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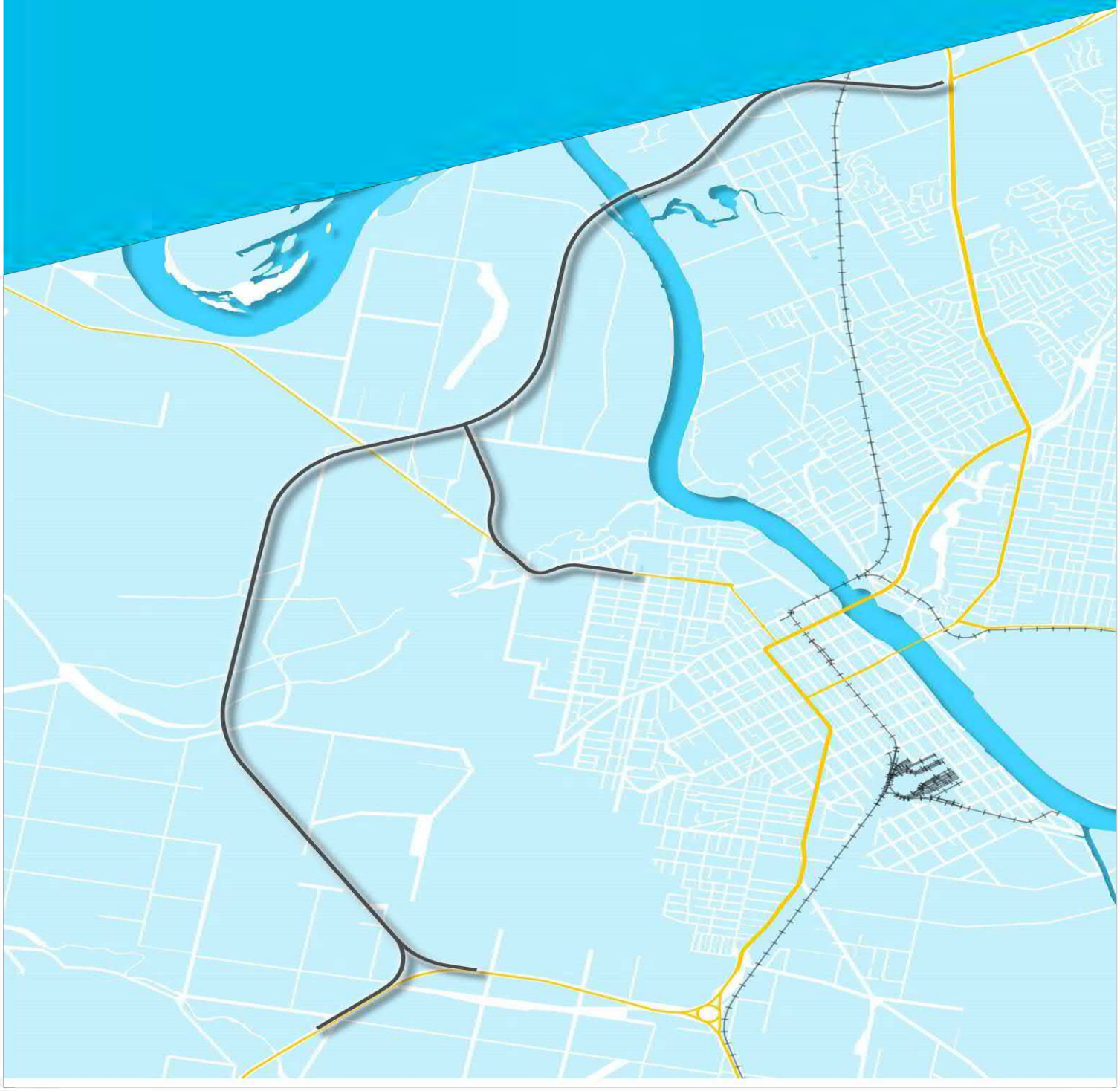
Rockhampton Ring Road
Department of Transport and Main Roads
20-Feb-2020
Doc No. 00004 - 60593305 - RRR BC - Threatened Turtle & Fish Habitat Assessment

Threatened Turtle & Fish Habitat Assessment

Rockhampton Ring Road - Business Case



Threatened Turtle & Fish Habitat Assessment

Rockhampton Ring Road - Business Case

Client: Department of Transport and Main Roads

ABN: 39 407 690 291

Prepared by

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1.0 Introduction

AECOM Australia Pty Ltd (AECOM) was commissioned by the Department of Transport and Main Roads (TMR) in November 2018 to carry out the Rockhampton Ring Road (RRR) Preliminary Evaluation (PE) and Detailed Business Case (DBC) Project (the Project).

In June 2019 AECOM undertook an aquatic ecology investigation for the BC phase of the Project. This assessment was undertaken with the objective of supporting the recommendations outlined in the Environmental Scoping Report (ESR) for the Project to complete further investigations of aquatic values (AECOM, 2019). The investigation included two components run concurrently, a targeted survey aimed at establishing the presence or potential presence of two threatened turtle species, white-throated snapping turtle (*Elseya albagula*) and Fitzroy River turtle (*Rheodytes leukops*) and a physical assessment of waterways within the alignment to understand the suitability of mapped waterways as habitat for fish passage.

