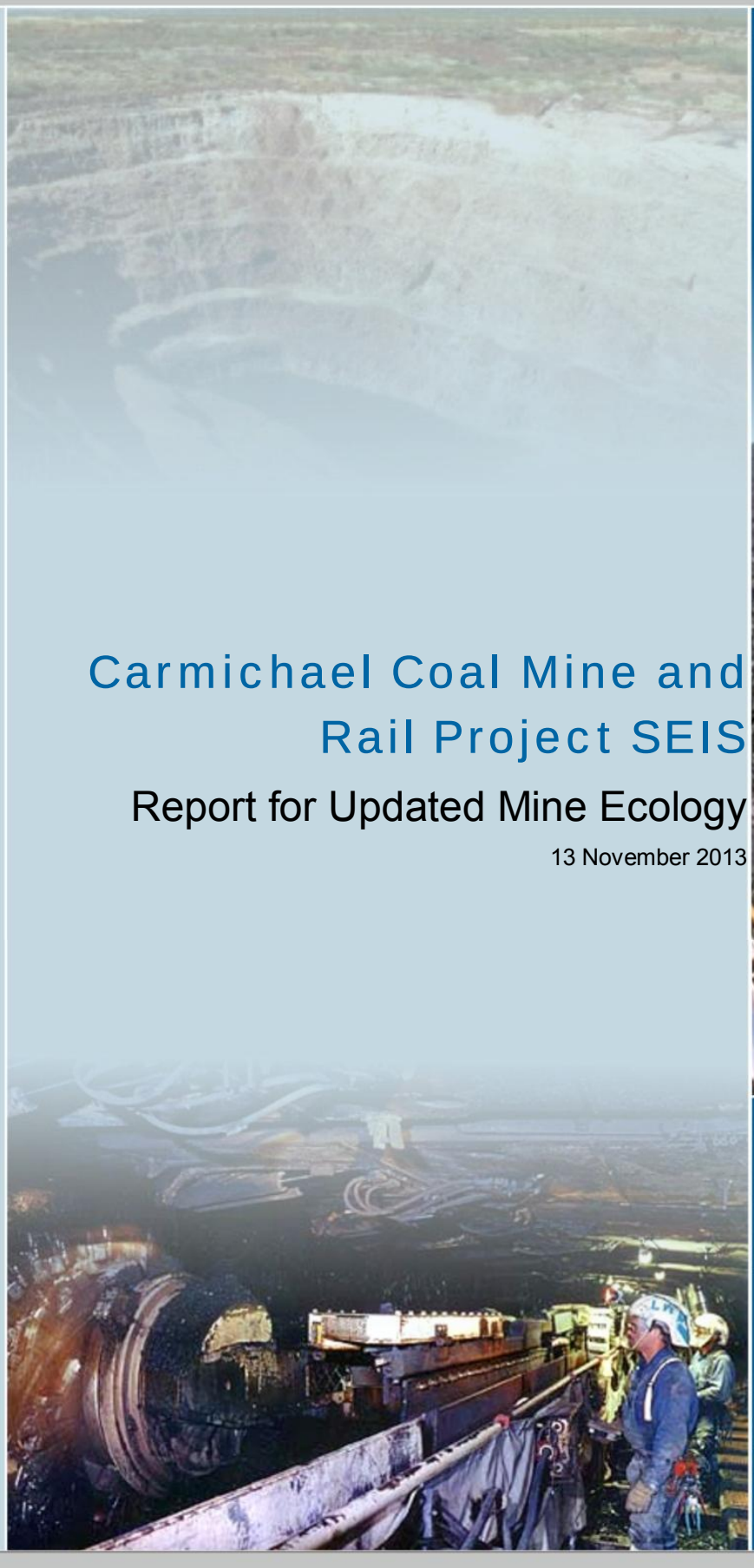
Adani Mining Pty Ltd

adani

Carmichael Coal Mine and Rail Project SEIS

Report for Updated Mine Ecology

13 November 2013



GHD

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Executive summary

Overview

Adani Mining Pty Ltd (Adani, the Proponent), commenced an Environmental Impact Statement (EIS) process for the Carmichael Coal Mine and Rail Project (the Project) in 2010. In November 2010, the Project was declared a 'significant project' and the Project was referred to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). The Project was determined to be a controlled action in January 2011. The Terms of Reference (ToR) for the Project EIS issued in May 2011.

The EIS for the Project was submitted in December 2012. Project components comprised the Project (Mine) and Project (Rail). Post-EIS work is now being carried out as part of a Supplementary Environmental Impact Statement (SEIS) in order to provide additional supporting information to the assessment of the Project's impacts.

The purpose of this report is to update the Project (Mine) components of the impact assessment with reference to:

- A number of additional ecological studies carried out for the Project (Mine)
- Amendments to the Mine Plan for the Project made since the EIS
- Submissions received on the EIS

This report brings together a number of key baseline ecological assessments from the EIS, namely terrestrial and aquatic ecological assessments and additional studies for the Commonwealth-listed black-throated finch and the nationally-important wetland Doongmabulla Springs.

Subsequent studies have now been undertaken with a focus on supplementary surveys for black-throated finch and Doongmabulla Springs, plus surveys of the offsite infrastructure areas, surveys for the Commonwealth-listed waxy cabbage palm, and investigations of mapped State-listed Great Barrier Reef (GBR) Wetland Protection Areas (WPAs). Potential indirect impacts to the GBR and other Commonwealth Marine Areas are assessed within a separate Matters of National Environmental Significance (MNES) Report (refer Volume 4 Appendix H Revised MNES Report) that has been revised since the submission of the EIS.

Key findings

The combined results of the aforementioned studies indicate that most significant ecological values that occur within the Project (Mine) Area, or may be subject to potential indirect impacts of the Project (Mine), are as follows:

Commonwealth matters

- The Brigalow Threatened Ecological Community (TEC) that exists within the Project (Mine) Area
- The Great Artesian Basin (GAB) Discharge Springs Wetlands TEC that exists at Doongmabulla Springs, 9.8 km directly west from the western edge of the Project (Mine) Area boundary

- One Commonwealth-listed threatened flora species confirmed present within the Mine Area: waxy cabbage palm. A total of 831 palms (90 percent of which were juveniles) were recorded from the Carmichael River corridor (within the Mine Area) and from Moses Springs, part of Doongmabulla Springs (approximately 9.8 km directly west from the western edge of the Project (Mine) Area boundary
- Four Commonwealth-listed threatened fauna species confirmed present within the Project (Mine) Area, namely the squatter pigeon (southern), black-throated finch (southern), koala and ornamental snake. Squatter pigeon (southern) and black-throated finch (southern) were found to be locally-abundant within suitable habitat areas across the broader landscape, koala and ornamental snake were recored as individuals within the Mine Area and the Mine (Offsite) Area respectively
- One Commonwealth-listed threatened fauna species assessed as likely to occur within the Project (Mine) Area, namely yakka skink
- Four Commonwealth-listed migratory bird species confirmed present within the Project (Mine) Area, with a further 11 migratory bird species assessed as likely to occur. All are wide-ranging, locally common and abundant species that occur throughout the broader landscape
- 25 Commonwealth-listed marine bird species confirmed present within the Project (Mine) Area, with a further 21 marine bird species assessed as likely to occur. All are wide-ranging, locally common and abundant species that occur throughout the broader landscape and are not included as threatened species under the EPBC Act.

State matters

- State-listed Regional Ecosystems (classified as endangered or of concern) are scattered throughout the Project (Mine) Area
- Bygana West Nature Refuge is a State-listed Category C Environmentally Sensitive Area (ESA) that exists within the south of the Project (Mine) Area
- In addition to the commonwealth matters which are also state listed, three State-listed threatened fauna species confirmed present within the Project (Mine) Area, namely black-necked stork, cotton pygmy-goose and little pied bat
- In addition to the commonwealth matters which are also state listed, three State-listed threatened fauna species assessed as likely to occur within the Project (Mine) Area, namely black-chinned honeyeater, square-tailed kite and brigalow scaly-foot
- Three State-listed WPAs occurring within the Mine Area
- Two watercourses, as defined by the Water Act, within the Project (Mine) Area, the Carmichael River and Cabbage Tree Creek.

Key impacts

Construction

The construction phase of the Project (Mine) will broadly involve the following actions:

- Road upgrades and construction of access and haul roads
- Construction of a mine workers accommodation village, including sewerage treatment plants
- Construction of an airstrip and industrial area
- Provision of offsite water supply from flood harvesting dam and pipeline
- Construction of Mine Infrastructure across the mining lease both centralised (e.g. CHPP, Offices, Workshops) and decentralised (e.g. power and water distribution)

Key impacts to terrestrial and aquatic ecological values during construction have been assessed as follows:

- Vegetation clearing (1,324 ha of remnant and 1,308 ha of non-remnant vegetation, including 31 ha of endangered and of concern REs, and 554 ha of the Brigalow TEC). The losses of remnant (or otherwise high value) vegetation experienced during construction are low, relative to the operation phase and comprise the further fragmentation of already isolated fragments within a broadly non-remnant, disturbed landscape
- Loss of potential habitat (up to 1,367 ha) for conservation significant species confirmed present or likely to occur (five Commonwealth-listed threatened species, 13 migratory species and seven State-listed threatened species). The vast majority of this habitat is within the Project (Mine) Area; very little of this habitat occurs within the Mine (Offsite) Area. Habitat loss will be generally localised during the construction phase, and will occur within a part of the local landscape of generally low connectivity value for fauna
- Terrestrial fauna mortality during vegetation clearing and construction may occur within remnant vegetation and/or regrowth areas in particular, but should not be significant given the controls the Proponent has committed to implementing (within the Project Environmental Management Plan (EMP))
- Introduction or spread of weed and/or pest species to Project (Mine) Area. The further introduction or proliferation of weed and/or pest species could have significant impacts to local flora and fauna and has therefore been identified as a high risk impact. Accordingly, Adani is committed to implementing a number of management measures set out in the Project EMP to mitigate this potential ecological impact.

Operation

The operational phase of the Project (Mine) will broadly involve the following actions:

- Staged underground mining and open cut mining operations
- Development and rehabilitation of overburden areas
- Diversion of creek lines, development of diversion drains, and creation of sediment ponds
- Establishment of a 500 m buffer from the Carmichael River and construction of levees

- Operation of the Mine (Offsite) Area

Key impacts to terrestrial and aquatic ecological values during operation have been assessed as follows:

- Vegetation clearing (9,123 ha of remnant and 8,482 ha of non-remnant vegetation, including 407 ha of endangered and of concern REs, 27 ha of which are constituents of the Brigalow TEC). Whilst a large proportion of the vegetation to be cleared is non-remnant (primarily within previously cleared areas) and the loss will be staged over the mine life (with some areas being rehabilitaed before others are cleared), the overall area of vegetation to be removed is substantial. Offsets will be required to mitigate this impact.
- Loss of the Bygana West Nature Refuge, Category C ESA. The loss of remnant vegetation associated with this refuge and its supporting function for the Commonwealth-listed species squatter pigeon (southern), black-throated finch (southern) and koala, will require offsetting
- Loss of potential habitat (up to 9,355 ha) for conservation significant species confirmed present and likely to occur represents areas approximately seven times that of the loss during construction. However, this potential habitat is identified based on RE assemblages that might be used by key species, as opposed to an area of actual usage, and there may be wide availability of that habitat type across the broader landscape, as is the case for the squatter pigeon (southern) and black-throated finch (southern), for example
- Terrestrial fauna mortality during vegetation clearing and operation could be significant, however implementation of the Project EMP, should reduce injury and mortality of wildlife to low levels
- Habitat fragmentation, andany reduction in connectivity or corridor function will be of focus in offsetting measures, particularly in the north and south of the Project (Mine) Area
- The loss of GBR WPAs and other aquatic habitats to the operation of the Project (Mine) is lessened by the reported relatively low values (to aquatic ecology) of the areas to be impacted and the provision of other surface water resources (farm dams) as part of the operational works
- Potentially significant local alterations to the surface water regime will result from the operation of the Project (Mine), with the proposed alterations to watercourses, removal of 25 percent of the local catchment area and disconnection of the floodplain
- Significant impacts to GDEs at Mellaluka Springs and in the Carmichael River in the eastern half of the Project (Mine) Area, including likely partial losses from the population of the vulnerable waxy cabbage palm
- Minor impacts to other GDEs, and to stygofauna
- Introduction or spread of weed and pest species to Project (Mine) Area. Of particular concern would be any further spread of buffel grass, at the expense of native grass species, which are the primary component of habitat for the black-throated finch
- Disruption of terrestrial fauna behaviour will occur throughout the operational phase of the Project (Mine). These impacts will be staged, as individual mine areas are extracted and

worked, whilst others are gradually rehabilitated. Nevertheless, there may be some sterilisation of potential habitat areas adjacent to operational activities

- Subsidence impacts to (up to 6,944 ha) of potential habitat for conservation significant species, which may result in localised changes to these habitats, are to be managed via a Project Subsidence Management Plan (SEIS Volume 4 Appendix I Subsidence Management Report. Some areas may in fact increase in value for listed fauna where additional surface water ponding, localised tree fall and/or surface cracking occurs

Rehabilitation

The rehabilitation phasing for the Project (Mine) is provided in detail in the Draft Rehabilitation Management Strategy (refer Volume 4 Appendix R1 and R2). The Rehabilitation objectives are as follows:

Short-term

Rehabilitation objectives in the short term are to:

- Progressively reshape and stabilise disturbed areas
- Provide short-term erosion control measures
- Mange soil to ensure suitability and beneficial reuse during rehabilitation
- Ameliorate wastes and soils as necessary to address physical and chemical constraints to revegetation and erosion stability
- Refine rehabilitation methods through continuing review and update of this RMS.

Medium-term

Rehabilitation objectives in the medium term will focus on:

- Establishing functionally important and structurally dominant species from the relevant native vegetation communities
- Demonstrating rehabilitation succession in comparison with analogue sites
- Reducing reliance on structural drainage and erosion control methods through landform design and construction that lends itself to the surrounding fluvial and landscape processes.

Long-term

The long-term rehabilitation objectives are to:

- Monitor rehabilitation areas to ensure succession of planted native vegetation with functionality trending toward analogue native vegetation communities
- Apply adaptive management measures if natural succession is not occurring
- Demonstrate rehabilitation performance.

For the purposes of rehabilitation management and planning, the mine site will be managed according to the following eight domains:

- Open-cut voids and slopes

- Underground mining area
- Mine infrastructure area
- Out-of-pit spoil dumps
- Water storage areas, including MAW dams, raw water dams and sediment ponds;
- Stream diversions
- Tailings drying cell
- Carmichael River corridor.

Conclusions

The predicted impacts to ecological values (both Commonwealth and State-listed) will be far higher during the operational phase of the Project (Mine) than during the construction phase. These impacts will be more substantial in magnitude, because of the increased scale of actions and activities during this latter phase, and in extent, occurring over a greater spatial area.

Whilst the approach to mitigating and managing impacts will include a combination of prevention or reduction of all avoidable impacts to the greatest extent possible, unavoidable losses of large areas of vegetation and fauna habitat, and fauna mortality, will occur. Active management and rehabilitation during the construction and operation of the Project (Mine) will be required, as will research and monitoring programs, to both inform the ongoing management of impacts at and near the Project (Mine) Area, and to contribute to the understanding and protection of regional ecological values across the Galilee Basin.

Where residual impacts of the Project (Mine) remain, the Project Offsets Strategy seeks to provide compensatory measures through the establishment and maintenance of offset sites across the local landscape and broader region, as necessary. The overall objective of the Offsets Strategy is to deliver a solution of no net loss to biodiversity values at a regional scale due to the Project (Mine).

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1. Introduction

1.1 Project overview

Adani Mining Pty Ltd (Adani, the Proponent), commenced an Environmental Impact Statement (EIS) process for the Carmichael Coal Mine and Rail Project (the Project) in 2010. On 26 November 2010, the Queensland (Qld) Office of the Coordinator-General declared the Project a 'significant project' and the Project was referred to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (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 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The controlling provisions for the Project include:

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

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

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

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

Project components are as follows:

- The Project (Mine): a greenfield coal mine over EPC 1690 and the eastern portion of EPC 1080, which includes both open cut and underground mining, on mine infrastructure and associated mine processing facilities (the Mine) and the Mine (offsite) infrastructure including a workers accommodation village and associated facilities, a permanent airport site, an industrial area and water supply infrastructure
- The Project (Rail): a greenfield rail line connecting 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: five local quarries to extract quarry materials for construction and operational purposes.

1.2 Purpose of this report

Post-EIS work has been carried out as part of a Supplementary Environmental Impact Statement (SEIS) in order to provide additional supporting information to assist the Coordinator-General in evaluating the EIS.

The purpose of this report is to update the Project (Mine) component of the impact assessment with reference to:

1. The additional ecological baseline survey work carried out for the Project (Mine)
2. Amendments to the Mine Plan for the Project
3. Submissions received about the EIS

1.3 Scope and limitations

This report brings together the key baseline information contained within the following reports from the EIS and post-EIS components of the Project (Mine):

EIS

- EIS Volume 4, Appendix N1, Mine Terrestrial Ecology Report (GHD, 2012a)
- EIS Volume 4, Appendix N2, Doongmabulla Springs Report (GHD, 2012b)
- EIS Volume 4, Appendix N3, Black-throated Finch Report (GHD, 2012c)
- EIS Volume 4, Appendix O1, Mine Aquatic Ecology Report (GHD, 2012d)

Post-EIS

- SEIS Volume 4 Appendix I1 Subsidence Report
- SEIS Volume 4, Appendix J2 Black-throated Finch Monitoring Survey 1
- SEIS Volume 4, Appendix J3 Springs Ecological Assessment Report
- SEIS Volume 4, Appendix J4 Waxy Cabbage Palm Assessment Report
- SEIS Volume 4, Appendix J5 Offsite Infrastructure Ecological Assessment Report
- SEIS Volume 4, Appendix J6 Offsite BioCondition Report
- SEIS Volume 4, Appendix J7 Offsite PVMP Report
- SEIS Volume 4, Appendix J7b Offsite PMAV Report
- SEIS Volume 4, Appendix J8 GBR Wetland Protection Areas Report

2. Summary of baseline reports

2.1 Survey work

The following survey work has been undertaken during the EIS and post-EIS phases of the Project (Mine) in order to inform the assessment of impacts. The locations and distribution of cumulative survey effort are shown in Figure 1, Figure 2 and Figure 3.

2.1.1 EIS

Ecological survey work was carried out in three separate areas relating to the Project (Mine), as follows, to establish the baseline that was assessed within the EIS.

These surveys were reported in (GHD, 2012a and d).

EPC 1690

Dry season surveys (terrestrial and aquatic) were carried out in November 2010 and wet season surveys (terrestrial and aquatic) were carried out in April/May 2011.

During these surveys, 60 percent of the EPC 1690 study area was found to comprise remnant vegetation (approximately 28,000 of 40,000 ha at that time), with the majority of cleared land occurring in the centre of this area (between the Carmichael River and the Moray Carmichael Road). Much of the habitat was found to be fragmented, with the main intact corridors associated with the Belyando River, Carmichael River, and Bygana West Nature Refuge. Disturbance to fauna habitats from cattle, weeds and feral animals was observed to be low.

In terms of Commonwealth listed matters, the Brigalow TEC was confirmed to be present and the threatened waxy cabbage palm (*Livistona lanuginosa*) was confirmed present within the Mine Area. Three species of threatened fauna were confirmed present, black-throated finch, squatter pigeon and koala, with both birds locally common in suitable habitats. Yakka skink and ornamental snake were assessed as being likely to occur. In addition, three common migratory bird species (great egret, rainbow bee-eater, satin flycatcher) were recorded; 15 others were assessed as likely to occur, but no important assemblages of migratory species were predicted to be present.

At the State level, three threatened fauna species were confirmed present, little pied bat, black-necked stork and cotton pygmy-goose, as well as the special least concern echidna. The protected area Bygana West Nature Refuge was identified, with squatter pigeon and black-throated finch located along its southern boundary.

The main riverine feature of the EPC 1690 study area is the Carmichael River and its flow was found to vary with the intensity of wet season conditions annually. The River represents the largest watercourse within the study area and maintains aquatic habitat throughout the year, even if in isolated pools. Cabbage Tree Creek also provides permanent aquatic habitat for flora and fauna. Other palustrine and lacustrine environments across the area comprise primarily farm dams, with numerous minor drainage lines and gilgais that do not retain water for long periods of time. Surveys detected a low diversity of aquatic flora and fauna species within the surveyed habitats. No conservation significant aquatic species or communities were observed or predicted to occur.

EPC 1080

Dry season surveys (terrestrial and aquatic) were carried out in November 2011.

The two dominant habitat types of the EPC 1080 study area were found to be ironbark-box woodland and open cleared land, with remnant vegetation occurring over 44 percent of the area, particularly as large tracts of remnant vegetation north of Moray Carmichael Road.

The Brigalow TEC was confirmed present, but no threatened flora species were located. Two Commonwealth-listed threatened birds were recorded, black-throated finch (southern) and squatter pigeon (southern), and one mammal, the koala. Three common migratory bird species (great egret, rainbow bee-eater, satin flycatcher) were also recorded from the EPC 1080 study area. Three State-listed threatened species were recorded, these being little pied bat, black-necked stork and cotton pygmy-goose, plus echidna as special least concern.

Offsite infrastructure

A rapid assessment of the offsite infrastructure area was carried out in June 2012 (Hyder Consulting Ltd). This did not add any further flora and fauna species to those previously found, but confirmed the mapped status and condition of the area as primarily cleared land (across 68 percent of the offsite infrastructure study area), with higher value habitats fragmented and comprising riparian woodland and grassland areas along watercourses and within floodplains.

Outside of Project (Mine) Area

An additional survey specifically for black-throated finch was carried out in May 2012. The focus of this survey was Moray Downs, within areas adjacent to the EPCs, as potential offset areas for the Project (Mine). A separate survey of the Doongmabulla Springs site (approximately 9.8 km directly west from the western edge of the Project (Mine)) was also undertaken in May 2012.

The additional survey for black-throated finch expanded on the previous data set and, in total, 105 finches were seen across 37 survey sites. The number of observations made during the survey further suggested that the species occurs in large numbers in the area, across both the EPCs and Moray Downs, and that the habitat is suitable for the species and in good condition.

The Doongmabulla Spring complex was found to be comprised of two spring groups, Moses and Joshua, at the confluence of three creek systems that join to form the Carmichael River. The Moses Spring group comprises 30 individual spring mounds, supporting a high level of endemicity, with seven (mostly flora) species present occurring only in association with the Great Artesian Basin (GAB) spring wetlands. The Joshua Spring group comprises one spring mound that has been modified into an artificial dam. These surveys were reported (GHD, 2012b and GHD, 2012c).

2.1.2 Post EIS

Black-throated finch

Following the confirmed presence of the species on site during investigations for the EIS, additional monitoring work was undertaken in May 2013. Consultation meetings were held with the Black-throated Finch Recovery Team (3 May 2013) and DSEWPaC (7 June 2013) and a draft monitoring program was developed. A key component of this was intensive local monitoring (observation) on the Mine Area. This monitoring assisted in responding to comments in submissions about the EIS.

The additional surveys established 80 monitoring sites: 52 x 2 ha woodland sites, 8 x water body count sites and 20 camera trap sites. Detailed vegetation and habitat data was collected at the 2 ha sites. Surveys were conducted over 8 days, by a four-person field team (i.e. 32 person field days). A total 208 records of black-throated finch were recorded from 2 ha counts in 12 locations (some may have been recounts of previously-seen birds), including 3 records of nesting. The camera traps recorded a further 6 locations and mainly utilising troughs and ephemeral water, with flocks between 1 and 41 birds. The highest numbers of finches consistently recorded in association with areas of intact remnant vegetation (particularly where in good condition) in the north-west, west and south-west of the Project (Mine) Area. The cumulative survey effort also indicates that black-throated finch is more likely to utilise small and ephemeral water sources than large, exposed water bodies. Nesting was confirmed within the Project (Mine) Area for the first time during this monitoring exercise, with one finch carrying nest material and two nests found, although nests may have been used for roosting rather than breeding at this time.

The full results of this monitoring are reported in Volume 4, Appendix J2 Black-throated Finch Monitoring Survey

Doongmabulla and Mellaluka Springs

Following the identification of potential indirect impacts to Doongmabulla Springs as a result of the Project (Mine) and the identification of a further potential spring group at Mellaluka, a further survey was carried out in March/April 2013. This survey assisted in responding to comments received in submissions about the EIS.

The additional work carried out revealed that, in general, the habitats present within the Doongmabulla Springs complex are intact and in good ecological condition exhibiting only minor disturbance and that the greatest habitat values of the complex are the permanency of water and the connectivity of the wetland to the nearby waterways and the surrounding region. It also revealed a lesser complexity of habitat within the Mellaluka Springs complex than at Doongmabulla and that the value of this habitat may be more limited for some species.

The full results of this survey are reported in Volume 4, Appendix J3 Report for Doongmabulla and Mellaluka Springs.

Waxy cabbage palm

Following the confirmation of the presence of the species on site during investigations for the EIS, an additional population survey was carried out in March/April 2013, to further map the location and extent of this species within and adjacent to the Mine Area. This survey assisted in responding to comments received in submissions about the EIS.

The additional work resulted in a total of 831 palms being located, with the majority of individuals situated within the Carmichael River within two areas of particular population density (of 479 palms and 155 palms, respectively). Adult palms accounted for only approximately 11 percent of this population. During the survey, four threatening processes were noted: weed infestation (particularly from rubber vine), feral pigs, cattle and bush fire.

The full results of this survey are reported in Volume 4, Appendix J4 Report for Population Survey of Waxy Cabbage Palm.

Offsite infrastructure

Following the finalisation of the Mine Plan in relation to the proposed location of offsite infrastructure, further surveys were carried out within the Mine (Offsite) Area in April/May 2013. These surveys assisted in responding to comments received in submissions about the EIS.

The additional work carried out revealed that the survey area is a predominantly cleared agricultural landscape and that remnant vegetation only occurred over approximately 4.5 percent of that area, primarily in association with two creek lines and their adjacent floodplain areas. The remnant vegetation present included approximately 10 ha of (constituent endangered REs of) Brigalow TEC. While no threatened flora or aquatic species were recorded during the survey, three EPBC Act listed fauna species were confirmed present: black-throated finch, squatter pigeon and ornamental snake, as well as the *Nature Conservation Act 1992* (NC Act) listed black-necked stork and cotton pygmy-goose.

The study area for these reports was defined by the Project (Mine) Offsite footprint. At the time of the surveys, the footprint included an offsite bore field and associated pipelines. The borefield is no longer a component of the Carmichael Coal Mine and Rail Project. As such, the study area for the offsite ecological assessments includes areas where the bore field was to be situated.

The offsite infrastructure ecological assessment also included a desktop assessment of officially mapped RE within the footprint of the Moray-Carmichael road upgrade and realignment. Areas of this footprint within the study area for the offsite surveys were field verified, and are included with the field verified RE within the offsite reports.

The full results of these surveys are reported in:

- Volume 4, Appendix J5 Offsite Infrastructure Ecological Assessment Report
- Volume 4, Appendix J6 Offsite BioCondition Report
- Volume 4, Appendix J7 Offsite PVMP Report

Wetland Protection Areas

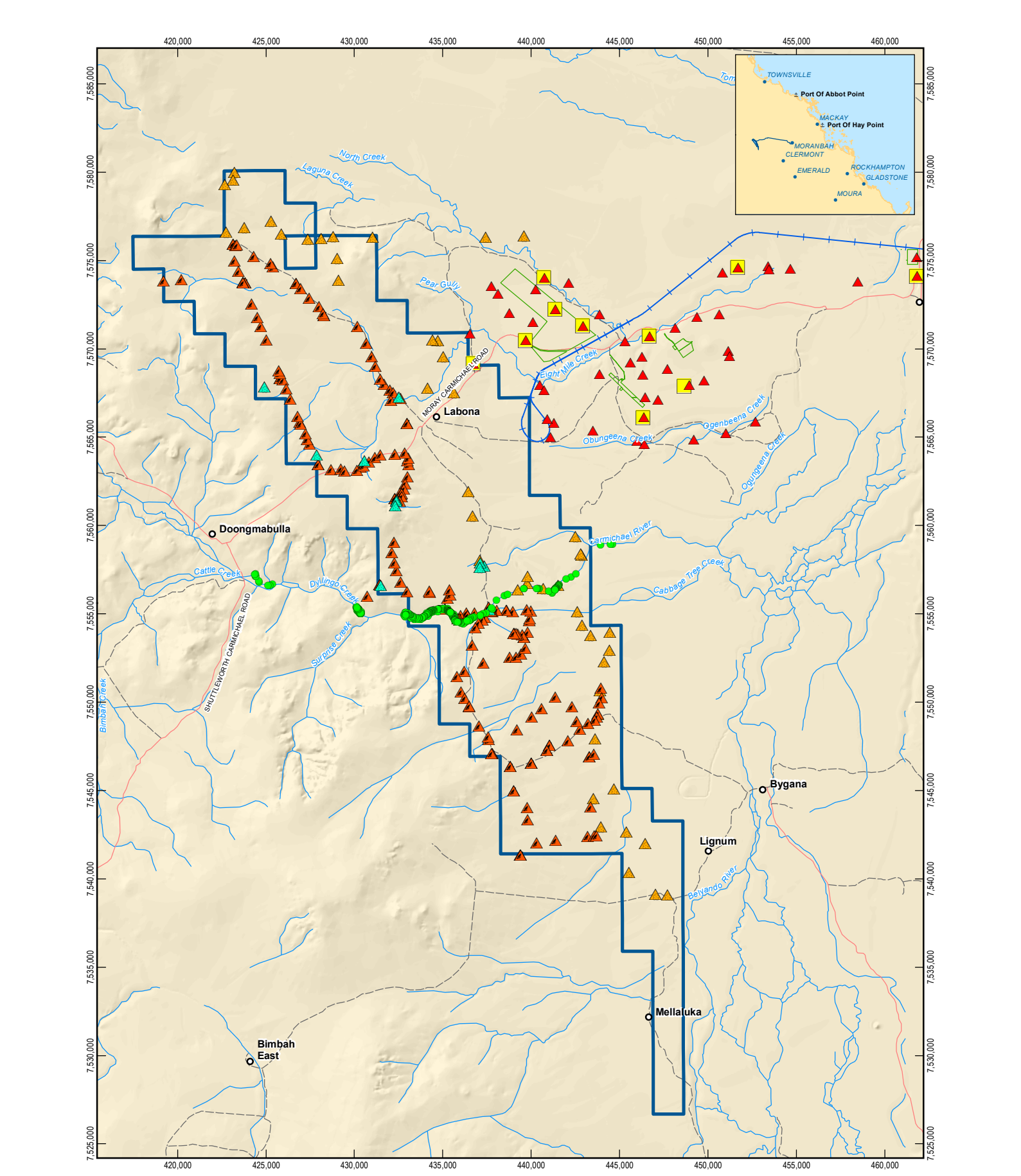
Following the identification of three potential (mapped) GBR WPAs within the Mine Area that were dry at the time of earlier survey work, additional surveys were carried out in May 2013 to seek confirmation of their status and condition. This survey assisted in responding to comments received from DEHP.

The additional work carried out revealed that although the areas were once again dry at the time of the survey, the soil characteristics (colour and alluvium nature) and flora species present were indicative of the areas being wetlands, as was the presence of snail and crab shells and burrows that may be utilised by freshwater fauna species. The three WPAs are considered to fit the Queensland wetland classification of a ‘semi-arid grass, sedge and herb swamp’.

The full results of this survey are reported in Volume 4, Appendix J8 Report for Great Barrier Reef Wetland Protection Areas.

Other supporting information

An ecological equivalence assessment (EEA) was carried out in April/May 2013 in relation to proposed exploration areas (geotechnical investigation work) within the Mine Area and this information has been used to clarify the status and condition of REs within that area.



LEGEND

- Homestead
- Waxy cabbage palm population
- Flora Rapid Survey Site 2010 Survey Project (Mine)
- Flora Rapid Survey Site - 2011 Survey Project (Mine)
- Flora Rapid Survey Sites - 2012
- Quaternary Assessment Sites MIne (Offsite) 2013
- BioCondition Assessment Site Mine (Offsite) 2013
- Local Road
- Track
- Watercourse
- Project (Rail)
- Project (Mine)
- Mine (Offsite)

1:275,000 (at A4)
0 1 2 3 4 5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project SEIS

Job Number 41-26422
Revision C
Date 15-10-2013

Distribution of Flora Survey Effort

Figure 1

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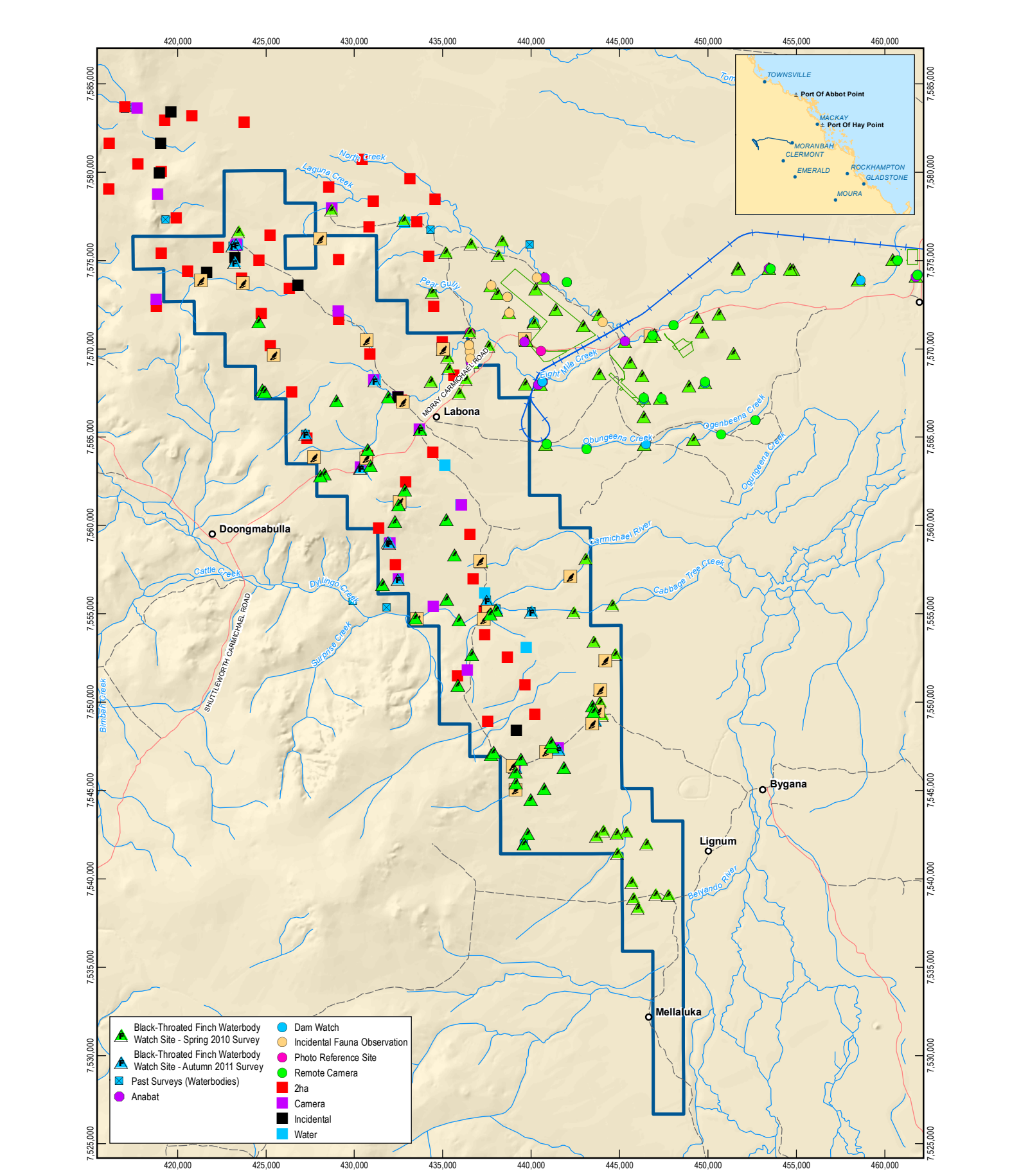
Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DME: EPC 1690 (2010), EPC 1080 (2011); DNRM: Regional Ecosystems v6.1 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007); Adani: Offsite Infrastructure, Alignment(2013); GHD: Flora Survey Sites (2011), Flora Sites (2010), Flora Sites (2013) Waxy Cabbage Palm population (2013). Created by: BW, CA



LEGEND

- Fauna Rapid Survey Sites
- Fauna Comprehensive Survey Sites
- Homestead
- Local Road
- Track
- Watercourse
- Project (Rail)
- Project (Mine)
- Mine (Offsite)

1:275,000 (at A4)

0 1 2 3 4 5

Kilometres

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

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Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project SEIS

Job Number	41-26422
Revision	B
Date	24-10-2013

Distribution of Fauna Survey Effort

Figure 2

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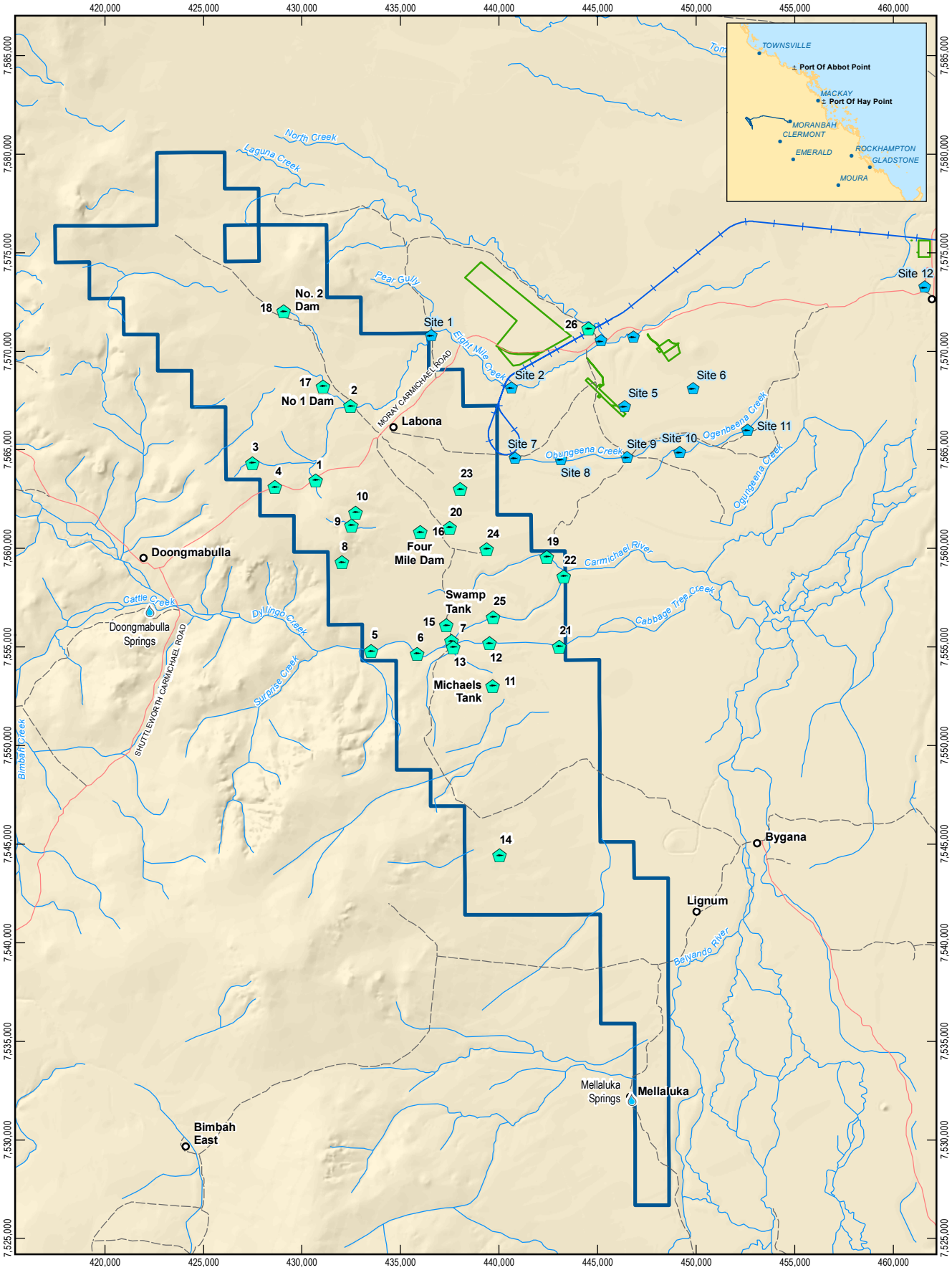
Data Source: DME: EPC 1690 (2010), EPC 1080 (2011); DNRM: Regional Ecosystems v6.1 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007); Adani: Offsite Infrastructure, Alignment(2013); GHD: Fauna Survey Sites (2011), Fauna Sites (2010), Fauna Sites (2013). Created by: BW, CA



LEGEND

- Springs Survey Site Locations
- Aquatic Ecology Mine (Onsite) Habitat Assessment Site
- Aquatic Ecology Mine (Offsite) Habitat Assessment Site
- Homestead
- Local Road
- Track
- Watercourse
- Project (Rail)
- Project (Mine)
- Mine (Offsite)

1:275,000 (at A4)
0 1 2 3 4 5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project SEIS

Job Number	41-26422
Revision	C
Date	24-10-2013

Distribution of Aquatic Survey Effort

Figure 3

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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: DME: EPC 1690 (2010), EPC 1080 (2011); DERM: Regional Ecosystems v6.1 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007); Adani: Alignment,Mine (Offsite) (2013); GHD: Aquatic Survey (2013). Created by: MS

2.2 Survey effort

Table 1 presents a summary of the ecological survey effort undertaken at the Mine Area and Mine (Offsite) Area.

