winter surveys.

One record of an individual *Goodenia nuda*, seven records of individual *Heliotropium muticum* and two records of individual *Pterocaulon* sp. A Kimberley Flora (B.J. Carter 599) were made during the winter survey, whereas no records of these species were made during the summer survey.

Table 4: Priority Flora Species Recorded During the Winter Survey

Taxa	Conservation Code	Site	Number of Individuals	Habitat
<i>Heliotropium muticum</i>	Priority 1	QT126	One	Spinifex Plain
		QN011	One	Sand Plain
		QN014	One	Sand Plain
		QN031	One	Sand Plain
		QN070	One	Sand Plain
		QN072	One	Sand Plain
		QN073	One	Sand Plain
<i>Tephrosia rosea</i> var. <i>venulosa</i>	Priority 1	QT002	Two	Dune
		QT003	One	Dune
		QT005	Eight	Dune
		QT007	One	Dune
		QT009	One	Dune
		QT010	Two	Dune
		QT054	One	Sand Plain
		QT094	One	Plain
<i>Pterocaulon</i> sp. A Kimberley Flora (B.J. Carter 599)	Priority 2	QT026	One	Spinifex Plain
		QT033	One	Spinifex Plain
<i>Goodenia nuda</i>	Priority 3	QT061	One	Spinifex Plain
<i>Gymnanthera cunninghamii</i>	Priority	QT074	Four	Drainage Line

4.2.3 Locally Significant Flora

The locations of locally significant flora are detailed in Appendix J, and results are summarised below.

Summer Survey

Three taxa of special interest were recorded during the summer survey: *Tephrosia rosea*, *Goodenia* sp. and liliaceous species.

A collection made during the summer survey was tentatively identified as being from the *Tephrosia rosea* complex. This collection may represent the Priority Flora species *Tephrosia rosea* var. *venulosa*. This specimen was recorded from outside of the proposed disturbance envelope.

One specimen of *Goodenia* was collected, but was in poor condition and could not be identified to species level. This collection may represent the Priority Flora species *Goodenia nuda* (Priority 3). This specimen was recorded outside the proposed disturbance envelope.

Two collections of a liliaceous species do not appear to represent taxa from the Pilbara (pers. comm., M. Trudgen). These collections possibly represent a range extension from the south-west Kimberley, and further collection following rain may assist in identification (pers. comm., M. Trudgen). These collections were recorded as occurring at 10 sites, two of which (sites QT025 and QT036) are within the proposed disturbance envelope for the Boodarie stockyards (see Figure 8).

Winter Survey

One species of interest was recorded during the winter survey, *Eriachne sulcata*.

Eriachne sulcata was recorded from seven locations within the additional winter survey areas (Appendix J3). This species is commonly recorded in the Kimberley region, but is considered rare in the Pilbara, and has only one known record in the region, at Nimingarra. The collection of this species within the Outer Harbour Development is considered a 100 km range extension, and represents the southernmost locality of this species (pers. comm., M. Trudgen). The species was recorded in small depressions within the Sandplain N vegetation community (see Plate 1). None of the seven locations of *Eriachne sulcata* are within the proposed disturbance envelope.



Plate 1: *Eriachne sulcata*

Comparison of Summer Sites Revisited in Winter

The *Tephrosia rosea* complex collection made during the summer survey was confirmed to also be *Tephrosia rosea* var. *venulosa* in October 2008 when further collections were made by ENV. The collection of *Goodenia* obtained during the summer survey may have been *Goodenia nuda*, as this species was recorded during the winter survey. No further collections of the liliaceous species were made during the winter survey.

4.2.4 Introduced Species

A total of 10 introduced species were recorded within the project area during both the summer and winter surveys, four during the summer survey and nine from the winter survey. No species were recorded in the additional winter areas which were not recorded in the revisited sites. The introduced species identified during the field surveys, with their ratings and criteria according to the Environmental Weed Strategy for Western Australia (CALM 1999) (refer to Appendix B for the criteria used for rating species) are included in subsequent tables. Fifty-eight sites contained introduced species, with the locations of these introduced species presented in Appendix K and Figure 10. No plant taxon recorded was listed as a Declared Plant by DAFWA (2007).

Summer Survey

Four introduced species were recorded during the summer survey (Table 5). A total of 51 sites contained an introduced species, with 14 containing two introduced species.

Table 5: Introduced Flora Species Recorded During the Summer Survey

Taxon	Common Name	Rating (CALM 1999)	Criteria			Number of Sites
			Invasiveness	Distribution	Impacts	
* <i>Aerva javanica</i>	Kapok	High	Yes	Yes	Yes	15
* <i>Cenchrus ciliaris</i>	Buffel Grass	High	Yes	Yes	Yes	49
* <i>Chloris virgata</i>	Feathertop Rhodes Grass	Low	-	-	-	1
* <i>Citrullus colocynthis</i>		Low	-	-	-	1

Winter Survey

Nine introduced species were recorded during the winter survey (Table 6). Of the revisited sites, forty-six sites contained an introduced species, 17 sites contained two introduced species, three sites had three introduced species and one site, QT115, contained five introduced species. QT115 is located in a major drainage line in Good to Poor condition in the south of the project area, directly adjacent to the existing BHP Billiton Newman to Port Hedland rail line. Twenty-four of the additional winter survey area sites contained introduced species.

Table 6: Introduced Flora Species Recorded During the Winter Survey

Taxon	Common Name	Rating (CALM 1999)	Criteria			Number of Sites
			Invasiveness	Distribution	Impacts	
* <i>Aerva javanica</i>	Kapok	High	Yes	Yes	Yes	32
* <i>Cenchrus ciliaris</i>	Buffel Grass	High	Yes	Yes	Yes	50
* <i>Stylosanthes hamata</i>	Verano Stylo	Mild	-	Yes	-	1

Taxon	Common Name	Rating (CALM 1999)	Criteria			Number of Sites
			Invasiveness	Distribution	Impacts	
* <i>Citrullus colocynthis</i>	-	Low	-	-	-	1
* <i>Digitaria ciliaris</i>	Summer Grass	Low	-	-	-	2
* <i>Merremia dissecta</i>	-	Low	-	-	-	1
* <i>Setaria verticillata</i>	Whorled Pigeon Grass	Low	-	-	-	2
* <i>Cucumis melo</i> subsp. <i>agrestis</i>	Ulicardo Melon	TBA	-	-	-	8
* <i>Portulaca oleracea</i>	Purslane	Not Listed	-	-	-	6

Comparison of Summer Sites Revisited in Winter

Collections of **Aerva javanica* at summer sites increased when revisited during winter. This species was recorded at 15 locations during the summer survey, compared with 23 locations during the winter survey. Conversely, collections of **Cenchrus ciliaris* decreased during the winter survey. This species was recorded at 49 locations during the summer survey and at 41 locations during the winter survey. A record of **Citrullus colocynthis* was made during both summer and winter surveys, at site QT115.

Six additional introduced species were recorded at summer sites revisited during winter that were not recorded during the summer survey: **Stylosanthes hamata*, **Merremia dissecta*, **Digitaria ciliaris*, **Setaria verticillata*, **Portulaca oleracea* and **Cucumis melo* subsp. *agrestis*. **Chloris virgata* was the only introduced species recorded during the summer survey that was not collected during the winter survey. None of these species, however, were widespread, with all recorded only at one or two locations.

4.2.5 Phreatophytic and Vadophytic Flora

Phreatophytic flora species are those which rely on groundwater sources for water uptake (Halpern, Glick and Maunsell 1999). One phreatophytic species, *Melaleuca argentea* was recorded at 3 sites during the surveys with a percentage cover of between 5 % and 12 %.

Vadophytic flora species are those which primarily rely on water held in the vadose (unsaturated) zone above the water table for water uptake (Jones *et al.* 1990). One vadophytic flora species, *Eucalyptus victrix* was recorded at 34 sites during the surveys with a percentage cover of between 1 % and 30 %.

4.2.6 Vegetation

A total of 34 vegetation communities (excluding areas devoid of native vegetation such as disturbed, washout and bare sand/reef areas) were mapped by ENV within the Outer Harbour Development project area. These vegetation communities were delineated using information gathered during both surveys. The vegetation communities, descriptions, example sites and vegetation condition are presented in Table 7 and are mapped in Figure 11.

Three vegetation communities were recorded within the additional winter survey areas that were not previously encountered in the original project area: Sandplain J, Sandplain K and Sandplain L. The Low Hill vegetation community covered most of the 2008 rail option (shown on Figure 2). This low hill community covers Boodarie Hill, which runs from the Decommissioned HBI Plant in the north towards Great Northern Highway in the south.

Four communities were considered uncommon in the project area, the billabong, rockpile, limestone hill and quartz outcrops. The billabong is locally known as Cooliarin Pool, and is considered uncommon as it is a permanent water body. The vegetation of the area surrounding Cooliarin Pool however was considered to be similar to that in the surrounding area and was largely degraded. The rockpile is, located to the west of the billabong, contains a number of tree species not commonly recorded throughout the rest of the project area, including *Ficus brachypoda* and *Clerodendrum tomentosum* var. *lanceolatum*. Neither of these species however are of conservation significance and both have records in the Port Hedland area on Florabase (Western Australian Herbarium 2009). The quartz outcrops are located to the east of the Fortescue Metals Group rail line and are an uncommon feature within the sand plains however they do not support any unique flora. The billabong, limestone hill and rockpile communities are located outside of the project disturbance envelope, however, one of the small quartz outcrops is located within the disturbance envelope (Figure 11). These four communities are considered to be locally significant, however are not considered to be of conservation significance.

One vegetation community, the mangroves, is considered of conservation significance. The mangroves are listed by Kendrick and Stanley (2001) as a wetland of subregional significance and are considered of high conservation value under the *Guidance for the Assessment of Environmental Factors: Protection of tropical arid zone mangroves along the Pilbara coastline, Guidance Statement No. 1* (EPA 2001). As a portion of this community is located within the project

disturbance envelope, a separate mangrove impact assessment has been undertaken (SKM 2009a).

Six of the vegetation communities mapped during the surveys match those previously mapped by Matiske Consulting (1994) in the Boodarie area. Two vegetation communities mapped during the surveys match those previously mapped by Biota (2008) in the DMMA A area.

The phreatophytic species *Melaleuca argentea* was recorded within the Major Drainage Line A vegetation community. The vadophytic species, *Eucalyptus victrix*, was recorded within the Billabong, Major Drainage Line A, Major Drainage Line B, Drainage Line A, Drainage Line B, and Sandplain D, E and P vegetation communities.

Table 7: Vegetation Communities of the Outer Harbour Development Project Area

Vegetation community	Vegetation description	Example sites	Vegetation condition
Mangroves (PH6)	A high closed <i>Ceriops tagal</i> and <i>Avicennia marina</i> shrubland.	QT12, QT14, QT17	Very Good to Excellent
Dunes A	Scattered <i>Acacia bivenosa</i> shrubs over a low open <i>Crotalaria cunninghamii</i> shrubland over a * <i>Cenchrus ciliaris</i> tussock grassland over scattered * <i>Aerva javanica</i> herbs.	QT02, QT03, QT10	Very Good to Excellent
Dunes B	An <i>Atalaya hemiglauca</i> , <i>Santalum lanceolatum</i> and <i>Acacia bivenosa</i> shrubland over a * <i>Cenchrus ciliaris</i> tussock grassland.	QT07	Good
Dunes C (PH8)	A low open <i>Acacia stellaticeps</i> , <i>Acacia bivenosa</i> and <i>Acacia ampliceps</i> shrubland over a <i>Spinifex longifolius</i> and * <i>Cenchrus ciliaris</i> open grassland over scattered <i>Gomphrena canescens</i> herbs.	QT01	Very Good
Samphire A	Scattered <i>Avicennia marina</i> shrubs over a low open <i>Halosarcia halocnemoides</i> , <i>Threlkeldia diffusa</i> and <i>Halosarcia pterygosperma</i> subsp. <i>denticulata</i> shrubland over a very open <i>Eragrostis falcata</i> tussock grassland.	QT06	Very Good
Samphire B (PH5) [ST]	Scattered <i>Avicennia marina</i> shrubs over a low open <i>Halosarcia halocnemoides</i> subsp. <i>tenuis</i> , <i>Halosarcia halocnemoides</i> and <i>Trianthema turgidifolia</i> shrubland.	QT15, QT19	Very Good

Vegetation community	Vegetation description	Example sites	Vegetation condition
Limestone Hill	An <i>Acacia bivenosa</i> and <i>Hakea lorea</i> subsp. <i>lorea</i> shrubland over scattered low <i>Rhagodia eremaea</i> and <i>Scaevola spinescens</i> shrubs over a scattered <i>Eriachne obtusa</i> tussock grasses.	QT16	Good to Very Good
Grassland A [GL]	<i>Triodia secunda</i> and <i>Triodia epactia</i> hummock grassland.	QT18	Very Good
Grassland B	<i>Triodia epactia</i> hummock grassland.		Good
Low Hill	An <i>Acacia tumida</i> var. <i>pilbarensis</i> shrubland over a low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland.	QN58, QN61, QN65	Very Good to Excellent
Major Drainage Line A (PH9)	Scattered low <i>Eucalyptus victrix</i> trees over a high open <i>Melaleuca argentea</i> , <i>Acacia ampliceps</i> and <i>Acacia trachycarpa</i> shrubland over scattered <i>Adriana urticoides</i> var. <i>urticoides</i> and <i>Pluchea ferdinandi-muelleri</i> shrubs over a open <i>Triodia epactia</i> hummock grassland.	QT74, QT81	Very Good
Major Drainage Line B	A low open <i>Eucalyptus victrix</i> woodland over an <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Acacia colei</i> var. <i>colei</i> shrubland over a very open <i>Triodia epactia</i> hummock grassland.	QN76	Very Good
Quartz Outcrop	Small low hills/rock piles with scattered <i>Acacia colei</i> subsp. <i>colei</i> and <i>Acacia inaequilatera</i> shrubs over scattered herbs over scattered <i>Triodia</i> sp. hummock grasses. .	QTR3	Excellent
Billabong	Scattered low <i>Eucalyptus victrix</i> trees over scattered mixed grasses.	QN75	Good