The targeted ecological investigation was a two-stage process, involving a literature review, followed by a field assessment between 10 and 14 June, 2019 with two ecologists from AECOM and Ecosure. The literature review analysed existing data on the ecology and behaviours of the two target species, identified potential fish species using the waterways and located waterways, which may be impacted by the Project, which are mapped as waterways for waterway barrier works. This review formed the basis of the field surveys, in which the two turtle species were targeted and physical habitat values documented.

This report describes the results of the survey in terms of trapping results, habitat values for white-throated snapping turtle and Fitzroy River turtle and for fish passage within the 'Project Area'.

1.1 Project Background

The RRR is the key piece of road infrastructure recommended in the Fitzroy River Floodplain and Road Planning Study (FRFRPS) (December 2011), which investigated long-term solutions for Bruce Highway flooding impacts on freight, road and rail transport in and around the city of Rockhampton. The section of the Bruce Highway, from the intersection with the Capricorn Highway through Rockhampton to the intersection with the Rockhampton – Yeppoon Road has a current AADT between 15,760 vehicles and 24,750 vehicles with a large cross river AADT of 33,050 vehicles which includes 2,670 heavy vehicles. The state-controlled Rockhampton – Yeppoon Road which includes the other road crossing of the Fitzroy River in Rockhampton has a current AADT across the bridge of 32,030 vehicles including 2,750 heavy vehicles. Cross river traffic on both roads shows slow average growth of 1-1.5 % annually.

Since the completion of the FRFRPS a number of further studies have been carried out to refine the alignment and to investigate issues of flood immunity and the implications of other major infrastructure proposed for the floodplain.

The Preliminary Evaluation was completed and approved by the IIC in June 2019 with the following recommendations:

- the RRR Project proceed through Gate 2, PE and commence the Detailed Business Case Development phase
- the TMR RRR project teamwork with BQ to develop a Detailed Business Case in accordance with the Queensland Government's BCDF
- the Detailed Business Case consider the preferred RRR Project option (Option 1: two-lanes) against the Base Case and investigate options further, including:
    - flood immunity and afflux impacts to develop an optimal outcome between bridging and embankment
    - interchange requirements to determine the need for at-grade or grade separated interchanges
    - traffic model sensitivity investigation to increase benefits of the RRR usage

- test economic assumptions in more detail through traffic modelling and explore additional RRR link benefits.

The Project will provide a western road link of the Bruce Highway to the west of Rockhampton, with key linkages into the city at the Capricorn Highway, West Rockhampton, Alexandra Street and Yaamba Road (Rockhampton-Yeppoon Road).

The Project alignment will integrate with major infrastructure already completed, including Yeppen North and Yeppen South, as well as current works in development including the Rockhampton Northern Access Upgrade and Capricorn Highway Duplication (Rockhampton – Gracemere).

The Project commences on the Capricorn Highway approximately 2 km west of the intersection of the Bruce and Capricorn Highways at the Yeppen Roundabout and its alignment traverses north through the Western Yeppen Floodplain, sweeping around the Rockhampton Airport at Pink Lily and connecting to West Rockhampton near Ridgelands Road before crossing the Fitzroy River north of Limestone Creek. After crossing the Fitzroy River, the RRR intersects Alexandra Street in Parkhurst and connects with the Bruce Highway at the Bruce Highway and Rockhampton - Yeppoon Road intersection. See Figure A.

