environmental management

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Carmichael Coal Project (Rail)
Separable Portion 1

Fauna Crossing Strategy

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surveying town planning urban design environmental management landscape architecture

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I. Introduction

The *Environmental Management Division* of **Saunders Havill Group** was engaged by **Adani Mining Pty Ltd** to prepare a Fauna Crossing Strategy for the Carmichael Coal Project (Rail) Separable Portion 1 (Refer to **Plan 1**).

The Project (Rail) has been declared a 'significant project' under the *State Development and Public Works Organisation Act 1971* (SDPWO Act) and, as such, an Environmental Impact Statement (EIS) is required. The Project (Rail) is also a 'controlled action' and requires assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

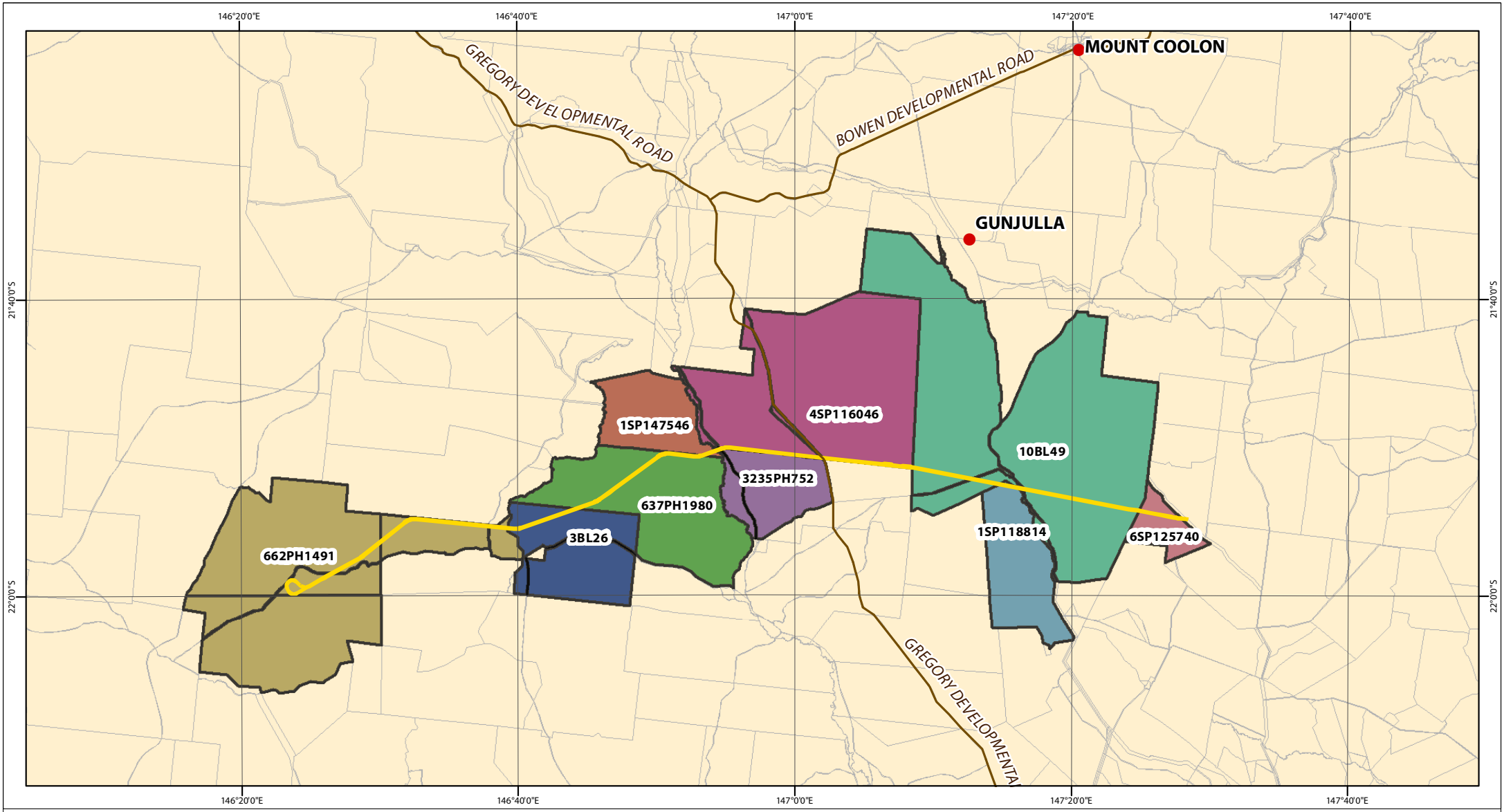
Adani propose a coal mine on their coal tenement (Exploration Permit for Coal (EPC) 1690) in the Galilee Basin, West of Moranbah in central Queensland. The proposed rail alignment links the Mine to the ports of Hay Point and Abbot Point. The rail line is divided as follows:

- **Separable Portion 1 (SP-1)** – known as 'west rail' which traverses approximately 120 km from the Mine site East towards Moranbah; and
- **Separable Portion 2 (SP-2)** – known as 'east rail' which connects 'west rail' with the existing Goonyella rail system and provides access to Dalrymple Bay and Hay Point coal terminals.

This report has been prepared to accompany EIS documentation and describe the strategy employed within the rail design to manage potential linkage and movement impacts on fauna due to the construction and operation of the rail line. The report has been prepared specifically for SP-1 of the rail alignment; however, strategies employed within the design have and will be incorporated within the SP-2 component of the project.

The Fauna Crossing Strategy outlined in this report was formulated entirely from fauna and habitat data presented in the *Carmichael Coal Project EIS* and related documents (**GHD** and collaborators) and, as such, is an amalgamation of recommendations aimed at encouraging safe fauna passage across the alignment.

It is noted this Fauna Crossing Strategy is focussed toward terrestrial fauna. Connectivity for aquatic fauna has been considered in relation to the *Fisheries Act, 1994* and *Fish Habitat Management Operational Policy* (FHMOP 008).



Legend

- Place Name
- Major Roads
- Rail Alignment Corridor (SP-1)
- QLD DCBD

Plan 1 *Rail Project Overview (SP-1)*

File ref. *6396 E 01 Rail Project Overview A*
Date *20/03/2013*
Project *Carmichael Coal Rail Project*

0 2 4 6 8 10 20 *km*

Scale (A4): 1:650,000 [GDA 1994 MGA Z55]

N

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Layer Sources *SP-1 Corridor, Crossing Locations (Adani Mining Pty Ltd 2012), DCDB, Major Roads, Towns (DNRM 2012), WWBW Waterways (DEHP 2013)*

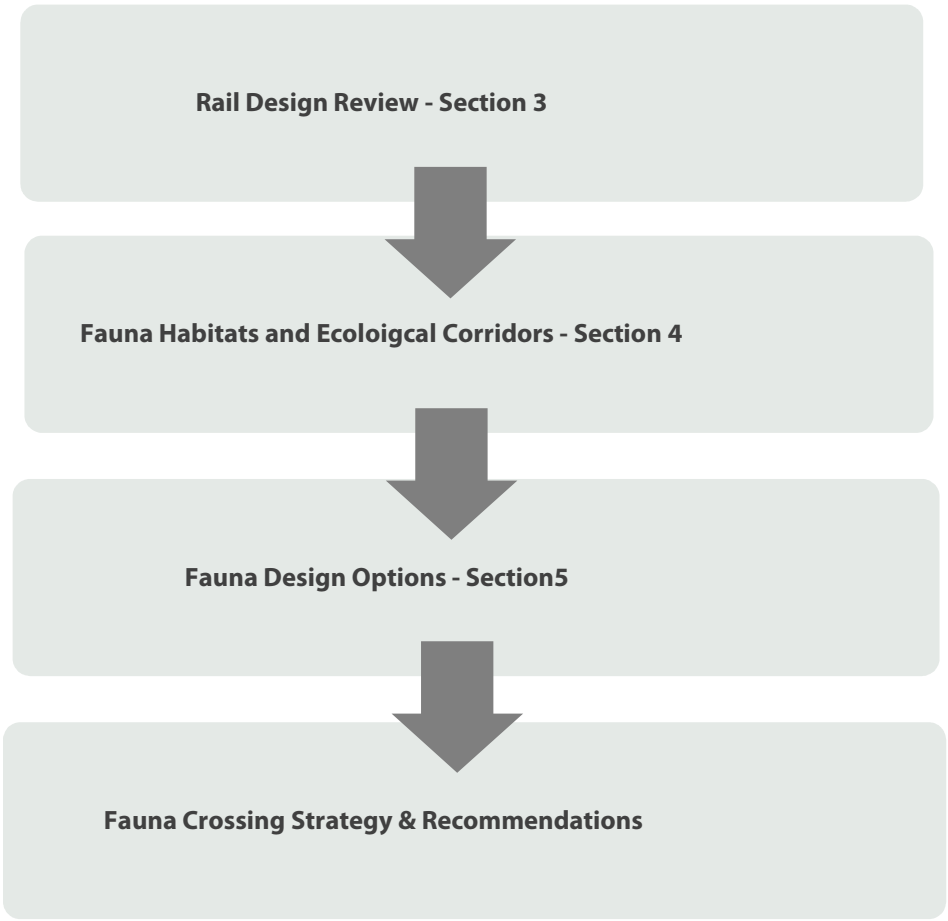
2. Fauna Crossing Strategy Overview

The proposed Carmichael Coal Project (Rail) SP-1 alignment minimises potential impacts on local protected flora and fauna communities primarily by avoidance. Where impacts are inevitable, due to the enormity of the project, mitigation strategies will be applied to promote cohesive integration between the alignment and surrounding ecological communities. Critical to this process is that the alignment maintains the ability for terrestrial fauna to disperse between local habitats and along corridor networks.

The Fauna Crossing Strategy was formulated in accordance with best practice methods outlined in the **Queensland Department of Transport and Main Roads** (DTMR) *Fauna Sensitive Road Design Volume 1: Past and Existing Practices* and *Fauna Sensitive Road Design Manual Volume 2: Preferred Practice*, and associated literature as referenced.

The process utilised to develop the fauna crossing strategy is summarised below and explained within the following sections.

Figure 1: Fauna Crossing Strategy Overview



3. Rail Design Review

3.1. Background

Integral to the formulation of this Fauna Crossing Strategy is an appreciation of the design requirements for the Carmichael Coal Project (Rail), including the various social, environmental and topographical constraints and opportunities.

The first stage of the Carmichael Coal Project (Rail) concept design development involved determining a suitable route for the Project (Rail) alignment. A 500 m wide corridor between the Mine and the connection with the Goonyella rail system was initially established to define the boundaries of the alignment. Upon confirmation of this route, more detailed design parameters and environmental analyses were undertaken and this corridor was reduced to a nominal 95 m wide corridor.

The design response to key environmental features has been developed in line with engineering constraints for a feasible Project (Rail) design. The Project (Rail) concept design is based on:

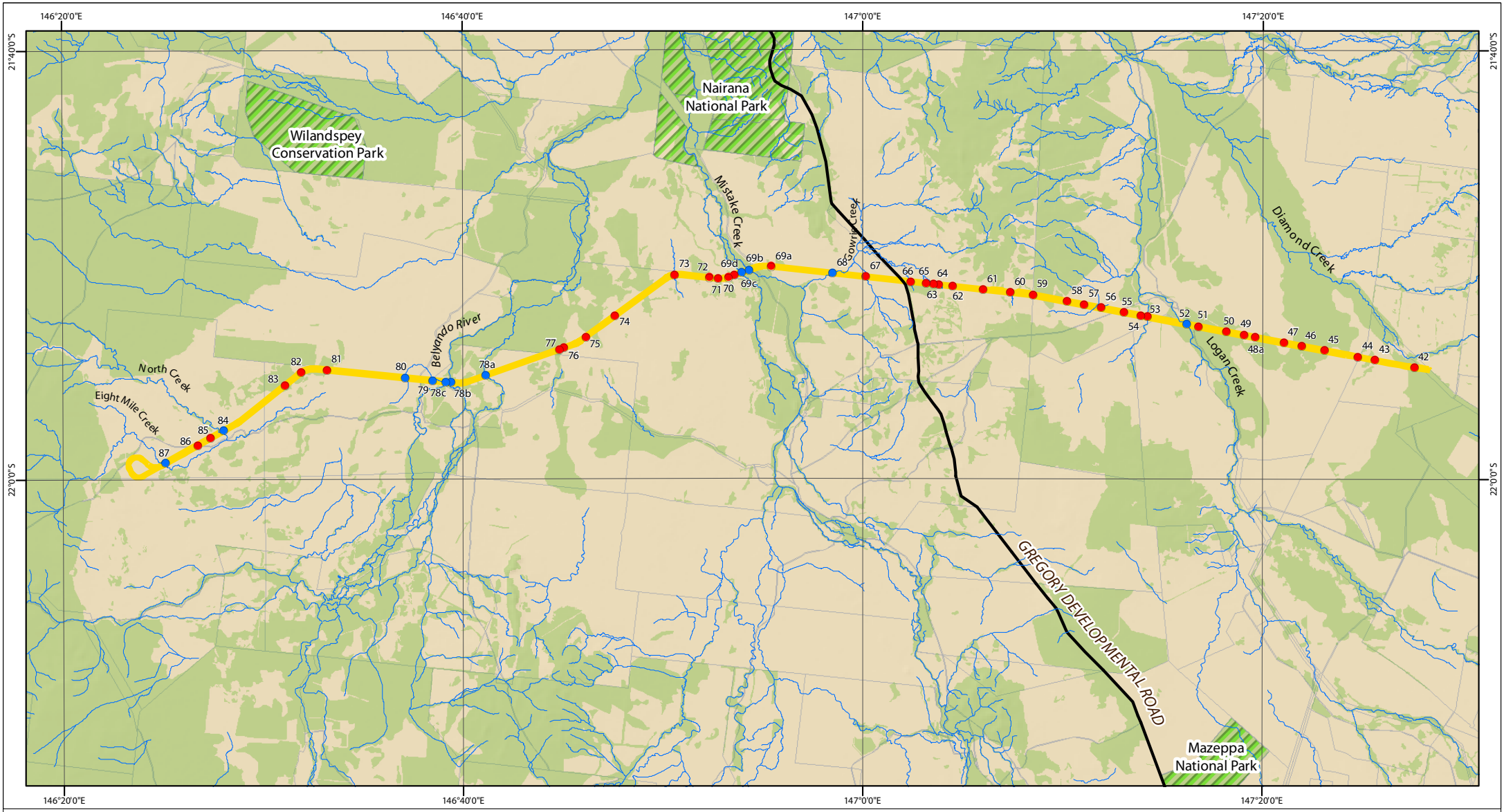
- Minimising environmental impact
- Minimising disturbance to existing infrastructure
- Limiting fragmentation of land holdings
- Meeting engineering design criteria

While all relevant environmental elements were considered and, where possible, negative impacts were avoided or minimised, the key environmental features that influence the engineering design are landform and hydrological conditions.

Of prime importance to the design process and this Fauna Crossing Strategy are the flood plains, especially those associated with the Belyando River, Mistake Creek, Logan Creek and Diamond Creek. These vegetated corridors form networks across the study site and are areas with the greatest opportunity to cater for fauna movement within the greater landscape. Crossing designs in these areas require formation levels that minimise the fill material required while satisfying hydrological requirements. These factors combined largely determine the fauna crossing potential of the SP-1 alignment.

3.2. Crossing Structures

Plan 2 and **Appendix A**, summarise crossing locations and structures along the SP-1 alignment. In addition a number of other crossing structures are required to provide access across the rail alignment and mitigate impacts to landholders. The combination of drainage and other crossing structures form the basis for this fauna crossing strategy.