Vegetation community	Vegetation description	Example sites	Vegetation condition
Rockpile	Scattered low <i>Ficus brachypoda</i> , <i>Clerodendrum tomentosum</i> var. <i>lanceolatum</i> and <i>Carissa lanceolata</i> trees over scattered herbs.		
Drainage A	A low open <i>Eucalyptus victrix</i> woodland over a high open <i>Acacia ampliceps</i> and <i>Acacia trachycarpa</i> shrubland over a low open <i>Acacia stellaticeps</i> , <i>Pluchea ferdinandi-muelleri</i> and <i>Corchorus incanus</i> subsp. <i>incanus</i> shrubland over a <i>Triodia epactia</i> hummock grassland over an <i>Aristida holathera</i> var. <i>latifolia</i> , <i>Eriachne obtusa</i> and * <i>Cenchrus ciliaris</i> tussock grassland.	QT30, QT75	Good to Very Good
Drainage B	A low open <i>Eucalyptus victrix</i> woodland over a high open <i>Acacia ampliceps</i> shrubland over a low open <i>Acacia stellaticeps</i> and <i>Pluchea ferdinandi-muelleri</i> shrubland over a closed <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grassland over an open <i>Eriachne obtusa</i> , <i>Aristida holathera</i> var. <i>latifolia</i> and * <i>Cenchrus ciliaris</i> tussock grassland.	QT31	Very Good
Sandplain A (PH1 and PH2)	Low <i>Acacia stellaticeps</i> shrublands over <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grasslands/ <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grasslands mosaic.	QT34, QT35,	Very Good to Excellent
Sandplain B	An open <i>Acacia coleii</i> var. <i>coleii</i> shrublands over low <i>Acacia stellaticeps</i> shrublands over <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grasslands/low <i>Acacia stellaticeps</i> shrublands over <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grasslands mosaic.	QT43, QT44	Very Good to Excellent

Vegetation community	Vegetation description	Example sites	Vegetation condition
Sandplain C (PH4)	A low open <i>Corymbia flavescens</i> woodland over an open <i>Acacia colei</i> var. <i>colei</i> shrubland over a low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland/ low <i>Acacia stellaticeps</i> shrublands over <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grasslands/ <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grasslands mosaic.	QT63, QT65, QT80, QT85	Very Good to Excellent
Sandplain D	A low <i>Eucalyptus victrix</i> woodland over an <i>Acacia colei</i> var. <i>colei</i> shrubland over a low open <i>Acacia stellaticeps</i> and <i>Pluchea tetranthera</i> shrubland over a <i>Triodia epactia</i> hummock grassland.	QT28	Very Good
Sandplain E	A low open <i>Corymbia flavescens</i> and <i>Eucalyptus victrix</i> woodland over an <i>Acacia colei</i> var. <i>colei</i> and <i>Acacia sericophylla</i> shrubland over a low open <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland.	QT70, QT79	Excellent
Sandplain F	An open <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Acacia colei</i> var. <i>colei</i> shrubland over an open <i>Triodia epactia</i> hummock grassland.	-	-
Sandplain G	A low open <i>Corymbia flavescens</i> woodland over an <i>Acacia colei</i> var. <i>colei</i> , <i>Carissa lanceolata</i> and <i>Acacia sericophylla</i> shrubland over a <i>Triodia epactia</i> hummock grassland over a very open * <i>Cenchrus ciliaris</i> , <i>Chrysopogon fallax</i> and <i>Eriachne obtusa</i> tussock grassland.	QT69	Excellent
Sandplain H	An <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Acacia colei</i> var. <i>colei</i> shrubland over a low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland/ low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland mosaic.	QT65, QT66, QT67, QT80	Very Good to Excellent

Vegetation community	Vegetation description	Example sites	Vegetation condition
Sandplain I	An <i>Acacia tumida</i> var. <i>pilbarensis</i> shrubland over a low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland/ low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland/ <i>Triodia epactia</i> hummock grassland mosaic.	QN40, QN42, QN43, QN44	Excellent
Sandplain J	Scattered low <i>Corymbia flavescens</i> trees over an open <i>Acacia tumida</i> var. <i>pilbarensis</i> shrubland over a low open <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grassland/ <i>Triodia secunda</i> and <i>Triodia epactia</i> hummock grassland mosaic.	QN55, QN56	Very Good to Excellent
Sandplain K	Scattered low <i>Owenia reticulata</i> trees over an <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Acacia colei</i> var. <i>colei</i> shrubland over a low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland/low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland mosaic.	QN94, QN96	Excellent
Sandplain L	A low open <i>Corymbia zygophylla</i> woodland over an open <i>Acacia colei</i> var. <i>colei</i> , <i>Acacia inaequilatera</i> and <i>Acacia ancistrocarpa</i> shrubland over a low <i>Acacia sericophylla</i> , <i>Acacia stellaticeps</i> , <i>Senna artemisioides</i> aff. subsp. <i>oligophylla</i> (thinly sericeous) and <i>Dodonaea coriacea</i> shrubland over a very open <i>Triodia lanigera</i> and <i>Triodia epactia</i> hummock grassland	QN39	Excellent
Sandplain M	An open <i>Acacia ancistrocarpa</i> , <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Acacia inaequilatera</i> shrubland over a <i>Triodia lanigera</i> hummock grassland.	QT117	Very Good to Excellent

Vegetation community	Vegetation description	Example sites	Vegetation condition
Sandplain N	A low open <i>Corymbia zygophylla</i> woodland over an open <i>Acacia ancistrocarpa</i> , <i>Acacia inaequilatera</i> , <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Acacia sericophylla</i> shrubland over <i>Acacia stellaticeps</i> low open shrubland over <i>Triodia epactia</i> and <i>Triodia lanigera</i> hummock grassland.	QN06, QN07, QT122, QT123	Excellent
Sandplain O	Scattered low <i>Eucalyptus victrix</i> and <i>Corymbia hamersleyana</i> trees over an open <i>Acacia ancistrocarpa</i> , <i>Acacia tumida</i> var. <i>pilbarensis</i> , <i>Acacia inaequilatera</i> and <i>Acacia trudgeniana</i> shrubland over a low open <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> and <i>Triodia lanigera</i> hummock grassland.	QN105, QN106	Excellent
Sandplain P	A low open <i>Eucalyptus victrix</i> , <i>Corymbia hamersleyana</i> and <i>Corymbia flavescens</i> woodland over an open <i>Acacia colei</i> var. <i>colei</i> shrubland over a low open <i>Acacia stellaticeps</i> and <i>Pluchea tetranthera</i> shrubland over a <i>Triodia epactia</i> hummock grassland.	QN22	Excellent
Sandplain Q	Scattered low <i>Corymbia flavescens</i> trees over an open <i>Acacia ancistrocarpa</i> and <i>Acacia bivenosa</i> shrubland over scattered low <i>Acacia stellaticeps</i> shrubs over a <i>Triodia epactia</i> and <i>Triodia lanigera</i> hummock grassland.	QT108, QT109	Excellent

NOTE: The corresponding Mattiske Consulting (1994) vegetation codes are show in brackets () and the Biota (2008) vegetation codes are shown in brackets [] below the vegetation community titles in Table 7.

4.2.7 Threatened Ecological and Priority Ecological Communities

Summer Survey, Winter Survey and Additional Winter Survey Areas

No communities listed as TECs under the EPBC Act 1999 or included on the State list were recorded in the project area.

No communities listed as PECs as per the DEC Priority list were recorded in the project area.

4.2.8 Vegetation Condition

The condition of the vegetation within the project area was described as Poor to Excellent, with most sites rated as Very Good (Appendix F). Seven vegetation communities were considered to be in Excellent condition, six in Very Good to Excellent condition, eight in Very Good condition and three in Good condition. Disturbances recorded in the project area included the presence of cleared areas associated with tracks and infrastructure, invasion by introduced species, evidence of pastoral activities, the presence of rubbish and burnt areas.

Comparison of of Summer Sites Revisited in Winter

There were no major changes in the vegetation condition recorded at summer sites that were revisited in winter. Part of the project area, near Boodarie Station, had been burnt after the summer survey and prior to the winter survey. The species recorded at these sites during winter therefore differed to the vegetation recorded in summer, with the sites containing more species during winter because of an increase in the number of annuals and pioneer species as a result of the fire.

5 DISCUSSION

5.1 FLORA ASSEMBLAGES

5.1.1 General

A total of 394 taxa were recorded within the project area across all surveys.

Although a number of surveys have been completed in the surrounding area, none have been completed on a similar spatial scale, or have covered similar habitats (Appendix L). Surveys conducted in the local area include three surveys, two of which were conducted along the access road to Finucane Island (Biota 2007, 2008), and one survey conducted at Boodarie (Mattiske Consulting 1994). All of these surveys were only one season surveys unlike the current survey which was multi-season. Other surveys in the area have recorded 24 taxa (Biota 2008), 107 taxa (Mattiske Consulting 1994) and 110 taxa (Biota 2007) (Appendix M).

Larger surveys completed in the area include the FMG rail line survey (Biota 2004) which covered 345 km over four IBRA subregions, the Hope Downs rail line survey (Hope Downs Management Services 2002), which covered 324 km, again over four IBRA subregions. The current survey was in a single IBRA subregion, and it is therefore difficult to relate the findings of this survey to other surveys (as species lists provided in the reports have not been separated by bioregion).

5.1.2 Seasonal Comparison of Recorded Flora

Two hundred and fifty taxa were recorded within the sites established in the summer survey, with 279 taxa recorded from the same sites during the winter survey and 212 taxa recorded from the additional winter survey sites.

The most commonly recorded families in both the summer and winter surveys were Poaceae, Papilionaceae and Malvaceae. These families were also the most commonly recorded within the Hope Downs rail corridor (Biota 2001) and at Utah Point (Biota 2007). The summer and winter surveys both recorded *Acacia* and *Sida* as the most common genera.

One hundred and seventy-three taxa were recorded during both the summer and winter surveys. One hundred and seventy-eight taxa (45 % of the total number of taxa recorded) were unique to one season, with 74 taxa recorded only during the summer survey and 104 taxa recorded only during the winter survey. The completion of seasonal surveys increased the number of species recorded within the area, but this difference may also reflect the increased time spent surveying the area as well as seasonal differences.

The most taxa rich families recorded during only one survey were Poaceae (22 taxa) and Papilionaceae (21 taxa). Both families had more taxa present during the winter survey than in the summer survey. This is most likely due to the presence of small annual grasses and other species that germinated after the summer rain. The difference in the number of taxa recorded between the two surveys is also thought to be due to the clarification of taxonomic identifications. A large number of collections made during the summer survey could be identified only to genus level, as low rainfall prior to the survey meant some taxa (especially annuals) lacked sufficient foliage to permit definitive identification.

Research has not been conducted within the project area to show the level of rainfall at which annuals and ephemerals are no longer present and at which germination is restricted. The winter season survey was considered to have been conducted in a comparatively poor season, as the area had received only 39 % of the average seasonal rainfall for the area. Overall, low rainfall before both the winter and summer surveys is believed to have resulted in a low number of annual and ephemeral species being recorded. Many perennials were also not in flower during both the surveys due to the lack of rainfall, making identifications complicated, as botanical identifications are based largely on flowering parts.

5.1.3 Flora of Conservation Significance

No Threatened species under the EPBC Act 1999 or Declared Rare Flora species under the WC Act 1950 were recorded within the summer and winter surveys. This was expected as no species were listed as potentially occurring within the project area.

Five Priority Flora species, *Heliotropium muticum* (Priority 1), *Tephrosia rosea* var. *venulosa* (Priority 1), *Pterocaulon* sp. A Kimberley Flora (B.J. Carter 599) (Priority 2), *Goodenia nuda* (Priority 3) and *Gymnanthera cunninghamii* (Priority 3) were recorded within the Outer Harbour Development project area. Locations of Priority Flora species previously recorded in the vicinity of the project area (from DEC search results and a literature review) are illustrated in Figure 12.

- *Heliotropium muticum* is a small perennial herb to 0.3 m, and has only three records on FloraBase (Western Australian Herbarium 2009). This species was recently added to the Priority Flora list and has few previous records. Two locations of this species are located within the disturbance envelope. This species has not been recorded in previous surveys in the vicinity of the project area.
- *Tephrosia rosea* var. *venulosa* was recorded during both the summer and winter surveys, mainly from Finucane Island. A collection was also tentatively identified during the summer survey as from the *Tephrosia rosea* complex, and this was confirmed also to be *Tephrosia rosea* var. *venulosa*. This

species was added to the Priority Flora list in December 2008 and is considered to have a restricted distribution, known only from the Port Hedland area and from Cape Lambert. Of the 13 locations of this species in the project area, four are located in the proposed disturbance envelope. At the time of the survey this species was not listed as Priority Flora and therefore targeted searches for this species were not undertaken. Following the completion of this survey two other botanical surveys have been conducted in the area which have also recorded *Tephrosia rosea* var. *venulosa* (ENV.Australia 2009b and 2009c).

