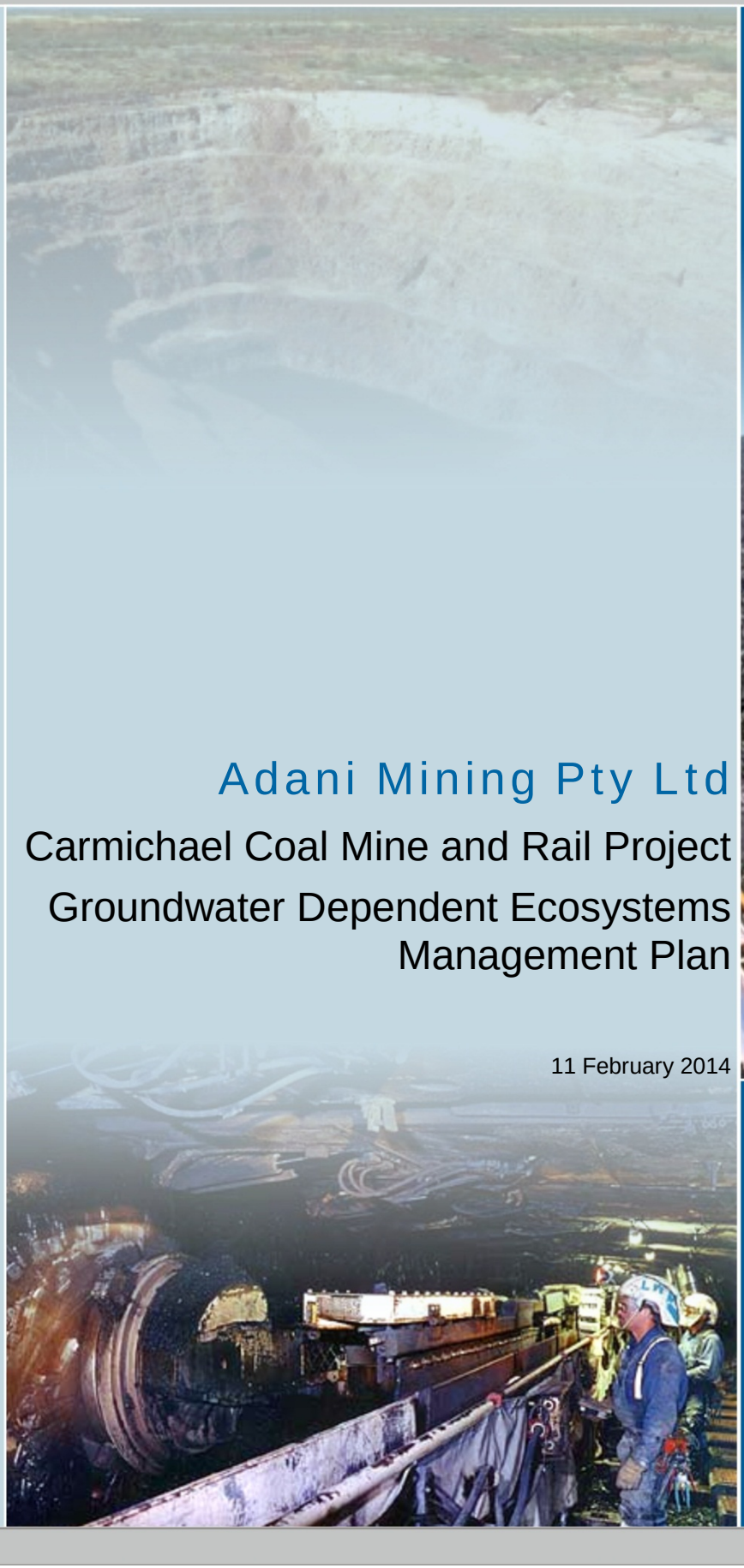
Adani Mining Pty Ltd



Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Groundwater Dependent Ecosystems Management Plan

11 February 2014

GHD

This Carmichael Coal Mine and Rail Project: Groundwater Water Dependent Ecosystems Management Plan (the Report) has been prepared by GHD Pty Ltd (GHD) on behalf of and for Adani Mining Pty Ltd (Adani) in accordance with an agreement between GHD and Adani.

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1. Introduction

1.1 Project description

Adani Mining Pty Ltd (Adani) is proposing to develop a 60 million tonne (product) per annum (Mtpa) thermal coal Mine in the north Galilee Basin approximately 160 kilometres (km) northwest of the town of Clermont, Central Queensland. All coal will be railed via a privately owned rail line connecting to the existing Goonyella rail system south of Moranbah, and shipped through coal terminal facilities at the Port of Abbot Point and/or the Port of Hay Point. The Carmichael Coal Mine and Rail Project will have an operating life of approximately 60 years. Key components of the Project include:

- 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, an airport, an industrial area and water supply infrastructure.
- The Project (Rail): a greenfield rail line connecting the 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 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 Purpose

This groundwater dependent ecosystem (GDE) management plan has been prepared to support an environmental impact assessment process for the Carmichael Coal Mine and Rail Project under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and Queensland *State Development and Public Works Organisation Act 1974* (SDPWO Act).

The GDE management plan (Plan) identifies and describes actions necessary to prevent or minimise, to the greatest extent possible, impacts to the following GDEs associated with the Project (Mine):

- Doongmabulla Springs complex
- Mellaluka Springs complex
- Ecosystems associated with the Carmichael River, with particular focus on waxy cabbage palm populations as well as characteristic eucalypts.

The Doongmabulla Springs complex and waxy cabbage palms (*Livistona lanuginosa*) are considered matters of national environmental significance (MNES) under the EPBC Act. The Doongmabulla Springs complex is recognised as the community of native species dependent on natural discharge of groundwater from the great artesian basin (GAB) (abbreviated to 'GAB

discharge spring wetlands') threatened ecological community (TEC) under the EPBC Act. The Doongmabulla Springs complex also contains a comparatively high number of flora and fauna species endemic to GAB spring wetlands, some of which are listed as vulnerable or endangered species under the *Nature Conservation Act 1992* (NC Act) and the EPBC Act. Waxy cabbage palms are listed as vulnerable under the NC Act and the EPBC Act, and are present at the Doongmabulla Springs complex and along the Carmichael River.

Both the Doongmabulla and Mellaluka Springs complex are important water sources and have bores installed which provide water for domestic use and livestock.

The Plan reflects the findings and recommendations of studies undertaken for the Environmental Impact Statement (EIS), Supplementary EIS (SEIS) and advice provided by Commonwealth Department of the Environment (DotE), Coordinator General (CG) and the Queensland Department of Environment and Heritage Protection (DEHP), and provides a framework for management of identified impacts and implementation of recommendations.

The Plan covers:

- Pre-construction requirements
- Construction phase activities
- Operation activities
- Post operation.

1.3 Objective

The Plan will be further developed as detailed design of the Project continues and to achieve compliance with conditions of approvals obtained. The Plan is designed to:

- Detail actions and procedures to be followed during the pre-construction, construction and operational phases of the Project in order to mitigate adverse impacts on GDEs.
- Facilitate compliance with relevant approval conditions specified by the Coordinator-General and the DotE.
- Facilitate compliance with commitments under the EIS and SEIS.

Environmental management of the GDEs will operate within an Environmental Management System (EMS) framework, in accordance with the ISO 14001: 2004 EMS standard.

1.4 Project timeframe

A combination of both open cut and underground mining methods are proposed to extract coal over a 60 year period (Figure 1). Adani has investigated potential sources of coal that meet its specific resource quantum and delivery timeframe requirements and has not identified any viable alternatives. Adani proposes to construct, operate and decommission the Project (Mine) as summarised in Table 1.

Table 1 Project (Mine) development timeframe

Stage	Year	Project development
1 2014-2020	2014	Undertake redevelopment of Moray Carmichael Road from Gregory Development Road to Mine site Commence construction of power, water supply and other external services Commence construction of power, construction water supply and other external services Construction of flood harvesting infrastructure Commence construction of open cut facilities including Pits B/C and D/E MIA's, Site Fencing, Water Storage Dams and Temporary Roads.
	2015	Commence B ,D & E Pit box-cut Complete Pit B Diversion Drains Construct Carmichael River Northern Flood Protection Levies Construct Additional Stages of Flood Harvesting Facilities
	2016	Commence C Pit box cut Produce first coal from open cut B, D & E Pits Complete open cut facilities for Pit B/C and D/E MIA, ROM and Overland Conveyors Complete B, D & E Pits HV Roads and HV Power Distribution Complete Coal Handling and Processing Plant Modules 1 & 2 and Tailings Cell Complete Product Handling and Train Load-out Facility
	2017	First Coal Production from open cut C Pit Construct Underground Mine 1 MIA facilities Complete C Pit water diversion drain and HV Roads
	2018	Commence development and longwall operations of underground mine UG 1 Complete Coal Handling and Processing Plant Modules 3 & 4
	2019	Complete development operations in UG1 and commence longwall operations Construct coal processing plant (CPP) Bypass systems
2 2021-2031	2021	Construct Carmichael River southern flood protection levee Construct Carmichael River Crossing Commence development of underground mine UG 5 Dragline 1 commences in D Pit Commence G Pit Commence minor rehabilitation of out of pit spoil emplacement (OOPSE)
	2022	Commence development of underground mines UG 4 and 5 Commence open cut facilities for Pit F/G and UG 4, MIA, ROM and Overland Conveyors
	2023	Complete open cut facilities for Pit F / G, Water Management
	2026	Commence F Pit Commence longwall operation of underground mine UG 5 Complete UG 5 MIA
	2027	Commence longwall operation of underground mine UG 4 Complete UG 4 overland conveyors and facilities
	2028	Commence development of underground mine UG 3 Complete expansion of Pit D/E MIA for UG 3
	2029	Rehabilitation works on Pits B, C, D, E OOPSE

Stage	Year	Project development
	2030	Complete UG 5 Infrastructure Complete UG 1 longwall Operations
3 2032-2071	2035	Commence development of underground mine UG 2 Commence UG 2 MIA
	2036	Commence longwall operation of underground mine UG 3 Complete UG 3 Infrastructure
	2040	Complete UG 4 longwall Operations
	2045	Complete UG 5 longwall Operations
	2051	Complete UG 3 longwall Operations Complete mining in C Pit commence final rehabilitation.
	2053	Complete mining in E Pit commence final rehabilitation
	2059	Complete UG 2 longwall Operations
	2061	Complete mining in D Pit commence final rehabilitation
	2068	Complete mining in G Pit commence final rehabilitation
	2069	Complete mining in F Pit commence final rehabilitation
	2070	Decommission Southern ROMs
	2071	Complete mining in B Pit commence final rehabilitation. Decommission Southern ROMs Commence mine site rehabilitation
	2072	Rehabilitate mine site

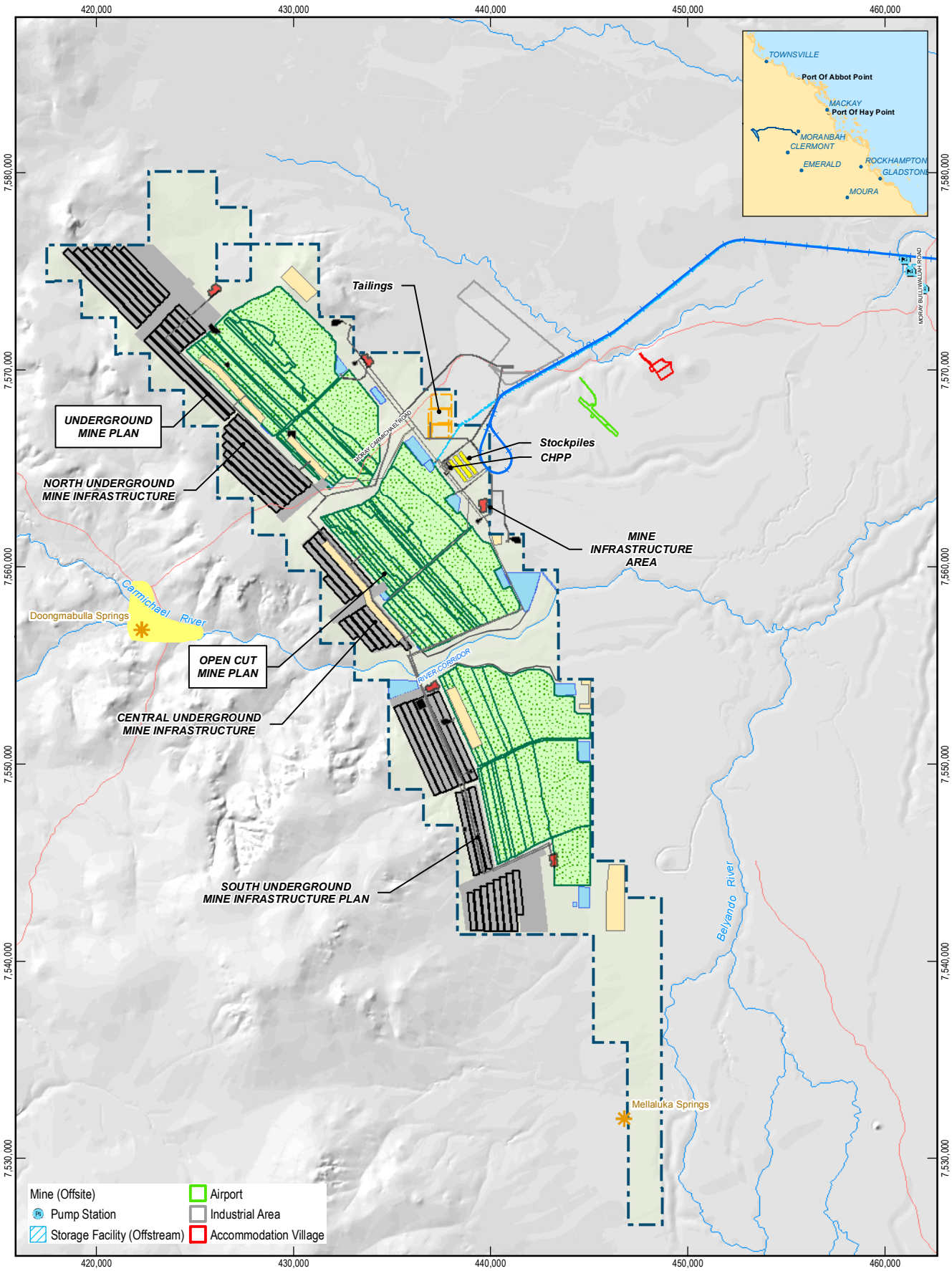
1.5 Links to other management plans

A number of other management plan developed or to be developed for the Project (Mine) are also relevant to the management of GDEs and should be read in parallel to this plan, they include:

- Weed and pest management plan
- Water (surface and groundwater) management plan
- Sediment and erosion control plan
- Receiving environment management plan
- Closure and rehabilitation strategy
- Offset management plan

Additional plans of relevance to this GDE plan:

- Fire management plan
- Final void management plan



LEGEND

- Local Road
- River / Watercourse
- Overland Conveyors
- Rail (West)
- Mine (Onsite)
- Spring Locations
- Directory of Important Wetlands
- Open Cut Blocks
- Water Management Dams
- Mine Infrastructure Area
- Mine Infrastructure
- Stockpiles
- Tailings Cell
- Top Soil Storage

1:275,000 (at A4)

0 2 4 6 8 10

Kilometres

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

N

Adani Mining Pty Ltd
Groundwater Dependant Ecosystems Management Plan

Job Number 41-26422
Revision A
Date 18-12-2013

Project Mine Area

Figure 1

G:\41\26422\GIS\Maps\MXD\0900_GDE_Management_Plan\41_26422_0900_rev_a.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: GA: Road, River / Watercourse (2007); DME:EPC1690 (2010), EPC1080 (2011); Adani: Alignment, Offsite(2013), Mine Layout / Infrastructure (2013); GHD: Spring Locations (2013); DNRM: DOI Wetlands (2005). Created by: MS

1.6 Structure

The report is structured as follows:

- Section 2– Legislative context
- Section 3– Performance indicators
- Section 4 – Roles and responsibilities
- Section 5 – Groundwater dependent ecosystems overview
- Section 6 – Doongmabulla Springs complex subplan
- Section 7 – Mellaluka Springs complex subplan
- Section 8 – Carmichael River subplan
- Section 9 – Waxy cabbage palms subplan
- Section 10 – Reporting and auditing
- Section 11 – Adaptive management framework
- Section 12 – Training
- Section 13 – Review and consultation

2. Legislative context

2.1 Status

The Doongmabulla Springs complex constitutes the GAB discharge spring wetlands TEC that is listed as endangered under the EPBC Act. The Doongmabulla Springs complex also supports flora species that are listed as vulnerable or endangered under the NC Act and the EPBC Act.

- Salt pipewort (*Eriocaulon carsonii* subsp. *orientale*) – listed as endangered under both the Queensland NC Act and the Commonwealth EPBC Act
- Blue devil (*Eryngium fontanum*) – listed as endangered under the NC Act and the EPBC Act
- *Hydrocotyle dipleura* – listed as vulnerable under the NC Act
- *Myriophyllum artesium* – listed as endangered under the NC Act
- *Sporobolus pamelae* – listed as endangered under the NC Act
- *Sporobolus partimpatens* – listed as near threatened under the NC Act.

The Mellaluka Springs are not associated with the GAB and do not represent the GAB discharge spring wetlands TEC.

The Carmichael River provides habitat for the waxy cabbage palm which are listed as vulnerable under the NC Act and the EPBC Act.

2.2 Commonwealth legislation

The EPBC Act is the Commonwealth's principal piece of environmental protection legislation. It provides a national framework for the protection of the Australian environment and its unique biodiversity. Specifically, the EPBC Act aims to protect the environment by reducing significant impacts to MNES.

The Federal Minister for the Environment determined the Project to be a 'controlled action' under the EPBC Act on 6 January 2011, due to the potential for the Project to impact upon MNES. Accordingly, the Project has been carefully assessed in terms of its potential impacts on the determined controlled provisions.

The Project is required to avoid, manage and mitigate impacts as far as practical. However, if residual impacts are predicted, environmental offsets (direct or indirect) are a mechanism of last resort to compensate for adverse significant impacts of developments on MNES protected by the EPBC Act.

2.3 Queensland legislation

2.3.1 Nature Conservation Act 1992

The NC Act provides for the conservation of nature through protection of all native plants and animals in Queensland. Protection is provided under the NC Act through conservation of land as protected areas and wildlife protection outside of protected areas. Actions impacting on protected native flora and fauna are regulated under the NC Act. Permits for disturbance to native flora and fauna can be administered under the NC Act. The Queensland *Nature Conservation (Wildlife) Regulation 2006* (NC Regulation) is subordinate to the NC Act and lists flora and fauna species

considered to be extinct in the wild, endangered, vulnerable, near threatened or special least concern in Queensland.

2.3.2 Vegetation Management Act 1999

The *Vegetation Management Act 1999* (VM Act) provides a framework for the regulation of woody, terrestrial native vegetation located outside of protected areas. The Act provides for the establishment and mapping of regional ecosystems (REs) that encompass vegetation community descriptions within a geological and bioregional context. Details on what clearing activities require assessment under the VM Act are provided by the *Sustainable Planning Regulation 2009* (SP Regulation).

2.3.3 Water Act 2000

The *Water Act 2000* (Water Act) and subordinate legislation (including the *Water Regulation 2002* and gazetted Water Resource Plans) provide for the sustainable management of water and other resources (i.e. quarry material and riverine vegetation) in Queensland.

2.4 National recovery plan

A national recovery plan has been prepared for GAB discharge spring wetlands (Fensham, Ponder and Fairfax, 2010). The overall objective of the recovery plan is to maintain or enhance groundwater supplies to GAB discharge spring wetlands, maintain or increase habitat area and health, and increase all populations of endemic organisms.

A recovery plan for waxy cabbage palms has not been prepared.

2.5 Lake Eyre Basin Springs Assessment project

The Lake Eyre Basin Springs Assessment (LEBSA) project is being jointly managed by the Queensland Department of Science, Information Technology, Innovation and the Arts (DSITIA) and the South Australian Department of Environment, Water and Natural Resources (DEWNR). The project will supply up to date scientific baseline data on spring vents and other groundwater dependent ecosystems and their function within the LEB, including GAB springs.

Key LEBSA deliverables for Queensland, which are relevant to the Doongmabulla and Mellaluka Spring complexes include:

- Improving the knowledge on spring vents and other groundwater dependent ecosystems and their function, and key landscape eco-hydrological processes for the Galilee and Cooper geological basins within the LEB.
- Production of pictorial conceptual models depicting the eco-hydrological processes associated with GDEs.
- Undertaking a basin-wide spring vent survey, including their location (such as source aquifer/s) and characteristics.
- Undertaking further targeted LEB surveys to verify attribution of GDEs.
- Identification of key knowledge gaps relating to the function of GDEs in the LEB and recommendations to address these in the future.

2.6 Significant impact guidelines

Specific policy statements that describe significant impact guidelines for the GAB discharge spring wetlands TEC or waxy cabbage palms have not yet been developed. However, DotE's *Significant Impact Guidelines version 1.1* provides general guidance for determining whether impacts to TECs and threatened species are significant.

With regards to the GAB discharge spring wetlands, DotE's *Significant Impact Guidelines version 1.1* states that an action is likely to have a significant impact on an endangered TEC if there is a real chance or possibility that it will:

- Reduce the extent of an ecological community
- Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines
- Adversely affect habitat critical to the survival of an ecological community
- Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns
- Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting
- Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to:
  - Assisting invasive species, that are harmful to the listed ecological community, to become established, or
  - Causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community, or
- Interfere with the recovery of an ecological community.

With regards to waxy cabbage palms, DotE's *Significant Impact Guidelines version 1.1* states that an action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

- Lead to a long-term decrease in the size of an important population of a species
- Reduce the area of occupancy of an important population
- Fragment an existing important population into two or more populations
- Adversely affect habitat critical to the survival of a species
- Disrupt the breeding cycle of an important population
- Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
- Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
- Introduce disease that may cause the species to decline, or
- Interfere substantially with the recovery of the species.

2.7 Environmental impact statement

Adani commenced an EIS process for the Carmichael Coal Mine and Rail Project in 2010. On 26 November 2010, the Queensland Office of the Coordinator General declared the Project a 'significant project' and the Project was referred to the (then) Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (referral No. 2010/5736). The Project was determined to be a controlled action on 6 January 2011 under section 75 and section 87 of the EPBC Act. The controlling provisions for the Project are:

- 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)
- Great Barrier Reef Marine Park (sections 24B & 24C)
- Protection of water resources (sections 24A & 24E).

The Queensland Government's EIS process has been accredited for 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 Coordinator-General in May 2011 (Queensland Government, 2011). The EIS process is managed under section 26(1) (a) of the SDPWO Act, which is administered by the 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 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 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 Port of Abbot Point over the 60 year (90 years in the EIS) Mine life. The Carmichael Rail will be operational for a period of 90 years, catering for third party operations as identified in the Carmichael Coal Mine and Rail EIS.

Submissions received on the EIS during the public exhibition period were addressed through a supplementary EIS (SEIS) which was submitted to the Coordinator General on 9 August 2013. The SEIS has been prepared in accordance with section 35 (2) of the SDPWO Act and the bilateral agreement between the Commonwealth of Australia and the State of Queensland. The SEIS provides revised and additional environmental studies undertaken to reflect the amendments made to the Project since the EIS publication and to address matters raised in submissions. It includes revised technical studies, impact assessment and management plans for a range of project issues.

The SEIS was released by the Coordinator-General for public, local, State and Federal government agency consultation in November/December 2013. A number of submissions were received relating to the management of GDEs. In particular, submissions from DotE, DEHP and NRM related to the preparation and implementation of a GDE management plan. The GDE management plan takes into account these submissions.

2.8 Offset requirements

An Environmental Offset Package for the Project has been developed by Ecofund Queensland on behalf of the Proponent (Ecofund, 2013). The package outlines the environmental offset requirements for the Project under both Queensland and Australian Government offset policies. The extent of offsets was based on information contained in the EIS and SEIS. The offset package included options for offset delivery and examples of properties that may be suitable to meet the identified offset requirements.

All offsets must be secured by a legally binding mechanism. The appropriate mechanism for each offset will be determined through negotiation with regulators, Adani and the landholder.

2.9 Approvals and permits

Approvals and permits relevant to GDEs are listed in Table 2 and Table 3.

Table 2 Approvals register

Legislation	Approval or permit	Trigger
EPBC Act	Approval to undertake a controlled action	Potentially significant impacts on matters of national environmental significance
NC Act	Permit to take protected plants	Clearing of native vegetation
Water Act	Licence to interfere with flow by impounding water	Required if impoundment of any watercourse, lake or spring is to occur. Confirm with NRM whether this might apply to subsidence
Water Act	Licence to interfere with the course of flow	Required for watercourse diversions. Confirm with NRM whether this might apply to subsidence
Water Act	Licence to take groundwater	Mine dewatering

Table 3 Other obligations register

Legislation	Obligation
EP Act	Notification of notifiable activities
LP Act	Management of Class 1 and 2 declared weeds
EP Act	Authorised officers under the EP Act must be allowed entry to the mine on request and must be given all reasonable assistance.

2.10 Approval conditions

This section will be completed upon receipt of relevant approvals and will contain the conditions relevant to GDEs.

2.11 Work permits

In accordance with CG-036 Work Permits, any non-routine activities that might adversely affect the environment must not be performed without a work permit. Non-routine works which have potential to cause environmental harm may include:

- Any ground disturbing activity
- Activities involving use of environmentally hazardous substances

- Activities in areas of native vegetation
- Activities in or immediately adjacent to streams and watercourses
- Activities within or adjacent to Category A or B environmentally sensitive areas.

The following matters will be covered as part of the process of issue of a work permit:

- Any legislative approval requirements and whether these approvals are in place
- Conditions of approvals or permits that might apply to the activity
- Whether there are any cultural heritage, flora or fauna monitoring requirements
- Measures to prevent environmental impacts, including:
  - Impacts on environmentally sensitive areas
  - Accidental clearing of vegetation
  - Erosion and sediment release
  - Accidental release of hazardous substances to land, water or air
  - Measures to prevent noise or dust emissions exceeding the environmental authority or other legislated requirements
- Any requirements in relation to incident response, such as spill kits and personal protective equipment (PPE).

3. Performance indicators

3.1 Objectives

The objectives of this Plan are as follows:

- To detail actions and procedures to be followed during the pre-construction, construction, operational and post operational phases of the Project (Mine) in order to mitigate adverse impacts on GDEs
- To facilitate compliance with relevant approval conditions specified by the Coordinator-General and the DotE
- To facilitate compliance with commitments under the EIS and SEIS.

3.2 Indicators

The *Mine Environmental Management Plan* (GHD, 2013a) identifies a number of performance outcomes. The outcomes relevant to the GDEs are:

- Impacts on groundwater dependent ecosystems do not cause unacceptable or unapproved losses of biodiversity values
- Environmental values relating to aquatic ecosystems, stock and domestic use and cultural values are maintained
- Discharge and overflow events are undertaken in accordance with the relevant conditions under an Environmental Authority issued by the Department of Environment Heritage and Protection (DEHP)
- Downstream habitats are not degraded by sediment deposition, scouring or water quality degradation
- Downstream flow changes remain within natural fluctuations
- No increase or spread of weeds beyond pre development conditions occur as a result of project activities
- No unapproved biosecurity management activities are undertaken
- Sediment releases from the mining activity do not cause degradation of aquatic ecosystem and water supply values downstream. Generally, this will be indicated by less than 10 percent increase in turbidity levels from upstream to downstream of activity areas.
- A stable and sustainable landform is created over subsided areas which maximises opportunities for the subsided areas to support native vegetation and fauna.

4. Roles and responsibilities

4.1 Overview

Adani Compliance Guidelines set out requirements for assigning roles and responsibilities in relation to environmental management. The preliminary roles and responsibilities for pre-construction, construction, operation and post operation phases are listed in Table 4. These will be revised once organisational structures for each phase of the project and mining activity are confirmed.

In accordance with the guideline:

- Position descriptions will contain responsibilities and accountabilities for environmental compliance and management.
- Performance against environmental compliance and management requirements will be part of the annual performance review and linked to remuneration and promotion of managers.

4.2 Expert Advisory Committee

An Expert Advisory Committee will be established to provide peer/technical expert input and reviews during implementation of this management plan. The Expert Advisory Committee will include representatives from the DEHP and DotE as well as technical specialists, Adani's Environment Manager and the construction/operation contractor's environment manager.

The Expert Advisory Committee will meet every six months to discuss the implementation and progress of monitoring and management actions, as well as any environmental incidents or corrective actions that have occurred.

In the event of an environmental incident involving GDEs or a non-compliance with the conditions of approval or this management plan, Adani's Environment Manager may engage the Expert Advisory Committee to assist in the development of appropriate preventative or corrective actions.

Table 4 Roles and responsibilities during pre-construction, construction and operation and post-operations

Role	Pre-construction	Construction	Operation	Post operation
CEO	Approve and endorse Environment and Sustainability Policy. Ensure that adequate resources are available to comply with the Environment and Sustainability Policy.	Approve and endorse Environment and Sustainability Policy. Ensure that adequate resources are available to comply with the Environment and Sustainability Policy. Demonstrate a visible and pro-active commitment to HSE issues as per Adani Guideline CG-128 Management Commitment.	Approve and endorse Environment and Sustainability Policy. Ensure that adequate resources are available to comply with the Environment and Sustainability Policy. Assign authorities and responsibilities for environmental compliance and performance. Demonstrate a visible and pro-active commitment to HSE issues as per Adani Guideline CG-128 Management Commitment.	Approve and endorse Environment and Sustainability Policy. Ensure that adequate resources are available to comply with the Environment and Sustainability Policy. Assign authorities and responsibilities for environmental compliance and performance. Demonstrate a visible and pro-active commitment to HSE issues as per Adani Guideline CG-128 Management Commitment.
Adani Senior Management	Ensure compliance with all legal requirements including requirements of EPBC approval, environmental authority and other approvals. Ensure that requirements of this Plan are incorporated into engineering and procurement processes, and that these processes do not conflict with environmental performance requirements. Ensure that adequate resources are available to meet all compliance requirements and implement the requirements of this Plan. Demonstrate a visible and pro-active commitment to environmental issues as per Adani Guideline CG-128 Management Commitment.	Ensure compliance with all legal requirements including requirements of EPBC approval, environmental authority and other approvals. Ensure that adequate resources are available within Adani and contractors to meet all compliance requirements and implement the requirements of this Plan. Monitor close-out of corrective actions. Review outcomes of incident investigations. Demonstrate a visible and pro-active commitment to environmental issues as per Adani Guideline CG-128 Management Commitment.	-	-

Role	Pre-construction	Construction	Operation	Post operation
Adani Contract Management and Procurement Team	Ensure that procurement and contracting strategies reflect environmental performance requirements and requirements of Adani Guidelines CG-022 Contractor's Management and CG-021. Procurement Ensure that specifications and contracts include performance requirements in relation to energy and water efficiency and other measures to reduce resource consumption and waste generation. Incorporate environmental performance requirements into contracts. Ensure that contractors hold necessary approvals and authorisations, particularly in relation to waste management services. Review environmental performance credentials of potential contractors. Demonstrate a visible and pro-active commitment to HSE issues as per Adani Guideline CG-128 Management Commitment.	Manage environmental performance requirements in contracts, including penalties in the event on non-compliance. Demonstrate a visible and pro-active commitment to HSE issues as per Adani Guideline CG-128 Management Commitment.	Ensure that specifications include performance requirements in relation to energy and water efficiency and other measures to reduce resource consumption and waste generation. Ensure that contractors hold necessary approvals and authorisations, particularly in relation to waste management services. Review environmental performance credentials of potential contractors. Demonstrate a visible and pro-active commitment to HSE issues as per Adani Guideline CG-128 Management Commitment. Meet requirements of Adani Guideline GE-021 Procurement in relation to purchasing.	Manage environmental performance requirements in contracts, including penalties in the event on non-compliance. Demonstrate a visible and pro-active commitment to HSE issues as per Adani Guideline CG-128 Management Commitment.
Environmental Manager and team	Provide advice to management, procurement and design teams in relation to environmental requirements. Conduct regular audits and checks of environmental performance. Manage technical studies and research activities relating to environmental assessment and management of the Project. Maintain and further develop the Plan.	Provide advice to Adani management teams and personnel in relation to environmental requirements. Integrate environmental management requirements into work procedures and practices. Conduct audits and checks of compliance and environmental performance of contractors. Monitor and report on compliance against all project approvals and	Provide advice to Adani managers and personnel in relation to environmental requirements. Assist and support managers, supervisors and workers in implementing the Plan and achieving environmental compliance. Conduct monitoring, auditing and reporting activities required in this Plan. Monitor and report on compliance	Provide advice to Adani managers and personnel in relation to the environmental requirements of this management plan and the closure and rehabilitation strategy. Assist and support managers, supervisors and workers in implementing this management plan and the closure and rehabilitation strategy and achieving environmental compliance.