Table 1 Summary of survey effort

Survey Technique	Survey Type	Within Project (Mine) Area	Outside of Project (Mine) Area
Standard	Terrestrial flora and fauna	42 days (230 person days) 5 days, 6 ecologists(Nov 2010) 15 days, 6 ecologists (April/ May 2011) 12 days, 6 ecologists (Nov 2011) 1 day, 2 ecologists (June 2012) (Hyder Consulting) 9 days, 4 ecologists (April/ May 2013)	
	Aquatic flora and fauna	12 days (24 person days) 5 days, 2 ecologists (Nov 2010) 4 days, 2 ecologists(April/ May 2011) 3 days, 2 ecologists (Nov 2011)	
	BioCondition	7 days(14 person days) (April/ May 2013)	
Targeted	Doongmabulla and Mellaluka Springs		15 days (30 person days) 3 days, 2 ecologists (May 2012- Doongmabulla only) 12 days, 2 ecologists (March/ April 2013)
	Waxy Cabbage Palm	12 days (24 person days) (March/ April 2013)	
	Black-throated finch	15 days (72 person days) 6 days, 6 ecologists(May 2012) 9 days, 4 ecologists (May 2013) 151 camera trap days (May 2013)	
	GBRWPA	1 day (2 person days) (May 2013)	
	Ecological Equivalence Assessment (ELA)	9 days (18 person days) (April/ May 2013)	
	PVMP	9 days (18 person days) (April/ May 2013)	
	Stygofauna	October 2011 August 2012	
Doongmabulla Springs, Mellaluka Springs, waxy cabbage palm and GBR WPA surveys were all conducted simultaneously and therefore some survey periods have been replicated.			

2.3 Summary of results

Table 2 presents a revised and consolidated likelihood of occurrence assessment for all Commonwealth and State values (species and communities) of relevance to the updated ecological assessment.

Table 2 Likelihood of occurrence key values

Status	Value	Likelihood of Occurrence	Impacts Assessed
Commonwealth: Listed Threatened Ecological Community	Brigalow	Confirmed present: within the Mine Area, predominately adjacent to the Carmichael River and in the south and east of the Mine Area.	Yes
	GAB Discharge Spring Wetlands	Confirmed present outside of the Mine Area: Doongmabulla Springs, approximately 9.8 km west of the western Mine Area boundary.	Indirect only (not within Project (Mine) Area
Commonwealth: Listed Threatened Species	Waxy cabbage palm	Confirmed present: total of 831 palms recorded from the Carmichael River (within the Mine Area) and from Moses Springs (approximately 8.8 km west of the western Mine Area boundary).	Indirect only (not within direct disturbance footprint)
	Squatter pigeon (southern)	Confirmed present: 30+ records in the Mine Area, as well as the Mine (Offsite) Area, within remnant and non-remnant vegetation.	Yes
	Black-throated finch (southern)	Confirmed present: Flocks of up to 40+ finches recorded at sites predominately in the north, south and west of the Mine Area in remnant *Eucalyptus melanophloia, E. similis and E. brownii/populnea* woodland and using mainly cattle trough, ephemeral scrapes and drainage lines, and occasionally large dams.	Yes
	Koala	Confirmed present: single koala recorded in open woodland habitat in south of the Mine Area.	Yes
	Ornamental snake	Confirmed present: recorded at two sites within the Mine (Offsite) Area.	Yes
	Yakka skink	Likely to occur: not recorded in the Mine Area or Mine (Offsite) Area during targeted surveys. Suitable habitat occurs within remnant open ironbark, yellow jacket, gidgee and brigalow woodland in the north and south of the Mine Area (where suitable microhabitats are present).	Yes
Commonwealth: Listed Migratory Species	4 migratory species	Confirmed present: widespread and abundant species that occur throughout the region.	Yes
	11 migratory species	Likely to occur suitable habitat occurs within the Mine Area and Mine (Offsite) Area.	Yes

Status	Value	Likelihood of Occurrence	Impacts Assessed
Commonwealth: Marine Species	25 marine species	Confirmed present: widespread and abundant species that occur throughout the region.	Yes
	21 marine species	Likely to occur: suitable habitat occurs within the Mine Area and Mine (Offsite) Area.	Yes
State: Endangered and Of Concern REs		Confirmed present: Of Concern and Endangered REs scattered through Mine Area.	Yes
State: ESAs	Bygana West (Category C)	Confirmed present: Bygana West Nature Refuge occurs south of the Carmichael River within the Mine Area.	Yes
State: Mapped High Value Regrowth		Mapped within Mine Area: small areas of High Value Regrowth area mapped in the in the east and south of the Mine Area.	Yes
State: Essential Habitat		None within Mine Area.	No
State: Threatened Flora and Fauna	Black-necked stork	Confirmed present: recorded utilising farm dams within the Mine Area and Mine (Offsite) Area.	Yes
	Cotton pygmy-goose	Confirmed present: recorded utilising farm dams within the Mine Area and Mine (Offsite) Area.	Yes
	Little pied bat	Confirmed present: recorded via Anabat at five sites within the Mine Area.	Yes
	Black-chinned honeyeater	Likely to occur: not recorded in the Mine Area during targeted surveys. Suitable habitat occurs within remnant woodland habitat, particularly within the riparian zone along the Carmichael River within the Mine Area.	Yes
	Square-tailed kite	Likely to occur: not recorded in the Mine Area during targeted surveys. Suitable habitat occurs within remnant woodland habitat, particularly within the riparian zone along the Carmichael River within the Mine Area.	Yes
	Brigalow scaly-foot[1]	Likely to occur: not recorded in the Project (Mine) Area during targeted surveys. Suitable habitat occurs within gidgee/brigalow shrubland and ironbark – box woodland	Yes

[1] Brigalow scaly-foot was previously considered unlikely to occur within the EIS phase of assessment. However, given new information on range expansions and advice from DSEWPaC, this assessment has been altered to likely to occur.

Status	Value	Likelihood of Occurrence	Impacts Assessed
State: Protected Areas	Bygana West	See State ESAs	Yes
	Doongmabulla	See Commonwealth TECs	Yes
	Wetland Protection Areas	3 WPAs confirmed present within the Mine Area.	Yes
	Watercourses	The Carmichael River, Cabbage Tree Creek and north Creek have been determined as watercourses, as defined in the Water Act.	Yes

3. Potential impacts and mitigation - construction

3.1 Introduction

This impact assessment has been structured to address impacts associated with the construction activities listed below. Full details about aspects of the construction phase of the Project (Mine) are provided in Volume 4, Appendix B Updated Mine Project Description.

Broadly, the construction phase of the Project (Mine) will involve the following activities over a period of approximately three years:

- Construction of access roads from Moray Carmichael Road to the workers accommodation village, airstrip and industrial area.
- Construction of the workers accommodation village. The village will be constructed in a number of stages. An initial stage of 1,000 beds will provide accommodation for workers undertaking early construction activities. Two subsequent stages will be constructed as the construction workforce grows and mobilisation of the operation workforce commences.
- Installation of sewage treatment systems and water treatment systems at the workers accommodation village, within the mine infrastructure area and also the industrial area and airport. The type of sewage treatment facilities and whether treated wastewater will be reused or disposed of by irrigation is to be determined in the detailed design stage.
- Construction of the airport and terminal facilities.
- Construction of the industrial area including fuel storage and refuelling areas, maintenance facilities, vehicle wash areas and office and administration facilities.
- Construction of offsite water supply components. This will include:
  - construction of an off-stream storage near the Belyando River; this will be five GL capacity “turkey nest” style dam
  - installation of a pipeline connecting the off-stream storage to the offsite infrastructure area and demand points within the proposed mine.

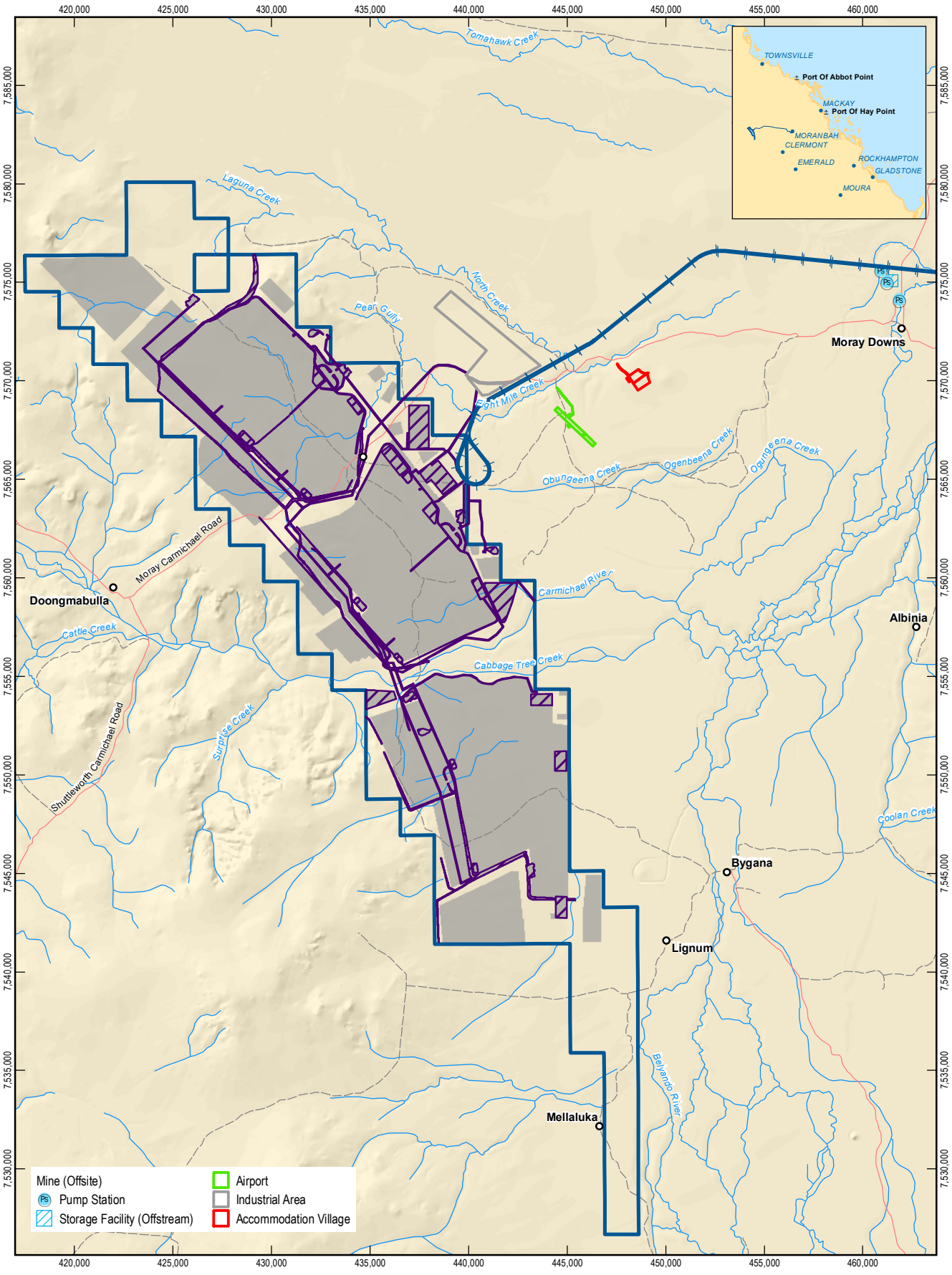
The locations of the mine infrastructure, airport and mine village are presented in Figure 4.

In terms of construction activities that may impact on the environment, the Project is designed such that:

- All water leaving construction areas will be captured and treated prior to discharge/reuse.
- Water required for construction will be sourced from a number of water supplies including offsite extraction from the Belyando River flood harvesting (Hyder Consulting, 2012).
- Wastewater for construction crew will be treated to A standard and discharged/reused onsite.

The potential construction phase impacts to terrestrial and aquatic ecological values have been considered, and appropriate management and mitigation measures proposed, to ameliorate identified impacts. The potential construction phase impacts are set out below:

- Vegetation clearing, including:
  - Loss of vegetation and fauna habitat (including loss of roosting, foraging and breeding areas)
  - Fauna mortality
  - Habitat fragmentation
  - Habitat degradation through erosion of topsoils, dust deposition on plants and water resources
- Loss of aquatic and riparian habitat
- Aquatic fauna mortality
- Degradation of water quality and aquatic habitats due to:
  - Run-off and sedimentation
  - Dust pollution
- Alteration of surface water regime including:
  - Changes in flow (catchment and diversions)
  - Barriers to flow
  - Floodplain connectivity
  - Loss of water resources for terrestrial species
- Introduction or exacerbation of feral animal and weed species:
  - Competition with native species, predation of native species, and habitat degradation (presence and prevalence of pest and weed species)
- Alteration to air quality and noise environments (i.e. altered exposure to disturbance):
  - Disturbance to breeding, roosting and foraging behaviours



LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- Riverine
- Palustrine
- Project (Rail)
- Project (Mine)
- Construction Phase Disturbance Footprint
- Mine Layout

1:275,000 (at A4)
0 1 2 3 4 5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project SEIS

Project (Mine) Area Active During Construction Phase

Job Number 41-26422
Revision B
Date 24-10-2013

Figure 4

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Data Source: DNRM: Waterbody (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Road, Homestead, Watercourse (2007); Adani: Project Rail 1 (Opt11 Rev2) & 2 (Opt9 Rev3), Facilities (2013), Construction Area (2013); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH.

3.2 Vegetation clearing – loss of vegetation and habitat

3.2.1 Overview

Loss of vegetation and associated fauna habitat is typically a substantial impact resulting from construction activities in greenfield sites. However, the direct loss of vegetation and associated fauna habitat resulting from construction of mine infrastructure and the Mine (Offsite) Area is expected to be a relatively small component of the total clearing for the Project. Environmental values have been considered in the site selection and layout of the Mine (Offsite) Area. This occurs predominantly in areas of non-remnant vegetation that offer relatively low value for native fauna. Nevertheless, some loss of vegetation and habitat will occur.

3.2.2 Potential impacts

Remnant and non-remnant vegetation is proposed to be cleared during the Project (Mine) construction phase (all RE calculations provided in this section are based on RE mapping ground-truthed against DNRMs Version 6.1 RE mapping). Approximately 1,324 ha of remnant vegetation and 1,308 ha of non-remnant vegetation (including 0.64 ha of high value regrowth vegetation) is proposed to be cleared for construction of the MIA (on lease). Approximately 5 ha of remnant vegetation and 1,137 ha of non-remnant vegetation is proposed to be cleared for construction of the offsite infrastructure (off lease). Remnant vegetation located within the MIA to be impacted by construction comprises the following REs (classified using biodiversity status):

- Endangered REs – 1.75 ha
- Brigalow TEC RE 11.4.9 – 554 ha
- Of concern REs – 29 ha
- No concern at present REs – 1,294 ha

The mapped remnant vegetation located within the MIA and offsite infrastructure areas to be impacted by construction comprises a number of mixed polygon REs within the Desert Uplands bioregion and the Brigalow Belt bioregion. Within the offsite infrastructure area, no of concern or endangered REs will be cleared. Approximately 31 ha of remnant vegetation in the Bygana Nature Refuge will be cleared during the construction phase. As the area of impact to these REs during the construction phase is minimal compared to impacts during the mine operation phase, further discussion of the impacts of clearing these vegetation types is contained within Section 4.2.

In general, clearing has been restricted to areas of non-remnant vegetation on previously cleared land. This will reduce the localised extent of habitat for some animals including a range of common ground-dwelling reptiles, macropods and cleared land birds. The reduction in the extent of this habitat is considered to be negligible due to its prevalence in the wider landscape as well as its low habitat value and extensive prior modification. Nevertheless, clearing will be minimised to the areas required for construction to reduce impacts on animals in this habitat, as well as to maintain a buffer between construction areas and areas of more significant habitat where possible.

3.2.3 Management and mitigation

Where clearing is required during construction, the following management and mitigation measures will be applied:

- The extent of clearing is to be restricted to the minimal amount necessary for the construction of mine infrastructure and the Mine (Offsite) Area and wherever possible, existing cleared areas are to be utilised. Where infrastructure must cross watercourses, locations where riparian vegetation is already disturbed will be preferentially selected, or, if not possible, the construction footprint in these areas will be minimised and selected to retain large habitat trees whereever possible
- The extent of vegetation clearing must be clearly identified on construction plans and in the field. Clearing extents are to be communicated to construction supervisors
- Any additional construction areas, such as site offices, construction stockpile locations, machinery/equipment laydown areas and storages, and construction camps are to be located within existing cleared or disturbed areas to the extent possible
- As soon as possible after cleared areas for temporary facilities such as laydown areas and site offices are no longer required and are not within the proposed mine footprint, the first stage of a phased rehabilitation will commence. This phased rehabilitation will involve vegetating disturbed areas to a state consistent with the adjacent landscape, in consideration of limitations associated with buffers relating to fire management. As these temporary construction disturbance areas will be sited in existing cleared areas (i.e. pasture), rehabilitation will involve revegetating using species that characterise the surrounding pasture
- Unavoidable loss of vegetation and fauna habitat will be offset in accordance with relevant Queensland and Commonwealth policies, as detailed in the Project Offset Strategy.

3.2.4 Summary

Clearing of land during the construction phase of the Project (Mine) is expected to result in a loss of approximately 1,324 ha of remnant vegetation and approximately 1,308 ha of non-remnant vegetation for construction of mine infrastructure. A total of 5 ha of remnant vegetation and 1,137 ha of non-remnant vegetation will be cleared for construction of the Mine (Offsite) Area. Most areas of non-remnant vegetation have only low habitat value for native fauna and support low species diversity. The loss of these areas is unlikely to have a significant impact on native fauna diversity.

3.3 Vegetation clearing – loss of habitat for listed species

3.3.1 Overview

Clearing of remnant vegetation for construction of the mine infrastructure and Mine (Offsite) Area will result in the direct loss of potentially suitable habitat for a number of species listed under the EPBC Act and NC Act.

3.3.2 Potential impacts

Clearing of remnant vegetation for the construction phase will result in the loss of areas of potentially suitable habitat for the following conservation significant species that have been confirmed present or are considered likely to occur within the Project (Mine) Area:

- Black-throated finch (southern) (confirmed present at the Project (Mine) Area) – loss of approximately 1,201 ha of potential habitat within areas designated for mine infrastructure and 3 ha within the Mine (Offsite) Area
- Squatter pigeon (southern) (confirmed present at the Project (Mine) Area) – loss of approximately 1,337 ha of potential habitat within areas designated for mine infrastructure and 3 ha within the Mine (Offsite) Area
- Koala (confirmed present at the Project (Mine) Area – loss of approximately 1,219 ha of potential habitat within areas designated for mine infrastructure and 3 ha within the Mine (Offsite) Area
- Yakka skink (likely to occur at the Project (Mine) Area – loss of approximately 1,241 ha of potential habitat in areas designated for mine infrastructure and 3 ha within the Mine (Offsite) Area
- Ornamental snake (confirmed present at the Project (Mine) Area) – loss of approximately 56 ha of potential habitat within areas designated for mine infrastructure and 314 ha within the Mine (Offsite) Area
- Little pied bat (confirmed present at the Project (Mine) Area) – loss of approximately 1,307 ha of potential habitat within areas designated for mine infrastructure and 3 ha within the Mine (Offsite) Area
- Black-necked stork (confirmed present at the Project (Mine) Area) – loss of approximately 9 ha of potential habitat within areas designated for mine infrastructure. No loss within the Mine (Offsite) Area
- Cotton pygmy-goose (confirmed present at the Project (Mine) Area) – loss of approximately 9 ha of potential habitat within areas designated for mine infrastructure. No loss within the Mine (Offsite) Area
- Square-tailed kite (likely to occur at the Project (Mine) Area) – loss of approximately 1,068 ha of potential habitat within areas designated for mine infrastructure. No loss within the Mine (Offsite) Area
- Black-chinned honeyeater (likely to occur at the Project (Mine) Area) – loss of approximately 1,068 ha of potential habitat within areas designated for mine infrastructure. No loss within the Mine (Offsite) Area
- Brigalow scaly-foot (likely to occur at the Project (Mine) Area) – loss of approximately 841 ha of potential habitat within areas designated for mine infrastructure and 4 ha within the Mine (Offsite) Area
- Echidna (confirmed present at the Project (Mine) Area) – loss of approximately 1,186 ha of potential habitat within areas designated for mine infrastructure and 3 ha within the Mine (Offsite) Area

- Rainbow bee-eater (confirmed present at the Project (Mine) Area) – loss of approximately 1,340 ha of potential habitat within areas designated for mine infrastructure and 286 ha within the Mine (Offsite) Area
- White-bellied sea-eagle (confirmed present at the Project (Mine) Area) – loss of approximately 9 ha of potential habitat within areas designated for mine infrastructure. No loss within the Mine (Offsite) Area
- The eastern great egret (confirmed present at the Project (Mine) Area) -9 ha of potential habitat within areas designated for mine infrastructure .
- The satin flycatcher (confirmed present at the Project (Mine) Area) – loss of approximately 5 ha of potential habitat within areas designated for mine infrastructure.
- Latham's snipe (considered likely to occur at Project (Mine) Area) – loss of approximately 15 ha of potential habitat within areas designated for mine infrastructure.
- Seven additional migratory species (considered likely to occur at the Project (Mine) Area) – loss of approximately 9 ha of potential habitat within areas designated for mine infrastructure.
- Potential habitat for two predominantly aerial migratory birds that are likely to occur exists within the construction phase footprint: Fork-tailed swift (likely to occur at the Mine Area) – loss of approximately 1,340 ha of potential habitat within areas designated for mine infrastructure and 286 ha within the Mine (Offsite) Area; White-throated needletail (likely to occur at the Mine Area) – loss of approximately 1,340 ha of potential habitat within areas designated for mine infrastructure and 286 ha within the Mine (Offsite) Area

Habitat loss will be localised during the construction phase, and will occur in a fragmented part of the local landscape. As larger areas of habitat for these species will be affected by the mine operations, further discussion of the impacts of the loss of these habitat types is provided in Section 4.3.2.

3.3.3 Management and mitigation

Pre-clearance surveys will be undertaken in areas identified as potential habitat for threatened species, prior to commencement of clearing. In areas where these surveys indicate the presence of habitat features observed to (or with the potential to) provide habitat for these species, a fauna spotter-catcher will be engaged to accompany clearing crews.

Unavoidable loss of vegetation and fauna habitat will be offset in accordance with relevant Queensland and Commonwealth policies, as detailed in the Project Offset Strategy.

As larger areas of habitat for these species will be affected by the mine operations, further discussion of the management and mitigation of the loss of these habitat types is provided in Section 4.3.3.

3.3.4 Summary

Direct loss of habitat for listed species has been minimised by locating the Mine (Offsite) Area in a location that has been historically cleared and now supports non-remnant vegetation. These areas have limited value for threatened species listed under the EPBC Act and NC Act. Nevertheless, construction of mine infrastructure and the Mine (Offsite) Area will require some

clearing of potential habitat for listed species. The loss of habitat will be incorporated into a coordinated offsets strategy to mitigate residual impacts resulting from the Project (Mine).

3.4 Vegetation clearing – injury and mortality of terrestrial fauna

3.4.1 Overview

Vegetation clearing for the construction phase has the potential to cause direct mortality of native fauna, either through direct collision with clearing machinery or through entrapment in construction areas. The risks of fauna mortality have been minimised by predominantly locating the Mine (Offsite) Area within non-remnant vegetation.

3.4.2 Potential impacts

Vehicles and machinery used to undertake land clearing for mine infrastructure and Mine (Offsite) Area have the potential to lead to direct mortality of terrestrial fauna in the event that individuals are struck. Those animals that are unable to disperse away from areas under active clearing are also particularly susceptible to injury or death. This includes amphibians, reptiles, small ground-dwelling mammals, arboreal mammals and nocturnal species that are inactive during daylight hours. Other potential causes of mortality include animals becoming trapped in excavations, and carrion eaters (some raptors) being struck when feeding on road kill.

Fauna mortality will result in a local reduction in the abundance of some less mobile species. Species present in the habitat types that will be affected by construction phase activities, including those that will be cleared, are predominantly common, widespread species, with potential for a small number of conservation significant species to also utilise these habitats. Given the landscape context in which the Project (Mine) Area occurs, and in particular, the availability of similar habitat types in the local region, this loss is not considered likely to adversely affect the biodiversity values of this landscape.

The management and mitigation measures outlined below will seek to reduce fauna mortality to the greatest extent possible.

3.4.3 Management and mitigation

Management and mitigation measures to reduce the potential for fauna mortality as a result of land clearing activities include:

- Pre-clearance surveys will be undertaken in areas identified as potential habitat for threatened species, prior to commencement of clearing. In areas where these surveys indicate the presence of habitat features observed to (or with the potential to) provide habitat for these species, a fauna spotter-catcher will be engaged to accompany and/or precede clearing crews. Pre-demarcated habitat features identified during the pre-clearance survey will be thoroughly checked by the fauna spotter-catcher prior to clearing. Provision for the relocation of fauna will be made prior to the commencement of clearing
- Vegetation clearing will be undertaken in a sequential manner to allow more mobile fauna species the opportunity to disperse away from clearing areas

- Procedures will be developed for the event that an animal is injured. Adani will have a suitably authorised and trained practitioner present on site to assess and treat injured animals
- Vehicles will be required to stay on pre-determined routes
- All vehicles and plant will adhere to site rules relating to speed limits. Speed limits will be clearly signposted so as to minimise the potential for road kill
- Any road kill will be taken to the edge of the road immediately and subsequently removed as quickly as practicable to reduce the potential for scavengers to be struck by vehicles
- Work areas will be checked for fauna that may have become trapped before work commences each day
- In instances where an animal has entered active construction areas, the site Environmental Manager will be immediately informed. An assessment of whether the animal is at risk of harm and/or poses a threat to construction personnel will be made by the Environmental Manager (or their delegate). Where possible, the animal will be encouraged to disperse out of/away from the construction area. Where the animal is not able to disperse away, a professional fauna spotter-catcher will be engaged
- If any pits/trenches are to remain open after daily site works have been completed, they will be securely covered or fenced, if possible, or fauna ramps (e.g. earth ramps) will be available to provide a potential means of escape for trapped fauna
- Site inductions are to include education regarding the local fauna of the site and protocols to be implemented if fauna are encountered

3.4.4 Summary

Fauna mortality will occur during the construction phase; however, given the habitat types that will be affected and their availability in the broader surrounding landscape, this localised loss of animals is not considered to represent an adverse impact to the region's biodiversity values. Direct mortality of fauna, and in particular conservation significant species, during the construction phase of the Project (Mine), will be reduced given the protocols outlined above will be implemented.

3.5 Vegetation clearing – terrestrial habitat fragmentation

3.5.1 Overview

Fragmentation of native habitats can have adverse impacts on native fauna by stranding wildlife within isolated remnants of habitat and restricting their access to resources. However, since the Mine (Offsite) Area and much of the mine infrastructure occurs in an environment that has already been highly fragmented, most animals that occur are already tolerant of fragmentation and are unlikely to be impacted by loss of large areas of non-remnant vegetation.

3.5.2 Potential impacts

The mine infrastructure and Mine (Offsite) Area are located in a locally fragmented landscape. Vegetation clearing at this localised scale may reduce the capacity of some less mobile fauna to move between habitats (including within cleared areas typified by non-remnant vegetation) that will be severed by the construction of facilities. This is particularly relevant to small, ground-

dwelling fauna such as amphibians, reptiles and some arboreal mammals. Given that the construction of these facilities will occur in discrete footprints, and not represent a lengthy (linear) barrier between habitats, it is not considered likely that fauna movement at a landscape (regional) scale will be significantly affected.

3.5.3 Management and mitigation

Management and mitigation measures to reduce the impact of habitat fragmentation to local fauna populations include:

- Landscape permeability will be retained where possible. Where fencing is required around cleared areas, it will be designed such that fauna can move through it (excluding those instances where fenced areas seek to protect fauna from threats such as trenches). Consideration will be given to avoiding the use of barbed wire on the top strand of wire fences
- Vegetation clearing will be undertaken in a sequential manner to allow more mobile fauna species the opportunity to disperse away from clearing areas

3.5.4 Summary

Habitat fragmentation associated with construction of mine infrastructure and the Mine (Offsite) Area will be localised and will largely affect common animals that utilise this modified habitat. The area is already fragmented as a result of historic land clearing associated with the current land use of cattle grazing.

3.6 Terrestrial habitat degradation

3.6.1 Overview

Construction activities have the potential to degrade adjacent habitats through exposure to dust, run-off and sedimentation. These impacts can be particularly damaging following rainfall, when sedimentation and erosion are exacerbated.

3.6.2 Potential impacts

Vegetation clearing has the potential to facilitate erosion (by water and wind). This can have a localised impact on species and habitat suitability by reducing the quality and abundance of refuges, microhabitats and food availability through the smothering of native vegetation with sediment.

Earthworks will result in dust emissions. Excessive dust settling on vegetation could also suppress vegetation growth by limiting the photosynthesis potential of plants in close proximity to the construction area (Nanos and Ilias, 2007). Plants with dust on leaves may also be less palatable as a food source for animals. Dust deposition associated with earthwork activities will generally occur relatively close to areas of disturbance and hence, plants within 50 m and 100 m of construction activities may be affected by dust. As construction activities are temporary, effects will be short lived, and rainfall will generally remove dust from plants. Dust suppression will be used to control dust and this will reduce the extent of vegetation affected by dust.

Given that the construction phase activities will occur in a fragmented and disturbed part of the local landscape, edge effects are not expected to significantly detract from the value of habitats characterised by remnant vegetation that will be cleared.

Where vegetation clearing occurs on floodplains and near drainage lines, erosion may cause sedimentation of waterways, potentially degrading downstream aquatic and riparian habitats.

3.6.3 Management and mitigation

Management of erosion and sedimentation in and adjacent to cleared areas will be undertaken in accordance with erosion and sediment controls set out in Volume 4, Appendix Q1 Environmental Management Plan (Mine) and Volume 4, Appendix Q2 Environmental Management Plan (Offsite). These plans identify all practices to be implemented prior to, during, and post-construction. The management approach to erosion and sediment control actions will include:

- Diversion of clean stormwater around disturbed areas, with scour protection as required to address any associated modifications in drainage paths
- Sediment fences and other sediment control devices, in particular in areas near earthworks, watercourses and key stormwater flow paths, will be installed and maintained
- All soil or mulch stockpiles will be protected from watercourses and key stormwater flow paths to limit potential for transport of these substances into the watercourses via runoff
- Design of stockpiles will consider soil properties to ensure side-slope stability and minimise susceptibility to failure due to erosion risk
- Dust suppression activities will be undertaken where appropriate and managed in accordance with the recommendations outlined in Volume 4 Appendix K3 Water Quality Report
- Areas will be stabilised as soon as practicable after disturbance
- Stormwater control works to be installed as soon as practicable in the construction of onsite and offsite infrastructure

Even without erosion control, it is unlikely that the quantities of suspended solids that might enter surface waters would degrade water quality to the extent that it became unusable for terrestrial animals. Given the dynamic nature of the climate in the region, and modified state of some habitats in the landscape, it is likely that animals will have some degree of tolerance to water carrying elevated sediment loads during and after rainfall events. Additionally, there are a number of other farm dams and watercourses within the local area that provide alternative water resources for terrestrial animals.

3.6.4 Summary

Controls are available for management of erosion and dust and these will be implemented at all stages of the construction phase. Given the suite of management actions that will be undertaken, the impacts of erosion on vegetation and fauna habitats within, adjacent to and downstream of the footprints of the construction phase infrastructure, are expected to be low.

3.7 Loss of aquatic and riparian habitat

3.7.1 Overview

Construction activities for the offsite water supply infrastructure will include disturbance to aquatic habitats associated with ephemeral creeks in the area. Opportunities to reduce impact on riparian habitats will be identified in the detailed design phase.

Construction of the bridge at the Carmichael River within the Mine Area, and pump sites at Belyando River in the Mine (Offsite) Area will have localised impacts on aquatic and riparian habitat. Construction of the Carmichael River bridge and the offsite water supply infrastructure will result in temporary disturbance of aquatic habitats.

Indirect loss of riparian habitat through groundwater drawdown and reductions to base flow is discussed in Section 4.12.

3.7.2 Potential impacts

Loss of aquatic habitat

Construction activities for the offsite water supply infrastructure and the bridge infrastructure crossing the Carmichael River will include disturbance to aquatic habitats. These include Carmichael River and Belyando River.

The Carmichael River is the largest watercourse in the landscape and has more continual flow than other watercourses in the Mine Area; this river provides the most connected aquatic habitat at the site. Installation of the infrastructure across this watercourse will potentially result in a small loss of aquatic habitat and may create a barrier to movement for native aquatic fauna species and/or alter hydrological flow. These effects will however be temporary during construction and the bridge is unlikely to have any medium or long term effects.

Where temporary or permanent barriers to fish movement are proposed, there may be restricted access to habitat areas of the Carmichael River within, upstream and downstream of the Mine Area. If these barriers occur for prolonged periods there may be a potential of a reduction in species abundance and distribution. .

Loss of riparian habitat

Disturbance of the riparian zone may trigger erosion and sedimentation impacts and resulting degradation of adjacent and downstream habitats, however, these impacts would be of a temporary nature. Construction areas for the offsite water supply infrastructure, including laydown areas and stockpiles will be located within the pipeline corridor, where possible to minimise vegetation clearing related impacts. The effect of increased erosion and sedimentation is discussed in Section 3.9.

The riparian zone of the Belyando River is characterised by a relatively consistent corridor of open forest and woodland dominated by *Eucalyptus coolabah* (coolabah) and *E. camaldulensis* var. *obtusa* (river red gum) canopy trees.

Riparian vegetation and macrophytes provide protection for aquatic fauna (particularly fish and turtles) from predatory birds. The organic matter that is shed from riparian vegetation also provides an important food and habitat resource for a number of aquatic taxa. The riparian zone also has a well-recognised role in acting as a buffer between the terrestrial and aquatic

environment. Established zones assist in stabilising soil, filtering toxicants and nutrients, provision of shade and as a source of large woody debris and organic matter for the functioning of aquatic ecosystems. The removal of riparian vegetation typically results in increased sediment and nutrient loads in waterways as nutrient cycling patterns are disrupted, the sediments from adjacent lands are washed directly into waterways during rainfall events, and the bank integrity is diminished with the removal of stabilising vegetation, resulting in the scouring, erosion and increased sediment loads.

The removal of a section of the riparian zone also exposes adjacent riparian communities to weed invasion. Discussion on the impacts of weed and pest species is in Section 3.11.

3.7.3 Management and mitigation

Wherever possible, direct construction impacts on aquatic and riparian habitat have been avoided. The planning and concept design for offsite water supply infrastructure has aimed to avoid areas of high aquatic value where possible by avoiding riparian habitat, referrable wetlands and gilgais. Sensitive areas in the vicinity of all construction will be clearly demarcated prior to construction to avoid accidental clearing or disturbance. A suitably qualified ecologist will be required to provide advice on the location of sensitive areas for demarcation.

An application under the *Fisheries Act 1994* will be required where construction occurs in a waterway. Where possible, it is recommended that construction undertaken in the waterway occur during dry conditions. Site specific management plans should incorporate bed and bank stabilisation measures to limit localised and downstream geomorphological changes to the ephemeral waterways, including requirements for flora and fauna passage.

Post construction, the removal of the temporary barrier is required to reinstate full passage for fish, and the waterway bed and banks must be returned to their original profile and stability so that long-term fish passage at the site is not compromised.

Specific design objectives for water way crossings include:

- Minimise the number, width and extent of waterway crossings to those absolute necessary to complete the works
- Minimise the disturbance to natural water courses and their in-stream and associated riparian zones
- Maintain the hydrological connectivity
- Maintain existing flow paths and prevent backwater effects

Site specific Management Plans will incorporate bed and bank stabilisation measures to limit localised and downstream geomorphological changes to the ephemeral watercourses, including requirements for flora and fauna passage.

While these design strategies will minimise the impacts on aquatic and riparian environments, some disturbance is expected to occur as a result of construction activities. Mitigation strategies will be based on compliance with the relevant Guidelines for carrying out activities in a watercourse, lake or spring and, if a riverine protection permit is required for any of the works, the conditions of this permit.

Mitigation strategies will include:

- Undertake in-stream works in nil or low flow conditions wherever practicable

- Minimise duration of in-stream works through prior planning such that all equipment and materials are available to allow works to be completed as quickly as possible
- Install sediment control measures where in-stream disturbance must be undertaken during flow conditions
- Minimise disturbance area within streams and riparian areas. Equipment parking and laydown areas will be located outside these areas. The area of disturbance within streams and riparian zones will be the minimum area required for safe working and the area of disturbance for infrastructure installation clearly marked
- Stabilise disturbed areas promptly to prevent flow-related scouring of bed and banks of stream. Stabilisation is to use "soft" engineering solutions rather than concrete or similar

If temporary in-stream barriers are used during construction, this may require a development approval. The Code for self-accessable development 'Temporary waterway barrier works' (DAFF, 2013) outlines the Queensland Government requirements for temporary in-stream barriers. They include:

- The maximum time any temporary barrier can be installed for is 360 days
- During construction, disturbance to the instream bed and bank sediment of the waterway beyond the barrier footprint must be minimised as much as possible
- If it is necessary to remove vegetation (including riparian) for the development, the vegetation is to be cut no lower than ground level and the roots are to be left in the ground to aid in stabilisation. If deep excavation is required during construction the roots may only be removed within the construction footprint area under this code.
- Impacts on water quality during construction, operation and removal of the barrier are to be minimized by undertaking works to the standards set out in the *Best Practice Erosion and Sediment Control* guidelines 2008.
- Work must not commence during times of elevated flows
- Provisions must be made to minimise the risk of fish kills arising from the works.
- In the event of fish that have been trapped by the works becoming distressed the Fisheries Queensland *Fish Salvage Guidelines* must be implemented immediately.
- For any part of the waterway bed or bank that has been altered by the temporary waterway barrier works, the site should be restored and/or rehabilitated, so that as a minimum:
  - The profiles of the bed and banks are re-instated to natural stream profiles and stability within five business days of completion of works.
  - The waterway bed is retained with natural substrate or reconstructed with substrate comparable to the natural substrate size and consistency.
  - Vegetation and cover is rapidly re-established so that the native plant community at the site can recover or be enhanced by using native species.

In order to ensure the continued lateral connectivity between the floodplain and the waterways construction should be outside the floodplain area where possible. Wherever possible, the natural drainage pathways and connectivity with the floodplain is to be maintained.

3.7.4 Summary

No aquatic habitat will be permanently lost as a result of the workers accommodation village or industrial precinct and airport in the Mine (Offsite) Area. Impacts to aquatic habitat as a result of the Carmichael River bridge and offsite water supply infrastructure may be temporary or permanent in nature depending on the design and construction method. Minor localised impacts to riparian habitat are anticipated associated with crossings at the Carmichael River.

Removal of riparian vegetation has the potential to lead to degradation of aquatic habitats. By minimising the disturbance width required for construction, implementing erosion and sediment control measures and weed management measures, any impact to riparian vegetation and aquatic habitats from activities in the riparian zone will be reduced.

3.8 Aquatic fauna mortality

3.8.1 Overview

Mortality or injury to resident native aquatic fauna can potentially occur when construction activities are undertaken for the offsite water supply infrastructure and the upgrade of the Moray Carmichael Road within or adjacent to a water body. This usually arises as a result of vehicle/machinery strike or strike from falling vegetation or woody debris, but also as a result of fish and other aquatic fauna being stranded when the water is drained from waterways or dams. Fish, turtles and crustaceans were detected in aquatic habitats in the Study Area during surveys, and these species are likely to occur in Eight Mile Creek. Consequently, there are likely to be aquatic species that are at risk of mortality or injury.

3.8.2 Potential impacts

Potential aquatic fauna mortality impacts with regard to construction of offsite water supply infrastructure are associated with construction activities within watercoursessuch as the pump station at Belyando River and the Carmichael River crossing. Construction within riparian zones and within the bed and banks of ephemeral creeks such as Eight Mile Creek may also result in both direct and indirect aquatic fauna mortality. For example, direct mortality will occur in the event that an individual is struck by machinery or a falling object.

With respect to the Carmichael River crossing, machinery and vehicles may be required to work within the watercourse to build the bridge infrastructure. Although this habitat will not be removed there is potential for vehicle or machinery to strike aquatic fauna resulting in injury or mortality. The temporary habitat loss as a result of construction within the watercourse is discussed in Section 3.7. Once built, fauna mortality is not considered to be an impact as the bridge will elevate all vehicles out of the aquatic habitats.

Indirect mortality may also occur in the event that a waterway is drained, or if there are significant and sudden changes in water quality and fish and other aquatic animals are unable to escape. For example, the removal of the riparian zone will reduce shading over the waterway. This will potentially result in an increase in surface water temperatures, a subsequent reduction in dissolved oxygen (as warmer water has reduced oxygen holding capacity) and death of aquatic biota due to hypoxic conditions.

When in flow, Eight Mile Creek provide dispersal pathways for aquatic flora and fauna. Consequently, when construction is undertaken during flow conditions there is a risk of fauna mortality along these waterways. Although aquatic fauna species present are common and loss

of individuals is not likely to have any significant impact on biodiversity of aquatic ecosystems, all native species are protected under the NC Act and destruction of native species is prohibited without the approval under the NC Act. Subsequently, all reasonable and practical measures will be undertaken to minimise the occurrence of such events.

3.8.3 Management and mitigation

To avoid mortality of aquatic fauna during drainage of dams, fauna salvage and relocation may be required where there is water in the dams at the time of construction. This will involve:

- Survey of the dams immediately prior to draining to identify presence of fish and large crustacean species
- Depending on species identified, develop relocation techniques to capture species and identify appropriate locations for relocation
- Monitor during drainage of dams to check for stranding

3.8.4 Summary

To avoid potential mortality of aquatic fauna during construction within riparian zones and within the bed and banks of ephemeral creeks, construction activities will ideally be undertaken during dry or controlled conditions. Timing of construction in and adjacent to watercourses during dry conditions will assist in minimising potential indirect impacts to aquatic ecosystems at crossing sites and downstream.

3.9 Degradation of water quality and aquatic habitats

3.9.1 Overview

The indirect impacts of vegetation clearing for the Project have the potential to degrade aquatic ecosystems by leading to changes in chemical (water quality) and physical (geomorphology and flow patterns) characteristics of the existing aquatic habitats within the construction footprint and downstream catchment.

3.9.2 Potential impacts

Material, whether sediment or other contaminants (including nutrients and metals), has the potential to mobilise directly into the waterways via runoff. Vegetation clearing has the potential to expose surfaces to runoff and erosion.The construction activities will occur in an environment that can be subject to heavy flooding with high potential for runoff.

Construction activities also have the potential to degrade adjacent aquatic habitats through exposure to dust. Earthworks will result in dust emissions and localised increases in dust emissions are anticipated due to the increase in vehicle movements along Carmichael Moray Road and maintenance tracks.

