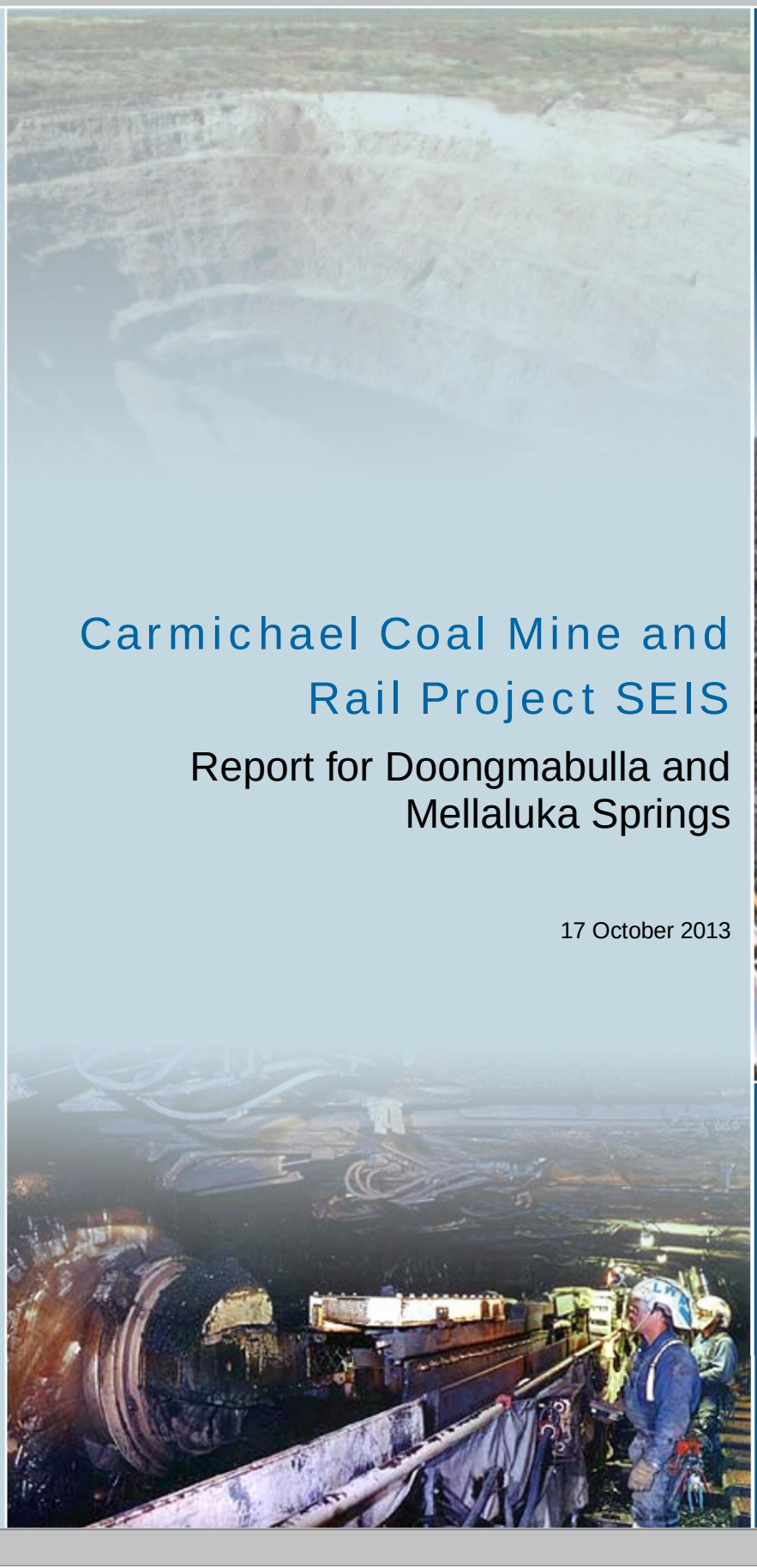
Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project SEIS

Report for Doongmabulla and Mellaluka Springs

17 October 2013



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Executive summary

This report provides a description of the aquatic and terrestrial flora, fauna and habitat values of both the Doongmabulla Springs complex, located 8 kilometres (km) to the west of the proposed Carmichael Coal Mine and Rail Project, and the Mellaluka Springs complex, located on the south eastern edge of Project Area. This assessment is based on a desktop investigation and a site inspection of the two spring complexes in March and April 2013.

Doongmabulla Springs complex

The Doongmabulla Springs complex contains three spring groups, Little Moses, Joshua and Moses, all of which contribute base flow to nearby riverine channels. These springs are located on Doongmabulla station near the confluence of three creek systems – Cattle Creek, Dyllingo Creek and Carmichael Creek, all of which join to form the Carmichael River. The Moses Spring group comprises at least 65 individual springs which contribute surface water to a series of adjacent wetlands.

The Doongmabulla Springs complex is recognised as the endangered threatened ecological community 'The community of native species dependant on natural discharge of groundwater from the Great Artesian Basin (GAB)' under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and contains a comparatively high number of flora and fauna species endemic to GAB spring wetlands. These perennial wetlands are comprised of grassland and sedgeland that contain seven plants listed as being of conservation significance under state or federal legislation.

The Doongmabulla Springs complex provides habitat for a wide range of least concern species of flora and fauna. In general, the habitats present within the Doongmabulla wetland are intact and in good ecological condition and exhibited only minor disturbance. While the wetland is exposed to introduced and native wildlife, minimal animal impacts were noted for most sites. Cattle trampling was observed only at the Moses spring group. The greatest damage to the wetlands was caused by feral pigs, with parts of some wetlands highly disturbed by pig wallowing and foraging.

The greatest habitat values of the Doongmabulla Springs complex are the permanency of water, and the connectivity of the wetland to the nearby waterways and the surrounding region. The reliable water supply provides an important resource for both flora and fauna during dry periods, but it is the habitat connectivity that provides the means for fauna to access the springs. Generally speaking, the Doongmabulla wetland, permanently inundated area associated with run off from spring complex, and adjacent areas consisted of a diverse range of habitats. All strata of terrestrial vegetation were present, from native grasses and herbs through to mature trees.

Open woodlands associated with the wetland were commonly utilised by the vulnerable squatter pigeon (*Geophaps scripta scripta*) (listed under the *Nature Conservation Act 1992* (NC Act) and the EPBC Act). It is likely that the diverse wood debris habitat within the Doongmabulla wetland would support a diverse and abundant range of reptiles. The Doongmabulla wetland was also used for bird nesting with mud nests especially common and stick nests also frequently observed. Hollows were plentiful on the periphery of the wetland and surrounds, and so it is very likely that a number of arboreal species will be present at the wetland. Such species would potentially include possums, gliders and bats.

The Doongmabulla Springs complex, and in particular the Moses spring group, provide suitable habitat for frogs in the region. The density of vegetation and abundance of perennial water makes the Doongmabulla Springs and associated wetlands an important amphibian habitat in an otherwise arid environment.

The Doongmabulla Springs maintain perennial surface water which may be significant for aquatic communities in the region by providing refugial habitat during seasonal conditions and periods of drought. The aquatic communities in these environments rely on the persistence of such refugial habitats. For this reason, the Doongmabulla Springs complex is likely to provide important habitat for aquatic fauna, including fish. Similarly to fish, turtles rely on perennial water during the dry season. For this reason, Doongmabulla Springs is likely to be of importance in maintaining viable habitat for freshwater turtles in the region. The Doongmabulla Springs also provide a diverse range of habitat for aquatic invertebrates, including freshwater mussels, crayfish, freshwater crabs and various insects.

The Joshua spring group was the most impacted, and is completely altered from its natural state. It now consists of a single turkey's nest dam and two associated scrapes. The overflow channel for the Joshua spring (which carries a significant volume of water) is infested with the grass *Hymenachne amplexicaulis,* a class two declared weed. However, given the depth of the turkey's nest dam and the permanency and high flow rate of this spring, it is predicted that the Joshua spring provides potential habitat for fish, amphibians, turtles and invertebrate species, especially during the dry season.

Overall, the Doongmabulla Springs complex provides habitat for a number of flora, birds, mammals, amphibians, reptiles, fish and invertebrates species.

Mellaluka Springs complex

The Mellaluka Springs complex contains three spring groups – Mellaluka Spring, Stories Spring and Lignum Spring. The Mellaluka Springs complex is not considered to be a part of the Great Artesian Basin, and the spring group and associated wetland is relatively poorly documented. While the Mellaluka Springs complex is identified by DERM's wetland mapping tool, they are not listed in the Directory of Important Wetlands. All of these springs are discrete environments that are not located within or near to any riverine waterways. No endemic species are known to be associated with the Mellaluka Spring complex.

All three springs have bores installed which provide water for domestic use (the Mellaluka Spring), and water for livestock (Stories and Lignum springs). The Mellaluka Spring (proper) was the largest spring which supported a wetland and dam.

The Mellaluka wetland is a permanently inundated area associated with run off from the Mellaluka Springs complex, and provides habitat for a range of aquatic and terrestrial fauna. These springs may also be regionally important as a refuge for fauna during droughts and dry periods. No threatened species of flora were located at the springs, or were predicted to be present, and there are no historic records of threatened flora from the site.

The Mellaluka Springs complex is commonly utilised by the vulnerable squatter pigeon (*Geophaps scripta scripta*) (listed under the NC Act and the EPBC Act).

The Mellaluka wetlands provide refugial habitat and a constant source of water for flora and fauna communities in the vicinity. While the Mellaluka Spring is the larger spring, it is relatively isolated from nearby grass and woodland, and terrestrial habitat connectivity may be

compromised for many species. However, Stories and Lignum springs are both situated in woodland where habitat connectivity is maintained. The Mellaluka Spring contained the largest community of flora species which in turn created a broad range of habitats.

There was, however, a lesser complexity of habitat within the Mellaluka wetlands than at the Doongmabulla Springs complex. This may account for the reduced bird species count at the Mellaluka Springs complex compared to Doongmabulla Springs complex.

Groundcover was thick, and included leaf litter, woody debris and grasses at Mellaluka Spring. Tree hollows were common on the mound in the tall river red gums, but were sparse in the surrounding paddocks. Stories and Lignum springs were both vegetated with *Typha domingensis*, and were situated within a large area of intact woodland with a high level of structural habitat complexity. Log piles and fallen timber were not common at the springs, and were very sparse at the Lignum Spring. The greatest habitat values for reptiles were the dense vegetation and leaf litter at the Mellaluka Spring. Mellaluka Spring is covered in vegetation, including mature trees with hollows and dense grasses and shrubs. The thick vegetation provides suitable cover for smaller ground-dwelling marsupials, and the hollows may support arboreal species. During dry periods, this spring may also act as a habitat refuge for mammals aside from being a perennial source of water.

The Mellaluka Spring provided abundant habitat for amphibians as it had a perennial water source and dense vegetative cover. While both Stories and Lignum springs contained frogs, the smaller size of the springs and the cattle associated disturbances to the springs make these vents less suitable for supporting large amphibian populations. The density of vegetation and abundance of perennial water makes the Mellaluka Springs and associated wetlands an important amphibian habitat in an otherwise arid environment.

The surface waters of the Mellaluka Spring are fringed by submerged, emergent and trailing vegetation, and some woody debris is present. Substrate consisted primarily of mud and/or peat; rocks or stones seemed absent. Overall aquatic habitat diversity is fairly limited; however, as a perennial waterbody, the Mellaluka Spring may provide valuable stable, refugial habitat for fish, if they are present.

The dam at Mellaluka Spring provides habitat for turtles as the surface waters are perennial, and prey (frogs, fish, insects and crustaceans) are predicted to be abundant. The aquatic invertebrate community is likely to consist of decapods (freshwater shrimps, prawns, crabs and crayfish), microcrustaceans and a range of aquatic insects. While there is little cover provided by submerged timber or floating macrophytes, the peat and clay substrate does provide an environment suitable for aquatic invertebrates.

Overall, the Mellaluka Springs complex provides habitat for a number of flora, amphibians, reptiles (particularly turtles), birds, mammals, fish and invertebrates species, although the value of this habitat is limited for some species.


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Abbreviations and glossary

Project specific terminology	
Abbreviation	Term
the Project	Carmichael Coal Mine and Rail Project
the Study Area	The area including and immediately adjacent to the relevant spring complex
Generic terminology	
Abbreviation	Term
BOM	Bureau of Meteorology
DEHP	Department of Environment and Heritage Protection (QLD)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPC	exploration permit for coal
GAB	Great Artesian Basin
km	kilometre
matters of NES	matters of national environmental significance
m	metre
mm	millimetre
NC Act	Nature Conservation Act 1992
NRM	Natural Resource Management
RE	regional ecosystem
spring complex	A cluster of spring groups in a similar geomorphic setting within six kilometres of each neighbouring spring group
spring group	A cluster of individual springs in a similar geomorphic setting where no one pair of springs is more than one kilometre apart
SEIS	Supplementary environmental impact statement
TEC	threatened ecological community
ToR	terms of reference

1. Introduction

1.1 Project overview

Adani Mining Pty Ltd (Adani) is proposing to develop a 60 million tonne (product) per annum Adani Mining Pty Ltd (Adani, the Proponent), commenced an Environmental Impact Statement (EIS) process for the Carmichael Coal Mine and Rail Project (the Project) in 2010. On 26 November 2010, the Queensland (Qld) Office of the Coordinator General declared the Project a 'significant project' and the Project was referred to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DDSEWPaC) (referral No. 2010/5736). The Project was assessed to be a controlled action on the 6 January 2011 under section 75 and section 87 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The controlling provisions for the Project include:

- World Heritage properties (sections 12 & 15A)
- National Heritage places (sections 15B & 15C)
- Wetlands (Ramsar) (sections 16 & 17B)
- Listed threatened species and communities (sections 18 & 18A)
- Listed migratory species (sections 20 & 20A)
- The Great Barrier Reef Marine Park (GBRMP) (sections 24B & 24C)
- Protection of water resources (sections 24D & 24E)

The Qld Government's EIS process has been accredited for the assessment under Part 8 of the EPBC Act in accordance with the bilateral agreement between the Commonwealth of Australia and the State of Queensland.

The Proponent prepared an EIS in accordance with the Terms of Reference (ToR) issued by the Qld Coordinator-General in May 2011 (Qld Government, 2011). The EIS process is managed under section 26(1) (a) of the *State Development and Public Works Act 1971* (SDPWO Act), which is administered by the Qld Government's Department of State Development, Infrastructure and Planning (DSDIP).

The EIS, submitted in December 2012, assessed the environmental, social and economic impacts associated with developing a 60 million tonne (product) per annum (Mtpa) thermal coal mine in the northern Galilee Basin, approximately 160 kilometres (km) north-west of Clermont, Central Queensland, Australia. Coal from the Project will be transported by rail to the existing Goonyella and Newlands rail systems, operated by Aurizon Operations Limited (Aurizon). The coal will be exported via the Port of Hay Point and the Point of Abbot Point over the 60 year (90 years in the EIS) mine life.

Project components are as follows:

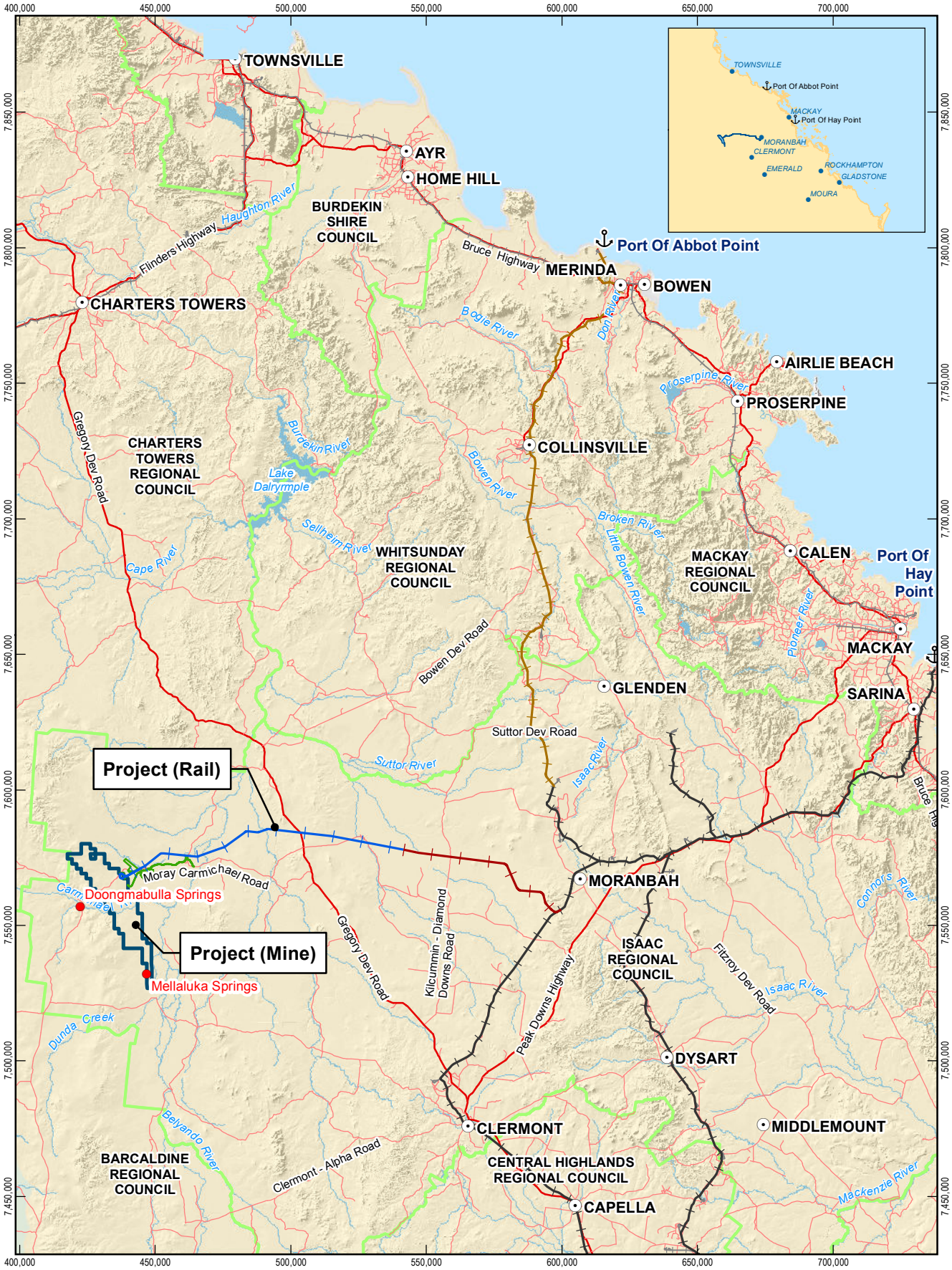
- The Project (Mine): a greenfield coal mine over EPC 1690 and the eastern portion of EPC 1080, which includes both open cut and underground mining, on mine infrastructure and associated mine processing facilities (the Mine) and the Mine (offsite) infrastructure including a workers accommodation village and associated facilities, a permanent airport site, an industrial area and water supply infrastructure

- The Project (Rail): a greenfield rail line connecting to mine to the existing Goonyella and Newlands rail systems to provide for the export of coal via the Port of Hay Point (Dudgeon Point expansion) and the Port of Abbot Point, respectively including:
  - Rail (west): a 120 kilometre (km) dual gauge portion running west from the Mine site east to Diamond Creek
  - Rail (east): a 69 km narrow gauge portion running east from Diamond Creek connecting to the Goonyella rail system south of Moranbah.
  - Quarries: The use of five local quarries to extract quarry materials for construction and operational purposes

1.2 Project background

The Project EIS was developed with the objective to ensure that all potential environmental, social and economic impacts of the Project are identified and assessed, and that identified adverse impacts are avoided or mitigated. A number of submissions were made to the Project EIS requesting further information on the Doongmabulla and Mellaluka springs complexes and the impacts that any changes to groundwater would have on the spring complexes. This report provides further information on the aquatic and terrestrial values of the Doongmabulla and Mellaluka springs and provides part of the response to the Project EIS submissions. Further information in regard to potential impacts is provided in the revised Ecological Assessment Report (SEIS Volume 4 Appendix I1) and the revised Mine Hydrogeology Report (SEIS Volume 4 Appendix K1) of the Supplementary Environmental Impact Assessment.

Figure 1 shows the Project location and Figure 2 shows the location of the Project (Mine) in relation to the Doongmabulla and Mellaluka spring complexes and the Great Artesian Basin.