- *Pterocaulon* sp. A Kimberley Flora (B.J. Carter 599) was recorded at two locations during the winter survey. *Pterocaulon* sp. A Kimberley Flora (B.J. Carter 599) is typically recorded in the Kimberley region of Western Australia, and its location in the project area is considered a range extension. A voucher specimen of this species has been lodged with the Western Australian Herbarium and the identification of the species has been confirmed. This species is a compact shrub to 0.5 m high, and one location of this species in the project area occurs within the proposed disturbance envelope. This species has not previously been recorded in the Pilbara, and is known from records along the Kimberley coast and from Broome and Anna Plains (Western Australian Herbarium 2009). Additional survey work to map the extent of the population was conducted in October 2008. No individuals of this species were recorded during this survey.
- *Goodenia nuda* was also recorded during the winter survey. *Goodenia nuda* is a herb to 0.5 m high, and has not previously been recorded in the project area, with most historical records of this species located further inland closer to Newman. The presence of this species in this survey is therefore considered a range extension (Western Australian Herbarium 2009). *Goodenia nuda* was recorded as part of the FMG rail line survey (Biota 2004) from further inland than the Outer Harbour Development project area. The locations of this species are outside the proposed disturbance envelope.
- *Gymnanthera cunninghamii* was recorded during the summer and winter surveys, and is a shrub 1-2 m high. This species has previously been recorded in the area during the survey for the FMG rail corridor and Hope Downs rail corridor (Biota 2001, 2004), and from other locations in the vicinity of the project area (Figure 12). The locations of this species are outside the proposed disturbance envelope.

From surveys conducted in the surrounding area, two Priority species that were expected to occur, but were not recorded from the project area, were *Bulbostylis burbidgeae* (Priority 3) and *Euphorbia clementii* (Priority 2). *Bulbostylis burbidgeae* was recorded near the Outer Harbour Development project area as part of the Utah Point survey (Biota 2007). As this species is an annual grass, it

may not have been recorded in the current survey because of a lack of rainfall. The survey in which it was recorded was completed in April 2007, after the area had received 390 mm during the cyclone season (Biota 2007). *Euphorbia clementii* has previously been recorded in the area as part of the Hope Downs and FMG rail corridor studies (Biota 2001, 2004). This species is also an annual, and therefore may not have been present at the time of survey, and its occurrence in the project area cannot be dismissed. This species is not shown on Figure 12, as exact locations of this species cannot be obtained.

5.1.4 Locally Significant Flora

Four species of local significance were recorded during the surveys, three during the summer survey; *Tephrosia rosea* (discussed above), *Goodenia* sp. (discussed above) and a liliaceous species, and one during the winter survey, *Eriachne sulcata*.

The liliaceous species collected during the summer survey was not collected during the winter survey. No species of conservation significance from this family are known to occur in the Pilbara, and therefore the collection is not considered of conservation significance. The liliaceous species collected, is likely to be the Kimberley species *Murdannia graminea* (pers. comm., M. Trudgen). If this species is located within the Outer Harbour Development project area, this would be a new record for the Pilbara and would represent a large south-westerly range extension for this species, making it locally significant. If heavy rainfall occurs in the project area, further collections of this species may be made to verify the identification and to confirm the range extension. This species is located at two sites within the proposed disturbance envelope for the Boodarie stockyards. *Murdannia graminea* has not been recorded in previous surveys conducted in the vicinity of the project area.

Eriachne sulcata was recorded during the winter survey in the additional areas, and is a species usually recorded from the Kimberley region. The presence of this species in the project area represents a considerable range extension. The collections of this species made in this survey are considered the southern most locations of this species' known distribution. This species was recorded from small depressions in the sandplains. Within these depressions, this species had a cover of more than 50 %, and in most cases it was the only species in the depression. No locations of this species occur within the proposed disturbance envelope. This species has not been recorded in previous surveys in the vicinity of the project area.

5.1.5 Phreatophytic Flora and Vadophytic Flora

The obligate phreatophyte *Melaleuca argentea*, was recorded within Major Drainage Line A which is located within South West Creek. This species is

reliant on groundwater sources for water uptake (Halpern, Glick & Maunsell 1999). *Melaleuca argentea* was also recorded within South West Creek by Mattiske (1994). This species has a shallow root system comprising of surface lateral roots (Graham 2001) and is unlikely to occur extensively where the depth to the watertable exceeds 2 to 3 m (Muir Environmental 1994, 1995; Weston & Trudgen 1995). Dames and Moore (1984) reported an increase in stress and/or death of this species in relation to drought conditions and increased depth to groundwater.

Eight vegetation communities recorded in the project area, Billabong, Major Drainage Line A, Major Drainage Line B, Drainage Line A, Drainage Line B, and Sandplain D, E and P, contained the tree species *Eucalyptus victrix*. This species is a vadophyte, which primarily relies on water held in the vadose (unsaturated) zone above the water table for water uptake (Jones *et al.* 1990). *Eucalyptus victrix* was also recorded during the Mattiske (1994) survey. Whilst not a true phreatophyte, *Eucalyptus victrix* is likely to exhibit stress with decreased access to groundwater (Muir Environmental 1995).

5.2 INTRODUCED FLORA SPECIES

A total of 10 introduced species were recorded within the proposed Outer Harbour Development project area during the summer and winter surveys. The most commonly recorded introduced species during the summer and winter surveys were **Aerva javanica* (Kapok) and **Cenchrus ciliaris* (Buffel Grass).

A greater number of introduced species were recorded during the winter survey (nine taxa), than in the summer survey (four taxa). There was also an increase in the presence of **Aerva javanica*. This increase may be a result of regrowth and resprouting of moribund introduced species after rainfall.

Four of the introduced species, **Citrullus colocynthis*, **Digitaria ciliaris*, **Setaria verticillata* and **Cucumis melo* subsp. *agrestis*, have not been previously recorded in the surveys conducted in the vicinity of the project area. All of these species however are common throughout the state.

All introduced species recorded were in sites with some level of disturbance, mainly due to clearing of access tracks and grazing or trampling by cattle. Introduced species were more common in areas surrounding existing infrastructure and previous disturbance with lower numbers recorded in the southern areas of the project area which have little previous disturbance. No Declared Plants (DAFWA 2007) were recorded during either survey.

5.3 VEGETATION

5.3.1 General

A total of 34 vegetation communities (excluding areas devoid of vegetation such as disturbed areas, washout or bare sand/reef areas) were identified within the project area. Similar vegetation communities have been recorded during other flora surveys undertaken in the Port Hedland area (e.g. Matiske Consulting 1994, Biota 2008, 2009). In particular, the vegetation communities mapped within the project area match with those mapped by Biota (2008) for the areas along the Finucane Island access road, and are similar to those mapped as part of the Hope Downs rail corridor and FMG rail corridor, with most of the area mapped as *Acacia stellaticeps* shrubland over *Triodia epactia* hummock grasslands (Biota 2001, 2004). A number of the communities also match the vegetation communities mapped by Matiske Consulting (1994).

The majority of the project area is comprised of vegetation communities associated with Sandplains, which are also well represented outside of the project area.

Four communities, the billabong, limestone hill, quartz outcrop and rockpile communities are considered uncommon in the project area. The billabong, limestone hill and rockpile communities are located outside of the project disturbance envelope; however, one of the small quartz outcrops is located within the disturbance envelope. These communities are considered unusual in that the billabong is a permanent water body, which is not common in the region, and the rock pile, limestone hill and quartz outcrops are not common within the Sandplain. Of these communities only the rock pile supports flora not broadly recorded in the project area. These communities are considered to be locally significant, however, they are not considered to be conservation significant.

5.3.2 Vegetation of Conservation Significance

No communities listed as TECs or PECs were recorded within the project area. This was expected as none are known to occur in the area.

One vegetation community considered of conservation significance (mangroves) was identified in the project area (Figure 11). Mangroves are listed as a wetland of subregional significance by Kendrick and Stanley (2001), but has not been identified for protection by *Guidance for the Assessment of Environmental Factors: Protection of tropical arid zone mangroves along the Pilbara coastline, Guidance Statement No. 1* (EPA 2001). Guidance Statement No. 1 however does consider the mangroves of the Port Hedland area to be of high conservation value (EPA 2001). A separate assessment on the project's potential impact on mangroves has been undertaken (SKM 2009a).

5.3.3 Vegetation Condition

The vegetation of the project area was considered to be in Poor to Excellent condition, with most sites rated as Very Good or Excellent. The main disturbances recorded within the project area were the presence of tracks and fences, introduced species and grazing and trampling by cattle. No major differences in vegetation condition were observed between the summer and winter season surveys. The additional areas surveyed during the winter survey showed less signs of disturbance as many of the additional winter survey areas were accessible only by foot, and therefore did not contain as much vehicle disturbance as in other parts of the project area.

The areas in which the majority of the non-rail infrastructure is proposed to be constructed is located near to previous areas of disturbance and other infrastructure. Proportions of the proposed Boodarie stockyards and rail loop are located in areas which are previously disturbed from the decommissioned Boodarie Iron Plant.

6 IMPACT ASSESSMENT AND RECOMMENDATIONS

6.1 OVERVIEW

Hazards associated with the proposed Outer Harbour Development and the potential impacts on terrestrial flora and vegetation that may result are summarised in Table 8.

Table 8: Potential Impacts on Terrestrial Flora and Vegetation from the project

Hazard	Source	Potential Impact
Clearing and Earthworks	Construction of terrestrial infrastructure (transfer pad, infrastructure corridor, stockyards, rail) Vehicle movements and importation of fill	<ul style="list-style-type: none"> • Direct loss of general vegetation and vegetation of conservation significance • Direct loss of flora of conservation significance. • Loss of vegetation outside of the disturbance envelope due to accidental clearing. • Degradation to vegetation due to unrestricted vehicle access. • Introduction or spread of weeds
Physical presence of infrastructure	Construction and operation of terrestrial facilities	<ul style="list-style-type: none"> • Degradation of vegetation due to drainage shadow effects or localised flooding
Fire	Vehicle exhaust and construction and operation of terrestrial facilities	<ul style="list-style-type: none"> • Direct loss of vegetation outside of the disturbance envelope
Dust	Vehicle movements and construction and operation of the facility	<ul style="list-style-type: none"> • Degradation of vegetation due to smothering of foliage
Uncontrolled discharge of wastes or chemicals	Domestic waste, hydrocarbons or chemicals	<ul style="list-style-type: none"> • Degradation of vegetation due to soil or surface water pollution
Groundwater Abstraction / Dewatering	Construction of rail and car dumpers	<ul style="list-style-type: none"> • Degradation or loss of groundwater dependant flora species through aquifer drawdown

6.2 IMPACTS ON FLORA

Of the five Priority Flora species recorded in the project area, three, *Tephrosia rosea* var. *venulosa*, *Heliotropium muticum* and *Pterocaulon* sp. A Kimberley Flora (B.J. Carter 599) occur within the proposed disturbance envelope.

Two locations of *Tephrosia rosea* var. *venulosa* are located within the proposed disturbance envelope; one within the transfer pad on Finucane Island and one within the 2008 rail option. This species has only recently been added to the Priority Flora list, and is considered to be geographically restricted. This species has also been recorded at nine locations outside of the disturbance envelope and has also been recorded in significant numbers at Lumsden Point (ENV 2009a) and along sections of the existing Goldsworthy Railway (ENV 2009b). Clearing is not likely to reduce the local representation of *Tephrosia rosea* var. *venulosa* as this species has been recorded in abundance along the Goldsworthy Railway and is likely to occur elsewhere in Port Hedland as it appears to favour disturbed areas.

One location of *Pterocaulon* sp. A Kimberley Flora (B.J. Carter 599) is located within the proposed disturbance envelope. This species is typically recorded in the Kimberley region of Western Australia, mainly along the Kimberley coast, and its location in the project area is considered a range extension, and a new record for the region. This species was also recorded outside of the disturbance envelope, to the east of the stockyards. Clearing of *Pterocaulon* sp. A Kimberley Flora may reduce the local representation of this species as the presence of this species in the Port Hedland area represents a range extension.

Two locations of *Heliotropium muticum* are located within the disturbance envelope. This species was recently added to the Priority Flora list and has few previous records. This species has been recorded at five other locations outside of the proposed disturbance envelope and therefore the proposed loss through clearing is not likely to reduce the local representation of this species.

The clearing of vegetation and construction of infrastructure for the project will see an increase in traffic and activity within the project area. This could lead to introduced species being dispersed throughout the area due to the movement of soil and seeds. The increase in traffic may also aid in the spread of introduced species. Introduced species may also be introduced to the area from the importation of fill for construction purposes.

Introduced species were recorded in high numbers around the proposed stockyards, rail loops and loadout facilities. Due to the presence of introduced species in these areas, care should be taken to ensure these species are not spread further, and that current covers of these species are not increased.

Effective management of these species in these areas should help to decrease covers and minimise spread.

Groundwater abstracted from shallow bores for use in dust suppression and dewatering that is required during construction of the car dumpers also has the potential to cause deterioration in the health or the loss of the phreatophyte *Melaleuca argentea* and the vadophyte *Eucalyptus victrix*. Permanent aquifer drawdown is unlikely to result from such activities as they will be temporary in nature (i.e. restricted to construction phase) and in the case of groundwater abstraction, typically involve small volumes of water (SKM 2009b). Furthermore, groundwater recharge is tidally influenced in the region of the car dumpers (SKM 2009b). The phreatophyte *Melaleuca argentea* and vadophyte *Eucalyptus victrix* are unlikely to be impacted by groundwater abstraction or dewatering given that permanent aquifer drawdown is unlikely to result and that these species are likely to be adapted to the short-term variation in groundwater levels (up to 2 m) seen with seasonal changes (BHP Billiton Iron Ore 2008). Furthermore, *Melaleuca argentea* is located at least 1 km from the proposed car dumpers which will require dewatering during construction.