Run-off and sedimentation impacts

Specific to the construction phase, aquatic ecosystems at risk of degradation are those within the construction area and extraction locations on Belyando River, and pipeline crossing locations. Additionally, any areas receiving runoff flows from areas of land cleared for the mine

infrastructure areas, workers accommodation village, industrial precinct and airport are likely to be impacted.

Physical changes in water quality have the potential to reduce the suitability of the aquatic environment for some aquatic flora and fauna species. The surface water quality of the Study Area is described in Volume 4, Appendix K3 Water Quality Report. The main sources of water quality changes are related to the mobilisation of sediments and pollutants.

In aquatic ecosystems, increased suspended sediment loads can reduce light penetration, clog fish and invertebrate gills, decrease water temperature, lead to a reduction in dissolved oxygen concentrations and introduce sediment-bound contaminants into the water (Dunlop et al., 2005). Increased turbidity can also reduce photosynthesis in submerged macrophytes and benthic and planktonic algae. Increased sediment loads can also reduce the capture rates of visual predators (e.g. raptors and fish) that rely on their prey being visible. When sediment settles out it may bury habitat and smother sedentary organisms.

Sediment load is also likely to increase around roads and other hard surfaces. These impacts will be largely managed through appropriate sediment and erosion controls during construction phases, including the use of sediment ponds.

Land clearing in the Mine Area will result in a local increase in exposed earth surfaces. The source of most suspended particulates (and in turn increase in turbidity), nutrients and other contaminants attached to particulates in waterways is mobilisation of soils through surface runoff, stream bank erosion and dust. Construction activities within or adjacent to watercourses for the Carmichael River bridge and the offsite water supply infrastructure will disturb bed and bank substrates and lead to localised erosion and sediment transport to downstream habitats.

Turbidity in disturbed catchments is closely connected with rainfall and surface runoff with spikes in turbidity typically occurring after rain events, and then reduced turbidity levels as flows reduce and sediment is able to settle. The pre development surface water quality assessment for the Project (Mine) identified that turbidity results were recorded above the nominated water quality objectives (WQO) on a number of occasions. Although aquatic ecosystems in highly ephemeral systems are likely to be adapted to peaks in high turbidity during some periods, an increase in the magnitude or the frequency of these peaks of turbidity has the potential to have a detrimental effect on aquatic ecosystems.

Sediment movement can also mobilise nutrients and pollutants to aquatic habitats. Soils from the exposed areas, and potential pollutants, will be readily mobilised into local drainage lines and water bodies via erosion processes. The potential for mobilisation of soils and potential pollutants will be maximised after rain events and during high winds. Nutrient pollution has the potential to impact upon a system via the stimulation of growth of nuisance plants and cyanobacteria (ANZECC and ARMCANZ, 2000). Growth of these plants can lead to changes in the biological community composition as well as flow on affects to habitat suitability and aspects of water quality such as dissolved oxygen concentration which can impact upon aquatic fauna communities.

Within the Mine Area concentrations of nutrients were generally higher in the still water bodies than in the Carmichael River. In the Carmichael River nutrient water quality sampling results were detected to be linked to rainfall and surface runoff. Nutrient concentrations recorded higher (above WQOs) at the end of the wet season followed by a decrease during drier months and a gradual increase back to values above WQOs in September when wet season conditions begin.

As with turbidity, aquatic ecosystems are adaptive to the existing seasonal variation in nutrients however increases in magnitude and frequency of peaks in this variable may have the potential to adversely impact ecosystems.

Dust impacts

Earthworks will result in dust emissions and localised increases in dust emissions are anticipated due to the increase in vehicle movements along Carmichael Moray Road and maintenance tracks.

Dust can settle within the waterways or in the terrestrial environment, where runoff can mobilise settled dust to waterways. Indirect deposition in waterways can occur when dust settles in the terrestrial environment. During precipitation events, the associated runoff transports dust from the terrestrial environment into nearby waterways. Dust generated during the construction phase, has the potential to have a negative impact on the water quality of Northand Eight Mile Creeks.

Water for dust suppression will be sourced from the mine affected water dams and/or sediment affected water dams. The main contaminants in the dam are expected to be coal particles, suspended sediment and salinity (electrical conductivity). Dust suppression water is likely to have increased conductivity and, due to evaporation, increased salt levels are expected on the haul road over time.

Oil, fuel and other chemicals

Oils, fuel, lubricants and other substances containing chemicals will be required to operate construction machinery. Accidental spills or leaks anywhere within the catchment, including within the workers accommodation village, industrial precinct and airport have the potential to result in contaminants being transported to the aquatic environment via rainfall runoff. Commonly used substances contain elements that, at high concentrations, can be toxic to aquatic organisms.

If introduced, these compounds can result in both short- and long-term degradation of water quality. Any introduction of contaminants has the potential to influence both the local surface water quality at the point source as well as downstream.

3.9.3 Management and mitigation

Mitigation measures detailed in the Mine and Offsite Environmental Management Plans, include erosion and sediment control requirements to be implemented and monitored throughout the construction phase of the Project (Mine).

To limit the degradation of water quality during construction activities, mitigation and management will focus on reducing the potential mobilisation of sediments or pollutants, diversion of stormwater flows from disturbed areas and limiting sediment transport from exposed areas.

Controlling site runoff from all areas disturbed during construction and minimising bank disturbance will be important in limiting the degradation of habitats downstream of the construction footprints. The management and mitigation of the mobilisation of sediment and pollutants during construction is described in Volume 4 Appendix K3 Water Quality Report and these measures will assist in limiting the degradation of aquatic habitats. The measures identified include (but are not limited to):

- Avoiding clearing of vegetation and major earthworks during overland flow events
- Installing stormwater diversion and collection systems as early as possible in the construction period
- Implementing erosion and sediment control plans. Further details on erosion and sediment control are provided in the Mine and Offsite Environmental Management Plans
- Maximising retention of surface cover by clearly delineating clearing areas and restricting activities to these areas
- Locating soil or mulch stockpiles away from watercourses and key stormwater flow paths to limit potential for transport of these substances into the watercourses via runoff
- Dust suppression activities to be undertaken where appropriate. Stabilisation of disturbed areas as soon as practicable after disturbance
- Wherever possible, staging the clearing of vegetation as construction progresses and minimising the disturbance footprint at all times
- Undertaking revegetation according to Rehabilitation Plan requirements
- Development of emergency response protocols and procedures for implementation in the event of a contaminant spill or leak and provision of spill response equipment
- Storage of fuels, chemicals, wastes and other potentially environmentally hazardous substances in bunded or otherwise contained areas away from watercourses
- Refuelling in areas away from watercourses
- Regularly checking vehicles and equipment for oil leaks

The design of the workers accommodation village, industrial precinct and airport will incorporate stormwater management infrastructure and mechanisms to manage runoff. This may include holding tanks and/or gross pollutant traps or other stormwater management techniques. Stormwater management mechanisms and monitoring requirements will be developed prior to any construction activities and incorporated in Volume 4, Appendix Q1 Environmental Management Plan (Mine) and Volume 4, Appendix Q2 Environmental Management Plan (Offsite).

Monitoring will include:

- Regular checks of fuel, chemical and waste storage areas for leaks or improper storage
- Regular checks, including checks prior to forecast rain events, of erosion and sediment control devices to make sure these are in good working order
- Pre-rain checks of erosion and sediment control devices
- Inspections of streams for scouring and sediment deposition
- Ongoing water quality monitoring (refer Volume 4, Appendix K3 Water Quality Report)

The Department of Environment and Heritage Protection has issued a “general approval of a resource for beneficial use – associated water” which sets out guidelines for the use of associated water for dust suppression in connection with authorised petroleum activities. The guideline is used as a general reference for Adani’s commitments about the use of its mine

affected water for dust suppression. The guideline states that the use of water for dust suppression must cease if any of the following occur:

- On-site ponding forms
- Runoff occurs
- A precipitation event occurs
- A precipitation event is imminent

All reasonable and practicable measures must be taken when using mine affected water for dust suppression to prevent or minimise the likelihood of environmental harm being caused (including avoiding soil erosion, soil structure damage and adverse effects on surface or groundwater quality). Appropriate water quality threshold levels and trigger values will need to be developed and will appear in the environmental authority (EA) for the Project (Mine) for any discharges from the sediment control devices and reuse water used for dust suppression.

Construction activities have the potential to impact aquatic habitats by changing both chemical and physical characteristics of the water quality and aquatic habitats within and downstream of the construction footprints.

3.9.4 Summary

Impacts can be effectively managed through the implementation of management measures to minimise erosion and prevent the mobilisation and transport of sediments and to prevent other potential water quality contaminants that may arise from spills and leaks of fuel and chemicals. Additionally, design measures have been adopted to condense and minimise the footprint of disturbance in the riparian zones.

Monitoring requirements will be included in the Mine and Offsite Environmental Management Plans for both effectiveness of the management measures and the water quality conditions.

Spills of hydrocarbons could make water unpalatable to terrestrial animals, and, depending on quantities, toxic. Controls proposed in relation to storage and handling of fuels, oils and other chemicals are detailed in the Mine Environmental Management Plan.

3.10 Alteration of surface water regime

3.10.1 Overview

Wherever possible, the offsite water supply infrastructure has avoided areas of riparian habitat, referrable wetlands and gilgais.

Construction of pump sites in the riparian zone Belyando River will have localised impacts on aquatic habitat. Construction of the offsite water supply infrastructure will result in temporary disturbance of aquatic habitats.

A small farm dam approximately 6 ha in size (Brigalow Dam) will be removed during construction. This has the potential to impact terrestrial ecological values through the localised reduction in availability and quality of drinking resources and foraging habitat, and potentially changes to riparian habitats in downstream watercourses due to changes in water quality and flow regimes. In particular, impacts realised from disturbance of water resources may include:

- Loss and disturbance of habitat for aquatic flora and fauna

- Change in or loss of aquatic habitat utilised by terrestrial species

The Belyando River storage dam is an off-stream storage and will be located on the footprint of an old quarry. A channel will be installed into the bank of the Belyando River leading to a pump station.

3.10.2 Potential impacts

Surface flows and geomorphology

Changing the direction or volume of runoff flows to watercourses and within watercourses has the potential to change the watercourse geomorphology as a result of scour and deposition. The mobilisation and subsequent deposition of sediments into watercourses has the potential to locally change bed and bank profiles. Such physical changes have the potential to reduce habitat suitability for existing communities and change the diversity and/or structure of the community by creating or removing microhabitat types to which the existing community has adapted.

The construction phase will result in a change to the current open grazing land with relatively permeable soils to compacted developed areas within the Mine (Offsite) Area footprint. The resultant land use will have increased potential for runoff of rainfall to occur as the permeability of the soils is reduced within the Mine (Offsite) Area footprint. As discussed in SEIS Volume 4 Appendix K5 Mine Hydrology Report, given the relatively small area of the catchment to be disturbed, it is unlikely that this increase in catchment permeability will substantially change runoff flow volume to the downstream catchment. Minor changes to topography will also occur as a result of construction which in turn may mean that flow paths change. Again, the magnitude of change in the context of the catchment is unlikely to result in any significant changes to stream flows.

A loss of connectivity can result from decreasing water quality. If the hydrology and geomorphology of the stream bed is not restored to previous conditions there is potential for localised internal ponding to develop with subsequent changes in water quality. Ponding of flowing water bodies creates favourable conditions for algal growth and settling of sediments.

The bridge crossing the Carmichael River will impact on the area, depth and inundation duration upstream of the bridge. A change in depth of < 1 m during a 1:1000 year ARI event upstream of the Carmichael River bridge is predicted with the duration of the increased flood depth during operation predicted to take approximately 70 hours for the water to be back at pre operation flood levels during a 1:1000 year ARI event. In general, bridge structures promote natural, unimpeded stream flow, allowing the free movement of fish underneath the structure during a wide range of hydrological conditions. However, bridges that are built too low, or whose piers and footings constrict the channel, can affect hydrological flows and aquatic habitat conditions (Fairfull and Witheridge, 2003). Possible impacts of bridge structures include:

- Large scale turbulence resulting from bridge piers
- Increased flood flow velocities
- Changes to in-stream and bank vegetation affecting water shading, habitat values and water velocities
- Limited light penetration under the bridge deck creating a nonphysical barrier for some fish species that may avoid dark areas during daylight hours

- Restrictions to dispersal and/or migration leading to the loss or decline of populations upstream and/or downstream, and the loss of gene flow and genetic diversity contained within those populations

Aquatic species may also avoid migration through the crossing especially when the area has activity such as construction or moving vehicles.

Temporary diversions

Should the construction occur during wet periods it has the potential to present a barrier to hydrologic connectivity between areas upstream and downstream of the construction. This has the potential to change freshwater flow paths and consequently velocities depending on the location of the barrier.

Floodplain connectivity

The construction of the industrial precinct, airport, workers accommodation and linear infrastructure may cause the floodplain to become disconnected from the waterways. The ability of biota, water and materials to move from one distinct ecosystem to another, for example from a floodplain to a river, is referred to as lateral connectivity (DEHP, 2012). The duration and timing of periods of lateral connection can be very important to allow opportunities for spawning, dispersal and migration. Species that migrate between ecosystems as part of their life cycles, such as diadromous fish, are particularly susceptible to a loss of lateral connectivity. This lateral connectivity also promotes the flow of genes between otherwise disconnected populations. For example, an aquatic community living in an off-channel farm dam may depend on seasonal connectivity to the floodplain for both the augmentation of surface waters, and for gene flow to maintain the existing genetic diversity. When a community becomes isolated, losses in genetic diversity may occur, and subsequently the community may not be able to adapt to environmental or biological challenges (Allendorf, 1983).

The lateral connectivity between a floodplain and a river largely determines the ability of organic and inorganic matter, aquatic flora and fauna and water to move between ecosystems (DEHP, 2012). Aquatic fauna can be highly reliant on the seasonal connectivity to floodplains for the purposes of feeding and breeding, but also in seeking refuge from fast flows (Bayley, 1995; Humphries et al., 1999; King et al., 2003). In Australia, many fish species will move out onto the inundated, highly productive floodplains, even if the periods of inundation are short, unpredictable and infrequent (Humphries et al., 1999; King et al., 2003; Arthington et al., 2005).

Loss of water resource for terrestrial species

Construction of the Mine infrastructure and Mine (Offsite) Area, and specifically the water supply infrastructure, is proposed to result in the loss of Brigalow Dam. This aquatic habitat is anthropogenic and occurs in a disturbed area with minimal fringing vegetation. The main value of this dam for fauna is for drinking water and the dam may also be utilised by some threatened bird species including the black-throated finch (southern), squatter pigeon (southern) and black-necked stork as well as commonly occurring listed migratory species. As most natural waterbodies in the Study Area are ephemeral, farm dams can become important in dry periods.

The planning and concept design for offsite water supply infrastructure has aimed to avoid areas of high value aquatic habitat where possible by avoiding riparian habitat, referrable wetlands and gilgais.

There are a number of similar dams throughout the local area and the loss of one dam is unlikely to cause any significant impact on native animals in the region.

3.10.3 Management and mitigation

The design and layout of water supply for Mine (Offsite) Area has considered areas of aquatic environmental value. Where construction is required, mitigation strategies will be based on compliance with the relevant DEHP Guidelines for carrying out activities in a watercourse, lake or spring and, where applicable, be undertaken in accordance with requirements for development approvals.

Mitigation strategies will include:

- In-stream works to be undertaken in nil or low flow conditions wherever possible
- Duration of in-stream works to be minimised through prior planning such that all equipment and materials are available to allow works to be completed as quickly as possible

The planning and concept design for offsite water supply infrastructure has aimed to avoid areas of high aquatic value where possible by avoiding riparian habitat, referrable wetlands and gilgais. A suitably qualified ecologist will be engaged to provide advice on the location of sensitive areas for demarcation.

An application under the *Fisheries Act 1994* will be required where construction occurs in a waterway. Changes to existing flow paths have the potential to occur at the pump station at Belyando River and the Carmichael River bridge crossing. Where possible, it is recommended that construction undertaken in the waterway occur during dry conditions and outside of fish spawning periods. Site management plans should incorporate bed and bank stabilisation measures to limit localised and downstream geomorphological changes to the ephemeral waterways, including requirements for flora and fauna passage. Scour and erosion can be managed through design treatments (for example, bank stabilisation) and ongoing management controls such as those that will be incorporated into the EMPs.

The design of these structures should be consistent with the Culvert Fishway Planning and Design Guidelines (Kapitzke, 2010), Waterway barrier works development approvals (Peterken et al., 2009), Fisheries Guidelines for Fish-Friendly Structures (Derbyshire, 2006), Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (Fairfull and Witheridge, 2003) and Fisheries guidelines for design of stream crossings (Cotterell, 1998).

Specific design objectives for water way crossings include:

- Minimise the number, width and extent of waterway crossings to the absolute necessary to complete the works
- Minimise the disturbance to natural water courses and their in-stream and associated riparian zone
- Incorporate necessary design features such as culverts and bridge structures to maintain flows within waterway
- Maintain the hydrological connectivity
- Maintain existing flow paths and prevent pooling or backwater effects

The design objectives of bridge structures will consider the following principles (based on Kapitzke, 2010 and Fairfull and Witheridge, 2003):

- Avoid locating bridge piers or foundations within the main waterway channel
- Design and orient bridge piers and pile caps, including those located within overbank areas, to avoid the formation of large-scale turbulence or the erosion of the bed and banks of the waterway
- Minimise turbulence from bridge piers, foundations and base slabs that may lead to stream erosion or to disorientation of fish
- When sizing the waterway area of the bridge, give appropriate consideration to fish passage requirements along the floodplains, including locating bridge abutments well away from the channel banks and the possible installation of floodplain culverts adjacent to the main crossing
- Minimise the use and extent of those bed and bank erosion control measures that may reduce aquatic habitat values or inhibit the regrowth of natural in-stream and bank vegetation

If temporary in-stream barriers are used during construction a development approval may be required.

The code for self-assessable development 'Temporary waterway barrier works' (DAFF, 2013) outlines the Queensland Government requirements for temporary in-stream barriers. They include:

- The maximum time any temporary barrier can be installed for is 360 days
- During construction, disturbance to the instream bed and bank sediment of the waterway beyond the barrier footprint must be minimised as much as possible
- If it is necessary to remove vegetation (including riparian) for the development, the vegetation is to be cut no lower than ground level and the roots are to be left in the ground to aid in stabilisation. If deep excavation is required during construction the roots may only be removed within the construction footprint area under this code.
- Impacts on water quality during construction, operation and removal of the barrier are to be minimized by undertaking works to the standards set out in the *Best Practice Erosion and Sediment Control* guidelines 2008.
- Work must not commence during times of elevated flows
- Provisions must be made to minimise the risk of fish kills arising from the works.
- In the event of fish that have been trapped by the works becoming distressed the Fisheries Queensland *Fish Salvage Guidelines* must be implemented immediately.
- For any part of the waterway bed or bank that has been altered by the temporary waterway barrier works, the site should be restored and/or rehabilitated, so that as a minimum:
  - The profiles of the bed and banks are re-instated to natural stream profiles and stability within five business days of completion of works.

- The waterway bed is retained with natural substrate or reconstructed with substrate comparable to the natural substrate size and consistency.
- Vegetation and cover is rapidly re-established so that the native plant community at the site can recover or be enhanced by using native species.

Post construction, the removal of the temporary barrier is required to reinstate full passage for fish, and the waterway bed and banks must be returned to their original profile and stability so that long-term fish passage at the site is not compromised.

In order to ensure the continued lateral connectivity between the floodplain and the waterways, construction should occur outside the floodplain area where possible. Wherever possible, the natural drainage pathways and connectivity with the floodplain needs to be maintained.

The loss of Brigalow Dam within the Mine Area is an unavoidable impact of the construction phase of the Project (Mine). Management of the removal of this water body and other management and mitigation strategies to minimise the impacts on aquatic environments are outlined in Volume 4 Appendix K3 Water Quality Report.

3.10.4 Summary

The construction phase will result in a change to the current open grazing land with relatively permeable soils to compacted developed areas within the Mine (Offsite) Area footprint. The resultant land use will have increased potential for runoff of rainfall to occur as the permeability of the soils is reduced within the Mine (Offsite) Area footprint. Minor changes to topography will also occur as a result of construction which, in turn, may mean that flow paths change.

Wherever possible, the offsite water supply infrastructure has avoided areas of riparian habitat, referrable wetlands and gilgais.

Construction of the offsite water supply infrastructure will result in temporary disturbance of aquatic habitats.

A loss of connectivity can result from decreasing water quality. If the hydrology and geomorphology of the stream bed is not restored to previous conditions there is potential for localised internal ponding to develop with subsequent changes in water quality. Ponding of flowing water bodies creates favourable conditions for algal growth and settling of sediments.

The bridge structure crossing the Carmichael River will impact on the area, depth and inundation duration upstream of the bridge. Aquatic species may also avoid migration through the crossing especially when the area has activity such as construction or moving vehicles.

Changes to existing flow paths have the potential to occur at the where diversions or culvert structures will be established. Should the construction occur during wet periods it has the potential to present a barrier to hydrologic connectivity between areas upstream and downstream of the construction. This has the potential to change freshwater flow paths and consequently velocities depending on the location of the barrier.

One farm dam will be lost during construction. The main value of this dam for fauna is for drinking water and the dam may also be utilised by some threatened bird species including the black-throated finch (southern), squatter pigeon (southern) and black-necked stork as well as commonly occurring listed migratory species. As most natural waterbodies in the Study Area are ephemeral, farm dams can become important in dry periods. The loss of Brigalow Dam within the Mine Area is an unavoidable impact of the construction phase of the Project (Mine).

3.11 Introduction and proliferation of weeds and feral species

3.11.1 Overview

Pest and feral species may disrupt ecosystems by outcompeting and replacing native species and increasing predation pressures, thus altering ecosystem diversity and potentially disrupting ecosystem function. A total of 28 introduced flora taxa were recorded from the Project (Mine) Area), five of which are declared as WONS and declared weeds under the LP Act. Nine introduced fauna species comprising seven mammals, one amphibian and one bird were also recorded during field studies.

3.11.2 Potential impacts

Terrestrial pests and weeds

Food waste produced by human settlements may provide additional resources for feral animals such as pigs, rats, mice, cats and dogs. These animals, confirmed present within the Project (Mine) Area, may increase in abundance if food and water become more accessible. An increase in pest fauna species may lead to increased competition for resources, increased predation and increased habitat degradation (e.g. erosion caused by rabbits and damage to riparian areas by pigs). There is also potential for pest animals such as ants to be introduced to sites through importation of vehicles, equipment, soils and similar media.

Increased movement of people, vehicles, machinery, vegetation waste and soil may facilitate the spread of weeds at and near the Project (Mine) Area. Despite the fact that 28 introduced plant species were recorded, weeds were not abundant across much of the Project (Mine) Area. Increasing the prevalence of weeds at the Project (Mine) Area (and potentially beyond to the surrounding landscape), may reduce the quality of habitats for some flora and fauna species, particularly by replacing native plants.

Most weeds typically have the capacity for rapid seed germination and plant growth. Soil disturbance associated with construction earthworks can allow seeds present in soil to germinate. Germination and plant growth for weeds is typically faster than for native species and this can lead to increased weed levels in disturbed areas and affect the ability for native vegetation to re-establish.

There is also significant potential for weeds, either as seeds or other plant propagules, to be introduced to sites attached to dirty vehicles and equipment or to be contained in soil or seed mixes brought to the site. This can lead to increased levels of weeds already present on the site, or infestation by new weeds. Areas particularly susceptible to weed and pest outbreaks include roadside verges and riparian habitats.

Aquatic pests and weeds

Terrestrial weeds can invade riparian zones and aquatic habitats, whereby reducing aquatic habitat quality, diversity and availability. Pest animals, such as pigs, can have detrimental effects to watercourses by rooting ‘ploughs’ up to 20 m around a water body (DEEDI, 2010). This could have potential detrimental impacts on recruitment of waxy cabbage palm. As an omnivorous animal, pigs will also consume aquatic fauna (e.g. freshwater mussels and crayfish) and aquatic flora within and adjacent to waterways. Additional impacts occur as a result of wallowing in surface water and mud, as pigs disturb the benthic zone (and benthos), suspend sediments and introduce nutrients to the water (through urination and defecation). This

disturbance can lead to degradation of downstream water quality and habitat for aquatic species by creating erosion (DEEDI, 2010) destroying in-stream habitat and allowing opportunity for weed establishment rather than native riparian communities.

A number of pest fish species occur within the Burdekin basin. Although no aquatic pest species were recorded within the Project (Mine) Area, the disturbance caused by construction activities makes local aquatic habitats susceptible to aquatic pest invasion. Aquatic pest species often flourish in disturbed habitats and in the event species are introduced (via translocation or stocking) have the potential to become prevalent closer to the Project (Mine) Area. The introduction of these species can adversely impact native fish communities through direct competition for resources (food and habitat), predation, habitat alteration and the introduction of diseases or parasites (DEEDI, 2011).

Aquatic weeds can also affect native communities by shading out native plants, reducing the quality of habitat for aquatic fauna communities and degrading water quality (DERM, 2011). Both weed and pest fauna species can be introduced when the numbers of people are visiting the area is increased. Weeds and weed seeds can be introduced in material (e.g. earth fill), water for water supply and vehicle (e.g. water trucks) vectors brought to the site during construction.

3.11.3 Management and mitigation

Pest and feral species spread, and the potential for introduction of new feral species, will require management during the construction phase of the Project (Mine). An integrated suite of actions should be developed to manage pest species, including:

- Waste management measures contained in Environmental Management Plans including containment of food scraps in securely sealed containers
- Avoid moving vegetation and soil waste to areas of lower weed infestation
- Monitor pest animal occurrence 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
- Undertake weed mapping 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
- Monitor weed levels in areas adjacent to construction activities and any areas that are rehabilitated after construction. 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 are detected, 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. Ongoing monitoring of weed infestation associated with construction activities will occur through the operational weed management program

- Inspect and certify all vehicles, equipment and materials brought onto site as free of weeds and weed seeds and carry a weed hygiene declaration. Records are to be kept of compliance with this requirement. A weed wash down facility will be constructed onsite
- Store soil stripped and stockpiled from areas containing known weed infestations in areas separate from areas free of weeds
- Prevent construction staff from bringing domestic animals to the Project (Mine) Area

3.11.4 Summary

Implementation of the proposed mitigation strategies will minimise the potential for pest plants and animals to increase in abundance at and near the Project (Mine) Area or for new pest plants and animals to be introduced. Regular, standardised monitoring is proposed to be a core component of the successful implementation of these measures, with weed or pest control to be undertaken at the earliest opportunity if monitoring reveals a new pest plant or animal introduction or a significant increase in abundance.

3.12 Disruption of terrestrial fauna behaviour

3.12.1 Overview

Habitat degradation and behavioural disruption may arise as a result of increased vehicular activity and a change in disturbance types at the Project (Mine) Area. Habitat degradation and associated behavioural disruption may result from increased dust mobilisation and increased exposure to noise, light and vibration.

3.12.2 Potential impacts

Construction activity at and near the construction zone associated with mine infrastructure and Mine (Offsite) Area may disrupt local fauna roosting, breeding and foraging activities, largely as a result of increased exposure to light, noise, dust, vehicles and people. Animals may also become more vulnerable to predation, because of increased light making it easier for predators to locate prey or noise levels making it harder for prey to detect approaching predators.

There is limited habitat for native animals (i.e. remnant vegetation) in and adjacent to construction areas. Native fauna occurring in areas designated for mine infrastructure and the Mine (Offsite) Area construction zones are common species that are generally tolerant of some disturbance. Furthermore, threatened species such as the black-throated finch (southern) and squatter pigeon (southern) are known to inhabit areas exposed to anthropogenic disturbance (roadways, railways, peri-urban Townsville including directly adjacent to military training areas in the case of the former; numerous towns in central Queensland for the latter).

Animals may exhibit initial fright behaviour, and will either adapt to the disturbance levels, or move away from the areas of activity into similar habitat that is extensively available in the adjacent landscape. Breeding activity is less likely to be associated with non-remnant vegetation; however, remnant areas will need to be checked as part of pre-clearing surveys.

3.12.3 Management and mitigation

Management and mitigation measures to reduce disruption to fauna behaviour during construction activities include:

- Pre-clearing surveys for active breeding sites
- Directional lighting will be used where possible to minimise light spill
- Restriction of movement of vehicles and humans to construction areas
- Dust suppression activities will be undertaken where appropriate and managed in accordance with the recommendations outlined in SEIS Volume 4 Appendix L Mine Air Quality Report
- Regular maintenance of machinery and plant will be undertaken to minimise unnecessary noise

3.12.4 Summary

Noise, light and general construction activity will disturb animals in the vicinity of construction areas, and animals will either habituate or move away. Dust may also affect quality of plant health and palatability. Construction activities generally do not take place close to sensitive habitats and impacts on significant biodiversity values are not expected. Implementation of the mitigation measures listed above will seek to prevent/reduce exposure to these potentially disruptive activities.

4. Potential impacts and mitigation - operation

4.1 Introduction

This impact assessment has been structured to address impacts associated with the operational phase activities listed below. Full details about the staged operations of the Project (Mine) are provided in Volume 4, Appendix B Updated Mine Project Description. It is important to note that some preliminary activities associated with the operation phase (i.e. stripping of vegetation prior to open-cut mining) will occur simultaneously with activities defined as occurring within the construction phase (as outlined in Section 3.1).

The operation phase of the Project (Mine) is proposed to involve the following activities:

- Underground mining through staged development with subsidence of mined areas
- Open cut mining through staged development and phased rehabilitation of pits over the duration of the Mine life
- Management of overburden through development and phased rehabilitation of waste areas over the duration of the Mine life
- Development and maintenance of clean water diversion drains through the mining lease to avoid mine affected area
- Establishment and maintenance of a 500 m buffer from each bank of the Carmichael River, with establishment of a flood levee bordering the outer edge of the 500 m buffer zone adjacent to the open cut mines
- Establishment of sediment ponds (water management dams) to receive dirty water from mining operations
- Diversion of Eight Mile Creek
- Operation of the Mine (Offsite) Area, comprising the operation of the workers accommodation village, airport, industrial area and offsite water supply infrastructure, including:
  - Pumping of water from the Belyando River during peak flow periods
  - Pumping of local groundwater reserves in the Moray Downs property, outside of the active mining leases

The indicative locations of the underground mining area, open cut mining area (blocks), out of pit waste dumps, water management dams, areas potentially exposed to subsidence (i.e. those areas above the underground Mine), and areas not to be subjected to operation phase activities, are presented in Figure 5.

The Mine Plan incorporates:

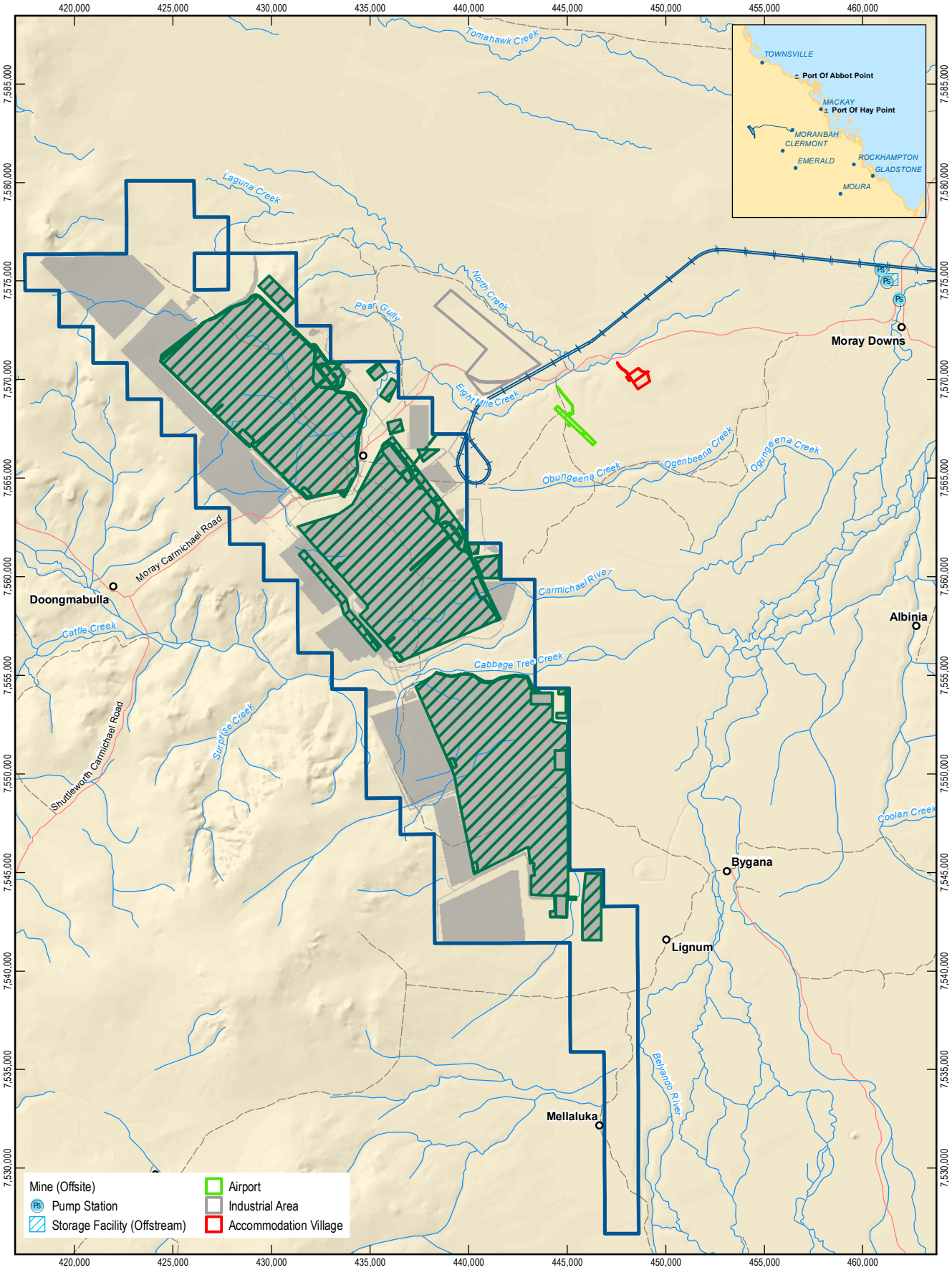
- Staged, non-sequential operation of the Mine is proposed to occur over 60 years, incorporating
  - Underground mining in the west of the Project (Mine) Area
  - Open cut mining in the middle of the Project (Mine) Area

  - Overburden disposal (out of pit waste dumping) and water management dams in the east of the Project (Mine) Area
- All clean water to be diverted to the Carmichael River will pass through sediment basins / traps prior to discharge
- Water management dams will be constructed and used for a variety of water treatment and storage requirements
- Discharges to surface water will occur under conditions of an environmental authority and will involve overflows from sediment ponds when rainfall exceeds the design capacity of those ponds and controlled discharges of mine affected water (central MAW dams) when sufficient dilution is available to address salinity levels
- Access to the southern part of the Project (Mine) Area will be achieved via one point, a spanned bridge across the Carmichael River
- All water runoff from the mine footprint will be captured, treated and reused
- No water will be extracted from the Carmichael River for operation of the mine
- Sewage from the operational workforce will be treated in a packaged plant to an A standard and all effluent will be recycled onsite

The potential operation phase impacts (as identified in Figure 5) to nature conservation values have been considered and appropriate management and mitigation measures proposed, to ameliorate identified impacts, as listed below:

- Clearing of land (vegetation clearing):
  - Loss of vegetation
  - Loss of fauna habitat
  - Fauna mortality
  - Habitat fragmentation
  - Habitat degradation
- Loss of aquatic habitat
- Aquatic fauna mortality
- Degradation of water quality and aquatic habitats
  - Run-off and sedimentation
  - Acid mine drainage
  - Sediment pond discharge
  - Dust pollution
- Alteration of surface water regime:
  - Changes in flow (catchment and diversions)
  - Barriers to flow
  - Floodplain connectivity
  - Subsidence
  - Loss of water resources utilised by terrestrial species
- Alteration in groundwater regime:

  - Changes to habitat due to groundwater drawdown
  - Potential indirect impacts to Doongmabulla Springs
  - Impact to stygofauna communities
- Proliferation of weeds and feral animals species:
  - Competition with native species, predation of native species, and habitat degradation (presence and prevalence of pest and weed species)
- Increased disturbance to habitats:
  - Disturbance to breeding, roosting and foraging areas and behaviours
  - Habitat alteration associated with subsidence
- Subsidence



LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- Project (Rail)
- Project (Mine)
- Operation Phase
- Disturbance Footprint
- Mine Layout

1:275,000 (at A4)
0 1 2 3 4 5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Carmichael Coal Mine and Rail Project SEIS

Project (Mine) Area Impacted During Operation Phase

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Revision B
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Figure 5

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

Data Source: DNRM: Waterbody (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Road, Homestead, Watercourse (2007);
Adani: Project Rail 1 (Opt11 Rev2) & 2 (Opt9 Rev3), Facilities (2013), Construction Area (2013); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH.

4.2 Vegetation clearing – loss of vegetation

4.2.1 Overview

Operations at the Mine Area will require vegetation clearing across the open cut mine footprint, spoil disposal areas and mine water management dams. Note that vegetation clearing is not required over the underground mine footprint and the effects of subsidence are discussed in Section 4.18.

Open cut mining is proposed to be staged over the life of the mine. Consequently vegetation clearing will not occur in a single event, but rather is proposed to be staged to correspond with the sequential development of coal mining.

Whilst recognising that vegetation clearing is proposed to be staged, and that at any particular point over the life of the mine, some areas may retain the existing vegetation coverage, and other areas may be under active rehabilitation, the assessment below considers the clearing of all vegetation proposed to occur within the indicative mining (operation) footprint (Figure 5) over the life of the Mine. It should be noted that all calculations presented are approximate and based upon digitisation of the preliminary Mine plan (as at July 2013).

4.2.2 Potential impacts

Loss of TECs

, Approximately 247 ha of the Brigalow TEC will be cleared. The TEC to be directly impacted represents 0.28 percent of that available within the Belyando Downs subregion. The proportional loss of Brigalow TEC will be relatively small in the context of its subregional extent, and offsets will be secured and managed to maintain, protect and where possible enhance local biodiversity values. The localised loss of Brigalow TEC at the Project (Mine) Area is not considered likely to adversely impact upon the biodiversity values of the region.The Brigalow TEC does not occur within the area potentially subject to subsidence from underground mining activities.

Loss of Category B ESAs

Approximately 904 ha of Category B ESA (RE with endangered biodiversity status) is proposed to be cleared for Mine operations. The Category B ESAs to be directly impacted represents 0.54 percent of that available within the two subregions intersected by the Project (Mine) (comprising the Alice Tableland subregion for the Desert Uplands REs, and the Belyando Downs subregion for the Brigalow Belt REs). Approximately 48 ha of Category B ESA may be subject to subsidence from underground mining activities.

Loss of endangered REs

Approximately 247 ha of endangered RE (VM Act status) is proposed to be cleared. The affected REs are those comprising the Brigalow TEC, addressed above. The endangered REs do not occur within the area potentially subject to subsidence from underground mining activities.

The area to be cleared comprises two endangered RE types (11.3.1 and 11.4.9) which are both located from the Brigalow Belt bioregion. These endangered REs form brigalow vegetation

communities and are constituents of the Brigalow TEC as well as Category B ESAs (discussed above).

Loss of of concern REs

Approximately 160 ha of least concern RE (VM Act status) is proposed to be directly impacted by vegetation clearing. This area is made up of one of concern RE from the Desert Uplands bioregion, RE 10.7.4, and two of concern REs from the Brigalow Belt bioregion, REs 11.3.3 and 11.4.6.

The proportional impact (i.e. loss of vegetation as a proportion of that remaining in the subregion) will be greatest for REs 11.4.6 and 10.7.4. Vegetation clearing for the operation of the Mine will result in a 0.51 percent and 0.40 percent of the current extent of these REs within the subregion respectively being cleared. RE 10.7.4 has a current bioregional extent of less than 7,500 ha, of which 69 percent of the total bioregional extent lies within the Alice Tableland subregion, where the Project (Mine) is located.

Approximately 37 ha of RE 10.7.4 falls within the area potentially subject to subsidence from underground mining activities.

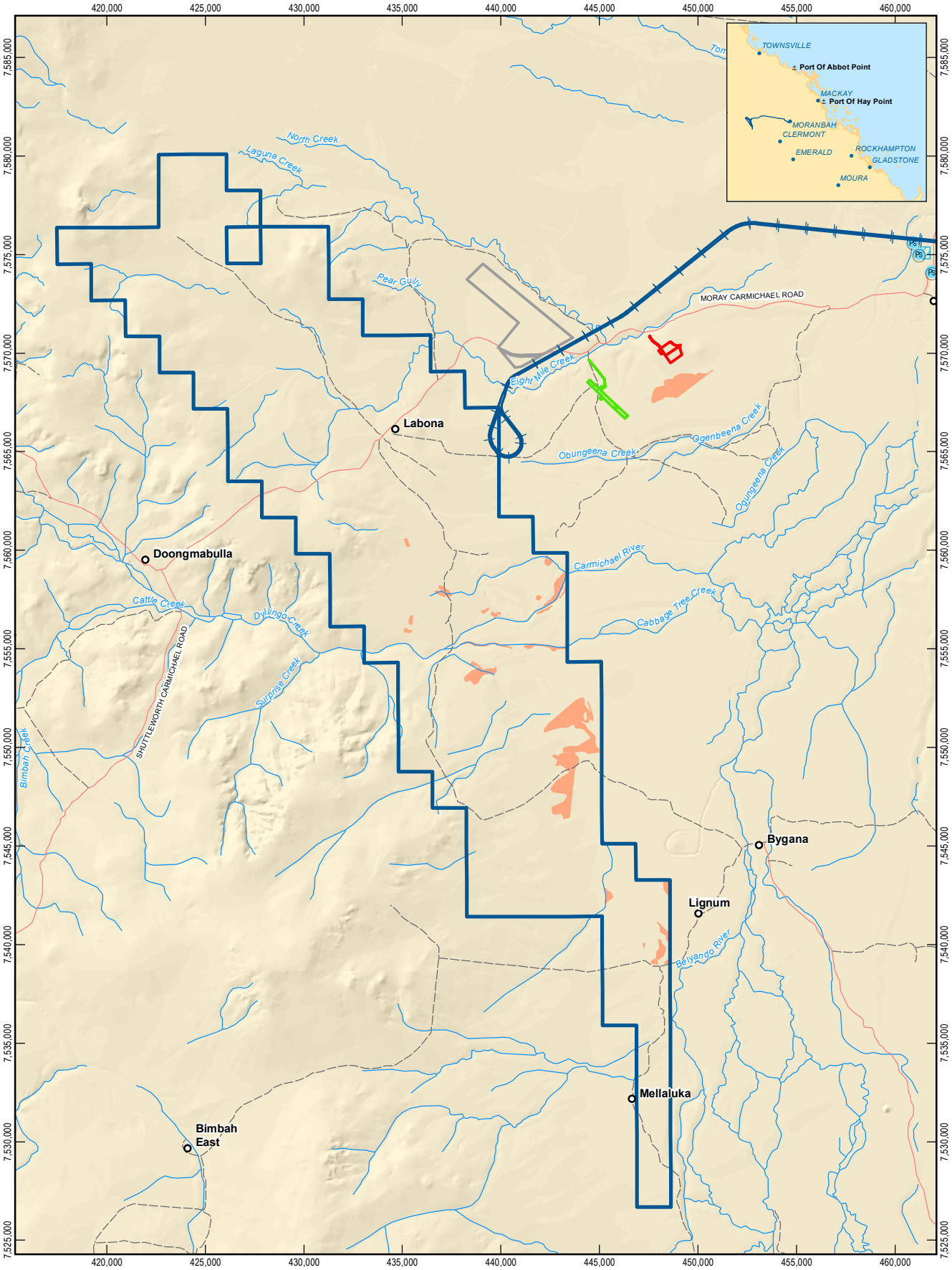
Loss of least concern REs

A total of 21 least concern RE types, 16 within the Desert Uplands bioregion and five in the Brigalow Belt bioregion, are proposed to be cleared for mining operations. This equates to a total removal of approximately 8,715 ha of least concern RE within the mining (operation) footprint over the lifespan of the Mine. The loss of least concern vegetation for the operation of the Mine is proposed to occur sequentially over the life of the Mine as new pits are developed and existing pits closed and partially rehabilitated.