LEGEND

- Spring Locations
- Town
- Major Port
- Other Rail Network
- Goonyella System
- Newlands System
- Local Road
- Watercourse
- Local Government Area
- Project (Rail)
- Rail (West)
- Rail (East)
- Project (Mine)
- Mine (Offsite)

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0 10 20 30 40 50

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

Adani Mining Pty Ltd
Doongmabulla and Mellaluka Springs
Existing Environment Report

Project Location

Job Number	41-25215
Revision	C
Date	05-09-2012

Figure 1

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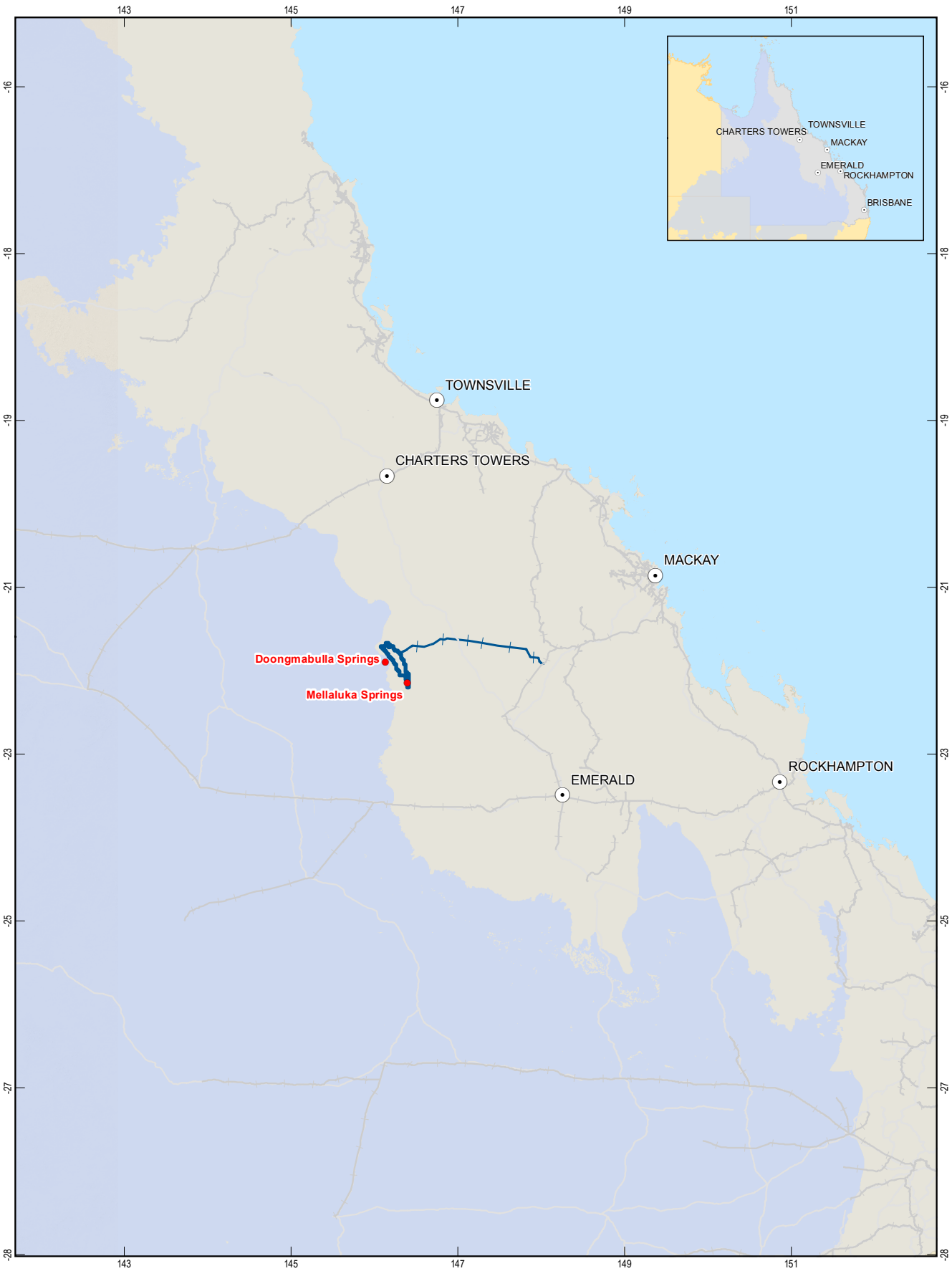
Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: © Commonwealth of Australia (Geoscience Australia): Town, Railways, Watercourses (2007); DERM: LGA, (2011), Hillshade (2009); DMR: State Roads (2008); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011); Adani: Alignment Opt9 Rev3 (2012) GHD:Spring Locations (2013). Created by: MS



LEGEND

- Locality
- Road
- Railway
- Springs
- Carmichael Rail Project
- Carmichael Coal Mine Site
- Great Artesian Basin
- Queensland
- Other State and Territories

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Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

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Adani Mining Pty Ltd
Doongmabulla and Mellaluka Springs
Existing Environment Report

Job Number	41-25215
Revision	B
Date	26-06-2013

Great Artesian Basin with Project Location

Figure 2

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Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DNRM: Artesian Basin, GA: Locality, Mainlands, Hill shade, Roads, Railway (2007), Springs (2009), DME: EPC1690 (2010), EPC1080 (2011);Adani: Alignment Opt9 Rev3 (SP1 & 2) (2012). Created by:MS

1.3 Report scope

This report describes the habitat values of the Doongmabulla and Mellaluka springs and wetlands. The habitat values of the springs and wetlands are discussed in relation to the aquatic and terrestrial flora and fauna that may be associated with the spring complexes.

Specifically, the following was determined:

- Flora species and vegetation community values of the Doongmabulla and Mellaluka springs and wetlands
- Presence of migratory birds and flora or fauna species of conservation significance
- Fauna species (aquatic and terrestrial) values of the Doongmabulla and Mellaluka springs and wetlands
- Habitat values of the Doongmabulla and Mellaluka springs and wetlands
- Basic mapping of the spring complexes and those wetlands reliant on the springs

A number of botanical surveys have been conducted at the Doongmabulla Springs complex over the past 20 years by the Queensland Herbarium (Queensland Herbarium, 2012). In addition, GHD undertook a survey at this spring complex in May 2012 (GHD, 2012a).

The purpose of the current (March/April 2013) survey at the Doongmabulla Springs complex was to:

- Determine the seasonal changes between May 2012 and March/April 2013 at the Doongmabulla Springs complex/wetland
- Determine the presence and habitat values for migratory birds
- Build on existing knowledge to determine the typical flora and fauna communities (both terrestrial and aquatic) of the Doongmabulla wetland, and the habitat values it provides.

This report is supported by information provided in the following Carmichael Coal Mine and Rail Project EIS Technical reports and supplementary environmental impact statement (SEIS) reports:

- Doongmabulla Springs Existing Environment Report (GHD, 2012a)
- Mine Terrestrial Ecology Report which assesses the terrestrial flora and fauna ecological values of the Project Area (GHD, 2012b)
- Aquatic Ecology Report which assesses the aquatic flora and fauna ecological values of the Project Area (GHD, 2012c)
- Mine Hydrology Report which assesses the surface water flows of the Project Area (GHD, 2012d)
- Mine Water Quality Report which assesses the surface water quality environmental of the Project Area (GHD, 2012e)
- Mine Hydrogeology Report which includes the assessment of the groundwater environments (including stygofauna) of the Study Area (GHD,2012f)
- Population Survey of the Waxy Cabbage Palm which reports on the population survey of the *Livistona lanuginosa* Rodd undertaken as part of SEIS studies for the Carmichael Coal Mine and Rail Project (GHD, 2013a)

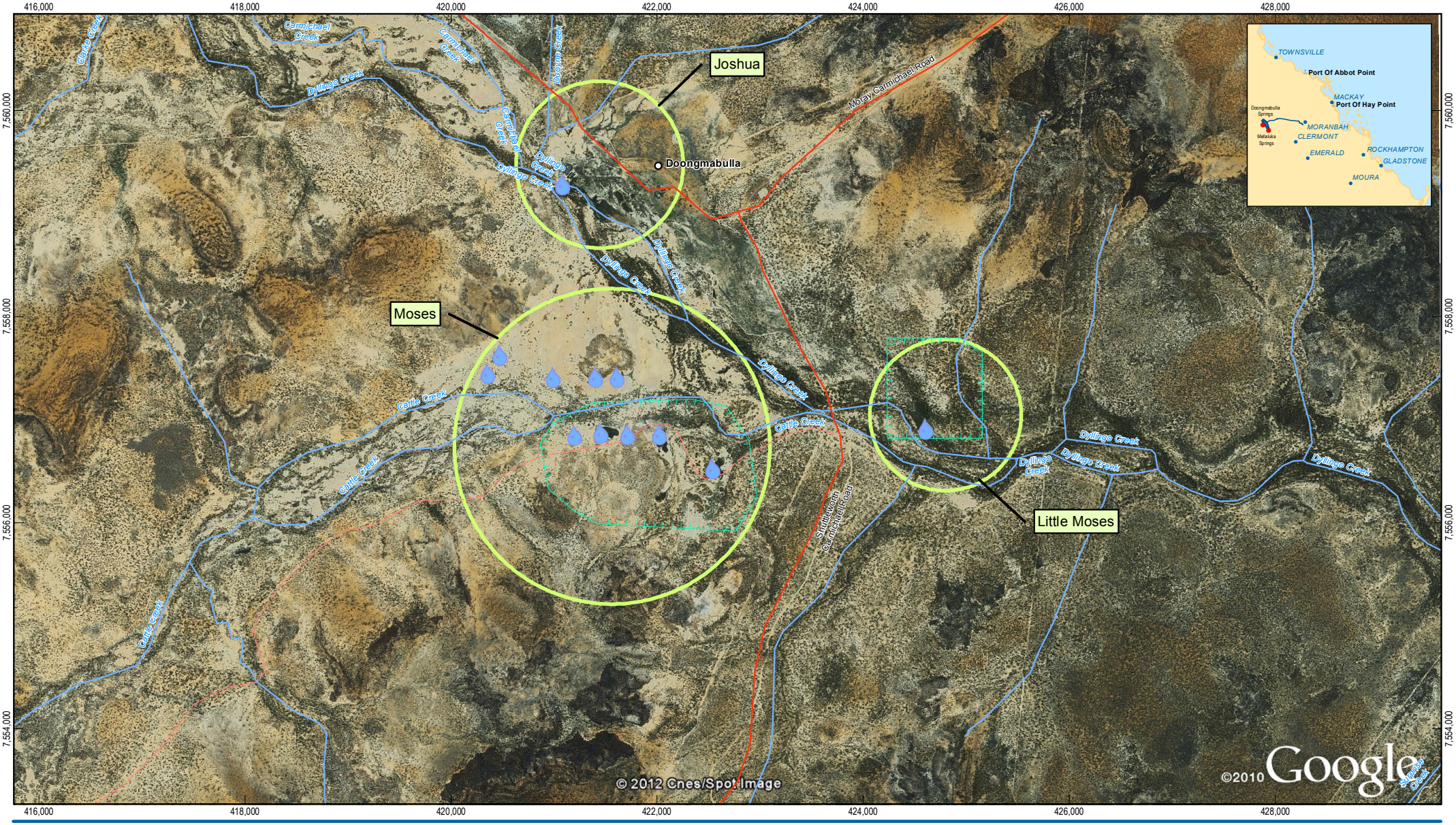
1.4 Study area

The Study Area for this report comprises:

- The Doongmabulla Springs complex (Figure 3); being the complex of Moses, Little Moses and Joshua spring groups and their associated wetlands, and the land in its immediate vicinity that provides habitat for flora and fauna
- The Mellaluka Springs complex (Figure 4); being the complex of Mellaluka, Lignum and Stories spring groups and associated wetland, and the land in its immediate vicinity that provides habitat for flora and fauna.

The Doongmabulla Springs complex comprises discrete pools and patches of grassland, sedgeland and woodland created by the outflow of artesian water from a cluster of spring groups (Joshua, Moses and Little Moses). Each spring group contains at least one spring – in the case of Moses, there are more than 65. Collectively, the spring groups are known as the Doongmabulla Springs complex. The Doongmabulla Springs complex is approximately 4.5 km in diameter, and is located approximately 8 km to the west of the Project (Figure 2).

The Mellaluka Springs complex (including the Mellaluka, Lignum and Stories spring groups consists of several pools (both modified and natural) and seeps which support dense vegetation. Both the Lignum and Stories spring groups consist of a single spring, whereas the Mellaluka Spring comprise several springs which feed several natural pools.



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Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Homestead
- Springs
- Minor Road
- Track
- Watercourse
- Spring Groups
- Doongmabulla Mound Springs Nature Refuge

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Existing Environment Report

Job Number	41-25215
Revision	C
Date	26-06-2013

Doongmabulla Springs Complex — Figure 3

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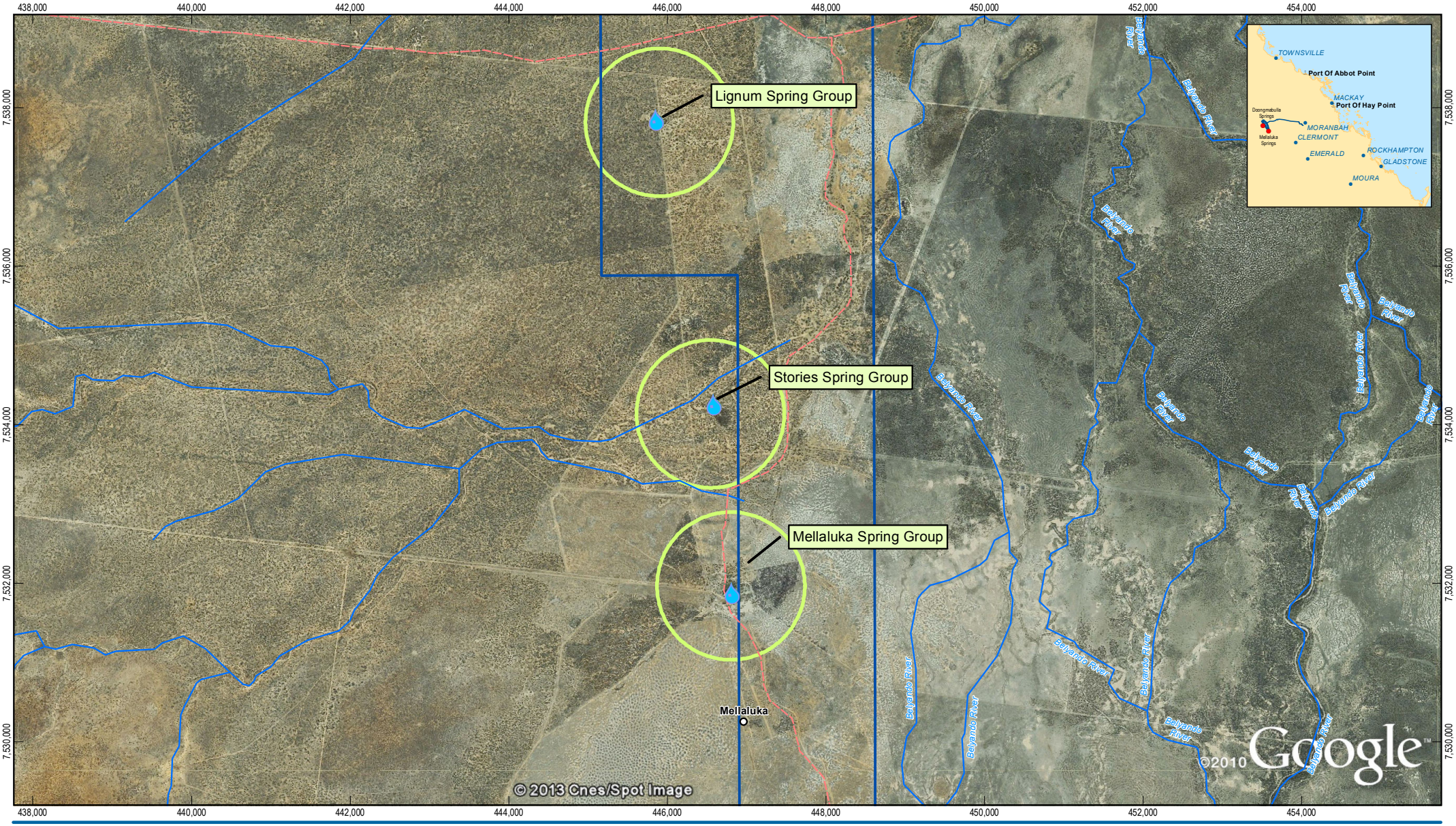
Data Source: GHD: Spring Complex/2012, Springs/2012; GA: Watercourses, Roads, Homesteads (2007); DNRM: Nature Refuge (2010); DME: Carmichael Mine Site; Google: Imagery (2012). Created by: SB,MS



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Homestead
- Spring Group (Surveyed)
- Track
- Watercourse
- Project (Mine)
- Spring Groups

Adani Mining Pty Ltd
Doongmabulla and Mellaluka Springs
Existing Environment Report

Job Number 41-25215
Revision B
Date 26-06-2013

Mellaluka Springs Complex Figure 4

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Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: GHD: Spring Complex and Groups/2013; GA: Watercourses, Roads, Homesteads (2007); DME: Carmichael Mine Site; Google: Imagery-2004 (2012); DNRM: WMA, WMA Trigger (2010). Created by:MS

1.5 Terminology

'Study Areas' plural refers to the two spring complexes, Doongmabulla and Mellaluka. The 'Doongmabulla Study Area' refers to the Doongmabulla Springs complex, and the 'Mellaluka Study Area' refers to the Mellaluka Spring complex.

While the Mellaluka Springs complex has similar characteristics and morphology to springs connected to the Great Artesian Basin (GAB), it is not considered to be a part of the GAB (Fensham and Fairfax, 2003). However, the threatening processes described for GAB springs are considered to be applicable to the Mellaluka Springs complex due to the similarity in characteristics and morphology between the springs.

Throughout this report, the term spring wetland refers to the permanently inundated areas associated with run off from springs. Otherwise, wetland is used in its usual sense. The term 'spring' when used in the singular refers to individual 'vents' or outlets of groundwater. Springs occur in clusters and are divided into the following groups (Fairfax and Fensham, 2002):

- A *spring group* is the smallest cluster, and represents multiple springs in a similar geomorphic setting where no one pair of springs are more than 1 km apart. This grouping may extend over many kilometres, but no single spring outlet is more than 1 km from at least one other spring. A spring group is often referred to in the singular as a spring
- A *spring complex* refers to a cluster of spring groups occurring in a similar geomorphic setting within 6 km of each neighbour
- A *supergroup* is a major regional cluster of spring complexes with broadly similar geomorphic characteristics and within a defined geographic proximity. The Doongmabulla Springs complex is located within the Barcaldine supergroup within the GAB.

All botanical binomials in this document follow those adopted in the Queensland Herbarium 2010 census of Queensland flora (Bostock and Holland, 2010). The regional ecosystem (RE) mapping provided and discussed is from the official DERM version 6.1 RE mapping layer. RE units are as defined in the Regional Ecosystem Description Database (Queensland Herbarium, 2013).

Scientific and common names for fauna are consistent with those used in the following sources:

- Handbook of Australian, New Zealand and Antarctic Birds Volume 1 – Volume 7 (Marchant and Higgins, 2004)
- A Field Guide to the Mammals of Australia (Menkhorst and Knight, 2004)
- A Complete Guide to Reptiles of Australia (Wilson and Swan, 2008)
- A Field Guide to Australian Frogs (Barker et al., 1995)
- Freshwater Fishes of Australia (Allen et al., 2002)
- Freshwater Fishes of North-Eastern Australia (Pusey et al., 2004).

2. Methods

2.1 Literature review and desktop assessment

Information relating to the ecological values of the Study Areas was obtained from a variety of sources. Details of these sources and search extents are provided in Table 1 (results of desktop searches can be found in the Appendices). A total of 10 search tools were used to predict conservation significance species, under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Nature Conservation Act 1992* (NC Act), identify the relevant ecosystem types and function, and the ecological communities that occur in the region.

Assessments of likelihood of occurrence for conservation significant terrestrial fauna were made using the following guidelines:

- Confirmed present – species recorded during field surveys at the Study Area
- Likely to occur – a species is considered to be likely to occur if:
  - it has been recorded from the Study Area previously
  - its recorded distribution encompasses the Study Area
  - habitat suitable for the species is present within, or adjacent to, the Study Area
- Unlikely to occur – a species is considered to be unlikely to occur if:
  - its recorded distribution does not encompass the Study Area
  - habitat suitable for the species is not present within, or adjacent to, the Study Area

Desktop studies and previous survey reports (refer Section 1.3) also provided information specific to the springs and surrounding areas pertaining to water bodies, sensitive habitats, flora and fauna species and communities within and/or of relevance to the spring complexes.

Table 1 Summary of desktop sources reviewed

Source and name	Description of information source	Search extent	Limitations of use
Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) Protected Matters Search Tool and Environmental Reporting Tool	The Protected Matters Search Tool identifies matters of national environmental significance (matters of NES) and other matters protected by the EPBC Act that may occur within or relate to the Study Area. The tool predicts the potential presence of a species/ecological community in an area based on bioclimatic modelling, known distribution and habitat preferences. The Environmental Reporting Tool was also queried to provide information on invasive species that have the potential to occur, and nationally important wetlands within or near the Study Area.	A point search at approximately the centre of the Study Area (-22.083, 146.247 for the Doongmabulla wetland; -22.317, 146.482 for the Mellaluka wetland) with a 5 km buffer was searched.	This is a predictive tool only – it does not necessarily indicate that a species/ecological community occurs in a defined area. Presence of a species/ecological community is predicted based on a combination of bioclimatic modelling, known distribution and habitat preferences. In predicting species/community presence, it allows for field survey efforts to be targeted.
DSEWPaC Directory of Important Wetlands	The Directory identifies nationally important wetlands. The DSEWPaC Protected Matters Search Tool (see above) lists nationally important wetlands occurring within or related to prescribed search extents and the directory provides more detailed information on the wetlands.	A point search at approximately the centre of the Study Area (-22.083, 146.247 for the Doongmabulla wetland; -22.317, 146.482 for the Mellaluka wetland) with a 5 km buffer was searched.	This mapping identifies the location of wetlands that satisfy at least one criterion agreed upon by the Australian and New Zealand Environment and Conservation Council Wetlands Network in 1994.

Source and name	Description of information source	Search extent	Limitations of use
Queensland Department of Environment and Resource Management [1] (DERM) Wetland mapping	Various mapping layers produced by DERM (including Wetland Protection Areas).	Mapping obtained for the Study Areas and adjacent landscape in an electronic data layer for GIS analysis.	Wetlands are identified using the DERM Aquatic Biodiversity Assessment Mapping Method – the on-ground values of individual wetlands identified through this method have not necessarily been assessed, as designation is primarily based on existing literature and expert opinion. As such, designation does not reveal the value of these systems for local flora and fauna.
DERM [1] Burdekin Natural Resource Management (NRM) Region Back on Track Actions for Biodiversity report (DERM, 2010)	This document identifies priority species in the Burdekin NRM region, details the regional threatening processes impacting upon these species, and proposes a range of actions to address regional threats. Priority taxa are identified through the DERM Back on Track species prioritisation framework, in consultation with a range of stakeholders from the region. The document seeks to guide priority species conservation in the region over the next five years.	The document covers the entire Burdekin NRM region (in which the Study Area occurs).	Since the Burdekin NRM region encompasses a large area of central Queensland some species/impacts listed in this document are not relevant to the Study Area.
DERM[1] Wildlife Online database	The DERM Wildlife Online database maintains a catalogue of animal and plant species records from specific localities across Queensland. As well as common species, records of animals and plants listed as threatened under the Nature Conservation Act 1992 (NC Act) are contained within the database.	A point search at approximately the centre of the Study Area (-22.083, 146.247 for the Doongmabulla wetland; -22.317, 146.482 for the Mellaluka wetland) with a 5 km buffer was searched.	This database catalogues records of species reported by the holders of various wildlife and research permits in their annual returns. It is not subject to verification, and is limited by the skill of the reporter, which is not known. DERM recommend that independent verification of records should be undertaken to inform the accuracy and completeness of information catalogued within this database (i.e. field surveys).