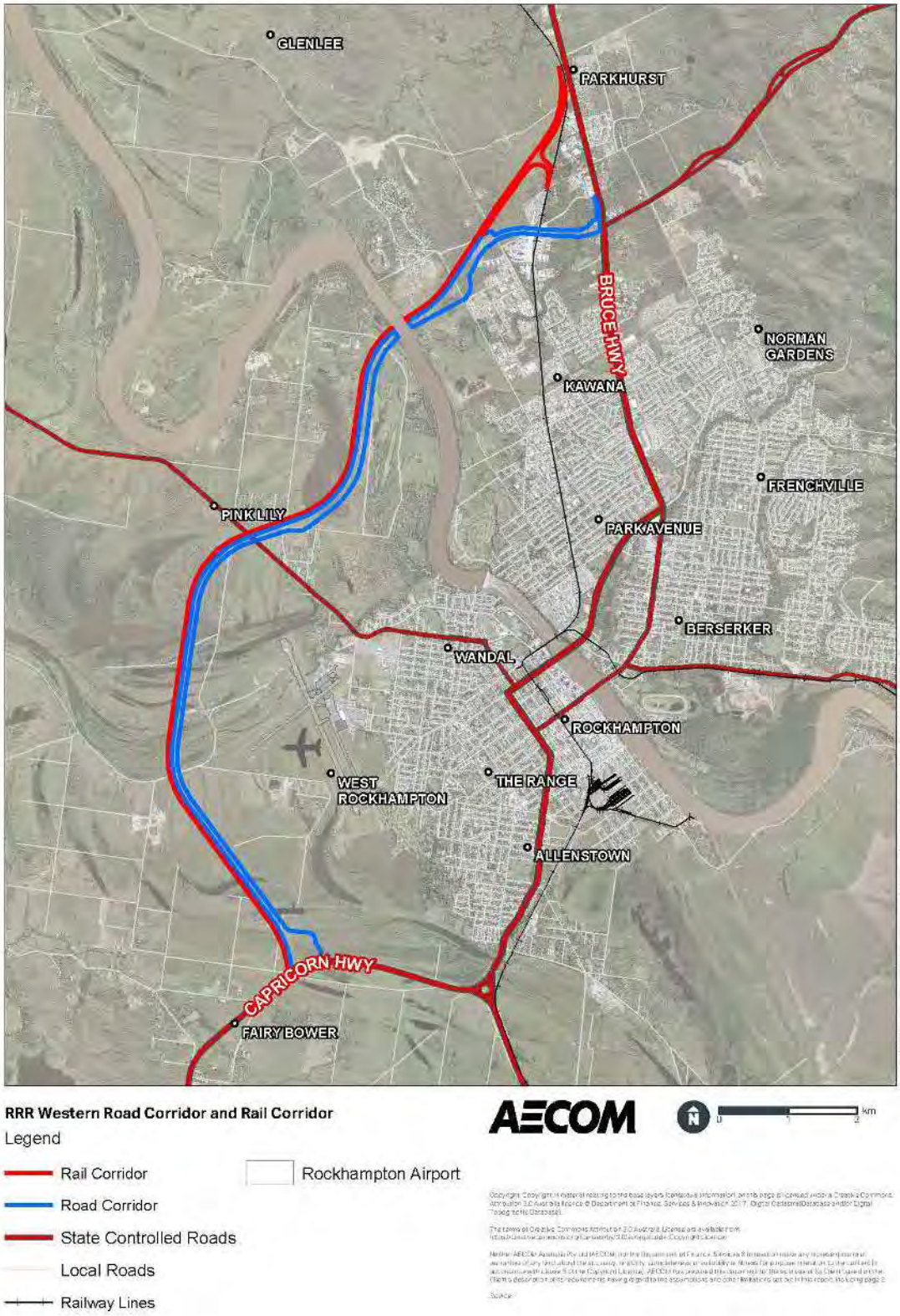


Figure A RRR Western Road and Rail Corridor

The Project proposes to deliver the following on the preferred alignment which will provide a highway standard ring road:

- Construction of roads and bridges to provide a fit for purpose flood immunity sealed highway, nominally 12.5m wide and incorporating 2 x 3.5m wide traffic lanes, a 1.0m wide centre line treatment, a 2.0m sealed shoulder on one side and a nominal 2.5m shoulder on the other providing cycle facilities plus provision for overhead lighting and safety barriers
- Provision of reserve allowance for the North Coast Rail Line (NCRL) across the Fitzroy River flood plain in conjunction with the road alignment
- Multi-modal corridor 140m (60m rail, 80m road)
- Construction of a new intersection at the Capricorn Highway, approximately 2km west of the Yeppen Roundabout
- Construction of a new connection to West Rockhampton at Pink Lilly
- Construction of a new intersection at Alexandra Street in Parkhurst
- Reconfiguration of roads and streets to implement improved access at West Rockhampton and Alexandra Street
- Intersection upgrade for the connection to the intersection of the Bruce Highway (10F) and Rockhampton - Yeppoon Road (196)
- Relocation of affected Public Utility Plant (PUP) including Ergon Energy high voltage assets, gas main, telecommunications optic fibre; and
- Service facilities including stopping places, service centre allowance, riverbank upgrades and upgrades to connection roads.

As discussed above, the Project includes the provision of reserve allowance for the North Coast Rail Line (henceforth referred to as the rail corridor). The development of the rail corridor is not included in the Project and is therefore not discussed further in this report. The preferred alignment and three connection points (excluding the rail corridor) is henceforth referred to as the Project Area.

1.1.1 Proposed Bridges

The design shown in Figure 1 and described below was current at the time of the PE phase of the Project.

The design of the Project includes the provision for 14 bridges, as detailed in Table 1 below. Proposed bridges are also displayed in Figure 1. The bridges mainly consist of floodplain bridges, road or rail overpasses, creek crossings and the Fitzroy River crossing. Apart from the Lion Creek Bridge (B14), there is no interface with existing structures. At Lion Creek, there is an existing bridge which is being replaced off line and therefore the impacts of the existing structure are considered to be minimal.