Legend

- Major Roads
- Mapped Watercourse v2.1
- Rail Alignment Corridor (SP-1)
- QLD DCBD
- QLD Protected Area
- Mapped Remnant Vegetation

Fauna Crossing Assessment Sites

- Bridge Structure
- Culvert Structure

Layer Sources SP-1 Corridor, Crossing Locations (Adani Mining Pty Ltd 2012), DCDB, Major Roads, Towns (DNRM 2012), WWBW Waterways (DEHP 2013)

Plan 2 *Water Crossing Structures and Locations*

File ref. *6396 E 01 Fauna Crossings Context A*
Date *28/03/2013*
Project *Carmichael Coal Rail Project*

0 2 4 6 8 10 20 *km*

N

Scale (A4): 1:450,000 [GDA 1994 MGA Z55]

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4. Fauna Habitats & Ecological Corridors

4.1. Fauna Summary

Potential fauna utilisation of the study area was determined on review and summation of the fauna desktop and field studies presented in the **GHD** EIS report. The **Saunders Havill Group** undertook an extensive vegetation survey and mapping exercise across the 95 m wide alignment to confirm and, where required, rectify mapped REs. These RE mapping amendments were used to refine and update information presented within the **GHD** EIS report.

In addition, localised field observations at key impact points along the alignment were collated to inform decision making processes adopted within this Fauna Crossing Strategy. Detailed information summarising fauna habitats and potential threatened species occurrence is presented in **Appendix B**.

4.2. Defining Ecological Corridors

Ecological corridors are identified based on their role in:

- facilitating seasonal movement (migration);
- facilitating movement through highly modified landscapes and access to unexploited habitat;
- improving dispersal success;
- increasing the effective size of meta-populations by allowing for the exchange of genes between subpopulations;
- allowing colonisation of empty patches and preventing and reversing local extinction;
- providing habitat for resident populations; and
- maintaining landscape scale ecological and evolutionary processes along geological, hydrological, altitudinal and climatic gradients and providing for ecological responses to climate change.

A strategic corridor network should function effectively for a large range of species, especially threatened species. Corridor dimensionality (length / width), habitat type, quality and diversity, habitat patchiness within the corridor and potential edge effects are important aspects which determine corridor function.

Terrestrial bioregional corridors, in conjunction with large tracts of remnant vegetation, maintain ecological and evolutionary processes at a landscape scale, by:

- Maintaining long term evolutionary / genetic processes that allow the natural change in distributions of species and connectivity between populations of species over long periods of time;
- Maintaining landscape / ecosystems processes associated with geological, altitudinal and climatic gradients, to allow for ecological responses to climate change;
- Maintaining large scale seasonal / migratory species processes and movement of fauna;
- Maximising connectivity between large tracts / patches of remnant vegetation; and
- Identifying key areas for rehabilitation and offsets.

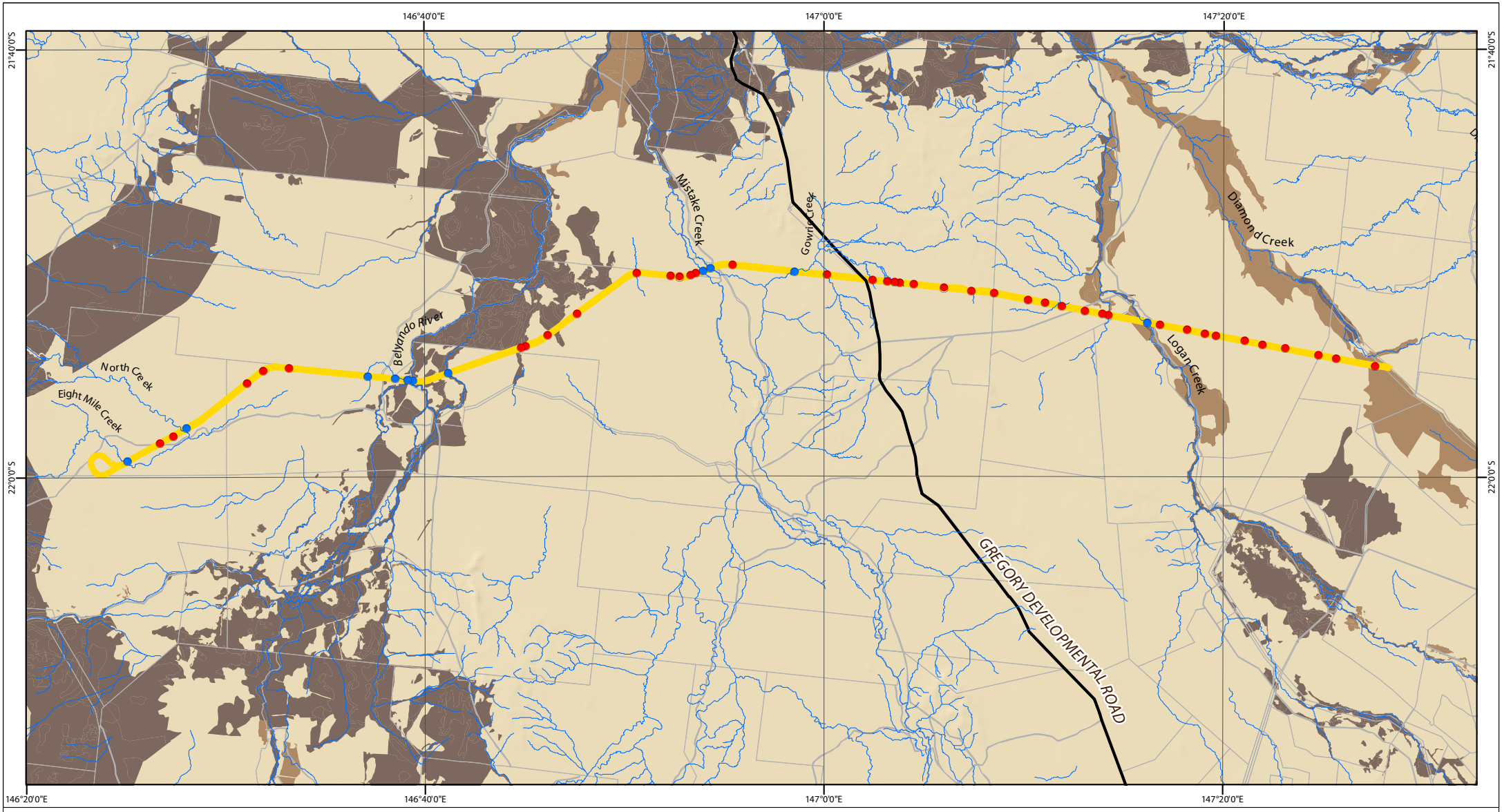
In landscape planning exercises the location of corridors is determined by the following principles:

- Complement riparian landscape corridors (i.e. minimise overlap and maximise connectivity);
- Follow major watershed / catchment and/or coastal boundaries;
- Incorporate major altitudinal / geological / climatic gradients;
- Include and maximise connectivity between large tracts / patches of remnant vegetation; and
- Include and maximise connectivity between remnant vegetation in good condition.

4.3. Biodiversity Assessment and Mapping Methodology

The Biodiversity Assessment and Mapping Methodology (BAMM) was developed by the **Department of Environment and Heritage Protection** (DEHP) to provide a consistent approach for assessing biodiversity values at the landscape scale in Queensland using vegetation mapping data generated or approved by the **Queensland Herbarium**. It has been used to generate Biodiversity Planning Assessments (BPAs) for bioregions in eastern Queensland under the most development pressure.

The mapping layers within BAMM were developed based on differing criteria that relate to ecological values of the landscape. Of most relevance to fauna connectivity across the proposed SP-1 alignment are Essential Criterion J – Corridors (**Plan 3**, next page) and Diagnostic Criterion G - Context & Connectivity (**Plan 4**, page 14). **Appendix C** provides further explanation of these Criteria.



Legend

- Major Roads
- Mapped Watercourse v2.1
- Rail Alignment Corridor (SP-1)
- QLD DCBD

Biodiversity Planning Assessment (J-Rating)
- Regional Corridor
- State Corridor

Fauna Crossing Assessment Sites
- Bridge Structure
- Culvert Structure

Plan 3 *Biodiversity Planning Assessement - State and Regional Mapped Corridors*

0 2 4 6 8 10 20 *km*

N

Scale (A4): 1:450,000 [GDA 1994 MGA Z55]

File ref. *6396 E 03 State / Regional Corridors A*
Date *28/03/2013*
Project *Carmichael Coal Rail Project*

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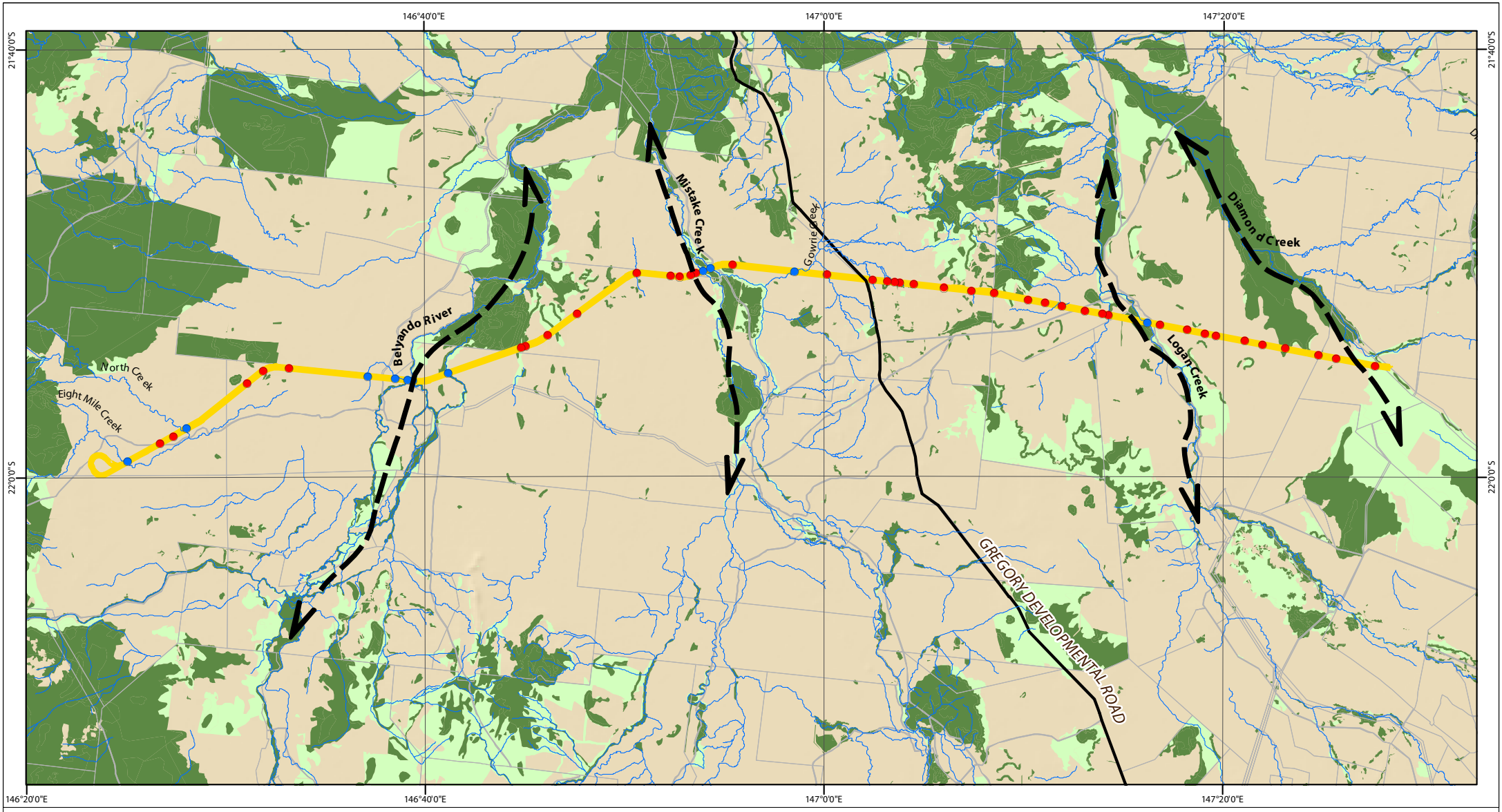
Layer Sources SP-1 Corridor, Crossing Locations (Adani Mining Pty Ltd 2012), DCDB, Major Roads, Towns (DNRM 2012), WWBW Waterways (DEHP 2013)



Legend

- Major Roads
- Mapped Watercourse v2.1
- Rail Alignment Corridor (SP-1)
- QLD DCBD

Biodiversty Planning Assessment (G-Rating)

- Very High
- High

Fauna Crossing Assessment Sites

- Bridge Structure
- Culvert Structure

Plan 4 *Biodiversity Planning Assessment - Context and Connectivity Rating*

0 2 4 6 8 10 20 *km*

Scale (A4): 1:450,000 [GDA 1994 MGA Z55]

N

File ref. *6396 E 04 Regional Landscape Corridors A*
Date *28/03/2013*
Project *Carmichael Coal Rail Project*

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Layer Sources SP-1 Corridor, Crossing Locations (Adani Mining Pty Ltd 2012), DCDB, Major Roads, Towns (DNRM 2012), WWBW Waterways (DEHP 2013)

5. Fauna Design Options

5.1. Impact mitigation

Rail or road corridors have the potential to negatively impact fauna in a number of ways:

- Loss, fragmentation and degradation of habitat
- Invasion by weeds, disease, pollution and feral fauna
- Disturbance due to vehicular movement
- Fauna mortality due to collisions
- Movement barriers
- Changed microclimatic conditions
- Establishment of funnel points for concentrated predator attack

These impacts can be effectively mitigated via application of a Fauna Crossing Strategy. The objectives of a fauna sensitive rail alignment design might include:

- Avoidance of environmentally sensitive areas where possible
- Amalgamation of fauna impact issues
- Mitigation goals
- Design mitigation structures to suit the widest range of fauna possible
- Conduct targeted research
- Monitoring and management
- Maintenance

The following information outlines the various mitigation strategies, design considerations and guidelines which underpin the principles adopted within the fauna crossing strategy and associated recommendations.

Table 1: Impact Mitigation Strategy

	Avoidance	Impact issues	Mitigation	Research	Design	Management	Maintenance
Habitat	Habitat fragmentation avoided where possible will inevitably occur due to the size of the rail corridor	Fragmentation issues include habitat reduction, loss of migratory channels, loss of genetic diversity	Ensure crossings located in Regional Ecosystem corridors and other significant habitats permit fauna dispersal	Discern habitat types and the fauna they support along the rail corridor	Design crossings to suit local fauna passage	Ensure suitable crossings are designed and constructed	Instigate an inspection and maintenance procedure to ensure fauna crossings remain viable
Invasion	Habitat modification and pollution may encourage feral species but are unavoidable	Resident and invasive feral species may displace or deplete indigenous species	Ensure crossings do not promote invasive predator and competitor advantage	Discern habitat types and the native and feral fauna they support along the rail corridor	Incorporate safe passage for native fauna in crossing designs that do not favour feral species dispersal	Ensure suitable crossings are designed and constructed	Instigate an inspection and maintenance procedure to ensure fauna crossings remain viable
Disturbance	Vehicular movement and associated disturbances are unavoidable	Noise, vibration and light pollution may inhibit fauna activity	Ensure crossings allow fauna to safely flee from approaching vehicles	Investigate avoidance characteristics of local fauna species	Design crossings to allow disturbance avoidance by local fauna	Ensure suitable crossings are designed and constructed	Instigate an inspection and maintenance procedure to ensure fauna crossings remain viable
Mortality	Fauna mortality is inevitable where there is vehicular movement	Fauna may be killed or injured by moving vehicles	Minimise fauna injury and mortality by encouraging the utilisation of specifically designed fauna crossings	Investigate the suitability to local fauna of crossing embellishments intended to minimise mortality	Incorporate structures in crossing design that encourage safe passage by fauna	Ensure suitable crossings are designed and constructed	Instigate an inspection and maintenance procedure to ensure fauna crossings remain viable

	Avoidance	Impact issues	Mitigation	Research	Design	Management	Maintenance
Barriers	The rail corridor potentially forms a barrier to terrestrial fauna dispersal	Barriers inhibit local dispersal which may be essential to fauna for survival	Reduce barrier impacts by incorporating specially designed fauna crossings	Discern habitat types and the fauna they support along the rail corridor	Design crossings to suit local fauna passage	Ensure suitable crossings are designed and constructed	Instigate an inspection and maintenance procedure to ensure fauna crossings remain viable
Microclimate	Impact on habitat microclimate is unavoidable	Habitat may be degraded such that microclimates are no longer suitable for fauna habitation and dispersal	Ensure crossings incorporate structures that sustain suitable microclimatic conditions for fauna dispersal	Discern habitat types, the fauna they support and their microclimatic requirements along the rail corridor	Design crossings to maintain microclimate and suit local fauna passage	Ensure suitable crossings are designed and constructed	Instigate an inspection and maintenance procedure to ensure fauna crossings remain viable

5.2. Design considerations

5.2.1 Crossing designs

The **Department of Transport and Main Roads** (DTMR) provide a tool to analyse crossing structure options that may cater to species identified during fauna surveys. In their manual, DTMR provide a suitability assessment of the different fauna crossing structures for different species or groups of species. **Table 2** specifically focuses on the suitability of different structures for the fauna likely to occur on site (See **Appendix B** for fauna details).