Source and name	Description of information source	Search extent	Limitations of use
Queensland Herbarium HERBRECS specimen database	The HERBRECS database catalogues flora specimen records obtained throughout Australia that have been submitted to the Queensland Herbarium, identified and incorporated into their collection. Specimens not incorporated into their collection are not included.	A rectangular area was searched, such that the diagonal extending from the approximate centre of the Study Area (-22.041, 146.364) to each corner was 50 km. The co-ordinates of the search were between 22.032 and 22.124 south and 146.192 and 146.296 east. This includes both Doongmabulla and Mellaluka spring complexes.	This database catalogues records of species lodged with the Queensland Herbarium and retained in their collection, within a defined area. It is not an exhaustive record of all species identified by the Herbarium, but a collection record. The lack of spatial precision associated with older records may limit their value for inclusion in current studies in some instances.
Queensland Museum Queensland Museum Data Search	The Queensland Museum catalogues records of fauna specimens submitted to the Museum for identification.	A rectangular area was searched, such that the diagonal extending from the approximate centre of the Study Area (-22.083, 146.247) to each corner was 5 km. The co-ordinates of the search were between 22.032 and 22.124 south and 146.192 and 146.296 east.	This database catalogues records of fauna specimens lodged with the Queensland Museum. It is not an exhaustive record, but a collection record. The age and lack of spatial precision of species records may limit their value for inclusion in current studies in some instances.
BirdLife Australia Atlas Bird Lists	The BirdLife Australia Atlas is a joint venture between Birds Australia and WildlifeLink. Bird sightings are documented in a spatial manner to determine bird communities in a given area.	A one degree square containing the point 146.23717, -22.32246 was searched.	The data is generated by volunteer bird watchers, and so sightings are not necessarily verified by a suitably qualified or experienced person. The large search area may incorporate sightings of species that are unlikely to occur at the springs and wetlands due to inappropriate habitat. Consequently, the listed bird community may be overestimated.

Source and name	Description of information source	Search extent	Limitations of use
Burdekin Dry Tropics and Australian Government Freshwater Fish of Burdekin Dry Tropics NRM Region	The report documents the diversity and distribution of freshwater fish species within the Burdekin Dry Tropics NRM Region.	The document covers the entire Burdekin Dry Tropics NRM region (in which the Study Area occurs).	Some species listed in this document are not relevant to the Study Area, as the Burdekin Dry Tropics NRM region encompasses a large area of central Queensland. Species distributions are described in terms of sub-catchments and distribution maps are useful to identify species with potential to occur.
DERM [1] (Natural Resources and Environment Division) Expert Panel Reports: Burdekin Region	These three reports; aquatic fauna, aquatic flora and aquatic ecosystems, are part of the Aquatic Conservation Assessment for riverine and non-riverine wetlands in the Great Barrier Reef catchment. The reports identify rare and threatened, priority and exotic species, species richness, and priority ecosystems and special features of the Burdekin region.	These documents assess the riverine and non-riverine wetlands of the Burdekin region	Some species listed in this document are not relevant to the Study Area, as the Burdekin catchment encompasses a large area of central Queensland.
1 Note, DERM is no longer the name of the administering authority for these documents. However, according to standard referencing practice the documents quoted above are attributed to the name of the department as it was at the time the source was procured (in the case of databases) or produced (in the case of documents).			

2.2 Field inspections

2.2.1 Overview

Field surveys included an inventory of spring-associated vegetation, assessments of habitat values for aquatic and terrestrial fauna, bird surveys, active searches and incidental sightings of fauna were conducted from 28 March to 8 April 2013. The location of all springs was recorded with a hand-held GPS device.

2.2.2 Flora assessment

The objectives of the flora assessment were:

- To determine the species composition of vegetation communities present at each spring group
- To confirm the presence of species of conservation significance and gain an understanding of their spatial distribution within the spring complexes
- To understand the context of the spring complexes in relation to local topography and vegetation.

In line with the quaternary site inspection methodology (Neldner et al, 1999), surveys were carried out to determine the species composition of vegetation communities and the presence of species of conservation significance within the wetland and adjacent.

Flora samples were collected for identification where this was not possible in the field. Samples were submitted to the Queensland Herbarium for confirmation where an identification was tenuous (these are identified in Appendix A).

2.2.3 Fauna assessment

Surveys were undertaken in accordance with Queensland *Animal Care and Protection Act 2001* under the following permits:

- Queensland Department of Agriculture, Fisheries and Forestry (DAFF) Scientific Users Registration Certificate (Registration Number 132)
- Queensland DEHP Scientific Purposes Permit (Permit Number WISP06498409)
- Queensland Primary Industries and Fisheries (QPIF) Animal Ethics Permits (Permit Number CA2009/11/398 and CA2008/07/280).

Survey techniques were approved by the GHD Animal Ethics Committee. Surveys were conducted by suitably qualified and experienced ecologists.

The fauna assessment involved active searches for aquatic and terrestrial species at both the Doongmabulla and Mellaluka wetlands. Active searches were carried out as part of the flora and aquatic habitat assessments and comprised observations of fauna species only, as opposed to detailed strategic sampling and/or trapping programmes. Surveys involved active (but unstructured) searches for amphibians, reptiles, mammals, fish, turtles and aquatic macroinvertebrates. This approach involved:

- Sifting through leaf litter and soil
- Lifting rocks and logs

- Lifting back bark
- 'Silent' searches where the observer walks quietly through an area (particularly effective for observing reptiles)
- 'Sit and wait' assessments where the observer makes little noise or movement, allowing animals to move freely without disturbance.

Additionally, a number of targeted bird (including migratory species) surveys were conducted at each wetland. These surveys were conducted throughout the day to capture the diversity of bird species that are active at different times. However, focus was placed on the early mornings and late afternoons – the times when the broadest number of bird species are active. Observations were also made of the habitat values provided at each site. Such features included:

- Structural characteristics of the vegetation within and surrounding the wetland (e.g. tree density, vertical profile (canopy, understory and ground cover))
- Physical connectivity of the landscape
- Complexity and characteristics of ground-level habitats (*e.g.* boulders, leaf litter, logs)
- Habitat features (*e.g.* water bodies, nests, hollows)
- Abundance of hollows and hollow-bearing (habitat) trees
- Disturbance and degradation of the area (*e.g.* introduced animals, introduced plants, land practices).

2.2.4 Aquatic habitat assessment

At each spring group, an assessment of the aquatic habitat values was undertaken to record the diversity and quality of aquatic habitat and its suitability for aquatic fauna. The current impacts (from both humans and animals) were noted for each spring group. The following variables were assessed at the both the Doongmabulla and Mellaluka wetlands:

- Substrate
- Water clarity
- Habitat features (for example, undercut banks, woody debris and/or overhanging vegetation)
- Presence of algae and macrophytes (submerged, floating and emergent)
- Opportunistic observations of aquatic fauna within and adjacent to springs
- Riparian zone quality and features
- Dimensions of mounds.

2.3 Weather condition

Weather data (presented below) was sourced from the Australian Bureau of Meteorology (BOM). The Carmichael weather station (station ID: 036122) was used as the closest proxy for rainfall measurements at the Doongmabulla Springs complex (BOM 2012). During the survey period (28 March to 8 April), no rainfall was recorded at the Carmichael weather station (19 km from the Doongmabulla Springs complex), although precipitation was noted at

the nearby Labona camp during two evenings through the survey period. Mean monthly rainfall for February and March was 31 mm and 0 mm respectively for the Carmichael weather station.

The Albro weather station (station ID: 36083) was used as the closest proxy for rainfall conditions at the Mellaluka Springs (BOM 2012). During the survey period, no rainfall was recorded at the Albro weather station (43 km from the Mellaluka wetland). Mean monthly rainfall for February and March was 40 mm and 0 mm respectively for the Albro weather station.

Neither the Carmichael or Albro weather stations record temperature. Consequently, the Clermont Airport weather station (station ID: 035124) was used as the closest proxy to both the Doongmabulla and Mellaluka wetlands. During the survey, weather conditions were typified by warm days and mild evenings, with some overcast and/or windy days. The minimum temperature at the Clermont Airport weather station during this time was 12.1 °C, with a maximum temperature of 31.7 °C. However, it should be noted that the precise temperatures in the Study Area are likely to differ from these recordings, as the Clermont Airport weather station is 160 km from the Doongmabulla wetlands, and 128 km from the Mellaluka wetlands. The temperature range between the Study Area and the wetlands would be similar to the temperatures recorded at the Clermont Airport weather station.

2.4 Limitations of the study

Seasonal variability in the spring complexes was not determined. This report is based on two surveys of the Doongmabulla Springs complex in May 2012 and March/April 2013 and one survey at the Mellaluka Springs complex in March/April 2013. Desktop sources of information were used to provide further background to the Study Areas and the ecological values of the spring complexes.

The survey of EPBC listed migratory species at the springs complexes was carried out in March and April 2013, this period is at the end of the typical peak in migratory bird species, October and March. Consequently, this survey period may not reflect the full community of migratory birds present from time to time at the Doongmabulla and Mellaluka springs complexes, however, the surveys still provide information on migratory birds present.

3. Springs characteristics and threats

3.1 Springs characteristics

For the purposes of this report, the springs observed within the Doongmabulla and Mellaluka springs complexes have been categorised into five main 'morphologies':

1. Small artesian seeps
2. Non-mounding artesian springs
3. Mound springs
4. Modified, high flow springs
5. Incipient mound springs

3.1.1 Small artesian seeps

These are small springs that appeared to be geologically 'new', or with historically low flow, resulting in seeps with no distinct, raised mound (Plate 1). Given the size and flow of these springs, no wetland has formed on the margins, and spring-dependant flora is sometimes absent. These springs potentially provide habitat for frogs, aquatic invertebrates and endemic flora, but are unsuitable for turtles and fish. They sometimes support *Sporobolus pamelae* tussocks, and are generally surrounded by a scalded margin of bare, sandy loam.

Plate 1 Small artesian seeps of the Doongmabulla Springs complex

3.1.2 Non-mounding artesian springs

Several springs within the Doongmabulla Springs complex do not form a mound, but vented from a point within a grove of river red gums (*Eucalyptus camaldulensis* var. *obtusa*) or weeping paperbark (*Melaleuca leucadendra*) (Plate 2). Some of these non-mounding artesian springs are associated with an adjacent shallow wetland providing valuable habitat for fish, invertebrates, amphibians and flora, including the endemic flora species *S. pamelae, Myriophyllum artesium*, blue devil (*Eryngium fontanum*) and salt pipewort (*Eriocaulon carsonii* subsp. *orientale*), and the threatened species *Hydrocotyle dipleura* (vulnerable under the NC Act) and *Sporobolus partimpatens* (near threatened under the NC Act). In the Doongmabulla wetland, the permanently inundated area associated with run off from the

Doongmabulla Springs complex, non-mounding artesian springs are situated beside an unnamed first order stream, and characterised by a fine sandy alluvial soil.

Within the Mellaluka Springs complex, both Lignum and Stories springs are also non-mounding. These springs are located some distance from each other (almost 2 km). Unlike the Doongmabulla non-mounding spring, the Lignum and Stories springs are discrete outlets that do not flow or contribute surface water to nearby waterways. Both these springs (inclusive of their wetlands) are small in size; 20 x 12 m for Stories Spring, and 20 x 6 m for the Lignum Spring) (Plate 3).

Plate 2 Non-mounding artesian springs with vegetated drainage pathways at the Moses Spring

Plate 3 Non-mounding Stories Spring (left) and Lignum Spring (right)

3.1.3 Mound springs

Mound springs form around vents (the spring's surface outlet) where subterranean pressure expresses water through cracks or faults. Mounds can form over time through three processes, as reported by Fairfax and Fensham (2002):

- Inorganic material is transported upwards under pressure and deposited at the spring vent
- Dissolved solids evaporate and gather at the spring vent
- Wetlands form around the vent and support dense vegetation, which forms peat as it dies in and is decomposed in an anaerobic environment.

Mound morphology can be variable, but are typically a raised mound with a central pool fringed by vegetation. In the GAB, mounds can be sizeable features, with the now inactive Hamilton Hill spring being some 40 m above the ground (Habermehl, 1982). Extant mound springs can be up to 8 m high and 30 m in diameter. A wetland may surround the mound, provided the flow rate is sufficient to sustain partial saturation. The size of the wetland is directly proportional to the spring flow rate (Williams and Holmes 1978). Flow rates can be highly variable between springs, but also within a spring, and can be dependent on many factors such as the evaporation rate and atmospheric pressure (Mudd, 2000).

Mound springs in the Doongmabulla wetland typically feature an easily distinguishable, raised mound – varying in height from approximately 0.4 – 1.5 m above the ground level. These mounds generally had central pools ranging in diameter from a few centimetres to a few metres, partially or completely congested with dense vegetation or peat. Several springs have open, shallow central pools. Spring discharge is variable, with some mounds feeding large wetlands (as in the background in the left hand image, in Plate 4). These moderately-sized springs often provide overland flow to nearby drainage lines and creeks, and provide potential habitat for fish, amphibians and turtles. Associated wetlands were generally saturated and characterised by grassland of *S. pamelae* or mixed sedgelands. These wetlands are generally located within large patches of bare sandy alluvium.

Plate 4 Typical mound springs of the Moses Spring group

The Mellaluka Spring is also categorised as a mound spring (Plate 5). The height above ground level is approximately 3 m, but with a long, gentle slope to the apex. Total width is approximately 100 m. There are several vents on the mound which feed a large pool about a 1 m deep, and several shallow overflow pools and associated wetlands at the foot of the mound (Plate 5). Large, scalded areas surrounded parts of the base of the mound spring. The spring itself is characterised by a dense substrate of peat, topped by a sedgeland to 2 m tall. Similarly to the Stories and Lignum springs, the Mellaluka Spring does not contribute surface water to any nearby waterways, being located near the margin of extensive clay plains to the south west, sand plains to the north west, and a large alluvial plain to the east associated with the Belyando River, which is approximately 9 km away.

Plate 5 Mellaluka mound spring (top left), run-off pool (top right), pool in peat (bottom left) and wetland (bottom right)

3.1.4 Modified, high flow spring

The spring known as Joshua has been modified to a 'turkey-nest' dam to service the domestic needs of Doongmabulla Station (Plate 6). This is the largest spring in both height and discharge, and although it is completely modified from its natural state it is considered to be of high value to aquatic fauna. It overflows to a long, narrow pool formed in what appears to be an abandoned channel section of the Carmichael River. This pool is generally dominated by *Juncus* sp. and cumbungi (*Typha domingensis*), however it contains the GAB spring endemic *M. artesium* in places, and *S. partimpatens* is present in low numbers growing around the edge of the saturated zone.

The outflow channel of this spring was choked with the grass olive hymenachne (*Hymenachne amplexicaulis*), a class two declared weed. Scalded earth was not observed at this site, and it is speculated that this spring may have historically appeared much as the Little Moses Spring does today (Plate 6), albeit with a much larger flow.

Plate 6 Joshua Spring, a large, modified mound spring used for domestic purposes

3.1.5 Incipient mound spring

A fifth spring type was observed at the Little Moses Spring group, approximately 2 km to the east of Moses Spring group, beside the Carmichael River (closer to the Project (Mine), and downstream from the other spring groups). This morphology has been given the tentative title 'incipient mound spring' based on the theory that a number of characteristics indicate it may be a young (incipient) spring that may eventually form a peat mound in the same manner as has occurred at Moses Spring. The main characteristics of this spring that differentiate it from the other spring morphologies and their associated habitats are that:

- It does not contain any of the GAB spring wetland endemics, or other spring associated species such as *H. dipleura* or *S. partimpatens*
- It is present in a dark, clay loam soil (instead of pale, sandy soil)
- It has not formed a peat based mound.

It discharges into a tear-drop shaped wetland situated in black clay (see Plate 7), in what appears to be an abandoned channel of the Carmichael River. This wetland is densely vegetated with a range of sedges, dominated by *Eleocharis pallens* and *Fuirena ciliaris.* There are at least two other small (approximately 10 m diameter), circular wetlands in the immediate vicinity with a similar species composition.

Plate 7 Little Moses Spring group

3.2 Threatening processes

Under the EPBC Act, ecological communities dependant on GAB discharge springs are listed under the endangered threatened ecological community (TEC) 'The community of native species dependant on natural discharge of groundwater from the Great Artesian Basin' (referred to in this report as the 'GAB discharge springs community TEC'). As the Mellaluka Springs complex is not considered to be a part of the GAB, it does not fall within the scope of this TEC.

The greatest threatening process for GAB springs is drawdown resulting from groundwater extraction for domestic and agricultural use and mining/coal seam gas extraction (Fensham et al., 2010). This threatening process is relevant to both the Doongmabulla TEC and Mellaluka Springs complexes. Extraction has led to the inactivity of the majority of artesian-fed springs, with an estimated 81 percent of springs currently listed as inactive since their discovery, due to reduced subterranean pressure (Fairfax and Fensham 2002).

Further impacts on the spring-associated ecological communities arise from artificial alterations of the seep points, with some springs being removed altogether, or modified to suit the needs of livestock (Fensham et al*.,* 2011). The Doongmabulla and Mellaluka springs complexes currently experience disturbance, with the Joshua Spring modified to a 'turkey-nest' dam to service the domestic needs of Doongmabulla Station (Plate 6). Further all springs within the Mellaluka wetland have bores installed which provide water for domestic use (the Mellaluka Spring), and water for livestock (Stories and Lignum springs).

Introduced plants and animals have had significant impacts on the integrity and robustness of both GAB and non-GAB spring communities, with pugging (from both feral animals and livestock), pig rooting, wallowing and direct and indirect competition for resources all acting to degrade ecological values of springs (Fensham and Price 2004). The Doongmabulla and Mellaluka springs complexes currently experience impacts in the form of pugging from cattle and pigs.

4. Doongmabulla Springs complex

4.1 Overview

The Doongmabulla Springs complex is situated approximately 8 km from the western edge of the Project Area (Figure 2), and includes the Doongmabulla Nature Refuge, which encompasses the Moses Spring group. The Doongmabulla Springs complex consists of the following three separate springs:

- Little Moses – possible incipient mound spring beside the Carmichael River with limited wetland
- Moses – a cluster of mounding and non-mounding artesian springs with large wetland areas
- Joshua – a large, modified spring, now a turkeys nest dam with associated wetland.

A description of the Doongmabulla Springs complex and a discussion of its values can be found in GHD (2012a). This section provides further information on the aquatic and terrestrial values of the Doongmabulla Springs complex and provides part of the response to the Project EIS submissions. The Doongmabulla Springs complex and associated wetlands are listed as being of national significance in the Directory of Important Wetlands as they meet the following criteria:

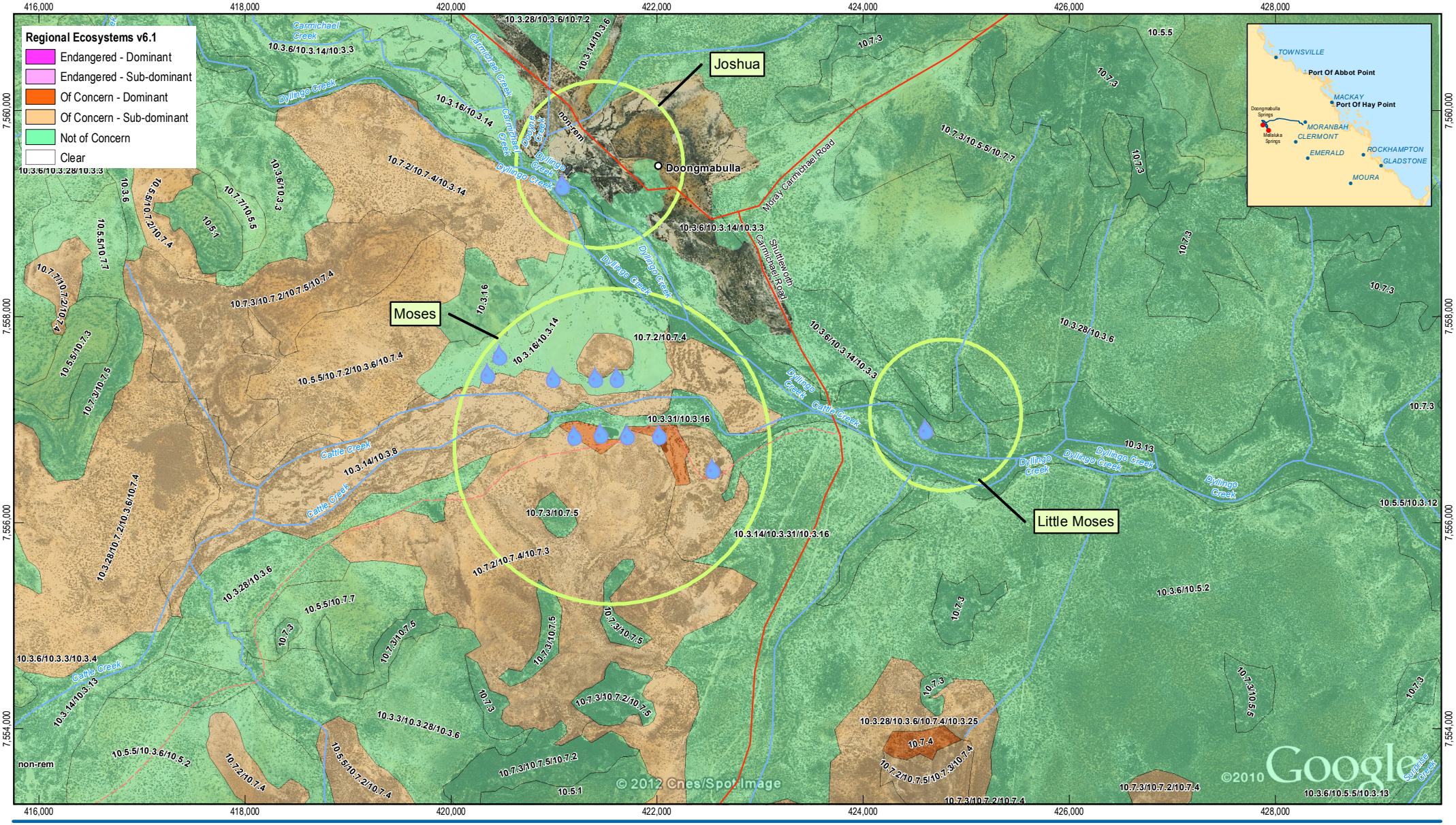
- It is a good example of a wetland type occurring within a biogeographic region in Australia
- It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail (DSEWPaC, 2010).

Groundwater assessments identified that Doongmabulla Springs provide base flow to the adjacent Carmichael River (GHD 2012d). Waterways surrounding the Doongmabulla Springs complex are displayed in Figure 3.

The Doongmabulla Springs complex is currently (and was historically) used for watering livestock, which directly impacts the springs through trampling, pugging, fouling of water and compaction. In addition, a large number of bores drilled historically in the bioregion has resulted in a lowering of hydrological pressure across the aquifer (the GAB in this region). Consequently, the springs are considered under threat (Mitchell et al., 2002).

4.2 Spring vegetation communities

A number of broad vegetation community types were observed within the Doongmabulla Springs complex. A RE map (based on the official version 6.1 RE mapping) for the Doongmabulla Springs complex is provided in Figure 5. All vegetation communities described in the following sections have been aligned with a corresponding RE. Any classification given for an RE in this report is according to the *Vegetation Management Act 1999* (the VM Act).