Three least concern REs, 10.3.6, 10.3.28 and 10.5.5 within the Project (Mine) Area are subject to the greatest area of impact from the loss of vegetation as all three REs are subject to a loss of 1,000 ha or more. RE 10.5.5 is proposed to be most impacted with an approximate area of 3,317 ha to be cleared for Mine operations. These three RE types are broadly characterised as *Eucalyptus brownii* or *Eucalyptus melanophloia* open woodlands which are the dominant vegetation types within the Project (Mine) Area. Vegetation loss of between 100 ha and 900 ha is proposed to occur in seven RE types (10.3.12, 10.4.3, 10.4.5, 10.5.1, 11.3.10). The remaining 11 RE types are proposed to be impacted by the removal of approximately 100 ha or less (10.3.3, 10.3.4, 10.3.14, 10.5.4, 10.7.2, 10.7.5, 10.7.7, 10.9.3, 11.5.3, 10.5.7, 11.3.5, 11.3.6, 11.3.7).

Loss of high value regrowth

Approximately 12 ha located within the Mine operations area is proposed to be cleared for mining operations. This regrowth vegetation is mapped as containing least concern REs. High value regrowth does not occur within the area potentially subject to subsidence from underground mining activities.



LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- Brigalow Threatened Ecological Community
- Project (Rail)
- Project (Mine)
- Mine (Offsite)
- Pump Station
- Storage Facility (Offstream)
- Airport
- Industrial Area
- Accommodation Village

1:275,000 (at A4)
0 1 2 3 4 5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Revision B
Date 24-10-2013

Brigalow Threatened Ecological Community

Figure 6

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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: DME: EPC 1690 (2010), EPC 1080 (2011); DNRM: Threatened Ecological Communities (2011), Field Verified Regional Ecosystems (2013); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007); Adani: Project Rail 1 (Opt11 Rev2) & 2 (Opt9 Rev3), Facilities (2013), Mine Layout (2013). Created by: BW, CA

Loss of vegetation – Bygana West Nature Refuge

The Bygana West Nature Refuge covers an area of 1,316 ha and is wholly contained within the mining footprint. Vegetation clearing for mining operations within the Bygana West Nature Refuge will result in the direct loss of approximately 1,238 ha of the remnant vegetation in the nature refuge, approximately 85 percent of its total vegetation coverage. 182 ha of the nature refuge within the Mine (operation) footprint may be exposed to subsidence as a result of underground mining activities.

Loss of vegetation – flora species and habitat, including least concern species and species of conservation significance

The only flora species of conservation significance confirmed present during the field surveys, waxy cabbage palm, is restricted to the Carmichael River channel. The Carmichael River channel, which represents known habitat for this species, will not be directly disturbed, nor will it be undermined, and a buffer is to be established. Therefore, there will be no clearing or loss of habitat for this species. Indirect impacts to this species may occur through groundwater drawdown, but this has been dealt with in the section on groundwater dependant ecosystems (see Section 4.12).

The footprint for mining operations may contain potentially suitable habitat for three flora species that may occur at the Project (Mine) Area, as determined through the likelihood of occurrence assessment. None of these species were confirmed present during field surveys of the Project (Mine) Area. The three species are:

- *Acacia ramiflora* (vulnerable EPBC Act; not listed NC Act) - may occur within Project (Mine) Area
- *Nesaea robertsii* (not listed EPBC Act; endangered NC Act) – may occur within Project (Mine) Area
- *Peripleura scabra* (not listed EPBC Act; near threatened NC Act) – may occur within Project (Mine) Area

It is likely that potentially suitable habitat for these species will be removed through sequential vegetation clearing for the operation of the mine over the lifespan of the mine. Outcomes of the likelihood of occurrence assessment and potential habitat requirements for each species are detailed further within Sections 3.2.4 and Section 3.3.5.

4.2.3 Management and mitigation

In response to unavoidable clearing of native vegetation, the following management and mitigation measures are recommended:

- Non-remnant areas within the Project (Mine) Area that are to remain unmined should be rehabilitated and managed (including monitoring) with the objective being to gradually achieve regrowth and remnant status to vegetation communities that are associated with similar land zones in the local landscape. This active management should occur to contribute to the maintenance of ecological values of the local landscape in which the Project (Mine) Area occurs, though it is recognised that cleared lands are generally seeded with exotic pastures and restoration of a native ground cover may be difficult to achieve, or a very long term outcome. Areas where such management could occur include along the Carmichael River corridor (north of the Carmichael River), in the eastern part of EPC 1080 (south and south east of the MIA), and at the southern part of EPC 1080 where no development is proposed to occur. A component of this active management should be implementation of ecologically sensitive grazing strategies
- The ecological values within the buffer area surrounding the Carmichael River are to be enhanced through a revegetation and active vegetation and habitat management program. The program should focus on providing east-west connectivity. A monitoring program should be implemented to monitor success of the revegetation and enhancement program as well as presence and utilisation by fauna, including threatened fauna. Results of monitoring of the revegetation program may be relevant to the latter stages of the phased rehabilitation and also management of offset areas on Moray Downs and adjacent properties
- The extent of vegetation clearing is to be restricted to the minimal amount necessary for mining operations. Areas that must not be cleared or damaged are to be clearly identified on operation plans and in the field. Clearing extents are to be communicated to all necessary personnel involved
- During mining operations, sequential clearing will be adopted in order to minimise the ongoing total area of impact through clearing
- Vegetation clearing operations are to be supervised to monitor compliance of vegetation clearing with the defined clearing extents
- Unavoidable (staged) loss of vegetation will be offset in accordance with Commonwealth and Queensland policies, with the objective of maintaining, and where at all possible, enhancing local biodiversity values. Identification of offsets will seek to realise opportunities to enhance local and regional biodiversity values, for example, through the procurement and management of areas that contribute to corridors in the region. Furthermore, these areas should be identified with a view to achieving a ‘no net loss’ of local biodiversity values, in consideration of the types of vegetation that will be cleared, and the conservation status of those vegetation communities.
- As soon as possible after disturbed areas (cleared areas, open cut pits, out of pit waste dumps etc.) are no longer required, the early stages of a phased rehabilitation will commence. This is to include, but not be limited to, measures including the reinstatement of topsoil, and revegetation using flora species of local provenance that are suitable for the reinstated soil and geomorphology. Management of previously disturbed land will

occur in accordance with the Mine Rehabilitation Management Plan (crefer Volume 4 Appendix R1 and R2). This plan will detail how disturbed land will be managed and rehabilitated, including (but not limited to) details about seed collection, flora regeneration and landscape architecture (i.e. topography), monitoring and adaptive management of rehabilitated areas. The objective of land rehabilitation should be to return disturbed areas to a vegetated state as quickly as possible after disturbance has ceased. In addition to monitoring and adaptive management of rehabilitated areas, opportunities for targeted rehabilitation activities that seek to enhance local biodiversity values should be identified and realised. These may include providing vegetated linkages across rehabilitation areas to larger areas of remnant vegetation, and provision of habitat resources for local fauna species

- The Rehabilitation Management Plan is to specify techniques for managing cleared vegetation and topsoil where this is to be used in rehabilitation.

4.2.4 Summary

The operation phase of the Mine is expected to result in the clearance of approximately 9,123 ha of remnant vegetation. In addition to the area of remnant vegetation required to be cleared, an additional 8,482 ha of non-remnant vegetation (approximately) will be cleared through the operation phase. In accordance with the proposed development of the coal resource, open cut mining and associated vegetation clearing will occur sequentially throughout the mining footprint over the life of the Mine. Due to the operational layout of the Mine, western sections of the Mine Area will not be cleared. The parts of the Mine Area where vegetation clearing is not proposed to occur contain both remnant (approximately 11,282 ha, approximately 40 percent of remnant vegetation within the Mine Area) and non-remnant vegetation (approximately 5,631 ha). Some areas not impacted by clearing may be subject to subsidence as a result of underground mining (discussed in Section 4.18).

The loss of vegetation within the footprint for the proposed mining operations will impact upon an EPBC Act listed TEC and a number of Queensland listed categories of ecological importance, including Category B ESAs, endangered and of concern regional ecosystems, regrowth vegetation and the Bygana West Nature Refuge. Relevant approvals will be required before the removal of these features, and appropriate offsetting obligations will be addressed. A summary of the loss of vegetation for the operation of the Mine is presented in Table 3.

Vegetation clearing is proposed to occur sequentially throughout the life of the Mine. With active management, the ecological values within each area will be maintained (such that these do not deteriorate over time) until such time that staged mining is to occur. Generally, the staged yet permanent loss of remnant vegetation for mining operations is proposed to have an acceptable impact on the REs located within the operational footprint of the Mine, given the proportional losses that will occur in the context of subregional and regional vegetation extents. Less than 1 percent of the current (2006) subregional RE extent for all endangered and of concern REs impacted by the Project (Mine) is proposed to be lost as a result of vegetation clearing.

In addition to onsite measures to minimise avoidable impacts to vegetation and manage and enhance areas that will not be subject to vegetation clearing, offsetting will be used to address the loss of TECs and endangered and of concern REs, and the ecological values provided by remnant vegetation. Offsetting will involve the identification, procurement and management of

available suitable areas in the surrounding landscape. The overarching objective of this onsite and offsite management will be to maintain, and where opportunities exist, enhance the biodiversity values of the landscape in which the Project (Mine) occurs.

Through the implementation of management actions within the Project (Mine) Area, in combination with the procurement and management of offsets (offsite), long-term, irreversible impacts to regional biodiversity values associated with conservation significant vegetation are not expected to occur.

Table 3 Summary of vegetation loss during mine operations

Category	Proposed area to be cleared (ha)
Endangered RE	247
Of concern RE	160
Least concern RE	8,715
(Total remnant vegetation)	9,123
Brigalow TEC	247
Category B ESA	820
Regrowth vegetation	12
Bygana West Nature Refuge (remnant vegetation)	1,238

4.3 Vegetation clearing – loss of habitat for terrestrial species

4.3.1 Overview

The mining operations will require vegetation clearing over the life of the Mine, encompassing open cut blocks, out of pit waste dumps and water management dams with a total area of 17,605 ha. This includes 9,123 ha of remnant vegetation (approximately 32 percent of remnant vegetation in the Project (Mine) Area) and 8,482 ha of non-remnant vegetation. The loss of vegetation will reduce the abundance and diversity of available habitats for terrestrial fauna.

4.3.2 Potential impacts

Table 4 summarises fauna habitat loss and degradation associated with vegetation clearing and subsidence impact. The staged loss of habitat, over the life of the mine, will reduce the local availability of foraging, breeding and shelter resources for a wide diversity of fauna species (approximately 32 percent of remnant vegetation at Project (Mine) Area). Mobile species may be able to disperse between similar habitats within the Project (Mine) Area during staged mine operations, or disperse away from the Project (Mine) Area to similar habitats in the landscape to the north, west and south of the Project (Mine) Area. Habitat loss may diminish opportunities for movement of less mobile fauna (i.e. ground-dwelling reptiles, amphibians, small ground-dwelling mammals) in the local landscape.

It is important to note that large parts of the Project (Mine) Area will not be exposed to vegetation clearing during staged operations of the mine. In total, 11,281 ha of land characterised by fauna habitats featuring remnant vegetation will not be cleared. In addition, 5,631 ha of open cleared land (characterised by non-remnant vegetation) will not be cleared during the mine's operation phase.

Table 4 Area of fauna habitat subject to clearing and subsidence impact and areas with no direct impact

Fauna habitat type	Clearing impact	Subsidence impact	No direct impact
Ironbark-box grassy woodlands and open woodlands on grey sand plains 'Ironbark-box woodland'	7,461 ha	5,109 ha	7,881 ha
Yellow jacket and rough leaved bloodwood shrubby low open woodland on red sand plains 'Shrubby low woodland'	159 ha	848 ha	1,518 ha
Tall mixed shrubland on red sand plains over ferricrete 'Tall mixed shrubland'	56 ha	782 ha	716 ha
Gidgee and/or brigalow shrubby woodland and low woodland, sometimes with Dawson's gum emergents, on clay and clay loam plains 'Gidgee / brigalow shrubland'	1,350 ha	22 ha	744 ha
Open forest and woodland fringing watercourses and relict stream channels, and alluvial plains subject to flooding 'Fringing open forest / woodland'	0 ha	3 ha	298 ha
Woodland and low open woodland associated with laterised sandstone rises and minor pediments 'Low woodland (sandstone rises)'	92 ha	179 ha	116 ha
Open, previously cleared areas lacking native vegetative cover 'Open cleared land'	8,475 ha	619 ha	5,627 ha

4.3.3 Management and mitigation

Where (staged) vegetation clearing is required for open cut blocks, out of pit waste dumps and water management dams, in accordance with staged development of the Mine, the following management and mitigation measures will be undertaken:

- Management of remnant vegetation at the Project (Mine) Area on land that is yet to be mined, or is to remain unmined (including areas at the northern and southernmost parts of the Project (Mine) Area), will be undertaken in accordance with the Project's overarching ecological management framework, embedded in the Project Environmental Management Plan. This framework details how land not subject to direct impacts (i.e. vegetation clearing) will be managed (including details relating to land use (cattle grazing), vegetation management, rehabilitation, weed and pest animal management, fencing and fire management), such that the terrestrial ecological values (including habitat quality and function) of such areas are maintained, and where possible,

enhanced. This strategy will make reference to the relevant environmental management actions outlined in Volume 4, Appendix Q1 Environmental Management Plan (Mine) and Volume 4, Appendix Q2 Environmental Management Plan (Offsite).

- Further to the above, suitable non-remnant areas within the Project (Mine) Area that are to remain unmined through the life of this Project (Mine) will be rehabilitated and managed as part of the overall offset strategy, with the objective being to gradually achieve remnant status that is consistent with the vegetation communities (and associated fauna habitats) that are associated with similar land zones in the local landscape. Areas where such management will occur include along the Carmichael River corridor (north of the Carmichael River), in the eastern part of EPC 1080 (south and south east of the MIA), and at the southern part of EPC 1080 where no development is proposed
- The ecological values within the buffer area surrounding the Carmichael River are to be enhanced through a revegetation and active vegetation and habitat management program. The program will focus on providing east-west connectivity. A monitoring program will be implemented to monitor success of the revegetation and enhancement program as well as presence of and utilisation by fauna, including threatened fauna. Results of monitoring of the revegetation program may be relevant to rehabilitation and management of offset areas on adjacent properties
- Vegetation clearing for discrete phases of the Project (Mine) operations will be undertaken in a manner that maximises the potential for fauna to disperse away from habitats within the clearing footprint, to adjacent areas, including onsite and offsite (offset) areas that are being actively managed for biodiversity outcomes. For example, prior to clearing, any opportunities to reduce the relative quality of habitats in a discrete clearing footprint whilst simultaneously enhancing the values of nearby habitats which may act as a sink for dispersing animals, should be realised. Such management may include gradually reducing the availability of surface water in the clearing footprint whilst simultaneously providing more of this resource in areas of (nearby) suitable alternative habitat. The management of cattle (i.e. stocking rates) may also be considered for this purpose. Vegetation clearing within the clearing footprint will be undertaken sequentially, in a manner that encourages animals to disperse towards adjacent habitats that will remain intact. To facilitate this further, corridors between proposed clearing areas and habitats that will be managed for biodiversity should be maintained and enhanced, or where they do not occur, should be provided through targeted revegetation actions. Implementation of this recommended approach will be underpinned by onsite research, with its efficacy to be monitored and adaptively managed such that the overall objective of no-net-loss of regional biodiversity values is achieved
- The extent of vegetation clearing is to be restricted to the minimal amount necessary for each applicable operational component of the Mine
- The extent of vegetation clearing is to be clearly identified on construction plans and in the field. Areas that must not be cleared or damaged are to also be clearly identified on construction plans and in the field. Clearing extents are to be communicated to all necessary construction supervisors
- Ssurveys will be undertaken in areas identified as potential habitat for threatened species, prior to commencement of clearing. In areas where these surveys indicate the

presence of habitat features observed to (or with the potential to) provide habitat for these species, a fauna spotter-catcher will be engaged to accompany clearing crews. Habitat features identified during the pre-clearance survey will be thoroughly checked by fauna spotter-catcher prior to clearing. Provision for the relocation of fauna will be made prior to the commencement of clearing

- Unavoidable (staged) loss of vegetation and the fauna habitat it provides will be offset in accordance with Commonwealth and Queensland policies, with the objective of maintaining, and where possible, enhancing the local biodiversity values identified in this baseline report such that local biodiversity values are not irreversibly affected in the long term. Identification of offsets should seek to realise opportunities to enhance local and regional biodiversity values, for example, through the procurement and management of areas that contribute to corridors in the region. Furthermore, these areas will be identified and managed with a view to achieving no net loss of local biodiversity values, in consideration of the types of vegetation that will be cleared and the conservation status of fauna species it provides habitat for. The management of these areas will seek to improve the quality and function of habitats, through identification and management of the threatening process with the potential to adversely affect fauna, and will be undertaken in accordance with the Project's overarching ecological management framework, embedded in the Project Environmental Management Plan. This framework will detail how land not subject to direct impacts (i.e. vegetation clearing) including offset areas will be managed (including details relating to land use (cattle grazing), vegetation management, rehabilitation, weed and pest animal management, fencing and fire management), as well as what targeted research and monitoring is required to inform this management, such that the terrestrial ecological values of these areas are maintained, and where possible, enhanced. This strategy will make reference to the relevant environmental management actions outlined in the Project Environmental Management Plan
- As soon as possible after disturbed areas (cleared areas, open cut pits, out of pit waste dumps etc.) are no longer required, rehabilitation will commence. This is to include, but not be limited to, measures including the reinstatement of topsoil, and revegetation using flora species of local provenance that are suitable for the reinstated soil and geomorphology. Management of previously disturbed land will occur in accordance with the Project Rehabilitation Management Plan. This plan details how disturbed land will be managed and rehabilitated, including (but not limited to) details about seed collection, flora regeneration, landscape architecture (i.e. topography), monitoring and adaptive management of rehabilitated areas. The objective of land rehabilitation will be to return disturbed areas to a vegetated state as quickly as possible after disturbance has ceased. The Rehabilitation Plan incorporates a phased approach, to be implemented over the short, medium and long term. The rehabilitation objectives will vary between phases. Short term rehabilitation will focus on landscape stabilisation and impact minimisation. Medium term rehabilitation will focus on the establishment of functionally important species and self-sustaining natural systems. The long term rehabilitation will focus on monitoring and adaptive management of those systems. In addition to monitoring and adaptive management of rehabilitated areas, opportunities for targeted rehabilitation activities that seek to enhance local biodiversity values should be identified and realised. These may include providing vegetated linkages across rehabilitation areas to larger areas of remnant vegetation, and provision of habitat resources within rehabilitated areas for local fauna species

4.3.4 Summary

Direct loss of habitat for terrestrial fauna will be more substantial during the Project (Mine) operation phase than the construction phase. However, the staged clearing process will assist in reducing the severity of impact on local fauna by allowing opportunities for animals to disperse into un-cleared areas and allowing opportunities for staged rehabilitation. Wherever practicable, the area of habitat to be cleared has been minimised. Where possible, rehabilitation will be undertaken at the earliest opportunity. Nevertheless, areas of habitat for fauna will be cleared. These will be subject to offsets in accordance with the Queensland Biodiversity Offset Policy (QBOP).

4.4 Vegetation clearing – loss of habitat for listed fauna

4.4.1 Overview

Clearance of remnant vegetation within the Mine Area will result in the direct loss of potential habitat for five threatened species listed under the EPBC Act, seven threatened species listed under the NC Act and 15 migratory species listed under the EPBC Act that were confirmed present or considered 'likely to occur' based on the likelihood of occurrence assessment.

4.4.2 Potential impacts

The operation of the Project (Mine) has the potential to result in the loss of habitat for the following EPBC Act listed fauna species.

Black-throated finch

Unavoidable vegetation clearing and resultant habitat loss (pre-management and mitigation) is considered to constitute a significant impact on the black-throated finch (southern), as a result of the (staged) loss of 8,154 ha of potential habitat within identified 'important areas' for the subspecies within the mining footprint.

Squatter pigeon (southern)

The proposed mining footprint to be cleared over the life of Mine incorporates 9,355 ha of the 28,835 ha of remnant vegetation, identified as potential habitat for the squatter pigeon (southern) within the Study Area. Based on the availability of similarly suitable habitat in the landscape surrounding the Project (Mine) Area including grazing land characterised by open grassy woodlands, and the stable nature of the subspecies' population at present, it is not considered that the Project (Mine) Area represents habitat critical to the survival of the (sub)species. Whilst local habitat availability will be reduced through staged mining operations, this loss is not considered to constitute a significant impact to an EPBC Act listed vulnerable species.

Koala

The proposed mining footprint to be cleared over the life of Mine incorporates 8,700 ha of the 26,535 ha of remnant vegetation within the Study Area, identified as potential habitat for the koala (based on field verified REs). The criteria used to define habitat critical to the survival of the species are relatively conservative and include much of the woodland vegetation in Queensland. Given the low densities at which koalas occur and the relatively restricted area of habitat to be cleared, the Project (Mine) is unlikely to have a significant impact on the koala.

Yakka skink

The mining footprint that is proposed to be cleared over the life of Mine incorporates 9,062 ha of the 27,023 ha of remnant vegetation within the Study Area, identified as potential habitat for the yakka skink (based on field verified REs). Based on the fact that the species was not detected at the Project (Mine) Area despite targeted surveys, and that similarly suitable habitat for the species is present in the landscape surrounding the Project (Mine) Area, it is not considered that the Project (Mine) Area represents habitat critical to the survival of the species for the yakka skink. Whilst local habitat availability will be reduced through staged mining operations, this loss is not considered to constitute a significant impact to an EPBC Act listed vulnerable species.

Ornamental snake

The mining footprint that is proposed to be cleared over the life of Mine incorporates 903 ha of the 1,769 ha of remnant and non-remnant vegetation, identified as potential habitat for the ornamental snake (based on field verified REs) within the Study Area. Based on the fact that the species was not detected at the Project (Mine) Area despite targeted surveys, and that similarly suitable habitat for the species is present in the landscape surrounding the Project (Mine) Area, it is not considered that the Project (Mine) Area represents habitat critical to the survival of the species for the ornamental snake. Whilst local habitat availability will be reduced through staged mining operations, this loss is not considered to constitute a significant impact to an EPBC Act listed vulnerable species.

Migratory birds

Land clearing for the Project (Mine) operational phase will reduce the local availability of habitat resources for three of the four EPBC Act listed migratory birds confirmed present at the Project (Mine) Area, as follows.

- Rainbow bee-eater – progressive loss of approximately 9,130 ha of potential habitat
- Eastern great egret – progressive loss of approximately 12 ha of potential habitat
- White-bellied sea-eagle – progressive loss of approximately 9 ha of potential habitat

The eastern great egret, rainbow bee-eater, and white-bellied sea-eagle are all widely distributed species. Habitat at the Project (Mine) Area is likely to be used on a temporary to permanent basis by these species. As these species are widespread, and suitable habitat is likely to occur over much of the surrounding landscape, habitat at the Project (Mine) Area for the eastern great egret, rainbow bee-eater, and white-bellied sea-eagle is not considered to constitute 'important habitat' as defined in the Significant Impact Guidelines (DEWHA, 2009c).

Eleven EPBC Act listed migratory birds that were not recorded at the Project (Mine) Area but are considered likely to occur, as determined through the likelihood of occurrence assessment, are similarly widespread and abundant, with suitable habitat widely available in the landscape in which the Project (Mine) Area occurs. The localised (staged) loss of potentially suitable habitat is not considered to constitute a significant impact to these species.

- Common sandpiper – progressive loss of approximately 12 ha of potential habitat
- Fork-tailed swift – progressive loss of approximately 9,130 ha of potential habitat – this species is predominantly aerial and thus habitat loss relates to overfly foraging habitat
- Curlew sandpiper – progressive loss of approximately 12 ha of potential habitat

- Latham's snipe – progressive loss of approximately 12 ha of potential habitat
- White-throated needletail– progressive loss of approximately 9,130 ha of potential habitat – this species is predominantly aerial and thus habitat loss relates to overfly foraging habitat
- Caspian tern – progressive loss of approximately 12 ha of potential habitat
- Black-tailed godwit – progressive loss of approximately 12 ha of potential habitat
- Glossy ibis – progressive loss of approximately 12 ha of potential habitat
- Common greenshank – progressive loss of approximately 12 ha of potential habitat
- Marsh sandpiper – progressive loss of approximately 12 ha of potential habitat

The eleven migratory species that were not recorded at the Project (Mine) Area, but are considered likely to occur, are similarly widespread and abundant, with suitable habitat widely available in the landscape in which the Project (Mine) Area occurs. The localised (staged) loss of potentially suitable habitat is not considered to constitute a significant impact to these species.

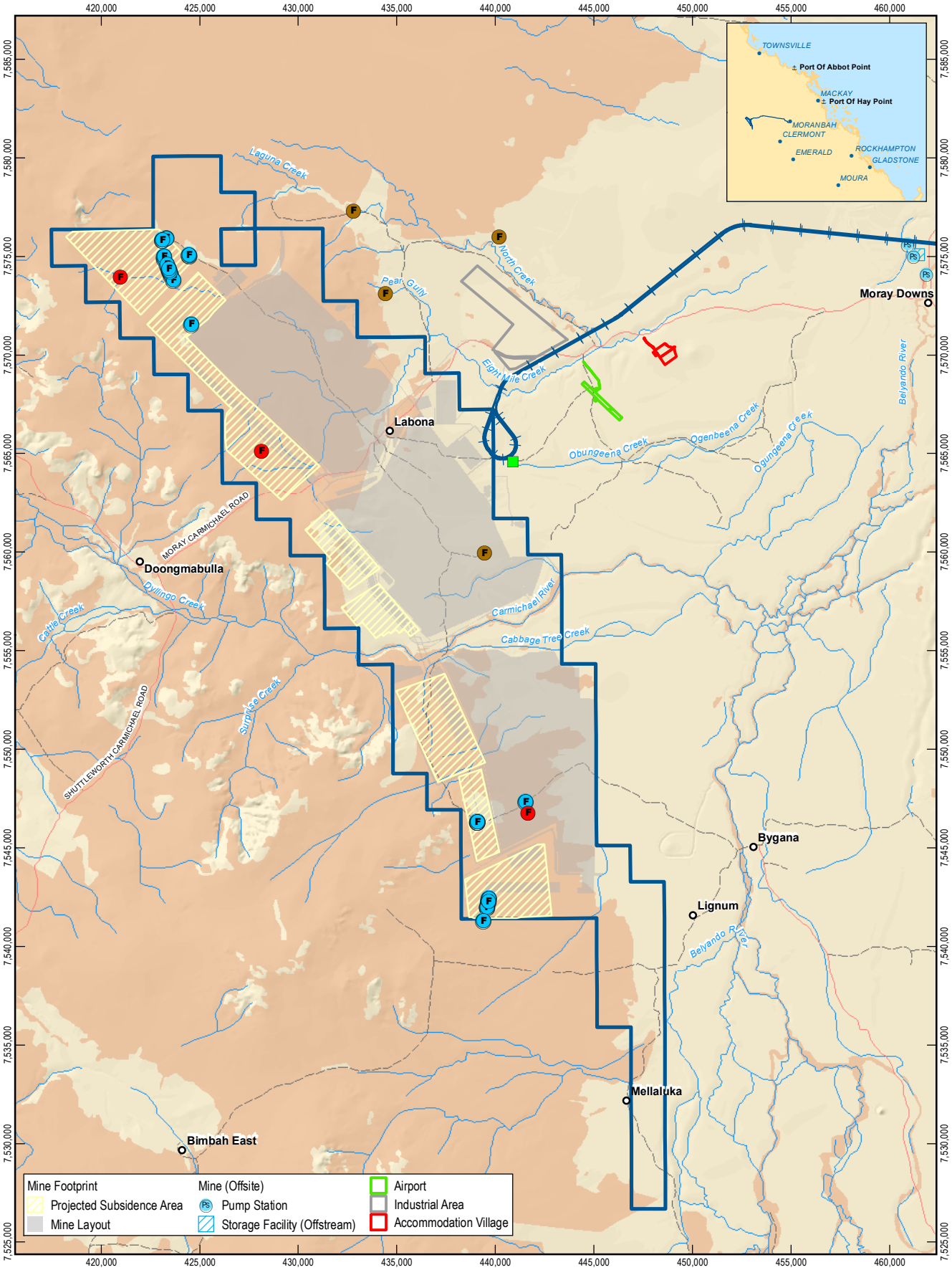
NC Act listed fauna

The operation of the Project (Mine) has the potential to result in the loss of the following habitat for NC Act listed fauna species confirmed present at the Project (Mine) Area.

- Little pied-bat – progressive loss of approximately 9,118 ha of potential habitat
- Black-necked stork – progressive loss of approximately 12 ha of potential habitat
- Cotton pygmy-goose – progressive loss of approximately 12 ha of potential habitat
- Echidna – progressive loss of approximately 8,811 ha of potential habitat

The operation of the Project (Mine) has the potential to result in the loss of the following habitat for NC Act listed fauna species likely to occur at the Project (Mine) Area, as determined through the likelihood of occurrence assessment.

- Square-tailed kite (likely to occur at Project (Mine) Area) – progressive loss of approximately 7,641 ha of potential habitat
- Black-chinned honeyeater (likely to occur at Project (Mine) Area) – progressive loss of approximately 7,641 ha of potential habitat
- Brigalow scaly-foot (likely to occur at the Project (Mine) Area – progressive loss of approximately 5,424 ha of potential habitat



LEGEND

- Black-throated Finch - Autumn 2012
- Black-throated Finch - August/September 2012 - Opportunistic sightings
- Black-throated Finch - Spring 2012
- Black-throated finch - Autumn 2013
- Homestead
- Local Road
- Track
- Watercourse
- Potential Black-Throated Finch (Southern) Habitat - Based on Field Verified Regional Ecosystems within the Mine Site and DNRM Certified Regional Ecosystems Version 6.0b outside the Mine Site
- Project (Rail)
- Project (Mine)

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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

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Potential Habitat for the Black-throated Finch (southern)

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Figure 7

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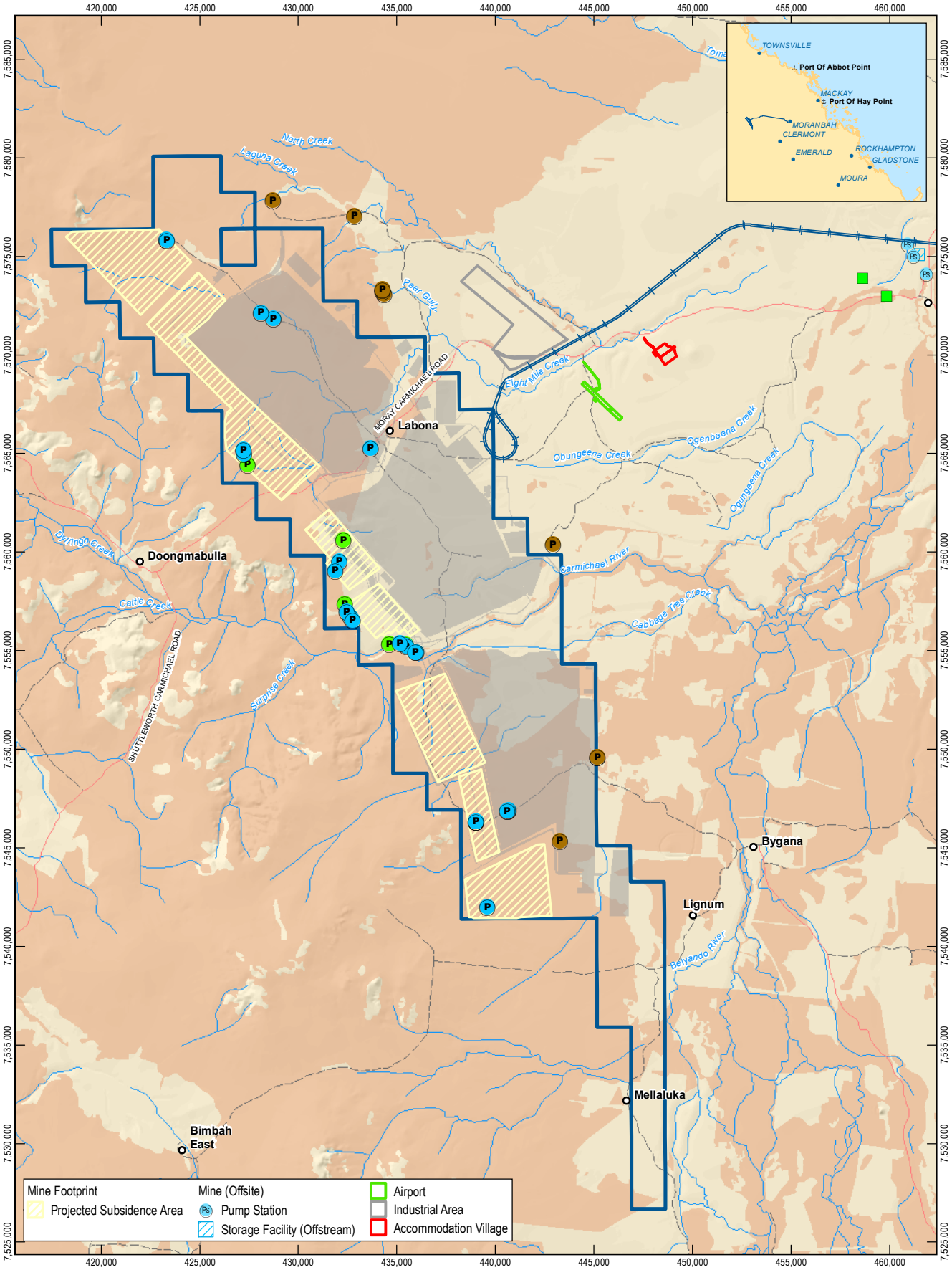

LEGEND

- Squatter pigeon sightings - Spring 2010
- Squatter pigeon sightings - Autumn 2011
- Squatter pigeon sightings - Spring 2011
- Squatter Pigeon (southern) Sightings - Autumn 2013
- Homestead
- Local Road
- Track
- Watercourse
- Potential Squatter Pigeon (Southern) Habitat - Based on Field Verified Regional Ecosystems within the Mine Site and DNRM Certified Regional Ecosystems Version 6.0b outside the Mine Site
- Project (Rail)
- Project (Mine)
- Mine Layout

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Revision C
Date 24-10-2013

Potential habitat for the Squatter Pigeon (southern)

Figure 8

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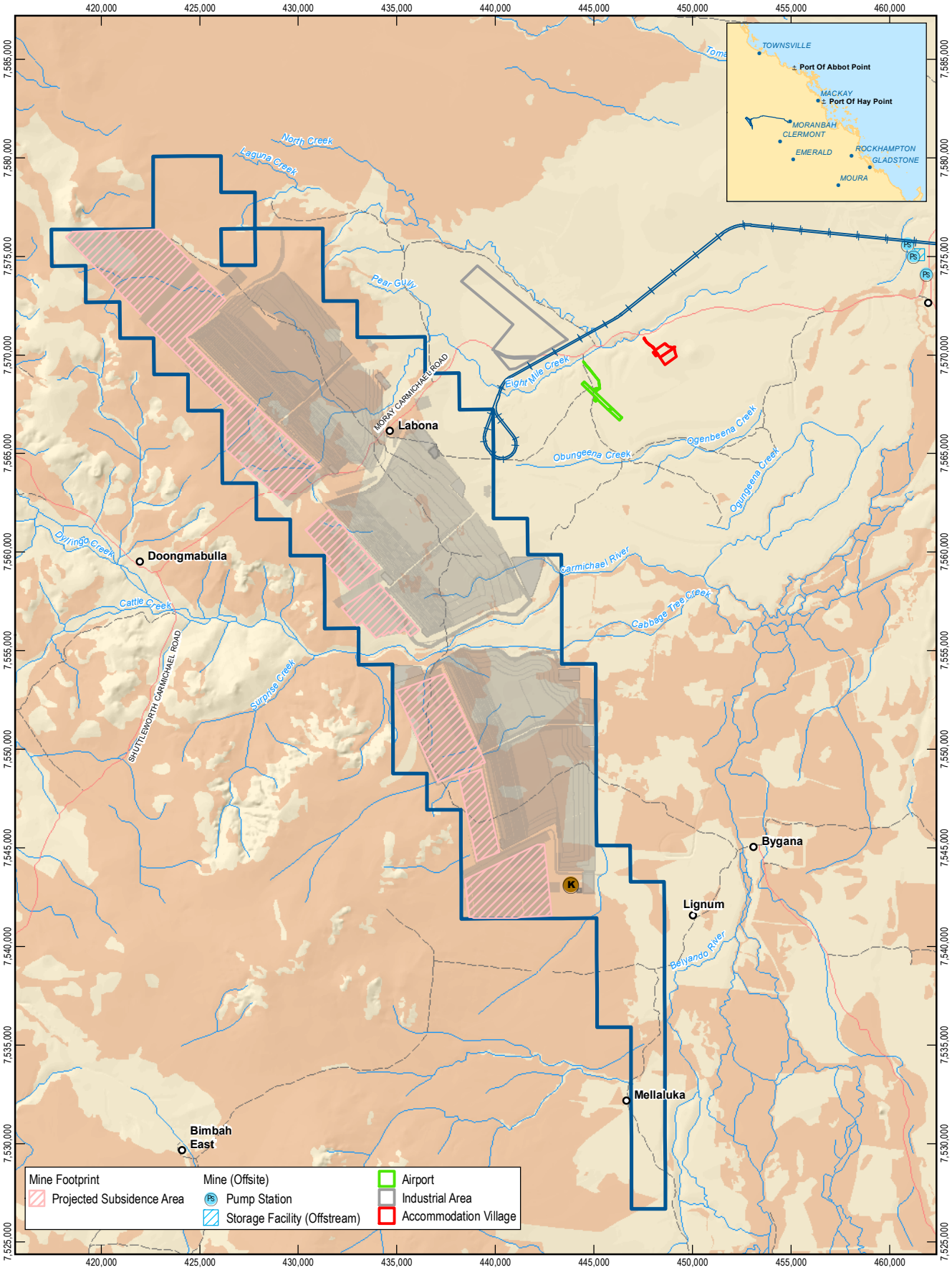

LEGEND

- Koala Sighting - Spring 2011
- Homestead
- Local Road
- Track
- Watercourse
- Potential Koala Habitat - Based on Field Verified Regional Ecosystems within the Mine Site and DERM Certified Regional Ecosystems Version 6.0b outside the Mine Site
- Project (Rail)
- Project (Mine)
- Mine Layout

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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

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Date 24-10-2013

Potential Habitat for the Koala

Figure 9

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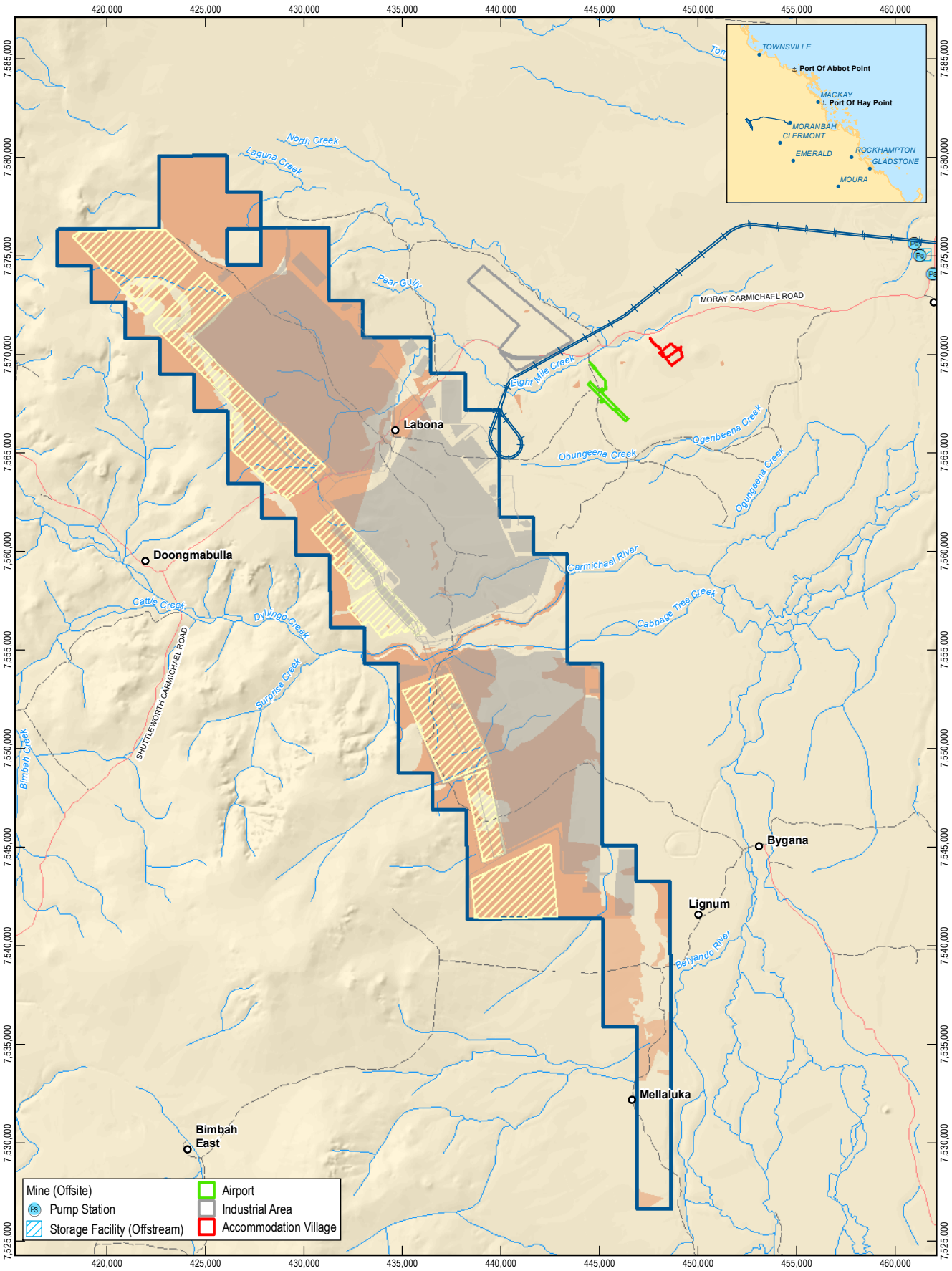

LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- Potential Yakka Skink Habitat
- Project (Rail)
- Project (Mine)
- Mine Footprint
- Projected Subsidence Area
- Mine Layout

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Map Projection: Universal Transverse Mercator
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Potential Habitat for the Yakka Skink Figure 10

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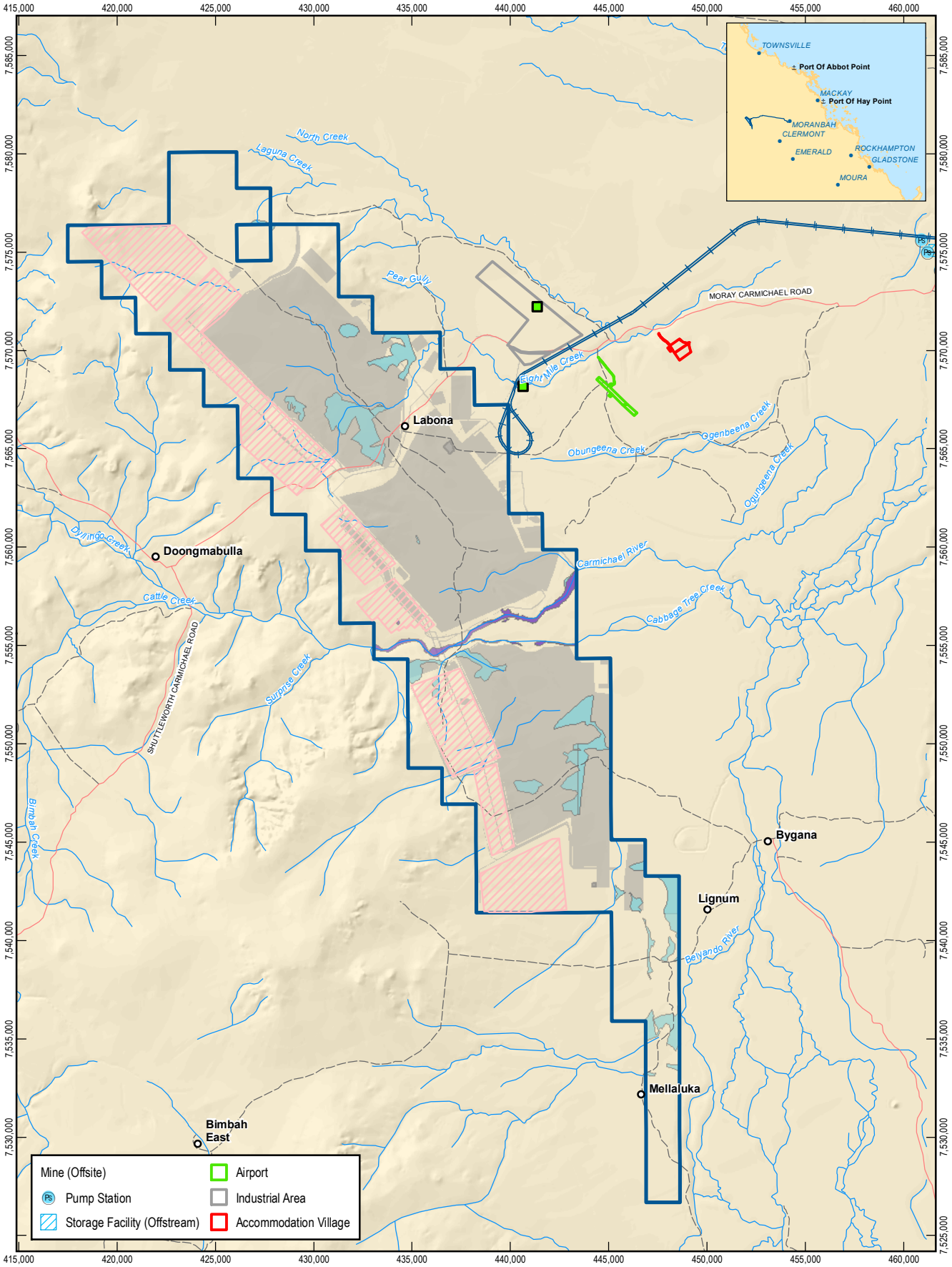

LEGEND

- Confirmed Location of Ornamental Snake
- Homestead
- Local Road
- Track
- Watercourse
- Gidgee and brigalow woodland on clay plains
- Open forest and woodland fringing streams and on flood plains
- Project (Rail)
- Project (Mine)
- Mine Footprint
- Projected Subsidence Area
- Mine Layout

1:275,000 (at A4)
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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

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Carmichael Coal Mine and Rail Project SEIS

Potential Habitat of the Ornamental Snake

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Revision C
Date 24-10-2013

Figure 11

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Adani: Project Rail 1 (Opt11 Rev2) & 2 (Opt9 Rev3), Facilities (2013), Mine Layout (2013); GHD: Potential Habitat (2011), Confirmed Sightings (2013). Created by: BW, CA

4.4.3 Management and mitigation

With respect to managing impacts in discrete clearing footprints during staged mining operations, targeted studies will be undertaken no more than one year prior to clearing, such that the management approaches are based upon information that is current.

The findings of such studies will be incorporated into Species Specific Management Plans for these animals (black-throated finch (southern), squatter pigeon (southern), koala, brigalow reptiles), and the outcomes will be directly linked to the overarching ecological management framework for the Project (Mine) embedded within the Project Environmental Management Plan, as well as the Project Offset Strategy and the Mine Rehabilitation Plan.

The Project Offset Strategy will address the unavoidable loss of habitat for conservation significant fauna resultant from Mine operations. This strategy will provide a framework for the identification of measures designed to maintain regional biodiversity values, where onsite impacts cannot be avoided. Such measures will include the identification and procurement of offsite land to be managed for conservation purposes, and investment in ecological research in the landscape in which the Project (Mine) Area occurs.

Black-throated finch (southern)

The loss of habitat for the black-throated finch (southern) will occur in stages, in accordance with the staged development of the operational components of the Mine Area. Management actions will seek to maintain and where possible enhance habitats and populations (e.g. pest control, water source, grazing and fire management) in unmined parts of the Mine Area, as well as in offset areas. Management actions to encourage dispersal away from areas that will be cleared for staged mine operations will also be developed. Offsets for black-throated finch (southern) habitat will be provided and an offsets strategy has been prepared that identifies suitable offsets on the Moray Downs property adjacent to the Mine Area.

The phased construction schedule will allow important population, movement and habitat information to be collected, particularly with respect to seasonal use, key areas, nest sites, important feeding areas and management of threatening processes. As such there will be opportunities to undertake construction and clearing in periods of least potential impact (i.e. non-nesting times) and potentially encourage dispersal away from the developed parts of the Mine Area, either to suitable habitat within other parts of the Mine Area, or to other suitable habitat in the landscape to the north, west and south of the Mine Area (see Figure 7). This includes areas procured and managed as offsets.

A draft Black-throated Finch Adaptive Monitoring Plan has been prepared comprising a four part monitoring program including:

1. Regional distribution (species distribution modelling)
2. Regional distribution (surveys)
3. Local monitoring (observational) on the Mine Area
4. Local monitoring (detailed) on the Mine Area

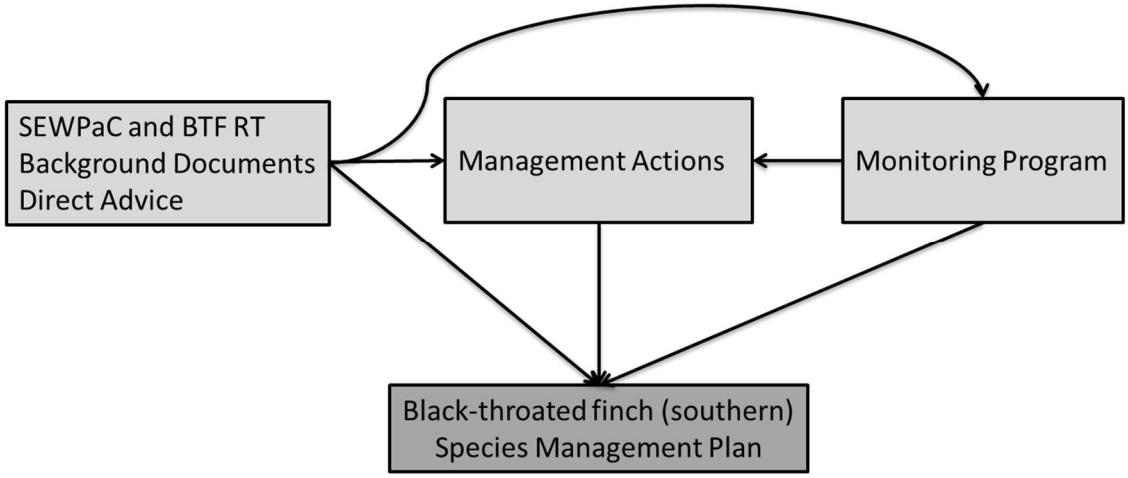
This plan will be incorporated into a larger Species Management Plan. The third component has commenced, and the first survey was conducted in May 2013 (Appendix I2 Black-throated Finch On-site Monitoring Survey 1) and this established 80 long term monitoring sites. Comprehensive

vegetation and habitat data is being collected at each site, and the survey methods follow those in EPBC Significant Impact Guidelines. The aim of this monitoring is to collect detailed information on habitat use, distribution across the Mine Area, nest sites, variation in sites where black-throated finch were present and absent, types of water sources preferred for use, habitat condition, weed, fire and grazing effects and landscape use. The surveys will continue over time to provide data on temporal and spatial variation of habitat use in the Mine Area and will contribute significant local data for incorporation into the Black-throated Finch Species Management Plan for the Mine Area, which will assist in refinement of species recovery actions and mitigation of impacts on the Mine Area. In the case of subsidence, which will occur gradually and in a complex and partly unpredictable manner, the data being collected by this monitoring will provide information regarding the best strategies over time to mitigate negative effects and manage key resources for black-throated finch on the Mine Area.

The highest numbers of black-throated finch are consistently recorded in mosaics of the intact remnant vegetation dominated by ironbark *Eucalyptus melanophloia* woodlands (10.5.5) and the associated yellowjack *E. similis* (10.5.1) and box *E. populnea/brownii* woodlands (10.3.6 / 10.3.28). This vegetation in these areas, especially in the north-west, west and south-west, is in particularly good condition due to the low level of artificial watering points, low degree of exotic pasture invasion, the presence of poison bush (*Gastrolobium grandiflora*) which is toxic to cattle, and seemingly a history of low or light grazing. Many grass species that are considered “decreasers” — that is vulnerable to disappear due to cattle grazing — are diverse and of a high cover abundance in these areas (e.g. *Alloteropsis*, *Triodia*, *Digitaria*, *Enteropogon*, *Eriachne*, *Panicum* which are considered preferred food sources for the black-throated finch). In many sites, where black-throated finch were absent despite the vegetation type being suitable, the influx of exotic pastures (Buffel grass, Indian Couch, *Stylosanthes*) was high and there was evidence of heavy grazing and low grass diversity. The reduction and removal of cattle grazing will be a significant management action, in addition to ecologically sensible fire regimes, and the protection of natural water sources and the provision of raised water troughs, which will also control feral animal abundance.

Management and monitoring of impacts to the black-throated finch (southern) will contribute to the recovery of the subspecies, as per the objectives of the National Recovery Plan for the Black-throated Finch Southern Subspecies (Black-throated Finch Recovery Team, 2007). The onsite and offsite (offset areas) habitat management and complementary monitoring program, as described above, will be developed and implemented in consultation with relevant stakeholders (i.e. Black-throated Finch Recovery Team, Commonwealth and State governments) (Figure 12).

Figure 12 Relationship between expert knowledge, management and monitoring actions for the SMP



Examples of recovery actions, as documented in the National Recovery Plan for the Black-throated Finch Southern Subspecies (Black-throated Finch Recovery Team, 2007), to be incorporated into the Species Specific Management Plan (Mine and Offsite (offset areas)) for the subspecies, may include:

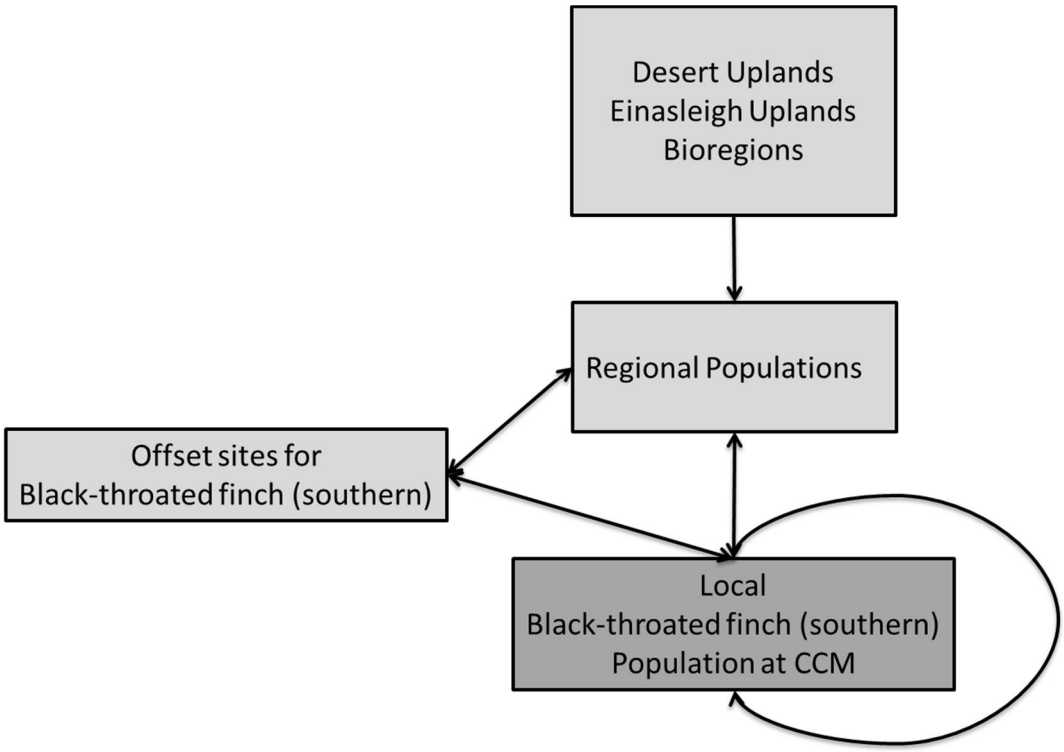
- Investigate breeding requirements and threats to key breeding areas (Action 1.1)
- Investigate feeding and other habitat requirements (Action 1.2)
- Undertake targeted surveys (to identify habitat) (Action 2.4)
- Secure selected sites for conservation (Action 3.1)
- Address threats on grazing lands (Action 3.2)
- Monitor management effectiveness (Action 3.3)
- Determine suitability of birds in captivity for a reintroduction project (Action 4.1)

To inform the development of the black-throated finch (southern) Species Management Plan, and contribute to the detailed design and implementation of management and mitigation measures (including management of offset areas) recommended here, it is proposed that the following be undertaken, such that the habitat values for the subspecies are maintained, and where possible enhanced, in the local landscape; and the management of areas for biodiversity onsite (in the Mine Area) and in the Mine (Offsite) area (in offset areas) contributes to the recovery actions for the black-throated finch (southern). Key components of the Species Management Plan will be;

- The development and application of adaptive monitoring program to inform management. The concept of adaptive monitoring has four key elements: (i) the requirement to pose tractable (flexible and evolving) questions; (ii) the need to employ a statistical design at the outset; (iii) the use of a conceptual model of the ecosystem or entity being examined; and (iv) acknowledgment that land managers need to know about ecosystem change.
- Monitoring that addresses questions of spatial scale which will be important in designing effective management and mitigation actions, namely (i) are the finches sedentary in this

area, (ii) are the finches locally migratory or (iii) are the finches regionally migratory in the wider area (Figure 13). As such there are four components of the monitoring program that address these questions as well as providing contextual life history and ecology information that can be used to provide management and mitigation actions.

Figure 13 Model of the spatial relationships between the components of the monitoring program



- Regional distribution (species distribution modelling). The intent of this component of the monitoring program is to review all records in the region (Einasleigh Uplands and Desert Uplands) and refine a habitat and distribution model using a combination of expert opinion and temporal and spatial species distribution models.
- Regional distribution (surveys). The aim of this component of the monitoring program is to undertake systematic surveys in the adjacent Desert Uplands, Einasleigh Uplands and perhaps Northern Brigalow Belt regions in order to understand the regional distribution of the black-throated finch (southern).
- Local monitoring (observational) on the Mine Area. The aim of this component of the monitoring is to undertake repeated and systematic surveys of black-throated finch (southern) distribution and habitat at the Mine Area to collect more detailed data regarding (i) habitat preferences, local habitat use (i.e. hotspots), preferred habitat structure and vegetation composition, diet, nesting sites and reliance on mixed species flocks, (ii) temporal variation in habitat use, (iii) coarse population estimates and any spatial and temporal variation in numbers, and (iv) response to existing land management effects (i.e. grazing, fire, weeds, water array).

- Local monitoring (detailed) on the Mine Area. The aim of this component of the monitoring is to undertake detailed surveys of black-throated finch (southern) habitat use, home range sizes, fine scale distribution changes over seasons, the genetic status of the local population and physiological health of the black-throated finch (southern) populations over time and especially in times of resource bottlenecks.

Furthermore, with specific regard to providing offsets for the loss of black-throated finch (southern) habitat, the following should be considered:

- The Project Offset Strategy will be based on securing “like for like” habitat. The Project Offset Strategy will include enhancement of habitat, and mitigation of any habitat loss via the careful conservation management of offset areas (i.e. reduced or no grazing, control of exotic pasture grass species, control of feral predators such as cats and foxes via innovative means such as reduced dingo control, raised watering troughs). This would be integrated with proposed research programs, where the most effective means to rehabilitate or enhance black-throated finch (southern) habitat are tested and used in on-going management
- The Project Offset Strategy will integrate at a landscape scale and form part of a network of landscape linkages across the eastern Desert Uplands region and to other known locations for black-throated finch (southern) populations and habitat. Project offsets will be of secure conservation land tenure, and will include programs for long term management and monitoring. Innovative options should be considered such as possible management partnerships of offset land through public and/or private partnership arrangements with well-established conservation organisations such as BirdLife Australia, Australian Wildlife Conservancy or Bush Heritage.

Koala

Habitat loss is considered a major impact to the koala (DSEWPaC, 2012). The Project (Mine) Area occurs within Koala District C of the *Nature Conservation (Koala) Conservation Plan 2006* (Qld) and Management Program 2006—2016 EPA, 2006)). Little research has been conducted in this area and there is a lack of data relating to koala populations, habitats and the impacts of development (EPA, 2006). The management of impacts to the koala and loss of habitat as a result of Mine operations will seek to enhance species knowledge and conservation initiatives as per the National Koala Conservation and Management Strategy 2009-2014 (NRMMC, 2009) and future recovery plans for the koala. Mitigation strategies will be guided by actions detailed within the National Koala Conservation and Management Strategy 2009-2014 and will focus on developing and implementing an onsite and offsite habitat management and research program in collaboration with relevant stakeholders (i.e. Commonwealth and State governments, natural resource management groups and landholders). Species specific management and research items to be included in the Project Species Specific Management Plan (on and offsite) for the koala (under the overarching ecological management framework) may include:

- Onsite and offsite research of koala populations, densities and habitats as this is a relatively unknown area for this species. Data gathered will be incorporated into the Commonwealth and State database of koala population distribution, density and habitat mapping data.

- Development and implementation of ongoing monitoring programs of koala populations and habitats encompassing the Project (Mine) Area and surrounding region, to research impacts of development on low density populations.
- Onsite and offsite (offset areas) management of koala habitat in areas of preferred habitat types including ironbark-box grassy woodlands and fringing riparian vegetation communities. The aim is to improve the condition of habitats within and surrounding the Project (Mine) Area, reduce fragmentation, and encourage connectivity and dispersal.
- Monitoring of pest dog populations in the Project (Mine) Area and implementation of a control program if necessary.

Yakka skink

Key threats for the yakka skink include habitat loss and degradation, and predation and destruction of habitat by feral species (in particular cats and foxes) (DSEWPaC, 2011a). Additional field studies will be required to determine the presence of individuals and/or populations/colonies as the species was not detected during surveys, but is considered likely to occur. In the event the species is detected, a Species Specific Management Plan will be developed to manage the impacts of the Project (Mine). The findings of the additional studies would inform the management approaches detailed in the Species Specific Management Plan, however, measures will focus on maintaining or enhancing suitable habitats (i.e. in offset areas) and managing the prevalence of predators in the area. Species specific mitigation and management measures may include:

- Establishment of microhabitat features preferred by the species (e.g. rock piles, logs) in actively managed onsite and offsite (offset) areas that have suitable core habitat features to enhance the values of existing potential habitat
- Identification of the locations of suitable microhabitats existing in actively managed onsite and offsite (offset) areas for the purposes of maintaining the habitat values for the species
- Monitoring of fox and cat populations in the Project (Mine) Area and implementation of a control program if necessary
- Engaging a fauna spotter-catcher to check areas of suitable habitat identified through pre-clearance surveys immediately prior to ground disturbance. In the event individuals/colonies are detected, they will be relocated to suitable habitat in offset areas

Ornamental snake

Factors that are considered likely to contribute to the decline of ornamental snake populations include habitat loss as a result of clearing, habitat degradation as a result of grazing and fragmentation, alteration of landscape hydrology associated with gilgai environments, alteration of water quality, predation by feral species and contact with cane toads (DSEWPaC, 2011b). Additional targeted field studies will be required to determine the presence of individuals and/or populations/colonies as the species was not detected during EIS surveys. If detected, a Species Specific Management Plan will be developed to manage potential impacts. The findings of the studies will inform the management approaches in the Species Specific Management Plan, however, similar to the yakka skink, measures will focus of maintaining or enhancing suitable habitats and managing the prevalence of predators in the local area, namely within offset areas. Species specific mitigation and management measures may include:

- Identification of the locations of suitable microhabitats existing in actively managed onsite and offsite (offset) areas for the purposes of maintaining the habitat values for the species throughout operation of the mine and providing potential areas for relocation, if individuals are found during pre-disturbance checks of mined areas
- Implementation of a sediment and erosion controls during operation of the mine
- Engaging a fauna spotter-catcher to check areas of suitable habitat identified through pre-clearance surveys immediately prior to ground disturbance. In the event individuals/colonies are detected, they will be relocated to suitable habitat in offset areas
- Monitoring of feral species populations in the Project (Mine) Area and implementation of a control program if necessary
- Monitoring of gilgai areas within the Project (Mine) Area and changes that may occur as a result of hydrological changes
- Implementation of a water quality monitoring program to assist in guiding erosion and sediment control during the operation of the mine

Migratory birds and NC Act listed black-necked stork and cotton pygmy-goose

For this Project, the management of impacts to the species will focus on maintenance and management of habitat for the species locally and regionally through the overarching ecological management strategy. Measures relating to management of impacts to migratory and other protected bird species include:

- Management of the water supply and raw water dams created during the operation of the mine such that migratory birds can utilise these habitats. If required, compensatory water resources will be provided in nearby parts of the Project (Mine) Area
- Weed and pest animal monitoring and management within the Project (Mine) Area
- Monitoring of species populations during breeding months to gain an understanding of the species' use of the area on a local scale. Further mitigation and management measures can be developed if important breeding activities are recorded

Little pied bat and echidna

The overarching ecological management strategy will provide opportunity for enhancement of suitable habitats for these species. Specific to the little pied bat, monitoring and management of the Carmichael River corridor will allow for adaptive management of the corridor that provides resources and facilitates dispersal of the species. Management will also include maintenance and enhancement of mature woodland areas occurring in actively managed onsite and offsite (offset) areas in order to provide ongoing habitat suitability.

4.4.4 Summary

With the exception of the black-throated finch (southern) (discussed below), the Project (Mine) Area is not considered to support an 'important population' or 'habitat critical to the survival' (as defined in the Significant Impact Guidelines (DEWHA, 2009c) of any EPBC Act listed threatened fauna species (i.e. squatter pigeon (southern) (recorded at Project (Mine) Area), koala (recorded at Project (Mine) Area), ornamental snake (likely to occur at Project (Mine) Area), yakka skink (likely to occur at Project (Mine) Area), red goshawk (may occur at Project (Mine) Area),

Australian Painted Snipe (may occur at Project (Mine) Area)). Thus, habitat loss resultant from vegetation clearing is not considered to constitute a 'significant impact' to these species. As for general fauna, where unavoidable impacts (i.e. habitat loss) cannot be satisfactorily managed/mitigated onsite, offsets will be provided in accordance with Commonwealth and State policies. Further studies at and near the Project (Mine) Area will assist in informing the implementation of the offsets strategy with respect to threatened species.

The Project (Mine) Area is not considered to support 'important habitat' (as defined in the Significant Impact Guidelines (DEWHA, 2009c)) for EPBC Act listed migratory species, and thus, vegetation clearing (and associated habitat loss) is not considered to constitute a 'significant impact' to these birds.

Impacts to the NC Act listed near threatened little pied bat, black-necked stork, cotton pygmy-goose, and special least concern echidna and koala are proposed to be managed to the greatest extent possible via the mechanisms outlined above, and offset where unavoidable impacts occur. In consideration of the proposed management and offsetting strategy proposed, it is not anticipated that localised, staged habitat loss will adversely impact upon the conservation status of these widely distributed species.

4.5 Vegetation clearing – terrestrial fauna mortality

4.5.1 Overview

Progressive clearing of vegetation for the Mine operational phase has the potential to cause direct injury or mortality of wildlife, where animals are physically struck by clearing machinery or falling vegetation.

4.5.2 Potential impacts

Vegetation clearing may result in the direct mortality of fauna. The scale of operational impacts as compared with those likely to occur during the construction phase is relatively greater, given the extent of the activities that will occur during the operational phase.

Vehicles and machinery used to undertake land clearing have the potential to lead to direct mortality of fauna in the event that individuals are struck. Those animals that are unable to disperse away from areas under active clearing are also susceptible to injury or death. This includes amphibians, reptiles, small ground-dwelling mammals, arboreal mammals and nocturnal species that are inactive during daylight hours. Other potential causes of mortality include animals becoming trapped in excavations, and carrion eaters (some raptors) being struck when feeding on road kill.

Fauna mortality will result in a local reduction in the abundance of some less mobile species. The habitat types that will be affected by operational phase activities, including those that will be cleared, support an array of common, widespread species, as well as potentially providing resources for a small number of conservation significant species. Given the landscape context in which the Project (Mine) occurs, and in particular, the availability of similar habitat types in the local region, this loss is not considered likely to adversely affect the biodiversity values of this landscape. The management and mitigation measures outlined below seek to reduce fauna mortality to the greatest extent possible. Furthermore, the management and mitigation measures proposed to address habitat loss, including management of habitats onsite and offsite for local biodiversity, will seek to alleviate potential impacts to animals dispersing away from

clearing areas. In particular, enhancement of these areas (through identification and removal of threatening processes and provision of habitat resources) will seek to improve the quality and function of these habitats, such that they can act as a temporary or permanent sink for animals displaced from cleared areas.

4.5.3 Management and mitigation

Management and mitigation measures to reduce the potential for fauna mortality as a result of operational phase activities include:

- Vegetation clearing for discrete phases of the Project (Mine) operations will be undertaken in a manner that maximises the potential for fauna to disperse away from habitats within the clearing footprint to adjacent areas, including onsite and offsite (offset) areas that are being actively managed for biodiversity outcomes. For example, prior to clearing, any opportunities to reduce the relative quality of habitats in a discrete clearing footprint whilst simultaneously enhancing the values of nearby habitats which may act as a sink for dispersing animals, should be realised. Such management may include gradually reducing the availability of surface water in the clearing footprint whilst simultaneously providing more of this resource in other areas. The management of cattle (i.e. stocking rates) may also be considered for this purpose. Vegetation clearing within the clearing footprint will be undertaken sequentially, in a manner that encourages animals to disperse towards adjacent habitats that will remain intact. To facilitate this further, corridors between proposed clearing areas and habitats that will be managed for biodiversity will be maintained and enhanced, or where they do not occur, will be provided through targeted revegetation actions. The implementation of this approach will need to be underpinned by onsite research, with its efficacy to be monitored and adaptively managed such that the overall objective of no-net-loss of regional biodiversity values is achieved
- Pre-clearance surveys will be undertaken in areas identified as potential habitat for threatened species, prior to commencement of clearing. In areas where these surveys indicate the presence of habitat features observed to (or with the potential to) provide habitat for these species, a fauna spotter-catcher will be engaged to accompany clearing crews. Pre-demarcated habitat features identified during the pre-clearance survey will be thoroughly checked by fauna spotter-catcher prior to clearing. Provision for the relocation of fauna will be made prior to the commencement of clearing
- Procedures in the event that an animal is injured will be developed. Given the distance to the nearest veterinary practitioner, this may involve euthanasia. Adani will engage a suitably-qualified and licensed practitioner to be present on site to assess, treat and where necessary, euthanize injured animals
- Vehicles will be required to stay on pre-determined routes
- All vehicles and plant will adhere to site rules relating to speed limits. Speed limits will be clearly signposted so as to minimise the potential for road kill
- Any road kill will be taken to the edge of the road immediately and subsequently removed as quickly as practicable to reduce potential for scavengers to be struck
- Work areas will be checked for fauna that may have become trapped before work commences each day

- In instances where an animal/animals have entered active construction areas, the site environmental manager will be immediately informed. An assessment of whether the animal is at risk of harm and/or poses a threat to construction personnel will be made by the environmental manager (or their delegate). Where possible, the animal will be encouraged to disperse out of/away from the construction area. Where the animal is not able to disperse away, a professional fauna spotter-catcher will be engaged
- If any pits/trenches are to remain open after daily site works have been completed, they will be securely covered or fenced, if possible, or fauna ramps (e.g. earth ramps) will be put in place to provide a potential means of escape for trapped fauna
- Site inductions are to include education regarding the local fauna of the site and protocols to be undertaken if fauna are encountered

4.5.4 Summary

Fauna mortality will occur during the operational phase; however, given the habitat types that will be affected and their availability in the surrounding landscape, this localised loss of animals is not considered to represent an adverse impact to the region's biodiversity values. Direct mortality of fauna, and in particular conservation significant species, during the operational phase of the Project (Mine) will be reduced by implementing the protocols outlined above.

4.6 Habitat fragmentation

4.6.1 Overview

Clearance of vegetation and the presence of mining infrastructure during the Mine operation phase have the potential to fragment wildlife habitats and restrict the level of fauna movement between remnant patches. Fragmentation of native habitats can have adverse impacts on native fauna by stranding wildlife within isolated remnants of habitat and restricting their access to resources.

4.6.2 Potential impacts

Given the approximately north-south orientation of the mine, and the length of the proposed footprint (approximately 45 km), the proposed mining activity has the potential to disrupt east-west flora and fauna movement in the landscape.

Large tracts of non-remnant vegetation occur over much of the central part of the Project (Mine) Area between the Carmichael River and the Moray Carmichael Road, and much of the eastern part of the Project (Mine) Area (where the MIA, Mine (Offsite) Area, some out of pit waste dumps and some water management dams are to be located). This cleared land extends beyond the Project (Mine) Area – much of the landscape to the east of the Project (Mine) Area is cleared land, featuring non-remnant vegetation. As such, the potential for east-west dispersal across the landscape through much of the central part of the Project (Mine) Area, notwithstanding the narrow strip along the Carmichael River, is limited by the presence of large tracts of non-remnant vegetation within and to the east of the Project (Mine) Area.

A wildlifecorridor, associated with tracts of remnant vegetation within and to the north east and west of the Project (Mine) Area may be fragmented by staged mining operations at the northern part of the Project (Mine) Area. Similarly, proposed mining operations in the southern part of the Project (Mine) Area will disrupt a belt of remnant vegetation that extends from west of the

Project (Mine) Area, through the Project (Mine) Area (at the Bygana West Nature Refuge) to the east towards the floodplain of the Belyando River.

Staged mining will also disrupt north-south movement through the Project (Mine) Area. Remnant vegetation coverage is extensive in the landscape to the west, northwest and south west of the Project (Mine) Area, and so, north-south habitat fragmentation resultant from Mine operations will be less disruptive to landscape scale flora and fauna movement, as compared with east-west movement.

The barrier that will be created by operation activities associated with the mine has the potential to limit the ability of flora and fauna to disperse across the landscape. This is particularly applicable to habitats at the north and south of the Project (Mine) Area, that retain some degree of connectivity to larger tracts of vegetation to the east and west in the adjacent landscape, as well as the narrow east-west strip of vegetation associated with the Carmichael River. Opportunities to alleviate the fragmentation caused by the mine will be realised through targeted onsite habitat management and the identification, procurement and management of offsite (offset) areas. The identification and management of these areas will seek to maintain and enhance local biodiversity values and will consider the function of these areas in the local landscape including how they contribute to connectivity.

4.6.3 Management and mitigation

Management and mitigation measures to reduce the impact of habitat fragmentation to local fauna populations include:

- The ecological values within the buffer area surrounding the Carmichael River are to be enhanced through a revegetation and active vegetation and habitat management program. The program will focus on providing east-west connectivity. A monitoring program will be implemented to monitor success of the revegetation and enhancement program as well as presence of and utilisation by fauna. Results of monitoring of the revegetation program may be relevant to rehabilitation and also management of offset areas on adjacent properties
- Management of land within the Project (Mine) Area (in consideration of the Project's staged operations, and including areas that are not within the mine footprint, unmined areas that will be mined at a later stage of operations, areas above the underground mine and rehabilitated areas) will be undertaken so as to maximise opportunities for localised flora and fauna dispersal in the Project (Mine) Area. This will include the management and enhancement of existing areas that provide connectivity (where these do not occur within the mine footprint) within and beyond the Project (Mine) Area, as well as the creation of corridors between habitats where this is possible
- The identification of offsets should take into consideration how these areas will contribute to landscape scale habitat function (including east-west connectivity). Given that east-west connectivity will be disrupted at the south of the Project (Mine) Area and is likely to be disrupted at the north of the Project (Mine) Area, the strategic procurement and subsequent management of offsets in the landscape adjacent to these parts of the Project (Mine) Area may alleviate the barrier effect caused by mining operations. This will be achieved through managing and where possible enhancing these areas such that they provide a conduit for fauna movement 'around' the northern and southern parts of the Project (Mine) Area, thereby allowing for east-west movement in the localities to be

maintained. Whilst the connectivity between habitats adjacent to the northern and southern parts of the mine will be more circuitous (less direct) than it is currently, enhancement of habitats (such as provision of habitat resources, management of/removal of threatening processes) in strategically procured offset in these areas should contribute to the maintenance of east-west movement in these specific localities

- Where fencing is required around cleared areas or along the mine boundary, it will be designed to provide access to fauna around and/ or through the fencing, except where fenced areas seek to protect fauna from threats such as actively mined areas. Barbed wire should not be used on the top strand of wire fences unless necessary for security or to control cattle
- Post-disturbance rehabilitation should seek to identify and create conduits for movement within and beyond the Project (Mine) Area. These corridors should link to existing areas that are likely to facilitate flora and fauna dispersal in the landscape

4.6.4 Summary

Mine operations may reduce the ability for fauna to disperse across the landscape. This is more likely in the northern and southern parts of the Mine Area where potential north-east-to-west/east-to-west fauna movement is likely to occur through the Mine Area. Offset identification will take into consideration procurement of areas near the north and south of the Mine Area, that can be managed for, amongst other things, providing a conduit for east-west movement around the Mine Area.

4.7 Terrestrial habitat degradation

4.7.1 Overview

The staged clearing of native vegetation throughout the Mine's operational life may result in the degradation of adjacent and downstream habitats. The potential impacts of habitat degradation, with respect to the Project's construction phase, are discussed in Section 3.6. Given the larger extent of land to be cleared as a result of mining operations, the spatial extent of potential degradation in the operational phase is also larger.

4.7.2 Potential impacts

The staged clearing of native vegetation throughout the Mine's operational life may result in the degradation of adjacent and downstream habitats. The potential impacts of habitat degradation, with respect to the Project's construction phase, are discussed in Section 3.6. Given the larger extent of land to be cleared as a result of mining operations, the spatial extent of potential degradation is relatively larger.

Edge effects may occur where remnant vegetation is exposed to a distinct ecotone associated with areas under active mining operations (or early stages of rehabilitation post-mining). Such effects may include increased exposure to noise, light, dust, wind, weeds and introduced animals. Exposure to any or some of these effects may alter habitat composition (i.e. reduced flora diversity and simplified flora structure) and quality (i.e. reduced availability of forage resources, increased exposure to predators) at the ecotone, thereby potentially changing species diversity in the altered habitat. Where edge effects degrade or simplify habitat at the

edge, it is possible the species diversity and habitat utilisation in this edge habitat will be reduced.

Earthworks will result in dust emissions. Excessive dust settling on vegetation could also suppress vegetation growth by limiting the photosynthesis potential of plants in close proximity to the area (Nanos and Ilias, 2007). Plants with dust on leaves may also be less palatable as a food source for animals. Dust deposition associated with earthworks activities will generally occur relatively close to areas of disturbance and hence, plants within 50 – 100 m of construction activities may be affected by dust. As construction activities are temporary, effects will be short lived, and rainfall will generally remove dust from plants. Dust suppression will be used to control dust and this will reduce the extent of vegetation affected by dust. Dust emissions from vehicles and plant travelling on unsealed roads will have localised impacts on vegetation and water bodies near these transport routes. Dust suppression techniques will be used to control dust on these roads.

Following extraction, coal will be processed and stockpiled in preparation for transport to port. Dust deposition may affect the physiology of plants as a result of increasing leaf temperatures and reducing photosynthesis (referenced in Chaston and Doley, 2006). Coal dust and overburden dust were found to affect plant functioning (leaf temperature) in an experimental situation where high dust loads were applied (Chaston and Doley, 2006). The experiment also indicated that the type of dust is related to impacts on leaf function, with fine dusts having impacts at much lower loads than dusts associated with mining activities where high dust loads are needed to cause an impact (Chaston and Doley, 2006). The authors concluded that dusts associated with mining activities will potentially impact plant physiology in instances where high dust loads may be deposited – typically within the immediate vicinity of the dust source (i.e. coal stockpile, overburden stockpile) (Chaston and Doley, 2006).

Impacts to habitats adjacent to and downstream of clearing areas will be managed such that habitat degradation is limited in its extent and magnitude. This will largely be undertaken in accordance with management and monitoring protocols established in the Project Environmental Management Plan.

4.7.3 Management and mitigation

The management and mitigation measures described for habitat degradation due to land clearing in the construction phase of the Project (i.e. construction of the MIA, airport and workers accommodation village) are largely applicable to land clearing and resultant habitat loss in the operational phase of the Project (Mine), and include:

- Management of erosion and sedimentation in and adjacent to cleared areas will be undertaken in accordance with protocols outlined in the Project Environmental Management Plan. This plan will include practices to be implemented prior to, during, and post-construction to minimise the potential for erosion to occur, including (but not limited to) timing of land clearing activities, sediment and erosion control measures to be implemented, performance criteria and corrective actions. Monitoring and reporting protocols will be detailed within this plan, and responsible parties for implementing the plan's actions will be identified
- Where land clearing occurs near or within ephemeral waterways, this will be primarily undertaken during low flow periods, to minimise the likelihood of erosion and sediment mobilisation during and after rainfall events

- A fundamental component of the management of onsite and offsite (offset) areas that are to be managed for biodiversity will relate to reducing exposure to, and minimising the impacts of habitat degradation including edge effects. This will be undertaken through implementation of weed and pest animal management, erosion management and dust management. These measures are included in the Project Environmental Management Plan. Further to this, consideration should be given to the creation of vegetated buffers around any critical habitat areas that are retained, where these areas occur directly adjacent to impact footprints. These buffers could comprise relatively fast growing trees of local provenance that could be strategically planted to provide a buffer between impact areas and managed habitat. Provisions for fauna movement through these buffers (i.e. from impact footprints, to adjacent habitat areas) would need to be factored into their design.

4.7.4 Summary

Vegetation clearing and other operation phase activities (i.e. vehicle movements on unsealed roads) have the potential to result in habitat degradation of adjacent and downstream habitats. Actions seeking to manage these potential indirect impacts will be implemented. Standardised monitoring and auditing of the application and performance of management and mitigation strategies is proposed to be undertaken, with corrective actions implemented where required.

4.8 Loss of habitat for aquatic species

4.8.1 Overview

Aquatic habitats within the Mine and Mine (Offsite) Areas that will be excavated, in-filled or impacted by subsidence include gilgai areas, permanent farm dams and a minimum of 9 ephemeral watercourses (streams orders 1 and 2 and drainage lines) (Figure 14).