Table 2: Structure Suitability

		Frogs	Reptiles	Mammals: macropods	Mammals: koala	Mammals: small
Fauna Crossing Structure	Land bridge	✓	✓	✓	✓	✓
	Small Roads	✓	✓	✓	✓	✓
	Canopy bridge	×	×	×	×	×
	Poles	×	×	✓	✓	✓
	Culvert	✓	✓	✓	✓	✓
	Tunnel	✓	✓	×	✓	✓
	Passage below bridge	✓	✓	✓	✓	✓
	Canopy connectivity	✓	×	×	×	×
Additional measures	Local traffic management	×	×	✓	✓	✓
	Fencing	✓	×	✓	✓	✓
	Chemical repellents	×	×	?	?	?

✓ - optimal solution ✓ - can be used with some adaption to local conditions × unsuitable ? unknown

The SP-1 alignment traverses a floodplain, and so, has extensive water crossings at regular intervals which may be utilised by local fauna. The majority of crossings along the alignment will be bridges and/or multi-cell pipe culverts. Bridges are most desirable for fauna crossings, and form the crux of fauna crossing strategies.

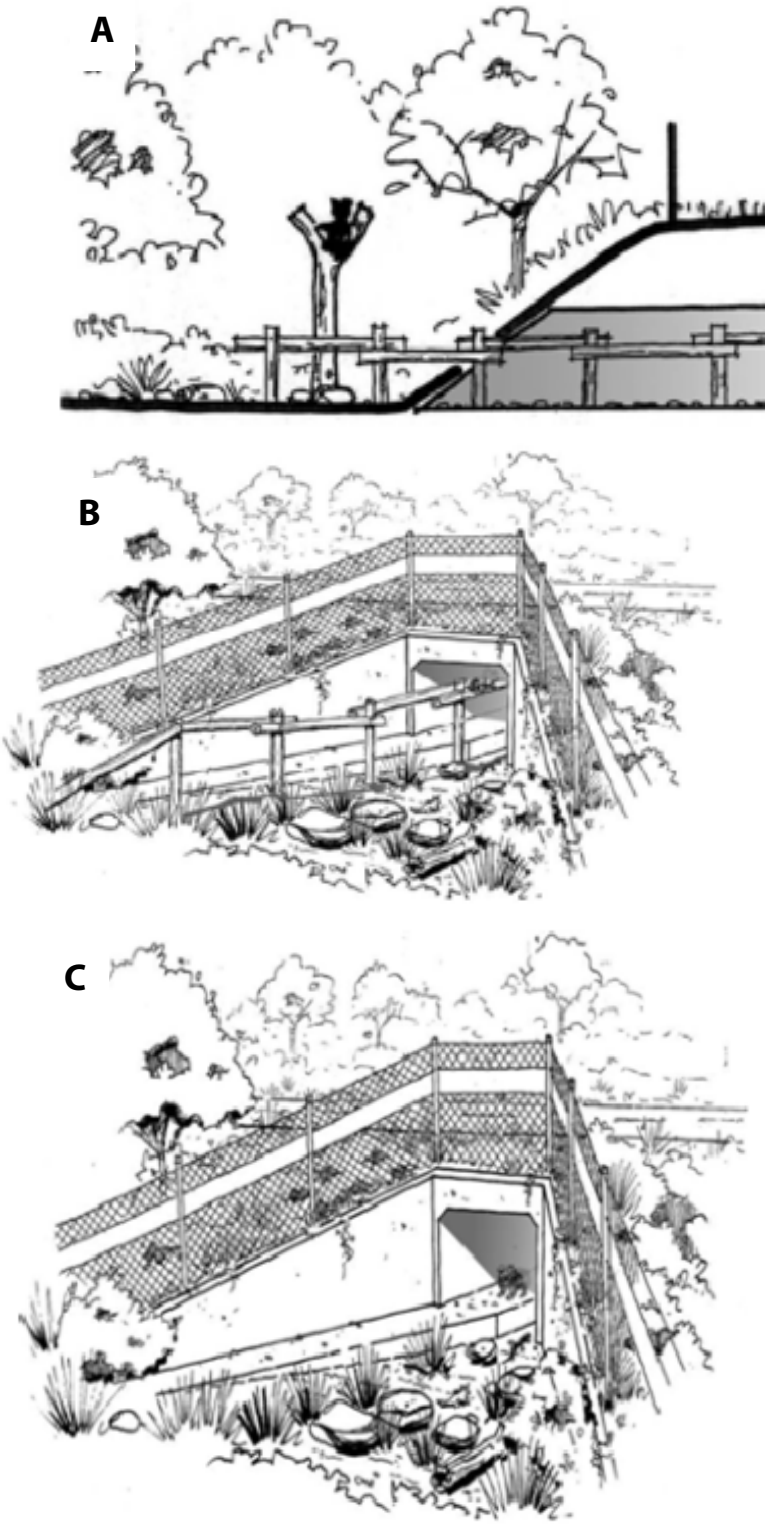
5.3. Fauna Crossing Guidelines

The following crossing structure design considerations, including figures, modified from DTMR (2010) were used in this strategy. These fauna crossing guidelines list various measures that may be adopted at any crossing location to enhance connectivity for target fauna. Linked to these measures is extensive research including case studies for specific fauna.

Table 3: Fauna crossing guidelines

Location	Locate crossings at regular intervals adjoining natural habitat, which must be clearly visible from within
	Should be sufficient in number to allow escape crossings e.g. during fire or flood
	Crossing openings must be obvious and unobstructed
	Avoid lighting nearby and within crossings, and artificial disturbance
	Situate so as not to cause pooling in the waterway
Structure	Minimum gradient of 1% and maximum gradient of 1:2 (depending on target species)
	Design to fauna requirements e.g. long narrow culverts deter macropods
	Concrete floors acceptable for echidnas, wallabies, kangaroos, possums and water rats, but not koalas
	Sedimentation provides a natural substrate
	Avoid skylights as they promote excess runoff and noise which deter fauna
	Several underpasses provide choice for predator evasion
Size	Openings where height is less than the width are preferred by fauna
	Openings ≥ 1.5 m diametre suit most mammals
	Macropods and semi-arboreal mammals, such as koalas, prefer ≥ 3 X 3 m openings
Furniture	Refuge poles (3 m tall and 200 mm diametre) (Figure 2, **A**) are effective for predator avoidance
	Interconnecting logs (Figure 2, **B**) placed high but ≤ 0.6 m from the ceiling provide dry passage
	Ledges with approach gradients ≥ 1:5 in the top 2/3 of the crossing are favoured by small fauna (Figure 2, **C**)
	Overlapping rocks, logs, tiles and mulch provide cover from predators and food habitat for small fauna
Vegetation	Provides forest structure to cater for fauna needs e.g. palatable grasses, shrubs and/or trees
	Provides cover for access to, and viewing of, crossing openings (Figure 2)
	Provides a continuum of habitat to crossing openings
Fencing	Protects fauna from predators, pests and disturbance
	Must not trap fauna, especially during fire
	Effectively funnels fauna into crossings
	Conventional fencing is inadequate for small fauna, which require more suitable wire-mesh size
Management	Ensure vegetation establishes
	Ensure vegetation consists of diverse species and heights where necessary
	Control weeds and silt build up
	Maintenance should occur at least once a fortnight during construction and be ongoing
	Maintain furniture
	Undertake regular inspection of entrances to ensure fauna access is viable

Figure 2: **Culvert designs**



6. Fauna Crossing Strategy

The principles for defining corridors listed in **Section 4.2** and BAMM overlays in **Section 4.3** were considered when reviewing the hierarchy of corridors within the landscape surrounding the project area. In addition, remnant vegetation mapping and potential fauna utilisation of the study area were considered to obtain an understanding of target fauna utilising these corridors and other habitats.

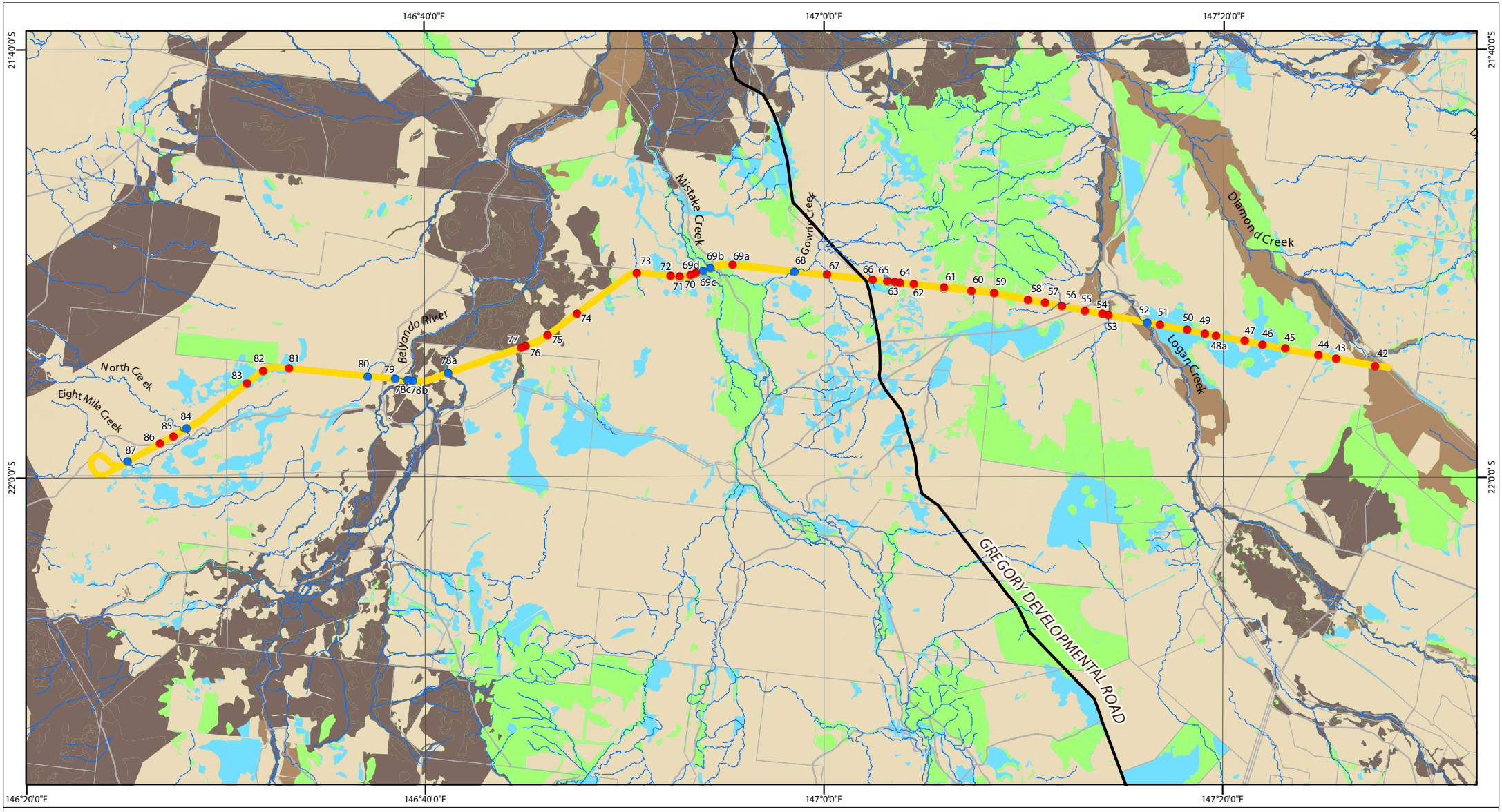
In the context of the SP1 alignment, the following hierarchy was adopted when considering the importance of an area from a fauna habitat and connectivity perspective (Refer **Table 4**). **Plan 5** summarises the location of crossing structures in relation to state corridors, regional corridors and other corridors and habitats.

Table 4 – Fauna Crossing Strategy Hierarchy

Feature	Description	Priority
State Corridors	Highest priority corridors that provide for fauna dispersal through the broader landscape. Areas contain high biodiversity values and potential habitats for listed species	**Highest** ↓
Regional Corridors	Priority corridors that provide movement opportunities through the landscape and connect to State Corridors. Areas contain high biodiversity values and potential habitat for listed fauna species.	
Other Corridors and habitats	Local Corridors: areas of very high to high context and connectivity with linkages to State and Regional Corridors. May provide habitat for listed fauna species.	
	Low Value Corridors: regrowth and isolated remnants generally associated with drainage features. Limited potential to provide habitat for listed fauna species	
	Fragmented / Isolated Remnants.	**Lowest**

The above hierarchy was applied to review crossing structures along the SP1 alignment and develop fauna impact and mitigation strategies (Refer principles established within **Section 5** – Fauna Design Strategy). As the hierarchy suggests, greater preference is given to mitigation strategies within high priority areas (State Corridors) as opposed to low priority areas (fragmented/isolated remnants).

Sections 7 to 10 of this document outline the proposed fauna crossing strategy that will be adopted within each of the State Corridor, Regional Corridor and Other Corridor and Habitat areas.



Legend

- Major Roads
- Mapped Watercourse v2.1
- Rail Alignment Corridor (SP-1)
- QLD DCBD

Biodiversity Planning Assessment (J-Rating)
- State Corridor
- Regional Corridor

Biodiversity Planning Assessment (G-Rating)
- Very High & High (Other Corridors)

Mapped Remnant Vegetation
- Fragmented / Isolated Remnant Vegetation

Fauna Crossing Assessment Sites
- Bridge Structure
- Culvert Structure

Layer Sources SP-1 Corridor, Crossing Locations (Adani Mining Pty Ltd 2012), DCDB, Major Roads, Towns (DNRM 2012), BPA (DEHP 2013)

Plan 5 *Corridors and Fragmented / Isolated Remnants*

File ref. 6396 E 05 Corridor Mapping Hierarchy A
Date 28/03/2013
Project Carmichael Coal Rail Project

0 2 4 6 8 10 20 km

Scale (A4): 1:450,000 [GDA 1994 MGA Z55]

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7. Belyando River State Corridor

7.1. Existing Environment

The Belyando River State Corridor can be divided into two sections including:

- Oogenbeena Creek / Belyando River (crossings 80-78a); and
- Remnants to the east of the State Corridor intersected by the rail alignment (crossings 77-74)

7.1.1 Crossings 80 – 78a

Ogenbeena Creek and the Belyando River form part of a BAMM State Corridor that connects vegetation in the South to extensive areas of vegetation in the North associated with both Wilandspey Conservation Park and Nairana National Park (Refer **Plan 5**).

Vegetation within this corridor that adjoins the SP-1 alignment is consistent with Regional Ecosystems 11.3.3, 11.3.25 and 11.3.37, with *Eucalyptus coolabah* and *Eucalyptus camaldulensis* co-dominant canopy species throughout. Few shrubs occur in this area with native and introduced grass species recorded within the ground layer. It is noted that no Brigalow communities consistent with RE 11.3.1 are present within this area of the SP-1 alignment (Refer to SHG document *Property Map of Assessable Vegetation - Carmichael Coal Rail Project - Separable Portion 1*, hereafter the PMAV).