1:50,000 (at A4)

0 500 1,000 1,500 2,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Homestead
- Springs
- Minor Road
- Track
- Watercourse
- Spring Groups

Adani Mining Pty Ltd
Doongmabulla and Mellaluka Springs
Existing Environment Report

Job Number 41-25215
Revision C
Date 26-06-2013

Doongmabulla Wetland Regional Ecosystem

Figure 5

G:\41\25215\GIS\Maps\MXD\300_Hydrogeology\41-25215_334_rev_c.mxd Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: GHD: Spring Complex/2012, Springs/2012; GA: Watercourses, Roads, Homesteads (2007); DNRM: Regional Ecosystems Version 6.1 (2011); DME: Carmichael Mine Site; Google: Imagery (2012). Created by:SB

4.2.1 Bare, scalded plains

Conspicuous in aerial photography, the approaches to the Moses Spring group wetland are dominated in places, particularly to the north, by large bare flood plain with a very fine, powdery sandy alluvium. It is characterised by a very sparse grass and herb coverage, including the near threatened grass *Sporobolus partimpatens, Diplachne fusca* (formerly *Leptochloa*), *S. coromandelianus* and low chenopod shrubs, particularly *Scerloaena tricuspis* and *S. glabra,* and *Trianthema* sp. (Coorabulka R.W. Purdie 1404). The unnamed grass, *Chloris* sp. (Edgbaston R.J.Fensham 5694) and unnamed daisy *Streptoglossa* sp. was located in this habitat type. This vegetation community is contained within the of concern RE 10.3.31 (Queensland Herbarium, 2009). This RE is incorporated in the GAB discharge springs community TEC.

4.2.2 Sporobolus pamelae grassland

Within the wetland, the main habitat type present (in terms of area) was grassland generally dominated by *Sporobolus pamelae* (see Plate 8) on the left, with mixed sedgeland occupying the foreground). This grass, growing to around 1.2 m tall, has a feathery appearance and is a conspicuous marker for the presence of artesian-fed spring water. This community contained other grasses, particularly *Ischaemum australe, Sacciolepis indica, Isachne globosa, Phragmites australis, Echinochloa inundata, Cenchrus purpurascens, Diplachne fusca* and *Leersia hexandra.* Common sedges were *Cyperus sanguinolentus, C. laevigatus, Fimbristylis ferruginea* and *Fimbristylis dichotoma.*

The vegetation community was generally growing in the saturated zone or very close to it, and it is considered to be an obligate groundwater dependent ecosystem (that is, it requires permanent access to groundwater for survival). This vegetation community is contained within the of concern RE 10.3.31 (Queensland Herbarium, 2009). This RE is incorporated in the GAB discharge springs community TEC.

Plate 8 *Sporobolus pamelae* grassland (left); mixed sedgeland (right) (April, 2013)

4.2.3 Mixed sedgeland

Growing alongside the *S. pamelae* grassland in the wetter areas was a mixed species sedgeland, with a high proportion of grasses in places. This is illustrated in Plate 8; mixed sedgeland occupies the foreground in the left side picture, and the background in the right picture (both taken at the main wetland in the Moses Spring group). The sedgeland was from

0.1 – 1.0 m tall, and was dominated by sedges such as *Cyperus laevigatus, C. polystachyos, C. sanguinolentus, C. difformis, Eleocharis cylindrostachys* and *Fuirena ciliaris.* Grasses present included *Leptochloa fusca, Isachne globosa, Ischaemum australe* and *Sacciolepis indica.* Other herbs present included the endangered species blue devil, salt pipewort (subsp. *orientale*) and *Myriophyllum artesium*. This sedgeland was often present within a mosaic dominated by *Sporobolus pamelae* grassland. The mosaic of sedgeland and grassland was frequently observed completely smothering mound springs to the extent that it (or peat formed by it) had formed an impenetrable roof tens of centimetres deep over the central pool. This vegetation community is contained within of concern RE 10.3.31 (Queensland Herbarium, 2009). This RE is incorporated in the GAB discharge springs community TEC.

In places outside the saturated wetland associated with the permanent artesian flows a variant of this sedgeland has formed. This variant is a low sedgeland to approximately 20 cm tall and has a much lower species diversity than the spring communities, generally being dominated by *Fimbristylis dichotoma.* It occurs on the margin of larger springs, and sometimes has very sparse, very small mound springs located within it, which may host a single *S. pamelae* tussock each. The herb *Hydrocotyle dipleura* is common. Both variants of this sedgeland are considered to be obligate groundwater dependent communities.

Coolibah/river red gum woodland and open woodland

Directly fringing the bare clay pan, and in some places with mound springs located within it, was woodland to open woodland dominated by coolabah (*Eucalyptus coolabah*) and river red gum (*E. camaldulensis* var. *obtusa*). This is the dominant woody vegetation type present along the braided channels of Cattle Creek, and surrounding the Joshua and Little Moses spring groups. This woodland is generally characterised by a sparse to mid-dense shrub layer of species such as currant bush (*Carissa ovata*), scrub leopardwood *(Flindersia dissosperma*), wilga (*Geijera parviflora*), ironwood (*Acacia excelsa*) and *Melaleuca nervosa*. However, in places (as at Little Moses) the woodland was grassy with a very sparse shrub layer, the ground layer being dominated by short grasses (at least, in the vicinity of the springs) such as freshwater couch (*Cynodon dactylon*). At Moses Spring there is also a small population of emergent waxy cabbage palm (*Livistona lanuginosa*), a vulnerable species of palm.

This vegetation community is contained within least concern RE 10.3.14. Both coolabah and river red gum are considered facultative groundwater dependant species, that is, not permanently dependant on access to groundwater, but adapted to periodic access as occurs on broad floodplains (Eamus et al., 2006). Therefore, this community is likely to be a facultative groundwater dependant ecosystem, although in this case, parts of this community are likely to have permanent access to groundwater supplies associated with the springs.

Weeping paperbark forest

Located at only one spot along the southern boundary of the Moses spring group are three small mono-specific stands of weeping paperbark (*Melaleuca leucadendra*). These stands are within the saturated zone of the wetland, and have a sedge-dominated ground layer (see Plate 9). This is considered to be an obligate groundwater dependant ecosystem. This vegetation community is contained within the of concern RE 10.3.31.

Plate 9 Weeping paperbark forest (left) and peppermint box open woodland (right) (April, 2013)

Peppermint box open woodland

Fringing the Moses spring group, and in some cases directly abutting wetland, is an arid habitat characterised by low open woodland of peppermint box (*Eucalyptus persistens*) over a grassy ground layer dominated by porcupine grass (*Triodia longiceps*) and soft spinifex (*T. pungens*) (see Plate 9). This community is located on low, undulating remnant sandstone surfaces that terminate in an abrupt, short scarp, sometimes metres from active mound springs. This community corresponds with the least concern RE 10.7.2, and is not groundwater dependant.

Reid River box woodland

The main habitat type fringing the Doongmabulla Springs is Reid River box (*Eucalyptus brownii*) woodland and open woodland on undulating plains with sandy alluvial soils. This vegetation community covers vast areas within the region. It has a very sparse shrub layer dominated by species such as quinine bush (*Petalostigma pubescens*)*, Melaleuca nervosa* and false sandalwood (*Eremophila mitchellii*), and a very sparse grassy ground layer. This community meets the description of least concern RE 10.3.6. As for the peppermint box open woodland, this community is not groundwater dependant.

4.3 Flora and fauna of the Doongmabulla Springs complex

The Doongmabulla Springs complex contains a comparatively high number of flora and fauna species endemic to GAB spring wetlands as identified by Fensham et al., (2010), including:

- Blue devil (*Eryngium fontanum*) – listed as endangered under the NC Act and the EPBC Act, with two known populations
- *Myriophyllum artesium* – listed as endangered under the NC Act, with 15 known populations
- Salt pipewort (*Eriocaulon carsonii*) – listed as endangered under both the Queensland NC Act and the Commonwealth EPBC Act, with 15 known populations
- *Sporobolus pamelae* – listed as endangered under the NC Act, with six other populations known

- *Gabbia rotunda* – a mollusc that is not listed under either the NC Act or the EPBC Act, but that is considered to be endemic to the Doongmabulla Springs complex.

It should be noted that none of the above flora species have been recorded from the Little Moses spring group, and only *M. artesium* from the Joshua Spring (growing in the adjacent wetland). During the 2013 survey, none of these species were observed at the Little Moses spring, and the Herbrecs database has no records from this location either. This may be due to the postulated young age of the Little Moses spring group, either because these endemics have not had time to disperse here yet, or because the conditions required for the endemics to survive (lighter soils and grassland/sedgelands) have not had time to develop (R. Fensham, pers. comm. 24/07/2012).

Two fauna taxa recorded from the Doongmabulla Springs complex are considered to be endemic – the mollusc *Gabbia rotunda* (only recorded from the Doongmabulla Springs complex) and the water mite *Mamersella* sp. AMS KS85341 (Fensham et al*.,* 2010). However, the Doongmabulla wetland is little studied and complex, and there remains the possibility for the discovery of more endemic, spring-adapted species or genetically distinct populations in the springs and/or surrounding aquatic habitats (Gotch et al., 2008; Fensham et al., 2011).

During the 2013 survey, two flora species of interest were submitted to the Queensland Herbarium for identification. One is an unnamed grass, *Chloris* sp. (Edgebaston R.J.Fensham5694), that was previously recorded only once from Doongmabulla, and has only been collected twice before (Bostock and Holland, 2010). The other is an unidentified daisy, *Streptoglossa* sp., which the Herbarium could not match to any species. It may be a new species, however further specimens are required to confirm whether it is in fact a new species.

4.3.1 Flora species of conservation significance

All listed threatened and near threatened flora species identified in desktop searches as potentially occurring within the Doongmabulla Springs complex were observed during field surveys. All species were present in the Moses Spring group, two were found at the Joshua spring, and only one was found at the Little Moses. These species are discussed below and included:

- Salt pipewort (*Eriocaulon carsonii*)
- Blue devil (*Eryngium fontanum*)
- *Hydrocotyle dipleura*
- Waxy cabbage palm (*Livistona lanuginosa*)
- *Myriophyllum artesium*
- *Sporobolus pamalae*
- *Sporobolus partimpatens*

Salt pipewort (*Eriocaulon carsonii* subsp. *orientale*)

Salt pipewort is a small aquatic herb growing in shallow water in permanent GAB discharge spring wetlands (see Plate 10). It is listed as endangered under the EPBC Act and the NC Act. This species was predicted to be present by the DSEWPaC Protected Matters Search

Tool, and there are previous records from Herbrecs. It has been recorded from 22 spring complexes, including Doongmabulla (Fensham et al., 2010). Three subspecies have been described – the subspecies found at Doongmabulla (within the Moses spring group) is *E. carsonii* subsp. *orientale*. The Doongmabulla Nature Refuge is believed to contain the only population of this species located within a protected area (Fensham et al., 2010).

Salt pipewort was observed during the 2013 survey at all of the wetlands within the Moses spring group, often growing in dense floating carpets (although the water was generally 10 cm deep at most). These mats can be seen clearly in Plate 10 on the right.

Plate 10 Salt pipewort (left) and growing in mats (right) (April, 2013)

Blue devil (*Eryngium fontanum*)

Blue devil is an erect herb in the family Apiaceae growing to 80 cm tall (see Plate 11). It is listed as endangered under the EPBC Act and the NC Act. This species was predicted to be present by the DSEWPaC Protected Matters Search Tool, and there are previous records from Herbrecs.

It occurs on floodplains associated with GAB discharge spring wetlands and is found in only two spring complexes, one of which is Doongmabulla Springs (Fensham et al., 2010). Fensham et al. (2004) estimates there are 10,000 individuals at Doongmabulla (making it the largest population of the species), and that only 20 percent of the Moses discharge spring wetland is suitable habitat for this species. It is believed that the Moses spring group contains the only population of this species protected under any type of legal agreement (in this case, a Nature Refuge Agreement).

Of all the species of conservation significance located at the Doongmabulla Springs complex, it was the rarest. Many more individuals were observed in the 2013 survey event than in 2012. It was recorded growing in dense sedgeland, *Sporobolus pamelae* grassland, and open sandy locations across Moses Spring, but most commonly within the largest wetland.

Plate 11 Blue devil (left) and *Hydrocotyle dipleura* (right) (April, 2013)

Hydrocotyle dipleura

Hydrocotyle dipleura is a perennial prostrate herb with kidney-shaped leaves (see Plate 11) and a specialised habitat, found only on the margins of GAB springs in saline soils, beyond the saturated zone (Bean and Henwood, 2003). *Hydrocotyle dipleura* is listed as vulnerable under the NC Act. However, it is not listed under the EPBC Act. Previous records for this species exist from the Moses spring group in Herbrecs. It has been recorded from south west of Cunnamulla, at Moses, and at another artesian spring to the west of Moses (Australian Virtual Herbarium, 2012).

During the 2012 survey, this species was primarily found along the margins of all of the wetlands within the Moses spring group, but in 2013 the species was also observed within *S. pamalae* grassland, including at isolated mounds situated many hundreds of metres from other populations, and often in association with *Fimbristylis dichotoma*.

Waxy cabbage palm (*Livistona lanuginosa*)

Waxy cabbage palm is a palm of the ‘cabbage tree’ variety (known as waxy cabbage palm), growing to 18 m tall, and is endemic to the Burdekin River catchment (Dowe and Jones, 2011). It is listed as vulnerable under the EPBC Act and NC Act. No previous records for this species exist from the Doongmabulla station area, and it was not predicted to occur by the DSEWPaC Protected Matters Search Tool.

During the 2013 survey it was observed growing in a stand of 19 individuals, most of which were sub-adult or adult, near the south east corner of the Moses spring group (see Plate 12). A few individuals were also recorded at the Little Moses spring group. A detailed report into a survey of the population of this species at Moses Spring and in downstream sections of the Carmichael River is included in Volume 4 Appendix I4 Population Survey of the Waxy Cabbage Palm.

Plate 12 Waxy cabbage palms at Doongmabulla Springs (April, 2013)

Myriophyllum artesium

Myriophyllum artesium is a creeping, mat-forming aquatic herb growing to 15 cm high (see Plate 13), and restricted to wetlands associated with artesian springs and their drains. It is listed as endangered under the NC Act, however, it is not listed under the EPBC Act. Records for this species from the Moses spring group exist in Herbrecs. It is a Queensland endemic, and is known from only 17 spring complexes (Halford and Fensham, 2001).

During the 2012 survey, this species was a common constituent of all the wetlands within the Moses spring group, growing in shallow pools. It was also recorded in the 2013 survey in the wetland associated with the Joshua spring group.

Plate 13 *Myriophyllum artesium* (left) and *Sporobolus pamelae* (right)

Sporobolus pamelae

Sporobolus pamelae is a perennial grass to 1.2 m tall with broad panicles (Simon, 1993). *Sporobolus pamelae* is listed as endangered in the NC Act, however, it is not listed under the EPBC Act. It is recorded for this spring group in Herbrecs. The type specimen was collected from the Moses spring group, and it is now known to be present from at least seven other GAB discharge spring wetland sites within Queensland (Australian Virtual Herbarium, 2012a).

During the 2013 survey, this grass was the most conspicuous element in the grasslands associated with the wetland areas within the Moses spring group, and was a useful indicator of the presence of artesian water at or near the surface (see Plate 13). It grows in shallow water and on dry land along the margins of the wetland, and is often found growing over even the largest mounds.

Sporobolus partimpatens

Sporobolus partimpatens is a perennial grass growing to 60 cm tall with a 'rat tail' type panicle (Simon, 1993). This species is listed as near threatened under the NC Act (it has not listing under the EPBC Act), and has been recorded previously at the Moses Spring group in Herbrecs. It has been recorded from at least seven other sites, all artesian springs within Queensland (with the exception of one record from a footpath in the town of Barcaldine) (Australian Virtual Herbarium, 2012b).

During the 2013 survey, *S. partimpatens* was commonly found on the edge of most of the wetlands within Moses Spring, and from Joshua Springs, growing in scalded or otherwise bare ground, or in sparse grassland.

4.3.2 Terrestrial fauna of conservation significance

A number of terrestrial fauna species of conservation significance were predicted to occur within the buffered search area including:

- Squatter pigeon (*Geophaps scripta scripta*)
- Ornamental snake (*Denisonia maculate*)
- Yakka skink (*Egernia rugosa*)
- Koala (*Phascolarctos cinereus*)
- Black throated finch (*Peophila cincta cincta*)
- Australian painted snipe (*Rostratula australis*)
- Greater bilby (*Macrotis lagotis*)

An assessment was made of the likelihood of occurrence for each of these species (see section 2.1 for method). A description of each predicted species and their likelihood of occurrence is given below.

A number of active searches were made during the 2013 survey in a variety of habitats to detect these species; however, only the squatter pigeon (*Geophaps scripta scripta*) was observed.

Squatter pigeon (Geophaps scripta scripta)

The squatter pigeon (southern) is listed as vulnerable under the EPBC Act and the NC Act. Squatter pigeons were observed on previous occasions during the Project (Mine) EIS (GHD, 2012b) and field survey of Doongmabulla Springs complex (GHD, 2012a), and appear to be a common constituent of the bird assemblage in the region. It favours open habitats in the vicinity of water and the Doongmabulla wetland is likely to offer perennial habitat of high quality (DSEWPaC, 2011c). Given previous (GHD, 2012a) and recent (2013) on site observations, this species is *confirmed present.*

Ornamental snake (Denisonia maculata)

The ornamental snake is listed as vulnerable under the EPBC Act and the NC Act. Its distribution is confined to the northern brigalow belt bioregion, where it is typically found in areas of brigalow, riverside woodland and open forest on natural levees (DSEWPaC, 2011a). Habitat features known to be utilised by the species include cracking clay and sandy substrates where water pools and frogs (its main food source) are present. Although there was no brigalow present at the Doongmabulla Springs complex, the presence of permanent water and sandy substrates are likely to provide a perennial food source for the ornamental snake, and as the Doongmabulla wetland occurs within the recorded distribution for this species, it is considered that it is *likely to occur*.

Yakka skink (Egernia rugosa)

The yakka skink is listed as vulnerable under the EPBC Act and the NC Act. It is endemic to dry sclerophyll open forests, woodlands and rocky areas of central and eastern Queensland, where it lives in communal burrow complexes, often taking refuge among low vegetation or under heaped dead timber, logs, rocks and in deep rock crevices (Wilson, 2005; DSEWPaC, 2011b). The Doongmabulla wetland contains woodland and rocky areas, and is located within the distribution of this species. Therefore, it is considered that it is *likely to occur* at the Doongmabulla wetland.

Koala (Phascolarctos cinereus)

The koala is listed as vulnerable within Queensland under the EPBC Act (it is only listed as vulnerable under the NC Act in the Southeast Queensland bioregion). Koalas utilise sclerophyll woodland that contain preferred food trees across much of central and south east Queensland, in particular riparian corridors (Van Dyck and Strahan, 2008). The Wildlife Online report for the Doongmabulla area has one record for the koala. In addition, Adani staff had recently observed a koala within the Mine lease close to the Doongmabulla Springs (S. Lovelock pers. comm. 22/03/2013). It is likely that koalas are present in the Study Area and may utilise the habitat at the Doongmabulla wetland, which includes sclerophyll woodland. Therefore, it is considered that the koala is *likely to occur* at the Doongmabulla wetland.

Black throated finch (Poephila cincta cincta)

The black throated finch (southern) is listed as endangered under the EPBC Act and the NC Act. There has been one previous record from the site, as recorded in Wildlife Online. However, this species was not observed during either Doongmabulla wetland field survey (2012 and 2013). Large flocks of black-throated finches have been recorded on the Project (Mine) Area nearby (GHD, 2012g). Potential suitable habitat for black-throated finches is present in the form of large areas of Reid River box woodland and coolabah woodland adjacent to permanent water provided at the Moses Spring group. In addition, black-faced woodswallows (*Artamus cinereus*) were seen frequently in Doongmabulla wetland surveys, and this species is considered an indicator for the presence of black-throated finches in suitable habitat (Department of Environment, Water, Heritage and the Arts, 2010). Therefore, it is considered that this species is *likely to occur* at the Doongmabulla wetland.

Australian painted snipe (Rostratula australis)

The Australian painted snipe is listed as vulnerable under the EPBC Act and the NC Act. This species has not been previously recorded, and was not observed during either Doongmabulla field survey (2012 and 2013). This species has a scattered distribution across eastern and northern Australia, utilising shallow freshwater wetlands. Such wetlands may include swamps, claypans, and inundated/waterlogged grassland (Marchant and Higgins, 1993). Therefore, although this species is naturally uncommon, it is possible that individuals may utilise the spring wetlands of Doongmabulla from time to time. As this area is within the recorded distribution of the Australian painted snipe, it is considered that this species is *likely to occur* at the Doongmabulla wetland.

Greater bilby (Macrotis lagotis)

The greater bilby is listed as vulnerable under the EPBC Act and endangered under the NC Act. This species was historically recorded through much of arid and semi-arid Australia. However, it is now restricted to desert areas of central Australia. In Queensland, the species is known from a small area between Birdsville and Boulia in the south west of the state (Van Dyck and Strahan, 2008). The Study Area and surrounding landscape is not within the current known distribution of the species, and there are no records for this species from the Doongmabulla Springs complex in the Wildlife Online database. Therefore, it is considered that the greater bilby is *unlikely to occur* at the Doongmabulla Springs complex.

4.3.3 Birds

During the 2013 survey, numerous bird species were observed within the Doongmabulla wetlands. Of particular note was the presence of the EPBC and NC Act listed squatter pigeon (*Geophaps scripta*) (as discussed in Section 4.3.2). A total of 70 bird species were observed within the Doongmabulla wetlands (Table 2).

Australia is party to international conventions and agreements to protect many migratory species, including:

- Japan-Australia Migratory Bird Agreement (JAMBA)
- China-Australia Migratory Bird Agreement (CAMBA)
- Republic of Korea - Australia Migratory Bird Agreement (ROKAMBA)
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)

Three observed birds are listed as migratory under the EPBC Act, brolga (*Grus rubicundus*), eastern great egret (*Ardea modesta*) and osprey (*Pandion haliaetus*). These species are also listed under the JAMBA, CAMBA, ROKAMBA or Bonn Convention agreements.

The observed birds can be generally categorised as common waterbirds, woodland and grassland birds. Woodland birds were most frequently observed. These birds include such species as the blue-faced honeyeater (*Entomyzon cyanotis*), the brown treecreeper (*Climacteris picumnus*) and double-barred finch (*Taeniopygia bichenovii*). The most common waterbirds included the white-faced heron (*Egretta novaehollandiae*), eastern great egret (*Ardea modesta*) and black-fronted dotterel (*Elseyornis melanops*).