Role	Pre-construction	Construction	Operation	Post operation
		commitments. Communicate environmental obligations and requirements to construction staff. Manage technical studies and research activities relating to environmental assessment and management of the Project. Raise corrective actions for any non-compliance with this Plan or in response to results of incident investigations. Conduct incident investigations Report to Adani on environmental performance including compliance, non-compliance and incidents and near misses with potential or actual environmental harm. Further develop the Plan.	against all project approvals and commitments. Communicate environmental obligations and requirements to construction and operational staff. Lead and assist with incident response and investigation where required to address environmental impacts of incidents. Conduct induction training and tool box talks on environmental topics. Compile monthly and quarterly environmental reports. Conduct audits and checks of compliance and environmental performance of contractors. Track changes in legislation, policy and other obligations and ensure these are incorporated into environmental compliance and management requirements and communicated to relevant managers and staff. Manage technical studies and research activities relating to environmental assessment and management of the Project. Review, update and further develop the Plan.	Conduct monitoring, auditing and reporting activities required in this management plan and the closure and rehabilitation strategy. Communicate environmental obligations and requirements to operational staff. Lead and assist with incident response and investigation where required to address environmental impacts or incidents. Compile monthly and quarterly environmental reports. Conduct audits and checks of compliance and environmental performance of contractors. Track changes in legislation, policy and other obligations and ensure these are incorporated into environmental compliance and management requirements and communicated to relevant managers and staff.
Stakeholder Manager	Manage external relations with landholders and other stakeholders. Coordinate investigation and response to complaints and incidents involving members of the public.	Manage external relations with landholders and other stakeholders. Coordinate investigation and response to complaints and incidents involving members of the public.	Manage external relations with landholders and other stakeholder. Coordinate investigation and response to complaints and incidents involving members of the public.	Manage external relations with landholders and other stakeholder. Coordinate investigation and response to complaints and incidents involving members of the public.

Role	Pre-construction	Construction	Operation	Post operation
Employees and contractors	Comply with all requirements of this Plan.	Comply with all requirements of this Plan.	Comply with all requirements of this Plan.	Comply with all requirements of this Plan.
Design Manager	Ensure that design requirements set out in this Plan and any other design requirements needed to meet conditions of approval are incorporated into design. Consider safety in design and minimisation of environmental impacts in design. Demonstrate a visible and pro-active commitment to HSE issues as per Adani Guideline CG-128 Management Commitment.	-	-	-
Design Leads	Develop design checklists to reflect design requirements set out in this Plan and maintain records of compliance with design requirements.	-	-	-
Construction Managers and supervisors	-	Implement all relevant requirements of this Plan. Integrate environmental management requirements into work procedures and practices. Provide initial responses to emergencies involving potential environmental impacts. Participate in incident investigations.	-	-
Contractor Environmental Managers and Officers	-	Assist and support managers, supervisors and workers in implementing the Plan and achieving environmental compliance. Conduct monitoring, auditing and reporting activities required in this Plan. Assist with incident response and	-	-

Role	Pre-construction	Construction	Operation	Post operation
		investigation where required to manage and address environmental impacts of incidents. Conduct induction training and tool box talks on environmental topics. Compile monthly and quarterly environmental reports.		
Mine General Manager		-	Implement Environment and Sustainability Policy. Ensure compliance with all legal requirements including requirements of EPBC approval, environmental authority and other approvals. Monitor actioning and close out of non-conformances. Ensure that adequate resources are available within Adani and contractors to meet all compliance requirements and implement the requirements of this Plan. Ensure that all personnel and contractors understand environmental authorities, responsibilities and requirements. Incorporate environmental performance and compliance requirements into job descriptions and performance reviews. Demonstrate a visible and pro-active commitment to HSE issues as per Adani Guideline CG-128 Management Commitment Reward outstanding performance in relation to environmental performance.	Implement Environment and Sustainability Policy. Ensure compliance with all legal requirements including requirements of EPBC approval, environmental authority and other approvals. Monitor actioning and close out of non-conformances. Ensure that adequate resources are available within Adani and contractors to meet all compliance requirements and implement the requirements of this Management Plan and the closure and rehabilitation strategy. Ensure that all personnel and contractors understand environmental authorities, responsibilities and requirements. Incorporate environmental performance and compliance requirements into job descriptions and performance reviews. Demonstrate a visible and pro-active commitment to HSE issues as per Adani Guideline CG-128 Management Commitment Reward outstanding performance in relation to environmental performance.

Role	Pre-construction	Construction	Operation	Post operation
Mine area managers	-	-	Ensure that requirements of this Plan are incorporated into all aspects of site operation and maintenance and are implemented. Integrate environmental management requirements with work procedures and practices. Raise corrective actions for any non-compliance with this Plan or in response to results of incident investigations Conduct incident investigations. Demonstrate a visible and pro-active commitment to HSE issues as per Adani Guideline CG-128 Management Commitment.	Ensure that requirements of this Management Plan are incorporated into all aspects of site operation and maintenance and are implemented. Integrate environmental management requirements with work procedures and practices. Raise corrective actions for any non-compliance with this Plan or in response to results of incident investigations Conduct incident investigations. Demonstrate a visible and pro-active commitment to HSE issues as per Adani Guideline CG-128 Management Commitment.
Mine supervisors	-	-	Comply and ensure compliance with all requirements of this Plan. Raise corrective actions for any non-compliance with this Plan or in response to results of incident investigations. Coordinate initial response to incidents with potential or actual environmental harm.	Comply and ensure compliance with all requirements of this Management Plan. Raise corrective actions for any non-compliance with this management plan or in response to results of incident investigations. Coordinate initial response to incidents with potential or actual environmental harm.

5. Groundwater dependent ecosystems overview

5.1 Groundwater dependent ecosystem characteristics

Ecosystems that rely on groundwater for some or all of their water requirements are classified as GDEs. Not all GDEs draw on groundwater directly and not all are solely reliant on groundwater. However, in many cases groundwater commonly provides an important and reliable source of water to many ecosystems, and can be the main factor controlling the distribution of ecosystem types. In many cases the groundwater provides baseflow in rivers that ecosystems depend on.

Six types of GDEs have been identified in Australia (GeoScience, 2013):

- Terrestrial vegetation that relies on the availability of shallow groundwater
- Wetlands such as paperbark swamp forests and mound springs
- River baseflow systems where groundwater discharge provides a significant baseflow component to the river
- Aquifer and cave ecosystems where life exists independent of sunlight
- Terrestrial fauna, both native and introduced species, that rely on groundwater as a source of drinking water
- Estuarine and near-shore marine systems, such as coastal mangroves, salt marshes and sea-grass beds, which rely on the submarine discharge of groundwater.

Four GDEs have been identified within or adjacent to the Project (Mine) Area, they are:

- Doongmabulla Springs complex
- Mellaluka Springs complex
- Carmichael River
- Waxy cabbage palms.

5.2 Great artesian basin springs (Doongmabulla)

The GAB discharge spring wetlands TEC comprises a community of species of flora and fauna including fish, invertebrates and aquatic and terrestrial plants clustered around discharge springs emanating from the GAB (Fensham et al., 2010). For this reason, the TEC is geographically limited to the GAB and is listed as endangered under the EPBC Act.

The GAB occupies approximately 1,711,00 km^2, covering much of Queensland and South Australia and extending into the Northern Territory and New South Wales (Noble et al., 1998; Ponder, 2002). The Doongmabulla Springs complex forms part of the Barcaldine GAB supergroup and is recognised as the endangered GAB discharge spring wetlands TEC under the EPBC Act.

Springs within the GAB 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 one kilometre apart. This

grouping may extend over many kilometres, but no single spring outlet is more than one kilometre from at least one other spring. A spring group is often referred to in the singular as a spring – this report concerns three spring groups, Little Moses, Moses and Joshua.

- A *spring complex* refers to a cluster of spring groups occurring in a similar geomorphic setting within six kilometres of each neighbour. The spring group cluster that is the subject of this report is the Doongmabulla spring complex.
- A *supergroup* is a major regional cluster of spring complexes with broadly similar geomorphic characteristics and within a defined geographic proximity. The Doongmabulla spring complex is located within the Barcaldine supergroup.

As a result of the unique and often hydrologically disconnected habitats presented by GAB springs, distinct groundwater associated communities often develop within or adjacent to these habitats (Fensham et al., 2011). Numerous species of fish, spiders, molluscs and crustaceans are known to be endemic to GAB spring wetlands (Ponder et al., 1995; Fensham and Fairfax 2003; Fensham and Price 2004). Perhaps the most diverse endemic fauna group is the hydrobiid snails (Perez et al., 2005). To date, over 15 species from five genera have been described (Mudd, 2000).

Floral endemism is also a significant feature of GAB discharge spring communities. In 2010, Fensham et al. listed 320 native flora species considered to be associated with GAB spring wetlands, of which 13 flora species from 10 genera were recognised as being endemic to spring wetlands (Fensham et al., 2010). All of the endemic flora species are herbs, sedges or grasses.

The GAB springs within and adjacent to the Project (Mine) Area can be categorised into four main 'morphologies':

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

5.2.1 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* (listed as endangered under the NC Act) tussocks, and are generally surrounded by a scalded margin of bare, sandy loam.

Plate 1 Small artesian seeps (March 2013)

5.2.2 Mound springs

Mound springs form around vents (the spring's surface outlet) where subterranean pressure expresses water through cracks or faults. They are typically a raised mound with a central pool fringed by vegetation. 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.

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).

5.2.3 Non-mounding artesian springs

Some artesian springs do not form a mound, but vented from a point (Plate 2). Some of these non-mounding artesian springs are associated with a grove of river red gums (*Eucalyptus camaldulensis* var. *obtusa*) or weeping paperbark (*Melaleuca leucadendra*). Shallow wetland adjacent to the vents may provide valuable habitat for fish, invertebrates, amphibians and flora, including the threatened flora species *S. pamelae, Myriophyllum artesium*, blue devil (*Eryngium fontanum*), salt pipewort (*Eriocaulon carsonii* subsp. *orientale*), *Hydrocotyle dipleura* and *Sporobolus partimpatens*, listed under the NC Act.

Plate 2 Non-mounding artesian springs with vegetated drainage pathways (March 2013)

5.2.4 Modified, high flow spring

The modified high flow spring is a spring that has been modified from its natural state. The spring known as Joshua has been modified to a 'turkey-nest' dam to service the domestic needs of Doongmabulla Station (Plate 4).

Plate 3 Joshua Spring, a large, modified mound spring used for domestic purposes (April 2013)

5.3 Other springs (Mellaluka)

The Mellaluka Springs are not associated with the GAB and do not represent the GAB discharge spring wetlands TEC. Specifically, the aquifer for Mellaluka springs is believed to be located in Permian strata, with additional studies to be undertaken to confirm this.

The springs comprising the Mellaluka complex can be categorised into two main 'morphologies':

1. Mound springs
2. Non-mounding artesian springs

Although not associated with the GAB, the process of formation and environmental characteristics of the mound springs and non-mounding artesian springs comprising the Mellaluka complex are similar to that described above for GAB springs (refer Sections 5.2.2 and 5.2.3).

5.4 Carmichael River

The Carmichael River is the major surface water resource which runs through the Project (Mine) Area. The flow regime of the Carmichael River is subject to seasonal variability as wet season overland flow drains from the catchment. Late in the dry season the Carmichael River is reduced to a low flow environment, interspersed with deeper pools. The Carmichael River is characterised by a well-established riparian zone that provided extensive shading of the water.

Information on observed surface water flows, groundwater levels and a comparison of groundwater and surface water quality data for the Carmichael River suggests that flows and/or water levels are at least partly supported by direct groundwater flow from the underlying units and/or by discharge from the Doongmabulla Springs. This suggests that Carmichael River and the associated remnant riparian vegetation are groundwater dependent to a degree and consequently the fauna which are attracted to these areas are also thought likely to be dependent on groundwater, but indirectly.

The sclerophyll community fringing the Carmichael River is dominated by river red gum (*E. camaldulensis* var. *obtusa*), weeping paperbark (*M. leucadendra*) and narrow-leaved paperbark (*M. fluviatilis*), often with waxy cabbage palm present.

5.5 Waxy cabbage palms

The waxy cabbage palm grows to approximately 20 m tall. Its leaves are broadly circular, and leaf stems have protruding sharp thorns. The species is distinctive for the long woolly hairs on the stems of the leaves and the flower stalks. All known populations of waxy cabbage palm are growing on sandy, ephemeral watercourses or their floodplains.

6. Doongmabulla Springs complex subplan

6.1 Environmental characteristics

The Doongmabulla Springs complex is recognised as the endangered GAB discharge spring wetlands TEC under the EPBC Act. The Doongmabulla Springs complex is situated approximately 8 km from the western edge of the Project (Mine) Area (Figure 2). 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.

Cumulatively, these spring groups are estimated to have a daily flow rate of 1.35 ML (Fensham, pers comm. 16 January, 2012). The Doongmabulla Springs complex forms part of the Barcaldine GAB supergroup, located within the Belyando catchment (a part of the greater Burdekin River catchment). The spring complex is situated on a gently undulating to undulating plain of Quaternary alluvium, surrounded by mid to late Triassic sandstone of the Moolayember formation (Bureau of Mineral Resources, Geology and Geophysics, 1972). It is located near the junction of three third order streams, Cattle Creek (in the south), Dyllingo Creek (in the centre) and Carmichael Creek (in the north). These watercourses converge within a kilometre of each other to form the Carmichael River (Figure 2).

The Doongmabulla spring complex and associated wetlands are listed as being of national significance in the directory of important wetlands, as they exhibit the following qualities:

- 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, 2012).

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).

6.2 Spring groups

Joshua Spring is a single spring now modified to a turkey's nest dam (adjacent to a second overflow dam), with an approximate daily flow of 432,000-864,000 litres (see Figure 3). This flow is directed to an adjacent shallow wetland of approximately 2 ha, and the remainder drains to the Carmichael River. The wetland contains the aquatic herb *M. artesium* (listed as endangered under the NC Act) and the grass *S. partimpatens* (listed as near threatened under the NC Act). It has been postulated that this spring contributes a proportion of the Carmichael River's base flow downstream of this point. Joshua Spring is located approximately 10.2 km directly west from the western edge of the Mine Area boundary.

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
- Moses Spring Boundary
- Spring Groups

Adani Mining Pty Ltd
Groundwater Dependant Ecosystems Management Plan

Job Number 41-26422
Revision A
Date 08-01-2014

Doongmabulla Springs Complex 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: GHD: Spring Complex/2012, Spring Boundary/2013; GA: Watercourses, Roads, Homesteads (2007); DNRM: Nature Refuge (2010); DME: Carmichael Mine Site; Google Earth Pro: Imagery (2012). Created by: MS

Moses Spring is a spring group protected as the Doongmabulla nature refuge that comprises at least 65 individual springs spread over an irregular area 2.5 km long and 1.3 km wide (approximately 325 ha). These springs are mostly mound springs, with mounds developed up to 1.5 m tall (see Figure 3 and Plate 4). However, some seepage springs are also present. All springs have a wetted area around them that generally encompasses at least the mound (or adjacent pools where there is no mound) and sometimes a much larger area. Five wetland areas larger than 0.5 ha have developed in association with the run-off from these springs. Seven threatened species are associated with Moses Spring (five of which are GAB endemics, and one of which is a partial endemic). Moses Spring is located approximately 8.8 km directly west from the western edge of the Project (Mine) Area boundary.

Moses Spring group meets the definition of a 'community of native species dependant on natural discharge of groundwater from the Great Artesian Basin' TEC (DSEWPaC, 2013f), declared as endangered under the EPBC Act.

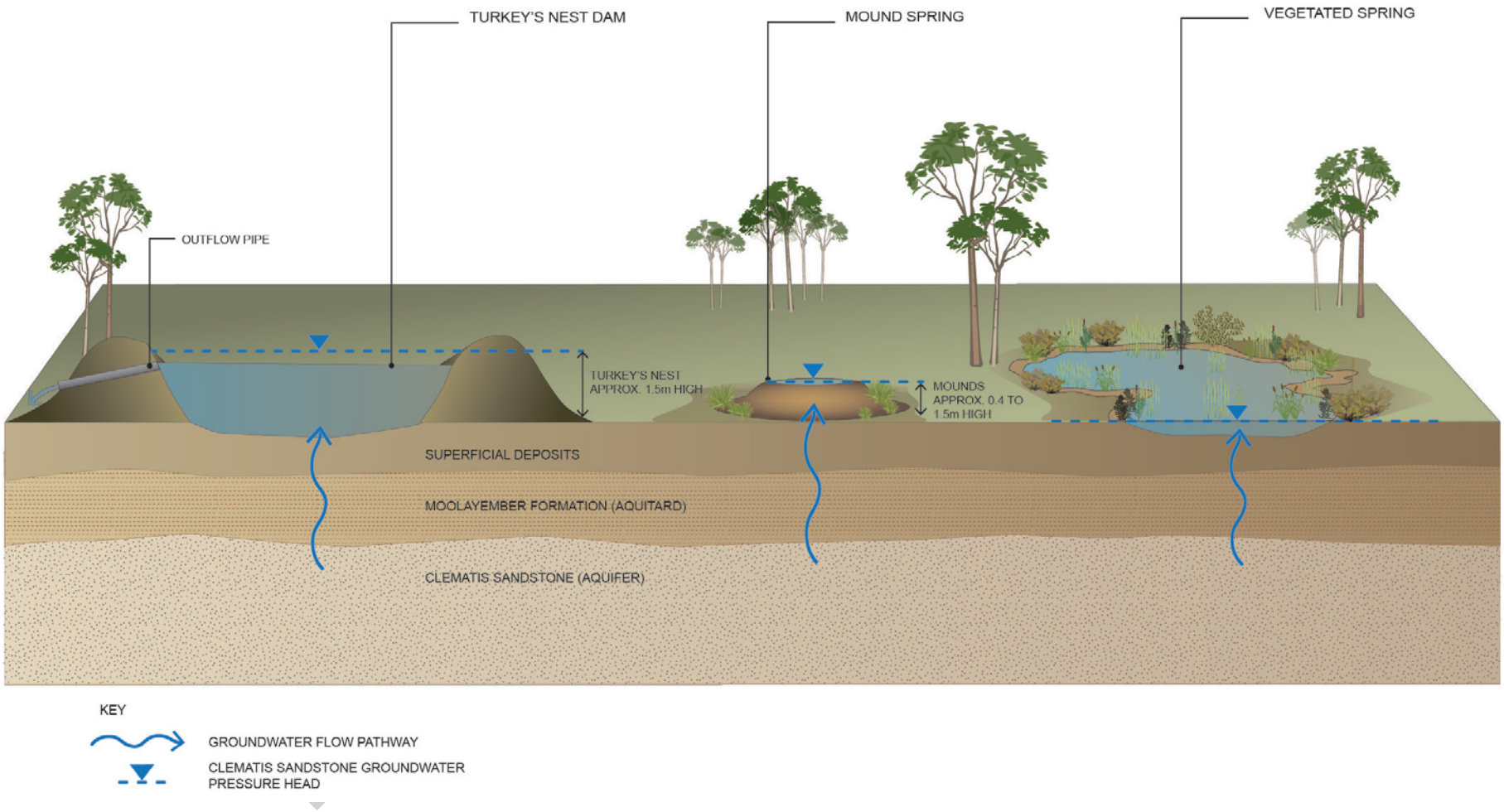
Plate 4 Typical mound springs of the Moses Spring group (April 2013)

Little Moses Spring is located directly beside the Carmichael River and comprising a group of seepages from the side of a low slope with one large pool. No threatened species or GAB endemic species occur at this spring. Little Moses is a tear-shaped inundated sedgeland/wetland approximately 200 m long and 50 m wide with an open pond in the centre. Little Moses Spring most resembles the vegetated spring illustrated in Figure 3 and Plate 5. Little Moses Spring is located approximately 7.0 km from the western edge of the Project (Mine) Area boundary.

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.

Plate 5 Little Moses Spring group (April 2013)

Figure 3 Conceptual model of spring types at Doongmabulla Springs complex



Source: GHD 2013b

6.3 Spring vegetation communities

A number of broad vegetation community types were observed within the Doongmabulla Springs complex. A regional ecosystem (RE) map (based on version 6.1 RE mapping) for the Doongmabulla Springs complex is provided in Figure 4. 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).

6.3.1 Bare, scalded plains

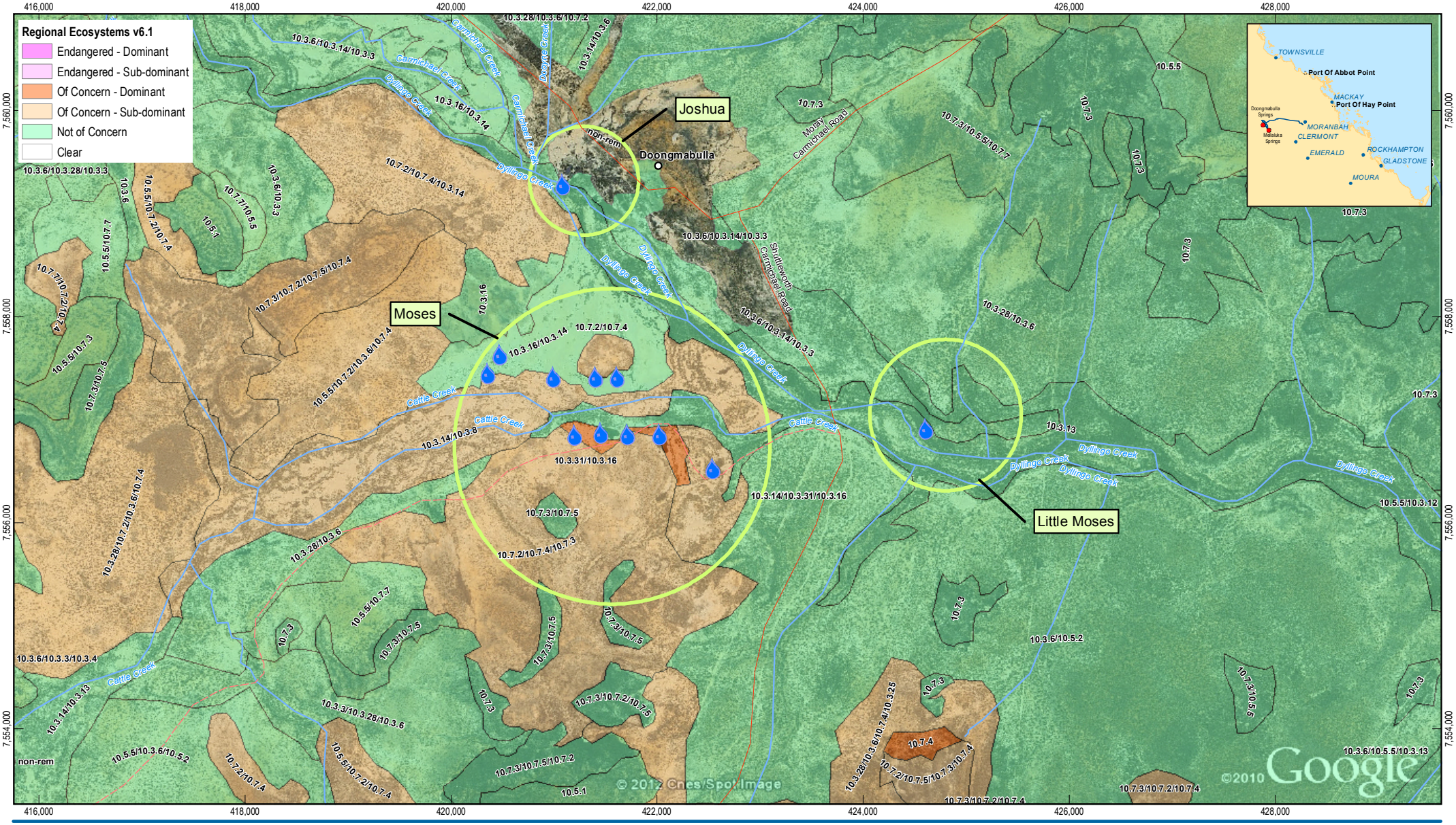
Conspicuous in aerial photography, the approaches to the Moses Spring group wetland are dominated in places, particularly to the north, by large bare flood plain with a very fine, powdery sandy alluvium. It is characterised by a very sparse grass and herb coverage, including the near threatened grass *S. partimpatens,* together with other grasses *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.

6.3.2 Sporobolus pamelae grassland

Within the wetland, the main habitat type present (in terms of area) was grassland generally dominated by *S. pamelae* (see Plate 6) 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, D. fusca* and *Leersia hexandra.* Common sedges were *Cyperus sanguinolentus, C. laevigatus, Fimbristylis ferruginea* and *F. 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 6 *Sporobolus pamelae* grassland (April 2013)



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

Groundwater Dependant Ecosystems Management Plan

Doongmabulla Springs complex

Regional Ecosystem mapping

Job Number 41-26422
Revision A
Date 18-12-2013

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/2012, Springs/2012; GA: Watercourses, Roads, Homesteads (2007); DNRM: Regional Ecosystems Version 6.1 (2011); DME: Carmichael Mine Site; Google Earth Pro: Imagery (2012). Created by:MS

6.3.3 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 (Plate 7 mixed sedgeland occupies the background). 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, I. globosa, I. australe* and *S. indica.* Other herbs present included the endangered species blue devil, salt pipewort (subsp. *orientale*) and *M. artesium*. This sedgeland was often present within a mosaic dominated by *S. 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.

Plate 7 Mixed sedgeland (April 2013)

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 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 *H. dipleura* is common. Both variants of this sedgeland are considered to be obligate groundwater dependent communities.

6.3.4 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 (*L. 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.

6.3.5 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 (*M. leucadendra*). These stands are within the saturated zone of the wetland, and have a sedge-dominated ground layer (see Plate 8). This is considered to be an obligate groundwater dependant ecosystem. This vegetation community is contained within the of concern RE 10.3.31.

Plate 8 Weeping paperbark forest (left) and peppermint box open woodland (right) (April 2013)

6.3.6 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 8). 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.

6.3.7 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*), *M. 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.

6.3.8 Flora of the Doongmabulla Springs complex

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 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.

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 further discussed below.

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.Fensham 5694), 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.

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 9). It is listed as endangered under the EPBC Act and the NC Act. 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 9 on the right.

Plate 9 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 10). It is listed as endangered under the EPBC Act and the NC Act. 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. It was recorded growing in dense sedgeland, *S. pamelae* grassland, and open sandy locations across Moses Spring, but most commonly within the largest wetland.

Plate 10 Blue devil (left) and *Hydrocotyle dipleura* (right) (April 2013)

Hydrocotyle dipleura

Hydrocotyle dipleura is a perennial prostrate herb with kidney-shaped leaves (see Plate 10) 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. This species was primarily found along the margins of all of the wetlands within the Moses spring group and within *S. pamalae* grassland, including at isolated mounds situated many hundreds of metres from other populations, and often in association with *F. 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. Waxy cabbage palms were 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 11). A few individuals were also recorded at the Little Moses spring group. Further details on the Waxy Cabbage Palm are provided in section 9.

Plate 11 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 12), 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. It is a Queensland endemic, and is known from only 17 spring complexes (Halford and Fensham, 2001). 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 wetland associated with the Joshua spring group.

Plate 12 *Myriophyllum artesium* (left) and *Sporobolus pamelae* (right) (April 2013)

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. 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 12). 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, however, it is not listing under the EPBC Act. *Sporobolus 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.

6.4 Fauna

A number of species of terrestrial fauna of conservation significance are predicted to be likely to occur within the Doongmabulla Springs complex 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*).

6.5 Habitat values

The greatest habitat values of the Doongmabulla Springs complex is 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, 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, 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 (*G. scripta scripta*), 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 13) was also found in a channel running through the wetland.

Plate 13 Black-necked stork nest at the Doongmabulla wetlands (March 2013)

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 14).

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.

Plate 14 Reptile habitat showing dense leaf litter (top left), fallen timber (top right), spinifex (bottom left) and rocky escarpments (bottom right)

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 15). 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 fish in the form of springs, wetlands and adjacent waterbodies.

Plate 15 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 16), 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 16 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.

Outside of the wetland, 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 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.

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. The greatest damage to the wetlands was caused by feral pigs. 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 (April 2013)

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.

6.6 Threatening processes

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). 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). This threatening process is relevant to the TEC and the Doongmabulla Springs complex as a whole.

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 Springs complex currently experiences disturbance, with the Joshua Spring modified to a 'turkey-nest' dam to service the domestic needs of Doongmabulla Station.

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 Springs complex currently experiences impacts in the form of pugging from cattle and pigs.

6.7 Potential impacts

A change in groundwater hydrology, specifically, a reduction in groundwater pressure is the primary potential impact on the Doongmabulla Springs complex and has the potential to occur as a result of the operational phase of the Project (Mine). While the TEC is not present within the Study Area, it was considered to have the potential to be impacted indirectly as a result of pressure reduction.

Conservative (i.e. worst case) modelling indicates that the influence of Mine dewatering reaches the location of the Doongmabulla Springs, with a maximum predicted reduction in pressure in the

aquifer of between <0.05 and 0.19 m (operation phase) and <0.05 and 0.16 m (post-closure) at these springs (Table 5). The reduction in pressure and the impacts on the different types of springs are also conceptually presented in Figure 5. It should also be stressed that predictions suggest that potential impacts will not occur until around 60 years into the proposed life time of the mine.

Table 5 Modelling predictions for pressure reductions in aquifers associated with the Doongmabulla Springs complex

Spring	Predicted reduction in pressure – Operation (metres)	Predicted reduction in pressure – Post-closure (metres)
Joshua Spring	0.19	0.16
Moses Springs		
Moses1	0.06	0.06
Moses2	0.08	0.08
Moses3	<0.05	0.05
Moses4	<0.05	<0.05
75A	0.08	0.07
75B	0.12	0.11
75C	0.12	0.11
75D	0.07	0.07
75E	0.09	0.09
Little Moses Spring	<0.05	<0.05

Source: GHD, 2013b

The high flow at the Doongmabulla Springs complex is evidence of a strong pressure head, amounting to at least 1 m above the surrounding plain. Joshua Spring is a high flow spring that has been converted to a turkey's nest dam which rises at least 1 m above the surrounding plain. The predicted reduction in pressure in the aquifer at Joshua Spring of 0.19 m is not expected to constitute more than a minor impact to this spring, as it has such a strong head of pressure.

The threatened species found at the Joshua Spring wetland, *M. artesium* and *S. partimpatens*, are unlikely to be impacted, as the water supply to the wetland in which they occur is not likely to be reduced to an extent that will affect these species.

The twelve mounds at Moses Springs were less than 20 cm high, 24 were 20 – 50 cm high, and 20 were higher than 50 cm. The highest mounds were approximately 1 – 1.5 m tall (that is, 1.5 m above the level of the surrounding plain). These springs support seven species that are of conservation significance, including a number of GAB endemic species. A reduction in pressure in the aquifer at Moses Springs is predicted to be between 0.12 m and less than 0.05 m (Table 5). The presence of mounds up to 1.5 m in height indicates that the spring has an existing pressure head up to 1.5 m above ground level. With the majority of springs in the Moses Spring group located in the western half, the predicted reduction in pressure is generally less than 0.08 m. These reductions in pressure are expected to have a minor impact on the springs and associated wetlands, falling within the range of seasonal fluctuations to which the springs are already adapted. Therefore, it is thought that the reduction in flow will be within a tolerable range.

The threatened species associated with the Moses Springs are generally present on or immediately adjacent to the mounds, seeps or pools. Most mounds are separated from other mounds by bare sections of plain. The majority of the population of endemic and/or threatened species at Moses are located within wetland areas fed by seepage from the springs. These wetlands generally form sedgeland or grassland, rarely with trees (weeping paperbark clumps or individual waxy cabbage palms).

Groundwater modelling predicts that reduction in pressure in the Little Moses Spring will be less than 0.05 m. This would result in the pond level dropping by 0.05 m, and it is expected this would represent a negligible impact on the ecology of the spring and the sedgeland that fills most of its surface area.

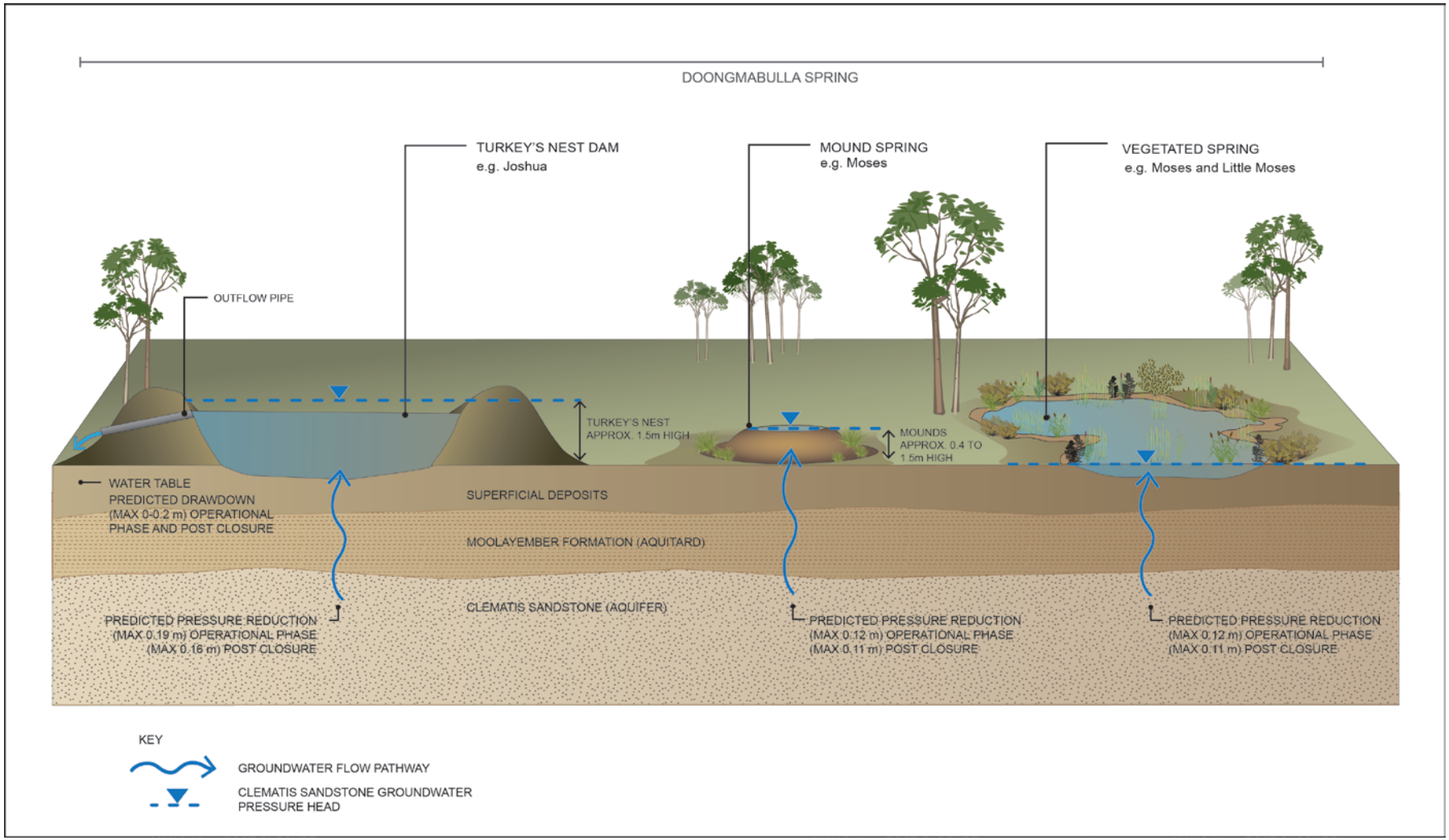
The size of these wetlands appears to vary greatly with the seasons. During the 2012 survey, the wetlands were extensive and were overflowing into pools in the Cattle Creek channel that were up to 1.5 m deep. However, during the 2013 survey, all of the deep pools observed in 2012 were dry. Seasonal fluctuations appear to be a normal part of the ecology of these wetland areas.