As per the Fauna Summary and Habitat Mapping (**Appendix B**) a number of listed fauna have the potential to occur within with Belyando River State Corridor. These species include:

- Ornamental snake, *Denisonia maculata*
- Yakka skink, *Egernia rugosa*
- Brigalow scaly-foot, *Paradelma orientalis*
- Northern quoll, *Dasyurus hallucatus*
- Koala, *Phascolarctos cinereus*

It is noted that none of these species were observed during assessments conducted as part of the **GHD** Carmichael Coal Project EIS (see **Appendix B Table B3**). Their potential presence is based on cross reference between REs preferred as habitat by each species and relevant RE mapping layers at the location of disturbance.

Supporting the area's status as a mapped State Corridor, remnants adjoining the Belyando River are of relatively high quality displaying few signs of negative impacts and fragmentation relative to other areas along the SP-1 alignment. Field surveys associated with local PMAV and waterway assessments noted a number of hollow bearing trees providing additional habitat complexity.

Photo: Belyando River with fringing vegetation

Photo: Typical tree bearing hollows within Belyando River corridor

7.1.2 Crossings 77-74

East of the Belyando River, the SP-1 alignment extends along the southeastern boundary of the broader remnant polygon and intersects with areas containing a mixture of Endangered RE 11.3.1 / 11.3.5, Of Concern RE 11.3.3 and Of Concern RE 11.4.6 (**Appendix B**). PMAV assessments at these locations identified a variety of historical disturbances typically associated with agricultural land uses, which have resulted in a disturbed canopy and ground layer dominated by Buffel grass (*Pennisetum ciliare*) and other non-native grass species.

Together, these REs form a mixture of habitat types broadly identified as potentially suitable for listed threatened species, including the Ornamental Snake, Yakka Skink and Koala (**Appendix B**). With respect to the Koala, habitats closely associated with the riparian corridor of the Belyando River are seen to provide greater potential for habitation and dispersal.

***Photo: Example of Of Concern RE 11.4.6 containing* Acacia harpophylla *and* Acacia cambagei**

***Photo: Example of Endagered RE 11.3.1 dominated by* Acacia harpophylla.**

7.2. Crossing Structures

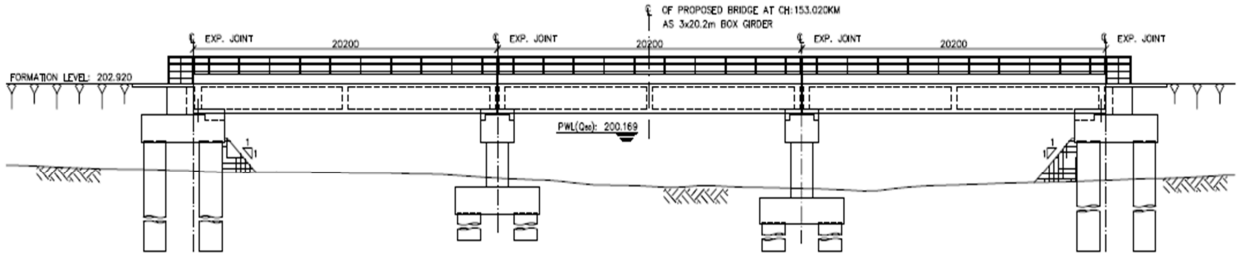
Approximately 1 km of fauna-permeable crossing structures are proposed to span the Belyando River State Corridor where it is crossed by the SP-1 alignment (**Table 5**). The alignment design through this corridor gave preference to bridge structures to cater for both hydraulic requirements and maximum fauna connectivity. As demonstrated in **Plan 5**, the major bridge structures (**Figure 3**) are proposed within core habitats immediately adjoining the Belyando River. These crossing structures range from 3 to 6 m in height and are capable of providing fauna connectivity for all likely fauna species (Refer to **Section 5**).

Where the alignment extends East of the Belyando River State Corridor it traverses the edge of remnants. This design approach has minimized impacts to and severing of remnant vegetation. At these locations the formation level of the rail alignment is relatively low due to natural variations in topography. As such, local crossing structures are limited to culverts with a diametre of approximately 1 m (Refer to **Table 5** Crossing Numbers 77 to 74).

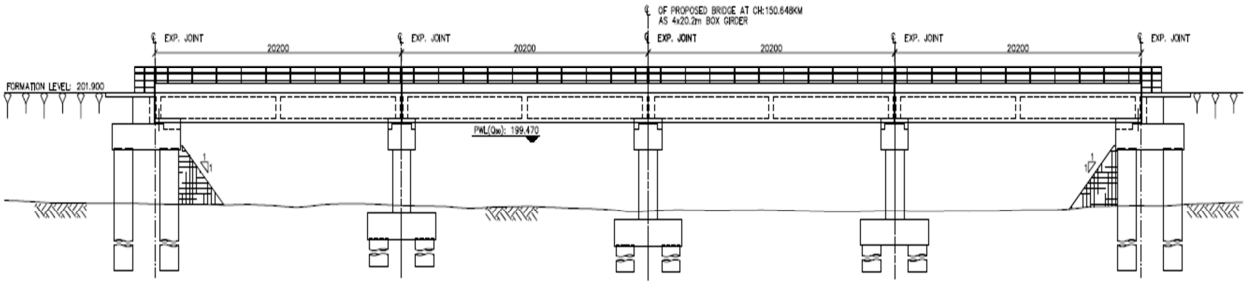
Table 5: Crossing Structures Associated with Belyando River State Corridor

Number	Name	Height (m)	Length (m)	Type
80	Ogenbeena Creek	3	132	Bridge (4 x 15 m Span) and Drainage Structure
79	Ogenbeena Creek (lower crossing)	3	133	Bridge (4 x 15 m Span) and Drainage Structure
78c	Belyando River Tributary	6	310.6	Bridge (10 x 20 m Span) and Drainage Structure
78b	Belyando River			
78a	Belyando River East Tributary			
77	-	1	222	Major drainage structure
76	-	1	33	Drainage structure
75	-	1	13	Drainage structure
74	-	1	149	Drainage structure

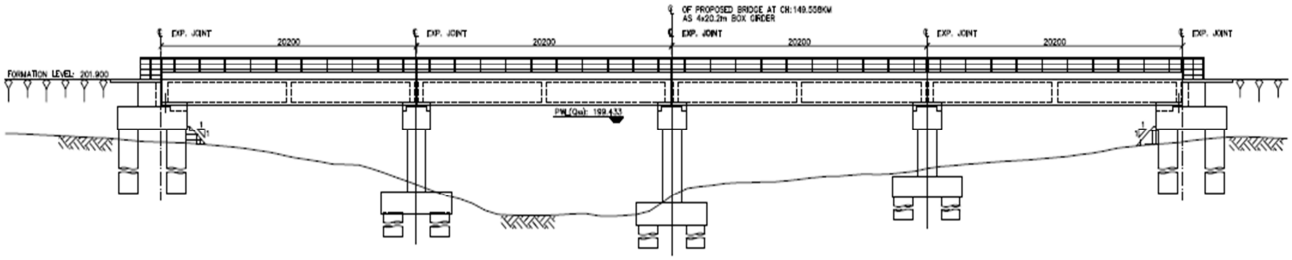
Figure 3: Belyando River State Corridor Bridge Structures



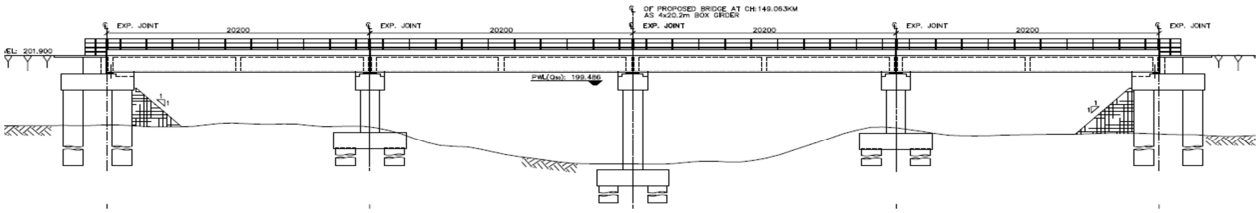
Ogenbeena Creek (Crossing 80)



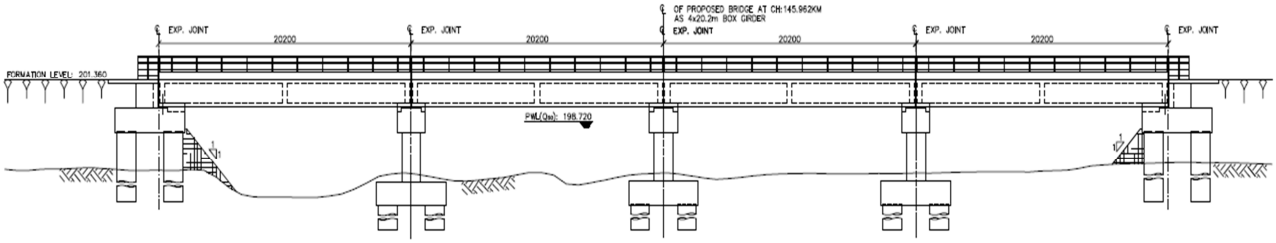
Ogenbeena Creek (Lower - Crossing 79)



Belyando River (Crossing 78c)



Belyando River (Crossing 78b)



To Carmichael Mine (West)

Belyando River (Crossing 78a)

7.3. Impacts & Recommendations

Total avoidance of negative impacts on fauna connectivity is not practical where the alignment crosses the Belyando State Corridor. The impact potential has largely been minimised by the use of bridge structures within core remnants immediately adjoining the Belyando River. These bridge structures alone cover a distance in excess of 300 m and range between 3 and 6 m in height. Additional sets of culverts adjoin these bridge structures and provide extended permeability and movement options for dispersing fauna.

The relative extent of bridge and culvert structures maintains permeability under most conditions, except in times of extreme flood (Q100 events) (Refer to *Carmichael Coal Mine and Rail Project EIS - Volume 3 Section 6 Water Resources*). However, fauna dispersal along the Belyando State Corridor would largely cease during such events with fauna either escaping to higher ground or sheltering within vegetation. The alignment design is not seen as an impediment to fauna dispersal during such conditions.

Minor impacts on fauna connectivity are likely within disturbed remnants located to the East of the Belyando State Corridor. However, it is noted that the alignment has been orientated to the edge of these remnant areas to reduce fragmentation. Based on the degraded nature of these areas and proximity of the alignment to remnant polygons, the potential impact is considered minimal. Culvert structures proposed within these locations provide some opportunity to retain connectivity. In addition, the lower formation level within these areas is likely to allow dispersal of some fauna directly over the rail infrastructure.

Overall the alignment will have limited impact on fauna dispersal along the Belyando State Corridor. Recommendations for this location are focused on:

1. Reducing impacts to fauna during construction;
2. Implementing effective rehabilitation strategies to maximise connectivity and fauna usage of crossing structures; and
3. Minimising the width of the disturbance zone.

8. Logan Creek State / Regional Corridor

8.1. Existing Environment

Logan Creek forms part of a relatively disturbed and fragmented mapped State and Regional Corridor situated toward the eastern end of the SP-1 alignment. Site vegetation assessment identified the western bank of Logan Creek as dominated by fringing Of Concern RE 11.3.3, described as *Eucalyptus coolabah* woodland with a grassy understory. The adjoining community is consistent with Of Concern RE 11.4.6, with a relatively low canopy layer dominated by *Acacia cambagei*. The change in vegetation communities corresponds with a change in elevation and therefore Land Zone type.

Large sections of the eastern bank of Logan Creek are disturbed by intensive agriculture. This expansive water body is formed by a weir structure that is located approximately 8 km downstream of the proposed bridge crossing.

Other plant species observed at the site include *Geijera parviflora, Acacia salicina, Eremophila bigoniiflora, Eremophila mitchellii, Carissa ovata, Pennisetum ciliare, Parthenium hysterophorus, Terminalia oblongata, Dichanthium sericeum, Leptochloa digitata* and *Cyperus exaltatus*.

Substantial aquatic habitats in the form of submerged logs and macrophytes are present. Numerous avifauna were observed utilising this watercourse, including Duck, Cormorant, Heron and Ibis species.

Photo: Mapped remnant polygon of Of Concern RE 11.3.3. **Pennisetum ciliare** ***dominant within ground layer***

Photo: Mapped remnant polygon of Of Concern RE 11.4.6. Note dominance of* Acacia cambagei *within T1 and T2 layers with Pennisetum ciliare within ground layer.

Photo: Logan Creek

As per the fauna summary (**Appendix B**) the following listed fauna species have the potential to occur within with Logan Creek State / Regional Corridor:

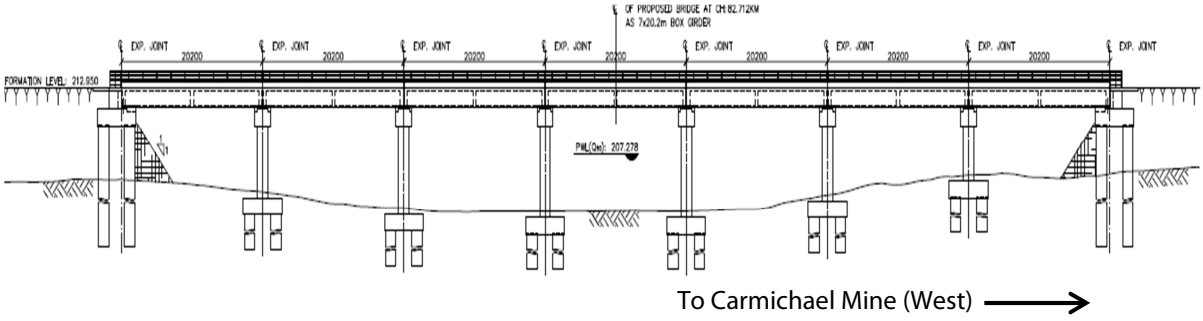
- Ornamental snake, *Denisonia maculata*
- Yakka skink, *Egernia rugosa*
- *Dunmall's snake, Furina dunmali*
- Brigalow scaly-foot, *Paradelma orientalis*
- Koala, *Phascolarctos cinereus*

It is noted that none of these species were observed within this location during assessments conducted as part of the **GHD** Carmichael Coal Project EIS (see **Appendix B Table B3**). Their potential presence is based on cross reference between REs preferred as habitat by each species and relevant RE mapping layers at the proposed crossing location.

8.2. Crossing Structure

A major bridge structure is proposed within the Logan Creek corridor. As detailed within **Figure 4**, most of this crossing structure is required to span the extensive water body formed by the downstream weir. Approximately 60 m of unobstructed permeability with a height of approximately 7m provides ongoing opportunity for terrestrial fauna passage on both banks.

Figure 4: **Logan Creek (Crossing 52)**



8.3. Impacts & Recommendations

Unlike the Belyando River State Corridor, crossing opportunities adjoining the Logan Creek State/Regional Corridor are constrained by topography. It is therefore imperative that this crossing structure facilitates the primary fauna passage.

With regard to existing habitats, the western bank of Logan Creek is more intact, including *Eucalyptus* woodland and *Acacia* forest. The bridge orientation of the structure has been located to align with these vegetated areas providing greater connectivity between existing habitat.

Key recommendations associated with the Logan Creek crossing relate to the reinstatement of microhabitat conditions post construction. The height of the bridge structure (approximately 7m) will allow targeted revegetation and reinstatement of ground and shrub layer species. In addition the placement of logs, hollows and other habitat features salvaged during clearing operations will assist in maximizing fauna dispersal opportunities.

Overall the design is considered to sufficiently cater for fauna movement.

9. Diamond Creek Regional Corridor

9.1. Existing Environment

The BAMM mapped Regional Corridor associated with Diamond Creek extends beyond the defined upper limit of the waterway itself, connecting to High Value remnants mapped by BAMM Criterion G (**Plan 5**). These remnant areas form an alluvial flood plain characterised by *Eucalyptus coolabah* dominated woodland with a native and introduced pasture grass understory.