Table 2 Bird species observed in the Doongmabulla wetlands in March/April 2013

Common name	Scientific name	Number of observations*
apostlebird	*Struthidea cinerea*	2
Australian white ibis	*Threskiornis molucca*	1
bar-shouldered dove	*Geopelia humeralis*	1
black kite	*Milvus migrans*	1
black-chinned honeyeater	*Melithreptus gularis*	1
black-faced cuckoo shrike	*Coracina novaehollandiae*	2
black-faced woodswallow	*Artamus cinereus*	12
black-fronted dotterel	*Elseyornis melanops*	3
black-necked stork	*Ephippiorhynchus australis*	2
black-winged stilt	*Himantopus himantopus*	2
blue-faced honeyeater	*Entomyzon cyanotis*	8
blue-winged kookaburra	*Dacelo leachii*	2
brolga	*Grus rubicundus*	1
brown falcon	*Falco berigora*	2
brown quail	*Coturnix ypsilophora*	1
brown thornbill	*Acanthiza pusilla*	2
brown treecreeper	*Climacteris picumnus*	5
budgerigar	*Melopsittacus undulates*	3
cockatiel	*Nymphicus hollandicus*	3
crested pigeon	*Ocyphaps lophotes*	2
double-barred finch	*Taeniopygia bichenovii*	9
dusky honeyeater	*Myzomela obscura*	2
eastern great egret	*Ardea modesta*	3
eastern koel	*Eudynamys orientalis*	3
Eurasian coot	*Fulica atra*	1
golden headed cisticola	*Cisticola exilis*	1
grey butcherbird	*Cracticus torquatus*	4
intermediate egret	*Ardea intermedia*	1
jacky winter	*Microeca fascinans*	2
laughing kookaburra	*Dacelo novaeguineae*	2
little pied cormorant	*Microcarba melanoleucos*	1
magpie	*Gymnorhina tibicen*	10
masked lapwing	*Vanellus miles*	4
mistletoe bird	*Dicaeum hirundinaceum*	1
mudlark	*Grallina cyanoleuca*	11
noisy friarbird	*Philemon corniculatus*	1
noisy miner	*Manorina melanocephala*	3
osprey	*Pandion haliaetus*	1

Common name	Scientific name	Number of observations*
Pacific black duck	*Anas superciliosa*	2
pale-headed rosella	*Platycercus adscitus*	9
peaceful dove	*Geopelia striata*	7
pelican	*Pelecanus conspicillatus*	1
pied butcherbird	*Cracticus nigrogularis*	6
rainbow lorikeet	*Trichoglossus haematodus*	1
red-backed fairywren	*Malurus melanocephalus*	2
red-kneed dotterel	*Erythrogonys cinctus*	1
red-winged parrot	*Aprosmictus erythropterus*	3
royal spoonbill	*Platalea regia*	2
rufous whistler	*Pachycephala rufiventris*	1
sacred kingfisher	*Todiramphus sanctus*	3
silvereye	*Zosterops lateralis*	2
singing honeyeater	*Lichenostomus virescens*	2
spotted pardalote	*Pardalotus punctatus*	1
squatter pigeon	*Geophaps scripta*	1
striated pardalote	*Pardalotus striatus*	3
striated thornbill	*Acanthiza lineata*	1
striped honeyeater	*Plectorhyncha lanceolata*	1
sulphur-crested cockatoo	*Cacatua galerita*	3
Torresian crow	*Corvus orru*	7
variegated fairywren	*Malurus lamberti*	1
wedge-tailed eagle	*Aquila audax*	1
weebill	*Smicrornis brevirostris*	3
whistling kite	*Haliastur sphenurus*	4
white-faced heron	*Egretta novaehollandiae*	3
white-naped honeyeater	*Melithreptus lunatus*	1
white-plumed honeyeater	*Lichenostomus penicillatus*	3
white-throated honeyeater	*Melithreptus albogularis*	2
white-winged fairywren	*Malurus leucopterus*	1
willie wagtail	*Rhipidura leucophrys*	11
yellow thornbill	*Acanthiza nana*	1
* Number of observations refers to the number of separate occasions the species was observed, not the number of individuals.		

4.3.4 Mammals

Records for this region exist only for the eastern grey kangaroo and the koala. A total of four mammal (including one introduced) species were observed at or adjacent to the Doongmabulla wetland during the 2013 survey:

- Dingo (*Canis lupus* dingo)

- Feral pig (*Sus scrofa*)
- Eastern grey kangaroo (*Macropus giganteus*) (Plate 14)
- Red kangaroo (*Macropus rufus*).

Plate 14 Eastern grey kangaroos drinking at the Doongmabulla wetland

4.3.5 Terrestrial reptiles

Both the ornamental snake and yakka skink were predicted to occur in the area using the Protected Matters Search Tool (see Section 4.3.2), but these species were not observed. Desktop records did not identify any other terrestrial reptiles in the search area for the Doongmabulla wetland.

Terrestrial reptiles were observed during the 2013 survey at the Doongmabulla wetlands, are listed below:

- Nobbi dragon (*Amphibolurus nobbi*)
- Ta ta lizard (*Amphibolurus gilberti*) (Plate 15)
- *Carlia munda*
- *Carlia pectoralis*
- *Carlia vivax*
- *Cryptoblepharus plagiocephalus*
- *Morethia boulengeri* (Plate 15)
- *Morethia taeniopleura*
- *Gehyra dubia*
- Bynoe's gecko (*Heteronotia binoei*)

Plate 15 Reptiles of the Doongmabulla wetlands, showing *Morethia boulengeri* (left) and *Amphibolurus gilberti* (right)

4.3.6 Amphibians

A total of 12 amphibian species were recorded in desktop assessments within or adjacent to the Doongmabulla Springs complex, or the Project Area, including:

- Cane toad (*Rhinella marina*)
- Desert tree frog (*Litoria rubella*)
- Green tree frog (*Litoria caerulea*)
- Spotted grass frog (*Limnodynastes tasmaniensis*)
- Ornate burrowing frog (*Platyplectrum ornatum*)
- Green striped burrowing frog (*Cyclorana alboguttata*)
- Eastern snapping frog (*Cyclorana novaehollandiae*)
- Bumpy rocketfrog (*Litoria inermis*)
- Roth's tree frog (*Litoria rothii*)
- Broad-palmed frog (*Litoria latopalmata*)
- Chubby gungan (*Uperoleia rugosa*)
- Striped rocketfrog (*Litoria nasuta*)

None of these species are listed as being of Commonwealth, state or regional significance.

During the 2013 survey, the desert tree frog and the bumpy rocketfrog were observed (see Plate 16) and a number of frogs were heard. As was expected, frogs appeared to be absent from small springs with little or no surrounding wetland (that is, little or no suitable habitat).

Plate 16 Desert tree frog (left) and bumpy rocketfrog (right) observed in the Doongmabulla wetland

4.3.7 Fish

As the Doongmabulla Springs complex occurs in an upper, arid region of the Burdekin River catchment, fish species are expected to be limited by the environmental and geographical factors associated with inland locations.

A total of 18 fish species were predicted to occur in surface waters either within, or adjacent to the Doongmabulla Springs complex (see Appendix B). In previous studies of fish communities in the Project Area (GHD, 2012c), 11 of these species were recorded, namely:

- Agassiz's glassfish (*Ambassis agassizii*)
- Midgley's carp gudgeon (*Hypseleotris* species 1)
- Purple-spotted gudgeon (*Mogurnda adspersa*)
- Sleepy cod (*Oxyeleotris lineolata*)
- Eastern rainbowfish (*Melanotaenia splendida splendida*)
- Hyrtl's tandan (*Neosilurus hyrtlii*)
- Spangled perch (*Leiopotherapon unicolor*)
- Barred grunter (*Amniataba percoides*)
- Flyspecked hardyhead (*Craterocephalus stercusmuscarum*)
- Western carp gudgeon (*Hypseleotris klunzingeri*)
- Bony bream (*Nematalosa erebi*).

Due to the distance upstream, no marine vagrants were predicted to occur within or adjacent to Doongmabulla Springs. A single amphidromous species (the flathead gudgeon) is expected to occur at Moses Spring. The majority of predicted species were identified as catadromous (migrating within freshwater reaches) or sedentary – behaviours that are largely adapted to the unpredictable, ephemeral hydrological connectivity of inland reaches of arid Australia. Due to the varying morphologies of each spring, few were considered to be directly habitable by aquatic macro-fauna communities.

No specific trapping surveys for fish were carried out in during the 2013 field survey, but visual searches were undertaken at each of the springs. During the 2013 survey, rainbowfish

and spangled perch were observed in the isolated pools of Cattle Creek. In addition, spangled perch were observed in the pool of a mound spring.

4.3.8 Aquatic reptiles

The distribution of several freshwater turtle species spans Doongmabulla Springs (Cann, 1998; Cann, 2008). These species are as follows:

- Cann's long-necked turtle (*Chelodina canni*)
- Snake-necked turtle (*Chelodina longicollis*)
- Irwin's turtle (*Elseya irwini*)
- Saw-shelled turtle (*Wollumbinia latisternum*)
- Krefft's river turtle (*Emydura macquarii krefftii*).

None of these turtle species are listed as being of conservation significance under the EPBC Act or NC Act. Irwin's turtle is endemic to the Burdekin catchment and has been listed as high priority for conservation under the DERM 'Back on Track' prioritisation framework for conservation management of Queensland's wildlife (DERM, 2010). The specific habitat requirements for Irwin's turtle and the saw-shelled turtle were not observed within or near to Doongmabulla Springs, and consequently these species are not expected to occur in the complex.

Potential habitat was observed for Cann's long-necked turtle, snake-necked turtle and Krefft's river turtle. While turtles were not observed during the 2013 survey of the Doongmabulla Springs, their presence is likely. Both the snake-necked turtle and Krefft's river turtle were observed in the 2012 survey in the Project Area (GHD, 2012c).

4.3.9 Aquatic invertebrates

Previous surveys of aquatic invertebrates in the Project Area identified numerous families of invertebrates (GHD, 2012c). Two endemic invertebrate species have previously been recorded at the Doongmabulla wetland, the mollusc *Gabbia rotunda* (endemic to this wetland) and the water mite *Mammersela* sp. AMS KS85341 (endemic to GAB spring wetlands) (Fensham et al., 2010). *Gabbia rotunda* is listed as 'data deficient' under the International Union for Conservation of Nature red list, but no conservation actions are recommended. While active searches were made for invertebrates, none were observed.

4.4 Habitat values

In general, habitats within the Doongmabulla wetland exhibited minor disturbance. While the wetland is exposed to introduced and native wildlife, minimal animal impacts were noted for most sites. Cattle trampling was observed only at the Moses spring group. It was also noted that vehicle traffic had increased between May 2012 and March 2013. More vehicle tracks had been established, and existing tracks were more defined. It is recognised that the most recent surveys may have taken place at a time when the land owner had been accessing the site. However, if increased vehicle traffic was to continue this would influence habitat condition. The very fine, powdery alluvial soils present around the edge of the wetland have a thin crust that acts to protect the surface from rain drop impact (which can start sheet or

gully erosion) and wind erosion. This crust is easily broken by vehicles, and once broken, soils are exposed to erosive forces.

The greatest damage to the wetlands was caused by feral pigs. In comparison to the May 2012 survey, the extent of pig damage was reduced, but concentrated in several areas. The mounds themselves did not seem to be utilised by either pigs or cattle. However, parts of some wetlands were highly disturbed by pigs wallowing and foraging (Plate 17). These actions degrade and reduce available habitat for aquatic organisms by changing the water quality and physically removing cover and food resources.

Plate 17 Damage ('rough' areas) to wetlands by pigs at the Moses Springs

The greatest habitat values of the Doongmabulla Springs are in the permanency of water, and the connectivity of the wetland to the nearby waterways, and the surrounding region. The reliable water supply provides an important resource for both flora and fauna during dry periods, but it is the habitat connectivity that provides the means for fauna to access the springs. Generally speaking, the Doongmabulla wetland and adjacent areas consisted of a diverse range of habitats. All strata of terrestrial vegetation were present, from native grasses and herbs through to mature trees.

The *S. pamalae* grasslands and mixed species sedgelands was common but did not appear to be utilised by many birds - only one species, the golden headed cisticola (*Cisticola exilis*), was observed here regularly. A great number of trees within the coolabah and river red gum woodlands had mistletoes clumps flowering at the time of the 2013 survey, most commonly erect mistletoe (*Amyema congener*), coolabah mistletoe (*Diplatia grandibractea*) and square-stemmed mistletoe (*Viscum articulatum*). These clumps appeared particularly important to the smaller passerine species, and were utilised by a range of honeyeaters and other small birds. Peppermint gum grassy open woodlands were commonly utilised by larger birds such as the vulnerable squatter pigeon (*Geophaps scripta scripta*) (listed under the NC Act and the EPBC Act), and the bare alluvial flats were inhabited by masked lapwings (*Vanellus miles*).

The Doongmabulla wetland was also used for bird nesting. Mud nests were especially common, highlighting the importance of this site as a resource for nest building materials, particularly during dry periods when mud may be scarce. Stick nests were also frequently observed within the Doongmabulla wetland. These nests belonged to some of the larger passerines (crows, magpies *etc.*) through to smaller species such as wrens. The nest of a

black-necked stork (*Ephippiorhynchus asiaticus*) (Plate 18) was also found in a channel running through the wetland.

Plate 18 Black-necked stork nest at the Doongmabulla wetlands

Hollows were plentiful on the periphery of the wetland and surrounds, so it is very likely that a number of arboreal species will be present at the wetland. Such species would potentially include possums, gliders and bats.

Woody debris was typically abundant in forested areas, but was (as would be expected) absent from the grasslands and wetlands. Leaf litter was dense in much of the forested parts of the wetland, particularly under the stands of weeping paperbark. Logs, lifted or fallen bark and fallen timber was common, and was confirmed to provide habitat for skinks, geckos and dragons. The Doongmabulla Springs are fringed by rocky rises, some with short but abrupt escarpments, populated by a grassy open woodland of peppermint gum with porcupine grass and soft spinifex. The rock mosaic and spinifex provide ideal habitat for reptiles. It is likely that this diverse habitat within the Doongmabulla wetland would support a diverse and abundant range of reptiles (Plate 19).

The Joshua Spring group was the most impacted, and is completely altered from its natural state. It now consists of a single turkey's nest dam and two associated scrapes. However, given the depth of the turkey's nest dam and the permanency and high flow rate of this spring, it is predicted that the Joshua Spring provides potential habitat for fish, amphibians, turtles and invertebrate species, especially during the dry season.

Plate 19 Reptile habitat in the Doongmabulla wetland showing dense leaf litter (top left), fallen timber (top right), spinifex (bottom left) and rocky escarpments (bottom right)

The Doongmabulla Springs complex, and in particular the Moses Spring group, provide abundant, suitable habitat for frogs in the region. The density of vegetation and abundance of perennial water makes the Doongmabulla Springs and associated wetlands an important amphibian habitat in an otherwise arid environment.

While the Doongmabulla Springs themselves may provide a relatively small area of habitat for fish, the value of these springs is in providing surface flows which in some areas drained directly into the neighbouring waterways. From this perspective, these springs maintain perennial surface water (this was confirmed in personal communications with the owner of the Doongmabulla Station - Bob O'Sullivan pers. comm. 01/04/2013). This surface water may be significant for aquatic communities in the region by providing refugial habitat during seasonal conditions and periods of drought.

Refugial habitats are of high value in arid regions of Australia, as the variable climate and seasonal precipitation typically results in surface waters receding, or evaporating entirely (see Plate 20). The aquatic communities in these environments (typified in the Burdekin River catchment) rely on the persistence of such refugial habitats. For this reason, the Doongmabulla Springs complex is likely to provide important habitat for fish in the form of springs, wetlands and adjacent waterbodies.

Plate 20 Comparison of seasonal changes at the Moses Spring between May 2012 (left) and March 2013 (right)

Overall, Doongmabulla Springs also provide a diverse range of habitat for aquatic invertebrates, including freshwater mussels (Plate 21), crayfish, freshwater crabs and various insects. The diversity and abundance of aquatic invertebrates is largely determined by the habitat structure and type (for example clay substrates with root masses) and the availability of foraging material (for example leaf litter and other organic detritus). Suitable habitat was observed within the springs themselves, within the wetlands, and also in adjacent waterways. Substrates ranged from sand (suitable for freshwater mussels) to clays (preferred by many aquatic insects), and were mostly provided with abundant organic matter utilised by invertebrates for shelter and as a food source.

Plate 21 Freshwater mussel shells of *Velesunio* sp. from a pool beside a mound spring (May 2012) (left) and within the dry bed of Cattle Creek alongside the Moses Spring (March 2013) (right)

Cann's long-necked turtle, snake-necked turtle and Krefft's river turtle occur in off-channel aquatic environments, including billabongs and swamps. While surface water in the wetlands was generally shallow (<0.05 m), some deeper pools were present. Of greater relevance to turtles were the nearby drainage lines, creeks and billabongs, which were supplemented by flows from the springs. Similarly to fish, turtles rely on perennial water during the dry season. For this reason, Doongmabulla Springs are likely to be of indirect importance in maintaining viable habitat for freshwater turtles in the region.

Fire had recently passed through the Little Moses Spring, and so the diversity of habitat was comparatively reduced from the May 2012 survey. However, this fire was low in intensity, so it is expected that groundcover, grasses and shrubs will recover quickly.

Most sites were also free of weeds, although the larger mound springs in the Moses spring group contained the tall aquatic grass *Phragmites australis*. Although native, species such as *P. australis* can dominate wetlands at the expense of species diversity. In addition, this species has a high transpiration rate, and if it becomes common, can increase the rate of moisture loss to the atmosphere, with negative consequences for the availability of surface water in the wetland (Fensham et al., 2010). However, *P. australis* was only present at two mound springs in the one wetland (the largest in the Moses spring group), and then only in low densities.

Outside of the wetland, the class two declared weed parthenium (*Parthenium hysterophorus*) was common. This weed does not grow in saturated ground and is not considered a threat to the wetland. It is well established in the surrounding ground and is not considered likely to become a greater problem than it is presently. In addition, the class two weed rubber vine (*Cryptostegia grandiflora*) was present along Cattle Creek. This weed was growing in very low densities, as scattered individuals. However, it is growing near mound springs within the Moses spring group, and is a potential future threat.

The overflow channel for the Joshua spring (which carries a significant volume of water) is infested with the grass olive hymenachne, a class two declared weed. Located this far up-catchment, this infestation is a major concern – if it becomes established in the Carmichael River it has the potential to infest large areas downstream. However, it was noted over ten years ago by Fairfax and Fensham at this same location (2002) and does not appear to have spread from in this time.

5. Mellaluka Springs complex

5.1 Overview

The Mellaluka wetland is a relatively unknown spring complex, with limited information within the scientific literature (Fensham et al., 2004 mentions it but provides very little detail). While Mellaluka Springs complex is identified by DERM's wetland mapping tool, it is not listed in the Directory of Important Wetlands. As described in Section 1.3, the Mellaluka Springs complex consists of the following three separate springs:

- Mellaluka Spring – a large mound spring with several vents (Plate 22)
- Stories Spring – a discrete non-mounding artesian spring (Plate 23)
- Lignum Spring – a discrete non-mounding artesian spring (Plate 24).

Mellaluka Springs complex is located in Mellaluka station, almost 30 km south east of Doongmabulla Springs, and 20 km south of the Carmichael River, with one spring group located in the Brigalow Belt Bioregion (Mellaluka Springs) and two located in the Desert Uplands Bioregion (Lignum and Stories springs). The spring groups are located in a line running north-south, with Stories Spring located in the middle, 3.6 km south of Lignum Spring and 2.3 km north of Mellaluka Spring. The northern two spring groups have only one spring or outlet each, and are relatively simple springs consisting of a shallow pond that appears to seep water. They are both situated within broad, level to gently undulating sand plains. By contrast, Mellaluka Spring is situated within a clay plain and has three or four springs (due to the dense overgrowing vegetation, it is not possible to be precise). The main spring has formed a peat mound approximately 3 – 4 m taller than the surrounding plain, and about 100 m diameter. Immediately to the south of this large mound, two further springs are located, both approximately 20 – 30 m diameter, but neither having formed a mound. This spring group appears to have created its own small alluvial plain, exhibiting the same pale, very fine powdery sandy soil around the edges of the springs as seen at Moses Spring.

Plate 22 Mellaluka Spring

Plate 23 Stories Spring

Plate 24 Lignum Spring

5.2 Spring vegetation communities

Mellaluka Spring is mapped as non-remnant vegetation (see Figure 6). However, there is approximately 3 – 4 ha of remnant vegetation associated with this spring that meets the description of the of concern RE 11.3.22, which is 'Springs. Associated with recent alluvia, but also including those on ancient alluvia' (Queensland Herbarium, 2013). There were three main vegetation communities recorded at this spring.

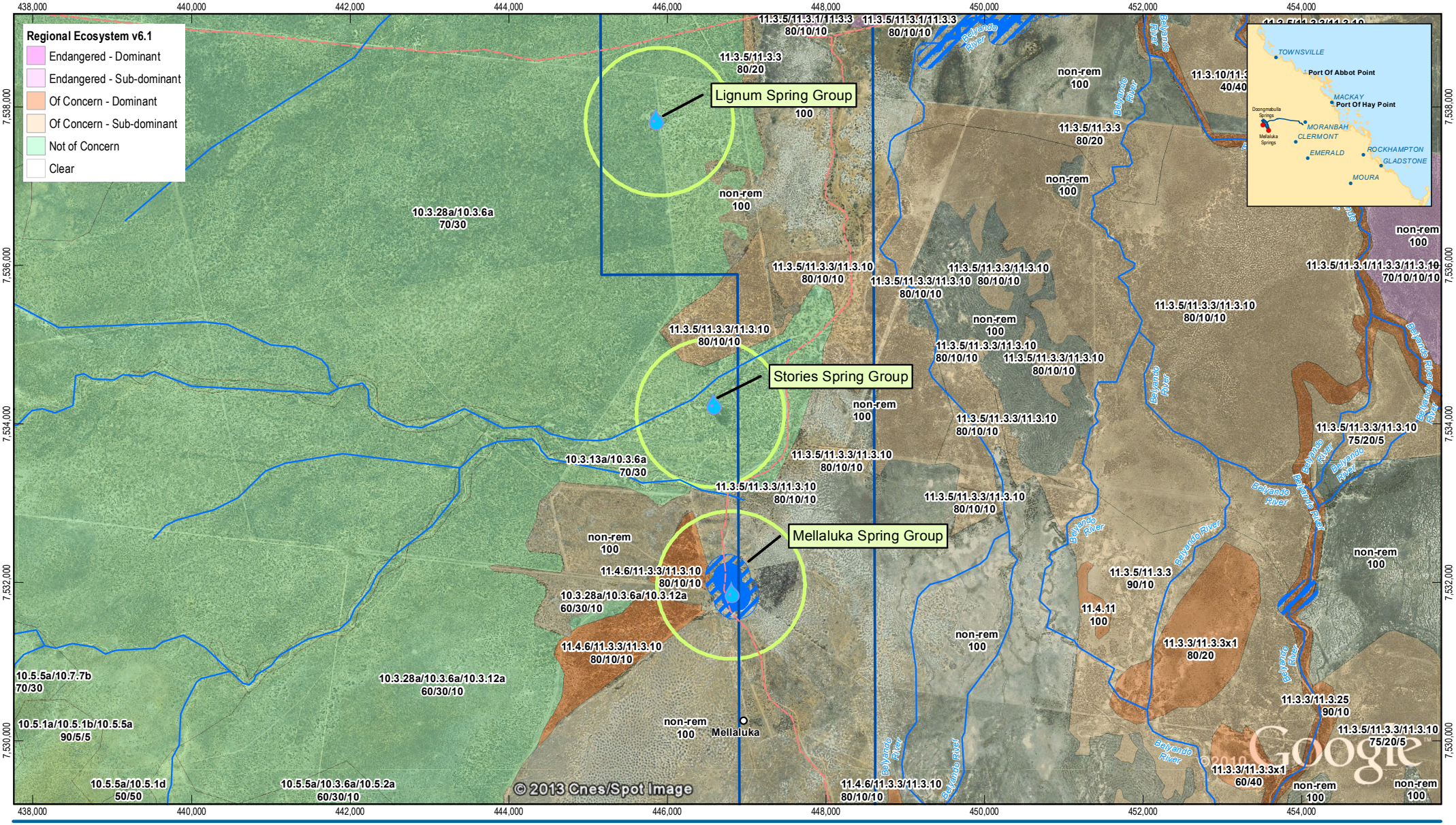
The main mound was predominately covered in a tall sedgeland to 2 m tall dominated by *Baumea rubiginosa* and *Schoenus falcatus*. *Phragmites australis,* cumbungi and the fern *Cyclosorus interruptus* were also common in places. Small groves of weeping paperbark were present in the sedgeland, all less than 5 m tall. Growing on the apex of the mound, but in sandy soil, were approximately ten tall (to 20 m) river red gums, forming a small open forest of half a hectare.