Table 1 Proposed bridges for the Project

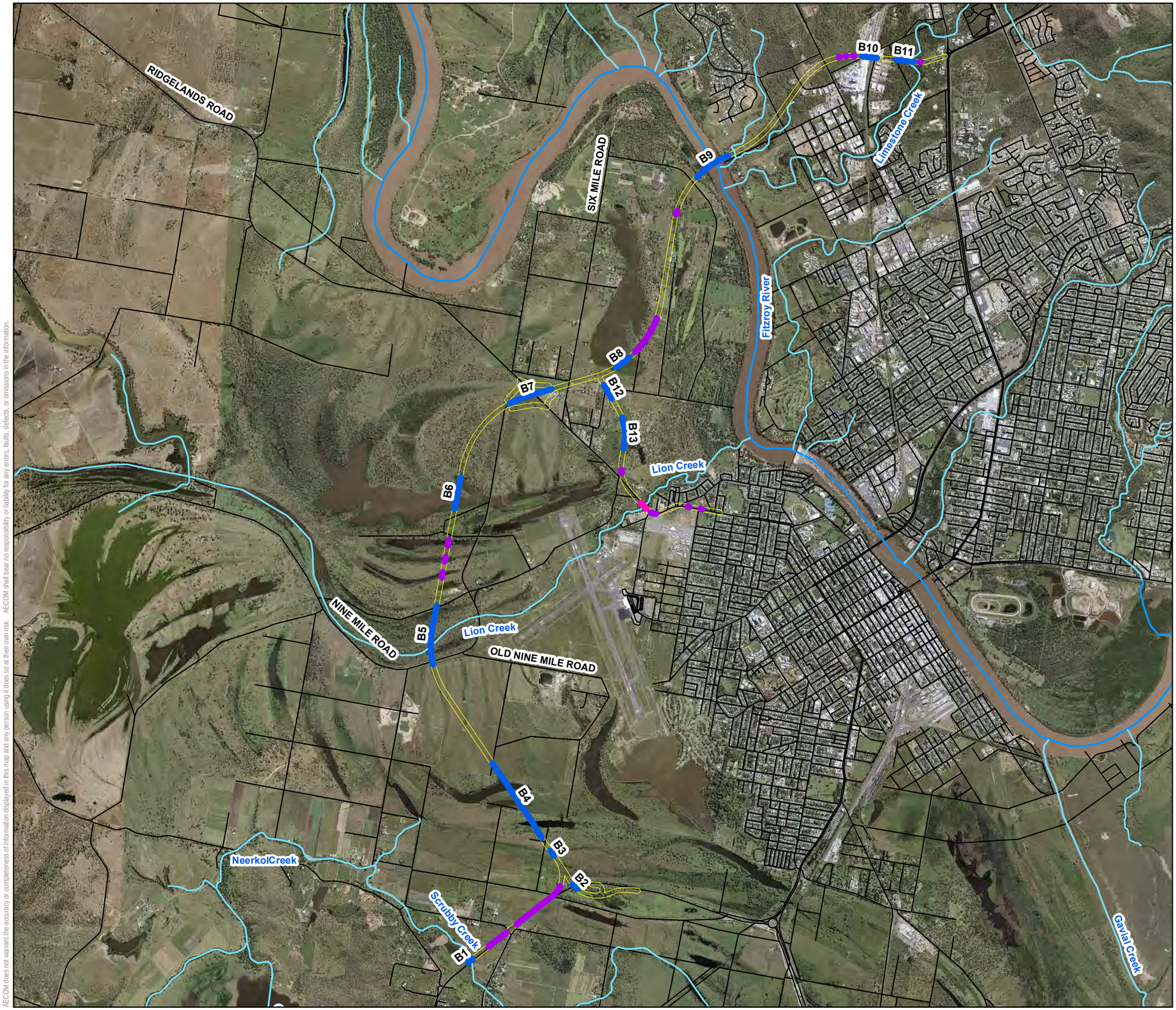
Bridge ID	Name/Location	Length (m)
B02	Capricorn Highway Overpass	70
B03	Capricorn Highway Duplication	550
B04	Floodplain	1290
B05	Floodplain	758
B06	Floodplain	419
B07	Ridgelands Road Overpass	560
B08	Floodplain	240
B09	Fitzroy River	660

Bridge ID	Name/Location	Length (m)
B10	Boundary Road / Monier Road / QR	208
B11	Limestone Creek Bridge	230
B12	Milner Road	195
B13	Ridgelands Wetlands	270
B14	Lion Creek Bridge	100
B15	Alexandra Street	130

1.2 Aims and Objectives

This assessment was undertaken with the objective of supporting the recommendations outlined in the ESR for the Project to complete further investigations into the potential presence of two threatened turtle species – white-throated snapping turtle (*Elseya albagula*) and Fitzroy River turtle (*Rheodytes leukops*) and fish passage at mapped waterways. Further, the investigation aims to determine if these species may be impacted by the construction and/or operation of the proposed road and connections. Specifically, this assessment is intended to:

- Review existing desktop data and available literature on the target species and taxa
- Establish further information on presence/absence of the target turtle species within the Project Area
- Determine if suitable nesting and/or foraging habitat exists for the target turtle species
- Evaluate the suitability of fish habitat at waterways intersected by the main alignment
- Identify potential impacts to the target turtle species and fish passage that may result from activities associated with the proposed Project.