Photo: Eucalyptus coolabah dominated canopy within mapped RE 11.3.3/11.4.11

As per the Fauna Summary (**Appendix B**) the following listed fauna species have the potential to occur within this area:

- Ornamental snake, *Denisonia maculata*
- Yakka skink, *Egernia rugosa*
- Koala, *Phascolarctos cinereus*

It is noted that vegetation within this location has been historically cleared and is consistent with maturing regrowth (see PMAV). When compared to similar habitats adjoining the Belyando River, this area displays less structural complexity and fauna diversity. As such, this area is considered to be of secondary importance from a biodiversity perspective than the mapped State Corridor associated with the Belyando River. These higher levels of disturbance also limit potential occurrence of the above listed fauna.

9.2. Crossing Structure

The Diamond Creek Regional Corridor is located within the upper limits of an alluvial floodplain and as such the formation level of the rail alignment is relatively low through this section (approximate embankment height 2.2 m). A series of 1 m diameter pipe culverts 12 m in length is currently proposed for this crossing.

9.3. Impacts & Recommendations

The current rail design across Diamond Creek Regional corridor provides limited opportunity for unimpeded fauna movement. Large and highly mobile fauna are likely to cross the rail formation in areas where the embankment height is lower. In addition, the proposed culvert structure will provide some opportunity for small mammal and reptile species to cross.

10. Other Corridors

10.1. Mistake Creek Local Corridor

The Mistake Creek Local Corridor is situated toward the centre of the SP-1 alignment and is approximately 20 km South of the Nairana National Park within an extensive floodplain (**Plan 5**). The area is not recognized as a State or Regional Corridor, however, is mapped as containing Criteria G (Very High and High) habitats connectivity by BAMM mapping. As such, the Mistake Creek Local Corridor is considered to provide for fauna dispersal and movement within the broader landscape.

Photo: Mistake Creek

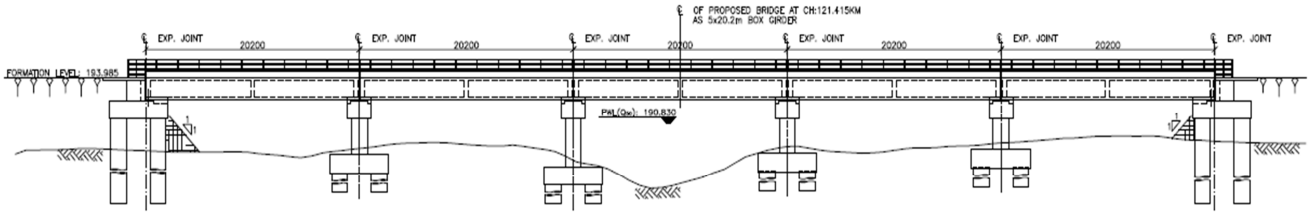
The section of the alignment that traverses the landscape surrounding Mistake Creek includes crossings 73 to 67 (**Plan 5**). Two Bridge Structures (69c & 69b) are proposed for this location, along with a number of culvert structures associated with crossings 70, 69d and 69a (**Plan 2**). A variety of fauna has the potential to utilise this area and, due to its robust width and location within a relatively degraded agricultural area, Mistake Creek provides an important corridor for fauna dispersal. Due to their location within a large flood plain, bridge structures require 3m of clearance, and so, are considered to cater for the types of fauna likely to utilise this corridor.

Crossing structures 73 to 71 include a series of culverts predominantly located within disturbed agricultural settings associated with local drainage features. The area was assessed as relatively insignificant from a fauna

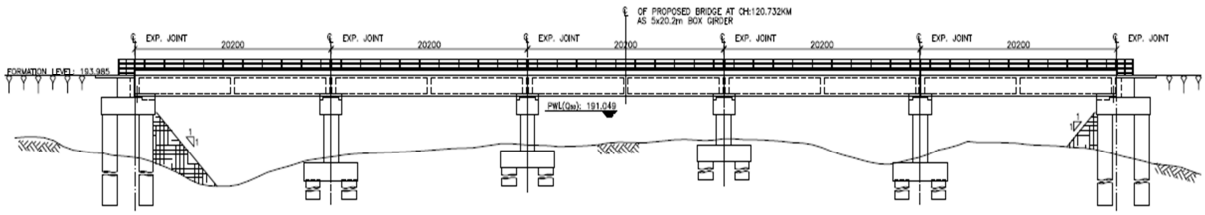
connectivity perspective. However proposed drainage features within this location may provide secondary local connectivity for small reptile and mammal species.

Overall the proposed drainage structure networks associated with Mistake Creek will provide multiple crossing options for the full array of fauna considered likely to utilise this corridor. Targeted rehabilitation plans that consider a range of micro climate features to promote fauna passage use will further enhance connectivity.

Figure 5: Mistake Creek Local Corridor



Mistake Creek Anabranch (Crossing 69c)



To Carmichael Mine (West) ⟶

Mistake Creek (Crossing 69b)

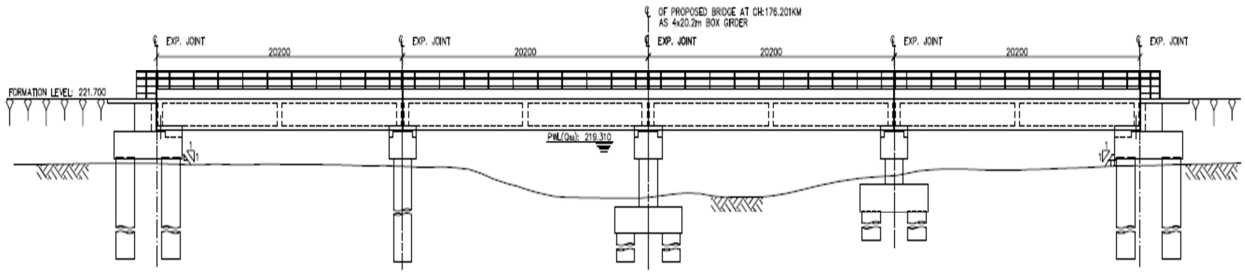
10.2. Low Value Corridors

Non-remnant waterways and drainage lines cross the SP-1 alignment at regular intervals. The more significant of these, such as Eight Mile Creek (Crossing 87), North Creek (Crossing 84) and Gowrie Creek (Crossing 68) have proposed bridge structures with a formation height of 1 to 2m (**Figure 6**). These locations generally retain a relatively disturbed riparian zone impacted by agricultural practices. It is anticipated that proposed structures within this existing disturbed environment will continue to support ongoing fauna dispersal. No other recommendations are proposed for these lower priority areas.

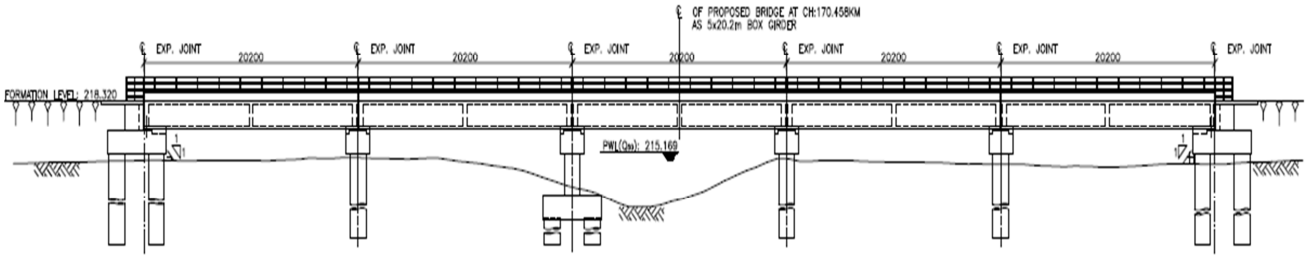
Photo: North Creek

Photo: Gowrie Creek

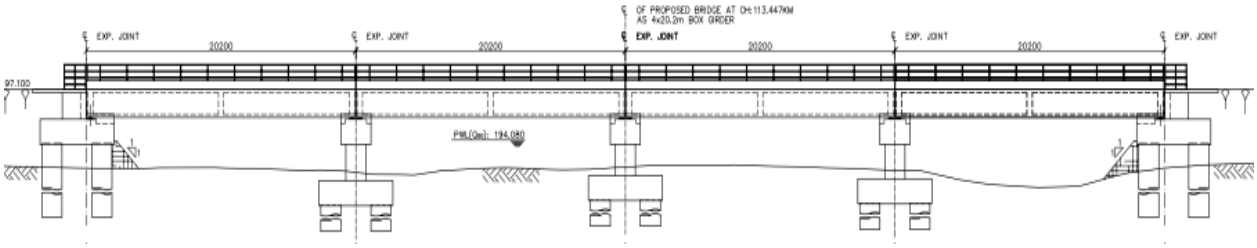
Figure 6: Low Value Corridor Bridges



Eight Mile Creek (Crossing 87)



North Creek (Crossing 84)



Gowrie Creek (Crossing 68)

10.3. Fragmented / Isolated Remnants

Interspersed between mapped corridors are expansive alluvial flood plains characterised by gilgais and occasional minor drainage depressions. Culvert structures are planned at regular intervals along these areas as described in **Appendix A**. Some of these locations coincide with isolated fragments of remnant vegetation. Small reptile and mammal species (which account for the majority of species expected to utilise these areas) have the potential to utilise culvert structures to cross the alignment. Other anticipated species in these locations are considered capable of traversing across or over the rail alignment

Photo: The area mapped as remnant grassland RE11.4.11 within the investigation area is dominated by* Pennisetum ciliare *(Buffel grass)

In a few locations, the alignment crosses isolated remnant polygons where crossing structures are not currently planned (**Plan 5**). The majority of these remnant areas have been assessed as demonstrating higher levels of disturbance caused from their isolation and ongoing agricultural practices.

It is noted that the rail alignment has been orientated to reduce impacts to these isolated remnant areas by orientating the alignment to the edge of polygons. This approach has minimized fragmentation and restricted disturbance to areas already impacted by ongoing land use practices and associated edge effects.

Where possible, consideration should be given to co-aligning the requirement for other (non-fauna related) crossing structures in these locations. However preferential treatment should be provided to higher priority areas as per the Fauna Crossing Strategy hierarchy (**Section 6**)

II. Recommendations

The following is a summation of recommendations to encourage fauna return to, and utilisation of, crossing structures for safe passage along the SP-1 alignment. These recommendations were formulated in part following review of Brennan et al. (2005) *Innovative Techniques for Promoting Fauna Return to Rehabilitated Sites Following Mining* (Australian Centre for Minerals Extension Research, Brisbane) and information provided in **Section 6**.

It is important to note that almost all crossings along the SP-1 alignment will remain predominantly dry due to broader landscape topography and the prevailing regional climate, which will permit almost continual fauna passage unobstructed by water bodies. Infrequent wet periods usually result in localised and regional flooding at which time fauna dispersal through water crossings along the SP-1 alignment seems unlikely as escape paths lead to higher ground.

II.I. General

1. Where possible, the rail design has attempted to avoid landscape corridors and important habitat areas. This was implemented during the concept design process.
2. Where fauna connectivity is impacted, a range of mitigation measures have been identified and incorporated into the design. This includes the appropriate selection of bridge structures within major corridors.
3. This report demonstrates that in most instances the alignment design has the potential to cater for fauna dispersal requirements, either through the current design or via a series of embellishments which will assist in promoting fauna passage.
4. In some locations, where there are degraded and isolated areas of fauna habitat, no crossing structures are proposed. A series of recommendations are made in **Section 11.1.2** regarding these locations.

II.I.I State and Regional Corridors

Landscape topography along the SP-1 alignment requires bridges to be constructed at the majority of major fauna corridors outlined within this document (State and Regional Corridors and Mistake Creek). Crossing designs in these areas require formation levels that minimise the fill material required to satisfy hydrological requirements. Bridge structures are proposed at the State Corridors associated with the Belyando River and Logan Creek and at Mistake Creek which contains very high and high value habitats as described by BPA Criteria G mapping. At each of these locations a revegetation plan will be required to ensure adequate habitat structure suitable for target fauna passage is established. Culvert structures are proposed at the Diamond Creek Regional corridor in addition to bridges within the Belyando State Corridor.

In general mitigation will be achieved following principles established within **Section 6** of this report. Appropriately planned clearing operations and implementation of targeted rehabilitation plans are proposed to ensure maintenance of fauna connectivity. Management and rehabilitation plans will consider the following broad principles to protect fauna and ensure maximised connectivity.

- Create a clear definition of all construction areas at crossing points to minimise the construction footprint

- Utilise directional tree felling to minimise potential damage to retained vegetation
- Retain for later replacement, or relocate into neighbouring undisturbed areas, fallen logs, larger rocks and other suitable habitat
- Retain significant habitat trees at crossing points where practical
- Shape earthworks to enhance connectivity and provide passage choice for fauna
- Strategically locate revegetation within corridor to enhance connectivity
- Utilise endemic ground cover and long-lived shrub species to provide habitat and cover for fauna
- Provide additional habitat and cover using strategically placed mulch piles and reinstatement of habitat features set aside during clearing operations

11.1.2 Other Corridors

Other Corridors along the alignment are generally associated with disturbed and non-remnant drainage lines and creeks and isolated remnants. Where bridge structures are proposed at Mistake Creek, Eight Mile Creek, North Creek and Gowrie Creek, functional connectivity is likely to remain with local fauna expected to continue to disperse underneath proposed bridge structures.

Multi-cell culvert structures are proposed at regular intervals along the SP-1 alignment within flood plain and degraded drainage gullies and depressions. These culverts are generally located in relatively disturbed habitats not likely frequented by larger fauna. The list of recommendations suitable for bridges, above, are likewise applicable at culvert crossing locations within higher value habitats. The following are the minimum recommendations specific to culvert crossings along the SP-1 alignment.

- Culvert openings must be obvious and unobstructed
- Appropriate revegetation linkage at culvert entry and exit points
- Culverts must be kept to minimal practical length
- A maximum gradient of 1% within culvert structure is optimal
- Situate so that no pooling occurs
- Encourage sedimentation of the culvert substrate to mimic surroundings

A limited number of locations along the SP-1 alignment, where the corridor intersects isolated and degraded remnants, do not currently have below rail crossing structures. It is noted that the rail alignment has been orientated to reduce impacts to these isolated remnant areas by orientating the alignment to the edge of polygons. This approach has minimized fragmentation and restricted disturbance to areas already impacted by ongoing land use practices and associated edge effects.

In addition these locations generally have a low formation level allowing dispersal of larger mobile fauna species. Regardless, the following recommendations will be considered within these locations:

- Other crossings, such as road and stock crossings, may be situated within these potentially fragmented habitats and could possibly cater as fauna crossing locations if modified to suit
- Selective revegetation within the alignment to maximise connectivity
- Localised retention of existing vegetation and habitat features where practical as part of post construction rehabilitation strategies

II.2. Fencing

Fencing is an integral part of land management and will be required to restrict stock movements across the 95 m corridor of the SP-1 alignment. Inappropriate fencing can have negative impacts on wildlife, such as feeding, migration and breeding inhibition. In Australia, barbed wire fencing is generally preferred over plain wire when large stock, which are capable of pushing through the latter, are to be contained. More than 70 Australian species of wildlife have been identified as occasional or regular victims of barbed wire fences (Land for Wildlife Queensland: Note G4). Most entanglements occur on the top one or two strands of a barbed wire fence and most animals that become entangled unfortunately die. Any barbed wire presents a risk of entanglement; however, higher risks exist:

1. Where fences are:
    - Newly constructed
    - On ridgelines
    - Crossing or surrounding waterways and dams
    - Near feed trees
    - Higher than surrounding vegetation
2. When weather conditions are windy
3. When visibility is poor (such as night time, especially when there is no moon)
4. For very old or young animals

To provide a balance between the safety requirements of excluding cattle from the alignment and protection of native fauna, it is recommended that a combination of barbed and plain wire fencing is utilised. This should include as a minimum a plain top wire, with barbed wire used on the other strands.