Elsewhere within this spring group, saturated areas were characterised by *Phragmites australis* grasslands with *Leersia hexandra* and *Fimbristylis ferruginosa,* or sedgeland dominated by an unknown tall *Cyperus* sp. (this sedge did not have any reproductive material at the time of the survey and could not be identified).

Dry areas adjacent to pools were comprised of the fine, powdery sand that appears to be characteristic of developed springs. These areas were characterised by grassland of *Sporobolus mitchellii* and freshwater couch with shrubs such as *Chenopodium auricomum* and *Atriplex* sp.

The area surrounding Mellaluka Springs is dominated by gidgee (*Acacia cambagei*) woodland on a clay plain, comprising the RE 11.4.6 (Queensland Herbarium, 2013).

Stories and Lignum springs are much simpler springs than those at Mellaluka Springs – both contained exclusively cumbungi. These springs are located in grassy woodland dominated either by silver-leaved ironbark (*Eucalyptus melanophloia*) or Reid River box. The RE mapping places the springs within a very large mixed polygon of REs 10.3.28/10.3.6 (70%/30%) (see Figure 6) – 10.3.6 represents the Reid River box woodland, and 11.3.28 the silver-leaved ironbark woodland.



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0 0.5 1 1.5 2
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND
- Homestead
- Spring Group (Surveyed)
- Track
- Watercourse
- Project (Mine)
- Wetland Management Area (WMA)
- Wetland Management Area (WMA) - Trigger
- Spring Groups

Adani Mining Pty Ltd
Doongmabulla and Mellaluka Springs
Existing Environment Report

Job Number 41-25215
Revision A
Date 26-06-2013

Mellaluka Wetland Regional Ecosystem Figure 6

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Data Source: GHD: Spring Complex and Groups/2013; GA: Watercourses, Roads, Homesteads (2007); DME: Carmichael Mine Site; Google: Imagery -2004 (2012); DNRM: RE v6.1, (2011) WMA, WMA Trigger (2010). Created by:MS

5.3 Flora and fauna of the Mellaluka Springs complex

5.3.1 Flora species of conservation significance

Desktop searches conducted found no flora species of conservation significance predicted to occur or actually recorded from the area (see Table 1 for a summary of desktop resources consulted). Field surveys did not locate any flora species of conservation significance.

An unidentified daisy, *Streptoglossa* sp., was collected on the main mound, this species was also collected at the Doongmabulla springs. The Herbarium could not match this specimen to any species and it may be a new species, however further specimens are required to confirm whether it is in fact a new species.

5.3.2 Terrestrial fauna of conservation significance

A number of species of terrestrial fauna of conservation significance were predicted to occur within the buffered search area including:

- Squatter pigeon (*Geophaps scripta scripta*)
- Red goshawk (*Erythrotriorchis radiates*)
- Ornamental snake (*Denisonia maculate*)
- Yakka skink (*Egernia rugosa*)
- Koala (*Phascolarctos cinereus*)
- Black throated finch (*Peophila cincta cincta*)
- Australian painted snipe (*Rostratula australis*)
- Greater bilby (*Macrotis lagotis*).

An assessment was made of the likelihood of occurrence for each of these species (see section 2.1 for method). A number of active searches were made during the 2013 survey in a variety of habitats to detect these species; however, only the squatter pigeon (*Geophaps scripta scripta*) was observed.

Squatter pigeon (Geophaps scripta scripta)

The squatter pigeon (southern) is listed as vulnerable under the EPBC Act and the NC Act. Squatter pigeons were observed during the Project (Mine) EIS (GHD, 2012b) and GHD field survey of Doongmabulla Springs complex (2012 and 2013). It was observed during the GHD field inspection of the Mellaluka Spring complex. It favours open habitats in the vicinity of water, and the Mellaluka wetland is likely to offer perennial habitat of high quality (DSEWPaC, 2011g). Given on site observations, this species is *confirmed present.*

Red goshawk (Erythrotriorchis radiatus)

The red goshawk has a relativity broad distribution across northern Australia (and parts of central Australia) through to north eastern New South Wales. However, the population is sparsely distributed within this region. This species is listed as vulnerable under the EPBC Act, and endangered under the NC Act. This species most commonly occurs in ecotones or moderately open, diverse forests and woodlands with abundant prey (typically birds) and

permanent water. Given the availability of prey and the permanency of water provided by the springs, the red goshawk is considered *likely to occur*.

Ornamental snake (Denisonia maculata)

The ornamental snake's distribution is confined to the northern brigalow belt bioregion, where it is typically found in areas of brigalow, riverside woodland and open forest on natural levees (DSEWPaC, 2011b). This species is listed as vulnerable under the EPBC Act and the NC Act. Habitat features known to be utilised by the species include cracking clay and sandy substrates where water pools and frogs (its main food source) are present. Brigalow was present alongside the Mellaluka Spring and the presence of permanent water and sandy substrates are likely to provide a perennial food source for the ornamental snake. As the Mellaluka wetland occurs within the recorded distribution for this species, it is considered that it is *likely to occur*.

Yakka skink (Egernia rugosa)

The yakka skink is listed as vulnerable under the EPBC Act and the NC Act. This species is endemic to dry sclerophyll open forests, woodlands and rocky areas of central and eastern Queensland, where it lives in communal burrow complexes, often taking refuge among low vegetation or under heaped dead timber, logs, rocks and in deep rock crevices (Wilson, 2005; DSEWPaC, 2011c). The Mellaluka wetland contains woodland but little rocky areas; however the site is located within the distribution of this species. Therefore, it is considered that it is *likely to occur* at the Mellaluka wetland.

Koala (Phascolarctos cinereus)

The koala is listed as vulnerable within Queensland under the EPBC Act (it is only listed as vulnerable under the NC Act in the Southeast Queensland bioregion). Koalas utilise sclerophyll woodland that contain preferred food trees across much of central and south east Queensland, in particular riparian corridors (Van Dyck and Strahan, 2008). Desktop sources contained no reports of koala for the search area. The Mellaluka wetland contains areas of sclerophyll woodland habitat which koalas utilise. Therefore, it is considered that the koala is *likely to occur* at the Mellaluka wetland.

Black throated finch (Poephila cincta cincta)

The black throated finch (southern) is listed as endangered under the EPBC Act and the NC Act. This species was not observed during field surveys at the Mellaluka wetland, and no records of this species exist in the Study Area. However, flocks of black-throated finches have been recorded within and adjacent to the Project (Mine) Area nearby, and it is considered possible that the Mellaluka wetland may host a population, particularly given the large areas of Reid River box woodland and silver-leaved ironbark woodland adjacent to permanent water at all three of the spring groups. Therefore, it is considered that this species is *likely to occur* at the Mellaluka wetland.

Australian painted snipe (Rostratula australis)

The Australian painted snipe is listed as vulnerable under the EPBC Act and the NC Act. This species has not been previously recorded, and was not observed during the Mellaluka field surveys. This species has a scattered distribution across eastern and northern Australia, utilising shallow freshwater wetlands, such as swamps, claypans, and

inundated/waterlogged grassland (Marchant and Higgins, 1993). Therefore, although this species is naturally uncommon, it is possible that individuals may utilise the spring wetlands of Mellaluka from time to time. As this area is within the recorded distribution of the Australian painted snipe, it is considered that this species is *likely to occur* at the Mellaluka wetland.

Greater bilby (Macrotis lagotis)

The greater bilby is listed as vulnerable under the EPBC Act and endangered under the NC Act. This species was historically recorded through much of arid and semi-arid Australia. However, it is now restricted to desert areas of central Australia. In Queensland, the species is known from a small area between Birdsville and Boulia in the south west of the state (Van Dyck and Strahan, 2008). The study area and surrounding landscape is not within the current known distribution of the species, and there are no records for this species from the Mellaluka Springs complex in the Wildlife Online database. Therefore, it is considered that the greater bilby is *unlikely to occur* at the Mellaluka Spring complex.

5.3.3 Birds

During the 2013 survey, a total of 44 bird species were identified within the Mellaluka wetlands (Table 3). As discussed in Section 5.3.1, the EPBC and NC Act listed squatter pigeon (*Geophaps scripta*) was observed at the Lignum Springs. Three observed birds are listed as migratory under the EPBC Act, brolga (*Grus rubicundus*), eastern great egret (*Ardea modesta*) and fork-tailed swift (*Apus pacificus*). These species are also listed under the JAMBA, CAMBA, ROKAMBA or Bonn Convention agreements. A small flock of domesticated Guinea fowl (*Numida meleagris*) were also present at the Mellaluka Spring.

Similarly to the Doongmabulla wetlands, typically birds were common waterbirds, woodland and grassland birds. Woodland birds were most frequently observed. These birds include such species as the double-barred finch (*Taeniopygia bichenovii*), pale-headed rosella (*Platycercus adscitus*) and black-faced cuckoo shrike (*Coracina novaehollandiae*). The most common waterbirds included the purple swamphen (*Porphyrio porphyrio*), eastern great egret (*Ardea modesta*) and black-tailed native hen (*Trybonix ventralis*).

Table 3 Bird species observed in the Mellaluka wetlands in March/April 2013

Common name	Scientific name	Number of observations*
apostlebird	*Struthidea cinerea*	2
Australasian darter	*Anhinga novaehollandiae*	1
Australian white ibis	*Threskiornis molucca*	1
bar-shouldered dove	*Geopelia humeralis*	1
black kite	*Milvus migrans*	1
black-faced cuckoo shrike	*Coracina novaehollandiae*	2
black-fronted dotterell	*Elseyornis melanops*	1
black-tailed native hen	*Tribonyx ventralis*	2
brolga	*Grus rubicundus*	1
budgerigar	*Melopsittacus undulates*	1
buff-rumped thornbill	*Acanthiza reguloides*	1

Common name	Scientific name	Number of observations*
cockatiel	*Nymphicus hollandicus*	1
dollarbird	*Eurystomus orientalis*	1
double-barred finch	*Taeniopygia bichenovii*	4
eastern great egret	*Ardea modesta*	2
fork-tailed swift	*Apus pacificus*	1
galah	*Eolophus roseicapillus*	2
grey teal	*Anas gracilis*	1
guinea fowl	*Numida meleagris*	1
jacky winter	*Microeca fascinans*	1
laughing kookaburra	*Dacelo novaeguineae*	1
magpie	*Gymnorhina tibicen*	3
magpie lark	*Grallina cyanoleuca*	1
masked lapwing	*Vanellus miles*	1
nankeen night heron	*Nycticorax caledonicus*	1
noisy friarbird	*Philemon corniculatus*	2
Pacific black duck	*Anas superciliosa*	1
pale-headed rosella	*Platycercus adscitus*	2
peaceful dove	*Geopelia striata*	1
purple swamphen	*Porphyrio porphyria*	2
rainbow lorikeet	*Trichoglossus haematodus*	1
red-backed fairywren	*Malurus melanocephalus*	2
royal spoonbill	*Platalea regia*	1
squatter pigeon	*Geophaps scripta*	1
straw-necked ibis	*Threskiornis spinicollis*	1
striated pardalote	*Pardalotus striatus*	1
sulphur-crested cockatoo	*Cacatua galerita*	3
Torresian crow	*Corvus orru*	2
varigated fairywren	*Malurus lamberti*	1
whistling kite	*Haliastur sphenurus*	1
willie wagtail	*Rhipidura leucophrys*	4
yellow-billed spoonbill	*Platalea flavipes*	1
yellow-faced honeyeater	*Lichenostomus chrysops*	1

** Number of observations refers to the number of separate occasions the species was observed, not the number of individuals.*

5.3.4 Mammals

No desktop records for mammals exist for the Mellaluka wetlands and surrounds. A total of six mammal (including four introduced) species were observed at or adjacent to the Mellaluka wetland, including:

- Feral pig (*Sus scrofa*)

- Eastern grey kangaroo (*Macropus giganteus*)
- Swamp wallaby (*Wallabia bicolor*) (Plate 25)
- Domestic cattle (*Bos taurus*)
- Domestic horse (*Equus ferus caballus*)
- Domestic dog (*Canis lupus familiaris*).

Plate 25 Swamp wallaby

5.3.5 Terrestrial reptiles

Both the ornamental snake and yakka skink were predicted to occur in the area using the Protected Matters Search Tool (see Section 4.3.2), but these species were not observed. Desktop records did identify the following terrestrial reptiles in the search area for the Mellaluka wetland:

- Box-patterned gecko (*Diplodactylus steindachneri*)
- Northern golden-tailed gecko (*Strophurus taenicauda albiocularis*)
- Ta ta lizard (*Amphibolurus gilbert*)
- Carpentaria snake (*Cryptophis boschmai*)
- Greater black whipsnake (*Demansia papuensis*).

None of the above species were observed in the wetland, however, four other species of terrestrial reptiles were observed at the Mellaluka wetland, and included:

- Open litter rainbow skink (*Carlia pectoralis*)
- Peron's snake eyed skink (*Cryptoblepharus plagiocephalus*)
- Common dwarf skink (*Menetia greyii*)
- Tommy roundhead (*Diporiphora australis*) (Plate 26).

Plate 26 *Diporiphora australis* at the Mellaluka wetlands

5.3.6 Amphibians

A total of 11 amphibian species have been previously recorded from the EIS Project Area, including:

- Cane toad (*Rhinella marina*)
- Desert tree frog (*Litoria rubella*)
- Green tree frog (*Litoria caerulea*)
- Spotted grass frog (*Limnodynastes tasmaniensis*)
- Ornate burrowing frog (*Platyplectrum ornatum*)
- Green striped burrowing frog (*Cyclorana alboguttata*)
- Eastern snapping frog (*Cyclorana novaehollandiae*)
- Bumpy rocketfrog (*Litoria inermis*)
- Roth's tree frog (*Litoria rothii*)
- Broad-palmed frog (*Litoria latopalmata*)
- Chubby gungan (*Uperoleia rugosa*).

None of these species are listed as being of Commonwealth, state or regional significance.

During the 2013 survey, the cane toad and the green-striped burrowing frog (Plate 27) were identified at Lignum and Stories springs. Frogs were heard or observed at all three springs in the Mellaluka wetland.

Plate 27 Green-striped burrowing frogs at the Lignum Spring (left) and Stories Spring (right)

5.3.7 Fish

The Mellaluka Springs are discrete and isolated waterbodies that share no physical connectivity to nearby riverine systems. In this regard, the fish community is likely to be more limited than that of the Doongmabulla Springs, as the physical (hydrological) connectivity is greatly reduced. With the exception of extreme flooding events, the only means for fish to colonise isolated waterbodies is through passive introductions where small fish, larvae or eggs inadvertently attached to the feet or feathers of waterbirds and are transported to the new site. Eight fish species may occur at the Mellaluka wetlands (see Appendix B).

No specific trapping surveys for fish were carried out in the 2013 field survey, but visual searches were undertaken at each of the springs. Lignum Spring has very limited surface water (Plate 28 left) and no fish were observed within the spring. It is unlikely that this spring contains fish. Stories Spring has a larger pool (Plate 28 right) which may contain a limited fish community. Again, no fish were observed in the pool, although this observation does not conclude that fish are absent from Stories Spring.

Plate 28 Surface pools at Lignum (left) and Stories (right) Springs

The Mellaluka Spring provides the most suitable habitat for fish, and fish were observed in the dam. Spangled perch (*Leiopotherapon unicolor*) and eastern rainbowfish (*Melanotaenia splendida splendida*) were positively identified, but it is likely that a number of other species inhabit the dam based on their habitat preferences, movement behaviour and environmental tolerances.

5.3.8 Aquatic reptiles

The distribution of several freshwater turtle species spans the Mellaluka Springs complex. The specific habitat requirements for Irwin's turtle and the saw-shelled turtle (i.e. perennial riverine habitats) were not observed within or near to the Mellaluka Springs complex, and consequently these species are not expected to occur in spring surface waters. However, the dam at the Mellaluka Spring does provide potential habitat for Cann's long-necked turtle, the snake-necked turtle and Krefft's river turtle. Both the snake-necked turtle and Krefft's river turtle were observed in the 2012 survey in the Project Area (GHD, 2012c).

5.3.9 Aquatic invertebrates

The Mellaluka Spring has been stocked with crayfish (*Cherax* sp.), although it appears that a population has not established (B. Cobb pers. comm. 01/04/2013). Freshwater crab (*Austrothelphusa transversa*) burrows were observed during the 2013 survey at the Mellaluka Spring, but were not seen at the Lignum or Stories Spring (although it is likely that this species will occur at these springs).

5.4 Habitat values

Habitats within the Mellaluka wetland have undergone a number of disturbances. The wetlands are accessed by a number of domestic and feral animals which have resulted in moderate disturbances from horses, cattle and domestic pigs. The proximity of Mellaluka Station to the Mellaluka Spring may also create some anthropogenic disturbances, for example, from noise and light, increased human activity, chemical spraying and the presence of domestic pigs (which were observed to utilise the wetland). Cattle and pigs have caused the greatest damage to the two northern Mellaluka Springs group wetlands, Lignum and Stories (see Plate 29) – they have noticeably degraded the water quality by stirring up sediment, and urinating and defecating in the water. Mellaluka Springs and its associated wetland were fenced off from cattle and do not appear to be accessible by them, although domestic pigs were present.

Plate 29 Cattle and pig damage (the 'rough areas') at Lignum Spring

The Mellaluka wetlands provide refugial habitat and a constant source of water for flora and fauna communities in the region. While the Mellaluka Spring is the larger spring (Plate 30), it is relatively isolated from nearby grass and woodland, and habitat connectivity may be compromised for many species. However, Stories and Lignum springs are both situated in woodland where terrestrial habitat connectivity is maintained. The Mellaluka Spring

contained the largest community of flora species which in turn created a broad range of habitats.

Plate 30 Pool at Mellaluka Spring

At Mellaluka Spring the groundcover was thick, and included leaf litter, woody debris and grasses. Tree hollows were common on the mound in the tall river red gums, but were sparse in the surrounding paddocks. Stories and Lignum springs were both vegetated with cumbungi, and were situated within a large area of intact woodland with a high level of structural habitat complexity. Log piles and fallen timber were not common at the springs, and were very sparse at the Lignum Spring. At Stories and Lignum springs, sparse, light ground cover was provided by leaf litter (Plate 31). The greatest habitat values for reptiles were the dense vegetation and leaf litter at the Mellaluka Spring.

Plate 31 Reptile habitat in the Mellaluka wetland showing fallen timber at Stories Spring (left), and dense vegetation at the Mellaluka Spring (right)

All of the spring groups were free of declared weeds, with the exception of parthenium, which is ever-present in low densities in eucalypt and gidgee woodland in this area. Species of native plants often attributed weed status present at the site included the tall aquatic grass *Phragmites australis* and cumbungi. *P. australis* was only present at Mellaluka, whilst cumbungi was present at all three spring groups.

There was a lesser complexity of habitat within the Mellaluka wetlands than at Doongmabulla Springs complex. The Mellaluka Spring, contained four main vegetation types within an area of approximately three to four hectares, the other two springs contain very small springs (about 10 to 15 m diameter in both cases) dominated by one species –

cumbungi. This may account for the reduced bird species count at Mellaluka Springs complex compared to Doongmabulla Springs complex.

Larger macropods were common in the areas around the Mellaluka wetland. However, the Stories and Lignum springs are unlikely to provide direct habitat for most mammal species, although some small mammals may seek refuge in the denser vegetation within the springs. Conversely, Stories and Lignum springs have value for mammals as a perennial source of water, particularly during dry periods. Mellaluka Spring is covered in vegetation, including mature trees with hollows and dense grasses and shrubs. The thick vegetation provides suitable cover for smaller ground-dwelling marsupials, and the hollows may support arboreal species. During dry periods, this spring may also act as a habitat refuge for mammals (aside from being a perennial source of water). It is still emphasised that the terrestrial habitat connectivity of the Mellaluka Spring is compromised, and mammals may not be physically able to reach the spring. An additional deterrent to mammals at the Mellaluka Spring (excluding the Stories and Lignum springs) are the presence of domestic dogs at the Mellaluka homestead.

The Mellaluka Spring provided particularly abundant habitat for amphibians as it had a perennial water source and dense vegetative cover. While both Stories and Lignum springs contained frogs, the smaller size of the springs and the associated disturbances to the springs make these vents less suitable for supporting large amphibian populations. The density of vegetation and abundance of perennial water makes the Mellaluka Springs and associated wetlands an important amphibian habitat in an otherwise arid environment.

The surface waters of the Mellaluka Spring are fringed by submerged, emergent and trailing vegetation, and some woody debris is present (Plate 32). Substrate consisted primarily of mud and/or peat; rocks or stones seemed absent. Overall aquatic habitat diversity is fairly limited; however, as a perennial waterbody, the Mellaluka Spring may provide valuable stable, refugial habitat for fish, if they are present.

Plate 32 Aquatic habitat at the Mellaluka Spring

The dam at the Mellaluka Spring provides a valuable habitat for turtles (Plate 33) as the surface waters are perennial, and prey (frogs, fish, insects and crustaceans) are predicted to be abundant. The aquatic invertebrate community is likely to consist of decapods (freshwater shrimps, prawns, crabs and crayfish), microcrustaceans and a range of aquatic insects. While there is little cover provided by submerged timber or floating macrophytes, the peat and clay substrate does provide an environment suitable for aquatic invertebrates.