The levels of reductions (generally less than 5 percent at Moses Springs and within the range of natural seasonal fluctuations) are likely to have negligible adverse impacts at Moses Springs and, at most, negligible adverse impacts to Joshua and Little Moses Springs.

No significant impacts to the GAB discharge spring wetlands TEC will occur, as the Project (Mine) will not:

- Reduce the extent of, fragment, or increase fragmentation of the ecological community
- Adversely affect habitat critical to the survival of the ecological community, or destroy or modify factors necessary for the survival of the community
- Cause substantial changes or reductions in species compositions, quality or integrity.

Figure 5 Groundwater pressure reductions in the aquifers at Doongmabulla Springs complex



Source: GHD, 2013b

6.8 Management and mitigation measures

Impacts to the ecological values of the Doongmabulla Spring complex within the operation and post closure of the Project (Mine) are likely to be greater than those occurring during construction. The approach to mitigating and managing operational phase impacts will therefore include a combination of prevention or reduction of all avoidable impacts to the greatest extent possible, active management to maintain and where possible enhance habitats that will not be impacted during staged operations, and active management of areas that will be disturbed during staged mining operations such that they retain their existing values until such time that they are disturbed.

Research and monitoring will be a fundamental component of the impact management approach, with a dual objective of informing an adaptive management approach over the life of the project to achieve reductions in environmental impacts at and near the Project (Mine) Area, as well as contributing to the understanding and protection of ecological values in the Galilee Basin. As unavoidable impacts are an inherent aspect of the Project (Mine), given that its operations are entirely related to the locality of the coal resource within the mining lease, offsets will form a substantial component of the impact management approach. Whilst all reasonable efforts will be made to minimise impacts to flora and fauna values within the operational phase footprint, vegetation loss, fauna habitat loss and fauna mortality will occur. The overarching objective of managing impacts during the operation phase will be to maintain and where at all possible enhance the ecological values that characterise the Project (Mine) Area and the surrounding landscape, with a view to achieving no-net-loss of regional biodiversity values.

Impacts to Doongmabulla Springs are recommended to be managed primarily through ongoing investigation and monitoring. The impacts identified on springs affected by the Project (Mine) are not expected to commence until approximately 2020, with reduction in pressure of the aquifers expected by approximately 2035.

Specific to understanding the significance of impacts to the stygofauna community, the following management approaches are recommended:

- Build on and extend the existing baseline survey by conducting annual stygofauna surveys in order to monitor and measure groundwater health and condition at Doongmabulla Springs

The management control measures at Doongmabulla Springs complex during pre-construction, construction, operation and post construction are outlined in Table 6, Table 7, Table 8 and Table 9.

Table 6 Pre-construction management control measures at Doongmabulla Springs complex

Issue	Control	Responsibility	Timeframe	Documentation
Management	Prepare a water management plan in accordance with the guideline *Preparation of Water Management Plans for Mining Activities* (DERM, 2009).	Environment Manager	Prior to commencement of mining	Water management plan and erosion and sediment control plan in place
Aquatic ecology	Establish control and impact monitoring sites at the Doongmabulla Springs.	Environmental Manager	Prior to commencement of mining	Aquatic ecology monitoring program
Groundwater	Use monitoring data to set groundwater quality trigger levels.	Environmental Manager	As per groundwater monitoring program	Trigger levels in environmental authority
	Liaise with adjacent landholders and develop bore monitoring programs to detect changes in bores used for water supply.	Environmental Manager	12 months prior to commencement of mining	Updated groundwater monitoring plan
	Enter into “make good” agreements with surrounding landholders in relation to potential groundwater impacts.	Stakeholder Manager	Prior to commencement of mining	Agreements in place

Table 7 Construction management control measures at Doongmabulla Springs complex

Issue	Control	Responsibility	Timeframe	Documentation
Groundwater	Groundwater will be managed as per the Water management plan.	Environmental Manager	Prior to construction	Approved plan is implemented
	Potential impacts on groundwater quality due to the discharge of potentially contaminated runoff will be prevented through the development and operation of a suitable surface water management system and associated management plan (SWMP).	Environmental Manager	Prior to construction	Approved plan is implemented
	Prior to the commencement of construction activities the status of each of the existing registered bores that could be significantly affected by the proposed Project (Mine) should be confirmed and a baseline assessment undertaken at each of the active bores in order to establish their pre-operational condition.	Environmental Manager	Prior to construction	Monitoring program and results
Pests	To minimise the risk of pest animal establishment within and adjacent to the Carmichael River, the measures outlined in the weed and pest management plan shall be implemented.	Environmental Manager	Prior to construction	Approved weed and pest management plan implemented.
	Monitoring of feral species populations in the Project Area and implementation of a control program if necessary.	Environmental Manager	During construction and operations	Monitoring records and logs Control Program
Fire	Fire management strategies will be implemented to reduce the potential for destructive high intensity fires to disturb habitats.	Environmental Manager	Ongoing	Approved plan is implemented

Table 8 Operation management control measures at Doongmabulla Springs complex

Issue	Control	Responsibility	Timeframe	Documentation
Groundwater	Re-run groundwater model to test drawdown effects on sensitive receptors, review management, monitoring and mitigation measures and develop additional measures as required.	Environmental Manager	Each time model is updated	Updated monitoring, management and mitigation measures
Pests	Monitoring of feral species populations in the Project Area and implementation of a control program if necessary.	Environmental Manager	During construction and operations	Monitoring records and logs Control Program
Fire	Fire management strategies will be implemented to reduce the potential for destructive high intensity fires to disturb habitats.	Environmental Manager	Ongoing	Approved plan is implemented

Table 9 Post operation management control measures at Doongmabulla Springs complex

Issue	Control	Responsibility	Timeframe	Documentation
Groundwater	Post closure groundwater modelling to be conducted at least 2 years prior to closure to confirm and/or validate predicted impacts and inform ongoing mitigation measures. Agreements to be in place with affected parties prior to post operations phase in regards to groundwater flow impacts.	Environmental Manager	Post operation	Closure and rehabilitation strategy

6.9 Offsets

As no significant impacts to the GAB discharge springs wetlands TEC (Doongmabulla Spring complex) are predicted, offsets under the EPBC Act will not be required. In the event that future monitoring and modelling suggest that impacts will be significant and mitigation and management measures are not feasible, offsets may be considered.

6.10 Monitoring

Proposed monitoring for Doongmabulla Springs to understand changes due to seasons and/or a reduction in aquifer pressure to this community include:

- Flow monitoring of the outlet at Joshua Spring to monitor changes in output, and in the Carmichael River immediately adjacent to Joshua Spring, to monitor contributions to surface water flow and seasonal changes.
- Mapping and measurement of the 'vegetated area' perimeter of the five main wetland areas at the Moses Spring group bi-annually.
- Mapping and measurement of selected isolated mound springs at Moses Spring group should be conducted on a seasonal basis by a suitably qualified botanist prior to and during the predicted drawdown impact. At least 10 mound springs should be selected over the entire spring group, focussing on differing sized mounds and gaining a good geographic spread over the entire group. This should include a complete species list and relative abundance of the mound vegetation, a photographic record, diameter, height and perimeter measurements, and flow measurements.
- Ecological studies of the two threatened species listed under the EPBC Act that occur at Moses Spring – blue devil and salt pipewort – should be conducted annually. This should be done in consultation with the Queensland Herbarium using an appropriate survey method for small herbs. Consideration should be given to changing the frequency of surveys if population changes are noted.
- A baseline survey of aquatic invertebrates and stygofauna at Moses Spring conducted by a suitably qualified ecologist/entomologist prior to mining operations commencing, to determine the presence of endemic species.
- A baseline water level should be established at a reference location for the springs, and water levels should be measured against this baseline on a quarterly basis during mining operations.
- These baseline monitoring events should commence at least one year before mining operations, and continue for at least one year after mining operations are completed.
- At the conclusion of baseline surveys a Baseline Ecological Condition report should be prepared for the springs.
- An annual report on the spring condition, including statistical comparison to baseline condition, should be provided including reporting on any change from baseline conditions and planned actions.
- These surveys should utilise data gained from studies into groundwater levels conducted within the Project (Mine) Area and in the vicinity.

- All surveys and other works will be conducted in consultation with the Doongmabulla property owner.

Monitoring sites

The proposed monitoring sites at the Doongmabulla Spring complex and the type of monitoring is outlined in Table 10 and Figure A1.

Table 10 Proposed Doongmabulla Spring complex monitoring sites

Monitoring Location	Description	Latitude	Longitude	Monitoring
DS1	Little Moses Spring	-22.091048	146.269163	Surface water flow Groundwater level and quality Aquatic fauna and stygofauna Spring vegetation survey
DS4	Moses Spring 1	-22.086698	146.239912	
DS3	Moses Spring 3	-22.091479	146.244128	
DS7	Moses Spring 75B	-22.0913	146.238604	
DS10*	Joshua Spring	-22.069449	146.23513	

The monitoring actions at Doongmabulla Springs complex during pre-construction, construction, operation and post construction are outlined in Table 11. Note that surface water and groundwater monitoring requirements are being developed as part of a Surface Water Monitoring Program and Groundwater Monitoring Program for the Project.

GDE specialists will be used in a review capacity to inform ongoing monitoring actions (refer Section 13.3).

Table 11 Monitoring at Doongmabulla Springs complex

Issue	Monitoring action	Responsibility	Frequency	Performance requirement
Aquatic ecology	Mapping and measurement of spring vegetation.	Environmental Manager	Bi-annually	Ongoing monitoring
	Threatened flora species surveys.	Environmental Manager	Annually	Ongoing monitoring
Surface water	Flow monitoring at spring outlet	Environmental Manager	As per groundwater monitoring program	Ongoing monitoring
Groundwater	Conduct groundwater quality monitoring across monitoring network for: • pH, DO, turbidity, EC, temperature (field and lab) • Total organic carbon • Major ions • Fluoride and sulfide • Nutrients • Dissolved metals • Hydrocarbons (TPH and BTEX)	Environmental Manager	As per groundwater monitoring program	Trigger levels set in environmental authority are not exceeded
	Conduct groundwater level monitoring across monitoring network.	Environmental Manager	As per groundwater monitoring program	Drawdown at Doongmabulla Springs does not exceed trigger level to be determined Drawdown at stock and domestic bores does not affect yield
	As Mining activity progresses, the monitoring network will be updated for inclusion of new bores or exclusion of bores in mined areas.	Environmental Manager	Continuous	Ongoing monitoring

6.11 Corrective measures

Triggers for corrective measures relevant to environmental characteristics of the Doongmabulla Springs complex are identified in Table 12, together with the corresponding corrective actions.

Table 12 Corrective measures at Doongmabulla Springs complex

Trigger	Responsibility	Corrective action
Trigger levels set in environmental authority are exceeded	Environmental Manager	Repeat monitoring immediately on receiving non-compliant results. If repeat results indicate persistent elevation, raise an incident report and commence incident investigation. Undertake corrective actions as identified in the incident investigation.
Drawdown at Doongmabulla Springs exceed trigger level to be determined	Environmental Manager	Implementation of adaptive monitoring program. Mine planning and rehabilitation mitigation measures implemented.
Drawdown at stock and domestic bores affects yield	Environmental Manager	Implementation of adaptive monitoring program. Mine planning and rehabilitation mitigation measures implemented. Implement make good agreements with landholders.

7. Mellaluka Springs complex subplan

7.1 Environmental characteristics

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. The Mellaluka Springs complex consists of the following three separate springs:

- Mellaluka Spring – a large mound spring with several vents
- Stories Spring – a discrete non-mounding artesian spring
- Lignum Spring – a discrete non-mounding artesian spring.

Mellaluka Springs complex is located near the south western corner of the eastern section of the Mine Area on the Mellaluka station, almost 30 km south east of Doongmabulla Springs, and 20 km south of the Carmichael River. 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 (Figure 6). All of these springs are discrete environments that were not located within or near to any riverine waterways.

The Mellaluka Springs complex is not considered to be fed by a GAB aquifer – the aquifer for this spring is believed to be located in Permian strata, however additional studies are required to confirm this.

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) is the largest spring which supports a wetland and dam.

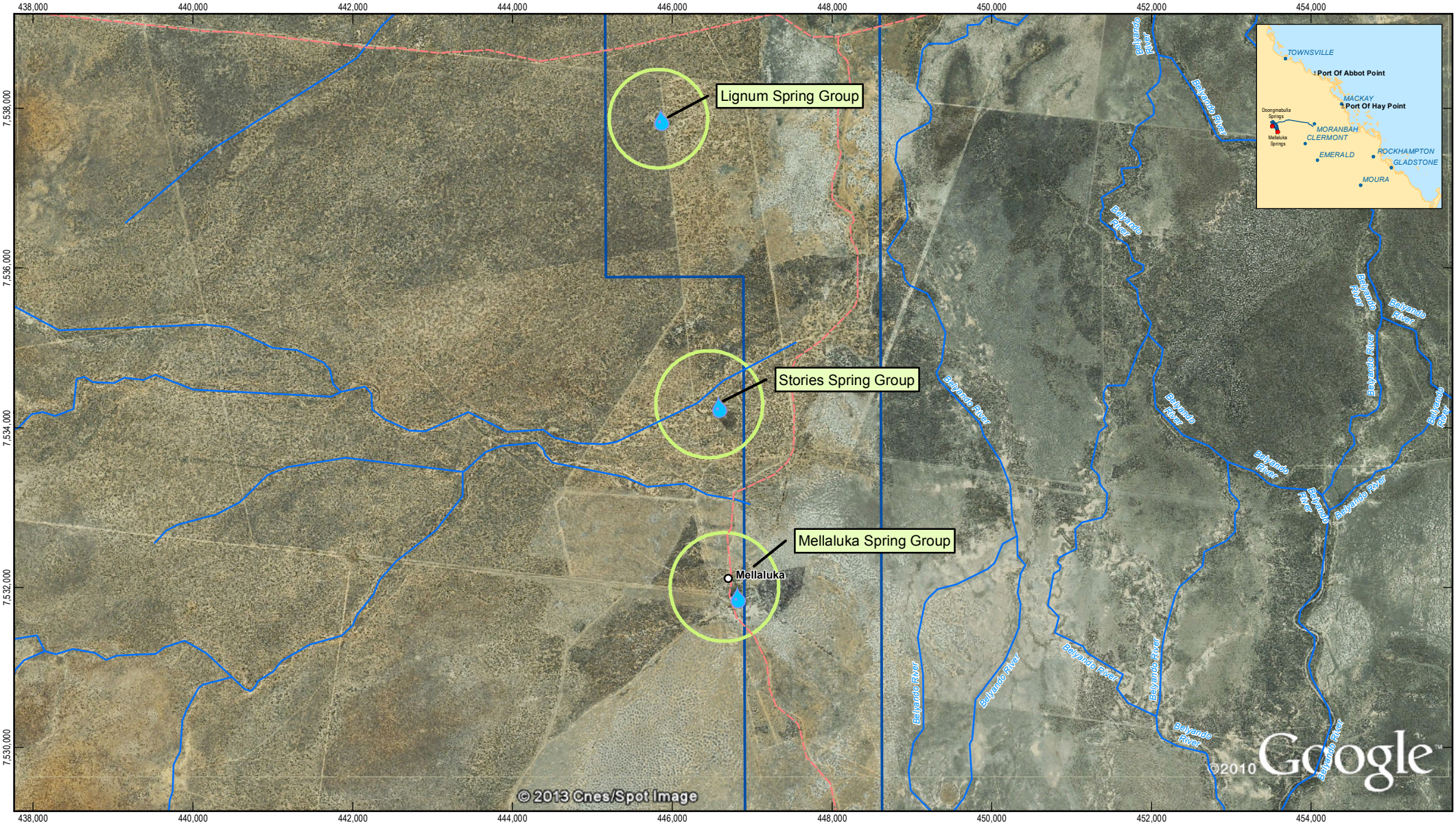
7.2 Spring groups

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 (Plate 18).

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 18). 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.

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.

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.



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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
Groundwater Dependant Ecosystems Management Plan

Job Number 41-26422
Revision A
Date 18-12-2013

Mellaluka Spring Complex

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: WMA, WMA Trigger (2010). Created by:MS

Plate 18 Mellaluka mound spring (top left), run-off pool (top right), pool in peat (bottom left) and wetland (bottom right) (April 2013)

The northern two springs (Lignum Plate 19 and Stories Plate 20 springs) have only one spring or outlet each, and consist of a shallow pond, approximately 0.5 – 1 m deep, that appears to seep water. They are both situated within broad, level to gently undulating sand plains.

Both Lignum and Stories springs are non-mounding. These springs are located some distance from each other (almost 2 km). 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).

Lignum and Stories Springs are slightly modified from their natural state to facilitate access by cattle, with water at just below ground level. Only Lignum Spring is located within the Mine Area – the other two are located just outside the Mine Area boundary.

No threatened or endemic species were recorded at Mellaluka Springs; however, an Asteraceae (daisy) species was collected that the Queensland Herbarium could not match to a known species.

Plate 19 Lignum Spring (April 2013)

Plate 20 Stories Spring (April 2013)

7.3 Spring vegetation communities

Mellaluka Spring is mapped as non-remnant vegetation (see Figure 7). 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.

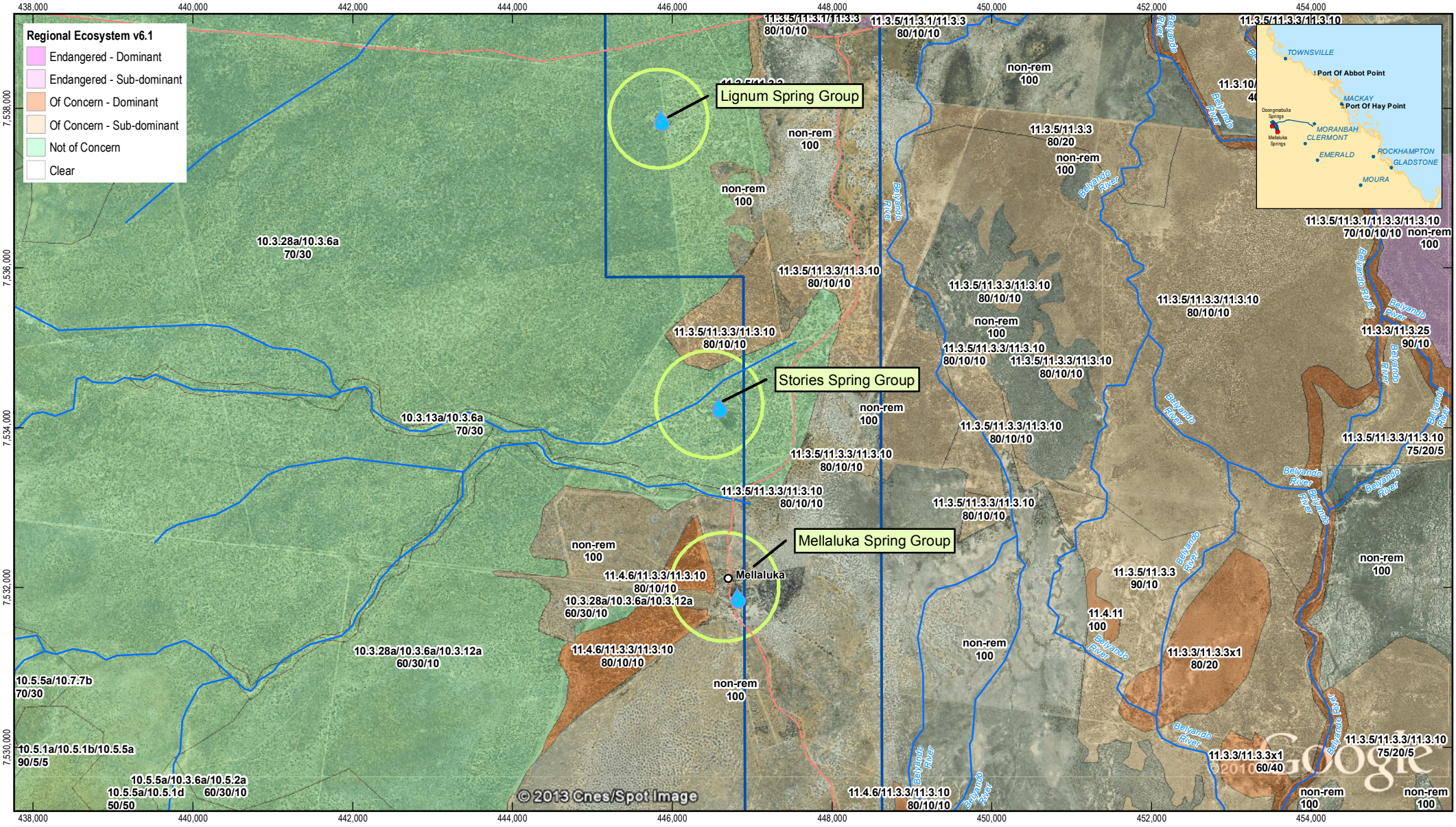
Elsewhere within this spring group, saturated areas were characterised by *P. australis* grasslands with *L. hexandra* and *Fimbristylis ferruginosa,* or sedgeland dominated by an unknown tall *Cyperus* sp.

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 7) – 10.3.6 represents the Reid River box woodland, and 11.3.28 the silver-leaved ironbark woodland.

An unidentified daisy, *Streptoglossa* sp., was collected on the main Mellaluka Spring 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.



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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
Groundwater Dependant Ecosystems Management Plan
Mellaluka Springs complex
Regional Ecosystem mapping

Job Number 41-26422
Revision A
Date 18-12-2013

Figure 7

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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

7.4 Fauna

A number of species of terrestrial fauna of conservation significance were predicted to be likely to occur within the Mellaluka Springs complex area including:

- Squatter pigeon (*G. scripta scripta*)
- Red goshawk (*E. radiates*)
- Ornamental snake (*D. maculate*)
- Yakka skink (*E. rugosa*)
- Koala (*P. cinereus*)
- Black throated finch (*P. cincta cincta*)
- Australian painted snipe (*R. australis*).

7.5 Habitat values

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, 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.

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 21). The greatest habitat values for reptiles were the dense vegetation and leaf litter at the Mellaluka Spring.

Plate 21 Reptile habitat in the Mellaluka wetland showing fallen timber at Stories Spring (left), and dense vegetation at the Mellaluka Spring (right) (April 2013)

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.

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 22). 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 22 Aquatic habitat at the Mellaluka Spring (April 2013)

The dam at the 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.

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 23) – 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 23 Cattle and pig damage (the 'rough areas') at Lignum Spring (April 2013)

7.6 Threatening processes

Although the Mellaluka Springs complex is not a GAB spring, the threatening processes are similar. The greatest threatening process for the springs is drawdown resulting from groundwater extraction for domestic and agricultural use and mining.

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 Mellaluka Springs complex currently experiences impacts in the form of pugging from cattle and pigs.

7.7 Potential impacts

A change in groundwater hydrology as a result of the operational phase of the Project (Mine), specifically, a reduction in groundwater pressure is the primary potential impact on the Mellaluka Springs complex. During the operational phase, the maximum predicted reduction in pressure for the Mellaluka Springs complex is in the Permian-age strata aquifer, with up to 1.14 m predicted at the Mellaluka spring, 8.22 m at Lignum Spring and 2.34 m at Stories Spring (Table 13). It should also be stressed that predictions suggest that significant impacts will not occur until around 60 years into the proposed life time of the mine. The reduction in pressure and the impacts on the different types of springs are also conceptually presented in Figure 8.

Table 13 Modelling predictions for pressure reductions in aquifers associated with the Mellaluka Springs complex

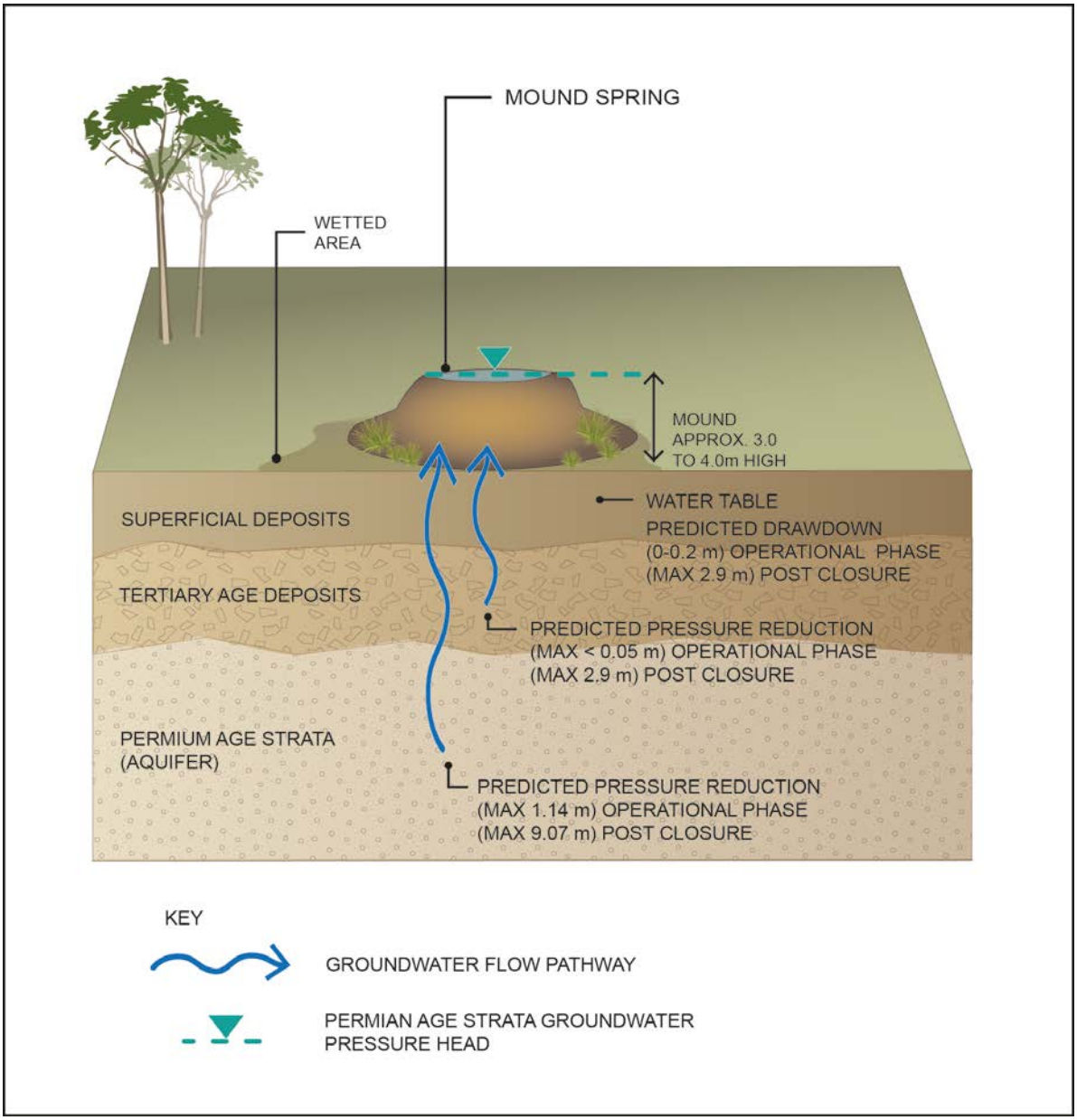
Spring	Predicted reduction in pressure – Operation (metres)	Predicted reduction in pressure – Post-closure (metres)
Mellaluka Spring	<0.05* – 1.14**	1.6* -9.07**
Stories Spring	<0.05* – 2.34**	8.2* – 13.4**
Lignum Spring	0.06* – 8.22**	14.8* - 25.6**

Note:
*Upper most aquifer; ** Permian-age strata
Source: GHD, 2013b

The predicted reduction in pressure at the two northern springs, Lignum and Stories, will be between <0.05 – 8.22 m during operation and between 8.2 – 25.6 m post-closure, whereas the Mellaluka Spring group is predicted to have between <0.05 and 1.14 m during operation and between 1.6 – 9.07 m post closure. This predicted reduction in pressure in the aquifers will have significant impacts on this spring group, which will essentially dry up at the surface.

The post-closure predicted reduction in pressure is likely to result in a loss of ecological function for all springs in the Mellaluka Springs group. This impact would occur around 2070, based on current planning for the Mine. It is predicted the main Mellaluka Spring will see drawdowns of up to 9.07 m in Permian-age strata, with the northern springs (Stories and Lignum Springs) predicted to experience drawdowns of up to 13.4 m and 25.6 m in Permian-age strata respectively. This is well below ground level and only the most deep-rooted trees associated with the springs will still be able to access groundwater at this depth. It is concluded that impacts to this spring group will be serious during operations for at least the Lignum and Stories Springs, and of significant magnitude post-closure for the entire spring group.

Figure 8 Groundwater pressure reductions in the aquifers at Mellaluka Springs



Source: GHD, 2013b

7.8 Management and mitigation measures

Impacts to the ecological values of the Mellaluka Spring complex within the operation and post closure of the Project (Mine) are likely to be greater than those occurring during construction. The approach to mitigating and managing operational phase impacts will therefore include a combination of prevention or reduction of all avoidable impacts to the greatest extent possible, active management to maintain and where possible enhance habitats that will not be impacted during staged operations, and active management of areas that will be disturbed during staged mining operations such that they retain their existing values until such time that they are disturbed. Research and monitoring will be a fundamental component of the impact management approach, with a dual objective of informing an adaptive management approach over the life of the project to

achieve reductions in environmental impacts at and near the Project (Mine) Area, as well as contributing to the understanding and protection of ecological values in the Galilee Basin. The Surface Water Monitoring Program and Groundwater Monitoring Program for the Project will provide information to update the groundwater model and confirm the source aquifer of the Mellaluka Spring complex and potential impacts.

Whilst all reasonable efforts will be made to minimise impacts to the Mellaluka Spring complex, vegetation and fauna habitat loss will occur. The overarching objective of managing impacts during the operation phase will be to maintain and where at all possible enhance the ecological values that characterise the Project (Mine) Area and the surrounding landscape, with a view to achieving no-net-loss of regional biodiversity values.

Impacts to Mellaluka Springs are recommended to be managed through the installation of pumps to supplement surface water availability, together with monitoring. The impacts identified on springs affected by the Project (Mine) are not expected to commence until approximately 2020, with reduction in pressure of the aquifers expected by approximately 2035.

The management control measures at Mellaluka Springs complex during pre-construction, construction, operation and post operation are outlined in Table 14, Table 15, Table 16 and Table 17.

Table 14 Pre-construction management control measures at Mellaluka Springs complex

Issue	Control	Responsibility	Timeframe	Documentation
Management	Prepare a water management plan in accordance with the guideline *Preparation of Water Management Plans for Mining Activities* (DERM, 2009).	Environment Manager	Prior to commencement of mining	Water management plan and erosion and sediment control plan in place
Aquatic ecology	Establish control and impact monitoring sites at the Mellaluka Springs	Environmental Manager	Prior to commencement of mining	Aquatic ecology monitoring program
Groundwater	Use monitoring data to set groundwater quality trigger levels.	Environmental Manager	As per groundwater monitoring program	Trigger levels in environmental authority
	Liaise with adjacent landholders and develop bore monitoring programs to detect changes in bores used for water supply.	Environmental Manager	12 months prior to commencement of mining	Updated groundwater monitoring plan.
	Enter into “make good” agreements with surrounding landholders in relation to groundwater impacts.	Stakeholder Manager	Prior to commencement of mining	Agreements in place

Table 15 Construction management control measures at Mellaluka Springs complex

Issue	Control	Responsibility	Timeframe	Documentation
Groundwater	Groundwater will be managed as per the Water management plan.	Environmental Manager	Prior to construction	Approved plan is implemented
	Potential impacts on groundwater quality due to the discharge of potentially contaminated runoff will be prevented through the development and operation of a suitable surface water management system and associated management plan (SWMP).	Environmental Manager	Prior to Construction	Approved plan is implemented
	Prior to the commencement of construction activities the status of each of the existing registered bores that could be significantly affected by the proposed Project (Mine) should be confirmed and a baseline assessment undertaken at each of the active bores in order to establish their pre-operational condition.	Environmental Manager	Prior to construction	Monitoring program and results
Pests	To minimise the risk of pest animal establishment within and adjacent to the Carmichael River, the measures outlined in the weed and pest management plan shall be implemented.	Environmental Manager	Prior to construction	Approved weed and pest management plan implemented.
	Monitoring of feral species populations in the Project Area and implementation of a control program if necessary.	Environmental Manager	During construction and operations	Monitoring records and logs Control Program
Fire	Fire management strategies will be implemented to reduce the potential for destructive high intensity fires to disturb habitats.	Environmental Manager	Ongoing	Approved plan is implemented

Table 16 Operation management control measures at Mellaluka Springs complex

Issue	Control	Responsibility	Timeframe	Documentation
Groundwater	Re-run groundwater model to test drawdown effects on sensitive receptors, review management, monitoring and mitigation measures and develop additional measures as required.	Environmental Manager	Each time model is updated	Updated monitoring, management and mitigation measures
Pests	Monitoring of feral species populations in the Project Area and implementation of a control program if necessary.	Environmental Manager	During construction and operations	Monitoring records and logs Control Program
Fire	Fire management strategies will be implemented to reduce the potential for destructive high intensity fires to disturb habitats.	Environmental Manager	Ongoing	Approved plan is implemented

Table 17 Post operation management control measures at Mellaluka Springs complex

Issue	Control	Responsibility	Timeframe	Documentation
Groundwater	Post closure groundwater modelling to be conducted at least 2 years prior to closure to confirm and/or validate predicted impacts and inform ongoing mitigation measures. Agreements to be in place with affected parties prior to post operations phase in regards to groundwater flow impacts.	Environmental Manager	Post operation	Closure and rehabilitation strategy

7.9 Offsets

The assessment of potential impacts to the Mellaluka Spring complex indicates that no offset is required. In the event that future monitoring and modelling suggest that impacts will be significant and mitigation and management measures are not feasible, offsets may be considered.