6.3 IMPACTS ON VEGETATION

The main impact associated with the project will be the loss of vegetation through clearing for the construction of rail infrastructure, stockyards, conveyors and access roads. The vegetation communities mapped within the project area by Beard (1975) are estimated to have 100 % of their pre-european extent remaining and therefore the project will not cause these vegetation communities to fall below the 30 % threshold set by the EPA.

The majority of vegetation clearing will be focused around the construction of the stockyards and rail loop, which will impact mainly upon the vegetation type Sandplain A. With exception of mangroves and quartz outcrops, vegetation communities within the proposed disturbance envelope that may be cleared are well represented in the local area and Pilbara region. Impacts to the mangroves, a vegetation community considered to be of conservation significance are dealt with in a separate study. The quartz outcrop vegetation which is present within the proposed disturbance envelope, although uncommon in the area, is not considered to be of conservation significance as it supports flora species which are broadly distributed across the project area. Furthermore, additional quartz outcrop areas are located outside of the proposed disturbance envelope.

A change in fire regimes has the potential to change ecosystems and the composition of vegetation communities. However, under correct management the impact of altered fire regimes should be minor. Dust caused by clearing, construction and operations may impact on surrounding flora and vegetation. Impact from this should be minor if appropriate management plans and dust

suppression measures are implemented. The construction of infrastructure as part of the proposed development may also alter hydrological regimes and potentially degrade vegetation due to drainage shadow effects or localised flooding. This is particularly pertinent to the proposed Western Spur Railway which intersects with the upper tributaries of South West Creek and South Creek.

One vegetation community considered of conservation significance, the mangroves, was identified in the project area. This is listed as a wetland of subregional significance by Kendrick and Stanley (2001), but it was not identified for protection by the *Guidance for the Assessment of Environmental Factors: Protection of tropical arid zone mangroves along the Pilbara coastline, Guidance Statement No. 1* (EPA 2001). The mangroves of the Port Hedland industrial area are considered to be of high conservation value and fall under Guideline 4, which states that 'the impacts of development on mangrove habitat and ecological function of the mangroves in these areas should be reduced to the minimum practicable level'. A separate mangrove impact assessment has also been undertaken for the project area (SKM 2009a).

7 CONCLUSIONS

The flora and vegetation assessment of the Outer Harbour Development involved a comprehensive multi-season survey of the project area. This multi-season survey recorded a total of 394 taxa including five Priority Flora species, four locally significant flora species and nine introduced species. Of these, three Priority Flora species will be impacted upon by the proposed development.

Thirty four vegetation communities were recorded within the project area. All of which are considered to be represented outside of the project area and are typical of the area.

One conservation significant vegetation community, the mangroves, will be impacted upon by the development with these impacts discussed further in a separate report (SKM 2009a).

Excluding the mangroves, which are being assessed separately, the regional representation of flora and vegetation will not be affected by the project development.

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STATEMENT OF LIMITATIONS

Scope of Services

This environmental site assessment report ('the report') has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and ENV.Australia Pty Ltd (ENV) ('scope of services'). In some circumstances the scope of services may have been limited by factors such as time, budget, access and/or site disturbance constraints.

Reliance on Data

In preparing the report, ENV has relied on data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ('the data'). Except as otherwise stated in the report, ENV has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or in part on the data, those conclusions are contingent upon the accuracy and completeness of the data. ENV will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, unavailable, misrepresented or otherwise not fully disclosed to ENV.

Environmental Conclusions

In accordance with the scope of services, ENV has relied on the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, express or implied, is made.

Report for Benefit of Client

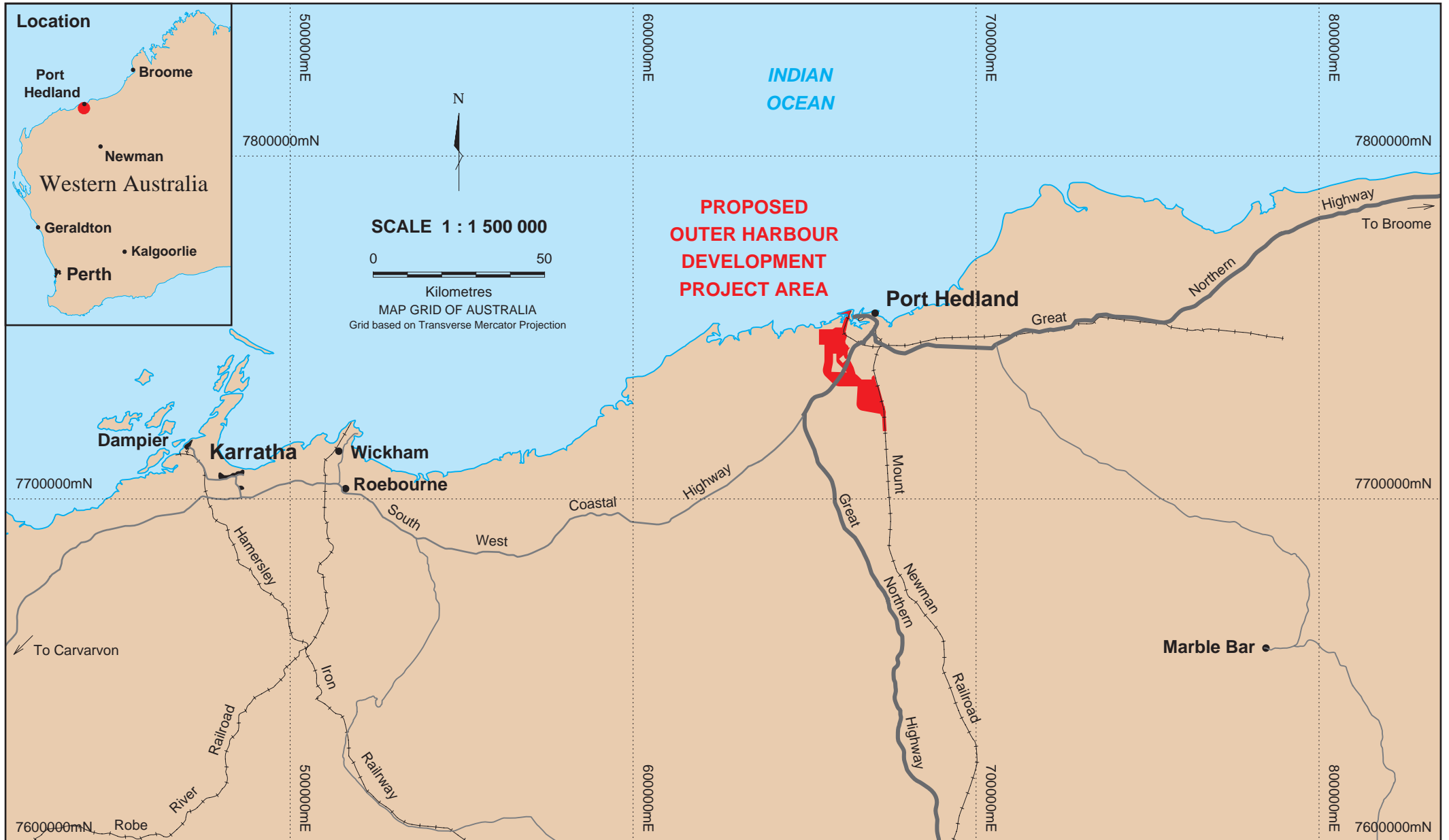
The report has been prepared for the benefit of the Client and for no other party. ENV assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including, without limitation, matters arising from any negligent act or omission of ENV or for any loss or damage suffered by any other party relying on the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions, and should make their own enquiries and obtain independent advice in relation to such matters.

Other Limitations

ENV will not be liable to update or revise the report to take into account any events or circumstances occurring or facts becoming apparent after the date of the report.

The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report, nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

FIGURES

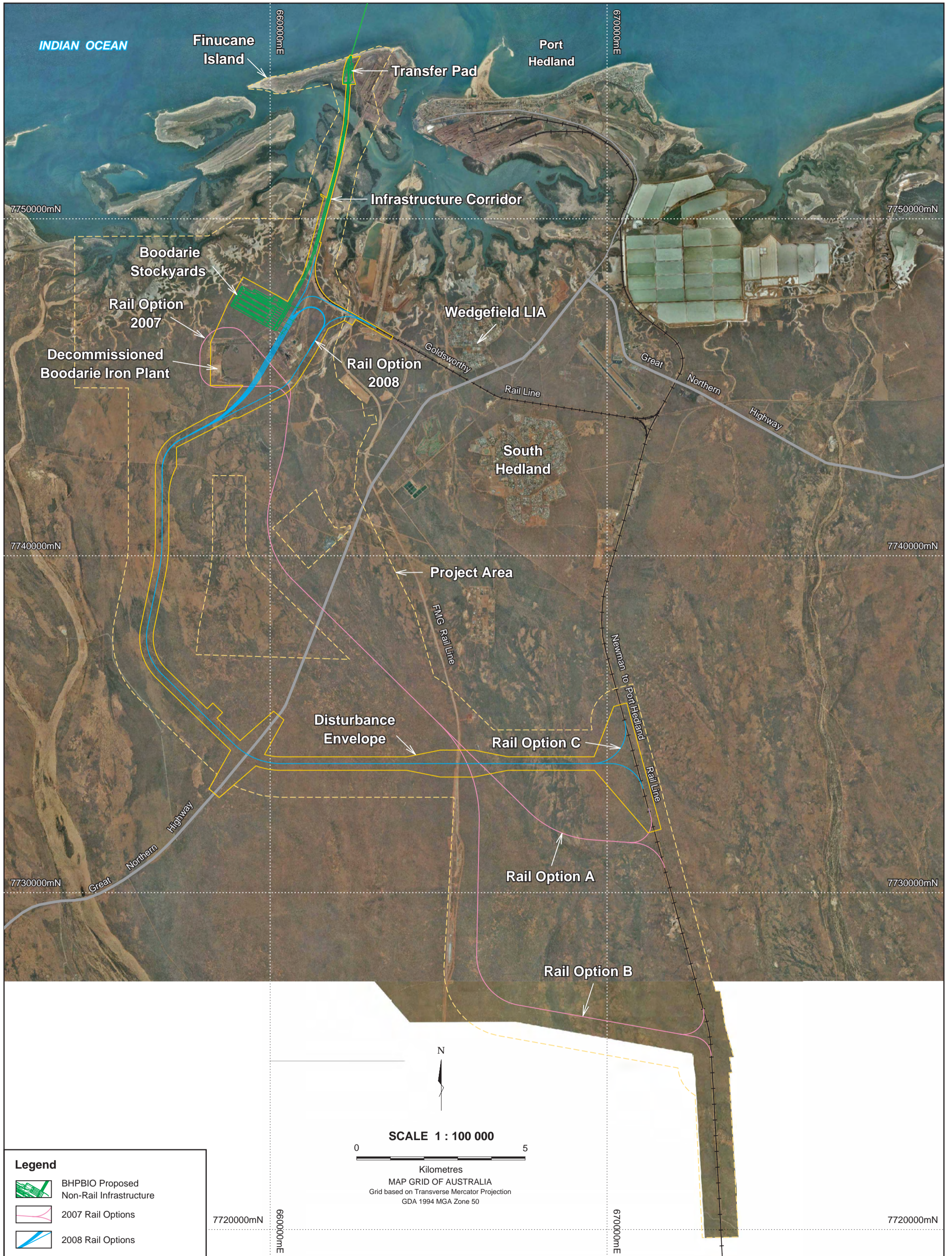





Author: E.Carroll
Drawn: S.Coleman
Status:
Job Number: 08.216

Client: **BHP BILLITON PTY LTD**
Project: **OUTER HARBOUR DEVELOPMENT
FLORA AND VEGETATION ASSESSMENT**

REGIONAL LOCATION

Date: 9 September 2009
Scale: 1: 1.5 Million
Figure No. **1**
Plan No. **QM-001**



- Legend**
-  BHPBIO Proposed Non-Rail Infrastructure
 -  2007 Rail Options
 -  2008 Rail Options



MAP GRID OF AUSTRALIA
Grid based on Transverse Mercator Projection
GDA 1994 MGA Zone 50