Plate 33 Turtle habitat at the Mellaluka Spring

6. Conclusion

6.1 Doongmabulla Springs complex

The Doongmabulla Springs complex contains three spring groups, Little Moses, Joshua and Moses, all of which contribute base flow to nearby riverine channels. Joshua Spring has the highest flow, but has been highly modified to a turkey's nest dam. However, the outflow of the Joshua Spring also contributes a considerable amount of water to the Carmichael River channel. The Moses spring group is almost entirely intact, with the exception of impacts from cattle and pigs. It straddles Cattle Creek, comprises approximately 65 vents or springs spread over 2.5 km, and forms a wetland of approximately 3.5 hectares. Moses Springs is located within the Doongmabulla Nature Refuge. The Little Moses spring group is located to the east of the Moses spring group. Little Moses differs from the main Moses spring group in being much smaller (it has approximately two vents) and located within a woodland with different soils. It is postulated that this spring group may be much younger than the springs of the Moses spring group.

The Doongmabulla Springs complex is recognised as the endangered threatened ecological community 'The community of native species dependant on natural discharge of groundwater from the Great Artesian Basin' under the EPBC Act. The Doongmabulla Springs complex contains a comparatively high number of flora and fauna species endemic to GAB spring wetlands, including:

- Salt pipewort – listed as endangered under both the Queensland NC Act and the Commonwealth EPBC Act, observed at Moses Spring during the 2013 field survey
- Blue devil – listed as endangered under the NC Act and the EPBC Act, observed at Moses Spring during the 2013 field survey
- *Hydrocotyle dipleura* – listed as vulnerable under the NC Act, observed confirmed at Moses Spring during the 2013 field survey
- Waxy cabbage palm – listed as vulnerable under the NC Act and the EPBC Act, observed at Moses and Little Moses Springs during the 2013 field survey
- *Myriophyllum artesium* – listed as endangered under the NC Act, observed at Moses and Joshua Springs during the 2013 field survey
- *Sporobolus pamelae* – listed as endangered under the NC Act, observed at Moses Spring during the 2013 field survey
- *Sporobolus partimpatens* – listed as near threatened under the NC Act, observed at Moses and Joshua Springs during the 2013 field survey.

During the 2013 survey, two flora species of interest were submitted to the Queensland Herbarium for identification. One is an unnamed grass, *Chloris* sp. (Edgebaston R.J.Fensham5694), that was previously recorded only once from Doongmabulla, and has only been collected twice before (Bostock and Holland, 2010). The other is a still unidentified daisy, *Streptoglossa* sp., which the Herbarium could not match to any species. It may be a new species, however further specimens are required to confirm whether it is in fact a new species.

A number of species of terrestrial fauna of conservation significance were predicted to be likely to occur within the buffered search area including:

- Squatter pigeon (*Geophaps scripta scripta*)
- Ornamental snake (*Denisonia maculate*)
- Yakka skink (*Egernia rugosa*)
- Koala (*Phascolarctos cinereus*)
- Black throated finch (*Peophila cincta cincta*)
- Australian painted snipe (*Rostratula australis*)

A number of active searches were made during the 2013 survey in a variety of habitats during which only the squatter pigeon was observed.

The Doongmabulla Springs complex provides habitat for a wide range of least concern species of flora and fauna. In general, the habitats present within the Doongmabulla wetland were mostly intact and in good ecological condition and exhibited only minor disturbance. While the wetland is exposed to introduced and native wildlife, minimal animal impacts were noted for most sites. Cattle trampling was observed only at the Moses Spring group. The greatest damage to the wetlands was caused by feral pigs, with parts of some wetlands being highly disturbed by pigs wallowing and foraging. These actions degrade and reduce available habitat for aquatic organisms by changing the water quality and physically removing cover and food resources. It was also noted that vehicle traffic had increased between May 2012 and March 2013. More vehicle tracks had been established, and existing tracks were more defined.

The greatest habitat values of the Doongmabulla Springs are in the permanency of water, and the connectivity of the wetland to the nearby waterways, and the surrounding region. The reliable water supply provides an important resource for both flora and fauna during dry periods, but it is the habitat connectivity that provides the means for fauna to access the springs. Generally speaking, the Doongmabulla wetland and adjacent areas consisted of a diverse range of habitats. All strata of terrestrial vegetation were present, from native grasses and herbs through to mature trees.

The *S. pamelae* grasslands and mixed species sedgelands were common within the Doongmabulla Springs complex, however, it did not appear to be utilised by many birds. A great number of trees within the coolabah and river red gum woodlands had mistletoes clumps flowering at the time of the 2013 survey. These clumps appeared particularly important to the smaller passerine species, and were utilised by a range of honeyeaters and other small birds. Peppermint gum grassy open woodlands were commonly utilised by larger birds such as the vulnerable squatter pigeon (listed under the NC Act and the EPBC Act), and the bare alluvial flats were inhabited by masked lapwings.

The Doongmabulla wetland was used for bird nesting with mud nests especially common and stick nests also frequently observed. Hollows were plentiful on the periphery of the wetland and surrounds, and so it is very likely that a number of arboreal species will be present at the wetland. Such species would potentially include possums, gliders and bats.

Woody debris was typically abundant in forested areas, but was (as would be expected) absent from the grasslands and wetlands. Leaf litter was dense in much of the forested parts

of the wetland, particularly under the stands of weeping paperbark. Logs, lifted or fallen bark and fallen timber was common, and was confirmed to provide habitat for skinks, geckos and dragons. The Doongmabulla Springs is fringed by rocky rises, some with short but abrupt escarpments, populated by grassy open woodland of peppermint gum with porcupine grass and soft spinifex. The rock mosaic and spinifex provide ideal habitat for reptiles. It is likely that this diverse habitat within the Doongmabulla wetland would support a diverse and abundant range of reptiles.

The Doongmabulla Springs complex, and in particular the Moses Spring group, provide abundant, suitable habitat for frogs in the region. The density of vegetation and abundance of perennial water makes the Doongmabulla Springs and associated wetlands an important amphibian habitat in an otherwise arid environment.

While the Doongmabulla Springs themselves may provide a relatively small area of habitat for fish, the value of these springs is in providing surface flows which in some areas drained directly into the neighbouring waterways. From this perspective, these springs maintain perennial surface water. This surface water may be significant for aquatic communities in the region by providing refugial habitat during seasonal conditions and periods of drought.

The aquatic communities in these environments rely on the persistence of such refugial habitats. For this reason, the Doongmabulla Springs complex is likely to provide important habitat for aquatic fauna, including fish, in the form of springs, wetlands and adjacent waterbodies. Overall, Doongmabulla Springs also provide a diverse range of habitat for aquatic invertebrates, including freshwater mussels, crayfish, freshwater crabs and various insects.

Cann's long-necked turtle, snake-necked turtle and Krefft's river turtle occur in off-channel aquatic environments, including billabongs and swamps. While surface water in the wetlands was generally shallow (<0.05 m), some deeper pools were present. Of greater relevance to turtles were the nearby drainage lines, creeks and billabongs, which were supplemented by flows from the springs. Similarly to fish, turtles rely on perennial water during the dry season. For this reason, Doongmabulla Springs is likely to be of importance in maintaining viable habitat for freshwater turtles in the region.

The Joshua Spring group was the most impacted, and is completely altered from its natural state. It now consists of a single turkey's nest dam and two associated scrapes. The overflow channel for the Joshua Spring (which carries a significant volume of water) is infested with the grass olive hymenachne, a class two declared weed. However, given the depth of the turkey's nest dam and the permanency and high flow rate of this spring, it is predicted that the Joshua Spring provides potential habitat for fish, amphibians, turtles and invertebrate species, especially during the dry season.

6.2 Mellaluka Springs complex

The Mellaluka wetland contains three spring groups – Lignum, Stories and Mellaluka springs. All of these springs were discrete environments that were not located within or near to any riverine waterways. However, all three springs have bores installed which provide water for domestic use (the Mellaluka Spring), and water for livestock (Stories and Lignum springs). The Mellaluka Spring (proper) was the largest spring which supported a wetland and dam.

However, the Mellaluka wetland (particularly the Mellaluka Spring) does provide habitat for a range of aquatic and terrestrial fauna. These springs may also be regionally important as a refuge for fauna during droughts and dry periods. No threatened species of flora were located at the springs, or were predicted to be present, and there are no historic records of threatened flora from the site.

An unidentified daisy, *Streptoglossa* sp., was collected on the main mound, this species was also collected at the Doongmabulla springs. The Herbarium could not match this specimen to any species and it may be a new species, however further specimens are required to confirm whether it is in fact a new species.

A number of species of terrestrial fauna of conservation significance were predicted to be likely to occur within the buffered search area including:

- Squatter pigeon (*Geophaps scripta scripta*)
- Red goshawk (*Erythrotriorchis radiates*)
- Ornamental snake (*Denisonia maculate*)
- Yakka skink (*Egernia rugosa*)
- Koala (*Phascolarctos cinereus*)
- Black throated finch (*Peophila cincta cincta*)
- Australian painted snipe (*Rostratula australis*)

A number of active searches were made during the 2013 survey in a variety of habitats however, only the squatter pigeon was observed.

Habitats within the Mellaluka wetland have undergone a number of disturbances. The wetlands are accessed by a number of domestic and feral animals which have resulted in moderate disturbances from horses, cattle and domestic pigs. Cattle have caused the greatest damage to the two northern wetlands forming the Mellaluka Springs complex, Lignum and Stories. Mellaluka Springs and its associated wetland were fenced off from cattle and do not appear to be accessible by them, although domestic pigs were present.

The Mellaluka wetlands provides refugial habitat and a constant source of water for flora and fauna communities in the region. While the Mellaluka Spring is the larger spring, it is relatively isolated from nearby grass and woodland, and terrestrial habitat connectivity may be compromised for many species. However, Stories and Lignum springs are both situated in woodland where habitat connectivity is maintained. The Mellaluka Spring contained the largest community of flora species which in turn created a broad range of habitats.

There was a lesser complexity of habitat within the Mellaluka wetlands than at the Doongmabulla Springs complex. The Mellaluka Spring, contained four main vegetation types within an area of approximately 3 – 4 ha, the other two springs contain very small springs (about 10 – 15 m diameter in both cases) dominated by one species – cumbungi. This may account for the reduced bird species count at the Mellaluka Springs complex compared to Doongmabulla Springs complex.

Groundcover was thick, and included leaf litter, woody debris and grasses at Mellaluka Spring. Tree hollows were common on the mound in the tall river red gums, but were sparse in the surrounding paddocks. Stories and Lignum springs were both vegetated with

cumbungi, and were situated within a large area of intact woodland with a high level of structural habitat complexity. Log piles and fallen timber were not common at the springs, and were very sparse at the Lignum Spring. At Stories and Lignum springs, sparse, light ground cover was provided by leaf litter. The greatest habitat values for reptiles were the dense vegetation and leaf litter at the Mellaluka Spring.

Larger macropods were common in the areas around the Mellaluka wetland. However, the Stories and Lignum springs are unlikely to provide direct habitat for most mammal species, although some small mammals may seek refuge in the denser vegetation within the springs. Conversely, Stories and Lignum springs have value for mammals as a perennial source of water, particularly during dry periods. Mellaluka Spring is covered in vegetation, including mature trees with hollows and dense grasses and shrubs. The thick vegetation provides suitable cover for smaller ground-dwelling marsupials, and the hollows may support arboreal species. During dry periods, this spring may also act as a habitat refuge for mammals (aside from being a perennial source of water).

The Mellaluka Spring provided particularly abundant habitat for amphibians as it had a perennial water source and dense vegetative cover. While both Stories and Lignum springs contained frogs, the smaller size of the springs and the associated disturbances to the springs make these vents less suitable for supporting large amphibian populations. The density of vegetation and abundance of perennial water makes the Mellaluka Springs and associated wetlands an important amphibian habitat in an otherwise arid environment.

The surface waters of the Mellaluka Spring are fringed by submerged, emergent and trailing vegetation, and some woody debris is present. Substrate consisted primarily of mud and/or peat; rocks or stones seemed absent. Overall aquatic habitat diversity is fairly limited; however, as a perennial waterbody, the Mellaluka Spring may provide valuable stable, refugial habitat for fish, if they are present.

The dam at Mellaluka Spring provides a valuable habitat for turtles as the surface waters are perennial, and prey (frogs, fish, insects and crustaceans) are predicted to be abundant. The aquatic invertebrate community is likely to consist of decapods (freshwater shrimps, prawns, crabs and crayfish), microcrustaceans and a range of aquatic insects. While there is little cover provided by submerged timber or floating macrophytes, the peat and clay substrate does provide an environment suitable for aquatic invertebrates.

All of the Mellaluka Springs complex were free of declared weeds, with the exception of parthenium, which is present in low densities in eucalypt and gidgee woodland in this area. *Phragmites australis* was only present at Mellaluka, whilst cumbungi was present at all three spring groups.

7. References

Allen, G.R., Midgley, S.H., and Allen, M, 2002, Field Guide to the Freshwater Fishes of Australia, Western Australian Museum.

Australian Virtual Herbarium, 2012, *Hydrocotyle dipleura* record search. Available from: http://avh.ala.org.au/occurrences/search?taxa=hydrocotyle+dipleura#map. (Accessed 29.06.2012).

Australian Virtual Herbarium, 2012a, *Sporobolus pamelae* record search. Available from: http://avh.ala.org.au/occurrences/search?taxa=sporobolus+pamelae#mapView (Accessed 29.06.2012).

Australian Virtual Herbarium, 2012b, *Sporobolus partimpatens* record search. Available from: http://avh.ala.org.au/occurrences/search?taxa=Sporobolus+partimpatens#mapView (Accessed 29.06.12).

Barker, J., Grigg G.C. and Tyler M.J, 1995, A Field Guide to Australian Frogs, Surrey Beatty and Sons, Chipping Norton. DERM, 2009 Queensland Water Quality Guideline

Bean, A.R. and Henwood, M.J, 2003, Six new species of *Hydrocotyle L.* (Apiaceae) from Queensland, Austrobaileya, vol. 6, no, 3, pp. 539.

Bostock, P.D. and Holland, A.E., 2010, Census of the Queensland Flora 2010, Queensland Herbarium, Department of Environment and Resource Management, Brisbane.

Bureau of Meteorology (BOM), 2012, Climate Statistics for Australian Locations – Summary Statistics. Available from: http://www.bom.gov.au/climate/averages/tables/ca_qld_names.shtml (Accessed 20.04.2013).

Cann, J, 1998, Australian Freshwater Turtles, Beaumont Publishing Pty Ltd, Singapore.

Cann, J, 2008, A Wild Australia Guide Freshwater Turtles, Steve Parish Publishing, Archerfield.

Carter, J., and Tait, J, 2008, Freshwater Fish of the Burdekin Dry Tropics NRM Region, Burdekin Dry Tropics NRM. Available from: http://www.environment.gov.au/cgi-bin/wetlands/report.pl, (Accessed 12.06.2012).

Department of Environment and Resource Management (DERM), 2010, Burdekin Natural Resource Management Region Back on Track for Biodiversity, Department of Environment and Resource Management, Brisbane.

Department of Environment, Water, Heritage and the Arts (DEWHA), 2010, Survey Guidelines for Australia's Threatened Birds, EPBC Act survey guidelines, Available from: http://www.environment.gov.au/epbc/publications/threatened-birds.html Accessed 29.06.2012.

Dowe, J.L. and Jones, D.L., 2011, *Arecaceae,* in Flora of Australia 39, *Alismatales* to *Arales*. Melbourne, ABRS/CSIRO, Australia.

DSEWPaC, 2010, Directory of Important Wetlands in Australia – Information Sheet: Doongmabulla Springs – QLD081. Available from: http://www.environment.gov.au/cgi-bin/wetlands/report.pl (Accessed 12.06.2012).

DSEWPaC, 2011a, *Denisonia maculata* in Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1193 (Accessed 02.06.2012).

DSEWPaC, 2011b, *Egernia rugosa* in Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1420 (Accessed 02.06.2012).

DSEWPaC, 2011c, *Geophaps scripta scripta* in Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=64440 (Accessed 08.06.2012).

Eamus, D, Hatton, T., Cook, P. and Colvin, C., 2006, Ecohydrology. Vegetation Function, Water and Resource Management. CSIRO Publishing, Melbourne.

Fairfax, R.J., and Fensham, R.J, 2002, 'In the Footsteps of J. Alfred Griffiths: a Cataclysmic History of Great Artesian Basin Springs in Queensland'. Australian Geographical Studies. Vol. 40. pp 210-230.

Fensham, R. J., and Fairfax, R. J, 2003, 'Spring wetlands of the Great Artesian Basin, Queensland, Australia'. Wetlands Ecology and Management. Vol. 11. pp 343-362.

Fensham, R., Ponder, W. and Fairfax, R., 2010, Recovery plan for the community of native species dependant on natural discharge of groundwater from the Great Artesian Basin, Department of Environment and Resource Management, Brisbane.

Fensham, R. J., and Price, R. J, 2004, 'Ranking spring wetlands in the Great Artesian Basin of Australia using endemicity and isolation of plant species'. Biological Conservation, Vol. 119. (1): pp 41-50.

Fensham, R.J., Silcock, J.L., Kerezsy, A., and Ponder, W, 2011, 'Four desert waters: setting arid zone wetland conservation priorities through understanding patterns of endemism'. Biological Conservation. Vol. 144. (10): pp 2459-2467.

GHD, 2012a, *Report for Carmichael Coal Mine and Rail Project: Mine Technical Report. Doongmabulla Springs Technical Report,* online report, available at: http://www.adanimining.com/EIS_PDFDocs_Listing. Accessed 26 April, 2013.

GHD, 2012b, *Report for Carmichael Coal Mine and Rail Project: Mine Technical Report. Terrestrial Ecology Report,* online report, available at: http://www.adanimining.com/EIS_PDFDocs_Listing. Accessed 26 April, 2013.

GHD, 2012c, *Report for Carmichael Coal Mine and Rail Project: Mine Technical Report. Mine Aquatic Ecology Report,* online report, available at: http://www.adanimining.com/EIS_PDFDocs_Listing. Accessed 26 April, 2013.

GHD, 2012d, *Report for Carmichael Coal Mine and Rail Project: Mine Technical Report. Hydrology Report.,* online report, available at: http://www.adanimining.com/EIS_PDFDocs_Listing. Accessed 7 May, 2013.

GHD, 2012e, *Report for Carmichael Coal Mine and Rail Project: Mine Technical Report. Water Quality.,* online report, available at: http://www.adanimining.com/EIS_PDFDocs_Listing. Accessed 7 May, 2013.

GHD, 2012f, *Report for Carmichael Coal Mine and Rail Project: Mine Technical Report. Hydrogeology Report.,* online report, available at: http://www.adanimining.com/EIS_PDFDocs_Listing. Accessed 7 May, 2013.

GHD, 2012g, *Report for Carmichael Coal Mine and Rail Project: Mine Technical Report. Black Throated Finch Report.,* online report, available at: http://www.adanimining.com/EIS_PDFDocs_Listing. Accessed 7 May, 2013.

Gotch, T.B., Adams M., Murphy N.P., and Austin A.D, 2008, 'A molecular systematic overview of wolf spiders associated with Great Artesian Basin springs in South Australia: evolutionary affinities and an assessment of metapopulation structure in two species'. Invertebrate Systematics. Vol 22. pp 151-165.

Habermehl, M.A, 1982, Springs in the Great Artesian Basin, Australia - their origin and nature, Bureau of Mineral Resources, Geology and Geophysics, Report 235.

Halford, D. & Fensham, R.J., 2001, A new species of *Myriophyllum L.* (Haloragaceae) from artesian springs in Queensland. Austrobaileya 6(1): 133-137.

Marchant S. and Higgins P.J (eds), 1993, Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings, Oxford University Press, Melbourne.

Marchant, S. and Higgins, P.J. (eds), 2004, Handbook of Australian, New Zealand and Antarctic Birds Volume 1-7, Oxford University Press, Melbourne.

Menkhorst P. and Knight F, 2004, A Field Guide to the Mammals of Australia. Oxford University Press, Melbourne. Wilson and Swan 2008 *A Complete Guide to Reptiles of Australia*

Mitchell C., Egan S., and Leverington A, 2002, Biodiversity Audit – Bioregional Case Study Desert Uplands bioregion, Queensland, Environmental Protection Agency, Queensland Government.

Mudd, G.M, 2000, 'Mound Springs of the Great Artesian Basin in South Australia: A Case Study From Olympic Dam'. Environmental Geology. Vol 39. (5): pp 463-476.

NHMRC, NRMMC, 2011, *Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy*. National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra.

Neldner, V.J., Wilson, B. A., Thompson, E.J. and Dillewaard, H.A, 2005, Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland (Version 3.1 Updated September 2005), Queensland Herbarium, Environmental Protection Agency, Brisbane.

Pusey, B, Kennard, M, and Arthington, A, 2004, Freshwater Fishes of North-eastern Australia, CSIRO Publishing, Melbourne.

Queensland Herbarium, 2012, Herbrecs records for Doongmabulla Springs complex, HERBRECS database, as supplied 16 May, 2012, Queensland Herbarium, Department of Environment and Resource Management, Queensland government.

Queensland Herbarium, 2013, Regional Ecosystem Description Database (REDD), Version 6.1, Februrary, 2013, Department of Science, Innovation, Information Technology and the Arts, Brisbane.

Simon, B.K., 1993, Studies in Australian grasses, 7. Four new species of Sporobolus R.Br. (Poaceae, Chloridoideae, Sporoboleae) from Australia. Austrobaileya 4(1): 61.

Van Dyck, S. and Strahan, R. (eds), 2008, The Mammals of Australia, New Holland Publishers Australia Pty Ltd, Sydney.

Williams, A.F., and Holmes, J.W, 1978, ‘A novel method of estimating the discharge of water from the Mound Springs of the Great Artesian Basin, central Australia’. Journal of Hydrology. Vol. 38. pp 263–272.

Wilson, S, 2005, A Field Guide to the Reptiles of Queensland, New Holland Publishers Australia Pty Ltd, Sydney.