7.10 Monitoring

Proposed monitoring for Mellaluka Springs to understand changes due to seasons and/or a reduction in aquifer pressure to this community include:

- A baseline water level should be established at a reference location for the springs, and water levels should be measured against this baseline on a quarterly basis during mining operations.
- These monitoring events should commence at least one year before mining operations (in order to continue a baseline understanding of existing conditions), and continue for at least two years after mining operations are completed.
- At the conclusion of baseline surveys (after at least one year of surveys prior to commencement of mining operations) a Baseline Ecological Condition report should be prepared for the springs.
- An annual report on the spring condition, including statistical comparison to baseline condition, should be provided including reporting on any change from baseline conditions and planned actions.
- These surveys should utilise data gained from studies into groundwater levels conducted by the Mine in the vicinity.
- Ongoing monitoring of Mellaluka Springs will be focused on groundwater studies and is outlined in the Mine Hydrogeology Report.

Pumping groundwater to the surface may act to offset the loss of some sections of the Mellaluka Spring wetland, and it is recommended that the proponent consider installing electric submersible pumps when drawdown commences for this purpose. A wetland remediation and management plan should be prepared at this time in consultation with the Mellaluka owner. A pump may also be required to ensure the continuation of water to the Mellaluka homestead. All surveys and other works will be conducted in consultation with the Mellaluka property owner.

Monitoring sites

The proposed monitoring sites at the Mellaluka Spring complex and the type of monitoring is outlined in Table 18 and Figure A1.

Table 18 Proposed Mellaluka Spring complex monitoring sites

Monitoring Location	Description	Latitude	Longitude	Monitoring
MS01	Mellaluka Spring	-22.318086	146.48369	Surface water flow Groundwater level and quality Aquatic fauna Spring vegetation survey
MS02	Stories Spring	-22.296555	146.481523	
MS03	Lignum Spring	-22.26406	146.47457	

The monitoring actions at Mellaluka Springs complex during pre-construction, construction, operation and post operation are outlined in Table 19.

Note that surface water and groundwater monitoring requirements are being developed as part of a Surface Water Monitoring Program and Groundwater Monitoring Program for the Project.. GDE specialists will be used in a review capcity to inform ongoing monitoring actions (refer Section 13.3).

Table 19 Monitoring at Mellaluka Springs complex

Issue	Monitoring action	Responsibility	Frequency	Performance requirement
Aquatic ecology	Monitor aquatic fauna and stygofauna in selected bores.	Environmental Manager	Annually	Ongoing monitoring
	Mapping and measurement of spring vegetation.	Environmental Manager	Bi-annually	Ongoing monitoring
Surface water	Flow monitoring at spring outlet	Environmental Manager	As per groundwater monitoring program	Ongoing monitoring
Groundwater	Conduct groundwater quality monitoring across monitoring network for: • pH, DO, turbidity, EC, temperature (field and lab) • Total organic carbon • Major ions • Fluoride and sulfide • Nutrients • Dissolved metals • Hydrocarbons (TPH and BTEX)	Environmental Manager	As per groundwater monitoring program	Trigger levels set in environmental authority are not exceeded
	Conduct groundwater level monitoring across monitoring network.	Environmental Manager	As per groundwater monitoring program	Drawdown at Mellaluka Springs does not exceed trigger level to be determined Drawdown at stock and domestic bores does not affect yield
	As Mining activity progresses, the monitoring network will be updated for inclusion of new bores or exclusion of bores in mined areas.	Environmental Manager	Continuous	Ongoing monitoring

7.11 Corrective measures

Corrective measures relevant to environmental characteristics at the Mellaluka Springs complex are identified in Table 20 below, together with corresponding corrective actions.

Table 20 Corrective measures at Mellaluka Springs complex

Trigger	Responsibility	Corrective action
Trigger levels set in environmental authority are exceeded	Environmental Manager	Repeat monitoring immediately on receiving non-compliant results. If repeat results indicate persistent elevation, raise an incident report and commence incident investigation. Undertake corrective actions as identified in the incident investigation.
Drawdown at Mellaluka Springs exceed trigger level to be determined Drawdown at stock and domestic bores affects yield	Environmental Manager	Implementation of adaptive monitoring program. Mine planning and rehabilitation mitigation measures implemented. Implement make good agreements with landholders.

8. Carmichael River subplan

8.1 Environmental characteristics

The Carmichael River, designated as a fifth order stream (DERM, 2009c) (Plate 24), is the major surface water resource potentially affected by the Project (Mine). The flow regime of the Carmichael River is subject to seasonal variability as wet season overland flow drains from the catchment. Late in the dry season the Carmichael River is reduced to a low flow environment, interspersed with deeper pools. The Carmichael River was characterised by a well-established riparian zone that provided extensive shading of the water.

Information on observed surface water flows, groundwater levels and a comparison of groundwater and surface water quality data for the Carmichael River suggests that flows and/or water levels are at least partly supported by direct groundwater flow from the underlying units and/or by discharge from the Doongmabulla Springs.

The sclerophyll community fringing the Carmichael River is dominated by river red gum (*E. camaldulensis* var. *obtusa*), weeping paperbark (*M. leucadendra*) and narrow-leaved paperbark (*M. fluviatilis*), often with waxy cabbage palm present. As the waxy cabbage palm is listed as an MNES and vulnerable under both the EPBC Act and the NC Act, and has the potential to be impacted, it is discussed separately in section 9.

Flows in the Carmichael River in the vicinity of the mine are understood to be relatively persistent. This suggests that Carmichael River and the associated remnant riparian vegetation are groundwater dependent to a degree in the regions upstream of the Project (Mine). Consequently the fauna which are attracted to these areas are also thought likely to be indirectly dependent on groundwater to a degree.

Plate 24 Carmichael River in May 2011 and April 2013

8.2 Potential impacts

8.2.1 Summary of impacts

Major infrastructure construction works are proposed to be undertaken within the Carmichael River flood plain consisting of:

- The bridge over the Carmichael River to convey the haul road and conveyors
- The Mine protection flood levees on the northern and southern banks of the River.

Works within the river floodplain can potentially cause scour and erosion leading to water quality problems and obstruction of flow leading to velocity and flood level problems.

The potential impacts on the Carmichael River as a result of the construction and operation of the Project (Mine) are:

- Alterations to the surface and groundwater regime
- Aquatic habitat degradation
- Water quality degradation
- Introduction or spread of aquatic and terrestrial weed and/or pest species to Project (Mine) Area
- Changes to fire regime.

The construction and operation activities and the potential environmental impact on the Carmichael River are listed in Table 21 and Table 22.

Table 21 Construction activities and the potential environmental impact on the Carmichael River

Construction activity	Potential environmental impact
Dewatering of excavations	• Drawdown of groundwater may occur, however most excavations are relatively shallow with respect to the groundwater levels, relatively small in volume and requiring dewatering only over a short period of time. Hence, impacts are not expected • Disposal of groundwater from dewatering has the potential to cause surface water degradation particularly if salinity is high
Alteration of surface water regimes	• Alteration to surface water regimes, which will be relatively localised and managed during construction
General construction activities	• Introduction of new weeds and pests • Spread of weeds and pests across the site • Habitat degradation from erosion and dust
Contamination from spills or leaks of environmentally hazardous substances	• Large spills of environmentally hazardous materials, or leaks that are allowed to continue over long periods of time may cause contamination of groundwater. Measures to prevent soil contamination will also address risk to groundwater
Vegetation clearing	• Habitat fragmentation, where the vast majority of clearance is to take place within a highly modified and disturbed landscape • Loss of aquatic and riparian habitat, to be minimised at creek and river crossings • Degradation of aquatic habitats and water quality

Table 22 Operation activities and the potential environmental impact on the Carmichael River

Operation activity	Potential environmental impact
Groundwater drawdown from mine dewatering	• Drawdown of 1 to 4 m may occur in the vicinity of the Carmichael River • Groundwater flows to the Carmichael River may be reduced by up to 7 % of groundwater inputs to the River
Mining activities within a floodplain	• Flooding of mine workings and subsequent generation of large volumes of flood affected waters • Increased afflux and flooding extent and duration upstream • Reduced flood flows downstream • Reduction in floodplain area connected to the Carmichael River
Watercourse diversion and works in and adjacent to watercourses	• Changes in downstream flows • Loss of aquatic habitat • Changes in geomorphological form in downstream areas due to scouring or sediment deposition
Altered topography due to subsidence	• There will be a small reduction in downstream flows due to ponding of water in the subsidence troughs. • Changes in hydrology of streams and overland flows may exacerbate erosion, however sediment mobilisation will be into the centre of the subsidence troughs and little if any sediment will be carried downstream.
Contamination from spills or leaks of environmentally hazardous substances	• Large spills of environmentally hazardous materials or leaks that are allowed to continue over long periods of time may cause contamination of groundwater and surface water • Improper irrigation of treated wastewater may cause nutrients to leach to groundwater and surface water
Draining of existing farm dams	• Potential for release of poor quality (low dissolved oxygen, high turbidity, high salinity) water to downstream environments
Dewatering of pits and underground workings	• Generation of mine affected water (MAW), discharge of which may cause high salinity and potentially introduce other contaminants to downstream areas
Ex-pit spoil disposal	• Change in surface topography and runoff characteristics • Release of sediments to water through erosive processes • Acidification if acid generating materials are exposed to oxidising conditions • Saline runoff if saline wastes are exposed
General site activities	• Introduction of new weeds and pests • Habitat degradation including pig damage of riparian areas and erosion caused by rabbit burrowing • Spread of weeds and pests across the site • Changed fire regime
Operation of MIA, including coal handling and processing and workshops	• Generation of MAW, which may contain suspended solids, hydrocarbons and potentially other contaminants

Operation activity	Potential environmental impact
Sediment mobilised by overland flow will be carried to drainage lines and watercourses.	• Increased turbidity, affecting light penetration and photosynthesis processes in aquatic environments • Direct smothering of aquatic ecosystems by deposition of sediment • Where large quantities of sediment are transported to watercourses, geomorphological changes may occur. For example, sediment deposition may obstruct flow causing exacerbation of flooding and alteration of channel pathways.
Vegetation clearing	• Loss of native plants and vegetation communities. • Degradation of adjacent habitat due to dust deposition, changes in overland flow regimes, exposure of edges to sunlight and increased predation • Proliferation of weeds and pests, including class 2 declare weeds and pests under the LP Act • Release of sediments to water through erosive processes
Wastewater generation and treatment	• If improperly managed, release of nutrients, pathogens and other contaminants to downstream waters

Impacts identified as significant in the EIS and SEIS are discussed in more detail below.

8.2.2 Alterations to the surface regime

The potential impacts of construction activities on surface water hydrology and hydraulics include:

- Temporary increased surface runoff as a result of vegetation clearance, topsoil removal and soil compaction on land adjacent to watercourses
- Changed flow velocities, increased erosion and subsequent changes in bed and bank stability as a result of works within or adjacent to watercourses
- Change in local flows (higher in some regions, lower in others) as a result of watercourse diversions or temporarily restricted flows during construction. This would be a localised effect and not expected to impact outside of the construction area.

The mining activities, in particular the development of the pits and underground workings are expected to have an impact on surface water at and around the Project (Mine) Area. Potential impacts include:

- Mine operations will result in the sequential alteration to and loss of water courses (i.e. ephemeral creeks and associated riparian habitat) and water bodies (i.e. farm dams, pools and billabongs in and adjacent to water courses, cattle water points).
- The Mine Area will remove 16,664 ha (25 percent) of the Carmichael River catchment (GHD, 2013c). The Project (Mine) will also result in loss and disturbance of aquatic habitats and fauna and the disconnection of the floodplain. Over staged development of the Mine, the local availability of surface water discharged from the Mine Area will be reduced by 33 percent (GHD, 2013d). This reduction is due to the reduced catchment area and subsidence ponding.
- Diversion drains will also be constructed to divert clean water from upstream catchments around the mine infrastructure. Impacts to surface water quality, including downstream impacts may occur where the geomorphology of waterways is altered, where sediment and/or contaminants are mobilised during construction activities and enter waterways during

and after rainfall or where an increase in localised flow may cause increased erosion and scouring.

- The management and mitigation of the mobilisation of sediment due to an increase in localised flow may cause increased erosion and scouring. Measures to minimise this will be included in the development and implementation of erosion and sediment control plans.
- Areas overlying the proposed underground mining area are expected to be subject to subsidence. Subsidence depths across the Mine Area are predicted to range between 2.0 – 5.5 m. Water will accumulate in subsidence depressions for approximately 24 hrs 60 percent of the time. Alterations in surface topography will lead to changes in surface drainage patterns.

The water balance study (GHD, 2013e) identifies all inflows and outflows on site and includes the proposed Mine water management principles. As part of the study the required major water management infrastructure, i.e. the water storages, have been identified, located and preliminary sized. The designed water management strategy focusses strongly on reusing water on site as much as possible and on minimising volumes of Mine affected water (MAW) on site. MAW is collected in two (2) central MAW dams, one (1) on each site of the Carmichael River. These dams are identified as the two (2) potential discharge points for MAW.

Proposed flood mitigation infrastructure in place with cause afflux to be significant within the Mine area due to the combined effect of minor increased inflows from some of the diverted waterways, reduced runoff coming from the developed Mine internal areas and hydraulic constriction by the flood protection levees, haul road and conveyor crossing. Upstream of the haul road crossing afflux was modelled to peak at 0.98 m for the 1 in 1,000 year ARI event, but at the downstream eastern boundary this had already reduced to peak at 0.09 m adjacent to the Carmichael River. These values are reduced in smaller events, with afflux at the Mine area boundaries generally being relatively insignificant (0 – 0.09 m).

8.2.3 Alterations to the groundwater regime

Groundwater modelling conducted during the SEIS indicate a reduction of around 1,000 m^3/d of river base flow within the Mine areas during the operation stages and 950 m^3/d at post closure (GHD, 2013f). For around 3 km upstream along the Carmichael River of the western boundary of the Mine Area, the predicted pre-development modelled long term average baseflow is approximately 4,150 m^3/day (see Figure 9). Model results suggest the Carmichael River predominantly upstream of the western boundary of the Mine Area is 'gaining' (see Figure 10), which is consistent with groundwater level and surface water flow observations at the site.

From a point some few hundred metres east of the western boundary of the Mine Area, pre-development groundwater flow modelling results suggest that the Carmichael River switches from generally gaining flow to losing flow (see Figure 11) which is consistent with groundwater level and surface water flow observations at the site. Between that point and the eastern Mine Area boundary, predicted pre-development long term average base flow gradually reduces to around 3,150 m^3/day (see Figure 9) and groundwater levels have been measured around 4.5 m below the channel bed.

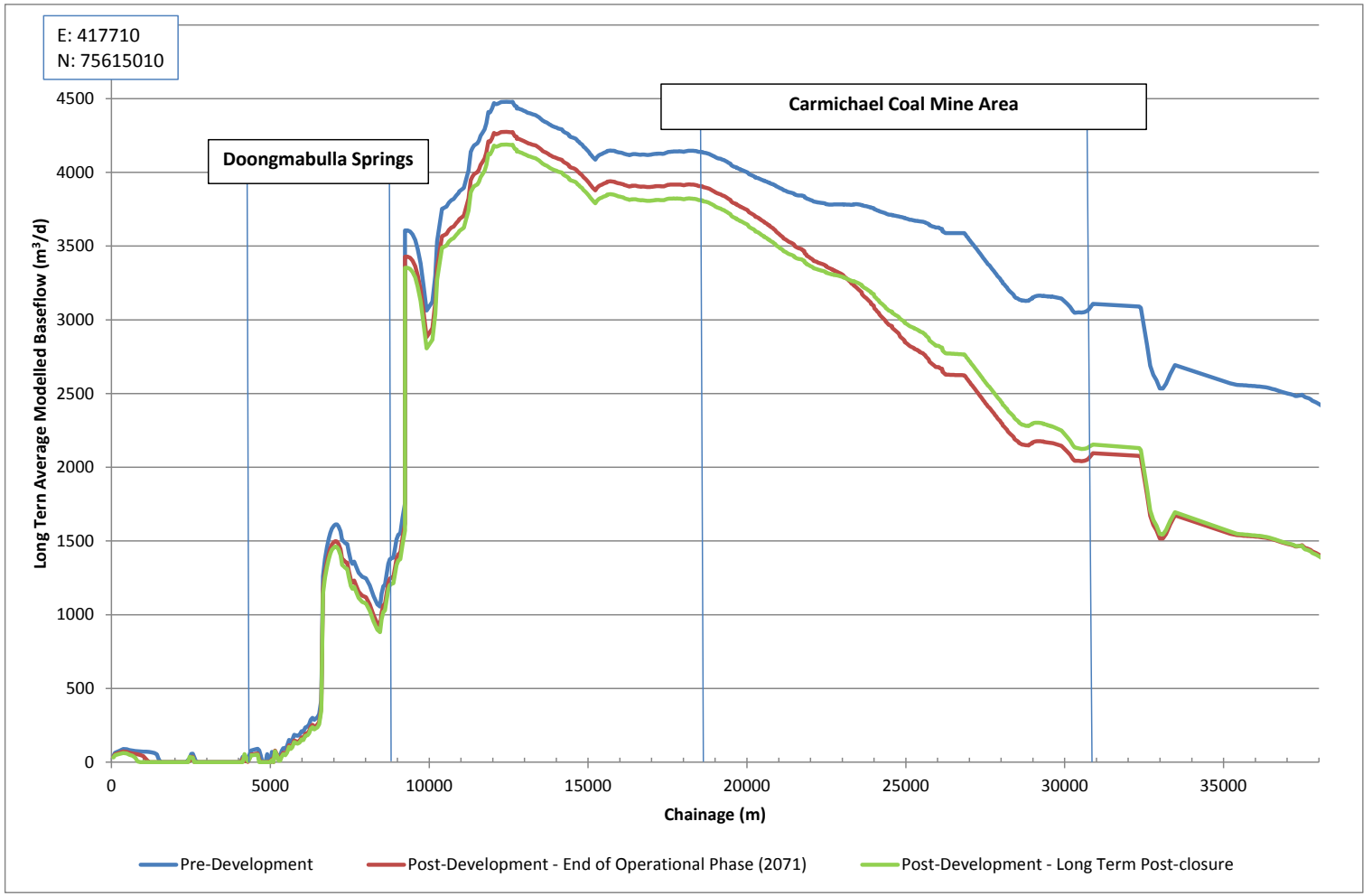
Drawdown of the water table is predicted to reduce the volume of base flow to the Carmichael River and cause the point of zero-base flow to migrate upstream (i.e. to lengthen so it is closer to the eastern boundary of the Mine Area). At the point of peak base flow (located 7 km upstream of the Mine Area boundary), base flow is predicted to be reduced by approximately 6.5 percent (about

200 – 300 m^3/day) during operation and post-closure. When losses due to drawdown within the Mine Area are considered, a total base flow reduction of up to around 1,000 m^3/day (33 percent of pre-development base flow) is predicted across the Mine Area during operation, falling slightly to approximately 950 m^3/day (31 percent of pre-development base flow) post-closure. These reductions are predicted to cause the point at which base flow in the Carmichael River is reduced to zero (through leakage to the ground in 'losing' sections of the river) to migrate 10 km upstream, from 25 km downstream of the eastern Mine Area boundary pre-development, to 15 km downstream post-development.

In general, drawdown of the water table along the Carmichael River is greatest near the middle of the Mine Area, at approximately 4 m, and decreases gradually towards both the western and eastern boundaries. Near the western boundary of the Mine Area, drawdown will be around 1 m and zero flow periods will increase to approximately 5 percent of the time, from 0 percent currently. The groundwater drawdown is predicted to effect the base flow in Carmichael River. It is predicted that the drawdown will result in longer dry periods and the potential loss of drought refuge in the Carmichael River.

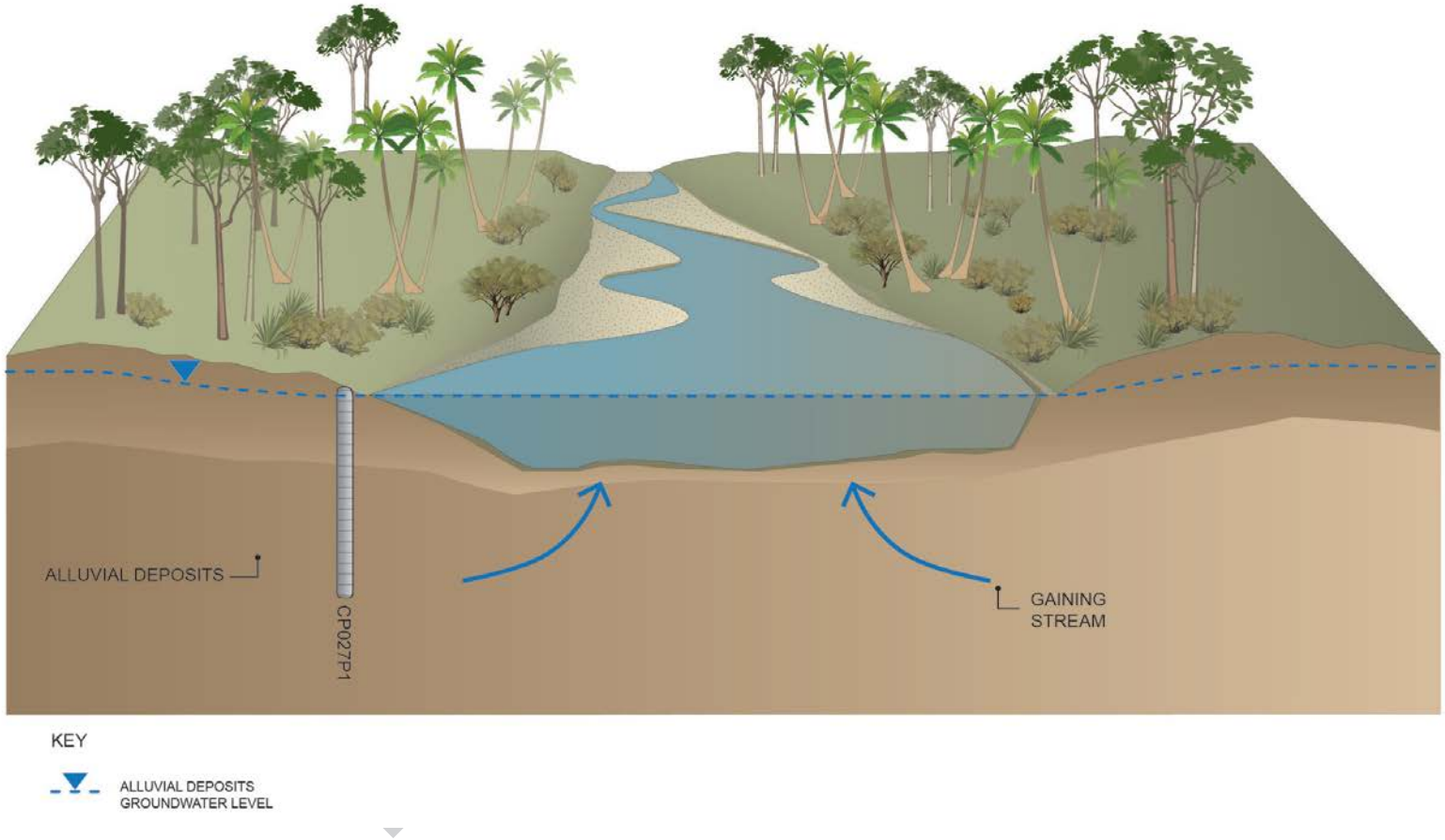
It is important to note that base flow to the river will naturally vary, is seasonally affected, and that current model predictions are effectively long term averages. It is normal for base flow to fluctuate and for many sections of the river to have periods of zero base flow – for example, late in the dry season, or during droughts. Zero base flow periods pre-development are predicted to occur approximately 30 percent of the time at the eastern Mine Area boundary.

Figure 9 Predicted Carmichael River base flow changes



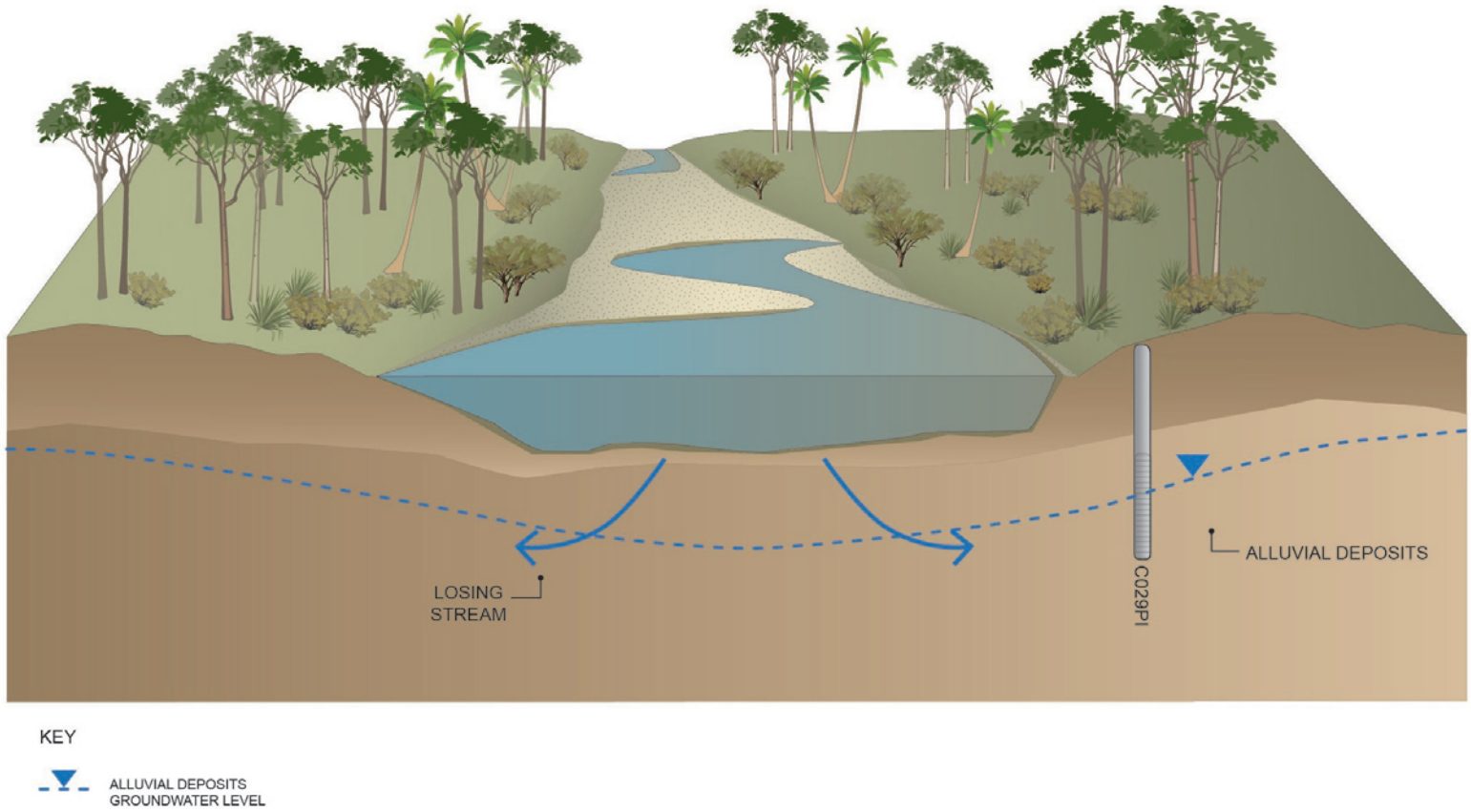
Source: GHD, 2013c

Figure 10 Conceptual river profile model of a 'gaining' river section



Source: GHD, 2013c

Figure 11 Conceptual river profile model of a 'losing' river section



Source: GHD, 2013c

8.2.4 Impacts to riparian vegetation

The Carmichael River riparian community is dominated by river red gums and paperbarks, with waxy cabbage palms (a vulnerable species under both the NC Act and the EPBC Act) sub-dominant in places. Within the Project (Mine) Area, the majority of the river is losing base flow to groundwater, with a section near the western boundary gaining base flow from groundwater. The groundwater drawdown modelling results which may impact on riparian vegetation include (GHD, 2013f):

- Near the western boundary of the Project (Mine) Area, drawdown will be around 1 m and zero flow periods will increase to approximately 5 percent of the time, from 0 percent currently.
- In general, drawdown of the water table along the Carmichael River is greatest near the middle of the Project (Mine) Area, at approximately 4 m, and decreases gradually towards both the western and eastern boundaries.
- At the eastern Project (Mine) Area boundary, base flow will be reduced by around 1,000 m^3/day (33 percent of pre-development base flow) during the operational phase, falling slightly to approximately 950 m^3/day reduction (31 percent of pre-development base flow) post-closure.
- Zero flow periods at the eastern Project (Mine) Area boundary will increase by 30 percent to 60 percent of the time during operation and post closure.

Therefore, impacts will be minimal in the western half of the Project (Mine) Area, and the riparian community are likely to be able to tolerate the predicted changes. In the eastern half of the Project (Mine) Area, existing depth to groundwater is greater than in the west, and therefore riparian vegetation may be more sensitive to changes in base flows.

The riparian community species composition is consistent over the entire length of the Carmichael River within the Project (Mine) Area. While the dominant riparian vegetation in the Carmichael River is tolerant of extended zero/low flow events, a predicted reduction in base flow volume and subsequent increase in zero flow periods is likely to stress plants in locations where groundwater is predicted to be drawn down by up to around 4 m in the near vicinity of the river. In the 800 m stretch where drawdown of between 1 and 4 m, these changes are likely to result in the death of some or all of the canopy trees (probably after a period of some years of slow decline).

It is also possible that some individual trees may be adversely affected in the eastern half of the Project (Mine) Area. River red gums are less affected by changes in base flow than by changes in depth to watertable (Rogers and Ralph, 2011), and are not expected to be affected significantly by the base flow changes due to the relatively low change predicted in the depth to the watertable. Some paperbark species are also known to be more sensitive to changes in groundwater depth than base flow (Eamus et al., 2006). As the eastern section of the Carmichael River within the Project (Mine) Area is mostly predicted to experience reductions in base flow than increases in depth to the water table, it is likely that only the waxy cabbage palm will be impacted significantly in this section. The maximum impact on base flow is expected to occur approximately 20 years into the operational life of the mine.

The primary impacts of reduced base flow to riparian vegetation as the result of drawdown of the groundwater table, reductions in base flow from upstream, and increases in the frequency of zero base flow events on this groundwater dependent ecosystem will result in:

- Potential reductions in health, leading to stress and mortality of the dominant riparian species (river red gums and paperbarks) in the eastern half of the Project (Mine) Area where drawdown is predicted to be up to 4 m.
- Potential impacts may commence with less deeply rooted paperbarks and smaller trees, and continue to more persistent species such as river red-gums (this latter stage may take decades). This dieback is expected to approach 100 percent of the canopy where drawdown will potentially reach 4 m (an 800 m stretch of the river near the centre), but may also occur (albeit not to as great an extent) in the eastern half of the Project (Mine) Area.
- Removal of an important water source providing habitats for aquatic flora and fauna, with consequent reductions in aquatic habitat diversity.

Where dieback of some or all of the trees in the canopy occurs:

- Loss of the open forest canopy will let in more light, favouring weeds and shrubs. In particular, rubber vine (*C. grandiflora* – a class two declared weed) infestations currently in the Carmichael River within the Mine Area will increase in height, area and density, with the capability to render the watercourse inaccessible to humans and large animals. Other weeds such as parkinsonia (*Parkinsonia aculeata* - another class two declared weed) and noogoora burr may also flourish.
- These weeds will increase the quantity of seed moved downstream to other sections of the Carmichael and Belyando Rivers.
- Such weed infestations provide havens for feral pigs, which damage seedlings and exacerbate erosion and bank damage.
- Increasing weeds can lead to a consequent reduction in species diversity and ecosystem complexity, reducing the ability of the watercourse to host a diverse range of species and life forms.
- Loss of the large trees growing in banks and channel bars will result in increased instability of those banks and channel bars. High flow events in future will result in increasing bank and channel erosion, and bank slumping.
- Increased erosion leads to increased sedimentation downstream, with consequent declines in water quality.
- Loss of the forest canopy alters environmental conditions (humidity, dappled shade/sun, temperature gradients in pools, etc.) that are important for instream aquatic macrophytes and invertebrates, with a high potential for reduction in the populations of these species.
- A general loss of breeding, roosting and foraging riparian habitat for fauna utilising the riparian community.