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DATUM GDA 1994, PROJECTION MGA ZONE XX

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Metres

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LEGEND

- Project Area
- Roads

Watercourses

- Non Perennial
- Perennial

Project Infrastructure

- Bridge
- Culvert
- Lion Creek Bridge

Data sources:
Base Data: (c) State of Queensland (Department of Natural Resources, Mines and Energy) 2019,
Baseline Roads and Tracks, Railway Network.
Aecom 2019, Corridor and RRR Data

ROCKHAMPTON RING ROAD

PROJECT AREA

PROJECT ID	60593305
CREATED BY	MCKEEJ2
LAST MODIFIED	12-Aug-2019
VERSION	<version number>

Figure 1

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2.0 Methodology

2.1 Desktop Assessment and Literature Review

A desktop assessment of ecological data and review of literature relating to the turtle and fish assemblage and usage was undertaken to characterise the habitat values and identify the potential presence of target species and/or suitable habitat within the Project Area. The objectives of the desktop study include:

- Review of relevant biodiversity databases and studies within the Project Area
- Review the current literature on the ecology, distribution, movement patterns and habitat requirements for the target turtle species and potentially present fish species
- The identification of suitable habitat values potentially present within the Project Area.

2.1.1 Data Sources

Existing ecological data relating to the Project Area was compiled through review of the following key references:

- Department of the Environment and Energy (DotEE) online EPBC Protected Matters Search Tool (PMST)
- Department of Environment and Science (DES) wildlife online database
- Atlas of Living Australia fauna records
- DES Regional Ecosystem (RE) and Essential Habitat Mapping
- A review of satellite imagery to identify vegetation patterns and gain an appreciation of the proximity of the proposed project area to sensitive areas
- Existing fauna studies undertaken within the region
- Species distribution maps from various current field guides.

Review of the above data sources was conducted to inform the field assessment, determine appropriate survey locations and provide an understanding of the target species' populations and habitat in the broader region.

2.2 Field Survey

2.2.1 Threatened Turtle Assessment

2.2.1.1 Survey Approach and Methodology

The turtle assessment approach included targeted investigations into potential populations of Fitzroy River turtle and/or white-throated snapping turtle within and adjacent to the Project Area. This investigation was undertaken using methodologies for survey of threatened turtle species as described in the *Survey Guidelines for Australia's Threatened Reptiles* (Department of Sustainability, Environment, Water, 2011) in conjunction with a detailed habitat assessment. Prior to the field assessment, potential survey sites were identified through desktop review and aerial photograph analysis. The suitability of these sites, specifically for trapping methods was then determined in the field and the final sites were selected. Methods employed during the field assessment included:

- Detailed physical habitat assessments
- Live capture and release trapping
- Active searches for turtle signs
- Opportunistic observations of turtles and predators.

The above methods are further described in Sections 2.2.1.1.1 to 2.2.1.1.4 below.

Several additional capture methods were also considered but ultimately abandoned due to the risk of estuarine crocodile (*Crocodylus porosus*). These included:

- Hand capture in shallow waters or upon rocks
- Dip netting from the banks in water deeper than 1 m
- Seine netting in small pools of water, less than 1 m deep
- Muddling in shallow pools less than 50 cm deep.

AECOM field staff and health and safety representatives assessed the suitability of these methodologies prior to the field assessment. Due to the location of the site, its connectivity to the Fitzroy River and the lack of water clarity, in even shallow pools, these methodologies were deemed unsafe due to the risk of estuarine crocodile, and consequently not undertaken.

Locations of all threatened turtle assessments are presented in Figure 2.

2.2.1.1.1 Habitat Assessment

Habitat assessments were conducted at a total of four sites which covered the representative habitats throughout the Project Area. One site was located on the banks of the Fitzroy River within the Project Area and the other three were located in isolated lagoons intersecting the Project Area.

The habitat assessments involved identifying habitat type and recording habitat parameters including:

- Stream channel and bank morphology
- Bank profile
- Substrate description
- Riparian and macrophyte plant communities
- Water flow velocity
- Availability of nesting habitat
- Availability of foraging habitat
- Potential for egg predation and nest trampling
- Stream landform units present (i.e. run/riffle/pool)
- Adjacent land use.

Locations of all habitat assessments are presented in Figure 3.

2.2.1.1.2 Live Capture and Release Trapping

To assess the turtle species present within the Project Area, live trapping was employed using cathedral nets and commercially available crab pots large enough to trap target species. Traps were baited with beef hearts, spinach, sardines and apple. Cathedral traps consist of nylon mesh nets with several chambers which sit vertically in the water column. Turtles enter through funnel entrances which act as one-way valves. Trapped turtles can move vertically to the upper chamber which is anchored to a structure in a manner that ensures sufficient head space for turtles to surface and breath. Prior to deployment, a 15 cm diameter Styrofoam float was inserted in the top chamber to ensure breathing space if the attachment point falters. A float was also inserted into crab pots which were used in a similar manner, anchored to an overhanging branch or structure with the top 5 cm of the trap exposed.