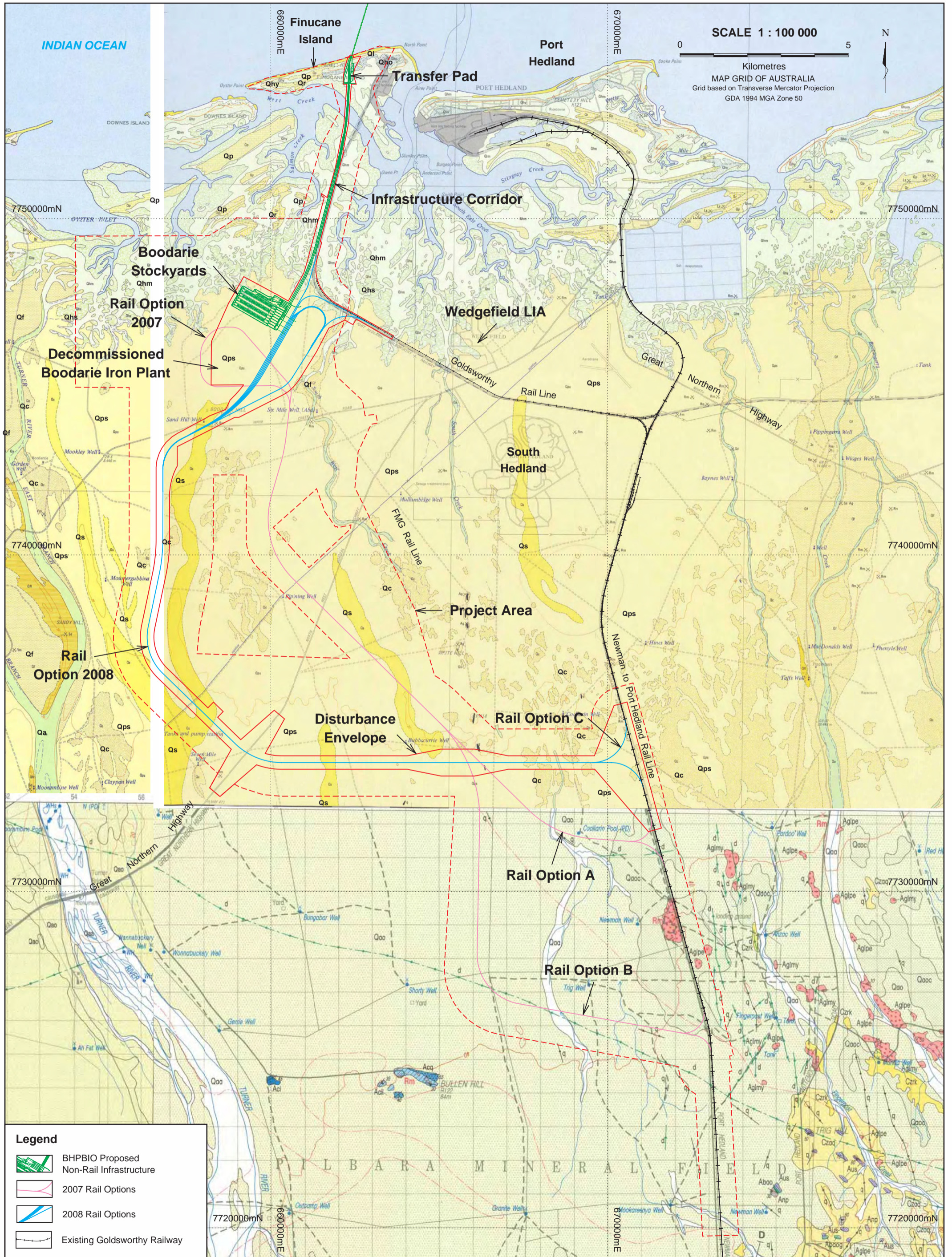
Author: E.Carroll
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Status:
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Client: **BHP BILLITON PTY LTD**
Project: **OUTER HARBOUR DEVELOPMENT
FLORA AND VEGETATION ASSESSMENT**

PROPOSED INFRASTRUCTURE

Date: 27 November 2009
Scale: 1:100 000
Figure No. **2**
Plan No. **QM-016**

A3



Legend	
	BHPBIO Proposed Non-Rail Infrastructure
	2007 Rail Options
	2008 Rail Options
	Existing Goldsworthy Railway

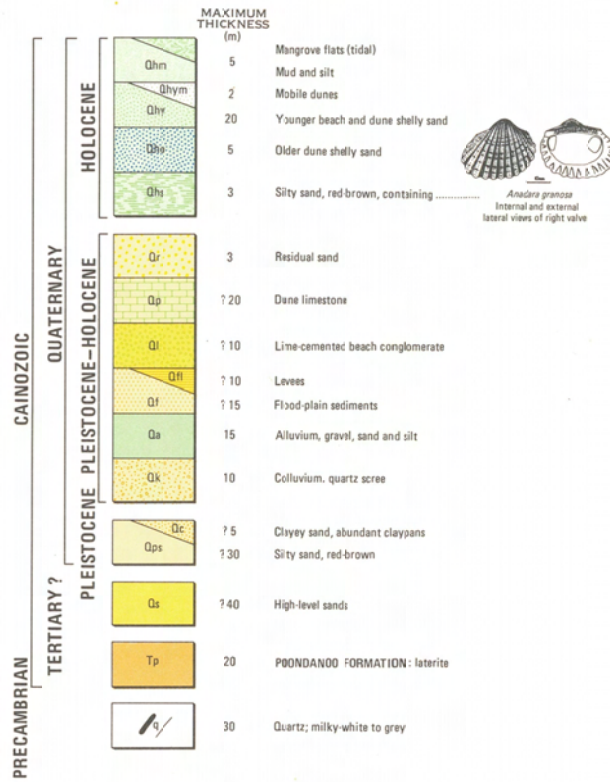
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	Drawn: S.Coleman
	Status:
	Job Number: 08.216

Client: BHP BILLITON PTY LTD
Project: OUTER HARBOUR DEVELOPMENT FLORA AND VEGETATION ASSESSMENT

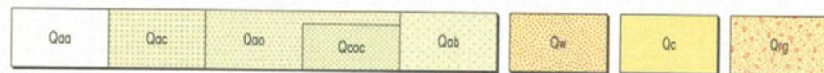
REGIONAL GEOLOGY	
Date: 27 November 2009	Scale: 1:100 000
Figure No. 5a	Plan No. QM-018

A3

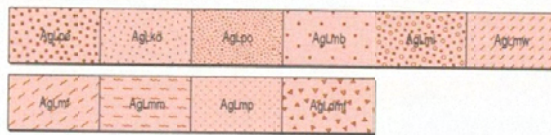
**1:50 000
Geology Legend
2557-2 (Boodarie)
2657-3 (Port Hedland)**



**1:100 000
Geology Legend
2556 (Yule)
2656 (Wallingara)**



- Qaa Alluvial sand and gravel in rivers and creeks; clay, silt, and sand in channels on floodplains
- Qac Clay and silt in claypan deposits on floodplains
- Qao Alluvial sand, silt, and clay on floodplains
- Qaac Mixed floodplain deposits with numerous small claypans
- Qab Alluvial sand, silt, and clay in floodplains, with gilgai surface in areas of expansive clay
- Qw Sheetwash deposits — silt, sand, and pebbles on distal outwash fans; no defined drainage
- Qc Colluvium — sand, silt, and gravel in outwash fans; scree and talus; proximal mass-wasting deposits
- Qrg Quartzofeldspathic eluvial sand with quartz and rock fragments; overlying and derived from granitoid rock



- CARLINDI GRANITOID COMPLEX**
- AgLpe Pegmatite; metamorphosed
 - AgLkd KADGEWARRINA MONZOGNANITE: muscovite-biotite-garnet monzogranite; equigranular to weakly porphyritic; massive to weakly foliated; metamorphosed
 - AgLpo POOCATCHE MONZOGNANITE: muscovite-biotite monzogranite; seriate to porphyritic; massive to weakly foliated; locally abundant pegmatite; metamorphosed
 - AgLmb Fine- to coarse-grained muscovite-biotite monzogranite; massive to weakly foliated; metamorphosed
 - AgLmi MINNAMONICA MONZOGNANITE: porphyritic biotite-muscovite monzogranite; fine- to coarse-grained; quartz and K-feldspar phenocrysts; massive to weakly foliated; metamorphosed
 - AgLmw Biotite-muscovite monzogranite, equigranular to weakly K-feldspar porphyritic; locally highly leucocratic and ghostbanded; massive to weakly foliated; metamorphosed
 - AgLmf Biotite monzogranite, strongly foliated; seriate to K-feldspar porphyritic; related to AgLmp; metamorphosed
 - AgLmm Mylonitized monzogranite; related to AgLmp; metamorphosed
 - AgLmp Biotite monzogranite, porphyritic (K-feldspar) to seriate; massive to weakly foliated; locally strong flow-alignment; metamorphosed
 - AgLmf Diorite granodiorite, monzogranite, and abundant felsic to mafic inclusions and dykes, strongly foliated; metamorphosed



CLEAVEVILLE FORMATION

- AGlc Chert; metamorphosed
- AGlcw Chert; weakly banded, grey and white; metamorphosed
- AGli Banded iron-formation; locally includes banded quartz-magnetite-grunerite rock; metamorphosed
- AGls Metamorphosed, fine- to medium-grained wacke; locally interbedded with serpentinite- and tremolite-rich schist and metamorphosed iron-formation and ferruginous siltstone



- As Sedimentary rock, undivided; metamorphosed
- Acl Banded iron-formation; locally includes banded quartz-magnetite-grunerite rock; metamorphosed
- Acl Banded iron-formation; strongly recrystallized and ironitized
- Acl Banded white and grey chert, and quartzite; local minor jaspillite and iron formation; locally includes banded quartz-grunerite rock; metamorphosed
- Anp Paragneiss; medium-grained, strongly recrystallized sedimentary rock



Client: **BHP BILLITON PTY LTD**

Project: **OUTER HARBOUR DEVELOPMENT FLORA AND VEGETATION ASSESSMENT**

GEOLOGY LEGEND

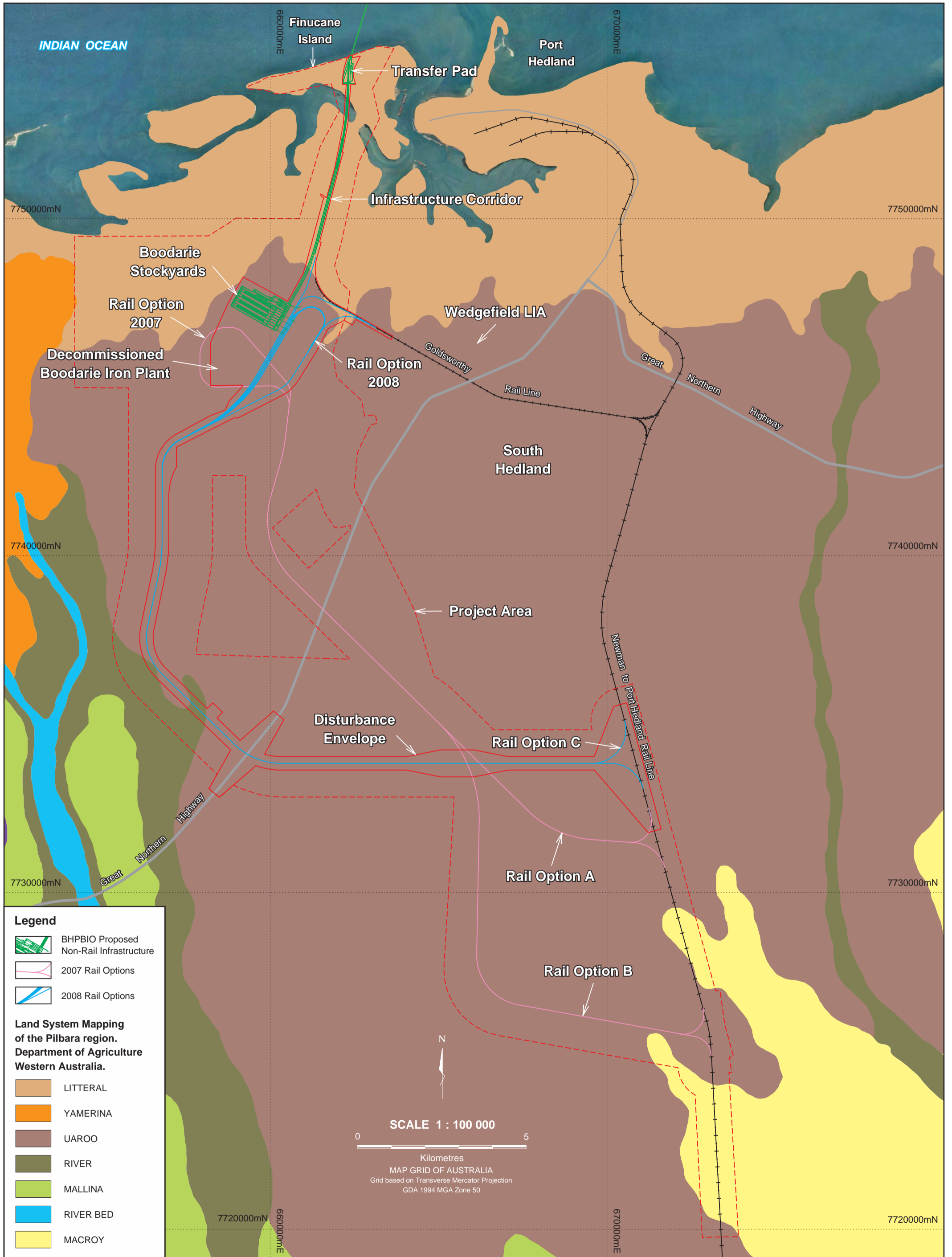
Date: 16 January 2009

Scale: NTS

Author: E.C. / S.C.