Appendices


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Appendix A – Flora species lists


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Family	Species	Status	Habitat Type
Aizoaceae	*Trianthema* sp. (Coorabulka R.W. Purdie 1404)^	LC	D: MxdSe
Apiaceae	*Eryngium fontanum*^	E, **E**	D: Bare, SpG, MxdSe
	Eryngium plantagineum^	LC	M: SpMiG
Arecaceae	*Livistona lanuginosa*^	V, **V**	D: Bare
Asteraceae	*Acmella grandiflora* var. *brachyglossa*	LC	D: SpG
	Pluchea rubelliflora^	LC	D: Bare
	Streptoglossa sp.^^	LC	D: Bare; M: CoW
Chenopodiaceae	*Chenopodium auricomum*	LC	M: Bare
	Sclerolaena tricuspis^	LC	D: Bare, CoW
Cyperaceae	*Baumea rubiginosa*^	LC	M: MxdSe, G
	Cyperus dactylotes	LC	M: MxdSe
	Cyperus flavidus	LC	D: MxdSe
	Cyperus rotundus	*	M: SpMiG
	Cyperus sanguinolentus	LC	D: MxdSe; M: MxdSe
	Eleocharis equisetina	LC	D: MxdSe
	Eleocharis plana	LC	D: CoW
	Fimbristylis dichotoma^	LC	D: SpG, MxdSe; M: MxdSe
	Schoenus falcatus^	LC	M: MxdSe
Droseraceae	*Drosera indica*^	LC	D: SpG
Juncaceae	*Juncus aridicola*^	LC	D: CoW
	Juncus continuus	LC	D: CoW; M: MxdSe
	Juncus polyanthemus^	LC	D: CoW
	Juncus usitatus^	LC	D: CoW
Poaceae	*Chloris* sp. (Edgbaston R.J. Fensham 5694)^	LC	D: Bare, CoW
	Cenchrus purpurascens^	LC	D: SpG
	Chrysopogon fallax^	LC	M: CoW
	Diplachne fusca var. *fusca*	LC	D: Bare, MxdSe, SpG
	Eragrostis elongata	LC	D: Bare, SpG; M: MxdSe
	Eragrostis parviflora^	LC	M: CoW
	Eragrostis sororia^	LC	M: MxdSe
	Eragrostis speciosa	LC	D: CoW, RRBoxW

Family	Species	Status	Habitat Type
	Isachne globosa	LC	D: MxdSe, SpG
	Panicum larcomianum^	LC	M: CoW
	Paspalidium jubiflorum	LC	M: CoW
	*Paspalum dilatum**	LC	M: SpMiG
	Phragmites australis	LC	D; SpG; M: G
	Sporobolus australasicus	LC	D: Bare; M: Bare
	Sporobolus coromandelianus	LC	D: Bare
	Sporobolus mitchellii^	LC	M: Bare, G
	Sporobolus pamalae	**E**	D: SpG, MxdSe
	Sporobolus partimpatens	NT	D: Bare
Thelypteridaceae	*Cyclosorus interruptus*^	LC	M: MxdSe
Typhaceae	*Typha domingensis*	LC	D: SpG/MxdSe; M: G, MxdSe

Status symbols
* = exotic - (2) refers to a declared weed listing if relevant; LC = least concern (NC Act); NT = near threatened (NC Act); V = vulnerable; E = endangered; **Bold** denounces EPBC Act listing
# = unnamed species known to the Queensland Herbarium; ^^ unnamed specimen unmatched to a sample – could be a new species, further investigation required by Queensland Herbarium ^ = identifications confirmed by the Queensland Herbarium
Location
D = Doongmabulla spring complex; M = Mellaluka spring complex
Habitat type
SpG = *Sporobolus pamelae* grassland; G = *Phragmites australis* grassland; SpMiG = *Sporobolus mitchellii* grassland; MxdSe = mixed sedgeland; Bare = bare flats; CoW = coolabah/river red gum woodland; RRBoxW = Reid River box woodland; PeBoxW = peppermint box woodland.

Appendix B – Predicted fish species lists


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Predicted fish species lists

Fish can be broadly categorised by their patterns of dispersal and migration, according to the following terms:

- Catadromous: species that may spend much of their lives in freshwater before migrating as adults to the sea or brackish/estuarine areas to spawn
- Amphidromous: species that migrate between freshwater and the sea at some stage in their life cycle but not for the purposes of reproduction
- Marine vagrant/facultative freshwater: marine or estuarine breeding species that are not dependent on access to freshwater though may spend limited to substantial time in freshwater, usually lower reaches
- Potadromous: species which undertake breeding or dispersal migrations wholly within freshwater
- Sedentary: species that do not actively or directionally migrate, which can fulfil their entire life cycle within a single wetland, pool or river reach.

The fish species that are predicted to occur within or adjacent to the Doongmabulla and Mellaluka Springs complex are listed in Table A-1. Of the species predicted to occur at the spring complexes a maximum of eight fish species may occur at the Mellaluka wetlands (listed in Table A-2).

Table A-1 Biological and ecological characteristics of fish species predicted to occur within or adjacent to the Doongmabulla and Mellaluka Spring complexes

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Atherinidae	Fly-specked hardyhead* (Craterocephalus stercusmuscarum)	Known to occur throughout the Burdekin Catchment, however the species is less common in turbid environments. Highly turbid waters were observed in the Carmichael River. Species is abundant in streams that are periodically disconnected during low flow which is characteristic of Cabbage Tree Creek.	Occurs in a variety of habitats including flood plains, billabongs, brackish estuaries and impoundments. Prefers low flow environments which contain macrophyte beds and gravel substrates. Aquatic root masses may be important for spawning.	Potamodromous – Undertakes local dispersal and colonisation movements. Entire life-cycle (including spawning) occurs in freshwater.	Increasing water temperature and elevated flows are likely to stimulate movement. This species can tolerate temperatures in excess of 30°C. Has been collected over a fairly large range of physicochemical conditions.
Chandidae	Agassiz's glassfish* (Ambassis agassizii)	Recorded in the Study Area during previous field survey. Found in Cabbage Tree Creek and Swamp Tank. Known to occur throughout the Burdekin Catchment and is relatively widespread in eastern Australian coastal and inland drainages.	Well-vegetated areas in rivers, creeks, swamps and ponds; generally in areas of little or no flow. Macrophytes and submerged marginal vegetation preferred for spawning. May be found in all freshwater habitats in the investigation corridor.	Potamodromous - Larger fish move upstream during late autumn and spring – possibly in response to increased flows. A freshwater species that does not require access to estuarine or marine environment at any stage of life cycle.	Tolerant to a wide range of physicochemical conditions (temperature, dissolved oxygen, pH and salinity). Increases in water temperature and elevated flows are believed to be cues for movement.
Clupeidae	Bony bream* (Nematalosa erebi)	Known to occur throughout the Burdekin Catchment. Widespread species throughout Australia and found in most major basins of Queensland.	A wide array of habitats, including salt lakes, rivers, billabongs, impoundments and streams. Requires well-oxygenated waters. Shallow, still habitats required for spawning.	Potamodromous – Adults and juveniles move upstream for dispersal. A freshwater species that does not require access to estuarine or marine environment at any stage of life cycle.	Is tolerant of a range of environmental conditions including high turbidity. However, is highly sensitive to reductions in dissolved oxygen.

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Eleotridae	Western carp gudgeon* (Hypseleotris klunzingeri)	Known to occur throughout the Burdekin Catchment and in coastal drainages south to central New South Wales.	Inhabits aquatic vegetation in slow-flowing parts of rivers, streams, as well as still water bodies such as lakes and impoundments. Aquatic macrophytes, submerged marginal vegetation and woody debris may be important for oviposition.	Possibly potamodromous – Move upstream during the wet season.	Tolerant of a wide range of physicochemical conditions. Typically a hardy species.
Eleotridae	Midgley's carp gudgeon* (Hypseleotris species[1])	Recorded in the Study Area during previous field survey. Found in Cabbage Tree Creek and Swamp Tank. Known to occur throughout the Burdekin Catchment and is found in most coastal drainages of eastern Australia.	Particularly common in wetlands and swamps. Found in a variety of habitats, including coastal streams, rivers, floodplains and impoundments. It is a benthic species that is often in direct contact with the substrate. Hard surfaces near the substrate are preferred for oviposition.	Potamodromous – Undertakes local dispersal and colonisation movements. Spawning peaks between September and January.	Regarded as a hardy species that can tolerate poor water quality. The species has been collected in heavily degraded habitats. Present in inland desert drainages suggesting a high temperature. Also tolerant of highly turbid environments. Increased water temperature and day length are suspected as cues for movement.
Eleotridae	Purple-spotted gudgeon* (Mogurnda adspersa)	Recorded in the Study Area during previous field survey. Found in Cabbage Tree Creek. Widely distributed throughout the Burdekin Catchment and occurs in most coastal drainages of eastern Australia from Cape York Peninsula to northern New South Wales.	Avoids areas of high water flow. Inhibits areas aquatic vegetation in slow-flowing parts of rivers and streams, often with rocky substrate. Also noted in still water bodies including billabongs. The species is highly dependent on bank-side structure. Aquatic macrophytes, rocks and woody debris required for oviposition.	Sedentary – Undertakes small-scale movements, but is not considered potamodromous. Possibly able to climb hard, wet surfaces around waterfalls.	Tolerant of a wide range of physicochemical conditions, but prefers lower turbidity.

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Eleotridae	Sleepy cod* (Oxyeleotris lineolata)	Recorded in the Study Area during previous field survey. Found in the Carmichael River. Occurs widely in northern Australia including easterly flowing rivers of Queensland. Species has been translocated above Burdekin Falls and now widely distributed in the upper catchment.	Slow-flowing water amongst submerged structure (vegetation, timber) in rivers, creeks, floodplains, lagoons and billabongs. Large woody debris is a key requirement for spawning and general cover.	Sedentary – A relatively sedentary species that does not undergo any specific migration or dispersal events.	Tolerant of turbid conditions. Collected in muddy lagoons with mud substrate. Species is not a powerful swimmer and is considered to be a still/slow flow species. Tolerant of hypoxia in still pools, although eggs are sensitive to oxygen depletion Wide thermal tolerance (15°C to 38°C). Not tolerant of saline conditions or pH values that deviate widely from neutral.
Eleotridae	Flathead gudgeon (Philypnodon grandiceps)	Recorded in the upper Burdekin River though not detected during surveys. Occurs in coastal catchments from central Queensland to south-eastern Australia.	Small coastal streams, rivers and floodplain habitats. Also found in saline lakes and coastal wetlands. Generally found in low elevations. Commonly found in riffles. Prefers coarse substrates with macrophytes, roots, undercuts, leaf litter.	Amphidromous – A predominantly freshwater species where access to estuarine or marine environments is not an essential component of the life history. However, reported to migrate to higher salinities to kill freshwater ectoparasites.	Tolerates low dissolved oxygen, mild acidity and higher salinity. Prefers lower turbidity, but is thought to tolerate higher levels. Sensitive to habitat degradation.
Melanotaeniidae	Eastern rainbowfish* (Melanotaenia splendida splendida)	Recorded in the Study Area during previous field survey. Found in Cabbage Tree Creek. Known to occur throughout the Burdekin Catchment and the east coast of Queensland.	A habitat generalist that occurs in a wide array of still to slow-flowing freshwater habitats. Includes creeks, swamps, wetlands, rivers and impoundments. Aquatic vegetation and root masses preferred for oviposition.	Potamodromous – Rising flows and increasing water temperature are suspected as cues for movement.	M. s. splendida tolerates a large range of water quality conditions. The species can tolerate moderate disturbance such as reductions in riparian canopy. Will not survive abrupt changes in salinity. Rising flows cues for movement.

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Percichthyidae	Golden perch2 (Macquaria ambigua)	Deliberately and accidentally translocated into the Burdekin Catchment and has been widely translocated into eastern Australian rivers.	Inhabits rivers, creeks, billabongs and lakes. Favours deeper, slow-flowing, turbid habitats with an abundance of in-stream debris and shade.	Potamodromous – Movement recorded in the Fitzroy River (through the Fitzroy Barrage) during spring and summer months. Migration seems to be in association with increased hydrological connectivity.	Tolerant of a wide range of temperatures and low oxygen levels. Can move between freshwater and saline environments. Tolerant of high turbidity levels. Spawning and recruitment triggered by increased flows and water temperatures above 23° C.
Plotosidae	Black catfish (Neosilurus ater)	Widespread and abundant throughout the Burdekin Catchment, occurring across northern Australia.	A benthic species that prefers still/slow flowing waters in streams and rivers. Also occurs in wetlands, pools, and slow-flowing tributaries and side-channels of rivers. Benthic species in close association with substrate. Spawning occurs in riffles.	Potamodromous – Migrations upstream thought to coincide with spawning at the outset of the wet season (January to February). Downstream migration of adults and juveniles post-spawning poorly understood.	Prefers higher temperatures of between 21° C and 34° C. Tolerates a wide range in dissolved oxygen, pH and turbidity, but is sensitive to saline conditions. The species has barbels which allow the species to forage in elevated turbidity and low light conditions.
Plotosidae	Hyrtl's tandan* (Neosilurus hyrtlii)	Recorded in the Study Area during previous field survey. Found in the Carmichael River. Widely distributed across the Burdekin Catchment and also Australia.	A benthic species that occurs in most freshwater habitats above estuarine reaches. Tributary streams and gravel substrates may be important for spawning.	Potamodromous – Upstream migrations from dry season refugia thought to coincide with spawning.	The species has barbels which allow the species to forage in elevated turbidity and low light conditions. Prefers warm waters and is able to withstand hypoxic conditions.
Plotosidae	Soft-spined catfish[1] (Neosilurus mollespiculum)	Endemic to the Burdekin Catchment with a patchy distribution. Reported in the Belyando River sub-catchment.	A benthic species that occurs in most freshwater habitats above estuarine reaches. Tributary streams and gravel substrates may be important for spawning.	Specific movement patterns are not understood for this species.	Prefers higher temperatures of between 21°C and 34°C. Tolerates a wide range in dissolved oxygen, pH and turbidity, but is sensitive to saline conditions. The species has barbels which allow the species to forage in elevated turbidity and low light conditions.

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Plotosidae	Rendahl's catfish (Porochilus rendahli)	Widely distributed throughout the Burdekin Catchment and patchily distributed across northern Australia.	A benthic species inhabiting river channels and tributaries generally containing muddy substrate.	Patterns of movement and dispersal are unknown, although spawning migration to muddy lagoons has been recorded.	Like other species of catfish can tolerate highly turbid water. Well-developed tolerance to hypoxia. Found only in warmer waters.
Terapontidae	Barred grunter* (Amniataba percoides)	A widely distributed, common, generalist species that occurs across coastal (and some inland) drainages of mid to northern Australia.	Benthic species that occurs in still to fast-flowing water. Collected in areas with a dominant substrate of sand. Not as associated with bank-side structure as other terapontids.	Sedentary – Some upstream movement recorded within catchments, but not considered potamodromous.	Tolerant of highly variable temperature and pH. Recorded in freshwater only. Can tolerate turbidity, but prefers clearer waters. Preference for fast-flowing riffle/run habitat suggests need for well-oxygenated water.
Terapontidae	Spangled perch* (Leiopotherapon unicolor)	Recorded in the Study Area during previous field survey. Found in the Carmichael River. Widely distributed throughout the Burdekin Catchment and Australia.	A generalist species that occurs in most permanent and temporary freshwater habitats including billabongs, bores, impoundments, rivers and streams. Non-flowing, shallow habitats with soft substrate are preferred for spawning.	Potamodromous – Depending on locality moves upstream or downstream within the freshwater environment to spawn. Spawning migrations coincide with the wet season (October – April). This species may also undertake substantial movements away from dry season habitats as they recede. Very adept at colonising newly inundated habitat.	Highly tolerant of environmental variability. Can tolerant saline conditions but rarely encountered in estuarine areas. Despite being a visual predator can survive in turbid inland drainages.
Terapontidae	Small-headed grunter[1] (Scortum parviceps)	Endemic to the Burdekin Catchment though patchily distributed. Most common in the main channel of the Burdekin River and larger south-west tributaries.	Most common in riverine reaches. Thought to prefer deep (>1 m) habitats with a sand, fine gravel substrate and little or no flow.	Dispersal patterns are not understood for this species.	Unlikely to tolerate salinity. Prefers warmer temperatures. Found in clear and turbid waters.

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Toxotidae	Seven-spot archerfish (Toxotes chatareus)	Widely distributed in the Burdekin River and also across northern Australia. Unlikely to occur in the Study Area due to unsuitable and degraded riparian vegetation.	Inhabits large low gradient rivers. Not believed to frequent fast- flowing streams. Heavily reliant on intact riparian zones. Waterways associated with degraded riparian systems contain very few individuals. Juveniles observed in macrophyte beds.	Sedentary – Considered to be sedentary, although some evidence of passive dispersal of juvenile individuals following large flows. Upstream migrations were performed soon after.	Susceptible to poor water quality. Tolerant of higher salinities. Can survive in turbid waters.

* - Species recorded during field surveys
[1] endemic species; [2] translocated species
Habitat and distribution information sourced from Allen et al. (2002), Pusey et al. (2004) and Carter and Tait (2008).

Table A-2 Biological and ecological characteristics of fish species predicted to occur within the Mellaluka wetland

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Chandidae	Agassiz's glassfish* (Ambassis agassizii)	Recorded in the Study Area during previous field survey. Found in Cabbage Tree Creek and Swamp Tank. Known to occur throughout the Burdekin Catchment and is relatively widespread in eastern Australian coastal and inland drainages.	Well-vegetated areas in rivers, creeks, swamps and ponds; generally in areas of little or no flow. Macrophytes and submerged marginal vegetation preferred for spawning. May be found in all freshwater habitats in the investigation corridor.	Potamodromous - Larger fish move upstream during late autumn and spring – possibly in response to increased flows. A freshwater species that does not require access to estuarine or marine environment at any stage of life cycle.	Tolerant to a wide range of physicochemical conditions (temperature, dissolved oxygen, pH and salinity). Increases in water temperature and elevated flows are believed to be cues for movement.
Eleotridae	Western carp gudgeon* (Hypseleotris klunzingeri)	Known to occur throughout the Burdekin Catchment and in coastal drainages south to central New South Wales.	Inhabits aquatic vegetation in slow-flowing parts of rivers, streams, as well as still water bodies such as lakes and impoundments. Aquatic macrophytes, submerged marginal vegetation and woody debris may be important for oviposition.	Possibly potamodromous – Move upstream during the wet season.	Tolerant of a wide range of physicochemical conditions. Typically a hardy species.
Eleotridae	Midgley's carp gudgeon* (Hypseleotris species[1])	Recorded in the Study Area during previous field survey. Found in Cabbage Tree Creek and Swamp Tank. Known to occur throughout the Burdekin Catchment and is found in most coastal drainages of eastern Australia.	Particularly common in wetlands and swamps. Found in a variety of habitats, including coastal streams, rivers, floodplains and impoundments. It is a benthic species that is often in direct contact with the substrate. Hard surfaces near the substrate are preferred for ovi-position.	Potamodromous – Undertakes local dispersal and colonisation movements. Spawning peaks between September and January.	Regarded as a hardy species that can tolerate poor water quality. The species has been collected in heavily degraded habitats. Present in inland desert drainages suggesting a high temperature. Also tolerant of highly turbid environments. Increased water temperature and day length are suspected as cues for movement.

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Eleotridae	Purple-spotted gudgeon* (Mogurnda adspersa)	Recorded in the Study Area during previous field survey. Found in Cabbage Tree Creek. Widely distributed throughout the Burdekin Catchment and occurs in most coastal drainages of eastern Australia from Cape York Peninsula to northern New South Wales.	Avoids areas of high water flow. Inhibits areas aquatic vegetation in slow-flowing parts of rivers and streams, often with rocky substrate. Also noted in still water bodies including billabongs. The species is highly dependent on bank-side structure. Aquatic macrophytes, rocks and woody debris required for oviposition.	Sedentary – Undertakes small-scale movements, but is not considered potamodromous. Possibly able to climb hard, wet surfaces around waterfalls.	Tolerant of a wide range of physicochemical conditions, but prefers lower turbidity.
Eleotridae	Sleepy cod* (Oxyeleotris lineolata)	Recorded in the Study Area during previous field survey. Found in the Carmichael River. Occurs widely in northern Australia including easterly flowing rivers of Queensland. Species has been translocated above Burdekin Falls and now widely distributed in the upper catchment.	Slow-flowing water amongst submerged structure (vegetation, timber) in rivers, creeks, floodplains, lagoons and billabongs. Large woody debris is a key requirement for spawning and general cover.	Sedentary – A relatively sedentary species that does not undergo any specific migration or dispersal events.	Tolerant of turbid conditions. Collected in muddy lagoons with mud substrate. Species is not a powerful swimmer and is considered to be a still/slow flow species. Tolerant of hypoxia in still pools, although eggs are sensitive to oxygen depletion Wide thermal tolerance (15°C to 38°C). Not tolerant of saline conditions or pH values that deviate widely from neutral.
Melanotaeniidae	Eastern rainbowfish* (Melanotaenia splendida splendida)	Recorded in the Study Area during previous field survey. Found in Cabbage Tree Creek. Known to occur throughout the Burdekin Catchment and the east coast of Queensland.	A habitat generalist that occurs in a wide array of still to slow-flowing freshwater habitats. Includes creeks, swamps, wetlands, rivers and impoundments. Aquatic vegetation and root masses preferred for ovi-position.	Potamodromous – Rising flows and increasing water temperature are suspected as cues for movement.	M. s. splendida tolerates a large range of water quality conditions. The species can tolerate moderate disturbance such as reductions in riparian canopy. Will not survive abrupt changes in salinity. Rising flows cues for movement.

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Plotosidae	Hyrtl's tandan* (Neosilurus hyrtlii)	Recorded in the Study Area during previous field survey. Found in the Carmichael River. Widely distributed across the Burdekin Catchment and also Australia.	A benthic species that occurs in most freshwater habitats above estuarine reaches. Tributary streams and gravel substrates may be important for spawning.	Potamodromous – Upstream migrations from dry season refugia thought to coincide with spawning.	The species has barbels which allow the species to forage in elevated turbidity and low light conditions. Prefers warm waters and is able to withstand hypoxic conditions.
Terapontidae	Spangled perch* (Leiopotherapon unicolor)	Recorded in the Study Area during previous field survey. Found in the Carmichael River. Widely distributed throughout the Burdekin Catchment and Australia.	A generalist species that occurs in most permanent and temporary freshwater habitats including billabongs, bores, impoundments, rivers and streams. Non-flowing, shallow habitats with soft substrate are preferred for spawning.	Potamodromous – Depending on locality moves upstream or downstream within the freshwater environment to spawn. Spawning migrations coincide with the wet season (October – April). This species may also undertake substantial movements away from dry season habitats as they recede. Very adept at colonising newly inundated habitat.	Highly tolerant of environmental variability. Can tolerant saline conditions but rarely encountered in estuarine areas. Despite being a visual predator can survive in turbid inland drainages.

* Species recorded during field surveys

[1] endemic species; [2] translocated species

Habitat and distribution information sourced from Allen et al. (2002), Pusey et al. (2004) and Carter and Tait (2008).

GHD

145 Ann Street Brisbane QLD 4000
GPO Box 668 Brisbane QLD 4001
T: (07) 3316 3000 F: (07) 3316 3333 E: bnemail@ghd.com

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