Three areas within the Mine Area are mapped as GBR WPAs under State Planning Policy 4/11: Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments (Figure 15).

The mine plan incorporates a number of water management dams that will be created for water storage and collection and treatment of runoff from mining operational areas and these will potentially replace aquatic habitat loss from the farm dams (dependant on the habitat values that are established).

4.8.2 Potential impacts

The majority of the watercourses within the footprint are ephemeral and many facilitate flow during heavy downpour or flooding events only, channelling runoff to the Carmichael River or Belyando River via Eight Mile Creek. Ephemeral habitat with intermittent base flow that is often reduced to unconnected waterholes is characteristic of the Burdekin Catchment (Negus et al., 2008); hence the habitat within the Mine and Mine (Offsite) Area is considered characteristic and well represented on a regional scale. The removal of the habitat described at the site will reduce the availability of aquatic habitat on a local scale however; the loss of these habitats is not expected to have an impact to the aquatic biodiversity of the region as:

- The types of habitat are well represented within the Burdekin Catchment

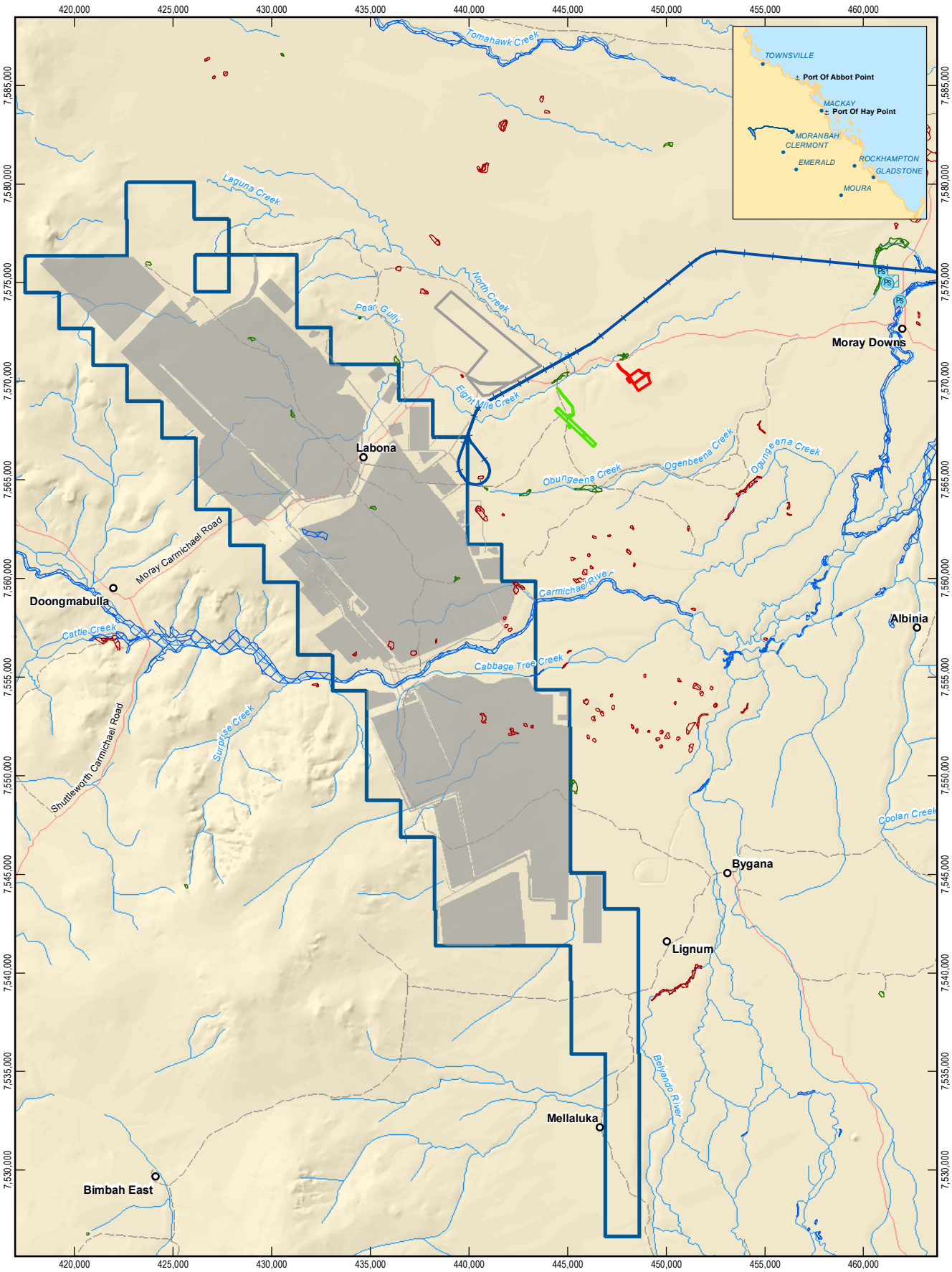
- Much of the habitat is farm dams or ephemeral waterways that do not contribute to regional re-colonisation or connect permanent aquatic habitats
- Studies show that aquatic habitats in the study area support low to moderate diversity and do not support any aquatic species of conservation significance

The removal of the ephemeral watercourse reaches will occur gradually throughout the entire mine operation (over 60 years). The majority of the watercourses are 1st or 2nd order streams draining to the Carmichael River.

Many of the farm dams exhibit cattle and pig disturbance, have a silt and clay substrate with limited benthic microhabitat and have limited connectivity to watercourses that would facilitate aquatic species recruitment. Infilling or excavation of those dams will have a localised impact to native aquatic flora and fauna diversity and no impact on a regional scale. The water management dams to be (progressively) created during the mining operation have the potential to provide aquatic habitats provided that water quality is appropriately managed. These artificial water bodies have the potential to provide similar habitat values as the existing farm dams.

The GBR WPAs are often dry for years and may only be wet for a short period (i.e. ephemerally). This makes their identification difficult. The local 10 year Average Recurrence Interval (ARI) flood model indicates a 10 percent chance of flooding to the north of the Carmichael River every year, with 0.08 – 1.00 m of water inundating each GBR WPAs. One of the GBR WPAs covers a mapped 1st order tributary of the Carmichael River, which may suggest that this GBR WPA will frequently be inundated. The 100 year ARI flood event modelling suggests that the GBR WPAs are inundated with 1 – 2 m of water during these events. The inundation of the GBR WPAs during 10 and 100 year ARI storm events suggest that they may be wetlands.

The GBR WPAs within the Mine Area are wetlands and they fit the Queensland wetland classified of a semi-arid grass, sedge and herb swamp. Semi-arid swamps are mostly situated in alluvial plains and typically subject to temporary inundation. They may be inundated annually or less regularly; some may be inundated once every three years at most. GBR WPA 1 will be impacted by the creation of the Central MAW Dam North and GBR WPA 2 and 3 are within the area designated as Pit E.



LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- Wetland Waterbody: Lacustine, Palustrine, Riverine
- Project (Rail)
- Mine (Onsite)
- Mine Layout
- Mine (Offsite): Pump Station, Storage Facility (Offstream)
- Airport
- Industrial Area
- Accommodation Village

1:275,000 (at A4)
0 1 2 3 4 5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Waterbodies within the Project (Mine) Area

Job Number 41-26422
Revision B
Date 24-10-2013

Figure 14

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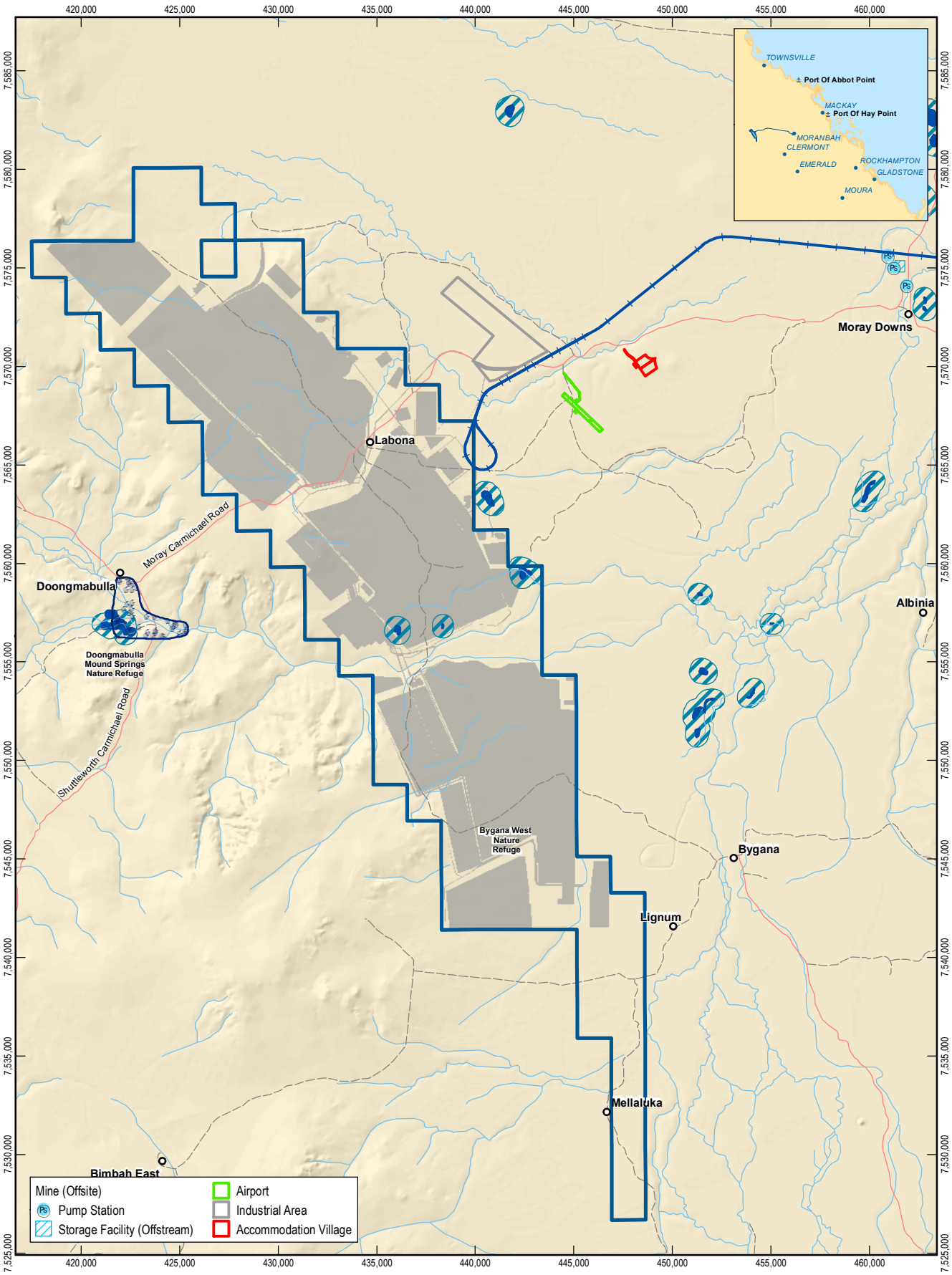
Data Source: DNRM: Wetlands (2012); © Copyright Commonwealth of Australia - Geoscience Australia: Road, Homestead, Watercourse (2007);
Adani: Mine (Onsite) (2013); Mine Footprint (2013); Project Rail (2013); Gassman/Hyder: Mine (Offsite) (2012). Created by: ES



LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- Great Barrier Reef Wetland Protection Area
- Great Barrier Reef Wetland Protection Trigger Area
- Directory of Important Wetlands
- Project (Rail)
- Project (Mine)
- Mine Footprint

1:275,000 (at A4)
0 1 2 3 4 5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project SEIS

Great Barrier Reef
Wetland Protection Areas

Job Number 41-26422
Revision B
Date 24-10-2013

Figure 15

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

Data Source: DNRM: DOI Wetland (2007), GBR Wetland Protection Areas (2009), Nature Refuges (2010)© Copyright Commonwealth of Australia - Geoscience Australia: Road, Homestead, Watercourse (2007); Adani: Project Rail 1 (Opt11 Rev2) & 2 (Opt9 Rev3), Facilities (2013); DME: EPC1690 (2010), EPC1080 (2011). Created by: BW,MS

4.8.3 Management and mitigation

The removal of the aquatic habitats of the farm dams and ephemeral, low stream order, watercourses within the Mine Area is unavoidable. Although these habitats are not considered to be high value, many provide habitat for native aquatic species. In recognition of the staged approach to the mining it will be important to maintain the ecological values of watercourses in undisturbed states until scheduled for disturbance in order to limit indirect impacts to downstream habitats.

Detailed design of the Central MAW Dam North will take into account the location of GBR WPA 1. Any loss of the GBR WPAs will require an offset. It is suggested that the wetlands contained on the Moray Downs property be rehabilitated to offset the GBR WPAs. A number of wetlands that are scored as very low and medium by the Aquatic Conservation Assessment are contained on the Moray Downs property.

The enhancement of aquatic habitats created will be undertaken in accordance with a Rehabilitation Management Plan. The Rehabilitation Management Plan will incorporate measures relevant to the protection of downstream aquatic habitats as described above and measures to enhance aquatic habitats that may be created throughout the mining operation including:

- Establishing riparian zones with suitable native species adjacent to new flow paths created within and around the mined open cut pits and overburden stockpiles.
- Establishing aquatic habitat structure in areas that may provide temporary or permanent aquatic habitats, for example in permanent topographical voids remaining at mined open cut pits or other depressions. This may include woody debris or other suitable structure that will promote establishment of aquatic flora and fauna.
- Identifying and implementing enhancement opportunities in undisturbed areas or waterbodies that may form as a result of subsidence.

A 500 m wide strip on each bank of the Carmichael River will not be cleared of vegetation for operation of the Project (Mine) which will assist in protecting the riparian ecosystem from direct impacts of mining operations. Management of the crossing will be required to limit the potential impact of this infrastructure on the aquatic ecosystems of the river at the crossing location and downstream. Measures to minimise the impact of the crossing of the Carmichael River include engineering solutions and management actions:

- 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. Spanning the watercourse will avoid the removal of aquatic habitat, avoid installation of a barrier to movement by aquatic fauna and avoid alteration of hydrological flows locally.
- Design of the bridge crossing will consider fish passage requirements. Although the crossing will not be physically within the watercourse bed or banks, other non-physical factors can influence fish movement such as light availability.

. Operational rules will be developed with the purpose of maintaining watercourse flows during flood harvesting on Belyando River, to maintain the physical connectivity of aquatic habitats between upstream and downstream catchment areas.

4.8.4 Summary

During operations on the Mine and Mine (Offsite) Areas aquatic habitats will be excavated or in-filled. The GBR WPAs within the Mine Area will be impacted by the Mine operations and GBR WPA 1 will be impacted by the creation of the Central MAW Dam North and GBR WPAs 2 and 3 are within the area designated as Pit E.

Detailed design of the Central MAW Dam North will take into account the location of GBR WPA 1. Any loss of the GBR WPAs will require an offset. It is suggested that the wetlands contained on the Moray Downs property be rehabilitated to offset the GBR WPAs. A number of wetlands that are scored as very low and medium by the Aquatic Conservation Assessment are contained on the Moray Downs property.

The mine plan incorporates a number of water management dams that will be created for water storage and collection and treatment of runoff from mining operational areas and these will potentially replace aquatic habitat loss from the farm dams (dependant on the habitat values that are established).

4.9 Aquatic fauna mortality

4.9.1 Overview

Mortality or injury to resident native aquatic fauna can potentially occur when construction activities are undertaken for the open cut mining within or adjacent to a water body. This usually arises as a result of vehicle/machinery strike or strike from falling vegetation or woody debris, but also as a result of fish and other aquatic fauna being stranded when the water is drained from waterways or dams. Fish, turtles and crustaceans were detected in aquatic habitats in the Mine and Mine (Offsite) Areas during surveys, and these species are likely to occur in Cabbage Tree Creek and Carmichael River. Consequently, there are likely to be aquatic species that are at risk of mortality or injury.

4.9.2 Potential impacts

As described in Section 3.8 mortality or injury to aquatic fauna has the potential to occur when activities are undertaken within or adjacent to a water body. There will be a number of farm dams and drainage lines that will be removed during the operation of the mine. Each of the dams has the potential to contain native fish, crustaceans and turtles, all of which are protected under the NC Act and destruction of native species is prohibited without approval.

Pumping of water from Belyando River may result in the entrainment of aquatic fauna species resulting in injury or death. Preventing entrainment at the point of water extraction presents the most suitable method of mitigating the effects of pumping systems on aquatic fauna. This approach will manage and maintain the water levels to this critical level. However, beyond this dams may also naturally dry during periods of drought.

4.9.3 Management and mitigation

For the dam habitats, the required mitigation and management is consistent with that outlined for the construction phase in Section 3.8, including the relocation and salvage of fauna that may be required.

The management of potential fauna mortality as a result of offsite water supply infrastructure operation will include:

- Screen pump intakes with mesh to protect aquatic life
- Develop operational procedures for flood harvesting

4.9.4 Summary

Aquatic fauna mortality will occur during the operational phase; however, given the habitat types that will be affected and their availability in the surrounding landscape, this localised loss of aquatic fauna is not considered to represent an adverse impact to the region's biodiversity values. Direct mortality of aquatic fauna during the operation phase of the Project (Mine) is expected to be reduced by implementing the mitigation measures outlined above.

4.10 Degradation of water quality and aquatic habitats

4.10.1 Overview

Vegetation will be extensively cleared to facilitate the open cut mining pits and also to provide overburden disposal areas when required. The requirement for the clearing follows the progression of the coal extraction, that is, land will be cleared for the open cut pits and overburden storage areas when they become active throughout the life of the mining operation.

Water quality and aquatic habitats can potentially be impacted by increased runoff and altered flows resulting from the presence of built and mine infrastructure and mine development within the Mine Area. Increased surface area associated with infrastructure has the potential to increase levels of runoff and linear infrastructure may alter flow with adverse effects for aquatic habitats.

Increased vehicle movements and activities have the potential to increase dust emissions and sedimentation and the use of hardened surfaces (i.e. bitumen or concrete surfaces) have the capacity to increase stormwater run-off and erosion. These factors have the capacity to result in the localised degradation of habitats adjacent to the Project (Mine).

The source of most suspended particulates (and in turn increase in turbidity), nutrients and other contaminants attached to particulates in waterways is mobilisation of soils through surface runoff, stream bank erosion and dust.

4.10.2 Potential impacts

Run-off and sedimentation impacts

Stormwater run-off and sedimentation typically increases in areas adjacent to man-made infrastructure where hardened surfaces (i.e. bitumen, steel and concrete) encourage run-off and afford no potential for natural permeation of rainwater into underlying substrates. There is a combined hard surface area of 1,475 ha in the Mine and Mine (Offsite) Areas for ANFO, Mine infrastructure areas, haul roads, accommodation camp, industrial precinct and airport. These areas will accumulate increased levels of local stormwater run-off. This has the potential to cause localised sedimentation and erosion and impact on water quality (See Section 3.9).

Mine water management works include the development of diversion channels and flood levees to ensure clean water from off the Project (Mine) site does not impact on mining operations, the

management of water from mining operations and the supply of raw water to the mining operations.

Acid mine drainage impacts

Acid mine drainage (AMD) can arise in coal seams where there is a high sulphur content. If this is the case, coal seams, when exposed to air and water can produce sulphuric acid (NSW Department of Planning, 2005). Acidic runoff into a watercourse is likely to have adverse impacts to surface water quality and in turn aquatic habitat suitability. The potential for acid mine drainage and management measures proposed is discussed in SEIS Volume 4 Appendix O1 Mine Waste Characterisation.

Water treatment within the mining operation will consider the potential for AMD and will be designed such that discharge from the footprint of the mine and into any watercourses achieves the required WQOs for the Project (Mine). WQOs will be developed for the Project (Mine) Area, including for all water to be released into the waterways of the area (refer to Volume 4, Appendix K3 Water Quality Report for further detail on WQOs).

Sediment and mine affected water

Drainage runoff from the mine site will be considered as sediment affected water (SAW) or mine affected water (MAW), depending on the location. Site drainage will compromise primarily of longitudinal 'v-shaped' drains channelling runoff into sediment ponds located onsite. Sediment ponds will be left to evaporate or alternatively, pumped to MAW storages where required. Runoff from site is to be classified as MAW and will be pumped to the MAW storages for reuse.

A MAW central and south dam will be located adjacent to the Carmichael River. Water will be treated if necessary and released under controlled events. No MAW is to be discharged into the sediment dams, however MAW can be used in the process water dam.

Spillways shall be designed to cater for an appropriate design event of the contributing catchment at the sediment dams. All spillway discharge will be diverted along a drain separate to the clean water system and discharged from site.

Scour protection will be provided for spillways and will be designed in accordance with QUDM / Austroads Waterways Design – A Guide to the new Hydraulic Design of Bridges, Culverts and Floodways, where appropriate.

Dust impacts

Increases in dust emissions are anticipated in response to the increase in vehicle movements along Carmichael Road and maintenance tracks and within the vicinity of rail sidings. Dust pollution can result in significant localised impacts on flora and fauna. By settling on vegetation, dust can suppress vegetation growth by limiting the plants' photosynthetic potential (Nanos and Ilias, 2007). Dust deposition is generally localised, only extending up to 100 m from unsealed road verges. The increased volumes of vehicular traffic during the Project's operational phase could exacerbate this existing dust impact. Mitigation is required to protect the integrity of habitats from dust deposition where possible.

Dust can settle within the waterways or in the terrestrial environments, where runoff can mobilise settled dust to waterways. Indirect deposition in waterways can occur when dust settles in the terrestrial environment. During precipitation events, the associated runoff transports dust from the terrestrial environment into nearby waterways. Dust generated during the construction

phase, has the potential to have a negative impact on the water quality of Eight Mile Creek and Pear Gully.

4.10.3 Management and mitigation

The disturbance of land within the operational footprint is unavoidable. Protection of the aquatic ecosystems downstream of the Mine Area is highly dependent on the management of the water quality of runoff and releases from the site.

To limit the degradation of downstream aquatic habitat during operation, mitigation and management will focus on reducing the potential mobilisation of sediments or pollutants, diversion of stormwater flows from disturbed areas and limiting sediment transport from exposed areas.

Measures to mitigate impacts of dust, sedimentation and erosion have been incorporated into the Mine and Offsite Environmental Management Plans, including erosion and sediment control requirements to be implemented and monitored throughout the operational phase of the Project. Key measures include:

- Ongoing monitoring of dust emissions at designated dust monitoring stations at key locations within the Study Area
- Dust suppression activities will be undertaken where appropriate and managed in accordance with the recommendations outlined in the Mine Air Quality Report (refer Volume 4, Appendix L)
- Incorporation of porous surfaces (i.e. gravel, steel lattices) that allow natural permeation of rainwater and reduce run-off
- Ongoing monitoring of erosion and sedimentation throughout the Project (Mine) Area, particularly before and after significant rainfall events
- Diversion of clean stormwater around disturbed areas, with scour protection as required to address any associated modifications in drainage paths
- Sediment fences and other sediment control devices will be installed and maintained adjacent to watercourses and key stormwater flow paths

Runoff within the mine footprint will be managed via a number of management and engineering solutions including:

- Development and maintenance of clean water diversion drains to be established along the western boundary of the lease, and separating clean inflows from dirty water areas
- Management of clean water through sediment basins/traps prior to discharge
- Management of dirty water from operations through capture in sediment ponds for reuse
- Overflows of water from sediment ponds to nearest drainage line only to occur in accordance with environmental authority conditions (refer Volume 4, Appendix K3 Water Quality Report)
- Sewage waste will be treated to Class A standard and preferentially recycled onsite.
- Contaminants that have the potential to cause environmental harm will not be released to the environment except under environmental authority conditions. Waters to be released to the environment must comply with the contaminant release limits which will be

identified in a Receiving Environment Monitoring Program (refer to Volume 4, Appendix K3 Water Quality Report)

- Identifying and implementing enhancement opportunities in newly created aquatic habitats that may arise as a result of subsidence

MAW has higher electrical conductivity than the receiving environment. The proposed strategy for controlled discharges is to release MAW on high flow events in the receiving environment such that a high level of dilution can be provided instantaneously (see Volume 4, Appendix K3 Water Quality Report). An analysis of flow volumes in the Carmichael River and Belyando River indicates that both rivers have sufficient high flow events to provide a level of dilution equivalent to that required in environmental authority conditions for the Alpha Coal Project (Alpha 2012)) (also within the greater Burdekin River Catchment).

As the mining operation, and hence habitat removal, will be staged, management and mitigation actions will correspond with activities of the time in order to protect areas not yet disturbed and the downstream catchment habitats. The Mine EMP takes into account the progression of the disturbance and identifies areas to be managed in terms of erosion and sediment control and at what stage the required management must be applied. These measures focus on limiting sediment transport, risk of erosion and pollutants and are consistent with those identified in Section 3.9.

Aquatic ecosystem monitoring will be incorporated into the receiving environment monitoring program (REMP). The REMP will set out monitoring requirements, water quality targets, ecological indicators, corrective actions and reporting requirements.

Scour and erosion can be managed through design treatments (for example, bank stabilisation) and ongoing management controls such as those that incorporated into the EMPs.

4.10.4 Summary

While increased activity associated with the Project's operation phase has the potential to cause local degradation of habitat through dust emissions, runoff and sedimentation, the environments adjacent to the Project (Mine) are in most cases, already disturbed to some extent and subject to periods of dust and sedimentation. These potential impacts will be monitored as part of the ongoing environmental management outlined in the EMP for the Project (Mine).

Although the large Offsite footprint creates the potential for increased runoff and altered flows, the design of infrastructure will incorporate stormwater runoff measures that will minimise the adverse effects.

4.11 Alteration of surface water regime

4.11.1 Overview

Mine operations and the operation of the offsite water supply infrastructure 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).

Water for the Project (Mine) will be obtained from the following sources:

- Flood harvesting from the Belyando River

- Groundwater harvesting from pit dewatering

Some overland flow harvesting may also be used through capture in MAW and SAW systems on the mining lease. The Mine Area will remove 16,664 ha (25 percent) from the Carmichael River catchment. The Project (Mine) will also result in loss and disturbance of aquatic habitats and fauna and the disconnection of the floodplain.

Subsidence is predicted to occur above the underground mining area. This may alter the local topography above underground mining areas and, in the long term, alter surface hydrology patterns and vegetation assemblages. The areas of land to be potentially subject to the impacts of subsidence have been estimated by calculating those areas that sit directly beneath the underground mine area.

4.11.2 Potential impacts

Surface flows and geomorphology

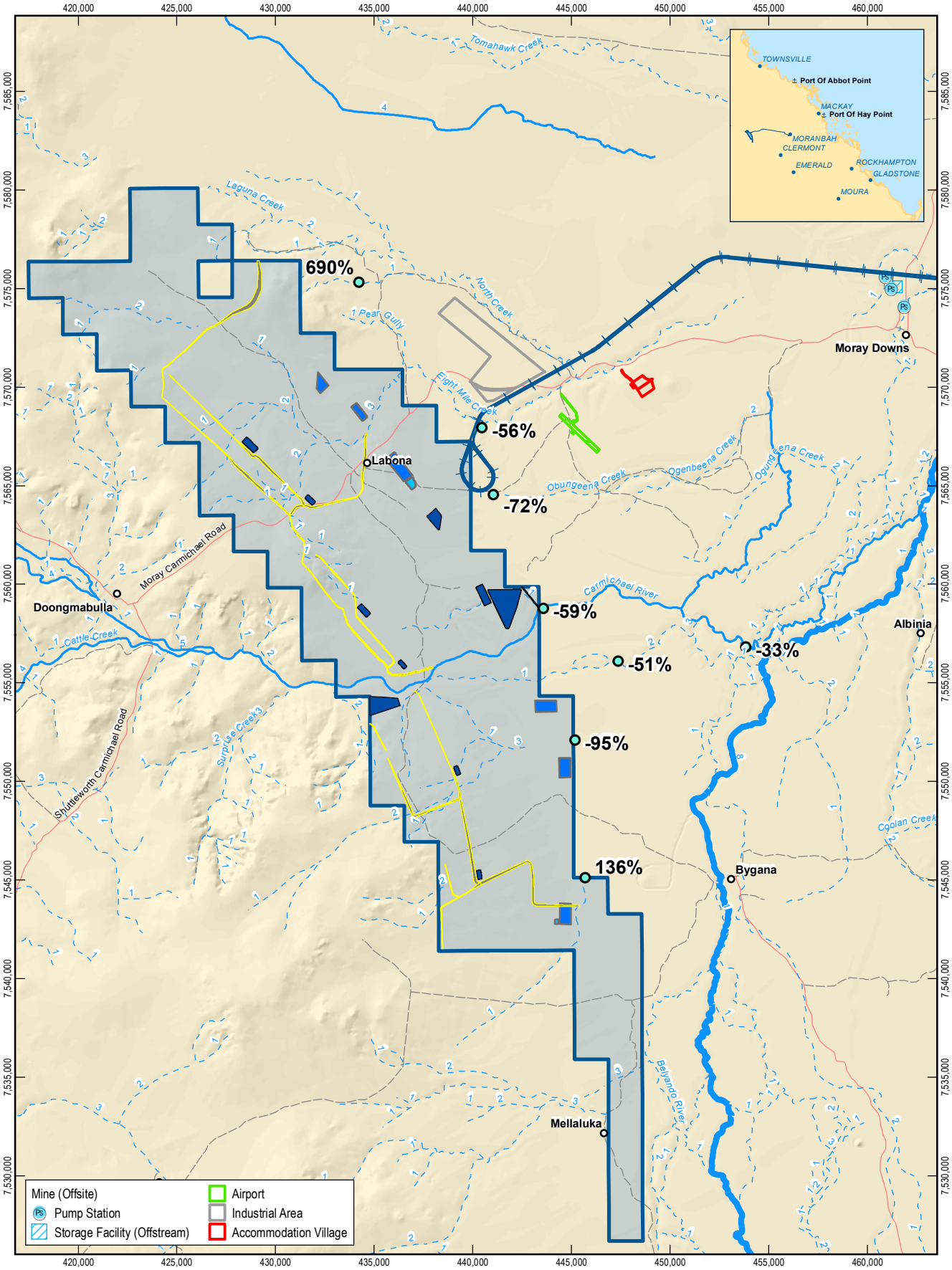
Over staged development of the Mine, the local availability of surface water discharged from the Mine Area will be reduced by 33 percent. This reduction is due to the reduced catchment area and subsidence ponding. There are, however, some 1st order streams which will receive an increase in flow during Mine operation (Figure 16), based on a water balance model for the Mine Area (see revised Mine Hydrology Report, Appendix K5 for further details). A change in depth of < 1 m during a 1:1000 year ARI event upstream of the Carmichael River bridge is also predicted with the duration of the increased flood depth during operation predicted to take approximately 70 hrs for the water to be back at post operation flood levels during a 1:1000 year ARI event. Post operation, however, the change in flood depth is greater and the duration at the increased depth will take longer to return to pre-construction flood levels.

Diversion drains will also be constructed to divert clean water from upstream catchments around the proposed mine infrastructure (Figure 17). Clean water will be discharged into existing gullies and creeks downstream. The diversion drains are to be designed for 100 year ARI flood capacity, and where required, flood protection levees will be provided along the sides of the drains to provide pit shells with 1000 year ARI immunity plus an additional 600 mm freeboard. 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 operational phase for offsite water supply infrastructure will incorporate extraction of water from the Belyando River (Moray Anabranch) during peak flow periods. Water captured from the above-mentioned water supply sources will be stored, captured, treated (where required) to fulfil mine site water demands.

A 5 GL balancing storage dam will be established on the footprint of a disused quarry. A pump and pump inlet will then be constructed on the bank of the Belyando River and will pump water to the balancing storage on flood flows. Modelling has indicated that the pump can be set to commence pumping when flows exceed 430 ML/day and then cease pumping when flows fall back below 430 ML/day. The pump will have a maximum capacity of 250 ML/day, although this may be revised once a detailed water balance has been undertaken. This approach allows the existing environmental flow objectives to be complied with, and does not adversely impact on downstream users.

Both proposed flood harvesting and in-stream extraction have the potential to alter the surface water flow regime (volume and frequency) of these ephemeral systems. Watercourses in the area are ephemeral and hence aquatic communities present and downstream reflect the seasonal nature of water flow and volume. The extent of impact to the aquatic ecosystems will relate to the volume of water extracted from the watercourses and the timing of the extraction. Water resource modelling undertaken for the Project (Mine) (Volume 4 Appendix K5) indicated that the proposed water extractions would have minimal impact against the Water Resource (Burdekin Basin) Plan 2007 environmental flows objectives. The plan defines hydrological characteristics of the connected water system that makes up the Burdekin Basin, including flow, velocities and flood extents at low, medium and high levels.



LEGEND

- Homestead
- Evaluation Point
- Local Road
- Track

Stream Order
- 1; 2; 3
- 4; 5; 6
- 7; 8; 9

- Surface Water Quality Study Area
- Proposed Diversion Drains
- Project (Rail)
- Mien (Onsite)
- MAW Dam
- Process/Sediment Water Dam
- Raw Water Dam

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

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Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project SEIS

Reduction in surface flow from the Mine Area

Job Number 41-26422
Revision B
Date 24-10-2013

Figure 16

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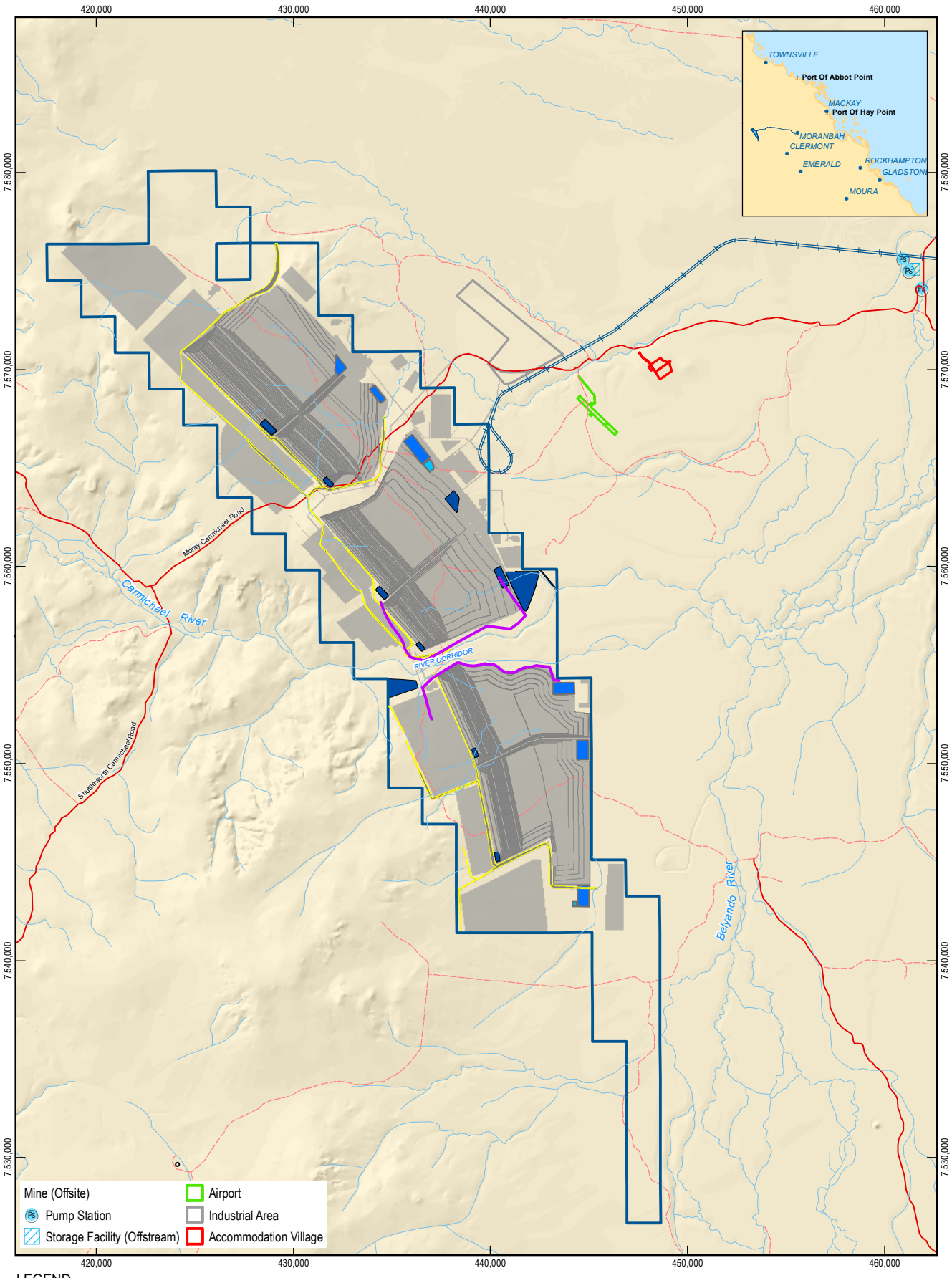
Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DNRM: Stream Network (2010); DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road (2007); GHD: Proposed Diversion Areas (2013); Adani: Project Rail 1 (Opt11 Rev2) & 2 (Opt9 Rev3), Facilities (2013). Created by: AJ.



LEGEND

- Homesteads
- Minor Road
- Track
- Watercourse
- Proposed Levees
- Proposed Diversion Drains
- MAW Dam
- Process/Sediment Water Dam
- Raw Water Dam
- Project (Rail)
- Mine Site
- Mine Layout

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

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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project SEIS

Dams, Levees and Diversions in the Project (Mine) Area

Job Number 41-26422
Revision B
Date 24-10-2013

Figure 17

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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: GA: Road, River / Watercourse (2007); DME:EPC1690 (2010), EPC1080 (2011); Adani: Mine Layout / Infrastructure (2013), Mine (Offsite) (2013). Created by: MS

Reduced base flow

Changes to groundwater hydrology have the potential to occur as a result of the operational phase of the Project (Mine). Groundwater model predictions suggest that mining induced drawdown will increase the rate of baseflow loss across the Mine Area. The model predictions suggest water table drawdowns of less than 1 m along most of the Carmichael River corridor, although impacts of up to around 4 m in the river closest to the proposed open cut pits are predicted (see SEIS Volume 4, Appendix K1 Revised Mine Hydrogeology Report).

Pre-development groundwater model results suggest a natural loss of around 1,000 m^3/d across the mining lease from west to east. Post development predictions suggest that losses would increase to around 1,800 m^3/d at the end of the mine life and to around 1,650 m^3/d post closure.

Total impacts through a combination of reduced baseflow upstream and increased baseflow losses in the Carmichael River across the Mine Area are predicted to be around 1000 m^3/d (33 percent of the pre-development baseflow) at the end of the mine life and 950 m^3/d (31 percent of the pre-development baseflow) post closure. No significant impacts on flows and/or levels are expected in any other local water courses, including the Cabbage Tree Creek, since these creeks are ephemeral in nature and not thought to currently receive any substantial discharges from groundwater.

It is predicted that the drawdown will result in longer dry periods and the potential loss of drought refuge in the Carmichael River. The groundwater model suggests that zero base flow would occur around 25 km downstream of the eastern Mine Area boundary pre development but only around 15 km downstream post development, suggesting a 10 km migration of the zero base flow point upstream.

Changes in the duration of zero flow were also estimated using the groundwater model outputs. The predicted impact at the upstream boundary of the Mine Area is a five percent increase in the duration of no flow periods and a 30 percent increase in no flow periods at the downstream boundary of the Mine Area.

Floodplain connectivity

The presence of built infrastructure and mine development will also cause the floodplain to become disconnected from the waterways. Flood levees will be constructed to protect the open cut pits and underground mine portals from flooding from the Carmichael River and possibly Eight Mile Creek. Flood protection levees are required along the diversion drains to provide 1000 year ARI flood immunity to the mine pit shells. A levee shall be provided along the north and south banks of the Carmichael River, with a 500 m buffer zone minimum distance between levee and centreline of the Carmichael River.

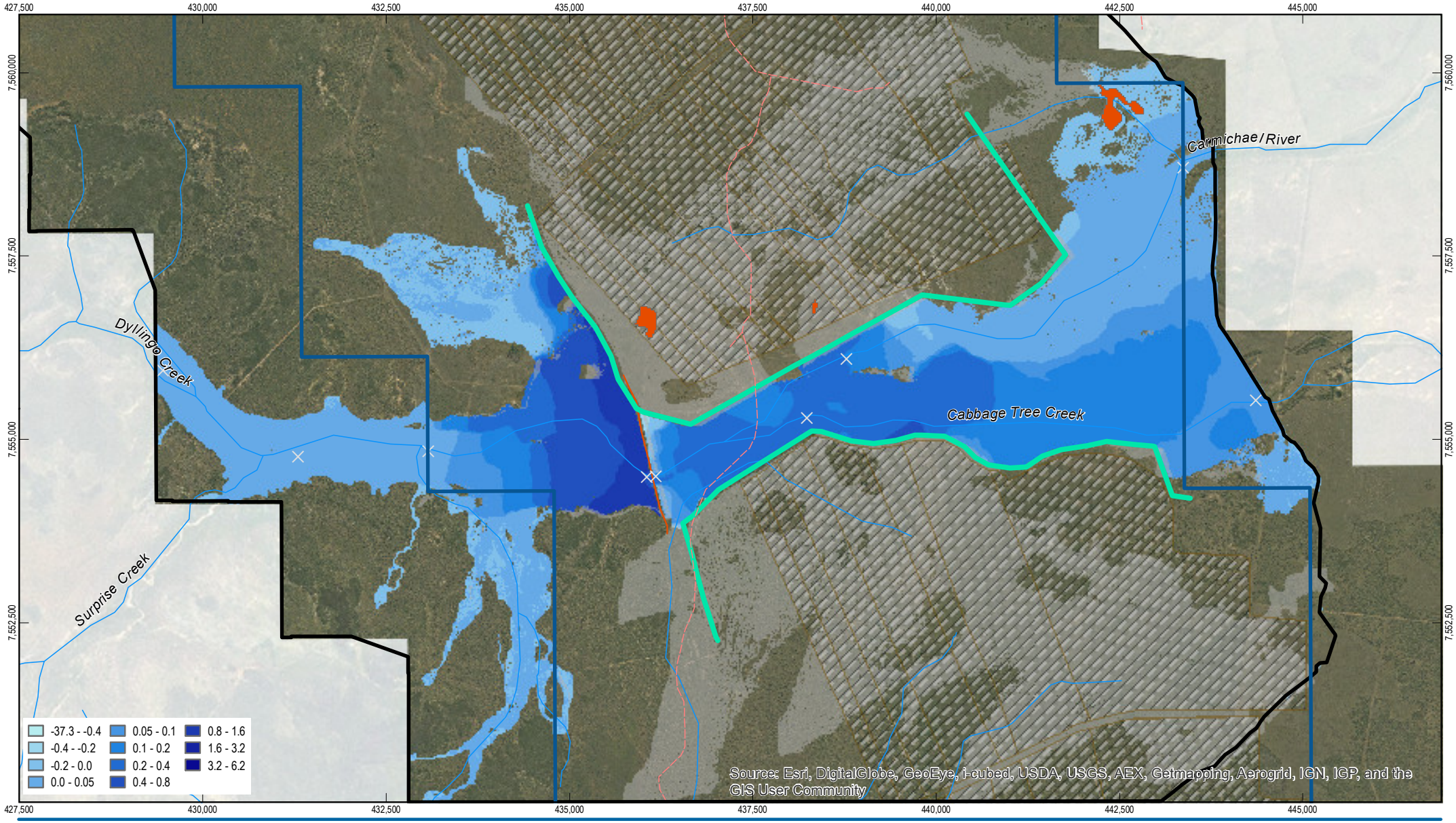
The levee along the north and south banks of the Carmichael River will disconnect the 852 ha of the floodplain and GBR WPAs 2 and 3 from the Carmichael River and these areas will be lost. As described in Section 3.10, the duration and timing of periods of lateral connection can be very important to allow opportunities for spawning, dispersal and migration. Aquatic fauna can be highly reliant on the seasonal connectivity to floodplains for the purposes of feeding and breeding, but also in seeking refuge from fast flows (Bayley 1995; Humphries et al., 1999; King et al., 2003).