Figure No. **5b**

Plan No. **QM-021**

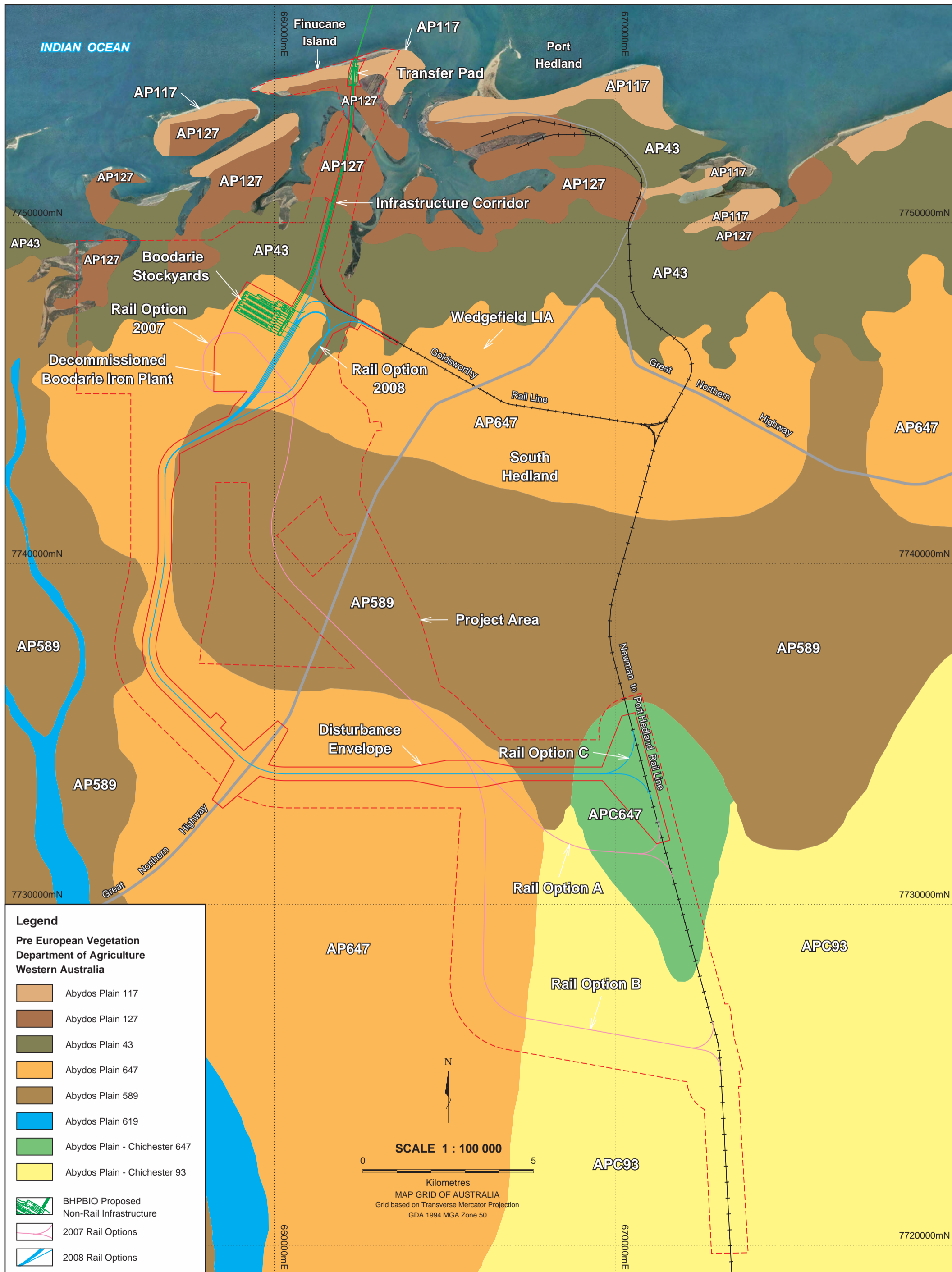


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 Status:
 Job Number: 08.216

Client: **BHP BILLITON PTY LTD**
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 FLORA AND VEGETATION ASSESSMENT**

LAND SYSTEM MAPPING

Date: 27 November 2009
 Scale: 1:100 000
 Figure No. **6**
 Plan No. **QM-019**



Legend

Pre European Vegetation
Department of Agriculture
Western Australia

- Abydos Plain 117
- Abydos Plain 127
- Abydos Plain 43
- Abydos Plain 647
- Abydos Plain 589
- Abydos Plain 619
- Abydos Plain - Chichester 647
- Abydos Plain - Chichester 93
- BHPBIO Proposed Non-Rail Infrastructure
- 2007 Rail Options
- 2008 Rail Options

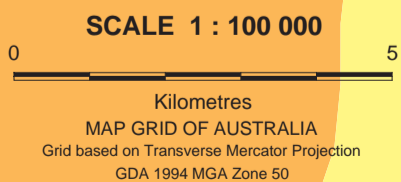


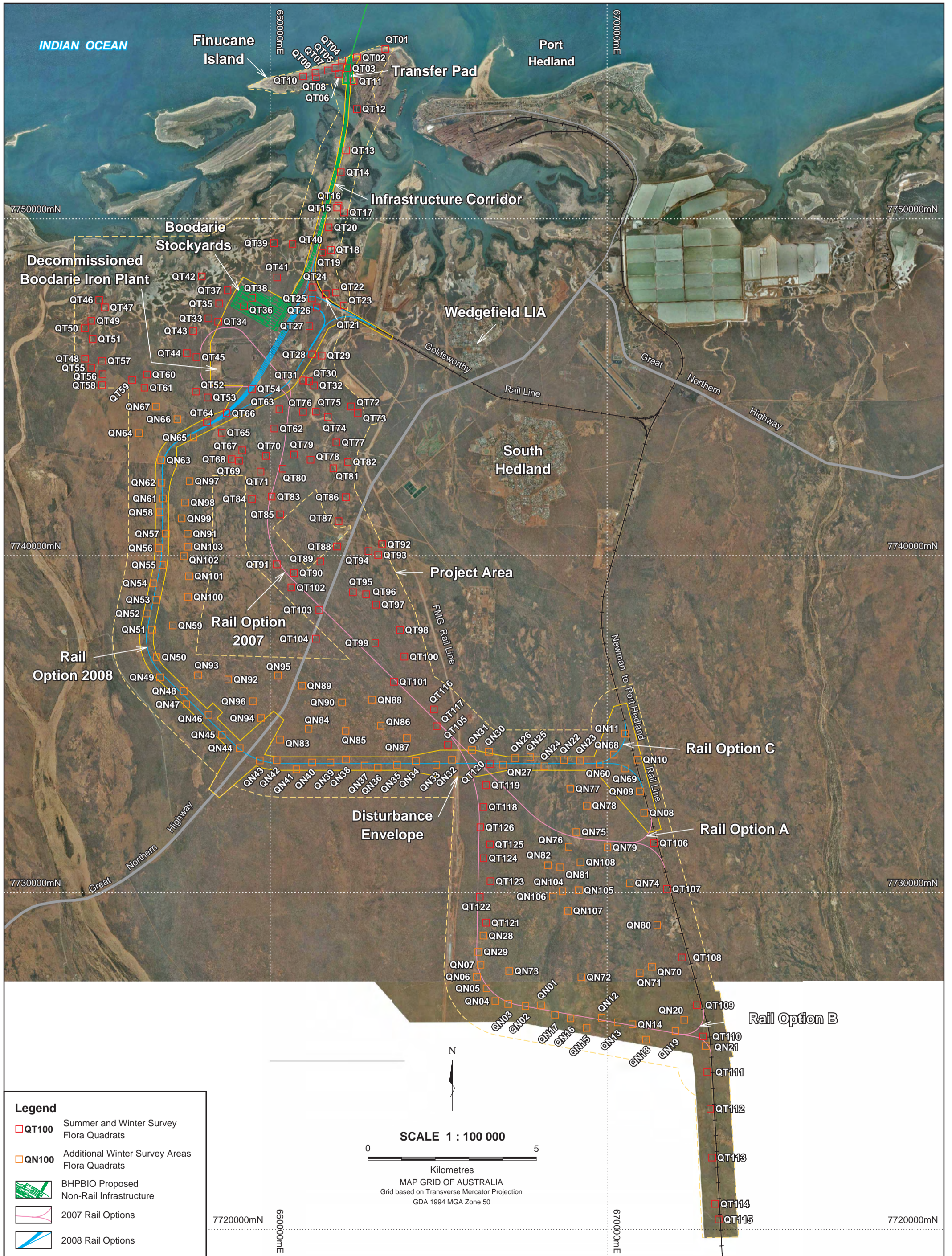
Author: E.Carroll
 Drawn: S.Coleman
 Status:
 Job Number: 08.216

Client: **BHP BILLITON PTY LTD**
 Project: **OUTER HARBOUR DEVELOPMENT
 FLORA AND VEGETATION ASSESSMENT**

REGIONAL VEGETATION

Date: 27 November 2009
 Scale: 1:100 000
 Figure No. **7**
 Plan No. **QM-020**





Legend

- QT100 Summer and Winter Survey Flora Quadrats
- QN100 Additional Winter Survey Areas Flora Quadrats
- BHPBIO Proposed Non-Rail Infrastructure
- 2007 Rail Options
- 2008 Rail Options

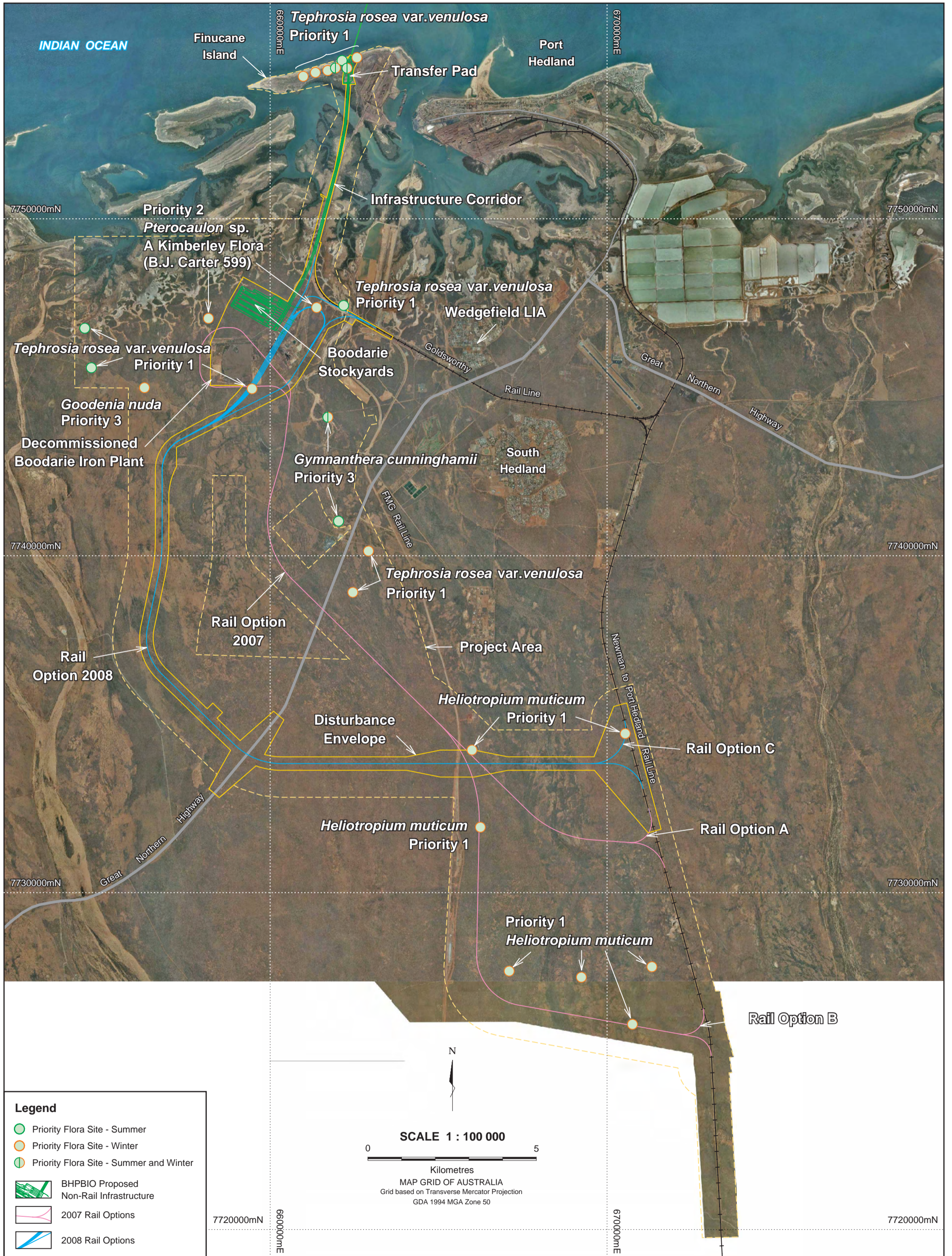


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 Drawn: S.Coleman
 Status:
 Job Number: 08.216

Client: **BHP BILLITON PTY LTD**
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 FLORA AND VEGETATION ASSESSMENT**

**FLORA SURVEY
 QUADRAT LOCATIONS**

Date: 27 November 2009
 Scale: 1:100 000
 Figure No. **8**
 Plan No. **QM-002**



Legend

- Priority Flora Site - Summer
- Priority Flora Site - Winter
- Priority Flora Site - Summer and Winter
- BHPBIO Proposed Non-Rail Infrastructure
- 2007 Rail Options
- 2008 Rail Options