Traps set in the morning were checked in the same afternoon and traps set in the afternoon were checked just after first light the following day. The trapping effort was based on the suitability and amount of habitat available at each water body and is summarised below in Table 2.

Table 2 Turtle trapping survey effort

Waterbody	Cathedral trap units	Crab pot units
Pink Lily Lagoon	16	4
Dunganweate Lagoon	5	-
Fitzroy River	5	-

The preferred survey methodology for Fitzroy River turtle (Department of Sustainability, Environment, Water, 2011) is direct observation in the riffle zones by snorkelling. Unfortunately, this technique was also ruled out due to risk of estuarine crocodile. Using meat baited traps to survey for this species has had varying success. However, with the preferred technique being unsuitable and as the species is known to have a partly carnivorous diet, this technique was still considered to be suitable.

2.2.1.1.3 Active Searches for Turtle Signs

Active searches involved traversing a section of the riparian zone of each waterbody (up to 500 m) and searching for signs of turtle activity. Signs include:

- Active nests
- Tracks to and from water
- Broken eggshells.

Active searches were conducted for a minimum of 30 minutes.

2.2.1.1.4 Targeted and Opportunistic Observation

At each habitat assessment site, opportunistic observations for turtles were conducted for a minimum of 30 minutes. This involved quietly scanning available habitat within the site, with preference for areas of clear, shallow water, basking logs or rocks or usable bank habitat where turtles are most easily observed. All turtles and other fauna encountered incidentally throughout the Project Area were also recorded.

Pink Lily Lagoon

Limestone Creek

Limestone Creek

Fitzroy River

Lion Creek

Lion Creek

Dunganweate Lagoon

Nelson Lagoon

Scrubby Creek

Gavial Creek

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Metres

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LEGEND

- Project Area

Watercourses

- Non Perennial
- Perennial
- Turtle Trapping Location
- Turtle Habitat Assessment and Active Search Areas

Data sources:
Base Data: (c) State of Queensland (Department of Natural Resources, Mines and Energy) 2019,
Baseline Roads and Tracks, Railway Network.
Aecom 2019, Corridor and RRR Data

ROCKHAMPTON RING ROAD

THREATENED TURTLE ASSESSMENT LOCATIONS

PROJECT ID	60593305
CREATED BY	MCKEEJ2
LAST MODIFIED	12-Aug-2019
VERSION	<version number>

Figure 2

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2.2.2 Fish Passage Assessment