Subsidence

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 and 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 underground mining footprint is traversed by minor ephemeral streams with small sub-catchments. Most of these flow roughly perpendicular to the longwall panel and subsidence trough orientation. As these streams are quite small and ephemeral, when flowing, the streams are likely to empty into the subsidence troughs and result in ponding at the surface, within some of the troughs. Higher points may become drier as surface water is diverted away from them. Ponding may also hold back surface water which will impact on surface water flow downstream of the Mine Area.

There is potential for rainfall runoff to accumulate in subsidence depressions, creating new water bodies. However, due to the short duration of the water ponding it will have limited values as habitat for aquatic flora and fauna. The impact of the subsidence and the potential benefits of the ponding for terrestrial flora and fauna are discussed in section 4.18.



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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

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LEGEND

- Afflux Points
- Watercourse
- Track
- Minor Road
- Proposed Carmichael River Levees
- Wetland Protection Area
- 2D Model Extent
- Project (Mine)
- Flood Extent Change

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project SEIS

Reduction in Floodplain in the Project (Mine) Area

Job Number	41-26422
Revision	A
Date	31-07-2013

Figure 18

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Roads, Watercourse (2007); Adani Pty Ltd: Open Cut Area (2013), Levees (2013); DNRM: Wetland Protection Area (2012); GHD: Modelling (2013). Created by: BW, CA

4.11.3 Management and mitigation

The management and mitigation of the mobilisation of sediment due to an increase in localised flow may cause increased erosion and scouring should be included in the development and implementation of erosion and sediment control plans. Further details on erosion and sediment control are provided in the Mine and Offsite Environmental Management Plans.

The design objectives for culverts used in the diversion channels should include:

- Locate culvert to maintain existing flow paths, inflows and draining into the stream
- Provide minimal afflux during flood events
- Maintain flow velocities below recommended limits during flood events to avoid scour
- Minimise velocities at culverts to prevent scouring
- Carry frequent flow events with low velocities that are conducive to maintaining the existing habitat
- Meet the fish passage requirements in accordance with the *Fisheries Act* and other relevant guidelines

Initial modelling undertaken on the Belyando system indicates that this quantity of water can be extracted without affecting downstream environmental flow objectives. Raw water will be stored in at raw water dams adjacent to Pit D and G and a system of pumps and pipes will transfer water from the Belyando River. The Belyando River flood harvesting will operate according to procedures that will be informed by the water modelling.

The flood harvesting will be undertaken such that small flows are largely unaffected. Pumps will activate when a defined flood level is reached and in accordance with a Water Licence. Pump stations will include flow meters and all pumps will be controlled remotely to ensure that permitted extraction volumes are not exceeded.

The value of water bodies created as a result of mining activities and offsite water infrastructure (for aquatic flora and fauna) will depend on the characteristics of the water body and its potential to provide habitat values. When new habitat (or potential habitat) is created an assessment on a case by case basis will be required to tailor management to the characteristics of the feature and opportunities for enhancement. Riparian zone establishment and habitat structure establishment actions will assist in promoting colonisation by aquatic species. However, the utilisation of artificially created water bodies by aquatic taxa is also dependent on the hydrological connectivity and persistence of the water body. The Rehabilitation Management Plan for the Project (Mine) incorporates measures to enhance aquatic habitats that may be created throughout the mining operation, where suitable.

Management and mitigation measures to reduce the impacts of subsidence to ecological features and resources will include:

- Implement the Subsidence Management Plan that has been produced for the Project (Mine)
- Ripping and re-profiling of the surface may be required for areas that are subject to subsidence. Where ponds develop due to the reversal of natural drainage pathways, monitoring should be undertaken to ensure that water quality standards are maintained.

- Investigate options to adaptively manage evolving habitat changes rather than attempt to rehabilitate areas to their previous condition. This could include retaining surface water within areas that become subject to ponding (rather than attempting to drain these), but as these new habitats evolve, there are also likely to be specific additional enhancements that can be made to these features, such as revegetation with native planting and the collection and aggregation of fallen woody material to create habitat piles

4.11.4 Summary

Mine operations and the operation of the offsite water supply infrastructure 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. 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. 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 thiswill be included in the development and implementation of erosion and sediment control plans.

Total impacts through a combination of reduced base flow upstream and increased losses across the site are therefore a decrease of 33 percent of the pre-development base flow at the end of the mine life and 31 percent of the pre-development base flow post closure. This 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.

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.

There is potential for rainfall runoff to accumulate in subsidence depressions, creating new water bodies. However, due to the short duration of the water ponding it will have limited values as habitat for aquatic flora and fauna. The impact of the subsidence and the potential benefits of the the ponding for terrestrial flora and fauna are discussed in section 4.18

The operation phase for offsite water supply infrastructure will incorporate extraction of water from the Belyando River (Moray Anabranch) during peak flow periods. The flood harvesting will be undertaken such that small flows are largely unaffected. Pumps will activate when a defined flood level is reached and in accordance with a Water Licence.

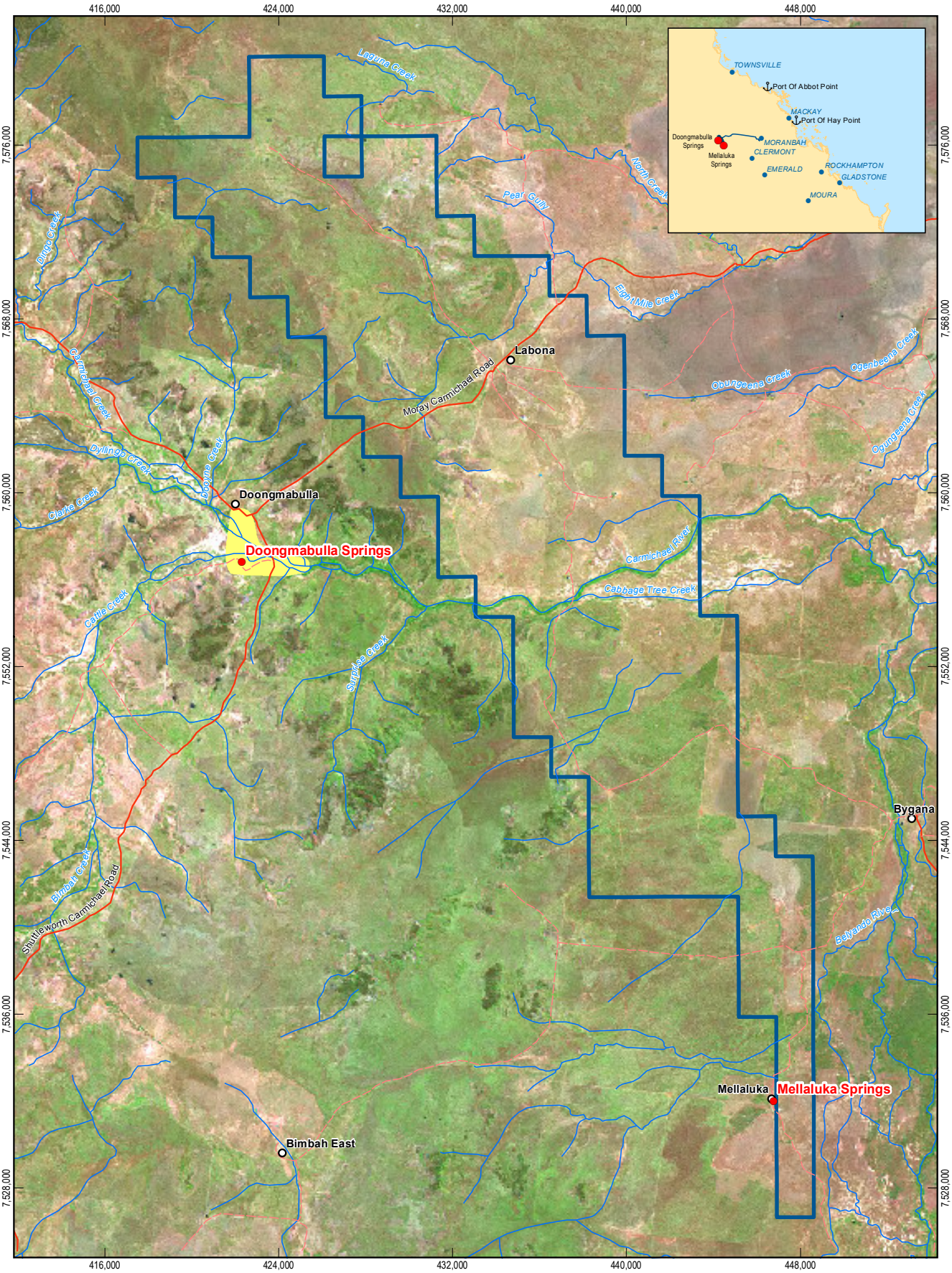
4.12 Impact of altered groundwater regime on groundwater-dependent ecosystems

4.12.1 Overview

The Project (Mine) Area and adjacent areas contain three groundwater dependent ecosystems (GDEs) (see Figure 19):

- Doongmabulla Springs
- Mellaluka Springs
- Groundwater dependent riparian vegetation communities of the Carmichael River reliant upon, in part, groundwater base flows

The ecological values of both of the springs have been described in Volume 4, Appendix J3 Report for Doongmabulla and Mellaluka Springs, and the Carmichael River community has been described below.



LEGEND

- Homestead
- Spring Locations
- Minor Road
- Track
- Watercourse
- Project (Mine)
- Directory of Important Wetlands

1:250,000 (at A4)

0 2 4 6 8

Kilometres

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

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Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project SEIS

Location of Doongmabulla and Mellaluka Springs

Job Number 41-26422
Revision A
Date 31-07-2013

Figure 19

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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: Data Source: GA: Watercourses, Roads, Homesteads (2007); DME: Carmichael Mine Site; DNRM: Springs, DOI Wetlands (2009), Landsat (2005); Adani: Alignment (SP1 & 2) (2013). Created by: AJ, MS

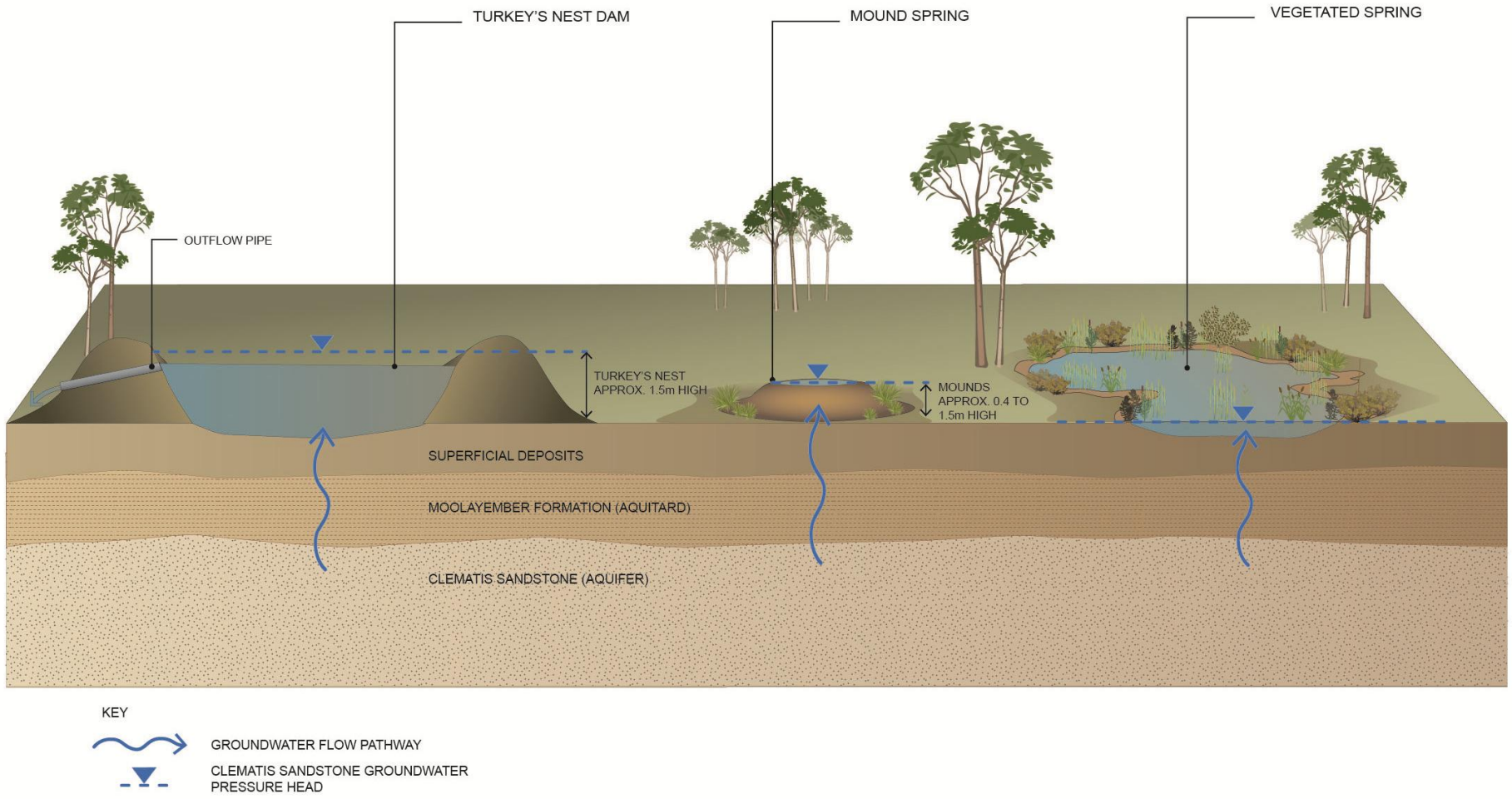
Doongmabulla Springs

Doongmabulla Springs is a GAB discharge spring located approximately 9.8 km directly west from the western edge of the Mine Area boundary. It comprises three spring groups:

- Joshua Spring, 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 20). 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 *Myriophyllum artesium* (listed as endangered under the NC Act) and the grass *Sporobolus 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.
- Moses Spring, 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 20). However, some are seepage springs only – that is, water seeps from beneath a rock or has not yet formed a mound - these often form a vegetated spring (see Figure 20). 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), and these are described in the springs technical report (Volume 4 Appendix J3). Moses Spring is located approximately 8.8 km directly west from the western edge of the Mine Area boundary.
- Little Moses Spring, 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. Along the same elevation as this main pond, groundwater was observed emanating from the ground during the 2012 survey, supporting the theory that this spring may be fed from local recharge (i.e. a recharge spring). It most resembles the vegetated spring illustrated in Figure 20. Little Moses Spring is located approximately 7.0 km from the western edge of the Mine Area boundary.

Moses Spring group also meets the definition of a threatened ecological community declared as endangered under the EPBC Act, The community of native species dependant on natural discharge of groundwater from the Great Artesian Basin.

Figure 20 Conceptual model of spring types at Doongmabulla Springs



Mellaluka Springs

Mellaluka Spring group is located near the south western corner of the eastern section of the Mine Area, on Mellaluka Station (see Figure 19). It is not considered to be fed by a GAB aquifer – the aquifer for this spring is believed to be located in Permian strata. Mellaluka Springs is comprised of three springs. The main Mellaluka Spring includes a cluster of approximately three springs and an associated wetland of approximately 4 ha, dominated by a large mound approximately 100 m wide and 2 – 3 m high with two shallow lagoons formed by run-off/ seepage (Figure 20). The station homestead is located approximately 100 m from the main spring.

The remaining springs in this group are two small outlying springs, Lignum and Stories Springs, both of which are small non-mounding artesian springs in the form of shallow ponds approximately 0.5 – 1 m deep, 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. The ecological values of this spring are presented in Volume 4 Appendix J3.

Carmichael River riparian community

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

As the waxy cabbage palm is listed as vulnerable under both the EPBC Act and the NC Act, and has the potential to be impacted, it is discussed in more detail herein (for the population study of this species, see Volume 4, Appendix J4 Report for Population Survey of Waxy Cabbage Palm).

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.

4.12.1 Potential impact

Overview

Impacts to groundwater and base flow in the Mine Area are discussed in Volume 4 Appendix K1 of the SEIS. The impact of the altered groundwater regime on groundwater-dependent ecosystems is discussed here in relation to:

- A reduction in pressure within the aquifer and therefore the impact of the springs
- Drawdown of the groundwater table and hence the groundwater-dependent ecosystems

Impact of pressure reduction on springs

A summary of modelling predictions for pressure reduction in the aquifers at the Doongmabulla and Mellaluka Spring groups from the Updated Mine Hydrogeology Report (refer Volume 4, Appendix K1) is provided as Table 5. The reduction in pressure and the impacts on the different types of springs is conceptually presented in Figure 21.

Table 5 Maximum predicted pressure reduction in the aquifers at Doongmabulla and Mellaluka Spring groups

Spring	Predicted pressure reduction – Operation (metres)	Predicted pressure reduction – Post-closure (metres)
Doongmabulla Spring group		
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
Mellaluka Spring group		
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**
*Upper most aquifer; ** Permian-age strata		

Doongmabulla Spring group is located in a zone where predicted pressure reduction in the aquifer during both the operational and post-closure phases of the mine is between 0 and 0.2 m, with the majority of springs predicted to have less than 0.12 m reduction. Joshua Spring is predicted to experience a pressure reduction close to the maximum predicted in this zone, with 0.19 m during operations and 0.16 m post-closure. The location of the individual springs in shown in Figure 22.

The water level in the turkey's nest dam at Joshua Spring is approximately 1 m above the height of the adjacent plain. A metal pipe coming from the side of the dam wall drains the dam, with an approximate outflow of 432,000-864,000 L/d based on two GHD surveys in 2012 and 2013 (approximately 5 – 10 L/s). This dam supplies water to the nearby Doongmabulla station homestead, and fills other dams and a nearby wetland, with the remainder of the water (the majority) draining into the Carmichael River channel.

The high flow is evidence of a strong head of pressure, amounting to at least 1 m above the surrounding plain and likely at least 1 m more. Therefore, it is probable that a 19 cm reduction in pressure in the aquifer supplying the Joshua Spring is likely to result in a negligible reduction in flow. 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. This wetland fills first, then the excess water flows to the Carmichael River. The negligible reduction in flow from the Joshua Spring is not expected to result in an impact to the volume of water reaching the Carmichael River.

At Moses Spring, a total of 65 active springs were counted, of which 56 had a recognisable mound, five were 'small artesian seeps' and the other four springs were 'non-mounding artesian springs' (springs that had a pool but no mound). Spring morphologies observed during surveys are discussed in more detail in the Doongmabulla and Mellaluka Springs technical report, SEIS Volume 4 Appendix J3. Twelve of the mounds 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).

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. However, 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). The wetlands contain pools of artesian water (diluted with rainwater during wet periods) that are generally quite shallow (10 – 15 cm), and together with large areas of dense, saturated, dead vegetation (similar to peat), and areas of saturated or damp sandy alluvium, form habitat required by the threatened species at the springs.

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 worst case predicted reduction in pressure in the aquifer at the Moses Spring group varies (see Figure 21), with springs closest to the Mine Area in the east are predicted to experience a reduction in pressure of 0.12 m (dropping to 0.11 m post-closure) and those in the far west are predicted to experience a reduction in pressure of less than 0.05 m (with no change post-closure). 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 are 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.

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 predicted reduction in pressure in the aquifers for the Mellaluka Springs is represented by a range of values (see Figure 21). This is due to the uncertainty in the source of the groundwater feeding the spring. The alluvial drawdown refers to the impacts on groundwater in the overlying

alluvium (which is fed by local recharge), whereas the Permian strata drawdown refers to the aquifer located in Permian-age strata that is under pressure and that feeds the springs.

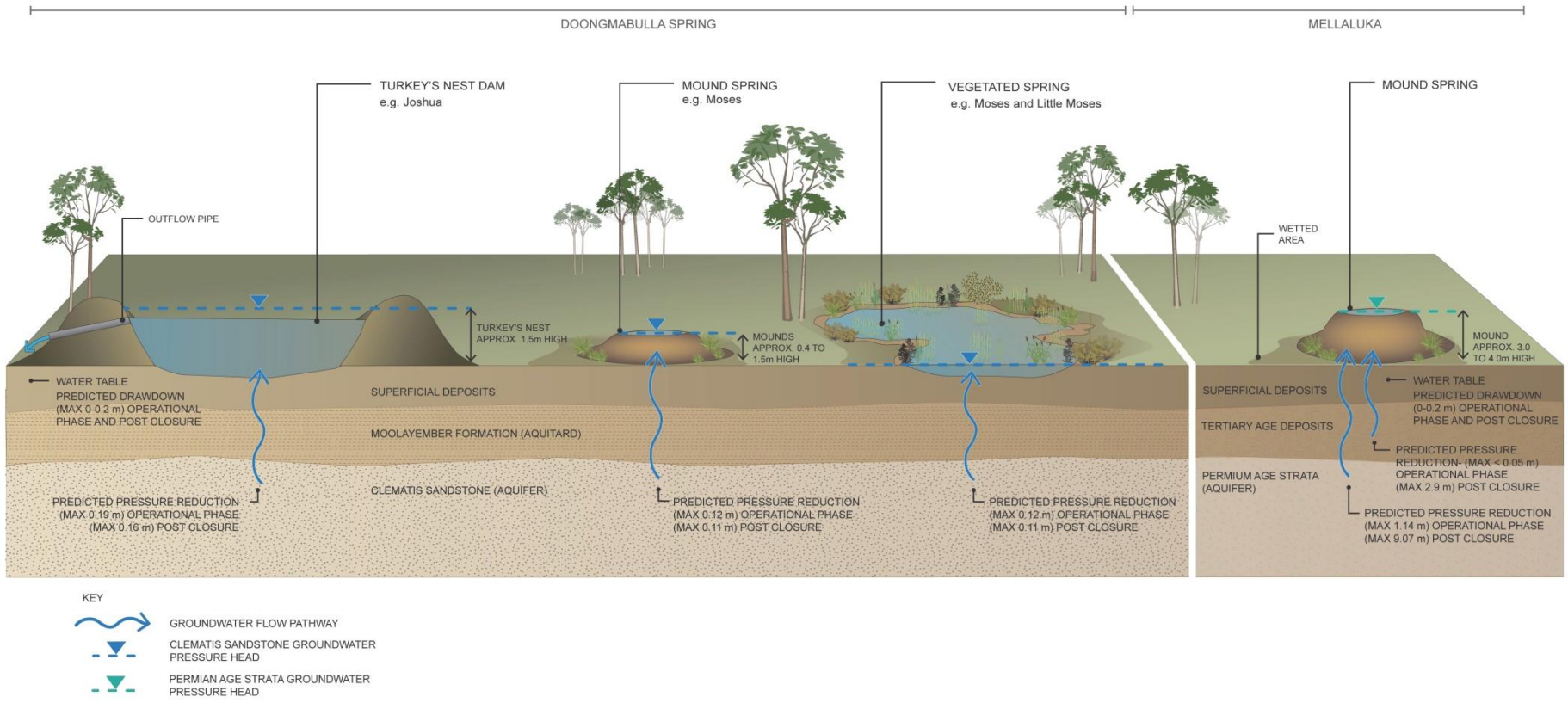
During the operational phase, the maximum predicted reduction in pressure for these springs is in the Permian-age strata aquifer, with up to 1.14 m predicted for at the Mellaluka Spring, 8.22 m at Lignum Spring and 2.34 m at Stories Spring.

The main Mellaluka Spring is likely to be able to accommodate this reduction in pressure, given its main mound is approximately 2 – 3 m high, but the associated wetland, including run off pools, may lose surface area. In addition, at least two other smaller mound springs are located within 200 m of the main Mellaluka mound, and these are both less than 1 m high. The predicted reduction in pressure may mean these springs have reduced flow to the surface. The two northern springs, Lignum and Stories, are not more than 1 m deep and predicted drawdowns of up to 8.22 and 2.34 m respectively is also likely to see these springs have reduced flow to the surface. This impact will occur when most southern pits are dug, planned for after 2060.

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 (see Figure 21). 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 and 25.6 m in Permian-age strata respectively. This is well below ground level and only the most deep-rooted trees 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 21 Groundwater pressure reductions in the aquifers at Doongmabulla and Mellaluka Springs



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Metres

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

N

LEGEND

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

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Carmichael Coal Mine and Rail Project SEIS

Job Number 41-26422
Revision A
Date 31-07-2013

Doongmabulla Springs
Spring Locations

Figure 22

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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: Imagery (2012). Created by: SB,MS

Drawdown of the groundwater table

For around 3 km upstream 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 23). Model results suggest the Carmichael River predominantly upstream of the western boundary of the Mine Area is 'gaining' (see Figure 24), 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 Mine Area, pre-development groundwater flow modelling results suggest that the Carmichael River switches from generally gaining flow to losing flow (see Figure 25) which is consistent with groundwater level and surface water flow observations at the site. Between here 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 23) 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 (see Figure 26 and Figure 27). However, apart from the reduced presence of waxy cabbage palms, there is no discernible difference in riparian vegetation along the 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 23 Predicted Carmichael River base flow changes

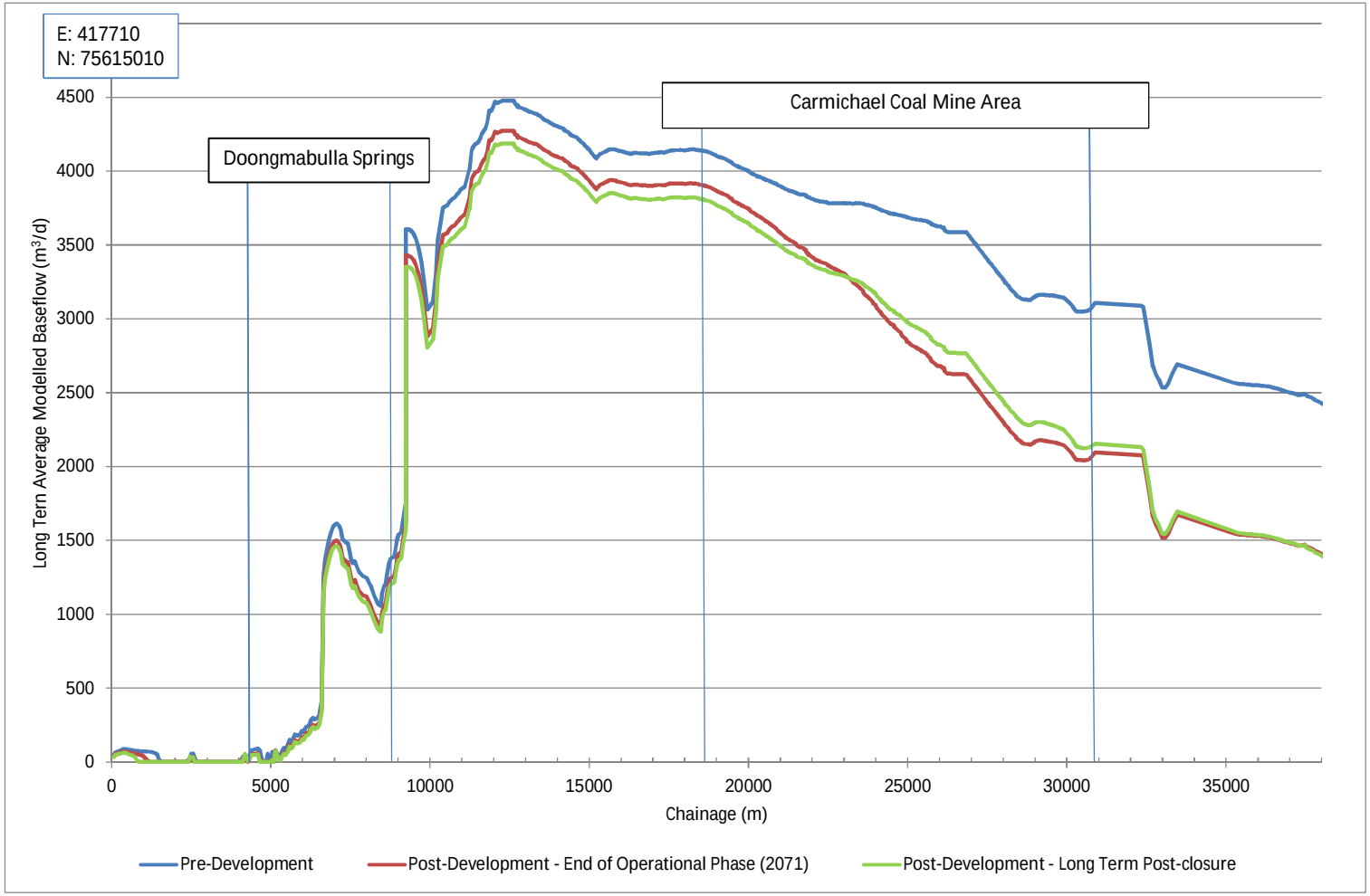


Figure 24 Conceptual river profile model of a 'gaining' river section

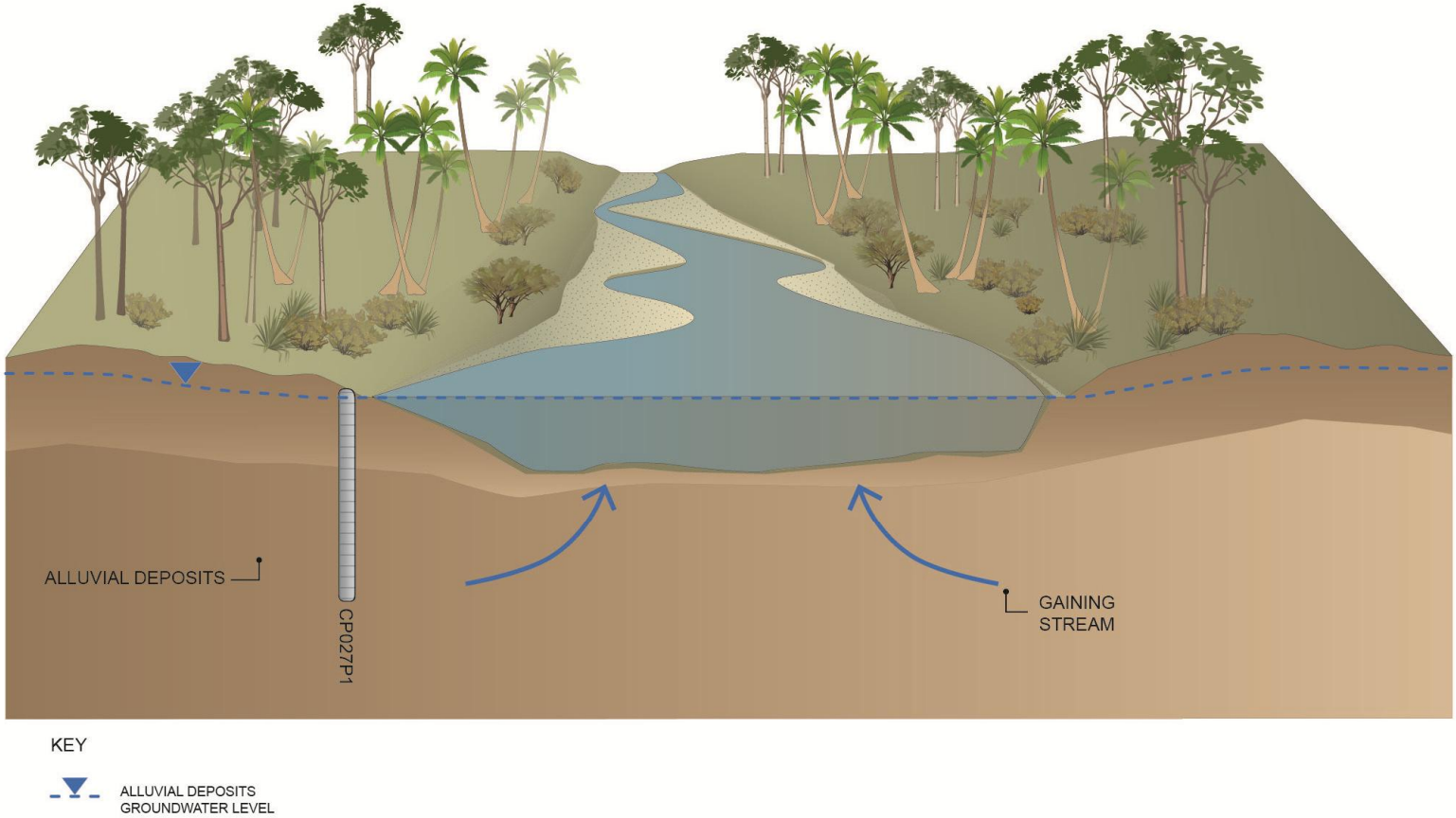
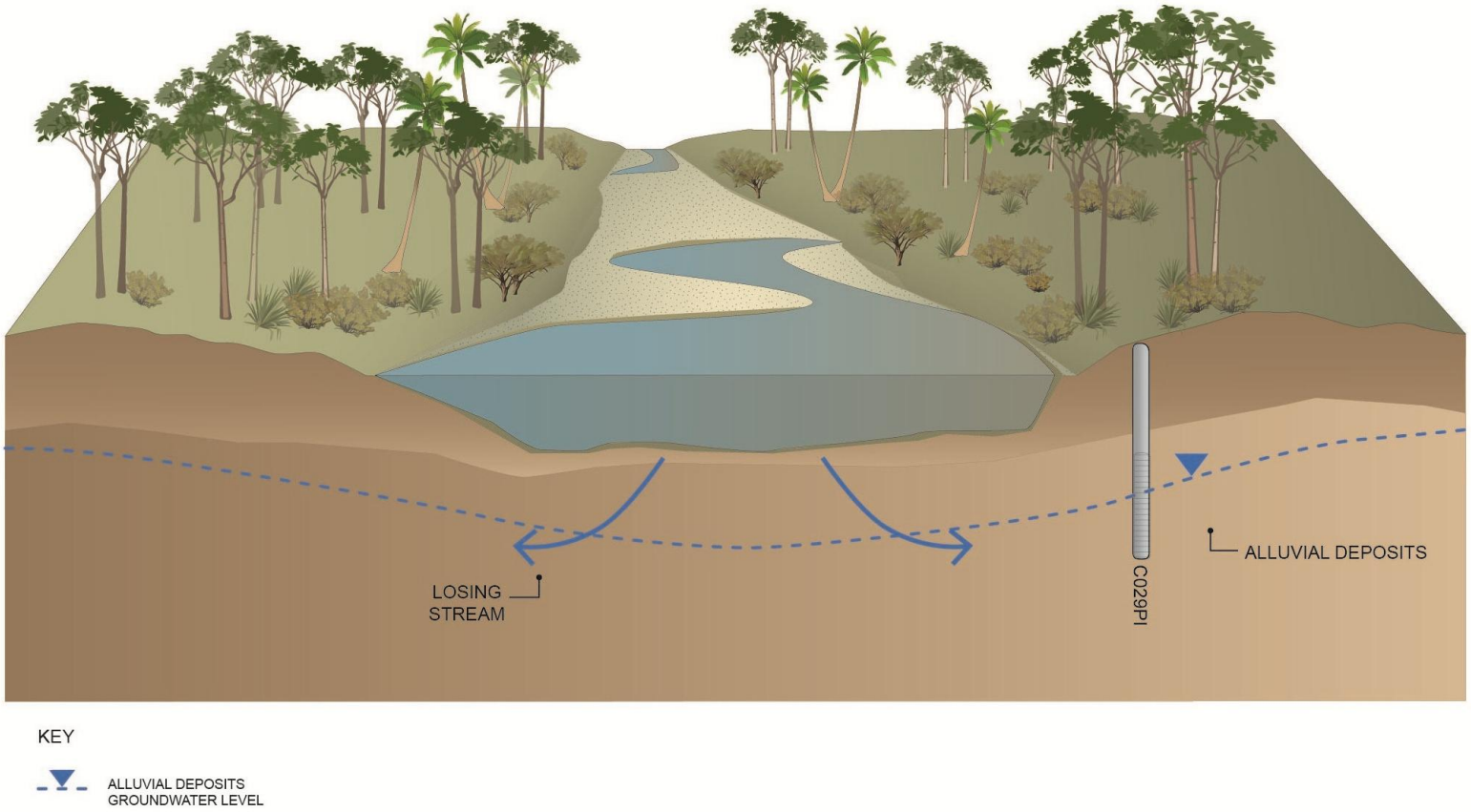


Figure 25 Conceptual river profile model of a 'losing' river section

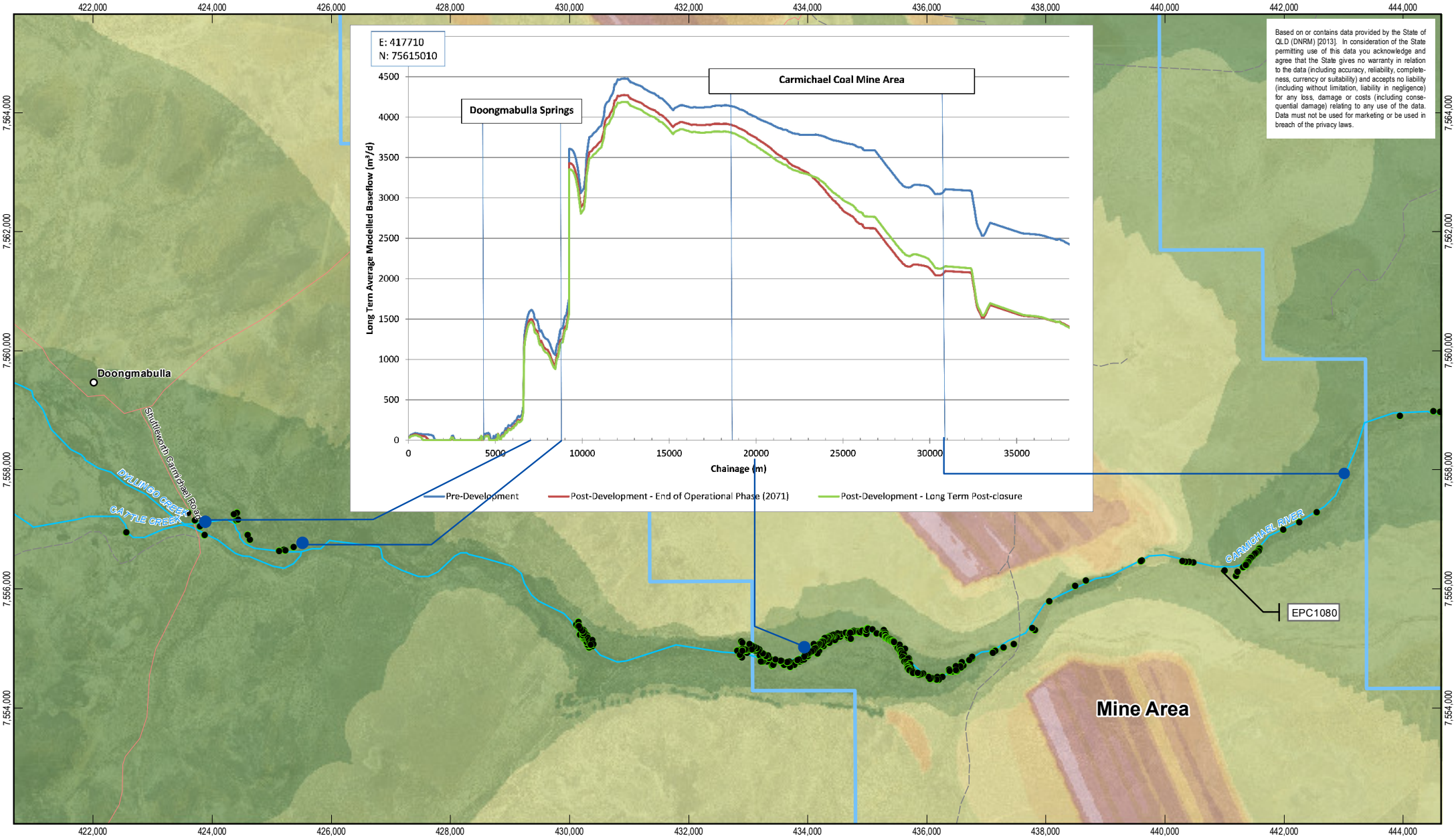


Predicted impacts on the current water table based on groundwater modelling results are mapped in Figure 26 for operational impacts and in Figure 27 for post-closure impacts (with baseflow predictions overlaid). The groundwater modelling results suggest that:

- 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 zero percent currently
- 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
- At the eastern 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 Mine Area boundary will increase by 30 percent to 60 percent of the time during operation and post closure

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.

The observed existing downward gradient from the Carmichael River to the underlying groundwater table (i.e. losing conditions) that has been modelled across the majority of the Mine Area suggests that existing riparian vegetation appears to be tolerant of a range of base flow/groundwater conditions. The riparian community species composition is consistent over the entire length of the Carmichael River within the Mine Area, with the exception of the dense cluster of waxy cabbage palms in the vicinity of the western 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 (see Figure 24)).