II.3. Aquatic fauna crossings

No threatened aquatic fauna are likely to inhabit the study site. Provided basic design parameters for maintaining aquatic fauna passage are incorporated into the planning and design process, no impacts on aquatic fauna dispersal are anticipated. In addition, careful consideration will need to be given to the construction planning process, especially in relation to temporary Waterway Barrier Works and the minimisation of disturbance to waterway beds and banks (see SHG document *Carmichael Coal Project (Rail) Separable Portion 1 Waterway Barrier Works* for an outline of fish passage requirements and crossing structures along the SP-1 alignment).

12. Appendices

Appendix A

SP1 Crossing Structure Summary

Appendix B

Fauna Summary

Appendix C

Biodiversity Assessment and Mapping Methodology

Appendix A

SPI Crossing Structure Summary

SP-1 Crossing Structures

Number	Name	Height (m)	Length (m)	Type
87	Eight Mile Creek	1	169	Bridge (3 x 15 m Span) and Drainage Structure
86		1	48	Drainage structure
85		1	17	Drainage structure
84	North Creek	2	131	Bridge (2 x 15 m Span) and Drainage Structure
83		1	123	Drainage structure
82		1	21	Drainage structure
81		1	36	Drainage structure
80	Ogenbeena Creek	3	132	Bridge (4 x 15 m Span) and Drainage Structure
79	Ogenbeena Creek (lower crossing)	3	133	Bridge (4 x 15 m Span) and Drainage Structure
78c	Belyando River Tributary	6	310.6	Bridge (10 x 20 m Span) and Drainage Structure
78b	Belyando River			
78a	Belyando River East Tributary			
77		1	222	Major drainage structure
76		1	33	Drainage structure
75		1	13	Drainage structure
74		1	149	Drainage structure
73	Unnamed Flow Path 1	1	96	Drainage structure
72		1	15	Drainage structure
71		1	11	Drainage structure
70		1	16	Drainage structure
69d	Water Body next to Mistake Creek	3	503.7	Drainage structure
69c	Mistake Creek Anabranch			5 x 20 m Span and Drainage Structure
69b	Mistake Creek			
69a				Drainage structure

Number	Name	Height (m)	Length (m)	Type
68	Gowrie Creek	2	122	Bridge (4 x 15 m) Span and Drainage Structure
67	Gowrie Creek Tributary (67)	2	52	Drainage structure
66	Gowrie Creek Tributary (66)	1	22	Drainage structure
65		1	8	Drainage structure
64	Gowrie Creek Tributary (64)	1	10	Drainage structure
63	Gowrie Creek Tributary (63)	1	86	Drainage structure
62		1	43	Drainage structure
61		1	37	Drainage structure
60	Unnamed Flow Path 2	1	11	Drainage structure
59	Unmapped Flow Path 1	1	40	Drainage structure
58		1	294	Drainage structure
57		1	16	Drainage structure
56	Unnamed Flow Path 3	1	34	Major drainage structure
55		1	237	Drainage structure
54		1	132	Drainage structure
53	Logan Creek Tributary	1	8	Major drainage structure
52	Logan Creek	7	104	Bridge (6 x 20 m Span)
51		1	12	Drainage structure
50		1	42	Drainage structure
49		1	11	Drainage structure
48a		1	4	Drainage structure
47		1	9	Drainage structure
46		1	24	Drainage structure
45		1	79	Drainage structure
44		1	44	Drainage structure

Number	Name	Height (m)	Length (m)	Type
43		1	73	Drainage structure
42	Diamond Creek	1	12	Major drainage structure

Appendix B

Fauna Summary

Fauna Summary

Potential fauna utilisation of the study area was formulated on review and summation of the fauna desktop and field studies presented in the **GHD** EIS report.

Terrestrial Fauna Habitats

The **GHD** EIS report includes an assessment of terrestrial fauna within the study area. The assessment utilised desktop searches for likely fauna, including threatened species, and provided a summary of potential occurrence based on known habitat attributes (see **GHD** *EIS* **Appendices C** and **F**). In addition, field surveys were conducted within accessible areas of the alignment to describe species present and identify the potential presence of listed species through either direct records or assessment of habitat availability (see **GHD** *EIS* **Table 1-1**, *page 1-10*, for fauna survey methods). Information from the desktop and field survey was reviewed to generate a list of fauna species known, and with potential to occur, within the study area. The **GHD** report used data from the desktop and field analysis to generate habitat maps linking potential species occurrence to habitats derived from RE classifications. These habitat classifications were in the form of Broad Vegetation Groups. Each of the field assessed RE's was assigned to a fauna habitat, which are summarised (A to H) in **Table C1**, next page. This mapping procedure was used to predict the potential occurrence of fauna within and surrounding alignment.

The **Saunders Havill Group** undertook an extensive vegetation mapping exercise across the 95 m wide alignment to confirm and, where required, rectify mapped REs. These RE mapping amendments were used to refine the **GHD** habitat maps. The refined habitat maps (see **Appendix B**) were then used as the basis for fauna predictions within the study area and subsequent considerations surrounding fauna movement requirements and associated strategies to maximise landscape permeability.

Threatened Fauna Species

Threatened species suggested potentially present following desktop searches and spotted fauna were then assigned habitat types according to the REs they may inhabit or were recorded in (see **Tables C2** and **C3**, next pages). For a summary of threatened species likely to inhabit areas surrounding the alignment, see **GHD** *EIS* **Table 2-6** (**GHD** *EIS page 2-83*). As the scope of this Fauna Crossing Strategy only encompasses terrestrial and semi-arboreal fauna, we included in our assessment consideration the following threatened fauna:

- Ornamental snake, *Denisonia maculata*
- Yakka skink, *Egernia rugosa*
- Dunmall's snake, *Furina dunmali*
- Brigalow scaly-foot, *Paradelma orientalis*
- Northern quoll, *Dasyurus hallucatus*
- Koala, *Phascolarctos cinereus*

For habitat requirement and biology details for these species see **GHD** *EIS* **3.2.4.2** Listed Threatened Fauna (**GHD** *EIS page 3-9*) and **GHD** *EIS* **Table 3.3** (**GHD** *EIS page 3-10*). The habitat types frequented by these species are summarised in **Tables C1** and **C2**, next pages.

Table B1: Habitat descriptions

Habitat	Description
A	Eucalypt open woodland with native grass and shrubby understorey
B	Gidgee or mixed Acacia woodland on clay and clay loam plains with sparse shrub layer
C	Brigalow shrubby woodland or open forest typically on clay and clay loam plains
D	Eucalypt and Acacia mixed woodland or forest often on clay soils
E	Riparian woodland or forest fringing watercourses and Coolabah open woodland on grassy floodplains often with weedy understorey
F	Native grassland with absent woody canopy or shrub layer
G	Open previously cleared areas lacking native remnant vegetative cover and/or with patchy regrowth
H	Natural and artificial water bodies

Table B2: Threatened fauna

Scientific name	Common name	RE's*	Habitat†	Size
Denisonia maculata	Ornamental snake	**11.3.1**, 11.3.3, 11.3.5, 11.3.7, 11.3.10, 11.3.25, 11.3.37, 11.4.6, **11.4.9**, 11.5.3, 11.5.9c, 11.10.3	A, B, C, D, E, H	Small
Egernia rugosa	Yakka skink	**11.3.1**, 11.3.3, 11.3.5, 11.3.7, 11.3.10, 11.3.25, 11.3.37, 11.4.6, **11.4.9**, 11.5.3, 11.5.9c, 11.10.3	A, B, C, D, E, H	Small
Furina dunmali	Dunmall's snake	**11.3.1**, 11.3.5, 11.4.6, **11.4.9**, 11.10.3	B, C	Small
Paradelma orientalis	Brigalow scaly-foot	**11.3.1**, 11.3.5, 11.3.10, 11.4.6, **11.4.9**, 11.5.3, 11.5.9c, 11.10.3	A, B, C, D	Small
Dasyurus hallucatus	Northern quoll	11.3.10, 11.5.3, 11.5.9c	A, D	Medium
Phascolarctos cinereus	Koala	11.3.3, 11.3.10, 11.3.25, 11.3.37, 11.5.3, 11.5.9c	A, E	Medium

*Regional Ecosystems, **bold** = endangered
†See Table 2 and GHD EIS page 2-68 for habitat descriptions

Table B3: Spotted fauna

Habitat*	Scientific name	Family	Common name	Site	Size†
A	*Rhinella marina*	Bufonidae	Cane toad	MR4	Small
	Macropus giganteus	Macropodidae	Eastern grey kangaroo	MR6	Large
	Trichosurus vulpecula	Phalangeridae	Common brushtail	SR9	Medium
	Tiliqua scincoides	Scincidae	Common blue-tongue	MR6	Small
B	*Gehyra dubia*	Gekkonidae	Dubious gecko	MR8	Small
	Oryctolagus cuniculus	Leporidae	European rabbit	MR8	Medium
D	*Macropus giganteus*	Macropodidae	Eastern grey kangaroo	SR10	Large
	Trichosurus vulpecula	Phalangeridae	Common brushtail	SR10	Medium
E	*Amphibolurus burnsi*	Agamidae	Burns dragon	MR3	Small
	Diporiphora australis	Agamidae	Tommy roundhead	SR5	Small
	Demansia psammophis	Elapidae	Yellow-faced whip snake	MC2	Small
	Gehyra dubia	Gekkonidae	Dubious gecko	MC2	Small
	Litoria inermis	Hyalidae	Bumpy rocket frog	SR1	Small
	Litoria rubella	Hyalidae	Desert tree frog	SR1	Small
	Macropus giganteus	Macropodidae	Eastern grey kangaroo	MR5	Large
	Limnodynastes tasmaniensis	Myobatrachidae	Spotted grass frog	MC1, MC2	Small
	Carlia munda	Scincidae	Shaded-litter rainbow skink	MC1	Small
	Carlia vivax	Scincidae	Lively rainbow skink	SR1	Small
	Cryptoblepharus virgatus	Scincidae	Wall skink	MR10, SR1	Small
	Ctenotus robutstus	Scincidae	Eastern striped skink	MR9	Small
	Menetia greyii	Scincidae	Common dwarf skink	MC2	Small
	Tiliqua scincoides	Scincidae	Common blue-tongue	MR3	Small
	Tachyglossus aculeatus	Tachyglossidae	Echidna	SR5	Medium
F	*Macropus giganteus*	Macropodidae	Eastern grey kangaroo	SR3	Large
G	NA	NA	NA	NA	NA

*See Table 2 and GHD EIS page2-68 for habitat descriptions
†M = May survey, S = September survey, C = comprehensive survey (= GHD sites F_1 - F_2), R = rapid survey (= GHD sites F_3 - F_24)

Fish species

Desktop investigations by **GHD** found 51 and 47 fish species known to occur within the Burdekin and Fitzroy Basins, respectively (DERM, 2011g; Carter and Tait, 2008). Forty of the identified species are common to both catchments. For details see **GHD** *EIS* **Section 2.6.2.3** *page 2-97*. Based on distributions, 17 of the freshwater fish species known from the Burdekin and Fitzroy Basins have the potential to occur in waterways intersected by, or of relevance to, the study area (Carter and Tait 2008, Allen *et al* 2003, see **Table C4**, page 48). None of these species are listed under the EPBC or Nature Conservation Acts (**GHD**).

Field investigations by **GHD** at the nearby site for the Project (Mine) (refer to *Volume 4 Appendix O Aquatic Ecology Report*) recorded 11 of the species detailed in **Table C4** (**GHD** *EIS* **Table 2-11**, *page 2-99*). All are common freshwater species which have been previously recorded in the upper Burdekin catchment.

All 17 fish species with the potential to occur in the study area are potamodromous, and so, do not require passage beyond their freshwater habitat for migratory purposes. Maximum dispersal rates for most of these species are likely to occur following flood peak as waters recede (Allen 1989, Carter and Tait, 2008). It is therefore important that natural flood flows are maintained by water passage structures along the rail corridor. Please see SHG document *Carmichael Coal Project (Rail) Separable Portion 1 Waterway Barrier Works* for an outline of fish passage requirements along the SP-1 alignment.

Aquatic reptile species

From desktop searches by **GHD**, 11 aquatic reptiles are known to inhabit the Burdekin and Fitzroy Basins (10 turtles and the estuarine crocodile, see **GHD** *EIS* **Table 2-12**, *page 2-105*). No aquatic reptiles have been previously recorded from the study area. According to **GHD**, of the aquatic reptiles that potentially inhabit the site,

*"…only the Fitzroy River turtle (*Rheodytes leukops*) is listed as vulnerable under both the EPBC Act and the NC Act. This species is endemic to the natural permanent riverine habitats of the Fitzroy River catchment (e.g. Fitzroy, Mackenzie and Dawson Rivers) hence the potential suitable habitat occurs only within the Fitzroy Basin portion of the Study Area. Preferred habitats include downstream from riffles, where the water is well oxygenated, as well as areas with an abundance of submerged logs, undercut banks and tree trunks (Cann, 2008). There are no records of its occurrence in the Study Area and it is considered not likely to occur.*

*The estuarine crocodile (*Crocodylus porosus*) is listed as vulnerable under the NC Act, and marine/migratory under the EPBC Act. The species occurs within the lower reaches of both the Burdekin and Fitzroy basins. The estuarine crocodile has only been recorded below the Burdekin Dam and as such is not considered likely to be found in the Study Area.*

The remaining nine aquatic reptiles are turtle species. The turtle species of the Burdekin catchment inhabit a variety of habitats ranging from ephemeral waterholes and pools to structurally complex rivers and creeks. None of these species are listed as conservation significant."

Of these turtle species, Cann's longneck (*Chelodina canni*) and Eastern snake-neck (*Chelodina longicollis*) turtles are likely to utilise undisturbed gilgais, and Krefft's River (*Emydura macquarii krefftii*) and Saw-shelled (*Wollumbinia latisternum*) turtles most aquatic waterways, along the alignment. Please see **GHD** *EIS* **Section 2.6.2.4**, *page 2-105*, for aquatic reptile details.

There are limited recommendations in Queensland guidelines for water crossing designs to suit turtle passage, other than culverts at least every 200 to 300 metres across permanent water bodies (DTMR, 2010). It is expected that current water crossing designs will provide sufficient passage for aquatic reptiles. Please see SHG document

Carmichael Coal Project (Rail) Separable Portion 1 Waterway Barrier Works for discussion related to water crossing structures along the SP-1 alignment.