8.2.5 Changes to water quality

Construction activities have the potential to impact on water quality via mobilisation of sediments and pollutants. Without controls, significant impacts on downstream water users may arise from major diesel spills, prolonged release of smaller quantities of hydrocarbons and release of untreated sewage. Suitable mitigation measures are available to avoid or mitigate potential impacts and risks to surface water quality and with these measures in place, significant impact or risk is not expected.

Operational activities have the potential to impact on water quality via discharge of contaminants to the environment. The potential for this to occur will be managed by a range of site water management strategies and environmental authority permit conditions. This is expected to negate any impacts to water quality of the site. There is however residual risk in the potential for events larger than design capacity to occur in extreme circumstances and cause uncontrolled releases of MAW or sediment affected water (SAW) into the environment.

8.3 Management and mitigation measures

The impacts to the Carmichael River will be managed and mitigated through the supplementary introduction of surface water to the channel near the upstream Project (Mine) Area boundary, intensive monitoring of riparian condition, base flows and groundwater levels, removal of weeds and pest animals, mine water management system and sediment and erosion control plan.

Appropriate design of the water management infrastructure, in conjunction with regular inspection, servicing and monitoring of the receiving environment will mitigate the potential for impacts associated with uncontrolled MAW releases due to infrastructure overtopping or failure. The mitigation options are expected to leave minimal residual probability of uncontrolled releases.

Construction activities should be undertaken in a way that minimises the disturbance in and immediately adjacent to waterways. Temporary fencing off of areas around waterways to avoid unnecessary disturbance should be implemented to help achieve this, as well as the use of stormwater, erosion and sediment control infrastructure and management techniques.

The design of sedimentation dams will be in accordance with IECA's (2008) *Best Practice Erosion and Sediment Control* to minimise the risk of erosion and loss of bed and bank stability. Assuming the above mitigation measures are included as part of the Project proposal, no significant impacts are expected to occur on surface water quantity and quality during construction.

Where practicable, preference should be given to completing works within watercourses or floodplains in dry periods. In areas where works cannot be completed before the wet season, work should be planned ahead so that all disturbed areas within or adjacent to watercourses can be stabilised and robust controls can be installed to minimise the potential effects of erosion.

Minimal impacts to the water quality of surface water resources onsite are expected to be realised from operational water usage if the reuse quality characteristics are achieved. The most likely parameter to be impacted is salinity, with MAW be used for operational water requirements.

The management control measures at the Carmichael River during pre-construction, construction, operation and post construction are outlined in Table 23, Table 24, Table 25 and Table 26.

Table 23 Pre-construction management control measures at Carmichael River

Issue	Control	Responsibility	Timeframe	Documentation
Aquatic ecology	Establish control and impact monitoring sites as follows: • Upstream location on Carmichael River • Midway and downstream location on Carmichael River.	Environmental Manager	Prior to construction	Aquatic ecology monitoring program
	Plan works in watercourses to minimise the period of disturbance to the watercourse.	Construction Manager	Prior to construction	Schedule
	Schedule works in watercourses and bulk earthworks to occur outside the wet season wherever possible.	Construction Manager	Prior to construction	Schedule
	As far as practicable, design pipeline crossings, culvert crossings and bed level crossings in accordance with: • Code for self-assessable development Minor waterway barrier works – part 3 culverts (WWBW01) (DAFF, April 2013) • Code for self-assessable development Minor waterway barrier works – part 4 – bed level crossings (WWBW01) (DAFF, April 2013) • Guideline – activities in a watercourse, lake or spring associated with mining operations (WAM/2008/3435) (DERM (2010a)). • Meet the fish passage requirements in accordance with the Fisheries Act and other relevant guidelines.	Design Manager	During detailed design	Design checklist
	Design and layout of the crossing will incorporate a bridge design that spans the watercourse bed and avoids construction within the banks as much as possible	Design Manager	During detailed design	Design checklist

Issue	Control	Responsibility	Timeframe	Documentation
	Develop a detailed 'ecological features' map for the Carmichael River to assist in dieback and river health monitoring, identifying priority management areas including the locations of waxy cabbage palms, rubber vine infestations, riparian composition and health, areas of connectivity/disconnection with the groundwater based on the modelling, gaining/losing areas of the river relative to the groundwater, as a minimum.	Environmental Manager	Prior to construction	Ecological features map
	Prior to the initialisation of works the location of roads, site offices, stockpiling/laydown areas and plant and equipment storage areas (incl. heavy machinery) will be demarcated on site plans and located on existing cleared lands at least 500 m from the Carmichael River.	Environmental Manager	Prior to construction	Site plan
	Finalise construction site plans, including: • Extent of the clearing works. • Environmentally sensitive areas. • Identification of 'no go' zones.	Environmental Manager	Prior to construction	Site plan
Vegetation clearing	Pre-clearing surveys conducted by a suitably qualified ecologist to identify and map habitat trees.	Environmental Manager	Prior to construction	Ecological features map
	Environmentally sensitive areas, including vegetation communities listed under EPBC Act and riparian zones of the Carmichael River will be clearly defined and mapped.	Environmental Manager	Prior to construction	Ecological features map
	Prior to the commencement of construction clearing, a suitably qualified and experienced Environment Officer will mark out with barricade webbing, flagging tape, fluorescent dye or similar, the approved clearing areas and both temporary and permanent 'no go' zones.	Environmental Manager	Prior to construction	Inspections

Issue	Control	Responsibility	Timeframe	Documentation
	Ensure 'no go zones' are clearly sign-posted/ delineated on site prior to the commencement of works.	Environmental Manager	Prior to construction	Inspections
Groundwater	Use monitoring data to set groundwater quality trigger levels.	Environmental Manager	As per groundwater monitoring program	Trigger levels in environmental authority
	Liaise with adjacent landholders and develop bore monitoring programs to detect changes in bores used for water supply.	Environmental Manager	As per groundwater monitoring program	Updated groundwater monitoring plan.
	Enter into "make good" agreements with surrounding landholders in relation to groundwater impacts.	Stakeholder Manager	Prior to commencement of mining	Agreements in place
Surface water	Develop a comprehensive water balance model for the mining operation. Utilise the water balance model to optimise sizing of MAW dams, sediment ponds and discharge infrastructure as well as raw water supply requirements.	Design Manager	Prior to commencement of mining	Model in place
	Review optimal location for MAW controlled discharge on the Carmichael River. Review should include consideration of: • Availability of sufficient dilution flows to control salinity • Potential effects of discharges from proposed mines upstream of the Carmichael Coal Mine • Ability to achieve high volume discharge by gravity.	Design Manager	Prior to construction	Design checklist Updated environmental authority (mining)
	Prepare a water management plan in accordance with the guideline *Preparation of Water Management Plans for Mining Activities* (DERM, 2009) and an erosion and sediment control plan.	Environment Manager	Prior to construction	Water management plan and erosion and sediment control plan in place

Issue	Control	Responsibility	Timeframe	Documentation
	Prepare detailed design for diversions, taking into account: • Hydraulic requirements including energy dissipation • Creation of a geomorphologically stable channel • Potential for environmental values to be reinstated • Potential erosion at outlet point • Maintain existing flows in waterways where practicable • Minimise disturbance to existing waterways. Current relevant guidelines are *Watercourse Diversions Guidelines – Central Queensland Mining Industry* (DERM, 2011).	Design Manager	During diversion design	Design checklist
	Construction of a flood protection levee along either side of the Carmichael River designed to withstand a 1,000 year ARI immunity.	Design Manager	During levee design	Design checklist
	Design all watercourse crossings to maintain flow and minimise afflux where this may affect sensitive receptors or infrastructure, minimise velocities at culverts to prevent scouring and carry frequent flow events with low velocities that are conducive to maintaining the existing habitat. See also design controls for aquatic ecology.	Design Manager	During crossing design	Design checklist
	Construction of bunded areas for chemical storage will be completed prior to any chemicals being delivered to site.	Environment Manager	Prior to any chemicals being delivered to site	Inspections
	Prepare a Receiving Environment Monitoring Program (REMP), including: • Establishing of background and impact monitoring locations for water and sediment quality • Determination of trigger levels and water quality objectives	Environment Manager	Prior to construction	REMP in place

Issue	Control	Responsibility	Timeframe	Documentation
	• A program for routine monitoring of water and sediment quality • A program for continuous monitoring of key parameters that would indicate uncontrolled releases or other mine-related impacts • Procedures for checking results against trigger levels and implementing corrective actions where trigger levels are reached.			
	Prepare a procedure for controlled discharge of MAW. The procedure should include: • Set water quality objectives in relation to controlled discharge of MAW, including: – Any upper limits on salinity in the receiving water, above which the discharge should cease – Any upper limits on salinity in MAW above discharge should not be allowed – Any other water quality related triggers that may be required to protect environmental values of the receiving water. • Monitoring requirements before, during and after a discharge event • Reporting requirements in relation to a discharge event.	Environmental Manager	Prior to operation	Controlled discharge procedure
Weeds and pests	A pest and weed management plan will be developed and will outline specific measures to minimise the risk of weed and pest animal establishment within the project area.	Environmental Manager	Prior to construction	Pest and weed management plan in place

Issue	Control	Responsibility	Timeframe	Documentation
	Weed mapping will be undertaken prior to commencement of construction. Mapping will cover the whole site but be particularly focused at high risk locations, such as areas of black soil so that weed hotspots can be identified. Baseline field surveys of identified hotspots within and near construction areas will be undertaken prior to commencement of construction. Weed control will be undertaken in areas that are very heavily infested or where WONS or Class 1 or 2 weeds declared under the LP Act are present prior to disturbance.	Environmental Manager	Prior to construction	Weed mapping report
Training	Prior to site entry, all site personnel including contractors shall be appropriately trained and made aware of the sensitive environs in which they will be working.	Environmental Manager	Prior to construction	Training log
	Where applicable booklets and other documentation will be provided to construction staff outlining what to do if a significant/threatened species is encountered.	Environmental Manager	Prior to construction	Information booklets

Table 24 Construction management control measures at Carmichael River

Issue	Control	Responsibility	Timeframe	Documentation
Management	No invasive works (eg clearing) is to be undertaken until all local, State and Commonwealth approvals are obtained.	Staff on site	Prior to commencement of construction	Approval
	The works must comply with all relevant approval conditions (eg. NC Act, EPBC Act, EP Act approval).	Staff on site	Prior to commencement of construction	Approval
	Implement measures outlined in the surface water management plan and the erosion and sediment control plan.	Construction Manager	During construction	Approved surface water management plan implemented Approved erosion and sediment control plan implemented
	Erect appropriate signage near sensitive habitats.	Environmental manager	Prior to commencement of construction	Inspections
	Weather conditions should be monitored and if significant rain events are forecast, any in-stream works should cease and disturbed streams should be stabilised	Construction Manager	During construction	Inspections
Aquatic ecology	Avoid undertaking works in streams in times of flow wherever possible.	Construction Manager	During construction	Schedule
	Riverine protection permit exemption requirements identified by the Department of Natural Resources and Mines (DNRM) should be adhered to, or if these cannot be met, conditions of a riverine protection permit should be complied with.	Construction Manager	During construction	Inspections
	Disturbance areas on either side of the haul road crossing and leeves should be kept minimal and stabilised as soon as reasonably possible.	Construction Manager	During construction	Schedule
	Laydown, storage areas and parking lots must not be placed in the vicinity of creeks or rivers (500 m from the Carmichael River) or near to sensitive receptors (i.e. groundwater bores or GDEs).	Construction Manager	Ongoing	Approved site plan

Issue	Control	Responsibility	Timeframe	Documentation
	For culvert and low level crossings for access roads, ensure that design requirements are met during construction and: • Remove topsoil and vegetation and set aside for reinstatement • Place culverts or pipes such that the bed level remains even • Use topsoil and vegetation in rehabilitation • Stabilise completed surfaces with “soft” techniques such as jute matting or geotechnical fabric as far as practicable.	Construction Manager	During construction	Stable work areas
	For diversions, ensure diversions are constructed as per design. Minimise construction activities during flow events where practical and stabilise works as quickly as possible after construction.	Construction Manager	During construction	Stable work areas
	Dust suppression mechanisms will be put in place to ensure excessive dust deposition does not occur, especially in environmentally sensitive area (including riparian vegetation and Carmichael River).	Construction Manager	During construction	
Groundwater	Identify presence and quality of groundwater in any areas where excavation is to occur and determine approach to managing groundwater from excavation such that degradation of surface water quality or land does not occur. Document management approach and monitoring requirements in the work permit application.	Construction Manager	Prior to any excavation more than 2 m below ground level	Work permit details
	Check that work permit applications include appropriate measures for management of groundwater from excavations.	Environmental Manager	Prior to issuing permit	Work permit
	Implement measures outlined in the surface water management plan to prevent potential impacts on groundwater quality due to the discharge of potentially contaminated runoff	Environmental Manager	During construction	Approved surface water management plan is implemented

Issue	Control	Responsibility	Timeframe	Documentation
	Prior to the commencement of construction activities the status of each of the existing registered bores that could be significantly affected by the proposed Project (Mine) should be confirmed and a baseline assessment undertaken at each of the active bores in order to establish their pre-operational condition.	Environmental Manager	Prior to commencement of construction	Monitoring program and results
Surface water	If farm dams are required to be drained: • Test water quality (pH, DO, turbidity and EC) • Utilise water for dust suppression as a first preference • If water cannot be used for dust suppression, then manage as follows: – If EC is less than 1300 us/cm, pH is in the range 6.5-8.5, turbidity is less than 130 NTU and DO is above 4 mg/l, water may be pumped to the downstream watercourse. Pump rate should be such that water does not overflow the channel, scouring does not occur and suspended sediment from the base of the storage is not suspended. Monitor turbidity levels through and cease discharge if turbidity exceeds 50 NTU. – If DO is below 4 mg/L, discharge to watercourse may be possible with aeration, however care must be taken not to stir up sediment from the bottom of the storage such that turbidity exceeds 130 NTU. – If EC is more than 1300 us/cm, pH is outside the range 6.5-8.5, or turbidity exceeds 50 NTU, consider suitability for irrigation of pasture areas or rehabilitation trials. Water is to be irrigated such that ponding and runoff does not occur. Alternatively, transfer to another storage for later use.	Construction Manager	When draining dams	Water quality data and discharge records, permit to disturb.

Issue	Control	Responsibility	Timeframe	Documentation
	Do not take water from the Carmichael River for use during construction.	All	At all times	No water taken from Carmichael River
Vegetation clearing	Clearing is a last resort – retention of vegetation, selective clearing and trimming is the first priority.	Environmental Manager	During construction	Site plan
	The clearing footprint and all 'no go' zones are adequately marked out for the clearing crew.	Environmental Manager	During construction	Inspections
	Clearing slopes leading to watercourses shall be delayed, where practicable, until construction of the crossing is imminent, or alternative measures are employed to prevent and/or minimise erosion and sedimentation risk.	Construction manager	During construction	Construction schedule
	Nominate or employ a suitably qualified and experienced officer to oversee the environmentally relevant tasks and activities.	Environmental Manager	During construction	
Weeds and pests	To minimise the risk of weed and pest animal establishment within and adjacent to the Carmichael River, the measures outlined in the weed and pest management plan shall be implemented.	Environmental Manager	During construction	Approved weed and pest management plan implemented.
	Conduct weed and pest control program for rubber vine, Parkinsonia, noogoora burr, feral cats, pigs and cane toads.	Environmental Manager	Annually	Records of control program
	Ensure that all earthmoving equipment has undergone correct wash-down procedures to minimise the risk of introducing weeds (declared or otherwise) to aquatic environments within the Project (Mine).	Construction Manager/ Environment Manager	During construction	Weed hygiene declaration
	Vegetation and soil waste should not be moved to areas of lower weed infestation.	Construction Manager	During construction and operations	Site management plans
	Pest animal occurrence will be monitored during construction. If increased densities of pest animals are observed, or new pest animals are identified, humane pest controls will be implemented to manage numbers.	Environmental Manager	During construction and operations	Monitoring records and logs

Issue	Control	Responsibility	Timeframe	Documentation
	Monitoring will be undertaken annually during construction, with results to be considered in terms of baseline information (collected prior to construction) and with reference to appropriate control (reference) sites. If significant infestations of any weeds occur, or if WONS or Class 1 or 2 weeds declared under the LP Act, weed control measures will be implemented. Weed control measures will be based on Queensland Department of Agriculture, Forestry and Fisheries and Isaac Regional Council advice. Declared pests listed under the *Plant Protection Act 1989* will also be monitored as part of the annual monitoring program during construction.	Environmental Manager	During construction and operations	Monitoring records and logs
	All vehicles, equipment and materials brought onto site will be certified as free of weeds and weed seeds and carry a weed hygiene declaration. Records are to be kept of compliance with this requirement. Adani will install a weed wash down facility onsite.	Plant Manager / Contractors	During construction and operations	Records Wash down facility
	Soil stripped and stockpiled from areas containing known declared pests listed under the *Plant Protection Act 1989* and weed infestations will be stored separately and are not to be moved to areas free of weeds and declared pests.	Site Manager	During construction and operations	Soil management plans and records
	Construction staff will not bring domestic animals to the Project Area.	Site Manager	During construction and operations	No domestic animals
	Monitoring of feral species populations in the Project Area and implementation of a control program if necessary.	Environmental Manager	During construction and operations	Monitoring records and logs Control Program
Fire	Fire management strategies will be implemented to reduce the potential for destructive high intensity fires to disturb habitats.	Environmental Manager	Ongoing	Approved plan is implemented

Issue	Control	Responsibility	Timeframe	Documentation
Training	Periodic toolbox training to be provided to all construction personnel to present new information or reiterate information relating to management of environmental values throughout construction.	Environmental Manager	Ongoing	Training log
	In the event of a non-compliance, the Proponent will issue a “stop work” order, upon which all work will cease until the non-compliance has been rectified and measures implemented to prevent the breach re-occurring.	Environmental Manager	Ongoing	Monitoring records and logs

Table 25 Operation management control measures at Carmichael River

Issue	Control	Responsibility	Timeframe	Documentation
Aquatic ecology	For culvert and low level crossings for access roads, ensure that design requirements are met during construction and: • Remove topsoil and vegetation and set aside for reinstatement • Place culverts or pipes such that the bed level remains even • Use topsoil and vegetation in rehabilitation Stabilise completed surfaces with "soft" techniques such as jute matting or geotechnical fabric as far as practicable.	Environmental Manager	During operations	Stable work areas
	Staff will be informed via a site specific induction of the aquatic species that are likely to be encountered within the Project Area.	Environmental Manager	During operations	Induction training records
Groundwater	Re-run groundwater model to test drawdown effects on sensitive receptors, review management, monitoring and mitigation measures and develop additional measures as required.	Environmental Manager	As per Groundwater Monitoring Program	As per Groundwater Monitoring Program
Surface water	Prepare and implement an operating plan for MAW and sediment dams, or incorporate operating requirements into the Plan of Operations. Operating plan is to include: • Annual dam surveillance inspections when dam is at a low level • Water quality monitoring • Operational requirements in relation to water levels, transfers between storages and reuse of MAW • Requirements for recording mine water management transfers and use • MAW discharge approval parameters.	Mine Manager	Before operating MAW and sediment dams Ongoing	Dam operating plan Monitoring and surveillance records, mine water management records

Issue	Control	Responsibility	Timeframe	Documentation
	Transfer all MAW to MAW dams. MAW is not to be placed in sediment basins or directly discharged except under EA Conditions.	Mine Manager	Ongoing	Mine water management records
	Utilise MAW for the following uses in preference to raw water: • Dust suppression • CHPP (except where raw water is required for particular processes) •	Area Managers	Ongoing	Mine water management records
	Review and update Mine Water Management Plan.	Mine Manager	Every five years or more frequently if required to address non-compliance	Updated plan
	Review and update Receiving environment monitoring plan.	Environmental Manager	Every five years or more frequently if required to address non-compliance	Updated plan
	Include maintenance of the following items in mine maintenance schedule: • Oil water separators • MIA stormwater systems • Pumps and pipes • Controlled discharge infrastructure.	Mine Manager	As per maintenance schedule	Maintenance records
Weed and pests	The measures outlined in the weed and pest management plan shall be implemented.	Environmental Manager	During operations	Approved weed and pest management plan implemented.
	Aquatic weed infestations will be identified and managed in accordance with the Isaac Regional Council Pest Management Plan and the weed and pest control strategies detailed within this EMP (Mine).	Environmental Manager	During operations	No increase in existing infestation or the occurrence of new infestations

Issue	Control	Responsibility	Timeframe	Documentation
	Wash-down of plant, machinery and vehicles will be undertaken in designated and controlled locations where waste water and weed seed material will be captured and prevented from discharging to watercourses.	Environmental Manager	During operations	Designated weed wash-down areas Weed hygiene declaration
Fire	Fire management strategies will be implemented to reduce the potential for destructive high intensity fires to disturb habitats.	Environmental Manager	Ongoing	Approved plan is implemented

Table 26 Post operation management control measures at Carmichael River

Issue	Control	Responsibility	Timeframe	Documentation
Riparian vegetation	Maintenance of revegetated areas until vegetation cover criteria is achieved.	Environmental Manager	Post rehabilitation	Closure and rehabilitation strategy
Weed and pests	Weed eradication and control as required during revegetation.	Environmental Manager	During revegetation	Closure and rehabilitation strategy
All	Monitoring of the Carmichael River corridor.	Environmental Manager	• Erosion – bi-annually • Surface water – quarterly and event based • Groundwater – quarterly and event based • Geotechnical (stability) – half yearly • Rehabilitation (Ecology) – annually All monitoring to continue 5 years after rehabilitation	Closure and rehabilitation strategy
Groundwater and surface water	Post closure groundwater modelling to be conducted at least 2 years prior to closure to confirm and/or validate predicted impacts and inform ongoing mitigation measures. Agreements to be in place with affected parties prior to post operations phase in regards to groundwater flow impacts.	Environmental Manager	Post operation	Closure and rehabilitation strategy

8.4 Offsets

The assessment of potential impacts to the Carmichael River indicates that an offset is required where unavoidable impacts to Waxy Cabbage Palm are predicted to occur, on the eastern portion of the Carmichael River through the Mining Lease. This represents 4 hectares of habitat requiring offsetting.

8.5 Monitoring

Proposed monitoring for the Carmichael River to understand changes in water quality, riparian vegetation and aquatic ecology due to seasons and/or a reduction in aquifer pressure to this community include:

- Baseline surface and groundwater quality and level should be established at reference locations for the Carmichael River , and water quality and levels should be measured against this baseline on a quarterly basis during mining operations.
- A baseline survey of aquatic invertebrates, aquatic weeds, fish species and abundance and macroinvertebrate taxa and abundance conducted by a suitably qualified ecologist prior to mining operations commencing.
- Mapping and measurement of the riparian vegetation bi-annually using permanent CORVEG primary monitoring transects.
- These monitoring events should commence at least one year before mining operations (in order to continue a baseline understanding of existing conditions), and continue for at least two years after mining operations are completed.
- At the conclusion of baseline surveys (after one year of surveys prior to commencement of mining operations) a Baseline Ecological Condition report should be prepared for the Carmichael River.
- An annual report on the Carmichael River condition, including statistical comparison to baseline condition, should be provided including reporting on any change from baseline conditions and planned actions.

Water quality parameters should include temperature, pH, Electrical Conductivity (EC), dissolved oxygen (DO), turbidity, total dissolved solids (TDS), total suspended solids (TSS), major anions and major cations; nutrients (total nitrogen, nitrate, nitrite, ammonia, total kjeldahl nitrogen (TKN) and total phosphorus); total and dissolved metals (aluminium, arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, zinc, boron, cobalt, manganese, molybdenum, selenium, silver, uranium and vanadium); and total petroleum hydrocarbons (TPH) C6-C36.

For all mine discharges, DEHP requires a minimum of a) one upstream (background) site to determine flows prior to discharging; and b) one downstream (potentially impacted) site to be sampled during discharge events to ensure that the environmental values (EVs) are maintained. Due to access constraints, the only effective way to monitor the upstream and downstream sites may be to install automated samplers in existing gauging stations, and/or establish all-weather access roads to sites.

Monitoring sites

The proposed GDE monitoring sites along the Carmichael River are outlined in Table 27 and Figure A1.

Table 27 Proposed waterway monitoring sites

Monitoring Location	Description	Latitude	Longitude	Monitoring
CAR01	Carmichael River downstream	-22.0740740	146.4675990	SWQ, SWL, GWL, F, M, AW, CORVEG
CAR02	Carmichael River mid-section	-22.0975750	146.4055550	SWQ, SWL, GWL, F, M, AW
CAR03	Carmichael River at Main Crossing	-22.1071410	146.3957890	SWQ, SWL, GWL, F, M, AW, CORVEG, WCP
CAR04	Carmichael River at upstream Gauging Station	-22.1087960	146.3527180	SWQ, SWL, GWL, F, M, AW, CORVEG, WCP
CAR05	Carmichael River upstream of proposed road crossing	-22.106072	146.3694	GWL, CORVEG, WCP
CAR06	Carmichael River at proposed road crossing	-22.112544	146.3827	GWL, CORVEG, WCP
CAR07	Carmichael River	-22.095602	146.4322	GWL, CORVEG, WCP
CAR08	Carmichael River at boundary	-22.074663	146.451	CORVEG
CCK01	Cattle Creek upstream of Dylingo confluence at Moses Springs	-22.0906570	146.2562410	SWQ, SWL, GWL, F, M, AW, CORVEG
CT01	Cabbage Tree Creek approx 2.5 km downstream of Carmichael River confluence	-22.1067830	146.4139080	SWQ, SWL, GWL, F, M, AW, CORVEG
DCK01	Dyllingo Ck at Carmichael/Moray Rd	-22.0888320	146.2606000	SWQ, SWL, GWL, F, M, AW, CORVEG, WCP
DCK02	Dyllingo Ck	-22.106886	146.3237	GWL, CORVEG, WCP

Monitoring codes:

AW	aquatic weeds
M	macroinvertebrates
CORVEG	riparian vegetation transect
SWL	surface water level
F	fish
SWQ	surface water quality
GWL	groundwater level
WCP	waxy cabbage palm health

The monitoring actions at the Carmichael River during pre-construction, construction, operation and post construction are outlined in Table 28. Note that surfacewater and groundwater monitoring requirements are being developed as part of a Surface Water Monitoring Program and Groundwater Monitoring Program for the Project.

8.6 Corrective measures

Corrective measures relevant to the environmental characteristics of the Carmichael River are identified in Table 29, together with corresponding corrective actions.

Table 28 Monitoring at the Carmichael River

Issue	Monitoring action	Responsibility	Frequency	Performance requirement
Aquatic ecology	Monitor aquatic ecology monitoring sites: • In situ water quality (at time and location of each aquatic ecology monitoring event) • Presence of aquatic weeds • Fish species and abundance • Macroinvertebrate taxa and abundance. Undertake statistical analysis of results including SIGNAL, PET and multivariate analysis.	Environmental Manager	At least two events prior to commencement of mining. Annually for first 10 years of mining. Every two years thereafter. Monitoring to take place towards the end of the wet season.	No statistically significant change in aquatic ecology between control and impact sites and between baseline and post impact results from each monitoring event compared to the approved condition.
Riparian vegetation	Permanent CORVEG primary monitoring transects will be established at regular intervals along the river for the purpose of establishing a riparian community health baseline. If possible, depth to groundwater data should be incorporated.	Environmental Manager	In the initial development/operational phases of the mine monitoring of the plots will be seasonal, reflecting high flow/low flow variability in the Carmichael River (twice annually). This monitoring should continue into the mid operational life of the mine.	No statistically significant change in riparian vegetation between control and impact sites and between baseline and post impact results from each monitoring event compared to the approved condition
Surface water and groundwater	Monitor base river flow, surface and groundwater flows in the Carmichael River.	Environmental Manager	As per the Groundwater and Surface Water Monitoring Programs	No more than 10 % variance in groundwater inflows compared to the approved condition (section 2.10)

Issue	Monitoring action	Responsibility	Frequency	Performance requirement
Groundwater	Conduct groundwater quality monitoring across monitoring network for: • pH, DO, turbidity, EC, temperature (field and lab) • Total organic carbon • Major ions • Fluoride and sulfide • Nutrients • Dissolved metals • Hydrocarbons (TPH and BTEX).	Environmental Manager	As per the Groundwater and Surface Water Monitoring Programs	Trigger levels set in environmental authority are not exceeded
Water quality	Monitor water quality in MAW dams.	Mine Manager	Monthly	For internal water management purposes only
	Monitor the mandatory reporting level in all high and significant hazard dams.	Mine Manager	Continuous	Below level specified in environmental authority
	Monitor background and impacted water quality as per REMP.	Mine Manager	As per REMP	Below triggers specified in REMP
	Monitor EC/salinity upstream and downstream of controlled discharge point and at point of discharge.	Mine Manager	As per Environmental Authority Conditions	To be determined
Weeds and pests	Monitor pest animal numbers at key water resource locations.	Environmental Manager	Quarterly	No increase in pest animal occurrence
	Conduct inspections of disturbed areas for weed proliferation.	Environmental Manager	Annually	Weed levels in disturbed areas are similar to pre-clearing

Table 29 Corrective measures at Carmichael River

Issue	Trigger	Responsibility	Corrective action
Aquatic ecology	Statistically significant change in aquatic ecology between control and impact sites and between baseline and post impact results from each monitoring event.	Environmental Manager	If significant differences are observed, an incident should be logged and an incident investigation carried out to determine cause of changes and develop corrective actions.
Riparian vegetation	Statistically significant change in riparian vegetation between control and impact sites and between baseline and post impact results from each monitoring event.	Environmental Manager	If significant differences are observed, an incident should be logged and an incident investigation carried out to determine cause of changes and develop corrective actions.
Groundwater	Greater than 10 % reduction in groundwater inflows compared to the approved condition (section 2.10)	Environmental Manager	Direct diversions to the Carmichael River or release high quality water to the River.
	Groundwater quality trigger levels set in environmental authority are exceeded.	Environmental Manager	Repeat monitoring immediately on receiving non-compliant results. If repeat results indicate persistent elevation, raise an incident report and commence incident investigation. Undertake corrective actions as identified in the incident investigation.
Water quality	MAW water quality greater than triggers specified.	Environmental Manager	Commence treatment to address contaminant levels. If necessary, transfer water between MAW dams to ensure that an uncontrolled overflow does not occur.
	Level in all high and significant hazard dams greater than trigger level.	Environmental Manager	Report to regulatory body (DEHP) that mandatory reporting level has been reached. Determine measures to reduce water level to below mandatory reporting level (controlled release, transfer to other dams).
	Water quality greater than triggers specified in REMP.	Environmental Manager	As specified in REMP
	EC/salinity upstream and downstream of controlled discharge point and at point of discharge greater than trigger levels.	Environmental Manager	Cease discharge if trigger level is reached at downstream monitoring location.

Issue	Trigger	Responsibility	Corrective action
Weed and pests	Increase in pest animal occurrence.	Environmental Manager	Conduct a pest animal control program. Control program will prioritise class 2 declared pest species listed under the LP Act that are known to occur within the Isaac Regional Council area.
	Weed levels in disturbed areas are greater than pre-clearing.	Environmental Manager	Conduct a weed control program. Control programs will prioritise class 2 declared weed species listed under the LP Act that are known to occur within the Isaac Regional Council area including: • Bellyache bush • Chinee apple • Giant rat's tail grass • Harrisia cactus • Hymenachne (aquatic sp.) • Mother of millions • Parkinsonia • Prickly acacia • Prickly pear • Rubber vine • Salvinia • Tobacco weed.

9. Waxy cabbage palm subplan

9.1 Environmental characteristics

The waxy cabbage palm (*L. lanuginosa*) is listed as vulnerable under the EPBC Act. The waxy cabbage palm grows to approximately 20 m tall. Its leaves are broadly circular, reaching up to 190 centimetres (cm) in width. Leaf stems grow up to 200 cm long, and have protruding sharp thorns (Rodd, 1998). The species is distinctive for the long woolly hairs on the stems of the leaves and the flower stalks.

In general, there is a shortage of records in Australian herbaria for the waxy cabbage palm (relative to other plant groups). All records of collections lodged with Australian herbaria are for palms located in tributaries of the Burdekin River, primarily upstream and within 130 km of Lake Dalrymple. Based on surveys conducted in 2002 by Dowe and Pettit, it was estimated that the total adult population of the species (at that time) was less than 1000 individuals (Pettit and Dowe, 2003, quoted in DSEWPaC, 2013c).

All known populations of waxy cabbage palm are growing on sandy, ephemeral watercourses or their floodplains. These watercourses are often braided or anastomosed systems, although populations do occur on single channel streams (Dowe, 2010; Rodd, 1998; DSEWPaC, 2013c). At some sites, palms have been located growing on the floodplain, and these have been associated with a high water table (Dowe, 2009). Individuals are usually located within or adjacent to the stream channel, where they can form an important component of the riparian canopy (Pettit and Dowe, 2003). Riparian canopy vegetation recorded as associated with the waxy cabbage palm includes *E. camaldulensis* var. *obtusa* (river red gum), *E. tereticornis*, *E. platyphylla, M. leucadendra* (weeping paperbark), *M. fluviatilis* (narrow-leaved paperbark)*, Casuarina cunninghamiana*, and *Corymbia brachycarpa* (Queensland Herbarium, 2013; Rodd, 1998; DSEWPaC, 2013a).