N

SCALE 1 : 100 000

0 ————— 5

Kilometres

MAP GRID OF AUSTRALIA
Grid based on Transverse Mercator Projection
GDA 1994 MGA Zone 50

env
Australia

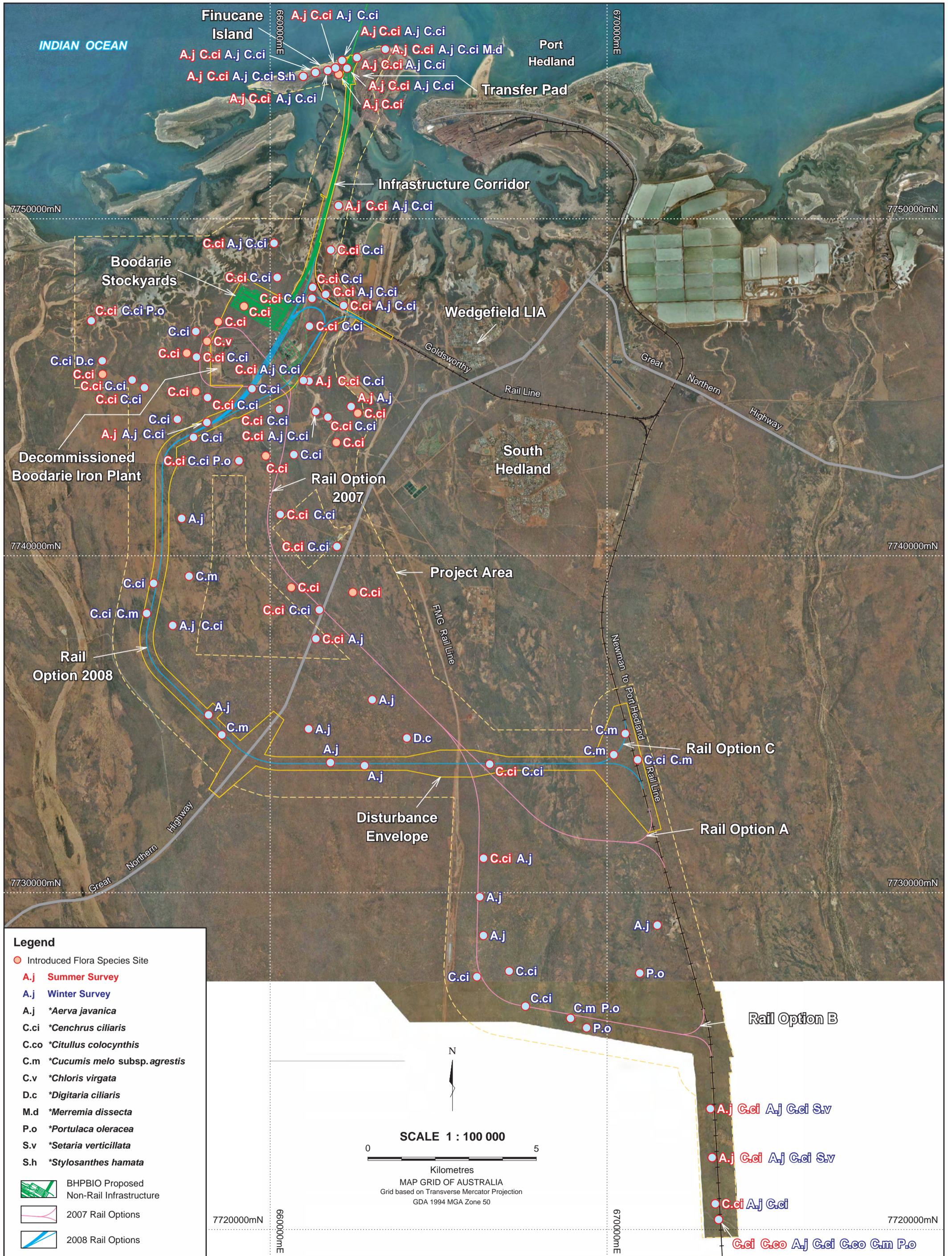
Author: E.Carroll
Drawn: S.Coleman
Status:
Job Number: 08.216

Client: **BHP BILLITON PTY LTD**

Project: **OUTER HARBOUR DEVELOPMENT
FLORA AND VEGETATION ASSESSMENT**

**LOCATIONS OF
PRIORITY FLORA SPECIES**

Date: 27 September 2009
Scale: 1:100 000
Figure No. **9**
Plan No. **QM-003**



Legend

- Introduced Flora Species Site
- A.j Summer Survey
- A.j Winter Survey
- A.j **Aerva javanica*
- C.ci **Cenchrus ciliaris*
- C.co **Citullus colocynthis*
- C.m **Cucumis melo subsp. agrestis*
- C.v **Chloris virgata*
- D.c **Digitaria ciliaris*
- M.d **Merremia dissecta*
- P.o **Portulaca oleracea*
- S.v **Setaria verticillata*
- S.h **Stylosanthes hamata*

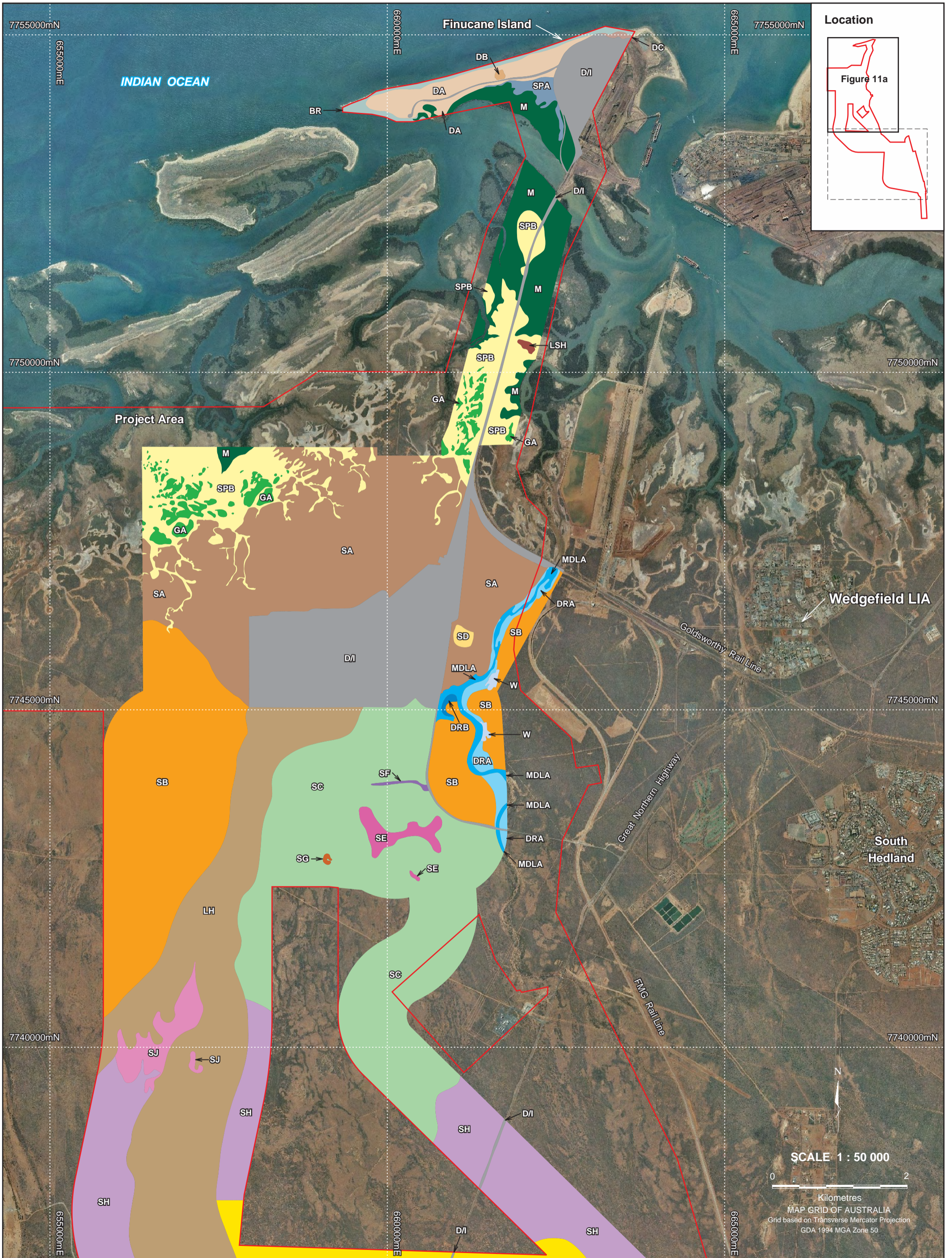
- BHPBIO Proposed Non-Rail Infrastructure
- 2007 Rail Options
- 2008 Rail Options

	Author: E.Carroll
	Drawn: S.Coleman
	Status:
	Job Number: 08.216

Client: BHP BILLITON PTY LTD
Project: OUTER HARBOUR DEVELOPMENT FLORA AND VEGETATION ASSESSMENT

LOCATIONS OF INTRODUCED FLORA SPECIES

Date: 27 September 2009
Scale: 1:100 000
Figure No. 10
Plan No. QM-004



Location

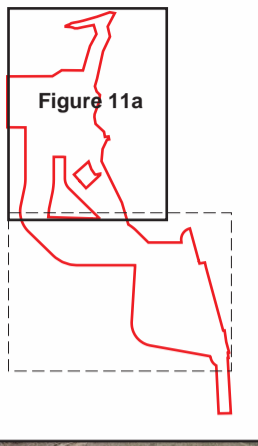


Figure 11a

SCALE 1 : 50 000

0 2 Kilometres

MAP GRID OF AUSTRALIA
Grid based on Transverse Mercator Projection
GDA 1994 MGA Zone 50

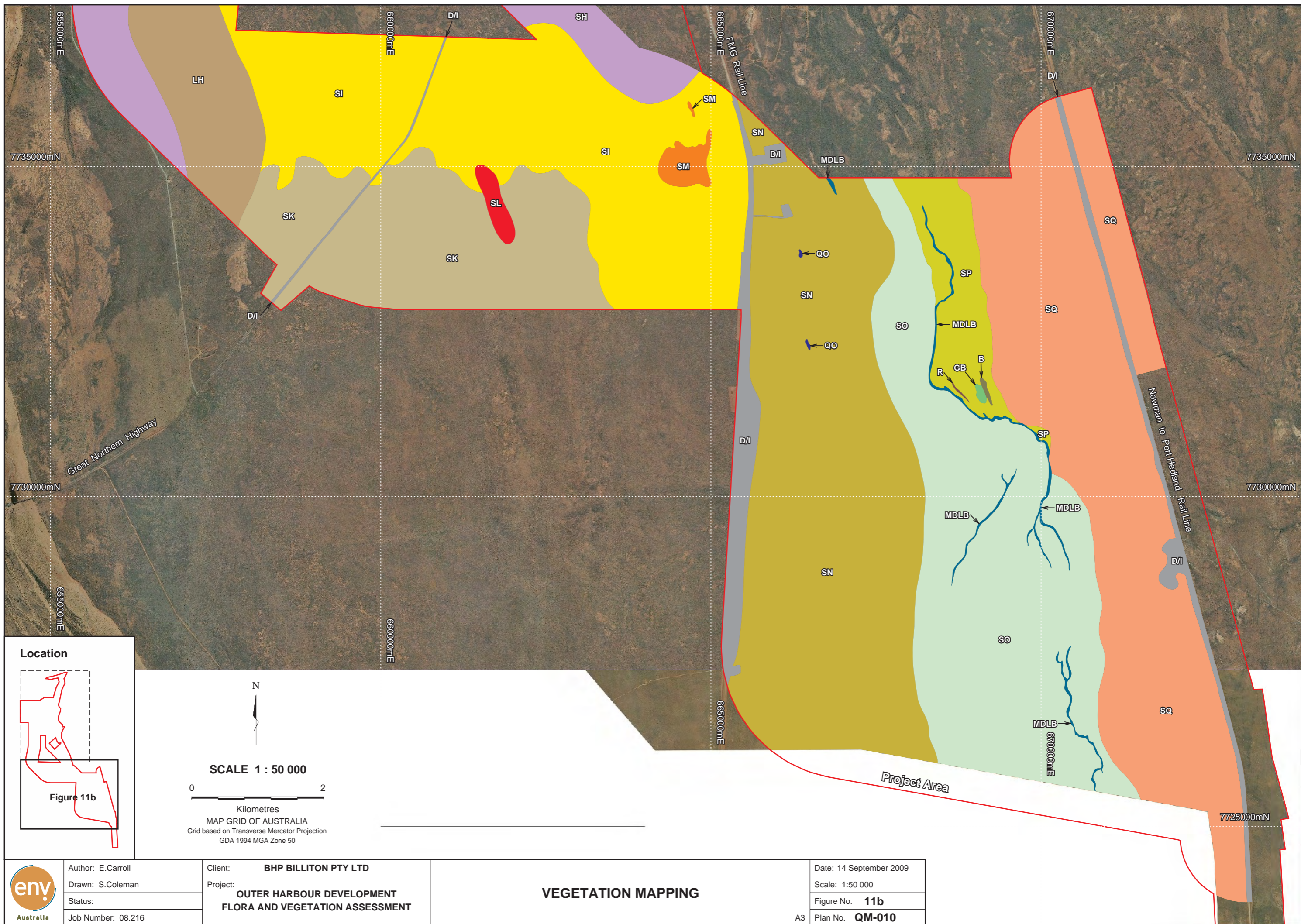


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Status:
Job Number: 08.216

Client: **BHP BILLITON PTY LTD**
Project: **OUTER HARBOUR DEVELOPMENT
FLORA AND VEGETATION ASSESSMENT**

VEGETATION MAP

Date: 14 September 2009
Scale: 1:50 000
Figure No. **11a**
Plan No. **QM-009**



Location

Figure 11b

N

SCALE 1 : 50 000

0 2

Kilometres

MAP GRID OF AUSTRALIA

Grid based on Transverse Mercator Projection

GDA 1994 MGA Zone 50






































	Author: E.Carroll
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	Status:
	Job Number: 08.216