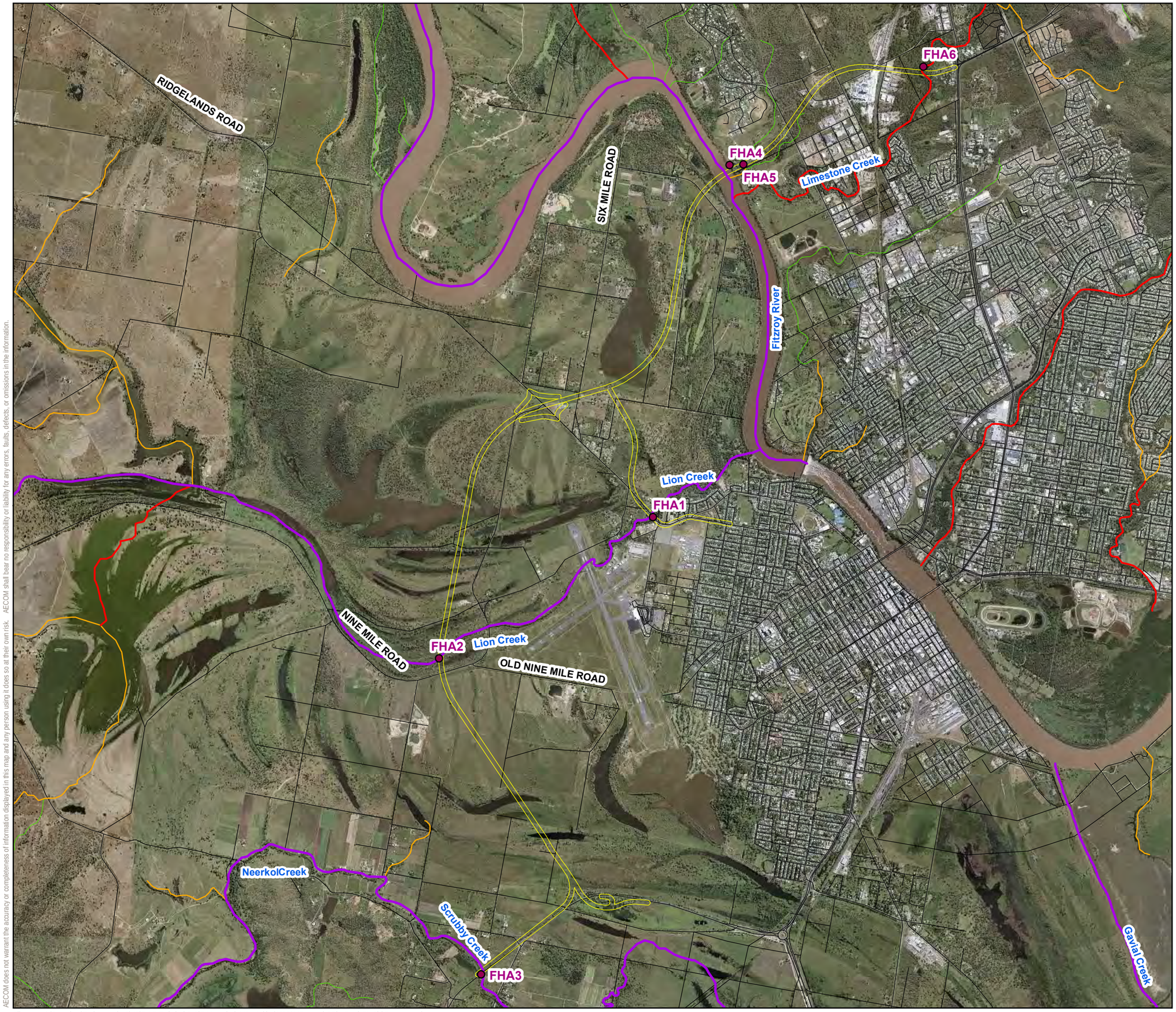
2.2.2.1 Survey Methodology

As part of the technical investigations for the Project, an aquatic assessment was undertaken at all water course crossings within the Project Area in order to determine aquatic habitat values relevant for waterway barrier works and fish passage. The location of these assessments is provided in Figure 3.

To achieve this, the AusRIVAS physical assessment protocol (Parsons, Thoms, & Norris, n.d.) was utilised to capture a range of macrohabitat and microhabitat features which may contribute to fish passage and habitat suitability within the context of the Project Area. These include:

- Local impacts on streams (i.e. bridges, dredging, grazing, litter, water extraction)
- Local land use
- Evidence of erosion
- Basic water chemistry
- Composition of the riparian zone (including representation of exotic species)
- Extent of trailing bank vegetation and shading of channel
- Physical barriers to local fish passage
- Channel shape and size
- Presence of large woody debris and/or undercut banks
- Extent of bedform features (i.e. pool, riffle, run sequence)
- Composition of macrophyte community
- Bank material and substrate composition.

No live capture and release of fish was completed for this survey.



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Metres

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LEGEND

- Project Area
- Roads
- Fish Passage Assessment Locations

Queensland Waterways for Waterway Barrier Works

Fish Passage

- 1 - Low
- 2 - Moderate
- 3 - High
- 4 - Major

Data sources:
Base Data: (c) State of Queensland (Department of Natural Resources, Mines and Energy) 2019,
Baseline Roads and Tracks, Railway Network.
Aecom 2019, Corridor and RRR Data

ROCKHAMPTON RING ROAD

FISH PASSAGE ASSESSMENT LOCATIONS

PROJECT ID	60593305
CREATED BY	MCKEEJ2
LAST MODIFIED	12-Aug-2019
VERSION	<version number>

Figure 3

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2.2.3 Assumptions and Limitations

This assessment was undertaken to provide information relating specifically to the potential presence/absence of the two target turtle species and potential impacts of waterway barrier works to fish communities within the Project Area. The survey effort combined with the desktop and literature review is considered suitable to assess the potential for these species to inhabit the Project Area and determine potential changes to fish passage due to Project activities. However, the following limitations apply:

- Surveys were not conducted within nesting/hatching season for Fitzroy River turtle or white-throated snapping turtle. As such nesting habitat could be assessed by habitat assessment only
- The *Survey Guidelines for Australia's Threatened Reptiles* (Department of Sustainability, Environment, Water, 2011) do not provide guidance on survey techniques for white-throated snapping turtle and guidelines for Fitzroy River turtle are not prescriptive in effort required
- The information regarding turtle species gathered during fieldwork for the Project is not considered to be conclusive, as limitations in survey techniques due to risk of estuarine crocodile may have resulted in some species remaining undetected
- Assessment of fish passage is based wholly on desktop information. No live capture and release of fish was completed during this survey.

3.0 Results

3.1 Desktop Results

3.1.1 Threatened Turtle Assessment

The Fitzroy River Catchment supports the highest species diversity of freshwater turtles in Australia with six species from five genera. Further, it has one of the highest levels of endemicity of freshwater turtles for Australia with two regionally endemic species, Fitzroy River turtle (*Rheodytes leukops*) and white-throated snapping turtle (*Elseya albagula*), the two target species of this investigation. The Fitzroy River turtle is endemic to the Fitzroy catchment and the white-throated snapping turtle is endemic to the combined Fitzroy-Burnett-Mary Catchments (DEHP, 2011).

The EPBC PMST and Wildlife Online database search recorded both the Fitzroy River turtle and white-throated snapping turtle as known to occur within 20 km of the Project Area. These species and their respective status under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Nature Conservation Act 1992* (NC Act) are detailed in Table 3. Both of these target species are also identified as high priority under the Queensland Government's Back on Track prioritisation framework for biodiversity conservation (DES, 2017).