Waxy cabbage palm were confirmed present within the Project (Mine) Area during investigations for the EIS at the Carmichael River and at Moses Spring on Doongmabulla Station (Plate 25) in 2012 (GHD, 2012).

Plate 25 Waxy cabbage palms at Moses Spring (left); waxy cabbage palms on Carmichael River channel bench (April, 2013)

Additional targeted field surveys in 2013 identified a total of 831 palms, with 19 of these individuals counted at Moses Spring, and the remainder in the Carmichael River (Figure 12) (GHD, 2013g). The majority of individuals were situated in two areas of high population density (of 479 palms and 155 palms, respectively). Adult palms accounted for only 11 percent of this population.

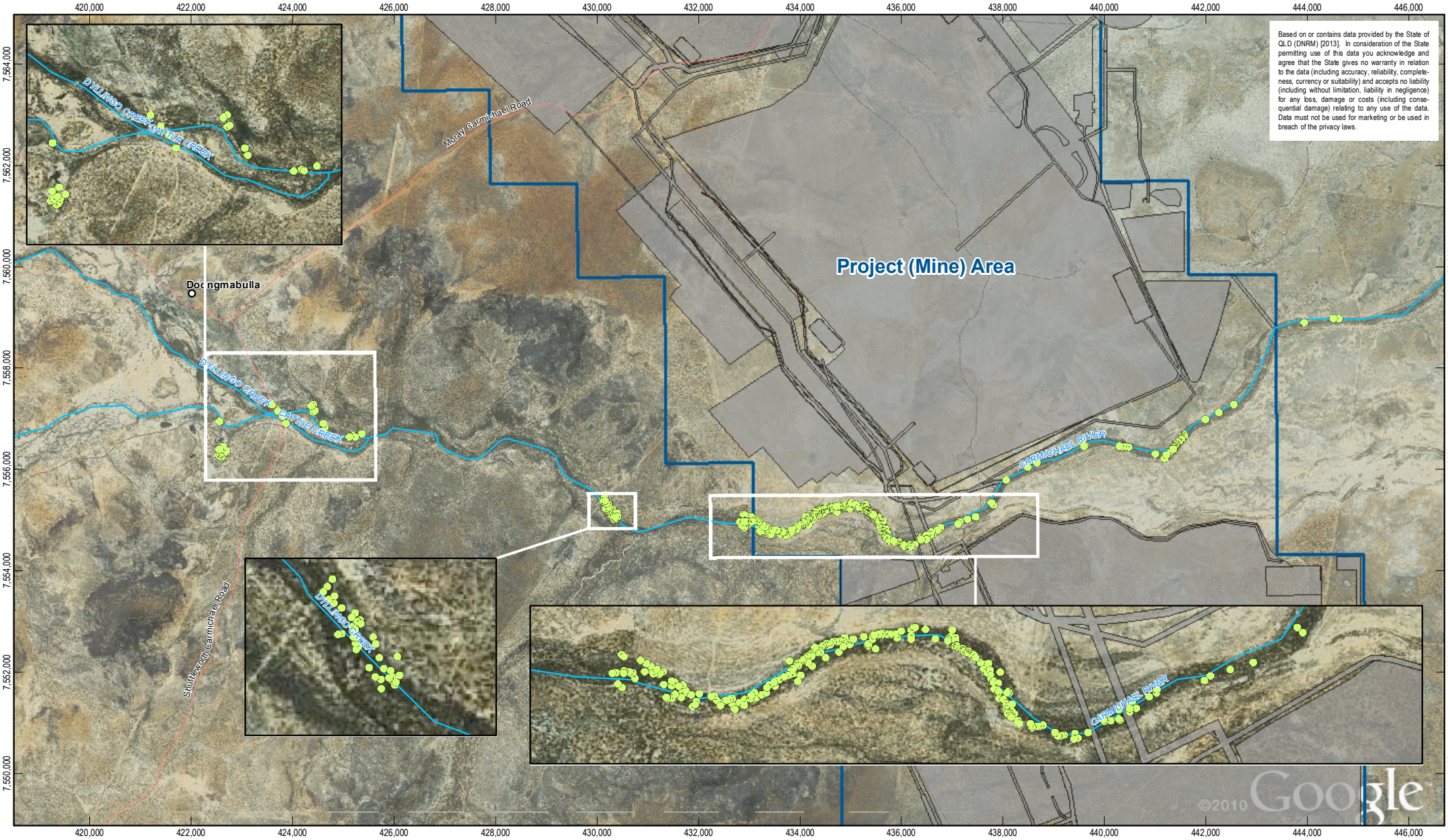
At Moses Spring, the palms are located at the interface between two vegetation communities – a *S. pamalae* grassland, and a river red gum (variety *obtusa*) and weeping paperbark woodland/open woodland, which comprises much of the vegetation adjoining the south-eastern edge of the Moses Spring.

All waxy cabbage palms at Moses Spring are located within 100 m of a central point, generally within the river red gum/weeping paperbark community on the outskirts of the spring wetland, with a core population of 16 palms located within a 50 m radius. Although the palms at Moses Spring are situated in the Carmichael River catchment, their location in a GAB spring wetland is unique for this species (based on current Australian herbaria records (CHAH, 2013) and the DSEWPaC website (DSEWPaC, 2013c)).

Within the Carmichael River, waxy cabbage palms were recorded on the banks of the river channel and within the adjacent floodplain. The habitat where the species was encountered is characterised by an open forest with a canopy from 20 – 25 m tall dominated primarily by river red gums, some up to 10 m in circumference, frequently with weeping paperbark and narrow leaved paperbark dominating or co-dominating in places. Waxy cabbage palm constitutes a sub-canopy where it is present, but elsewhere there is a negligible to absent lower tree and shrub layer. The ground layer is generally dense, and is dominated by mat rush, with *Juncus continuus* growing in the channel beds and grasses including kangaroo grass (*Themeda triandra*), golden beard grass (*Chrysopogon fallax*), Queensland blue grass (*Dichanthium sericeum*), *Eragrostis elongata* and *Bothriochloa bladhii*.

The SEIS survey findings indicate that the population is not spread evenly along the Carmichael River. Furthermore, the waxy cabbage palm population structure differs between the Moses Spring (which is much smaller, located in atypical habitat, and relatively isolated) and Carmichael River (which has a high level of internal connectivity and is located in more typical habitat for the species) populations. The Carmichael River populations have considerably higher numbers of seedlings than in the sub-adult or adult stages, and no other sub-population trends upwards as sharply or permanently as age increases.

Little is known of the groundwater dependence of the waxy cabbage palm – it is a species restricted to watercourses and the immediate flood plain, and a connection with groundwater has been postulated as likely by at least one researcher (Pettit and Dowe, 2003). In the population study of this species at the Mine and in nearby reaches of the Carmichael River (17.5 km of river in total), including at Moses Spring, it was found that more than 60 percent of all waxy cabbage palm individuals in the survey area, including more than 80 percent of the adults, are located in one 3 km long cluster. This cluster is situated on a reach of the river inside the western boundary of the Mine Area, where groundwater is recorded as being 0.5 m above the floor of the river channel, implying a correlation.



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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Homestead
- Waxy cabbage palm population
- Local Road
- Track
- Watercourse
- Project (Mine)
- Mine (Onsite)

*Note: Some points represent clusters of 2 or 3 individuals

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Groundwater Dependant Ecosystems Management Plan

Location of waxy cabbage palm population associated with the Study Area: Carmichael River

Job Number 41-26422
Revision B
Date 15 Jan 2014

Figure 12

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It is considered that the Carmichael River and Moses Spring supports an 'important population' of the waxy cabbage palm, noting that an important population of an (EPBC Act) vulnerable species is defined as a population that is necessary for a species' long-term survival and recovery, including populations identified as such in recovery plans, and/or that are:

- Key source populations either for breeding or dispersal
- Populations that are necessary for maintaining genetic diversity
- Populations that are near the limit of the species range (DEWHA, 2009a).

Furthermore, habitat for this species within the Carmichael River and Moses Spring is considered 'habitat critical to the survival of the species', as defined in the Significant Impact Guidelines (DEWHA, 2009a).

9.2 Threatening processes

Threatening processes listed for the waxy cabbage palm by DSEWPaC (2013c) are:

- Inappropriate or modified fire regimes
- Changes to hydrology including building dams and barriers
- Weeds and pests through direct competition or habitat degradation
- Restricted geographic distribution
- Grazing pressure - stock will browse seedling leaves (Dowe, 2007)
- Grazing pressure - trampling seedlings and disturbing the hydrology of its habitat
- Clearing and fragmentation for agriculture.

The waxy cabbage palm itself is believed to be somewhat fire resistant (Pettit and Dowe, 2003; Dowe, 2010). However, frequent fires combined with continuous grazing may overcome this resistance (Pettit and Dowe, 2003). In particular, Pettit and Dowe (2003) stressed the threats to the species from frequent fires, heavy weed infestations, and grazing (mostly associated with trampling, not just of seedlings but also through damage to riverbeds and banks, which form habitat for the species). These authors considered that these threats together with 'its limited geographic range and the small isolated population size makes it vulnerable to rapid decline given unfavourable natural conditions such as extended drought periods' (Pettit and Dowe, 2003).

During the SEIS survey, four threatening processes were noted: weed infestation, feral pigs, cattle and bush fire. Rubber vine is established at various points along the Carmichael River.

9.3 Potential impacts

9.3.1 Summary of impacts

The potential impacts on the waxy cabbage palms as a result of the construction and operation of the Project (Mine) are:

- Alterations to the surface and groundwater regime
- Water quality degradation
- Introduction or spread of aquatic and terrestrial weed and/or pest species to Project (Mine) Area

- Changes to fire regime.

The construction and operation activities and the potential environmental impact on the waxy cabbage palm are listed in Table 30 and Table 31.

Table 30 Construction activities and the potential environmental impact on the waxy cabbage palm

Construction activity	Potential environmental impact
Dewatering of excavations	• Drawdown of groundwater may occur, however most excavations are relatively shallow with respect to the groundwater levels, relatively small in volume and requiring dewatering only over a short period of time. Hence, impacts are not expected. • Disposal of groundwater from dewatering has the potential to cause surface water degradation particularly if salinity is high
Alteration of surface water regimes	• Alteration to surface water regimes, which will be relatively localised and managed during construction
General construction activities	• Introduction of new weeds and pests • Spread of weeds and pests across the site • Habitat degradation from erosion and dust
Contamination from spills or leaks of environmentally hazardous substances	• Large spills of environmentally hazardous materials, or leaks that are allowed to continue over long periods of time may cause contamination of groundwater. Measures to prevent soil contamination will also address risk to groundwater
Vegetation clearing	• Loss of waxy cabbage palms • Degradation of water quality

Table 31 Operation activities and the potential environmental impact on the waxy cabbage palms

Operation activity	Potential environmental impact
Groundwater drawdown from mine dewatering	• Drawdown of 1 to 4 m may occur in the vicinity of the Carmichael River • Groundwater flows to the Carmichael River may be reduced by up to 7 % of groundwater inputs to the River
Mining activities within a floodplain	• Flooding of mine workings and subsequent generation of large volumes of flood affected waters • Increased afflux and flooding extent and duration upstream • Reduced flood flows downstream
Watercourse diversion and works in and adjacent to watercourses	• Changes in downstream flows • Replacement of natural watercourses with artificial watercourses • Changes in downstream flows • Scouring and degradation of bed and banks • Changes in geomorphological form in downstream areas due to scouring or sediment deposition
Contamination from spills or leaks of environmentally hazardous substances	• Large spills of environmentally hazardous materials or leaks that are allowed to continue over long periods of time may cause contamination of groundwater and surface water • Improper irrigation of treated wastewater may cause nutrients to leach to groundwater and surface water
Draining of existing farm dams	• Potential for release of poor quality (low dissolved oxygen, high turbidity, high salinity) water to downstream environments

Operation activity	Potential environmental impact
Dewatering of pits and underground workings	• Generation of mine affected water (MAW), discharge of which may cause high salinity and potentially introduce other contaminants to downstream areas
Ex-pit spoil disposal	• Release of sediments to water through erosive processes • Acidification if acid generating materials are exposed to oxidising conditions • Saline runoff if saline wastes are exposed
General site activities	• Introduction of new weeds and pests • Habitat degradation including pig damage of riparian areas and erosion caused by rabbit burrowing • Spread of weeds and pests across the site • Changed fire regime
Operation of MIA, including coal handling and processing and workshops	• Generation of MAW, which may contain suspended solids, hydrocarbons and potentially other contaminants
Sediment mobilised by overland flow will be carried to drainage lines and watercourses.	• Where large quantities of sediment are transported to watercourses, geomorphological changes may occur. For example, sediment deposition may obstruct flow causing exacerbation of flooding and alteration of channel pathways
Vegetation clearing	• Loss of waxy cabbage palms. • Degradation of adjacent habitat due to dust deposition, changes in overland flow regimes, exposure of edges to sunlight and increased predation and • Proliferation of weeds and pests, including class 2 declare weeds and pests under the LP Act. • Release of sediments to water through erosive processes
Wastewater generation and treatment	• If improperly managed, release of nutrients, pathogens and other contaminants to downstream waters

Impacts identified as significant in the EIS and SEIS are discussed in more detail below.

9.3.2 Habitat loss

Direct impact to areas of mapped waxy cabbage palm habitat includes less than 4 ha of direct clearing associated with the construction of the haul road across the Carmichael River. Based on current survey results this constitutes five individual plants. This area of direct impact has been minimised through design, including the location of the Carmichael River buffer, and the location of the haul road.

9.3.3 Changes to hydrology

For around 3 km upstream of the western boundary of the Project (Mine) Area, the predicted predevelopment modelled long-term average base flow is approximately 4,150 m^3/day. Model results suggest the Carmichael River predominantly upstream of the western boundary of the Project (Mine) Area is 'gaining' (see Figure 10), which is consistent with groundwater level and surface water flow observations at the site. This section corresponds to the location of a dense cluster of waxy cabbage palms.

From a point some few hundred metres east of the western boundary of the Project (Mine) Area, predevelopment groundwater flow modelling results suggest that the Carmichael River switches

from generally gaining flow to losing flow (see Figure 11), which is consistent with groundwater level and surface water flow observations at the site. Between that location and the eastern Project (Mine) Area boundary, predicted pre-development long-term average base flow gradually reduces to around 3,150 m^3/day and groundwater levels have been measured around 4.5 m below the channel bed.

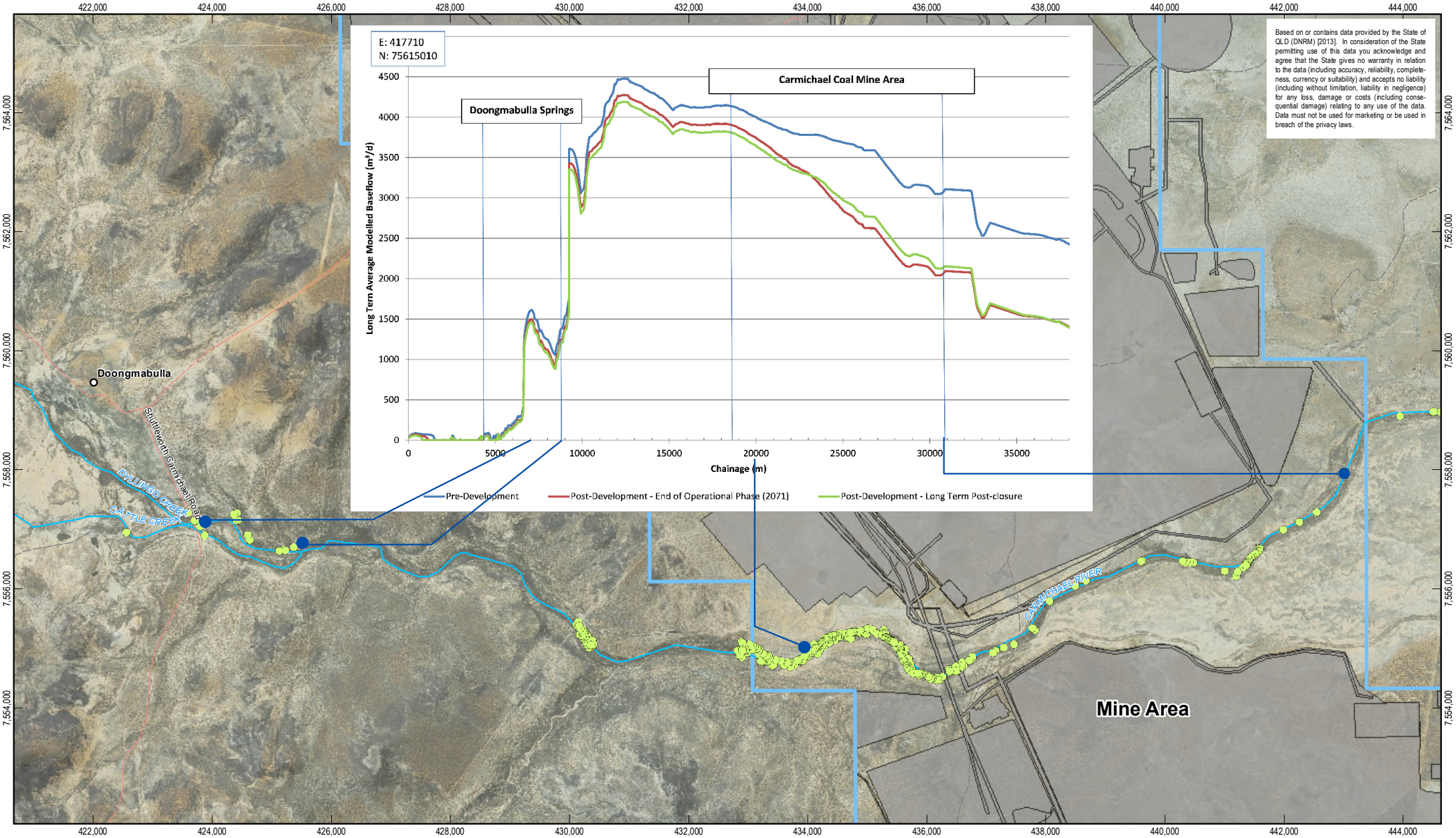
Waxy cabbage palms are present along the Carmichael River and become progressively less common from west to east. The location of the waxy cabbage palms and the predicted Carmichael River base flow changes is presented in Figure 13.

The riparian community species composition is consistent over the entire length of the Carmichael River within the Project (Mine) Area, with the exception of the dense cluster of waxy cabbage palms in the vicinity of the western Project (Mine) Area boundary (where an upward hydraulic gradient has been observed) suggesting that the river may be generally gaining flow from groundwater in this area.

The waxy cabbage palm is the species likely to be the most vulnerable to increased drawdown combined with reduced base flow volume and increased periods of zero base flow. This species is dependent on a seasonal recharging of soil water, which includes pockets and lenses that store water and which palms in arid watercourses often rely on (Paul Forster, Queensland Herbarium, pers. comm., 21.09.2012). Unlike the other characteristic riparian species (river red gums and paperbarks), these palms have a root ball which does not extend more than several metres in diameter. The SEIS survey found waxy cabbage palms growing primarily in sandy alluvial soil on channel benches, channel bars, and in the bed of the Carmichael River, in situations where groundwater is likely to be closest to the surface, and clustered along a section of the river, which may be ‘gaining’ flow.

In sections of the river further downstream which appear to be ‘losing’ flow, the palms were recorded in much lower densities. This suggests the species does not favour areas where groundwater is less accessible. However, it should also be noted that waxy cabbage palms occur in relatively arid areas (relative to most other Livistonas), and are able to persist through drought periods when recharge is infrequent.

The majority of waxy cabbage palms (including most of the adults) are located within the western half of the Project (Mine) Area and, in this section, are considered likely to persist despite the predicted changes, together with other species in the riparian zone.



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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Waxy cabbage palm population
- Homestead
- Local Road
- Track
- Watercourse
- Project Area
- Mine (Onsite)

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Groundwater Dependant Ecosystems Management Plan

Job Number	41-26422
Revision	A
Date	15 Jan 2014

Predicted Operational Drawdown along Carmichael River

Figure 13

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The maximum impact on base flow is expected to occur approximately 20 years into the operational life of the Mine. A predicted reduction in base flow volume, and a predicted increase in zero flow periods is likely to stress waxy cabbage palms in locations where groundwater is predicted to be drawn down by up to around 4 m in the near vicinity of the river. The predicted declines in base flow combined with increased zero base flow events are thought likely to result in stress to the 169 waxy cabbage palms (including nine adults) recorded in the eastern section of the Project (Mine) Area, with stress levels increasing with proximity to the eastern boundary.

The relatively low percentage of adult waxy cabbage palms in the 800 m stretch of the river where drawdown of between 1 and 4 m is predicted is likely to be indicative of the existing difficulties seedlings and sub-adults experience to become established where groundwater is deep, base flow volume is low, and zero baseline flow events are more common than upstream. It is not clear how many of the large number of juveniles in this section of the river will survive under existing conditions; based on the low relative number of adults present, high mortality rates are expected. However, all waxy cabbage palms (juveniles, sub-adults and adults) are expected to be challenged by the likely groundwater changes predicted by the modelling.

Impacts to the waxy cabbage palm are likely to result from reduced base flow as the result of drawdown of the groundwater table, reductions in base flow from upstream, and increases in the frequency of zero base flow events. These impacts will result in a reduction in health, stress and probable mortality of waxy cabbage palm individuals located in the eastern half of the Project (Mine) Area, including 9 adults and 160 juveniles.

In summary, significant impacts to waxy cabbage palm in the eastern section of the Carmichael River are predicted to occur as a result of groundwater drawdown within the river channel, as it is likely that the Project will:

- Lead to a long-term decrease in the size of an important population of a species
- Reduce the area of occupancy of an important population
- Adversely affect habitat critical to the survival of a species.

9.4 Management and mitigation measures

No recovery plan exists for the waxy cabbage palm, but the Project's mitigation and management actions focusing on ameliorating weed and pest impacts through removal and management and providing additional base flows to the Carmichael River are consistent with addressing acknowledged threats to the species. Proposed mitigation and management measures for the waxy cabbage palm include:

Habitat fragmentation and degradation

Management of land that is yet to be mined, or is to remain unmined, will be undertaken in accordance with a Project Land Management (Flora and Fauna) Plan. This plan will detail how land not subject to direct impacts (i.e. vegetation clearing) should be managed (including details relating to land use (cattle grazing) and fire management), such that the terrestrial ecological values, including connectivity, of such areas are maintained, and where possible, enhanced. This represents a positive measure for areas of waxy cabbage palm currently subject to impact from grazing that will be subject to improved management and potential increased habitat values associated with a reduction in habitat impact.

Changes to hydrology

Consideration was given to supplementing base flows in the Carmichael River during dry periods through controlled release from the Mine Site, at a point in the river where there is a “gaining” section. This mitigation measure is however unlikely to be achievable from mine related discharges and hence the SEIS has presented an Offset for unavoidable impacts to approximately 4ha of Waxy Cabbage Palm.

Ongoing ecological monitoring in response to hydrological changes will be undertaken of the Waxy Cabbage Palm population in the western section of the Carmichael River where the population is expected to persist. This monitoring, together with groundwater and surface water monitoring data will be used to review and refine mitigation measures for the Waxy Cabbage Pal in this area.

Weeds, pests and fire risk

Existing weed infestations, rubber vine present within the river bed (that is still at a manageable stage) will be managed in order to reduce the likelihood that canopy dieback will result in the excessive growth of weeds. This will safeguard existing populations of waxy cabbage palm, it is recommended that the weed infestation is removed and that ongoing management measures are implemented to monitor any resurgence. In addition, the existing pig population, which is damaging waxy cabbage palm habitat and seedlings, should be controlled, resulting in a potential increase in habitat values in the managed areas.

The management control measures for waxy cabbage palms during pre-construction, construction, operation and post operation are outlined in Table 32, Table 33, Table 34 and Table 35.

Table 32 Pre-construction management control measures for waxy cabbage palms

Issue	Control	Responsibility	Timeframe	Documentation
Management	No invasive works (eg clearing) is to be undertaken until all local, State and Commonwealth approvals are obtained.	Staff on site	Prior to commencement of construction	Approval
	The works must comply with all relevant approval conditions (e.g. NC Act, EPBC Act, EP Act approval).	Staff on site	Prior to commencement of construction	Approval
	Erect appropriate signage near sensitive habitats.	Environmental manager	Prior to commencement of construction	Inspections
Aquatic ecology	Establish control and impact monitoring sites as follows: • Upstream location on Carmichael River • Midway and downstream location on Carmichael River.	Environmental Manager	Prior to construction	Aquatic ecology monitoring program
	Develop a detailed 'ecological features' map will be made for the Carmichael River to assist in dieback and river health monitoring, identifying priority management areas including the locations of waxy cabbage palms, rubber vine infestations, riparian composition and health, areas of connectivity/disconnection with the groundwater based on the modelling, gaining/losing areas of the river relative to the groundwater, as a minimum.	Environmental Manager	Prior to commencement of mining	Ecological features map
	Prior to the initialisation of works the location of roads, site offices, stockpiling/laydown areas and plant and equipment storage areas (incl. heavy machinery) will be demarcated on site plans and preferably located on existing cleared lands at least 500 m from the Carmichael River.	Environmental Manager	Prior to construction	Site plan

Issue	Control	Responsibility	Timeframe	Documentation
	Finalise construction site plans, including: • Extent of the clearing works. • Environmentally sensitive areas. • Identification of 'no go' zones.	Environmental Manager	Prior to construction	Site plan
	Nominate or employ a suitably qualified and experienced officer to oversee the environmentally relevant tasks and activities.	Environmental Manager	Ongoing	
Vegetation clearing	Pre-clearing surveys conducted by a suitably qualified ecologist to identify and map Waxy cabbage palms.	Environmental Manager	Prior to construction	Ecological features map
	Environmentally sensitive areas, including vegetation communities listed under EPBC Act and riparian zones of the Carmichael River will be clearly defined and mapped.	Environmental Manager	Prior to construction	Ecological features map
	Prior to the commencement of construction clearing, a suitably qualified and experienced Environment Officer will mark out with barricade webbing, flagging tape, fluorescent dye or similar, the approved clearing areas and both temporary and permanent 'no go' zones.	Environmental Manager	Prior to construction	Inspections
	Ensure 'no go zones' are clearly sign-posted/ delineated on site prior to the commencement of works.	Environmental Manager	Prior to construction	Inspections
Groundwater	Use monitoring data to set groundwater quality trigger levels.	Environmental Manager	As per the Groundwater Monitoring Program	Trigger levels in environmental authority

Issue	Control	Responsibility	Timeframe	Documentation
Surface water	Review optimal location for MAW controlled discharge on the Carmichael River. Review should include consideration of: • Availability of sufficient dilution flows to control salinity • Potential effects of discharges from proposed mines upstream of the Carmichael Coal Mine • Ability to achieve high volume discharge by gravity.	Design Manager	Prior to construction	Design checklist Environmental Authority Conditions
	Prepare a water management plan in accordance with the guideline *Preparation of Water Management Plans for Mining Activities* (DERM, 2009) and an erosion and sediment control plan.	Environment Manager	Prior to construction	Water management plan and erosion and sediment control plan in place
	Design all watercourse crossings to maintain flow and minimise afflux where this may affect sensitive receptors or infrastructure, minimise velocities at culverts to prevent scouring and carry frequent flow events with low velocities that are conducive to maintaining the existing habitat. See also design controls for aquatic ecology.	Design Manager	During crossing design	Design checklist
	Prepare a Receiving Environment Monitoring Program (REMP), including: • Establishing of background and impact monitoring locations for water and sediment quality • Determination of trigger levels and water quality objectives • A program for routine monitoring of water and sediment quality • A program for continuous monitoring of key parameters that would indicate uncontrolled releases or other mine-related impacts • Procedures for checking results against trigger levels and implementing corrective actions where	Environment Manager	Prior to commencement of construction	REMP in place

Issue	Control	Responsibility	Timeframe	Documentation
	trigger levels are reached.			
	Prepare a procedure for controlled discharge of MAW. The procedure should include: • Set water quality objectives in relation to controlled discharge of MAW, including: – Any upper limits on salinity in the receiving water, above which the discharge should cease – Any upper limits on salinity in MAW above discharge should not be allowed – Any other water quality related triggers that may be required to protect environmental values of the receiving water. • Monitoring requirements before, during and after a discharge event • Reporting requirements in relation to a discharge event.	Environmental Manager	Prior to commencement of mining	Environmental Authority Conditions
Weeds and pests	A pest and weed management plan will be developed and will outline specific measures to minimise the risk of weed and pest animal establishment within the project area.	Environmental Manager	Prior to construction	Pest and weed management plan in place
	Weed mapping will be undertaken prior to commencement of construction. Mapping will cover the whole site but be particularly focused at high risk locations, such as areas of black soil so that weed hotspots can be identified. Baseline field surveys of identified hotspots within and near construction areas will be undertaken prior to commencement of construction. Weed control will be undertaken in areas that are very heavily infested or where WONS or Class 1 or 2 weeds declared under the LP Act are present prior to disturbance.	Environmental Manager	Prior to construction	Weed mapping report

Issue	Control	Responsibility	Timeframe	Documentation
Training	Prior to site entry, all site personnel including contractors shall be appropriately trained and made aware of waxy cabbage palms.	Environmental Manager	Prior to construction	Training log
	Where applicable booklets and other documentation will be provided to construction staff outlining what to do if a significant/threatened species is encountered.	Environmental Manager	Prior to construction	Information booklets

Table 33 Construction management control measures

Issue	Control	Responsibility	Timeframe	Documentation
Management	Implement measures outlined in the erosion and sediment control plan.	Construction Manager	During construction	Approved erosion and sediment control plan implemented
Aquatic ecology	Avoid undertaking works in streams in times of flow wherever possible.	Construction Manager	During construction	Schedule
	Laydown, storage areas and parking lots must not be placed in the vicinity of creeks or rivers (500 m from the Carmichael River) or near to waxy cabbage palms.	Construction Manager	Ongoing	Approved site plan
	Dust suppression mechanisms will be put in place to ensure excessive dust deposition does not occur, especially in environmentally sensitive area (including waxy cabbage palms and Carmichael River).	Construction Manager	During construction	Work permit details
Groundwater	Identify presence and quality of groundwater in any areas where excavation is to occur and determine approach to managing groundwater from excavation such that degradation of surface water quality or land does not occur. Document management approach and monitoring requirements in the work permit application.	Construction Manager	Prior to any excavation more than 2 m below ground level	Work permit details
	Check that work permit applications include appropriate measures for management of groundwater from excavations.	Environmental Manager	Prior to issuing permit	Work permit
	Implement measures to prevent potential impacts on groundwater quality due to the discharge of potentially contaminated runoff	Environmental Manager	During construction	Approved surface water management plan is implemented

Issue	Control	Responsibility	Timeframe	Documentation

Surface water	If farm dams are required to be drained:
	• Test water quality (pH, DO, turbidity and EC)
	• Utilise water for dust suppression as a first preference
	• If water cannot be used for dust suppression, then manage as follows:
	  − If EC is less than 1300 us/cm, pH is in the range 6.5-8.5, turbidity is less than 130 NTU and DO is above 4 mg/l, water may be pumped to the downstream watercourse. Pump rate should be such that water does not overflow the channel, scouring does not occur and suspended sediment from the base of the storage is not suspended. Monitor turbidity levels through and cease discharge if turbidity exceeds 50 NTU.
	  − If DO is below 4 mg/L, discharge to watercourse may be possible with aeration, however care must be taken not to stir up sediment from the bottom of the storage such that turbidity exceeds 130 NTU.
	  − If EC is more than 1300 us/cm, pH is outside the range 6.5-8.5, or turbidity exceeds 50 NTU, consider suitability for irrigation of pasture areas or rehabilitation trials. Water is to be irrigated such that ponding and runoff does not occur. Alternatively, transfer to another storage for later use.
		Construction Manager	When draining dams	Water quality data and discharge records, permit to disturb.