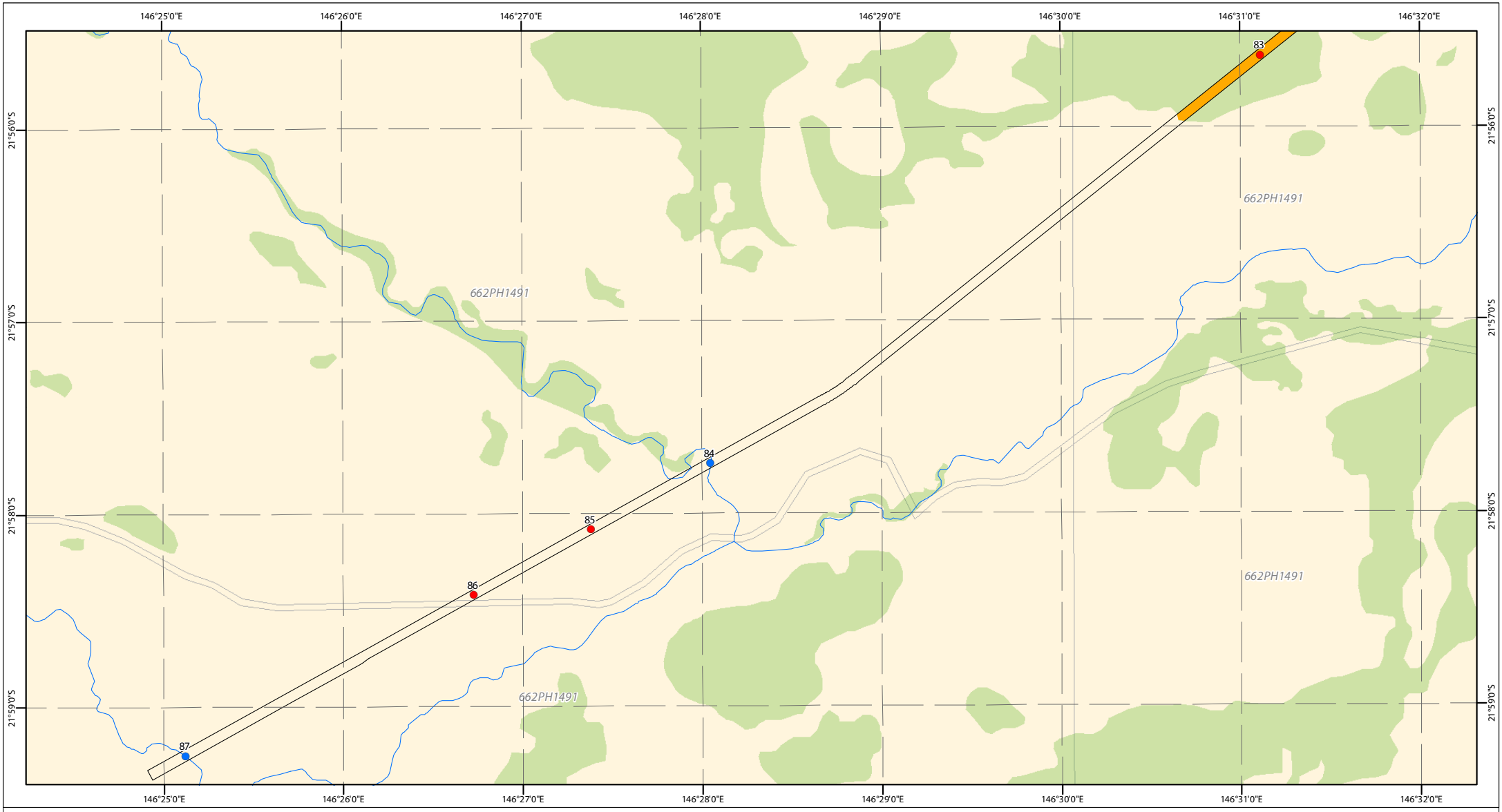
Table C4: Fish species

Status*	Scientific name	Family	Common name	Size†	Habitat§
Present	*Craterocephalus stercusmuscarum*	Atherinidae	Fly-specked hardyhead	S	All
	Ambassis agassizii	Chandidae	Agassiz's glassfish	S	All
	Hypseleotris sp.	Eloteridae	Midgley's carp gudgeon	S	All
	Mogurnda adspersa		Southern Purple-spotted gudgeon	M	All
	Oxyeleotris lineolata		Sleepy cod	L	Slow
	Melanotaenia splendida splendida	Melanotaeniidae	Eastern rainbowfish	M	All
	Neosilurus hyrtlii	Plotosidae	Hyrtl's tandan	L	All
	Leiopotherapon unicolor	Terapontidae	Spangled perch	L	All
Possible	*Nematalosa erebi*	Clupeidae	Bony bream	M	All
	Hypseleotris klunzingeri	Eloteridae	Western carp gudgeon	S	All
	Philypnodon grandiceps		Flathead gudgeon	S	Slow
	Macquaria ambigua	Percichthyidae	Golden perch	L	Slow
	Neosilurus ater	Plotosidae	Black catfish	L	Fast
	Neosilurus mollespiculum		Soft-spined catfish	M	Slow
	Porochilus rendahli		Rendahl's catfish	M	Slow
	Scortum parviceps	Terapontidae	Small-headed grunter	L	Fast
	Toxotes chatareus	Toxotidae	Seven-spotted archerfish	L	Slow

*Present = recorded as present at either the mine or rail site by GHD, Possible = GHD desktop search predicted (see GHD Table 2-11, page 2-99),

†Size as adult, S = small (<10cm), M = medium (10-20cm), L = large (>20cm)

§Slow = relatively still and slow waters, Fast = relatively swift moving waters



Legend

- Major Roads
- Mapped Watercourse v2.1
- 95m Rail Alignment Corridor
- QLD DCBD
- Mapped Remnant Vegetation

Fauna Crossing Assessment Sites

- Bridge Structure
- Culvert Structure

Habitat Types

- A
- B
- C
- E
- F

Layer Sources SP-1 Corridor, Crossing Locations (Adani Mining Pty Ltd 2012), DCDB, Major Roads, Towns (DNRM 2012), WWBW Waterways (DEHP 2013)

Plan 6 *Fauna Crossing Habitat Types*

File ref. *6396 E 06 Fauna Crossing Habitat Types A*
Date *28/03/2013*
Project *Carmichael Coal Rail Project*

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Scale (A4): 1:50,000 [GDA 1994 MGA Z55]

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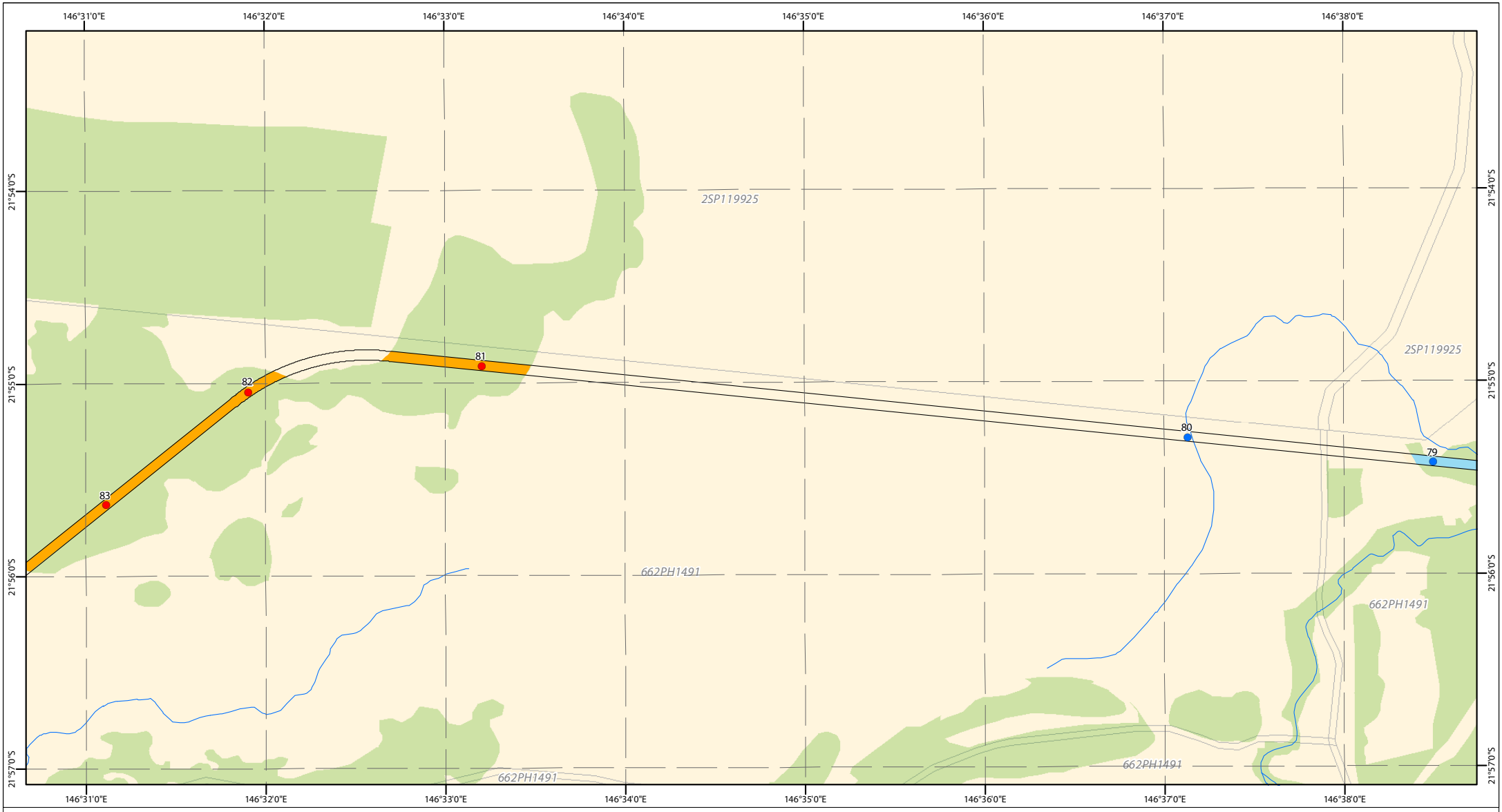

Legend

- Major Roads
- Mapped Watercourse v2.1
- 95m Rail Alignment Corridor
- QLD DCBD
- Mapped Remnant Vegetation

Fauna Crossing Assessment Sites

- Bridge Structure
- Culvert Structure

Habitat Types

- A
- B
- C
- E
- F

Layer Sources SP-1 Corridor, Crossing Locations (Adani Mining Pty Ltd 2012), DCDB, Major Roads, Towns (DNRM 2012), WWBW Waterways (DEHP 2013)

Plan 7 *Fauna Crossing Habitat Types*

File ref. *6396 E 07 Fauna Crossing Habitat Types A*
Date *28/03/2013*
Project *Carmichael Coal Rail Project*

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Scale (A4): 1:50,000 [GDA 1994 MGA Z55]

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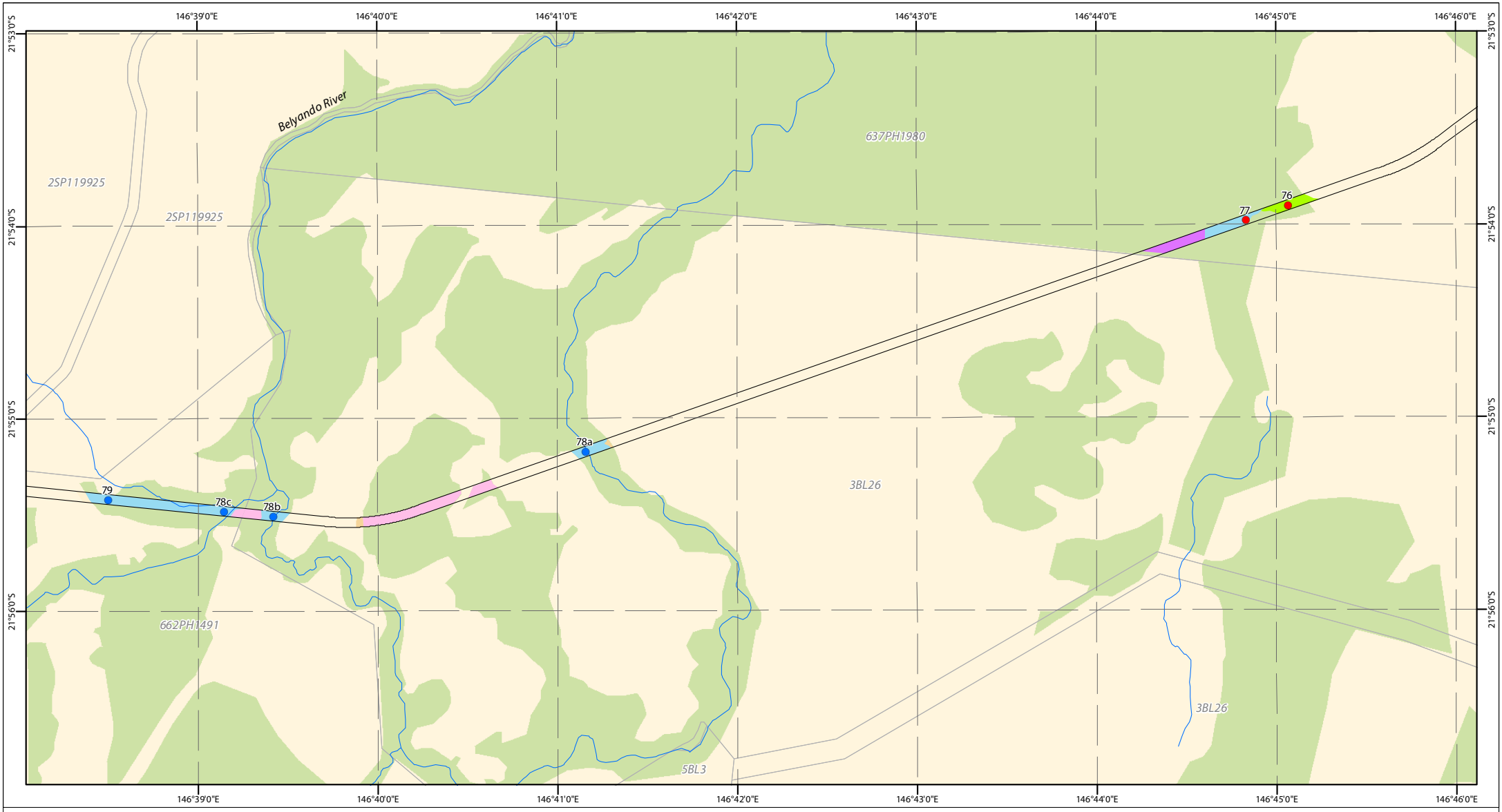

Legend

- Major Roads
- Mapped Watercourse v2.1
- 95m Rail Alignment Corridor
- QLD DCBD
- Mapped Remnant Vegetation

Fauna Crossing Assessment Sites

- Bridge Structure
- Culvert Structure

Habitat Types

- A
- B
- C
- E
- F

0 0.5 1 2 km

Scale (A4): 1:50,000 [GDA 1994 MGA Z55]

N

Plan 8 *Fauna Crossing Habitat Types*

File ref. *6396 E 08 Fauna Crossing Habitat Types A*
Date *28/03/2013*
Project *Carmichael Coal Rail Project*

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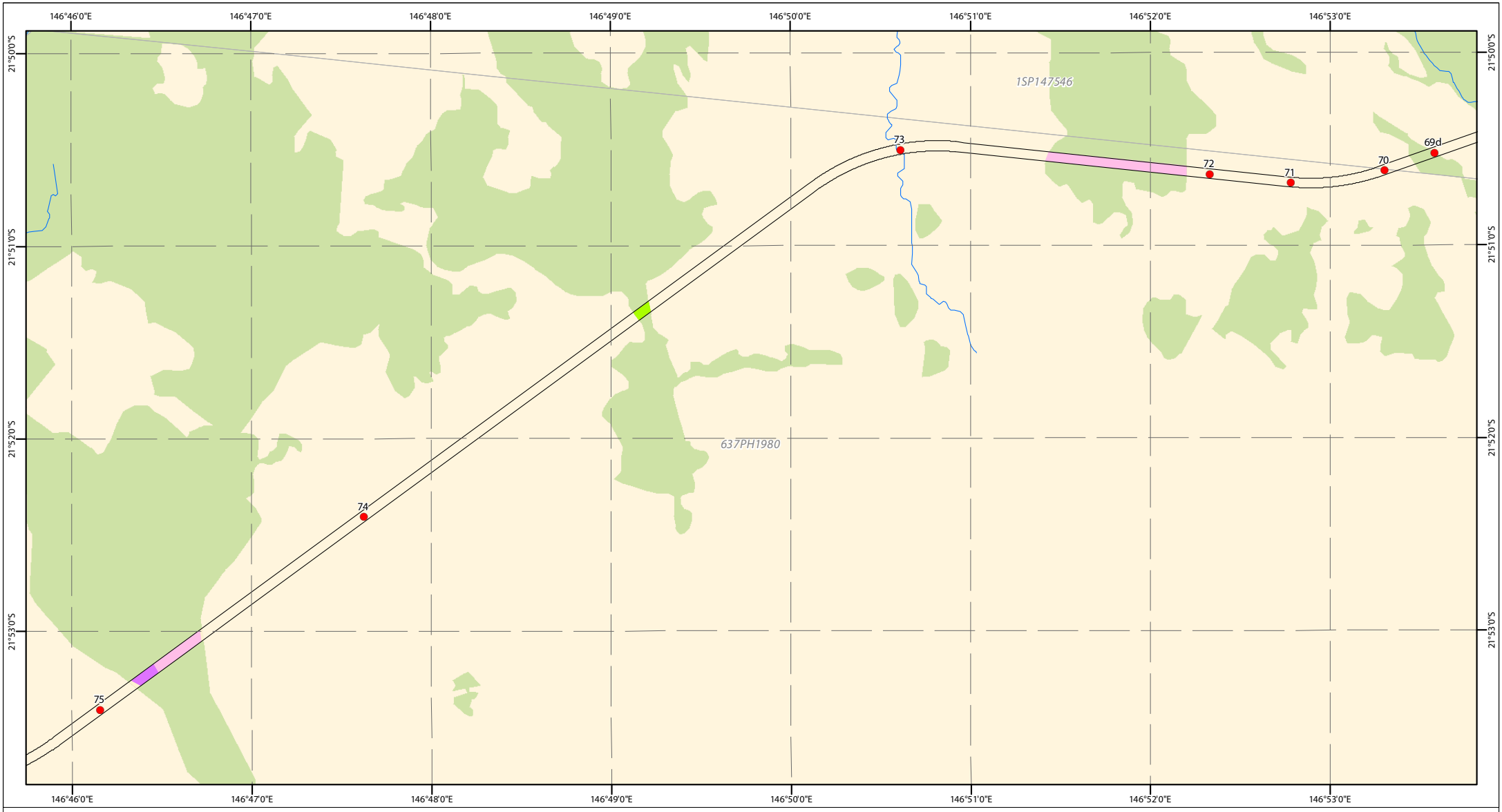
Layer Sources SP-1 Corridor, Crossing Locations (Adani Mining Pty Ltd 2012), DCDB, Major Roads, Towns (DNRM 2012), WWBW Waterways (DEHP 2013)