1:85,000 Paper Size A4

0 0.5 1 2

Kilometres

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

N

LEGEND

- Homestead
- Waxy cabbage palm population
- Watercourse
- Local Road
- Track
- Project Area

Water Table Drawdown (m)

- 0 - 0.2
- 0.2 - 1
- 1.0 - 10
- 10.0 - 20
- 20.0 - 50
- 50.0 - 100
- 100.0 - 150
- 150.0 - 200
- 200.0 - 250
- 250.0 - 300
- 300.0 - 350

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project SEIS

Job Number 41-26422
Revision A
Date 31 Jul 2013

Baseflow zones and Predicted Operational Drawdown zones along Carmichael River

Figure 26

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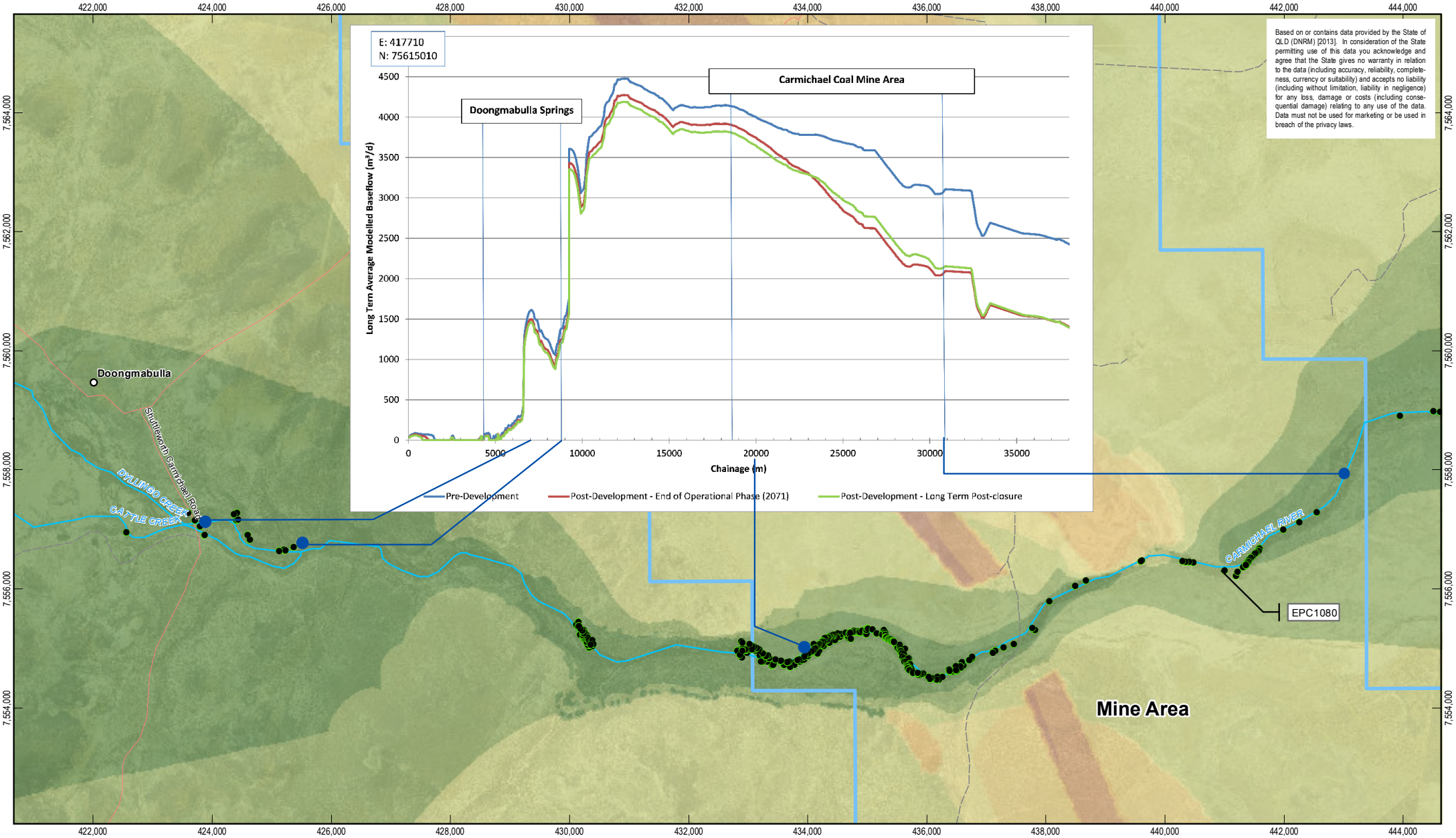
145 Ann Street Brisbane QLD 4000 Australia T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com W www.ghd.com



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0 0.5 1 2

Kilometres

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

N

LEGEND

- Homestead
- Waxy cabbage palm population
- Watercourse
- Local Road
- Track
- Mine Area

Water Table Drawdown (m)

- 0 - 0.2
- 0.2 - 1
- 1.0 - 10
- 10.0 - 20
- 20.0 - 50
- 50.0 - 100
- 100.0 - 150
- 150.0 - 200
- 200.0 - 250
- 250.0 - 300
- 300.0 - 350

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Carmichael Coal Mine and Rail Project SEIS

Job Number 41-26422
Revision B
Date 31 Jul 2013

Baseflow zones and Predicted Post-closure Drawdown zones along Carmichael River

Figure 27

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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, Qld Herbarium, pers. comm. 21/9/2012). 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 population study 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. Further downstream, in sections of the river which appear to be 'losing' flow the palms were recorded in much lower densities (see population mapping in Figure 26 or Figure 27). 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 *Livistona*), 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 Mine Area, and in this section it is considered likely to persist despite the predicted changes, together with other species in the riparian zone. In this western section, predicted operational and post-closure drawdown of up to 0.2 m would see groundwater levels likely to remain at or just below the river channel bed, and decreases in predicted base flow of approximately 300 m^3/day, equivalent to 7 percent of total pre-development flows (see Figure 23).

East of this point, predicted drawdown is less than 0.2 m for half of the western section, decreasing to a maximum of 1 m of drawdown for the remainder of the western half. In this latter section of the river, groundwater levels are believed to be approximately 4.5 m below the bed of the adjacent Carmichael River. Existing waxy cabbage palms in this vicinity are sparse, with only 25 counted, most of which are clustered towards the west (where existing groundwater levels are higher and drawdown is predicted to be closer to 0.2 m than to 1 m).

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 palms 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, in the absence of effective mitigation measures 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). In particular, the waxy cabbage palm is unlikely to be able to tolerate such a combined reduction in access to base flow and groundwater, although the population survey counted only two juvenile palms in this section of the river.

In the eastern half of the Mine Area, to the east of the 800 m stretch predicted to have a drawdown of up to around 4 m in the near vicinity of the river. Existing lower water tables (believed to be more than 4.5 m below the channel floor and possibly getting deeper with distance towards the east) will be combined with initial predicted drawdown of 0.2 – 1 m, which decreases towards the east to be less than 0.2 m. However, there is a predicted reduction in pre-development base flows (by 31 percent post-closure at the eastern Mine Area boundary – see Figure 23) and a doubling in zero flow frequencies (from 30 – 60 percent of the time).

Where existing depth to groundwater is relatively deep (in relation to the root ball of a waxy cabbage palm), the waxy cabbage palm is likely to be more reliant on regular base flows and floodwaters 'topping up' soil water. In the eastern half of the Mine Area, existing depth to groundwater is greater than in the west, and so the waxy cabbage palm population is likely to be more sensitive to changes in base flows. Therefore, 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 Mine Area, with stress levels increasing with proximity to the eastern boundary (and beyond, for waxy cabbage palm that are located downstream (east) of the Mine Area eastern boundary).

The relatively low percentage of adults in the eastern section of the river 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 relatively low 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 changes predicted by the modelling.

It is also possible that some individual trees may be adversely affected in the eastern half of the 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, Hatton, Cook and Colvin, 2006). As the eastern section of the Carmichael River within the 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.

Nineteen waxy cabbage palms are located at the Moses Spring. The population is located along the south eastern boundary, near one of the wetlands. The predicted drawdown in this location of 0.06 m (during both operation and post-closure phases) is not likely to result in dieback of any individuals, given artesian water is seeping from the ground at numerous locations in the vicinity of this population (indicating groundwater levels are already very close to the surface). Therefore, this population is not expected to be impacted at all by the predicted drawdown.

The primary impacts (without mitigation measures) of 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 on this groundwater dependent ecosystem will result in:

- Reductions in health, leading to stress and mortality of waxy cabbage palm individuals (a vulnerable species under both the EPBC Act and the NC Act) located in the eastern half of the Mine Area, including 9 adults and 160 juveniles.
- 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 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 eastern Mine Area section.

- 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 (*Cryptostegia 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 waxy cabbage palm 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.

Further information on groundwater modelling and impacts are included within SEIS Volume 4 Appendix K1 Mine Hydrogeology Report.

4.12.2 Management and mitigation

The impacts identified in Section 4.12.1 on GDEs affected by the Project (Mine) are not expected to commence until approximately 2020, with full drawdown expected by approximately 2035 (refer Volume 4, Appendix K1 Revised Mine Hydrogeology Report). Actions proposed to address these impacts are discussed below.

Springs

Proposed monitoring for Doongmabulla and Mellaluka 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 (using GPS equipment capable of sub-metre accuracy) of the 'vegetated area' perimeter of the main wetland areas at the Moses Spring group quarterly (there are five main wetland areas).
- Mapping and measurement (using GPS equipment capable of sub-metre accuracy) of selected isolated mound springs (those discrete mounds outside the wetland areas) 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 should be selected over the entire spring group (these same 10 to then be resurveyed at each repeat survey), focussing on differing sized mounds and gaining a good geographic spread over the entire group. This should include a complete species list of the mound vegetation, a photographic record (taken from at least two locations consistently), diameter, height and perimeter measurements (diameter taken from the same places each time), and flow measurements. If a mound should disappear during the mine life, a nearest neighbour replacement should be selected.
- 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 (the latter of which is a clumping species). Consideration should be given to changing the frequency of surveys if population changes are noted.
- A baseline survey of aquatic invertebrates 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 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 (refer Volume 4 Appendix K1).

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 Doongmabulla and Mellaluka property owner.

Carmichael River

Proposed mitigation and management measures for the Carmichael River include:

- Water recycling to supplement base flows in the Carmichael River will be conducted in accordance with procedures outlined in the Water Balance Report (refer Volume 4, Appendix K2). This will see excess and treated water discharged to the river near the western Mine Area boundary, in accordance with any water quality conditions. The intent is that this water will be introduced to the channel in a 'gaining' section of the river, where it will remain in the channel and thus contribute to base flows downstream.
- 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.
- In order to reduce the likelihood that canopy dieback will result in the excessive growth of weeds, and so as to safeguard existing populations of waxy cabbage palm, it is recommended that the infestation of rubber vine present within the river bed (that is still at a manageable stage) 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 removed if possible.
- 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. If possible, depth to groundwater data should be incorporated.
- Monitoring of the health of the waxy cabbage palm population should be undertaken twice yearly, preferably at the start of the wet season and the start of the dry season (December and May). Cabbage palms are able to be transplanted, and where practical and feasible (given that large machinery is required, gaining access may do more damage to the river than is practical), advice should be sought from the relevant agency at the time to transplant as many of these as possible to other locations, should there be evidence of stress directly related to reductions in river base flows. If possible, this should be done in partnership with a university or the Queensland Herbarium.

- 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 a research program is developed, 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 flow monitoring and measurements of groundwater depth changes at three locations along the river where adult waxy cabbage palms are located (preferably chosen to contrast different change regimes). Complete mapping of the Carmichael River waxy cabbage palm population (particularly downstream of the Mine Area, where base flow reductions will have an impact) is also recommended.
- Vegetation monitoring should be undertaken having regard to groundwater monitoring/base flow monitoring (in addition to surface flow monitoring). Locations for monitoring bores should be chosen with respect to selected environmental features along the Carmichael River (such as deep pools, and areas with waxy cabbage palm) to enable more meaningful interpretation of potential direct interactions between these features and the groundwater.
- Monitoring the base river flow, including the establishment of gauging stations, should be undertaken in areas of particular ecological interest. Flow data should be monitored on an ongoing basis prior to construction, during operation and post operation upstream, downstream and within the Project (Mine) Area. Adani has recently established and commissioned a number of surface water flow and quality monitoring stations.
- Undertaking detailed monitoring of groundwater levels and surface water flows at the Carmichael and Belyando Rivers prior to construction, during operation and post operation upstream, downstream and within the Project (Mine) Area to measure changes to groundwater and surface flows.

Further management and mitigation measures are included within Volume 4 Appendix K1 Mine Hydrogeology Report and Volume 4 Appendix K2 Water Balance Report.

4.12.3 Summary

In summary, three GDEs are predicted to be impacted by the Project (Mine):

- Doongmabulla Springs
- Mellaluka Springs
- Groundwater dependent riparian vegetation communities in riparian areas of the Carmichael and Belyando Rivers reliant upon, in part groundwater base flows.

The impact of the altered groundwater regime on groundwater-dependent ecosystems is discussed in relation to:

- A reduction in pressure within the aquifer and therefore the impact of the springs
- Drawdown of the groundwater table and hence the groundwater-dependent ecosystems

Impact of pressure reduction on springs

There are three spring groups at Doongmabulla Springs. 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, and that provides water to the Doongmabulla station homestead, to a shallow wetland nearby, and the excess flows to the Carmichael River. Predicted reduction in pressure in the aquifer 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 Moses Springs are comprised of at least 65 springs spread over 325 ha, with approximately 5 ha of wetland associated with run-off from the springs. 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 is predicted to be between 0.12 m and less than 0.05 m. This is expected to have a minor impact to the springs, as most springs have existing pressure heads much higher than 0.12 m, and the wetlands are subject to natural variation that exceeds the variation expected as a result of this drawdown prediction.

Little Moses Spring is a non-mounding artesian spring (although it is not clear if this spring is connected to the GAB) comprised of a number of seeps and a single 2 ha heavily vegetated pool. A reduction in pressure in the aquifer of 0.05 m is predicted at this location, and this is expected to represent a minor impact to the spring ecology.

Impacts to Doongmabulla Springs are recommended to be managed primarily through ongoing investigation and monitoring.

The Mellaluka Springs is comprised of three spring groups, the main Mellaluka Springs and two single spring 'groups'. It is not considered to be a GAB-fed spring, although the origin of this spring is not clear. The main Mellaluka Springs consist of three mound springs (one being 100 m wide and 2 – 3 m tall) and an associated wetland of approximately 4 ha, which includes a small lagoon. To the north of this spring group are two isolated springs, Lignum and Stories, which are comprised of small lagoons fed by seepage.

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. These impacts are recommended to be managed through the installation of pumps to supplement surface water availability, together with monitoring.

Drawdown of the groundwater table

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. This community is at least partly reliant on access to groundwater and regular base flows. Within the 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 (which coincides with the majority of the waxy cabbage palm individuals in the Mine Area).

The groundwater modelling results suggest that:

- 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.

- 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.
- At the eastern 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 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 Mine Area, and the riparian community including the waxy cabbage palm are likely to be able to tolerate the predicted changes. In the eastern half of the Mine Area, existing depth to groundwater is greater than in the west, and so the waxy cabbage palm population is likely to be more sensitive to changes in base flows. Therefore, 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 Mine Area. It is also possible that some individual trees may be adversely affected in the eastern half of the Mine Area.

These impacts will be managed and mitigated through the supplementary introduction of surface water to the channel near the upstream Mine Area boundary, intensive monitoring of riparian condition, base flows and groundwater levels and removal of weeds and pest animals.

4.13 Impact of altered groundwater regime on stygofauna

4.13.1 Overview

Many species of stygofauna are restricted to small geographical areas. This means that any process that threatens the aquifer, potentially threatens an entire species and community. There is also a high degree of endemism in alluvial aquifers, even between adjacent systems (Hancock and Boulton, 2008).

Mining activities have the potential to impact stygofauna communities with respect to the extent of the proposed groundwater drawdown zone. Both these factors, over time, may cause prospective stygofauna habitat to be degraded or lost with the potential for significant impact on groundwater communities.

4.13.2 Potential impacts

The Doongmabulla Springs are located approximately 8 kmfrom the western edge of the Mine Area boundary, and are permanent artesian springs which provide base flow to the adjacent Carmichael River. The groundwater model predicted maximum reduction in pressure in the aquifer in the Clematis Sandstone, thought to represent the source aquifer for these springs, range from <0.05 to 0.19 m at the two closest springs to the proposed mining area, i.e. the Little Moses Spring to the east and the Doongmabulla Spring to the west.

Mellaluka Springs are located beside the south western boundary of the eastern half of the Mine Area. Little is known about the Mellaluka Spring system. The geology at the spring location is thought likely to comprise shallow near surface Quaternary and or Tertiary age strata overlying the older Permian units. Model results predict maximum reduction in pressure in the aquifers at

the Mellaluka Springs of up to 9.07 m (post closure – during operations, drawdown is predicted to range between 1.03 and 1.14 m).

Further details regarding the groundwater modelling are reported in the SEIS Volume 4 Appendix K1 Mine Hydrogeology Report. Mining activities of the Project (Mine) have the potential to have direct effects on groundwater dependent ecosystems due to:

- Reduction in aquifer pressure may have a detrimental impact on stygofauna. This may occur within and outside the operation area (for example at Mellaluka Springs and to a lesser extent the Doongmabulla Springs).
- Acid mine drainage and other geological or soil type influences to recharge have the potential to adversely impact stygofauna communities through changing groundwater quality. Section 4.10.2 describes impacts relating to acid mine drainage.
- Excavation below the water table will result in groundwater drawdown around mine pits and changes to groundwater quality which can extend beyond the mine operation area. It will be important to assess the location and distribution of the stygofauna recovered against the aquifers from which they originated and the forecast drawdown zone.

The stygofauna collected from two bores within the western Mine Area have been identified as Trombiidae and Pexidae (belonging to the Acarina families), Parabathyneliidae (belonging to the Syncarid family) and Cyclopoida (belonging to the Copepod family). The level of taxanomic analysis undertaken in this study is in accordance with that specified by DEHP in the ToR. No stygofauna surveys have been carried out at Mellaluka Springs.

4.13.3 Management and mitigation

Management and mitigation approaches will align with those identified to manage impacts to groundwater quality, quantity and interactions (Volume 2 Appendix R Mine Hydrogeology Report).

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 during mine construction, operation and closure phases in order to monitor and measure groundwater health and condition both within the Project (Mine) Area and outside (i.e. the Doongmabulla and Mellaluka Springs)
- Extend the stygofauna sampling to Mellaluka and Doongmabulla Springs to determine the presence of stygofauna and to identify if endemicity in the stygofauna community exists within the aquifer.

4.13.4 Summary

Stygofauna sampled from two bores within the western Mine Area were identified as belonging to three families that are common to all Australian states. Ongoing stygofauna surveys are recommended, in particular at Mellaluka and Doongmabulla Springs.

4.14 Introduction of terrestrial weeds and pest species

4.14.1 Overview

Increased movement of people, vehicles, machinery, vegetation waste and soil may facilitate the spread of weeds and pest fauna at and near the Project (Mine) Area. Pest and feral species may disrupt ecosystems by outcompeting and replacing native species, thus altering ecosystem diversity and potentially disrupting ecosystem function.

4.14.2 Potential impacts

Five WONS that are also declared plants under the LP Act are known to occur at the Study Area - parkinsonia (*Parkinsonia aculeata*), parthenium, prickly pear, velvety tree pear (*Opuntia tomentosa*) and rubber vine (*Cryptostegia grandiflora*). Despite the fact that 28 introduced plant species were recorded, weeds were not found to be abundant across much of the Study Area. Increasing the prevalence of weeds at the Project (Mine) Area (and potentially beyond to the surrounding landscape), may reduce the quality of habitats for some flora and fauna species, particularly by replacing native plants.

It is a characteristic of many weeds that seeds can rapidly germinate and plant growth is also rapid. Vegetation clearing and soil disturbance allows seeds present in soil to germinate. Germination and plant growth for weeds is typically faster than for native species and this can lead to increased weed levels in disturbed areas and affect the ability for native vegetation to re-establish.

There is also significant potential for weeds, either as seeds or other plant propagules, to be introduced to sites attached to dirty vehicles and equipment or to be contained in soil or seed mixes brought to the site. This can lead to increased levels of weeds already present on the site or infestation by new weeds.

Nine introduced fauna species comprising seven mammals, one amphibian and one bird were also recorded during field studies. Food waste produced by human settlements may provide additional resources for feral animals such as pigs, rats, mice, cats and dogs. These animals, confirmed as present within the Study Area, may increase in abundance should easier access to forage resources be provided. Increased availability of water due to sediment ponds and water storages is beneficial to pest animals.

An increase in the prevalence of these animals may adversely impact native fauna in that it may lead to:

- Increased competition for resources
- Increased predation of native species by introduced animals
- Habitat degradation including pig damage of riparian areas and erosion caused by rabbit burrowing

There is also potential for pest animals such as ants to be introduced to sites through importation of vehicles, equipment, soils and similar media.

4.14.3 Management and mitigation

Pest and feral species spread, and the potential for introduction of new feral species, will require management during the operational phase of the Project (Mine). An integrated suite of actions should be developed to manage pest species, including:

- Waste management measures incorporated into environmental management plans will include containment of food scraps in securely sealed containers
- Vegetation and soil waste will not be moved to areas of lower weed infestation
- 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
- 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
- Weed levels will be monitored in areas adjacent to construction activities and any areas that are rehabilitated after construction. 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. Ongoing monitoring of weed infestation associated with construction activities will occur through the operational weed management program
- All vehicles, equipment and materials brought on to the 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
- Soil stripped and stockpiled from areas containing known weed infestations will be stored separately and are not to be moved to areas free of weeds
- Construction staff will not bring domestic animals to the Project (Mine) Area

4.14.4 Summary

Rigorous implementation of the proposed mitigation strategies will assist in minimising the potential for pest plants and animals to increase in abundance at and near the Project (Mine) Area. Regular, standardised monitoring will be a core component of the successful implementation of these plans, with corrective actions (including targeted eradication) to be undertaken at the earliest opportunity after monitoring reveals a new pest plant or animal outbreak.

4.15 Introduction of aquatic weeds and pest species

4.15.1 Overview

Soil disturbance and clearing of vegetation during the Mine operational phase has the potential to result in the introduction and/or spread of aquatic weed and pest species. This may have adverse impacts on local aquatic fauna and flora communities by increasing competition, reducing resource availability and altering existing predator-prey relationships.

4.15.2 Potential impacts

As discussed in Section 3.11.2 there are a number of pest fish species that occur in the Burdekin catchment. Although no pest species were recorded within the Study Area, pest species often flourish in disturbed habitats and in the event species are introduced (via translocation or stocking) or become prevalent closer to the Study Area, aquatic habitats may be susceptible to infestation. The introduction of these species can affect native fish communities through direct competition for resources (food and habitat), predation, habitat alteration and the introduction of diseases or parasites (DEEDI, 2011).

Aquatic weeds can also affect native communities by shading out native plants, reducing the quality of habitat for aquatic fauna communities and degrading water quality (DERM, 2011). Both weed and pest fauna species can be introduced when the numbers of people visiting the area is increased. Weeds and weed seeds can be introduced in material (e.g. earth fill), water for water supply and vehicle (e.g. water trucks) vectors brought to the site during construction. The water supply plan for the Project (Mine) incorporates the extraction of water from Belyando River outside the Study Area for use. In the event the water extraction location is in an area where aquatic weeds are present, seeds and propagules have the potential to be introduced.

Some terrestrial weed species and pest animals also have the potential to impact upon the aquatic environment directly and indirectly. Terrestrial weeds can invade riparian zones and aquatic habitats, whereby reducing aquatic habitat quality, diversity and availability. Pest animals such as pigs can have detrimental effects to watercourses by rooting 'ploughs' up to 20 m around a water body (DEEDI, 2010). This disturbance can lead to degradation of downstream water quality and habitat for aquatic species by creating erosion (DEEDI, 2010) destroying in-stream habitat and allowing opportunity for weed establishment rather than native riparian communities.

Introduction of pest and weed species locally has the potential to impact all aquatic habitats in the affected catchment if these species establish locally and spread to area with more permanent aquatic habitat such as the Carmichael River and Cabbage Tree Creek.

4.15.3 Management and mitigation

Weed and pest species spread and the potential for their introduction will require management during the operational phase of the Project (Mine). An integrated suite of actions is embedded in the Mine and Offsite Environmental Management Plans (Volume 2, Section 13 & 14) to manage both aquatic and terrestrial introduced species, including:

- Assessment of risk of aquatic weed transport at water supply extraction point such that filters or screens can be used to inhibit seeds and propagules or eggs being transferred to the Project (Mine) Area

- Disposal of vegetation waste (in a manner that minimises potential for spread of weeds)
- Monitoring of weed levels and where increased weed levels occur, weed control programs
- Cleaning of vehicles, equipment and plant before entry to the site
- Regular weed and pest monitoring of the Project (Mine) Area to confirm adequacy of management and mitigation approaches. Monitoring requirements and corrective actions will be clearly articulated in a Construction Management Plan.

Implementation of those measures will manage the impact to the aquatic ecosystems as well as terrestrial ecosystems.

4.15.4 Summary

Implementation of the proposed mitigation strategies will minimise the potential for aquatic weeds and pest animals to increase in abundance at and near the Project Area or for new aquatic pests and weeds to be introduced. Regular, standardised monitoring is proposed to be a core component of the successful implementation of these measures, with weed or pest control to be undertaken at the earliest opportunity if monitoring reveals a new pest plant or animal introduction or a significant increase in abundance.

4.16 Disruption of terrestrial fauna behaviour

4.16.1 Overview

Operational activities associated with Mine Area will result in localised increases in light, noise and vibration. Without mitigation measures, these factors have the potential to adversely affect local fauna by disrupting their normal behavioural activities and potentially compromising their foraging, breeding, sleeping and nesting efficiency.

4.16.2 Potential impacts

The higher intensity of land use at and near disturbed areas associated with Mine operations may disrupt local fauna behaviour, largely as a result of increased exposure to light, noise, dust, vehicles and people. Behavioural disruption may be direct (i.e. increased susceptibility to predation due to increased noise reducing prey vigilance, or increased light increasing prey detectability) or indirect (i.e. habitat degradation reducing local resource availability therefore increasing foraging dispersal distances for fauna). Given that the Project (Mine) Area is currently exposed to some disturbance (as it is a working cattle property), the suite of species that occur exhibit a degree of disturbance tolerance. The black-throated finch (southern) and squatter pigeon (southern) are known to inhabit areas exposed to anthropogenic disturbance (peri-urban Townsville including directly adjacent to military training areas in the case of the former; numerous towns in central Queensland for the latter). However the persistence of normal behaviours is dependent on the persistence of access to drinking, foraging and nesting resources and opportunities for dispersal to adjacent habitats.

Animals may exhibit initial fright behaviour in response to the increased intensity of disturbance at the Project (Mine) Area, and will either adapt to the disturbance levels, or move away from the areas of activity into similar habitat that is extensively available in the adjacent landscape.

Dispersal will be facilitated by active management and where possible enhancement of habitats occurring onsite (outside the mine footprint) and offsite (offset areas).

Negative impacts to fauna from noise associated with operations of the Project (Mine) are unlikely to occur (refer Volume 4 , Appendix N Revised Mine Noise and Vibration Report).

4.16.3 Management and mitigation

Management and mitigation measures to reduce disruption to fauna behaviour during Project (Mine) activities include:

- Pre-clearing surveys for active breeding sites
- Directional lighting will be used where possible to minimise light spill
- Restriction of movement of vehicles and humans to construction areas
- Dust suppression activities will be undertaken where appropriate and managed in accordance with the recommendations outlined in Volume 4, Appendix L Updated Mine Air Quality Assessment.
- Regular maintenance of machinery and plant will be undertaken to minimise unnecessary noise

4.16.4 Summary

Throughout the operational phase of the Project (Mine), habitats adjacent to mined areas and related infrastructure will be exposed to disturbance. Implementation of the mitigation measures referenced to and listed above will seek to prevent/reduce exposure to these potentially disruptive activities and processes.

4.17 Changes to fire regime

4.17.1 Overview

The increased human activity associated with the operational phase of the Project (Mine) will increase the potential for accidental fires and the need for prescribed burns to reduce fuel loads. The change in fire regime may have consequences for local fauna communities.

4.17.2 Potential impacts

Increased human activity may alter the fire regime of the local landscape, either deliberately through the need to manage bushfire risk, or through the accidental ignition of bushfires. Accidental or uncontrolled fires may have more pronounced impacts upon vegetation (and habitat) within and adjacent to the Project (Mine) Area.

4.17.3 Management and mitigation

Fire management strategies are outlined in the Project Environmental Management Plan, and these will be implemented for all phases of the Project. As well as documenting protocols and actions for preventing accidentally-lit fires, the plan will outline how fuel loads will be monitored and maintained across the Project (Mine) Area, as well as in offsite (offset) areas being managed for biodiversity. Ecological considerations will be incorporated into the further development of this plan and response procedures.

Implementation of a fire management protocols should reduce the potential for destructive high intensity fires to disturb habitats at and near the Project (Mine) Area.

4.17.4 Summary

Implementation of fire management protocols will reduce the potential for destructive high intensity fires to disturb habitats at and near the Project (Mine) Area.

4.18 Subsidence

4.18.1 Overview

Subsidence is predicted to occur above the underground mining area. This may alter the local topography above underground mining areas and, in the long term, alter surface hydrology patterns and vegetation assemblages. The areas of land to be potentially subject to the impacts of subsidence have been estimated by calculating those areas that sit directly beneath the underground mine area. In total, this equates to an area of 7,922 ha.

4.18.2 Potential impacts

Potential environmental impacts of subsidence include:

- Alterations in surface topography leading to changes in surface drainage patterns. For example, the bed profiles of streams may be affected by the subsidence profile. The underground mining footprint is traversed by a number of minor ephemeral streams with small sub-catchments. Approximately three such streams occur to the south of the Carmichael River and four to the north, within the area of potential subsidence impact. Most of these flow roughly perpendicular to the longwall panel and subsidence trough orientation (flowing west to east, or south-west to north-east). As these streams are quite small, shallow and ephemeral, when flowing, the streams are likely to empty into subsidence troughs (if not diverted prior to works) and result in ponding at the surface within some of the troughs. Higher points may become drier as surface water is diverted away from them.
- Alteration to below-ground geological profiles resulting in changes to sub-surface drainage patterns. The root zones of vegetation may be affected by the changes to sub-surface flow conditions resulting from subsidence, though there is broadly a low risk of hydraulic connection from surface to the coal seam(s). Altered hydrology may result in areas of wetter or drier conditions for plants. Affected vegetation may fall over in localised areas, may become less stable, or more gradual impacts may occur in line with changes in water availability to root systems.
- Tension cracks may form in the ground surface, particularly across areas of shallow depths of cover (primarily the east and north-east of the Project (Mine) Area). The width and depth of tension cracks will depend on the underlying geology and also the speed at which subsidence occurs and this will vary across the Project (Mine) Area. As subsidence will be staged, this may reduce the formation of tension cracking, but such cracking may further alter surface and/or sub-surface water flows and result in a direct loss of vegetation and/or pre-existing habitat features in some localised areas.

As a result of these effects, the nature of vegetation communities over underground mining areas may change over time. In severe cases of subsidence (i.e. in areas of significant tension

cracking), taller trees may fall over or gradually die due to the physical or hydrological changes. However the Subsidence Report (refer Volume 4, Appendix I1) indicates subsidence levels are likely to be moderate and levels of cracking inconclusive. Consequently, the disturbance to canopy vegetation may be less severe. Shrubs and grasses are generally less likely to be affected by the physical changes of subsidence; however, changes in hydrology may lead to progressive changes in the nature of vegetation, as water tolerant species colonise the base of troughs and more drought tolerant species colonise the ridges above the pillars. During this transition, there will also be significant potential for weed invasion to occur, as weeds may be better able to take advantage of the changed conditions. However, this would simply make conditions more conducive to the spread of existing weeds, rather than increase the importation of new weeds to areas of susbidence.

The surface topography within the Project (Mine) Area consists of low-lying and gently sloping plains of generally less than 2 percent gradient. The Carmichael River is the most significant watercourse in the area, in the southern part of the mining lease area, and the proposed longwalls have been set back from the River, with the closest longwall panel some 655 m from the River.

It is considered that impacts to individual REs are unlikely to be significant in terms of their distribution and conservation status at a local or bioregional level, and whilst changes to habitat structure (such as areas of tree loss) and species compositions in localised areas are likely to result from the levels of subsidence predicted (2.0 – 5.5 m), the general (overall) functionality of the fauna habitats present across the Project (Mine) Area is unlikely to be significantly compromised.

For three threatened species confirmed present or likely to occur, the majority of the overall area predicted to be subject to subsidence (7,922 ha) represents potentially suitable habitat as follows:

- black-throated finch (southern): 6,308 ha being 80 percent of subsidence area
- squatter pigeon (southern): 6,537 ha being 82 percent of subsidence area
- yakka skink: 5,737 ha being 72 percent of subsidence area

These species utilise a wide range of grassland and open woodland habitats. Only very small areas of the predicted impact area represent potential habitat for ornamental snake, with no potential habitat for black-necked stork or cotton pygmy-goose to be impacted. In the case of waxy cabbage palm, the species' restriction to the Carmichael River riparian corridor means that the species does not occur within an area predicted to be subject to subsidence.

While subsidence may occur over much, if not all, of the predicted subsidence area, the type and extent of subsidence will vary greatly in distribution and magnitude of effect over time. Because the vast majority of the impact area represents known and potential habitat for four of these species, the effects of variable levels of subsidence across this area (and in turn variable impacts to the habitats upon which they rely) are likely to be reduced and result in impacts that could be locally significant, but are unlikely to be significant at the wider, regional population level. The greatest impacts are likely to be those involving the loss of historical breeding sites, where there is a high fidelity to those sites amongst species; this may be the case for black-throated finch (southern) and yakka skink (communal breeders), but is less likely to be applicable to the other threatened species present within the area.

Those species with a noted affiliation to water (squatter pigeon (southern), black-throated finch (southern) and ornamental snake in particular) may be able to take advantage of the creation of additional ponded surface water areas as a result of subsidence, even where this resource is temporary, though the destructive impact on surface habitat might negate this effect. Black-throated finch (southern) requires an abundance of reliable water sources within its localised habitat ranges. Furthermore, they have been observed (during survey work) to drink from water sources in areas of cleared land or non-wooded vegetation and therefore any localised changes in habitat structure around existing or new water sources may not affect the subspecies' ability to use these water sources, so long as the requisite grassland and woodland habitats remain present within the nearby surrounds. However as the subsidence will occur gradually and in a complex and partly unpredictable manner, the data being collected by this long term monitoring in the Mine Area will provide information regarding the best strategies over time to mitigate negative effects and manage key resources for black-throated finch (southern) on the Mine Area. Important habitats for ornamental snake comprise gilgais, melon-holes and/or fringing vegetation along watercourses, within brigalow or open woodland complexes. The same may apply to any increase in dead wood habitat created by fallen trees in areas of subsidence, which would be of potential benefit to species including ornamental snake and yakka skink.

4.18.3 Management and mitigation

Management and mitigation measures to reduce the impacts of subsidence to ecological features and resources will include:

- Implementation of the Subsidence Management Plan that has been produced for the Project (Mine) , which allows for the offsetting of longwall panels between the seams (to reduce vertical displacement, tilt and curvature), the early diversion of small watercourses (where necessary), the packing and backfilling of tension cracking, and the regular review of subsidence management in general
- Monitoring of the effects of subsidence on key species and habitats should also be carried out by suitably qualified ecologists, with monitoring events phased and scheduled following the cessation of excavations within each longwall panel (as well as the prior establishment of pre-impact benchmark sites as necessary). The monitoring should focus on documenting resulting changes to habitat types (using indicators such as vegetation cover and plant species diversity) and fauna species' use of these areas (primarily the key threatened species listed above)
- Using the data from monitoring, specific rehabilitation plans should be produced and implemented, if necessary, to act upon any identified adverse impacts to habitats or features, where these are considered to pose a threat to key habitat communities and/or threatened species populations. Key performance indictors should be developed which, if not met, should result in corrective actions to directly address any functional loss in biodiversity and result in specified outcomes for net conservation gain. For example, earthworks may be required to manage natural gradients along drainage lines found to be adversely impacted by subsidence
- It will most likely be preferable to adaptively manage evolving habitat changes rather than attempt to rehabilitate areas to their previous condition, which would be difficult to achieve. This would include retaining surface water within areas that become subject to ponding (rather than attempting to drain these), but as these new habitats evolve, there is

also likely to be specific additional enhancements that can be made to these features, such as revegetation with native planting and the collection and aggregation of fallen woody material to create habitat piles.

4.18.4 Summary

Large areas of potential habitat for conservation significant fauna species may be subject to subsidence during the operation of the Project (Mine). 72 – 82 percent of the total subsidence area represents potential habitat for threatened species known to occur (squatter pigeon, black-throated finch) and likely to occur (yakka skink). Subsidence may take the form of surface cracking and areas of heave and/or collapse, and may result in tree fall, ponding, and localised changes to vegetation communities. These would lead to the alteration of habitat in places, but not necessarily adverse impacts to fauna in all cases. For example, increased extents of surface ponding may benefit certain species, such as squatter pigeon (southern) and black-throated finch (southern) and any areas of fallen timber may be of value to species including ornamental snake and yakka skink. Subsidence will require adaptive management as it occurs, because of the difficulty of predicting the location and magnitude of effects, but any effects, whilst impacting large areas, are likely to be localised.

5. Potential impacts and mitigation - rehabilitation

The mining at the Project (Mine) Area is scheduled to be carried out for approximately 60 years. There are a number of aspects of relevance to environmental management during progressive rehabilitation of the Project (Mine).

With respect to the potential impacts to the environment and associated mitigation for this phase, the decommissioning of the Mine will require detailed planning. Planning and subsequent development of a Project Decommissioning Environmental Management Plan should incorporate a phase of impact assessment that includes consideration of the potential impacts to the terrestrial ecosystems within, surrounding and downstream of the Project (Mine) Area as they occur at the time of decommissioning, with reference to pre-mining state.

The plan should consider (but not be limited to) incorporation of the following with respect to the management of habitats for nature conservation values.

- Rehabilitation and ongoing management of terrestrial systems disturbed at any stage of Mine operations to occur, with the objective of revegetating cleared areas as soon as possible after disturbance, and wherever possible, providing a suite of habitat resources for flora and fauna that replicates as closely as possible the resources available prior to the commencement of mining (as detailed in baseline assessments of the existing ecological values of the Project (Mine) Area). A key aspect of this rehabilitation will be restoring and maintaining connectivity across the local landscape, particularly between intact habitats within and near the Project (Mine) Area.
- Remediation and development of the final landform to consider drainage, erosion resistance and potential resultant change to vegetation communities (and thus fauna habitats), and surface water flows (direct and volume) in order to minimise changes to the aquatic habitats of the Carmichael River and downstream
- Rehabilitation requirements for any watercourse crossings
- Rehabilitation or re-establishment of riparian zones for watercourses
- Monitoring requirements for aquatic communities and water quality

6. Conclusions

6.1 Summary of construction impacts

The primary residual ecological impacts to result from the construction of the Project (Mine) are:

- Vegetation clearing (1,324 ha of remnant and 1,308 ha of non-remnant vegetation, including 31 ha of endangered and of concern REs, 1.75 ha of which are constituents of the Brigalow TEC)
- Loss of potential habitat (up to 1,367 ha[2]) for conservation significant species confirmed present or likely to occur (five Commonwealth-listed threatened species, 13 migratory species and seven State-listed threatened species)
- Terrestrial fauna mortality during vegetation clearing and construction
- Introduction or spread of weed and/or pest species to Project (Mine) Area

Other impact types are considered to be less significant and manageable to the extent that no measurable residual impacts to ecological values will result from the construction of the Project (Mine). These are:

- Habitat fragmentation, where the vast majority of clearance is to take place within a highly modified and disturbed landscape
- Habitat degradation from erosion and dust, the effects of which will be managed with issue-specific plans within the Project EMP
- Loss of aquatic and riparian habitat, to be minimised at creek and river crossings, and compensated for through the construction of new surface water features (dams)
- Aquatic fauna mortality, where construction works within watercourses will take place in dry or controlled conditions
- Degradation of aquatic habitats and water quality, where control plans, such as sediment control, and construction monitoring will be applied within the Project EMP
- Alteration to surface water regimes, which will be relatively localised and managed during construction
- Disturbance to conservation significant species during construction, where the majority of activities are located away from the most sensitive habitat areas

6.2 Summary of operational impacts

The primary residual ecological impacts to result from the operation of the Project (Mine) are:

- Vegetation clearing (9,123ha of remnant and 8,482 ha of non-remnant vegetation, including 407 ha of endangered and off concern REs, 247 ha of which are constituents of the Brigalow TEC)
- Loss of the Bygana West Nature Refuge
- Loss of potential habitat (up to 9,355 ha) for conservation significant species confirmed present and likely to occur (as Section 6.1)

[2] Excluding migratory aerial bird species

- Terrestrial fauna mortality during vegetation clearing, staged throughout operation
- Habitat fragmentation, where any reduction in connectivity or corridor function will be the focus of offsetting measures, particularly in the north and south of the Project (Mine) Area
- The loss of GBR WPAs and other aquatic habitats to the operation of the Project (Mine)
- Alterations to the surface water regime
- Impacts to GDEs at Mellaluka Springs and in the Carmichael River in the eastern half of the Mine Area, including likely partial losses from the population of the vulnerable waxy cabbage palm
- Minor impacts to other GDEs, and to stygofauna
- Introduction or spread of weed and/or pest species to Project (Mine) Area
- Disruption of terrestrial fauna behaviour
- Subsidence impacts to (up to 6,944 ha) of potential habitat for conservation significant species, which may result in localised changes to be managed within a Project Subsidence Management Plan

Other impact types are considered to be less significant and manageable to the extent that no measurable residual impacts to ecological values will result from the operation of the Project (Mine). These are:

- Terrestrial habitat degradation, with potential impacts managed by the Project EMP
- Aquatic fauna mortality, where construction works within watercourses will take place in dry or controlled conditions
- Aquatic habitat or water quality degradation to be managed by the Project EMP
- Introduction of aquatic weeds and/or pests to be managed by the Project EMP
- Changes to fire regime

Impacts to ecological values within the operation 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.

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