	Do not take water from the Carmichael River for use during construction.	All	At all times	No water taken from Carmichael River
Vegetation	Clearing is a last resort – retention of vegetation, selective clearing and trimming is the first priority.	Environmental Manager	During construction	

Issue	Control	Responsibility	Timeframe	Documentation
clearing	The clearing footprint and all 'no go' zones are adequately marked out for the clearing crew.	Environmental Manager	During construction	Inspections
	Clearing slopes leading to watercourses shall be delayed, where practicable, until construction of the crossing is imminent, or alternative measures are employed to prevent and/or minimise erosion and sedimentation risk.	Construction manager	During construction	
	Nominate or employ a suitably qualified and experienced EO to oversee the environmentally relevant tasks and activities.	Environmental Manager	During construction	
	Determine requirements to manually relocate individuals from areas to be cleared based on pre-clearing survey results and conduct relocations as required.	Environmental Manager	Prior to clearing	Offset management plan Records of translocations
	Based on pre-clearing survey results, determine any particular requirements in relation to clearing and document in permit to disturb application. Requirements may include the salvage of waxy cabbage palms.	Construction Manager/Area Manager	Prior to clearing	Permit to disturb specifies optimal clearing approach
	Clearly delineate areas for vegetation clearing and ensure that all personnel involved are aware of the clearing limits.	Construction Manager/Area Manager	Prior to clearing	Clearing limits delineated
Weeds and pests	The measures outlined in the weed and pest management plan shall be implemented.	Environmental Manager	During construction	Approved weed and pest management plan implemented.
	Conduct weed and pest control program for rubber vine, Parkinsonia, noogoora burr and pigs.	Environmental Manager	Annually	Records of control program.
	Ensure that all earthmoving equipment has undergone correct wash-down procedures to minimise the risk of introducing weeds (declared or otherwise) to aquatic environments within the Project (Mine).	Construction Manager/ Environment Manager	During construction	Weed hygiene declaration

Issue	Control	Responsibility	Timeframe	Documentation
	Vegetation and soil waste should not be moved to areas of lower weed infestation.	Construction Manager	During construction and operations	Site management plans No spread of infestations
	Pest animal occurrence will be monitored during construction. If increased densities of pest animals are observed, or new pest animals are identified, humane pest controls will be implemented to manage numbers.	Environmental Manager	During construction and operations	Monitoring records and logs
	Monitoring will be undertaken annually during construction, with results to be considered in terms of baseline information (collected prior to construction) and with reference to appropriate control (reference) sites. If significant infestations of any weeds occur, or if WONS or Class 1 or 2 weeds declared under the LP Act, weed control measures will be implemented. Weed control measures will be based on Queensland Department of Agriculture, Forestry and Fisheries and Isaac Regional Council advice. Declared pests listed under the *Plant Protection Act 1989* will also be monitored as part of the annual monitoring program during construction.	Environmental Manager	During construction and operations	Monitoring records and logs
	All vehicles, equipment and materials brought onto site will be certified as free of weeds and weed seeds and carry a weed hygiene declaration. Records are to be kept of compliance with this requirement. Adani will install a weed wash down facility onsite.	Plant Manager / Contractors	During construction and operations	Records Wash down facility
	Soil stripped and stockpiled from areas containing known declared pests listed under the *Plant Protection Act 1989* and weed infestations will be stored separately and are not to be moved to areas free of weeds and declared pests.	Site Manager	During construction and operations	Soil management plans and records
	Monitoring of feral species populations in the Project Area and implementation of a control program if necessary.	Environmental Manager	During construction and operations	Monitoring records and logs Control Program

Issue	Control	Responsibility	Timeframe	Documentation
Fire	Fire management strategies will be implemented to reduce the potential for destructive high intensity fires to disturb habitats.	Environmental Manager	Ongoing	Approved plan is implemented
Training	Periodic toolbox training to be provided to all construction personnel to present new information or reiterate information relating to management of environmental values throughout construction.	Environmental Manager	ongoing	Training log
	In the event of a non-compliance, the Proponent will issue a “stop work” order, upon which all work will cease until the non-compliance has been rectified and measures implemented to prevent the breach re-occurring.	Environmental Manager	ongoing	Monitoring records and logs

Table 34 Operation management control measures for waxy cabbage palms

Issue	Control	Responsibility	Timeframe	Documentation
Vegetation	Staff will be informed via a site specific induction of the waxy cabbage palms that are likely to be encountered within the Project Area.	Environmental Manager	During operations	Induction training records
Groundwater	Re-run groundwater model to test drawdown effects on sensitive receptors, review management, monitoring and mitigation measures and develop additional measures as required.	Environmental Manager	As per groundwater water monitoring program	Updated monitoring, management and mitigation measures
Surface water	Develop a comprehensive water balance model for the mining operation. Utilise the water balance model to optimise sizing of MAW dams, sediment ponds and discharge infrastructure as well as raw water supply requirements.	Design Manager	Prior to operation	Model in place
	Prepare and implement an operating plan for MAW and sediment dams, or incorporate operating requirements into the Plan of Operations. Operating plan is to include: • Annual dam surveillance inspections when dam is at a low level • Water quality monitoring • Operational requirements in relation to water levels, transfers between storages and reuse of MAW • Requirements for recording mine water management transfers and use • MAW discharge approval parameters.	Mine Manager	Before operating MAW and sediment dams Ongoing	Dam operating plan Monitoring and surveillance records, mine water management records
	Transfer all MAW to MAW dams. MAW is not to be placed in sediment basins or directly discharged.	Mine Manager	Ongoing	Mine water management records

Issue	Control	Responsibility	Timeframe	Documentation
	Utilise MAW for the following uses in preference to raw water: • Dust suppression • CHPP (except where raw water is required for particular processes)	Area Managers	Ongoing	Mine water management records
	Review and update Mine Water Management Plan.	Mine Manager	Every five years or more frequently if required to address non-compliance	Updated plan
	Review and update Receiving environment monitoring plan.	Environmental Manager	Every five years or more frequently if required to address non-compliance	Updated plan
	Include maintenance of the following items in mine maintenance schedule: • Oil water separators • MIA stormwater systems • Pumps and pipes • Controlled discharge infrastructure.	Mine Manager	As per maintenance schedule	Maintenance records
Weed and pests	The measures outlined in the weed and pest management plan shall be implemented.	Environmental Manager	Prior to construction	Pest and weed management plan in place
	Aquatic weed infestations will be identified and managed in accordance with the Isaac Regional Council Pest Management Plan and the weed and pest control strategies detailed within this EMP (Mine).	Environmental Manager	During operations	No increase in existing infestation or the occurrence of new infestations
	Wash-down of plant, machinery and vehicles will be undertaken in designated and controlled locations where waste water and weed seed material will be captured and prevented from discharging to watercourses.	Environmental Manager	During operations	Designated weed wash-down areas Weed hygiene declaration

Issue	Control	Responsibility	Timeframe	Documentation
Fire	Fire management strategies will be implemented to reduce the potential for destructive high intensity fires to disturb habitats.	Environmental Manager	Ongoing	Approved plan is implemented

Table 35 Post operation management control measures for waxy cabbage palms

Issue	Control	Responsibility	Timeframe	Documentation
Riparian vegetation	Maintenance of revegetated areas until vegetation cover criteria is achieved.	Environmental Manager	Post rehabilitation	Closure and rehabilitation strategy
Weed and pests	Weed eradication and control as required during offset.	Environmental Manager	During revegetation	Closure and rehabilitation strategy
Waxy cabbage palms	Monitoring of the waxy cabbage palms.	Environmental Manager	Annually for 5 years after rehabilitation	Closure and rehabilitation strategy
Groundwater and surface water	Post closure groundwater modelling to be conducted at least 2 years prior to closure to confirm and/or validate predicted impacts and inform ongoing mitigation measures. Agreements to be in place with affected parties prior to post operations phase in regards to groundwater flow impacts.	Environmental Manager	Environmental Manager	Post operation

9.5 Offsets

Offset obligations under the EPBC Act are proposed for the waxy cabbage palm for the Project (Mine) area, with 4 ha of waxy cabbage palm impacted. The availability of suitable habitat for offsets for the species is 2,744 ha; the Project requirement therefore represents approximately 0.15 percent of this potentially available and suitable offset resource.

Residual project impacts on waxy cabbage palm can therefore be sufficiently offset through the delivery of land-based direct offsets. In addition to the delivery of direct offsets and the proposed mitigation measures, indirect offsets may also be delivered through the following methods:

- Seed collection and planting programs within upstream reaches of the Carmichael River
- Relocation of individual plants if deemed a viable and successful method
- Contributing to further research objectives for the species to broaden the understanding of distributional range, water dependency requirements and threatening process triggers
- Consideration of conservation activities for the waxy cabbage palm in areas not directly impacted by the Project, or identified as having high conservation value.

9.6 Monitoring

The approved Commonwealth conservation advice for waxy cabbage palm (TSSC 2008) includes research priorities for designing and implementing monitoring programs and more precisely assessing population sizes, distribution, ecological requirements and the relative impacts of threatening processes. The monitoring program for waxy cabbage palms will be designed with this advice in mind and in consultation with the appropriate experts and organisations at that time.

Detailed monitoring and research is proposed which will significantly increase the current level of information for the waxy cabbage palm particularly as the species has not previously been recorded within the locality. Much of the focus of the waxy cabbage palm monitoring is to allow for adaptive management in addressing inevitable indirect impacts of groundwater drawdown, as follows:

- Update mapping of the Carmichael River waxy cabbage palm population is recommended.
- Permanent CORVEG primary monitoring transects will be established at regular intervals along the river for the purpose of establishing a riparian community health baseline. In the initial development/operational phases of the Mine monitoring of the plots will be seasonal, reflecting high flow/low flow variability in the Carmichael River (twice annually). This monitoring should continue into the mid operational life of the Mine, and increase to a quarterly frequency when drawdown is at its maximum.
- Monitoring of the health of the waxy cabbage palm population should be undertaken on a bi-annual basis, preferably at the start of the wet season and the start of the dry season (December and May).
- The relationship between waxy cabbage palm and groundwater is poorly understood, as is the reaction of this species to drawdown (this lack of knowledge extends to most of the *Livistona* genus). This Project (Mine) provides a unique opportunity to learn more about these subjects. It is recommended that long-term research be conducted, preferably in partnership with a university, on the population on the Carmichael River and its response to observed changes in groundwater depth and base flow volume and frequency. This should

include long-term flow monitoring and measurements of groundwater depth changes at least three locations along the river where adult waxy cabbage palms are located.

Monitoring sites

The proposed waxy cabbage palm monitoring sites are outlined in Table 36 and Figure A1.

Table 36 Proposed waxy cabbage palm monitoring sites

Monitoring Location	Description	Latitude	Longitude	Monitoring
CAR03	Carmichael River at Main Crossing	-22.1071410	146.3957890	SWQ, SWL, GWL, F, M, AW, CORVEG, WCP
CAR04	Carmichael River at upstream Gauging Station	-22.1087960	146.3527180	SWQ, SWL, GWL, F, M, AW, CORVEG, WCP
CAR0	Carmichael River upstream of proposed road crossing	-22.106072	146.3694	GWL, CORVEG, WCP
CAR06	Carmichael River at proposed road crossing	-22.112544	146.3827	GWL, CORVEG, WCP
CAR07	Carmichael River	-22.095602	146.4322	GWL, CORVEG, WCP
DCK01	Dyllingo Ck at Carmichael/Moray Rd	-22.0888320	146.2606000	SWQ, SWL, GWL, F, M, AW, CORVEG, WCP
DCK02	Dyllingo Ck	-22.106886	146.3237	GWL, CORVEG, WCP
DS	Moses Spring	-22.09636	146.2499	GWL, CORVEG, WCP

Monitoring codes

AW	aquatic weeds
M	macroinvertebrates
CORVEG	riparian vegetation transect
SWL	surface water level
F	fish
SWQ	surface water quality
GWL	groundwater level
WCP	waxy cabbage palm health

The monitoring actions for waxy cabbage palms during pre-construction, construction, operation and post construction are outlined in Table 37. Note that surfacewater and groundwater monitoring requirements are being developed as part of a Surface Water Monitoring Program and Groundwater Monitoring Program for the Project.

Waxy cabbage palm specialists will be used in a review capacity to inform ongoing monitoring actions (refer Section 13.3).

9.7 Corrective measures

Corrective measures relevant to the environmental characteristics of waxy cabbage palm populations are identified in Table 38, together with corresponding corrective measures.

Table 37 Monitoring actions for waxy cabbage palms

Issue	Monitoring action	Responsibility	Frequency	Performance requirement
Riparian vegetation	Permanent CORVEG primary monitoring transects will be established at regular intervals along the river for the purpose of establishing a riparian community health baseline. If possible, depth to groundwater data should be incorporated.	Environmental Manager	In the initial development/operational phases of the mine monitoring of the plots will be seasonal, reflecting high flow/low flow variability in the Carmichael River (twice annually). This monitoring should continue into the mid operational life of the mine.	No statistically significant change in riparian vegetation between control and impact sites and between baseline and post impact results from each monitoring event compared to the approved condition.
Waxy cabbage palms	Monitoring of the health of the waxy cabbage palm population.	Environmental Manager	Bi-annual basis, preferably at the start of the wet season and the start of the dry season (December and May).	Waxy cabbage palm monitoring plan
Surface water and groundwater	Monitor base river flow, surface and groundwater flows in the Carmichael River.	Environmental Manager	As per Groundwater and Surface Water monitoring plans	No more than 10 % reduction in groundwater inflows compared to the approved condition (section 2.10)
	Conduct groundwater quality monitoring across monitoring network for: • pH, DO, turbidity, EC, temperature (field and lab) • Total organic carbon • Major ions • Fluoride and sulfide • Nutrients • Dissolved metals • Hydrocarbons (TPH and BTEX).	Environmental Manager	As per Groundwater monitoring plans	Trigger levels set in environmental authority are not exceeded
	Monitor background and impacted water quality as per REMP.	Mine Manager	As per REMP	Below triggers specified in REMP

Issue	Monitoring action	Responsibility	Frequency	Performance requirement
	Monitor EC/salinity upstream and downstream of controlled discharge point and at point of discharge.	Mine Manager	At least 12 hours prior to discharging and until 12 hours after discharging MAW or groundwater from advanced dewatering	To be determined
Offsets	Conduct monitoring of offset areas.	Environmental Manager	As per offset strategy and management plan	As per offset strategy and management plan
Weeds and pests	Conduct inspections of disturbed areas for weed proliferation.	Environmental Manager	Annually	Weed levels in disturbed areas are similar to pre-clearing
	Monitor pest animal numbers at key water resource locations.	Environmental Manager	Annually	No increase in pest animal occurrence

Table 38 Corrective measures for waxy cabbage palms

Issue	Trigger	Responsibility	Corrective action
Riparian vegetation	Statistically significant change in riparian vegetation between control and impact sites and between baseline and post impact results from each monitoring event.	Environmental Manager	If significant differences are observed, an incident should be logged and an incident investigation carried out to determine cause of changes and develop corrective actions.
Groundwater	Groundwater quality trigger levels set in environmental authority are exceeded.	Environmental Manager	Repeat monitoring immediately on receiving non-compliant results. If repeat results indicate persistent elevation, raise an incident report and commence incident investigation. Undertake corrective actions as identified in the incident investigation.
Water quality	Water quality greater than triggers specified in REMP.	Environmental Manager	As specified in REMP
	EC/salinity upstream and downstream of controlled discharge point and at point of discharge greater than trigger levels.	Environmental Manager	Cease discharge if trigger level is reached at downstream monitoring location.
Weeds and pests	Increase in pest animal occurrence.	Environmental Manager	Conduct a pest animal control program. Control program will prioritise class 2 declared pest species listed under the LP Act that are known to occur within the Isaac Regional Council area.
	Weed levels in disturbed areas are greater than pre-clearing.	Environmental Manager	Conduct a weed control program. Control programs will prioritise class 2 declared weed species listed under the LP Act that are known to occur within the Isaac Regional Council area.

10. Reporting and auditing

10.1 External reporting

External reporting is expected to be required in response to legislative requirements of relevance to this management plan. Initial reporting requirements are set out in Table 39 and this will be updated based on conditions of approval.

Table 39 External environmental reporting requirements

Reporting trigger	Report content	Report recipient	Adani responsibility
Annual return under environmental authority	Compliance with environmental authority requirements	DEHP	General Manager Environment
Incidents causing actual or potential environmental harm	Incident investigation and corrective actions	DEHP	Environmental Manager

In accordance with the *Corporations Act 2001*, Adani's annual report will include compliance with environmental requirements.

External reporting will also include the provision of monitoring data to appropriate stakeholders for consideration. The reporting of monitoring data to external stakeholders is summarised in Table 40.

Table 40 Monitoring data reporting

Reporting trigger	Report content	Report recipient	Adani responsibility
Completion of a monitoring round	Monitoring data/results and initial interpretation	Expert Advisory Committee	Environmental Manager
Completion of Annual Environment Report	An overview of GDE management and monitoring that has occurred throughout the year and an overview of future proposed activities	DotE, CG and DEHP	Environmental Manager

10.2 Internal reporting

Corporate communications will take place in accordance with management system requirements. Within the Carmichael Coal Mine, communications regarding environmental matters will include:

- Environmental compliance, incidents, initiatives and corrective actions as agenda items in all management meetings
- Regular toolbox talks on environmental matters
- Environmental inductions and other training as described in Section 12
- Incorporation of environmental risk assessment and management into all risk assessment activities
- Posting of information on environmental issues, impacts and performance on noticeboards

- Inclusion of environmental performance and issues in weekly, monthly and annual reports.

10.3 Documentation, document control and records

Document control in relation to environmental management will be through the site EMS as set out in CG-008 Documentation and Document Control. This EMP and all associated sub plans, documents and registers will be controlled documents subject to unique document identifiers and version control. The corrective action register will be managed through a database to ensure that updates on the status of corrective actions are available to managers and supervisors.

Other documentation and records to be retained will include:

- Incident investigation reports
- Completed site checklists
- Records of training and induction
- Audit reports
- All monitoring records.

Monitoring records in relation to the environmental authority must be retained for five years and must be available for provision to the administering authority within 10 business days of any request.

The document control and records management system will meet the requirements of Adani's Management Standard ST-04 Documentation, Document Control and Records.

10.4 Audits

10.4.1 Overview

Adani Compliance Guideline CG-004 Audits and Assessment sets out requirements for audits of performance. An audit program has been developed to meet these requirements.

The following standards may be relevant to auditing activities:

- AS/NZS ISO 14012-1996 Guidelines for Environmental – Qualification Criteria for Environmental Auditors
- AS/NZS ISO 14015-2003 Environmental Management – Environmental Assessment of Sites and Organizations
- AS/NZS ISO/IEC 17021:2011 Conformity assessment – Requirements for bodies providing audit and certification of management systems
- AS/NZS ISO 19011-2003 Guidelines for Quality and/or Environmental Management Systems Auditing
- ISO 19011:2011 Guidelines for auditing management systems.

Draft audit reports will be reviewed by the Environmental Manager. Once an audit report is finalised:

- Audit reports will be circulated to the mine manager and area managers
- Recommendations will be entered into the corrective action register

- Findings will be discussed at management meetings
- Where relevant, findings will be presented as tool box talks
- Reports and findings will be tabled at management reviews
- Any non-compliances that are required to be reported under legislation or conditions of approval will be reported.

10.4.2 Construction

Auditing during construction will depend on the contracting strategy selected and whether contractors and subcontractors operate under Adani's management systems or the contractor's own environmental management system.

If contractors/subcontractors are utilising their own environmental management systems, Adani will conduct audits on a six monthly basis, or for shorter duration contracts, at least once during the contract duration.

These audits will cover:

- Contractor's compliance with legal and other obligations
- Whether contractor's management plans have appropriately identified environmental impacts and risks
- Whether roles, responsibilities and training and competency requirements have been identified and followed
- Whether adequate management and control strategies are in place to achieve compliance with legal requirements and performance requirements documented in this EMP
- Whether management and control strategies are being implemented
- Monitoring approaches and outcomes, and identification and implementation of corrective actions
- Adequacy of record keeping and reporting.

It would also be expected that contractors will have internal and external audit programs. If contractors and subcontractors are utilising Adani's management system, system compliance audits will be conducted based on agreed and approved audit requirements.

10.4.3 Operation

Environmental audit processes will meet the requirements of Adani's Management Standard ST-18 Reviews, Audits and Inspections. A preliminary audit schedule for the Carmichael Coal Mine is shown in Table 41. Where audit outcomes and recommendations require corrective actions, these will be entered into the corrective action register.

Compliance with approval conditions issued under State and Commonwealth legislation, including conditions under the NC Act, EP Act, EPBC Act and Environmental Authority will be audited. Where non-compliance occurs with regard to the conditions of approval, a report must be submitted to relevant authority. The report will outline the type of non-compliance and the remedial actions taken to ensure that the matter is resolved within a reasonable time frame. The time frame will be specified in writing by the relevant approval agency.

Table 41 Preliminary Audit Schedule

Audit Type	Scope	Frequency
Environmental monitoring review	Review results of environmental monitoring activities. Identify whether environmental performance requirements are achieved, and whether degradation of values or resources has occurred that may be attributable to the mining activity. Identify further investigations and/or corrective actions.	Annual
General environmental audit	Environmental impacts and risks have been correctly identified. Management controls are effective in managing the impacts and risks identified. EMP is consistent with environmental authority conditions. Environmental management requirements are being implemented and evidence is available.	Bi-annual

11. Adaptive management framework

11.1 Overview

Management of ecological systems to anthropogenic impacts is a complex process with significant uncertainties. Knowledge of the response of GDEs to anthropogenic impacts, such as groundwater drawdown, is limited. Therefore, an adaptive management approach, which is based on continually improving understanding and measured responses is considered appropriate to the manage GDEs within and adjacent to the Project (Mine) Area.

The adaptive GDE management approach incorporates a number of components (Figure 14), each of which is used to inform the others. In this approach:

- Mathematical and conceptual models are used to estimate the range of potential impacts
- A risk-targeted monitoring plan is developed and implemented
- Management and mitigation actions are implemented
- When monitoring identifies adverse trends attributed to the mine activities corrective measures are implemented.

The first component of this approach (modelling) was developed during the EIS and SEIS process.

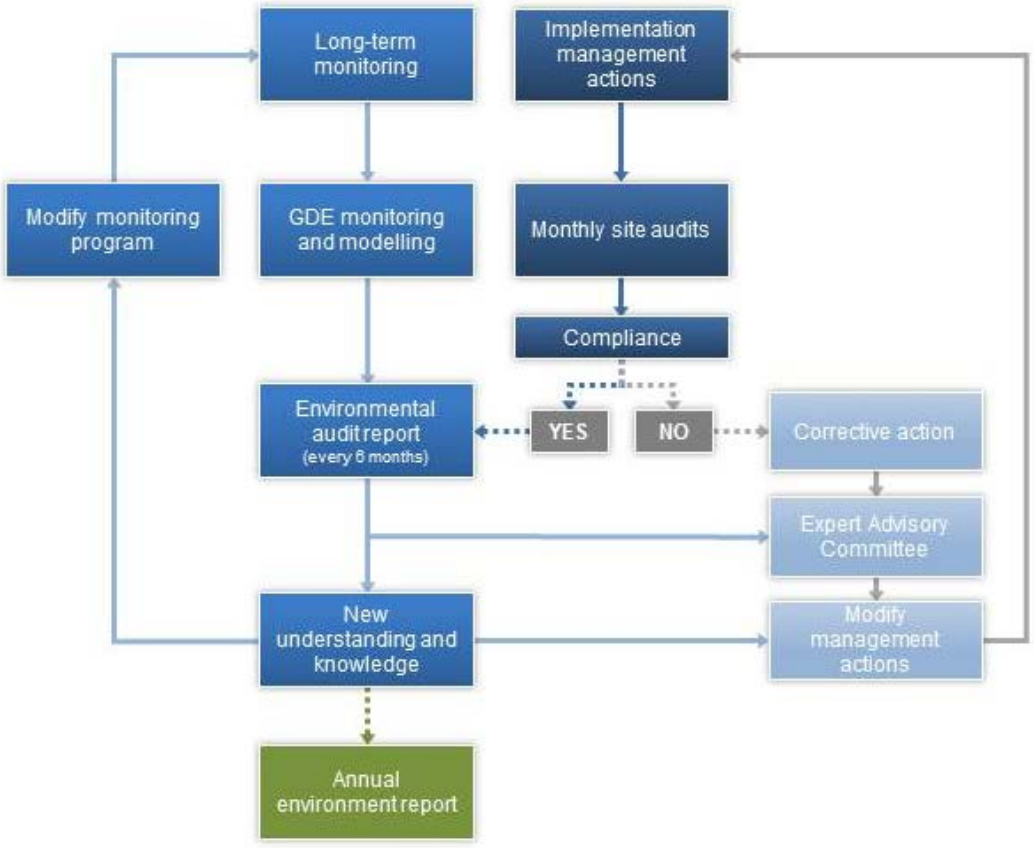

Figure 14 Adaptive management approach

11.2 Implementation of management actions

Management of GDEs in response to anthropogenic impacts is a complex process with significant uncertainties. Therefore, an adaptive management approach will be implemented so as to continually assess and improve the management of GDEs within and adjacent to the Project (Mine) Area. Implementation of management and mitigation actions, as described herein, will based on mathematical and conceptual models that were used to estimate the range of potential impacts, together with risk-targeted monitoring.

11.3 Assessment of effectiveness

The effectiveness of implemented management actions will be assessed by comparing results of on-ground monitoring with baseline data and the mathematical modelling predictions. When monitoring identifies adverse trends attributed to the mine activities, corrective measures are implemented.

11.4 Continuous improvement

Continuous improvement to the management of GDEs within and adjacent to the Project Area will be facilitated through corrective measures. Such measures will be implemented when an evaluation of observed effects is attributed to the project's activities and there is a identified risk of detrimental impact to physiological or ecological characteristics of the GDEs.

12. Training

12.1 Site inductions

Site induction training will be provided to ensure all contractors and staff working onsite are aware of their environmental obligations including the requirements of this GDE management plan. Staff, contractors and visitors will be suitably inducted to ensure that they incorporate environmentally appropriate work practices on a day-to-day basis. This will enable staff to identify emerging environmental issues and respond proactively to avoid incidents of this nature.

The provision of training will be in accordance with the Adani's HSE Management Standard HSE-ST-03 -Training and Competence. The induction program will include:

- Overview of relevant policies
- Duty of care and duty to notify
- Incident response and reporting procedures
- Roles and responsibilities
- Environmental awareness
- Identification of GDEs
- Relevant mitigation and management measures to be implemented
- Safe driving with respect to flora
- Weed hygiene procedure and importance of weed control
- For selected members - fire suppression and control.

12.2 Toolbox talks

At the commencement of each work shift, tool-box talks will be undertaken with contractors and staff to communicate relevant environmental considerations for the shift. Of particular importance, will be when works commence in a new location or new activities will be undertaken. In regard to the GDE management plan, information that will be communicated through tool box talks will include:

- Sensitive environmental areas in proximity to where works are being undertaken
- Any mitigation and management measures that are relevant to works
- Recent environmental incidents and the corrective actions that are being undertaken.

13. Review and consultation

13.1 GDE management plan review

The GDE management plan will be reviewed at least twice per year to assess the adequacy and effectiveness of the Plan. This will be undertaken as part of Adani's management system requirements to review the Project EMP at least twice per year (CG-011 Management Review). Participants in the review process are to include Adani's senior management team. In relation to the environmental component of the management review, the management review will examine:

- Adequacy and effectiveness of the EMP
- Compliance with Adani management system
- Opportunities for improvement
- Opportunities for waste minimisation.

Inputs to the management review will include:

- Results of monitoring and audits
- Status of achievement of performance requirements and indicators
- Summary of environmental incidents, non-compliances and complaints
- Status of corrective actions
- Communications and complaints
- Follow up of actions from previous management review
- Significant changes affecting environmental management, including legislation and policy changes.

Decisions and actions arising from the management review will be documented and actions will be entered into the corrective action register.

The modelling revision based on the results of surface water, groundwater and GDE monitoring needs to estimate the:

- Impact of project related groundwater pressure reductions on the ecology of springs and spring flow dependent communities during mining and post-closure, including maximum potential impact
- Time lag between groundwater extraction at the mine and reflection of drawdown and associated ecological impact at the springs and other GDE (palms)
- Time lag between corrective action at the mine (e.g. filling of voids) and reflection at the springs.

13.2 Expert Advisory Committee review

In the event an environmental incident/non-conformance during construction or operation of the Project, the Expert Advisory Committee will be notified of incident as well as the proposed corrective action. Any changes that may be required to management actions as a result of the

corrective action will also be communicated. As results from monitoring the corrective actions success become available, the Expert Advisory Committee will also be notified where requested.

A copy of the annual environmental report will also be provided to the Expert Advisory Committee and will provide information of the following:

- Monitoring progress throughout the year including results
- Environmental incidents/non compliances and the corrective actions implemented
- Proposed monitoring program for the coming year
- Application of adaptive monitoring and management principles and how they are influencing management of GDEs.

13.3 Consultation

Adani will undertake consultation with GDE specialists, regulatory agencies and landholders in a review capacity to inform the ongoing monitoring and management of GDEs covered by this Plan.

Meetings with specialist on the Exert Panel will be held bi-annually to discuss the monitoring results and any potential implications it may have on our understanding of the GDEs in the Project site, potential improvement of management actions and future monitoring.

The consultation process will involve a meeting to provide progress updates regarding management and monitoring activities that have been undertaken in the previous six months. During this process, participants will be provided the opportunity to identify any recommendations regarding amendments to the Plan and future actions.

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Appendices

Appendix A – Groundwater dependent ecosystems management, monitoring and corrective measures summary

1. Management

1.1 Spring management

Table 1 Pre-construction management control measures at Doongmabulla and Mellaluka Spring complexes

Issue	Control	Responsibility	Timeframe	Documentation
Management	Prepare a water management plan in accordance with the guideline *Preparation of Water Management Plans for Mining Activities* (DERM, 2009).	Environment Manager	Prior to commencement of mining	Water management plan and erosion and sediment control plan in place
Aquatic ecology	Establish control and impact monitoring sites at the Doongmabulla and Mellaluka Springs.	Environmental Manager	Prior to commencement of mining	Aquatic ecology and stygofauna monitoring program
Groundwater	Use monitoring data to set groundwater quality trigger levels.	Environmental Manager	As per groundwater monitoring program	Trigger levels in environmental authority
	Liaise with adjacent landholders and develop bore monitoring programs to detect changes in bores used for water supply.	Environmental Manager	12 months prior to commencement of mining	Updated groundwater monitoring plan.
	Enter into “make good” agreements with surrounding landholders in relation to potential groundwater impacts.	Stakeholder Manager	Prior to commencement of mining	Agreements in place

Table 2 Construction management control measures at Doongmabulla and Mellaluka Spring complexes

Issue	Control	Responsibility	Timeframe	Documentation
Groundwater	Groundwater will be managed as per the Water management plan.	Environmental Manager	Prior to construction	Approved plan is implemented
	Potential impacts on groundwater quality due to the discharge of potentially contaminated runoff will be prevented through the development and operation of a suitable surface water management system and associated management plan (SWMP).	Environmental Manager	Prior to construction	Approved plan is implemented
	Prior to the commencement of construction activities the status of each of the existing registered bores that could be significantly affected by the proposed Project (Mine) should be confirmed and a baseline assessment undertaken at each of the active bores in order to establish their pre-operational condition.	Environmental Manager	Prior to construction	Monitoring program and results
Fire	Fire management strategies will be implemented to reduce the potential for destructive high intensity fires to disturb habitats.	Environmental Manager	Ongoing	Approved plan is implemented
Pests	To minimise the risk of pest animal establishment within and adjacent to the Carmichael River, the measures outlined in the weed and pest management plan shall be implemented.	Environmental Manager	Prior to construction	Approved weed and pest management plan implemented.
	Monitoring of feral species populations in the Project Area and implementation of a control program if necessary.	Environmental Manager	During construction and operations	Monitoring records and logs Control Program

Table 3 Operation management control measures at Doongmabulla and Mellaluka Spring complexes

Issue	Control	Responsibility	Timeframe	Documentation
Groundwater	Re-run groundwater model to test drawdown effects on sensitive receptors, review management, monitoring and mitigation measures and develop additional measures as required.	Environmental Manager	Each time model is updated	Updated monitoring, management and mitigation measures
Fire	Fire management strategies will be implemented to reduce the potential for destructive high intensity fires to disturb habitats.	Environmental Manager	Ongoing	Approved plan is implemented
Pests	Monitoring of feral species populations in the Project Area and implementation of a control program if necessary.	Environmental Manager	During construction and operations	Monitoring records and logs Control Program

Table 4 Post operation management control measures at Doongmabulla and Mellaluka Spring complexes

Issue	Control	Responsibility	Timeframe	Documentation
Groundwater	Post closure groundwater modelling to be conducted at least 2 years prior to closure to confirm and/or validate predicted impacts and inform ongoing mitigation measures. Agreements to be in place with affected parties prior to post operations phase in regards to groundwater flow impacts.	Environmental Manager	Post operation	Closure and rehabilitation strategy

1.1 Waterway and waxy cabbage palm management

Table 5 Pre-construction management control measures

Issue	Control	Responsibility	Timeframe	Documentation
Aquatic ecology	Establish control and impact monitoring sites as follows: • Upstream location on Carmichael River • Midway and downstream location on Carmichael River.	Environmental Manager	Prior to construction	Aquatic ecology monitoring program
	Plan works in watercourses to minimise the period of disturbance to the watercourse.	Construction Manager	Prior to construction	Schedule
	Schedule works in watercourses and bulk earthworks to occur outside the wet season wherever possible.	Construction Manager	Prior to construction	Schedule
	Weather conditions should be monitored and if significant rain events are forecast, any in-stream works should cease and disturbed streams should be stabilised.	Construction Manager	During construction	Inspections
	As far as practicable, design pipeline crossings, culvert crossings and bed level crossings in accordance with: • Code for self-assessable development Minor waterway barrier works – part 3 culverts (WWBW01) (DAFF, April 2013) • Code for self-assessable development Minor waterway barrier works – part 4 – bed level crossings (WWBW01) (DAFF, April 2013) • Guideline - activities in a watercourse, lake or spring associated with mining operations (WAM/2008/3435) (DERM (2010a)). • Meet the fish passage requirements in accordance with the *Fisheries Act* and other relevant guidelines.	Design Manager	During detailed design	Design checklist
	Design and layout of the crossing will incorporate a bridge design that spans the watercourse bed and avoids construction within the banks as much as possible.	Design Manager	During detailed design	Design checklist

Issue	Control	Responsibility	Timeframe	Documentation
	Riverine protection permit exemption requirements identified by the Department of Natural Resources and Mines (DNRM) should be adhered to, or if these cannot be met, conditions of a riverine protection permit should be complied with.	Construction Manager	Prior to construction	Inspections
	Develop a detailed 'ecological features' map for the Carmichael River to assist in dieback and river health monitoring, identifying priority management areas including the locations of waxy cabbage palms, rubber vine infestations, riparian composition and health, areas of connectivity/disconnection with the groundwater based on the modelling, gaining/losing areas of the river relative to the groundwater, as a minimum.	Environmental Manager	Prior to construction	Ecological features map
	Prior to the initialisation of works the location of roads, site offices, stockpiling/laydown areas and plant and equipment storage areas (incl. heavy machinery) will be demarcated on site plans and located on existing cleared lands at least 500 m from the Carmichael River.	Environmental Manager	Prior to construction	Site plan
	Finalise construction site plans, including: • Extent of the clearing works. • Environmentally sensitive areas. • Identification of 'no go' zones.	Environmental Manager	Prior to construction	Site plan
	Nominate or employ a suitably qualified and experienced officer to oversee the environmentally relevant tasks and activities.	Environmental Manager	Ongoing	
Vegetation clearing	Pre-clearing surveys conducted by a suitably qualified ecologist to identify and map habitat trees and waxy cabbage palms.	Environmental Manager	Prior to construction	Ecological features map
	Environmentally sensitive areas, including vegetation communities listed under EPBC Act, waxy cabbage palms and riparian zones of the Carmichael River will be clearly defined and mapped.	Environmental Manager	Prior to construction	Ecological features map