Client: BHP BILLITON PTY LTD
Project: OUTER HARBOUR DEVELOPMENT FLORA AND VEGETATION ASSESSMENT

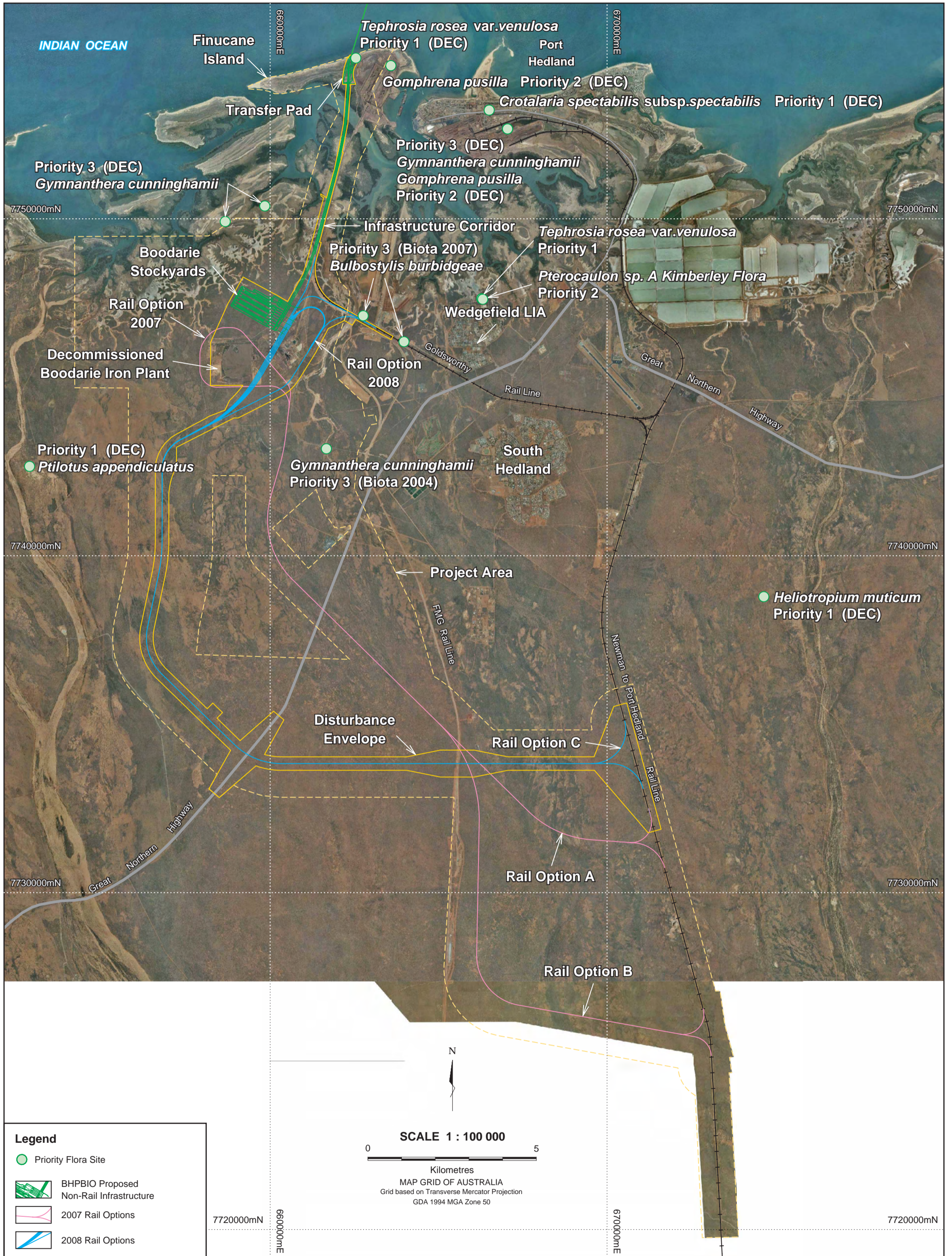
VEGETATION MAPPING

Date: 14 September 2009
Scale: 1:50 000
Figure No. 11b
Plan No. QM-010

Legend

	Beach / Reef		Sandplain A - Low <i>Acacia stellaticeps</i> shrublands over <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grasslands / <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grassland mosaic.
	Mangroves - A high closed <i>Ceriops tagal</i> and <i>Avicennia</i> shrubland.		Sandplain B - An open <i>Acacia coleii</i> var. <i>coleii</i> shrublands over low <i>Acacia stellaticeps</i> shrublands over <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grasslands / low <i>Acacia stellaticeps</i> shrublands over <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grassland mosaic.
	Samphire A - Scattered <i>Avicennia marina</i> shrubs over a low open <i>Halosarcia halocnemoides</i> , <i>Threlkeldia diffusa</i> and <i>Halosarcia pterygosperma</i> subsp. <i>denticulata</i> shrubland over a very open <i>Eragrostis falcata</i> tussock grassland.		Sandplain C - A low open <i>Corymbia flavescens</i> woodland over an open <i>Acacia coleii</i> var. <i>coleii</i> shrubland over a low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grasslands / low <i>Acacia stellaticeps</i> shrublands over <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grasslands / <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grassland mosaic.
	Samphire B - Scattered <i>Avicennia marina</i> shrubs over a low open <i>Halosarcia halocnemoides</i> subsp. <i>tenuis</i> , <i>Halosarcia halocnemoides</i> and <i>Trianthema turgidifolia</i> shrubland.		Sandplain D - A low <i>Eucalyptus victrix</i> woodland over an <i>Acacia coleii</i> var. <i>coleii</i> shrubs over a low open <i>Acacia stellaticeps</i> and <i>Pluchea tetranthera</i> shrubland over a <i>Triodia epactia</i> hummock grassland.
	Major Drainage Line A - Scattered low <i>Eucalyptus victrix</i> trees over a high open <i>Melaleuca argentea</i> , <i>Acacia ampliceps</i> and <i>Acacia trachycarpa</i> shrubland over scattered <i>Adriana urticoides</i> var. <i>urticoides</i> and <i>Pluchea ferdinandi-muelleri</i> shrubs over an open <i>Triodia epactia</i> hummock grassland.		Sandplain E - A low open <i>Corymbia flavescens</i> and <i>Eucalyptus victrix</i> woodland over an <i>Acacia coleii</i> var. <i>coleii</i> and <i>Acacia sericophylla</i> shrubs over a low open <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland.
	Major Drainage Line B - A low open <i>Eucalyptus victrix</i> woodland over an <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Acacia coleii</i> var. <i>coleii</i> shrubland over a very open <i>Triodia epactia</i> hummock grassland.		Sandplain F - An open <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Acacia coleii</i> var. <i>coleii</i> shrubs over an open <i>Triodia epactia</i> hummock grassland.
	Drainage A - A low open <i>Eucalyptus victrix</i> woodland over a high open <i>Acacia ampliceps</i> and <i>Acacia trachycarpa</i> shrubs over a low open <i>Acacia stellaticeps</i> , <i>Pluchea ferdinandi-muelleri</i> and <i>Corchorus incanus</i> subsp. <i>incanus</i> shrubland over <i>Triodia epactia</i> hummock grassland over an <i>Aristida holathera</i> var. <i>latifolia</i> , <i>Eriachne obtusa</i> and <i>*Cenchrus ciliaris</i> tussock grassland.		Sandplain G - A low open <i>Corymbia flavescens</i> woodland over an <i>Acacia coleii</i> var. <i>coleii</i> , <i>Carissa lanceolata</i> and <i>Acacia sericophylla</i> shrubland over a <i>Triodia epactia</i> hummock grassland over a very open <i>*Cenchrus ciliaris</i> , <i>Chrysopogon fallax</i> and <i>Eriachne obtusa</i> tussock grassland.
	Drainage B - A low open <i>Eucalyptus victrix</i> woodland over a high open <i>Acacia ampliceps</i> shrubland over low open <i>Acacia stellaticeps</i> and <i>Pluchea ferdinandi-muelleri</i> shrubland over a closed <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grassland over an open <i>Eriachne obtusa</i> , <i>Aristida holathera</i> var. <i>latifolia</i> and <i>*Cenchrus ciliaris</i> tussock grassland.		Sandplain H - An <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Acacia coleii</i> var. <i>coleii</i> shrubland over a low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland / <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland mosaic.
	Billabong - Scattered low <i>Eucalyptus victrix</i> trees over scattered mixed grasses.		Sandplain I - An <i>Acacia tumida</i> var. <i>pilbarensis</i> shrubland over a low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grasslands / low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland / <i>Triodia epactia</i> hummock grassland mosaic.
	Washout - Bare areas of sand alongside river.		Sandplain J - Scattered low <i>Corymbia flavescens</i> trees over an open <i>Acacia tumida</i> var. <i>pilbarensis</i> shrubs over a low open <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grasslands / <i>Triodia epactia</i> and <i>Triodia secunda</i> hummock grassland mosaic.
	Dunes A - Scattered <i>Acacia bivenosa</i> shrubs over a low open <i>Crotalaria cunninghamii</i> shrubland over a <i>*Cenchrus ciliaris</i> tussock grassland over scattered <i>*Aerva javanica</i> herbs.		Sandplain K - Scattered low <i>Owenia reticulata</i> trees over an <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Acacia coleii</i> var. <i>coleii</i> shrubland over a low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland / low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland mosaic.
	Dunes B - An <i>Atalaya hemiglaucula</i> , <i>Santalum lanceolatum</i> and <i>Acacia bivenosa</i> shrubland over a <i>*Cenchrus ciliaris</i> tussock grassland.		Sandplain L - A low open <i>Corymbia zygophylla</i> woodland over an open <i>Acacia coleii</i> var. <i>coleii</i> , <i>Acacia inaequilatera</i> and <i>Acacia ancistrocarpa</i> shrubland over a low <i>Acacia sericophylla</i> , <i>Acacia stellaticeps</i> , <i>Senna artemisioides</i> aff. subsp. <i>oligophylla</i> (thinly sericeous) and <i>Dodonaea coriacea</i> shrubland over a very open <i>Triodia lanigera</i> and <i>Triodia epactia</i> hummock grassland.
	Dunes C - A low open <i>Acacia stellaticeps</i> , <i>Acacia bivenosa</i> and <i>Acacia ampliceps</i> shrubland over a <i>Spinifex longifolius</i> and <i>*Cenchrus ciliaris</i> open grassland over scattered <i>Gomphrena canescens</i> herbs.		Sandplain M - An open <i>Acacia ancistrocarpa</i> , <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Acacia inaequilatera</i> shrubland over a <i>Triodia lanigera</i> hummock grassland.
	Limestone Hill - An <i>Acacia bivenosa</i> and <i>Hakea lorea</i> subsp. <i>lorea</i> shrubland over scattered low <i>Rhagodia eremaea</i> and <i>Scaevola spinescens</i> shrubland over a scattered <i>Eriachne obtusa</i> tussock grasses.		Sandplain N - A low open <i>Corymbia zygophylla</i> woodland over an open <i>Acacia ancistrocarpa</i> , <i>Acacia inaequilatera</i> , <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Acacia sericophylla</i> shrubland over <i>Acacia stellaticeps</i> low open shrubland over <i>Triodia epactia</i> and <i>Triodia lanigera</i> hummock grassland.
	Low Hill - An <i>Acacia tumida</i> var. <i>pilbarensis</i> shrubland over a low <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> hummock grassland.		Sandplain O - Scattered low <i>Eucalyptus victrix</i> and <i>Corymbia hamersleyana</i> trees over an open <i>Acacia ancistrocarpa</i> , <i>Acacia tumida</i> var. <i>pilbarensis</i> , <i>Acacia inaequilatera</i> and <i>Acacia trudgeniana</i> shrubs over a low open <i>Acacia stellaticeps</i> shrubland over a <i>Triodia epactia</i> and <i>Triodia lanigera</i> hummock grassland.
	Quartz Outcrop - Small low hills / rock piles with scattered <i>Acacia coleii</i> subsp. <i>coleii</i> and <i>Acacia inaequilatera</i> shrubs over scattered herbs over scattered <i>Triodia</i> sp. hummock grasses.		Sandplain P - A low open <i>Eucalyptus victrix</i> , <i>Corymbia hamersleyana</i> and <i>Corymbia flavescens</i> woodland over an open <i>Acacia coleii</i> var. <i>coleii</i> shrubland over low open <i>Acacia stellaticeps</i> and <i>Pluchea tetranthera</i> shrubland over a <i>Triodia lanigera</i> hummock grassland.
	Grassland A - <i>Triodia secunda</i> and <i>Triodia epactia</i> hummock grassland.		Sandplain Q - Scattered low <i>Corymbia flavescens</i> trees over an open <i>Acacia ancistrocarpa</i> and <i>Acacia bivenosa</i> shrubland over scattered low <i>Acacia stellaticeps</i> shrubs over a <i>Triodia epactia</i> and <i>Triodia lanigera</i> hummock grassland.
	Grassland B - <i>Triodia epactia</i> hummock grassland.		
	Rockpile - Scattered low <i>Ficus brachypoda</i> , <i>Cleorodendrum tomentosum</i> var. <i>lanceolatum</i> and <i>Carissa lanceolata</i> trees over scattered herbs.		
	Disturbed / Infrastructure		

 Australia	Author: E.Carroll	Client: BHP BILLITON PTY LTD	VEGETATION MAP LEGEND	Date: 11 September 2009
	Drawn: S.Coleman	Project:		Scale: NTS
	Status:	OUTER HARBOUR DEVELOPMENT FLORA AND VEGETATION ASSESSMENT		Figure No. 11c
	Job Number: 08.216			Plan No. QM-011
				A3



Legend

- Priority Flora Site
- BHPBIO Proposed Non-Rail Infrastructure
- 2007 Rail Options
- 2008 Rail Options

SCALE 1 : 100 000

0 5

Kilometres

MAP GRID OF AUSTRALIA
Grid based on Transverse Mercator Projection
GDA 1994 MGA Zone 50

Author: E.Carroll
 Drawn: S.Coleman
 Status:
 Job Number: 08.216

Client: **BHP BILLITON PTY LTD**
 Project: **OUTER HARBOUR DEVELOPMENT
 FLORA AND VEGETATION ASSESSMENT**

**PRIORITY FLORA PREVIOUSLY RECORDED
 IN THE VICINITY OF THE PROJECT AREA**

Date: 27 November 2009
 Scale: 1:100 000
 Figure No. **12**
 Plan No. **QM-017**