Legend

- Major Roads
- Mapped Watercourse v2.1
- 95m Rail Alignment Corridor
- QLD DCBD
- Mapped Remnant Vegetation

Fauna Crossing Assessment Sites

- Bridge Structure
- Culvert Structure

Habitat Types

- A
- B
- C
- E
- F

Layer Sources SP-1 Corridor, Crossing Locations (Adani Mining Pty Ltd 2012), DCDB, Major Roads, Towns (DNRM 2012), WWBW Waterways (DEHP 2013)

Plan 9 *Fauna Crossing Habitat Types*

File ref. *6396 E 09 Fauna Crossing Habitat Types A*
Date *28/03/2013*
Project *Carmichael Coal Rail Project*

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Scale (A4): 1:50,000 [GDA 1994 MGA Z55]

N

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Legend

- Major Roads
- Mapped Watercourse v2.1
- 95m Rail Alignment Corridor
- QLD DCBD
- Mapped Remnant Vegetation

Fauna Crossing Assessment Sites
- Bridge Structure
- Culvert Structure

Habitat Types
- A
- B
- C
- E
- F

Layer Sources SP-1 Corridor, Crossing Locations (Adani Mining Pty Ltd 2012), DCDB, Major Roads, Towns (DNRM 2012), WWBW Waterways (DEHP 2013)

Plan 10 *Fauna Crossing Habitat Types*

File ref. *6396 E 10 Fauna Crossing Habitat Types A*
Date *28/03/2013*
Project *Carmichael Coal Rail Project*

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Scale (A4): 1:50,000 [GDA 1994 MGA Z55]

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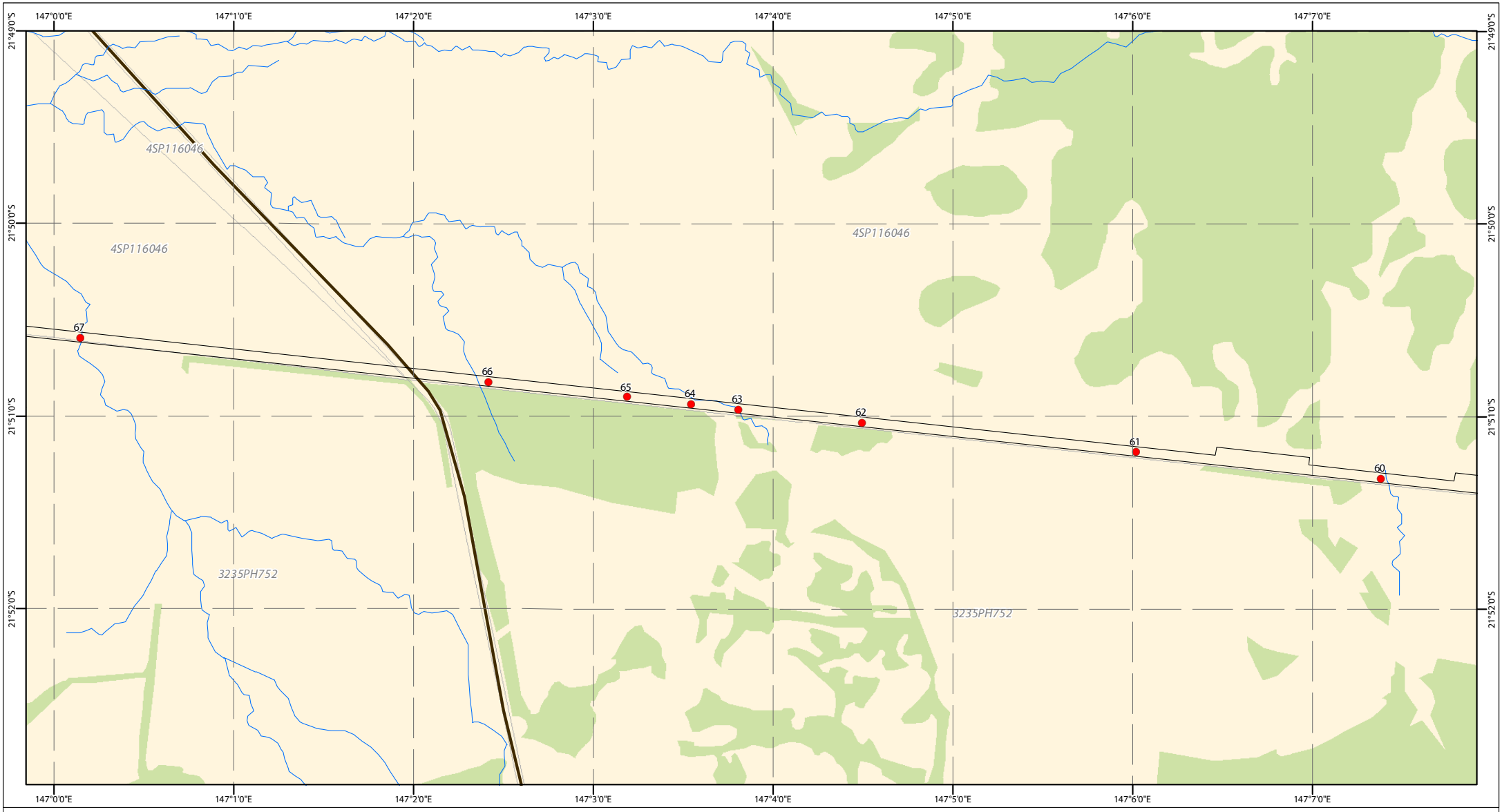

Legend

- Major Roads
- Mapped Watercourse v2.1
- 95m Rail Alignment Corridor
- QLD DCBD
- Mapped Remnant Vegetation

Fauna Crossing Assessment Sites
- Bridge Structure
- Culvert Structure

Habitat Types
- A
- B
- C
- E
- F

Layer Sources SP-1 Corridor, Crossing Locations (Adani Mining Pty Ltd 2012), DCDB, Major Roads, Towns (DNRM 2012), WWBW Waterways (DEHP 2013)

Plan 11 *Fauna Crossing Habitat Types*

File ref. *6396 E 11 Fauna Crossing Habitat Types A*
Date *28/03/2013*
Project *Carmichael Coal Rail Project*

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Scale (A4): 1:50,000 [GDA 1994 MGA Z55]

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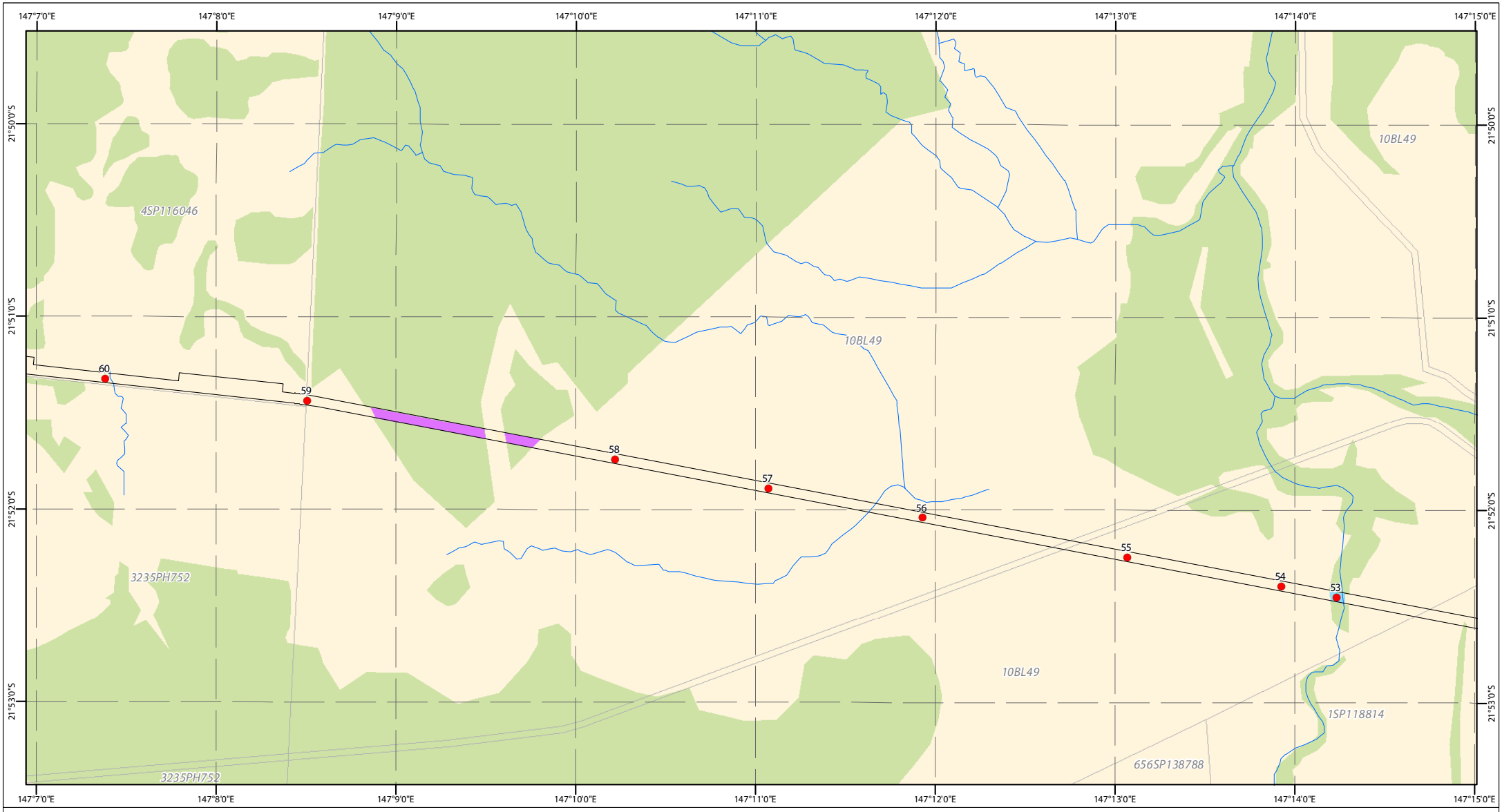

Legend

- Major Roads
- Mapped Watercourse v2.1
- 95m Rail Alignment Corridor
- QLD DCBD
- Mapped Remnant Vegetation

Fauna Crossing Assessment Sites

- Bridge Structure
- Culvert Structure

Habitat Types

- A
- B
- C
- E
- F

Layer Sources SP-1 Corridor, Crossing Locations (Adani Mining Pty Ltd 2012), DCDB, Major Roads, Towns (DNRM 2012), WWBW Waterways (DEHP 2013)

Plan 12 *Fauna Crossing Habitat Types*

File ref. *6396 E 12 Fauna Crossing Habitat Types A*
Date *28/03/2013*
Project *Carmichael Coal Rail Project*

0 0.5 1 2 *km*

Scale (A4): 1:50,000 [GDA 1994 MGA Z55]

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Legend

- Major Roads
- Mapped Watercourse v2.1
- 95m Rail Alignment Corridor
- QLD DCBD
- Mapped Remnant Vegetation

Fauna Crossing Assessment Sites

- Bridge Structure
- Culvert Structure

Habitat Types

- A
- B
- C
- E
- F

Layer Sources SP-1 Corridor, Crossing Locations (Adani Mining Pty Ltd 2012), DCDB, Major Roads, Towns (DNRM 2012), WWBW Waterways (DEHP 2013)

Plan 13 *Fauna Crossing Habitat Types*

File ref. *6396 E 13 Fauna Crossing Habitat Types A*
Date *28/03/2013*
Project *Carmichael Coal Rail Project*

0 0.5 1 2 *km*

Scale (A4): 1:50,000 [GDA 1994 MGA Z55]

N

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Legend

- Major Roads
- Mapped Watercourse v2.1
- 95m Rail Alignment Corridor
- QLD DCBD
- Mapped Remnant Vegetation

Fauna Crossing Assessment Sites
- Bridge Structure
- Culvert Structure

Habitat Types
- A
- B
- C
- E
- F

Layer Sources SP-1 Corridor, Crossing Locations (Adani Mining Pty Ltd 2012), DCDB, Major Roads, Towns (DNRM 2012), WWBW Waterways (DEHP 2013)

Plan 14 *Fauna Crossing Habitat Types*

File ref. *6396 E 14 Fauna Crossing Habitat Types A*
Date *28/03/2013*
Project *Carmichael Coal Rail Project*

0 0.5 1 2 *km*

Scale (A4): 1:50,000 [GDA 1994 MGA Z55]

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Appendix C

Biodiversity Assessment and Mapping Methodology

Essential Criterion J (Corridors)

Areas identified under this criterion qualify either because they are existing vegetated corridors important for contiguity including regrowth, or cleared areas that could serve this purpose if revegetated. Some examples of corridors include riparian habitats, transport corridors and 'stepping stones'.

BAMM Criterion J overlays State and Regional corridors that are crossed by the SP-1 alignment in the Belyando River, Logan Creek and Diamond Creek floodplains (Refer to **Plan 3**). Where the SP-1 alignment crosses Mistake Creek, no State or Regional corridors are mapped, although there is a substantial corridor to the North.

Note that physical connection between contiguous Remnant Units is addressed in Diagnostic Criterion G (Context & Connection), below.

Diagnostic Criterion G (Context & Connectivity)

This criterion applies where waterways and wetlands have been mapped at an appropriate scale and integrated with the RE coverage. Buffers for waterways and wetlands follow State policies for vegetation management on freehold and State lands and the State *Coastal Management Plan*. Where a Remnant Unit buffers a waterway or important wetland, the area of the Remnant Unit outside the buffer is flagged in the database by assigning a Medium value and cartographically identified as a potentially important buffer area.

Remnant Units bordering Endangered REs have additional importance as buffers. Buffers are only applied to Heterogeneous Remnant Units where the Endangered RE represents more than 30% of the Remnant Unit. Where a Remnant Unit buffers an Endangered RE, the area of the Remnant Unit outside the 200 m buffer is flagged in the database by assigning a Medium value and cartographically identified as a potentially important buffer area.

The degree to which a Remnant Unit is connected to other vegetation is termed its Physical Connection. Connected Remnant Units are more representative of biodiversity, contribute more to a habitat network and have greater resilience to the effects of disturbance than small isolated Remnant Units.

The extent of the SP-1 alignment requires it to be assessed at the regional landscape scale, a scale at which Criterion G values of High and Very High are most applicable. BAMM Criterion G applies a mix of High and Very High Context & Connectivity overlays across the SP-1 alignment in each of the Belyando River, Mistake Creek, Logan Creek and Diamond Creek floodplains (Refer to **Plan 4**). Fauna passage through these corridors forms the crux of this Fauna Crossing Strategy.