Issue	Control	Responsibility	Timeframe	Documentation
	Prior to the commencement of construction clearing, a suitably qualified and experienced Environment Officer will mark out with barricade webbing, flagging tape, fluorescent dye or similar, the approved clearing areas and both temporary and permanent 'no go' zones.	Environmental Manager	Prior to construction	Inspections
	Ensure 'no go zones' are clearly sign-posted/ delineated on site prior to the commencement of works.	Environmental Manager	Prior to construction	Inspections
Groundwater	Use monitoring data to set groundwater quality trigger levels.	Environmental Manager	As per groundwater monitoring program	Trigger levels in environmental authority
	Liaise with adjacent landholders and develop bore monitoring programs to detect changes in bores used for water supply.	Environmental Manager	As per groundwater monitoring program	Updated groundwater monitoring plan.
	Enter into "make good" agreements with surrounding landholders in relation to groundwater impacts.	Stakeholder Manager	Prior to commencement of mining	Agreements in place
Surface water	Develop a comprehensive water balance model for the mining operation. Utilise the water balance model to optimise sizing of MAW dams, sediment ponds and discharge infrastructure as well as raw water supply requirements.	Design Manager	Prior to commencement of mining	Model in place
	Review optimal location for MAW controlled discharge on the Carmichael River. Review should include consideration of: • Availability of sufficient dilution flows to control salinity • Potential effects of discharges from proposed mines upstream of the Carmichael Coal Mine • Ability to achieve high volume discharge by gravity.	Design Manager	Prior to construction	Design checklist Updated environmental authority (mining)
	Prepare a water management plan in accordance with the guideline *Preparation of Water Management Plans for Mining Activities* (DERM, 2009) and an erosion and sediment control plan.	Environment Manager	Prior to construction	Water management plan and erosion and sediment control plan in place

Issue	Control	Responsibility	Timeframe	Documentation
	Prepare detailed design for diversions, taking into account: • Hydraulic requirements including energy dissipation • Creation of a geomorphologically stable channel • Potential for environmental values to be reinstated • Potential erosion at outlet point • Maintain existing flows in waterways where practicable • Minimise disturbance to existing waterways Current relevant guidelines are *Watercourse Diversions Guidelines – Central Queensland Mining Industry* (DERM, 2011).	Design Manager	During diversion design	Design checklist
	Construction of a flood protection levee along either side of the Carmichael River designed to withstand a 1,000 year ARI immunity.	Design Manager	During levee design	Design checklist
	Design all watercourse crossings to maintain flow and minimise afflux where this may affect sensitive receptors or infrastructure, minimise velocities at culverts to prevent scouring and carry frequent flow events with low velocities that are conducive to maintaining the existing habitat. See also design controls for aquatic ecology.	Design Manager	During crossing designs	Design checklist
	Construction of bunded areas for chemical storage will be completed prior to any chemicals being delivered to site.	Environment Manager	Prior to any chemicals being delivered to site	Inspections

Issue	Control	Responsibility	Timeframe	Documentation
	Prepare a Receiving Environment Monitoring Program (REMP), including: • Establishing of background and impact monitoring locations for water and sediment quality • Determination of trigger levels and water quality objectives • A program for routine monitoring of water and sediment quality • A program for continuous monitoring of key parameters that would indicate uncontrolled releases or other mine-related impacts • Procedures for checking results against trigger levels and implementing corrective actions where trigger levels are reached.	Environment Manager	Prior to construction	REMP in place
	Prepare a procedure for controlled discharge of MAW. The procedure should include: • Set water quality objectives in relation to controlled discharge of MAW, including: – Any upper limits on salinity in the receiving water, above which the discharge should cease – Any upper limits on salinity in MAW above discharge should not be allowed – Any other water quality related triggers that may be required to protect environmental values of the receiving water. • Monitoring requirements before, during and after a discharge event • Reporting requirements in relation to a discharge event.	Environmental Manager	Prior to commencement of mining	Controlled discharge procedure
Weeds and pests	A pest and weed management plan will be developed and will outline specific measures to minimise the risk of weed and pest animal establishment within the project area.	Environmental Manager	Prior to construction	Pest and weed management plan in place

Issue	Control	Responsibility	Timeframe	Documentation
	Weed mapping will be undertaken prior to commencement of construction. Mapping will cover the whole site but be particularly focused at high risk locations, such as areas of black soil so that weed hotspots can be identified. Baseline field surveys of identified hotspots within and near construction areas will be undertaken prior to commencement of construction. Weed control will be undertaken in areas that are very heavily infested or where WONS or Class 1 or 2 weeds declared under the LP Act are present prior to disturbance.	Environmental Manager	Prior to construction	Weed mapping report
Training	Prior to site entry, all site personnel including contractors shall be appropriately trained and made aware of the sensitive environs in which they will be working, including waxy cabbage palms.	Environmental Manager	Prior to construction	Training log
	Where applicable booklets and other documentation will be provided to construction staff outlining what to do if a significant/threatened species is encountered.	Environmental Manager	Prior to construction	Information booklets

Table 6 Construction management control measures

Issue	Control	Responsibility	Timeframe	Documentation
Management	No invasive works (eg clearing) is to be undertaken until all local, State and Commonwealth approvals are obtained.	Staff on site	Prior to commencement of construction	Approval
	The works must comply with all relevant approval conditions (eg. NC Act, EPBC Act, EP Act approval).	Staff on site	Prior to commencement of construction	Approval
	Implement measures outlined in the surface water management plan and the erosion and sediment control plan.	Construction Manager	During construction	Approved surface water management plan implemented. Approved erosion and sediment control plan implemented.
	Erect appropriate signage near sensitive habitats.	Environmental manager	Prior to commencement of construction	Inspections
	Weather conditions should be monitored and if significant rain events are forecast, any in-stream works should cease and disturbed streams should be stabilised	Construction Manager	During construction	Inspections
Aquatic ecology	Avoid undertaking works in streams in times of flow wherever possible.	Construction Manager	During construction	Schedule
	Disturbance areas on either side of the haul road crossing and leeves should be kept minimal and stabilised as soon as reasonably possible	Construction Manager	During construction	Schedule
	Laydown, storage areas and parking lots must not be placed in the vicinity of creeks or rivers (500 m from the Carmichael River) or near to sensitive receptors (i.e. groundwater bores or GDEs) and waxy cabbage palms.	Construction Manager	Ongoing	Approved site plan

Issue	Control	Responsibility	Timeframe	Documentation
	For culvert and low level crossings for access roads, ensure that design requirements are met during construction and: • Remove topsoil and vegetation and set aside for reinstatement • Place culverts or pipes such that the bed level remains even • Use topsoil and vegetation in rehabilitation • Stabilise completed surfaces with "soft" techniques such as jute matting or geotechnical fabric as far as practicable.	Construction Manager	During construction	Stable work areas
	For diversions, ensure diversions are constructed as per design. Minimise construction activities during flow events where practical and stabilise works as quickly as possible after construction.	Construction Manager	During construction	Stable work areas
	Dust suppression mechanisms will be put in place to ensure excessive dust deposition does not occur, especially in environmentally sensitive area (including riparian vegetation, the Carmichael River and waxy cabbage palms).	Construction Manager	During construction	
Groundwater	Identify presence and quality of groundwater in any areas where excavation is to occur and determine approach to managing groundwater from excavation such that degradation of surface water quality or land does not occur. Document management approach and monitoring requirements in the work permit application.	Construction Manager	Prior to any excavation more than 2 m below ground level	Work permit details
	Check that work permit applications include appropriate measures for management of groundwater from excavations.	Environmental Manager	Prior to issuing permit	Work permit
	Implement measures outlined in the surface water management plan to prevent potential impacts on groundwater quality due to the discharge of potentially contaminated runoff	Environmental Manager	During construction	Approved surface water management plan is implemented

Issue	Control	Responsibility	Timeframe	Documentation
	Prior to the commencement of construction activities the status of each of the existing registered bores that could be significantly affected by the proposed Project (Mine) should be confirmed and a baseline assessment undertaken at each of the active bores in order to establish their pre-operational condition.	Environmental Manager	Prior to commencement of construction	Monitoring program and results
Surface water	If farm dams are required to be drained: • Test water quality (pH, DO, turbidity and EC) • Utilise water for dust suppression as a first preference • If water cannot be used for dust suppression, then manage as follows: – If EC is less than 1300 us/cm, pH is in the range 6.5-8.5, turbidity is less than 130 NTU and DO is above 4 mg/l, water may be pumped to the downstream watercourse. Pump rate should be such that water does not overflow the channel, scouring does not occur and suspended sediment from the base of the storage is not suspended. Monitor turbidity levels through and cease discharge if turbidity exceeds 50 NTU. – If DO is below 4 mg/L, discharge to watercourse may be possible with aeration, however care must be taken not to stir up sediment from the bottom of the storage such that turbidity exceeds 130 NTU. – If EC is more than 1300 us/cm, pH is outside the range 6.5-8.5, or turbidity exceeds 50 NTU, consider suitability for irrigation of pasture areas or rehabilitation trials. Water is to be irrigated such that ponding and runoff does not occur. Alternatively, transfer to another storage for later use.	Construction Manager	When draining dams	Water quality data and discharge records, permit to disturb.
	Do not take water from the Carmichael River for use during construction.	All	At all times	No water taken from Carmichael River
Vegetation	Clearing is a last resort – retention of vegetation, selective clearing and trimming is the first priority.	Environmental Manager	During construction	Site Plan

Issue	Control	Responsibility	Timeframe	Documentation
clearing	The clearing footprint and all 'no go' zones are adequately marked out for the clearing crew.	Environmental Manager	During construction	Inspections
	Clearing slopes leading to watercourses shall be delayed, where practicable, until construction of the crossing is imminent, or alternative measures are employed to prevent and/or minimise erosion and sedimentation risk.	Construction manager	During construction	Construction schedule
	Nominate or employ a suitably qualified and experienced officer to oversee the environmentally relevant tasks and activities.	Environmental Manager	During construction	
	Determine requirements to manually relocate waxy cabbage palms from areas to be cleared based on pre-clearing survey results and conduct relocations as required.	Environmental Manager	Prior to clearing	Offset management plan Records of translocations
	Based on pre-clearing survey results, determine any particular requirements in relation to clearing and document in permit to disturb application. Requirements may include the salvage of habitat features and waxy cabbage palms.	Construction Manager/Area Manager	Prior to clearing	Permit to disturb specifies optimal clearing approach
	Clearly delineate areas for vegetation clearing and ensure that all personnel involved are aware of the clearing limits.	Construction Manager/Area Manager	Prior to clearing	Clearing limits delineated
Weeds and pests	To minimise the risk of weed and pest animal establishment within and adjacent to the Carmichael River, the measures outlined in the weed and pest management plan shall be implemented.	Environmental Manager	During construction	Approved weed and pest management plan implemented.
	Conduct weed and pest control program for rubber vine, Parkinsonia, noogoora burr, feral cats, pigs and cane toads.	Environmental Manager	Annually	Records of control program
	Ensure that all earthmoving equipment has undergone correct wash-down procedures to minimise the risk of introducing weeds (declared or otherwise) to aquatic environments within the Project (Mine).	Construction Manager/ Environment Manager	During construction	Weed hygiene declaration
	Vegetation and soil waste should not be moved to areas of lower weed infestation.	Construction Manager	During construction and operations	Site management plans

Issue	Control	Responsibility	Timeframe	Documentation
	Pest animal occurrence will be monitored during construction. If increased densities of pest animals are observed, or new pest animals are identified, humane pest controls will be implemented to manage numbers.	Environmental Manager	During construction and operations	Monitoring records and logs
	Monitoring will be undertaken annually during construction, with results to be considered in terms of baseline information (collected prior to construction) and with reference to appropriate control (reference) sites. If significant infestations of any weeds occur, or if WONS or Class 1 or 2 weeds declared under the LP Act, weed control measures will be implemented. Weed control measures will be based on Queensland Department of Agriculture, Forestry and Fisheries and Isaac Regional Council advice. Declared pests listed under the *Plant Protection Act 1989* will also be monitored as part of the annual monitoring program during construction.	Environmental Manager	During construction and operations	Monitoring records and logs
	All vehicles, equipment and materials brought onto site will be certified as free of weeds and weed seeds and carry a weed hygiene declaration. Records are to be kept of compliance with this requirement. Adani will install a weed wash down facility onsite.	Plant Manager / Contractors	During construction and operations	Records Wash down facility
	Soil stripped and stockpiled from areas containing known declared pests listed under the *Plant Protection Act 1989* and weed infestations will be stored separately and are not to be moved to areas free of weeds and declared pests.	Site Manager	During construction and operations	Soil management plans and records
	Construction staff will not bring domestic animals to the Project Area.	Site Manager	During construction and operations	No domestic animals
	Monitoring of feral species populations in the Project Area and implementation of a control program if necessary.	Environmental Manager	During construction and operations	Monitoring records and logs Control Program
Fire	Fire management strategies will be implemented to reduce the potential for destructive high intensity fires to disturb habitats.	Environmental Manager	Ongoing	Approved plan is implemented

Issue	Control	Responsibility	Timeframe	Documentation
Training	Periodic toolbox training to be provided to all construction personnel to present new information or reiterate information relating to management of environmental values throughout construction.	Environmental Manager	Ongoing	Training log
	In the event of a non-compliance, the Proponent will issue a “stop work” order, upon which all work will cease until the non-compliance has been rectified and measures implemented to prevent the breach re-occurring.	Environmental Manager	Ongoing	Monitoring records and logs

Table 7 Operation management control measures

Issue	Control	Responsibility	Timeframe	Documentation
Aquatic ecology	For culvert and low level crossings for access roads, ensure that design requirements are met during construction and: • Remove topsoil and vegetation and set aside for reinstatement • Place culverts or pipes such that the bed level remains even • Use topsoil and vegetation in rehabilitation Stabilise completed surfaces with "soft" techniques such as jute matting or geotechnical fabric as far as practicable.	Environmental Manager	During operations	Stable work areas
	Staff will be informed via a site specific induction of the aquatic species that are likely to be encountered within the Project Area.	Environmental Manager	During operations	Induction training records
Vegetation	Staff will be informed via a site specific induction of the waxy cabbage palms that are likely to be encountered within the Project Area.	Environmental Manager	During operations	Induction training records
Groundwater	Re-run groundwater model to test drawdown effects on sensitive receptors, review management, monitoring and mitigation measures and develop additional measures as required.	Environmental Manager	Each time model is updated	Updated monitoring, management and mitigation measures
Surface water	Develop a comprehensive water balance model for the mining operation. Utilise the water balance model to optimise sizing of MAW dams, sediment ponds and discharge infrastructure as well as raw water supply requirements.	Design Manager	Prior to operation	Model in place
	Prepare and implement an operating plan for MAW and sediment dams, or incorporate operating requirements into the Plan of Operations. Operating plan is to include: • Annual dam surveillance inspections when dam is at a low level • Water quality monitoring • Operational requirements in relation to water	Mine Manager	Before operating MAW and sediment dams Ongoing	Dam operating plan Monitoring and surveillance records, mine water management records

Issue	Control	Responsibility	Timeframe	Documentation
	levels, transfers between storages and reuse of MAW • Requirements for recording mine water management transfers and use • MAW discharge approval parameters.			
	Transfer all MAW to MAW dams. MAW is not to be placed in sediment basins or directly discharged except under EA conditions.	Mine Manager	Ongoing	Mine water management records
	Utilise MAW for the following uses in preference to raw water: • Dust suppression • CHPP (except where raw water is required for particular processes) • Vehicle washing.	Area Managers	Ongoing	Mine water management records
	Review and update Mine Water Management Plan.	Mine Manager	Every five years or more frequently if required to address non-compliance	Updated plan
	Review and update Receiving environment monitoring plan.	Environmental Manager	Every five years or more frequently if required to address non-compliance	Updated plan
	Include maintenance of the following items in mine maintenance schedule: • Oil water separators • MIA stormwater systems • Pumps and pipes • Controlled discharge infrastructure.	Mine Manager	As per maintenance schedule	Maintenance records
Weed and pests	The measures outlined in the weed and pest management plan shall be implemented.	Environmental Manager	During operations	Approved weed and pest management plan implemented.
	Aquatic weed infestations will be identified and managed in accordance with the Isaac Regional Council Pest Management Plan and the weed and pest control strategies detailed within this EMP (Mine).	Environmental Manager	During operations	No increase in existing infestation or the occurrence of new infestations

Issue	Control	Responsibility	Timeframe	Documentation
	Wash-down of plant, machinery and vehicles will be undertaken in designated and controlled locations where waste water and weed seed material will be captured and prevented from discharging to watercourses.	Environmental Manager	During operations	Designated weed wash-down areas Weed hygiene declaration
Fire	Fire management strategies will be implemented to reduce the potential for destructive high intensity fires to disturb habitats.	Environmental Manager	Ongoing	Approved plan is implemented

Table 8 Post operation management control measures

Issue	Control	Responsibility	Timeframe	Documentation
Riparian vegetation	Maintenance of revegetated areas until vegetation cover criteria is achieved.	Environmental Manager	Post rehabilitation	Closure and rehabilitation strategy
Waxy cabbage palms	Monitoring of the waxy cabbage palms.	Environmental Manager	Annually for 5 years after rehabilitation	Closure and rehabilitation strategy
Weed and pests	Weed eradication and control as required during revegetation.	Environmental Manager	During revegetation	Closure and rehabilitation strategy
All	Monitoring of the Carmichael River corridor.	Environmental Manager	• Erosion – bi-annually • Surface water - quarterly and event based • Groundwater – quarterly and event based • Geotechnical (stability) – half yearly • Rehabilitation (Ecology) - annually All monitoring to continue 5 years after rehabilitation	Closure and rehabilitation strategy
Groundwater and surface water	Post closure groundwater modelling to be conducted at least 2 years prior to closure to confirm and/or validate predicted impacts and inform ongoing mitigation measures. Agreements to be in place with affected parties prior to post operations phase in regards to groundwater flow impacts.	Environmental Manager	Post operation	Closure and rehabilitation strategy

2. Monitoring

2.1 Monitoring sites

The proposed GDE monitoring sites are outlined in Table 9 and Table 10 and Figure A1.

Table 9 Proposed Doongmabulla and Mellaluka Spring monitoring sites

Monitoring Location	Description	Latitude	Longitude	Monitoring
DS1	Little Moses Spring	-22.091048	146.269163	Surface water flow Groundwater level Groundwater quality Aquatic fauna Stygofauna Spring vegetation survey
DS4	Moses Spring 1	-22.086698	146.239912	
DS3	Moses Spring 3	-22.091479	146.244128	
DS7	Moses Spring 75B	-22.0913	146.238604	
DS10*	Joshua Spring	-22.069449	146.23513	
MS01	Mellaluka Spring	-22.318086	146.48369	
MS02	Stories Spring	-22.296555	146.481523	
MS03	Lignum Spring	-22.26406	146.47457	
DS	Moses Spring	-22.09636	146.2499	GWL, CORVEG, WCP

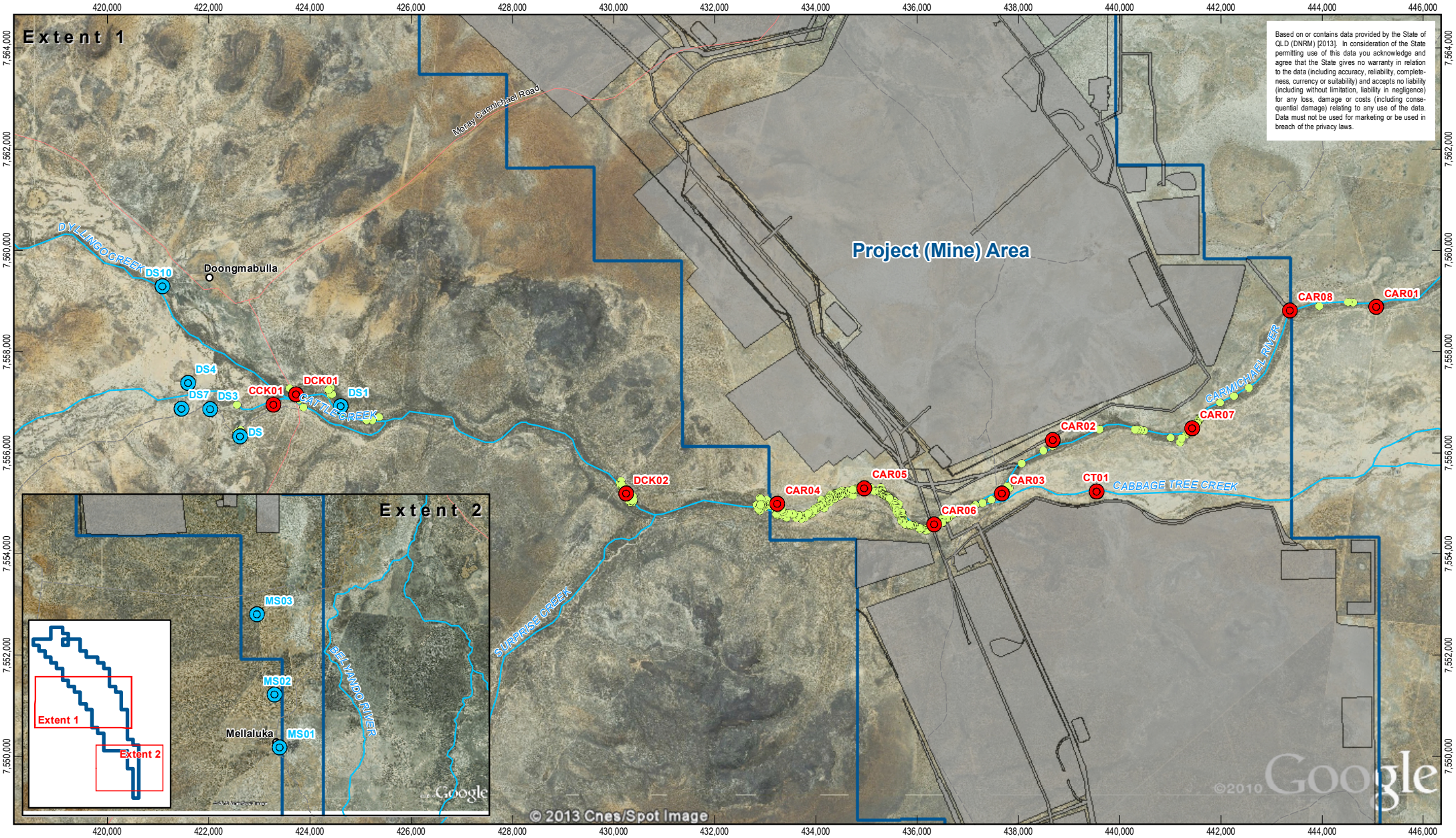
Table 10 Proposed waterway and waxy cabbage palm monitoring sites

Monitoring Location	Description	Latitude	Longitude	Monitoring
CAR01	Carmichael River downstream	-22.0740740	146.4675990	SWQ, SWL, GWL, F, M, AW, CORVEG
CAR02	Carmichael River – mid section	-22.0975750	146.4055550	SWQ, SWL, GWL, F, M, AW
CAR03	Carmichael River at Main Crossing	-22.1071410	146.3957890	SWQ, SWL, GWL, F, M, AW, CORVEG, WCP

Monitoring Location	Description	Latitude	Longitude	Monitoring
CAR04	Carmichael River at upstream Gauging Station	-22.1087960	146.3527180	SWQ, SWL, GWL, F, M, AW, CORVEG, WCP
CAR05	Carmichael River upstream of proposed road crossing	-22.106072	146.3694	GWL, CORVEG, WCP
CAR06	Carmichael River at proposed road crossing	-22.112544	146.3827	GWL, CORVEG, WCP
CAR07	Carmichael River	-22.095602	146.4322	GWL, CORVEG, WCP
CAR08	Carmichael River at boundary	-22.074663	146.451	CORVEG
CCK01	Cattle Creek upstream of Dylingo confluence at Moses Springs	-22.0906570	146.2562410	SWQ, SWL, GWL, F, M, AW, CORVEG
CT01	Cabbage Tree Creek approx 2.5 km downstream of Carmichael River confluence	-22.1067830	146.4139080	SWQ, SWL, GWL, F, M, AW, CORVEG
DCK01	Dyllingo Ck at Carmichael/Moray Rd	-22.0888320	146.2606000	SWQ, SWL, GWL, F, M, AW, CORVEG, WCP
DCK02	Dyllingo Ck	-22.106886	146.3237	GWL, CORVEG, WCP

Monitoring codes

Code	Description	Code	Description
AW	aquatic weeds	SWF	surface water flow
CORVEG	riparian vegetation transect	SWL	surface water level
F	fish	SWQ	surface water quality
GWL	groundwater level	WCP	waxy cabbage palm health
GWQ	groundwater quality	SWF	surface water flow
M	macroinvertebrates	SWL	surface water level



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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- Mine (Onsite)
- Project (Mine)
- Proposed GDE monitoring sites
- Proposed spring monitoring sites
- Waxy cabbage palm population

*Note: Some WCP points represent clusters of 2 or 3 individuals

Adani Mining Pty Ltd
Groundwater Dependant Ecosystems Management Plan

Job Number	41-26422
Revision	A
Date	14 Jan 2014

Proposed Groundwater dependant ecosystems monitoring sites

Figure A1

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2.2 Spring monitoring

Table 11 Monitoring at Doongmabulla and Mellaluka Spring complexes

Issue	Monitoring action	Responsibility	Frequency	Performance requirement
Aquatic ecology	Mapping and measurement of spring vegetation.	Environmental Manager	Bi-annually	Ongoing monitoring
	Threatened flora species surveys at Doongmabulla Springs.	Environmental Manager	Annually	Ongoing monitoring
Surface water	Flow monitoring at spring outlet.	Environmental Manager	As per surface water monitoring program	Ongoing monitoring
Groundwater	Conduct groundwater quality monitoring across monitoring network for: • pH, DO, turbidity, EC, temperature (field and lab) • Total organic carbon • Major ions • Fluoride and sulfide • Nutrients • Dissolved metals • Hydrocarbons (TPH and BTEX)	Environmental Manager	As per groundwater monitoring program	Trigger levels set in environmental authority are not exceeded
	Conduct groundwater level monitoring across monitoring network.	Environmental Manager	As per groundwater monitoring program	Drawdown at Doongmabulla and Mellaluka Springs does not exceed trigger level to be determined Drawdown at stock and domestic bores does not affect yield
	As Mining activity progresses, the monitoring network will be updated for inclusion of new bores or exclusion of bores in mined areas.	Environmental Manager	Continuous	Ongoing monitoring

2.1 Waterway and waxy cabbage palm monitoring

Table 12 Monitoring at the Carmichael River and Waxy Cabbage Palm sites

Issue	Monitoring action	Responsibility	Frequency	Performance requirement
Aquatic ecology	Monitor aquatic ecology monitoring sites: • In situ water quality (at time and location of each aquatic ecology monitoring event) • Presence of aquatic weeds • Fish species and abundance • Macroinvertebrate taxa and abundance. Undertake statistical analysis of results including SIGNAL, PET and multivariate analysis.	Environmental Manager	At least two events prior to commencement of mining. Annually for first 10 years of mining. Every two years thereafter. Monitoring to take place towards the end of the wet season.	No statistically significant change in aquatic ecology between control and impact sites and between baseline and post impact results from each monitoring event compared to the approved condition
Riparian vegetation	Permanent CORVEG primary monitoring transects will be established at regular intervals along the river for the purpose of establishing a riparian community health baseline. If possible, depth to groundwater data should be incorporated.	Environmental Manager	In the initial development/operational phases of the mine monitoring of the plots will be seasonal, reflecting high flow/low flow variability in the Carmichael River (twice annually). This monitoring should continue into the mid operational life of the mine.	No statistically significant change in riparian vegetation between control and impact sites and between baseline and post impact results from each monitoring event compared to the approved condition
Waxy cabbage palms	Monitoring of the health of the waxy cabbage palm population.	Environmental Manager	Bi-annual basis, preferably at the start of the wet season and the start of the dry season (December and May).	Waxy cabbage palm monitoring plan
	Relationship between waxy cabbage palm and groundwater.	Environmental Manager	Bi-annually	Waxy cabbage palm monitoring plan

Issue	Monitoring action	Responsibility	Frequency	Performance requirement
Surface water and groundwater	Monitor base river flow, surface and groundwater flows in the Carmichael River.	Environmental Manager	As per the Groundwater and Surface Water Monitoring Programs	No more than 10 % variance in groundwater inflows compared to the approved condition (section 2.1)
Groundwater	Conduct groundwater quality monitoring across monitoring network for: • pH, DO, turbidity, EC, temperature (field and lab) • Total organic carbon • Major ions • Fluoride and sulfide • Nutrients • Dissolved metals • Hydrocarbons (TPH and BTEX).	Environmental Manager	As per the Groundwater and Surface Water Monitoring Programs	Trigger levels set in environmental authority are not exceeded
Water quality	Monitor water quality in MAW dams.	Mine Manager	Monthly	To be determined
	Monitor the mandatory reporting level in all high and significant hazard dams.	Mine Manager	Continuous	Below level specified in environmental authority
	Monitor background and impacted water quality as per REMP.	Mine Manager	As per REMP	Below triggers specified in REMP
	Monitor EC/salinity upstream and downstream of controlled discharge point and at point of discharge.	Mine Manager	As per Environmental Authority Conditions	To be determined
Offsets	Conduct monitoring of waxy cabbage palm offset areas.	Environmental Manager	As per offset strategy and management plan	As per offset strategy and management plan
Weeds and pests	Monitor pest animal numbers at key water resource locations.	Environmental Manager	Quarterly	No increase in pest animal occurrence
	Conduct inspections of disturbed areas for weed proliferation.	Environmental Manager	Annually	Weed levels in disturbed areas are similar to pre-clearing

3. Corrective measures

Table 13 Corrective measures at Doongmabulla and Mellaluka Spring complexes

Issue	Trigger	Responsibility	Corrective action
Groundwater	Trigger levels set in environmental authority are exceeded.	Environmental Manager	Repeat monitoring immediately on receiving non-compliant results. If repeat results indicate persistent elevation, raise an incident report and commence incident investigation. Undertake corrective actions as identified in the incident investigation.
	Drawdown at Doongmabulla and Mellaluka Springs exceed trigger level to be determined.	Environmental Manager	Implementation of adaptive monitoring program. Mine planning and rehabilitation mitigation measures implemented.
	Drawdown at stock and domestic bores affects yield.	Environmental Manager	Implementation of adaptive monitoring program. Mine planning and rehabilitation mitigation measures implemented. Implement make good agreements with landholders.

Table 14 Corrective measures for waterway and waxy cabbage palms

Issue	Trigger	Responsibility	Corrective action
Aquatic ecology	Statistically significant change in aquatic ecology between control and impact sites and between baseline and post impact results from each monitoring event.	Environmental Manager	If significant differences are observed, an incident should be logged and an incident investigation carried out to determine cause of changes and develop corrective actions.
Riparian vegetation	Statistically significant change in riparian vegetation between control and impact sites and between baseline and post impact results from each monitoring event.	Environmental Manager	If significant differences are observed, an incident should be logged and an incident investigation carried out to determine cause of changes and develop corrective actions.
Groundwater	Greater than 10 % variance in groundwater inflows compared to the approved condition (section 2.1).	Environmental Manager	Direct diversions to the Carmichael River or release high quality water to the River.
	Groundwater quality trigger levels set in environmental authority are exceeded.	Environmental Manager	Repeat monitoring immediately on receiving non-compliant results. If repeat results indicate persistent elevation, raise an incident report and commence incident investigation. Undertake corrective actions as identified in the incident investigation.

Issue	Trigger	Responsibility	Corrective action
Water quality	MAW water quality greater than triggers specified.	Environmental Manager	Commence treatment to address contaminant levels. If necessary, transfer water between MAW dams to ensure that an uncontrolled overflow does not occur.
	Level in all high and significant hazard dams greater than trigger level.	Environmental Manager	Report to regulatory body (DEHP) that mandatory reporting level has been reached. Determine measures to reduce water level to below mandatory reporting level (controlled release, transfer to other dams).
	Water quality greater than triggers specified in REMP.	Environmental Manager	As specified in REMP
	EC/salinity upstream and downstream of controlled discharge point and at point of discharge greater than trigger levels.	Environmental Manager	Cease discharge if trigger level is reached at downstream monitoring location.
Weed and pests	Increase in pest animal occurrence.	Environmental Manager	Conduct a pest animal control program. Control program will prioritise class 2 declared pest species listed under the LP Act that are known to occur within the Isaac Regional Council area.
	Weed levels in disturbed areas are greater than pre-clearing.	Environmental Manager	Conduct a weed control program. Control programs will prioritise class 2 declared weed species listed under the LP Act that are known to occur within the Isaac Regional Council area including: • Bellyache bush • Chinee apple • Giant rat's tail grass • Harrisia cactus • Hymenachne (aquatic sp.) • Mother of millions • Parkinsonia • Prickly acacia • Prickly pear • Rubber vine • Salvinia • Tobacco weed.

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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C	J Keane	J Keane	On file	J Keane	On file	23/01/2014
0	Nil	J Keane		J Keane		11/02/2014

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