Table 3 Desktop results for conservation significant turtle species

Scientific Name	Common Name	NC Act Status	EPBC Act Status	Back on Track – High Priority
Elseya albagula	White-throated snapping turtle	Endangered	Critically Endangered	✓
Rheodytes leukops	Fitzroy River turtle	Vulnerable	Vulnerable	✓

A search of Atlas of Living Australia identified two records of Fitzroy River turtle and six records of white-throated snapping turtle within 20 km of the Project Area. Although most records for these species are available from the main channel of the Fitzroy River, records do exist in smaller tributaries and even estuarine environments up and downstream of the Project Area.

Expert distribution maps for each species were also available from Atlas of Living Australia for both species. The majority of the Project Area was mapped as within the expert distribution for both species. Essential habitat for these species has not been mapped within the Project Area.

A likelihood of occurrence assessment for Fitzroy River turtle and white-throated snapping turtle was conducted for the ESR (AECOM, 2019). This was based on observations during flora and fauna surveys. This assessment concluded that both turtle species are considered as having a 'High' likelihood of occurrence within the Fitzroy River. The results of this assessment are presented in Table 4.

Table 4 Likelihood of occurrence

Scientific Name	Common Name	Status (EPBC Act; NC Act)	Discussion	Likelihood
Elseya albagula	White-throated snapping turtle	Critically Endangered; Endangered	This species occurs only in three catchments (Burnett, Mary and Fitzroy) and is considered a habitat specialist. The white-throated snapping turtle prefers clear, flowing, well-oxygenated water associated with their ability to extract oxygen from the water via cloacal respiration. Populations occur at much lower	**High.** This species is likely to occur in the Fitzroy River. Multiple records of the species occur in the wider Rockhampton region, the closest being north west near Mount Zion.

Scientific Name	Common Name	Status (EPBC Act; NC Act)	Discussion	Likelihood
			densities where flow is reduced (upstream of dams, weirs etc.) (Department of the Environment, 2019).	
Rheodytes leukops	Fitzroy River turtle	Vulnerable; Vulnerable	The bulk of records for this species are associated with the large primary streams of the Fitzroy River system: the Nogoa, Comet, MacKenzie, Connors, Isaac, Dawson and Fitzroy Rivers. Fitzroy River turtles are generally attributed to fast-flowing clear freshwater rivers and rivers with large deep pools with rocky, gravelly or sandy substrates, connected by shallow riffles, commonly in association with *Eucalyptus tereticornis, Casuarina cunninghamiana, Callistemon viminalis, Melaleuca linariifolia* and *Vallisneria* sp (Department of the Environment, 2019).	**High.** This species is likely to occur in the Fitzroy River. Multiple records near the Project Area exist.

3.1.1.1 Fitzroy River turtle (*Rheodytes leukops*) literature review

Description

The Fitzroy River turtle is a freshwater turtle with a light to dark brown carapace that grows to a maximum of 26 cm in length. The Fitzroy River turtle has scattered darker spots and blotches on the upper shell surface, a pale yellow or cream belly and dull olive-grey exposed fleshy parts. The shell is broadly oval and the neck is covered with large, pointed conical tubercles (Harold G Cogger, 2000). The Fitzroy River turtle has distinctive eyes with black pupils surrounded by a narrow white inner ring (adults) or a metallic silvery-blue iris (hatchlings). The back edge of the shell on hatchlings is serrated (Harold G Cogger, 2000). The Fitzroy River turtle has relatively long forelimbs with five long claws and a large cloacal bursae which has a respiratory function (Wilson & Swan, 2003).

Distribution and habitat

The Fitzroy River turtle is endemic to the Fitzroy Basin catchment, Queensland, with the species' distribution extending over a total area of less than 10,000 km^2 (H. G Cogger, Cameron, Sadlier, & Eggler, 1993). Known sites include Boolburra, Gainsford, Glenroy Crossing, Theodore, Baralba, the Mackenzie River, the Connors River, Duaringa, Marlborough Creek, and Gogango (Venz, Mathieson, & Schulz, 2002).

Preferred habitat areas have high water clarity, and are often associated with Ribbon weed (*Vallisneria sp.*) beds (H. G Cogger et al., 1993). Common riparian vegetation associated with the Fitzroy River turtle includes *Eucalyptus tereticornis* (river red gum), *Casuarina cunninghamiana* (river sheoak), *Melaleuca viminalis* (weeping bottlebrush) and paperbark species including *Melaleuca linariifolia*) (Tucker et al., 2001).

While riffle zones are considered particularly important habitat, the species also inhabits pools, runs and creeks (Legler & Cann, 1980). Undercut banks, root mats, logs and rocks provide important sheltering habitat. Whilst flowing waters are thought to be preferred by the species, the Fitzroy River turtle retreats into non-flowing, potentially isolated pools during the dry season (Tucker et al., 2001).

Reproductive biology and nesting habitats

The Fitzroy River turtle reaches sexual maturity at around 15-20 years old. Nesting occurs between September and October (Legler, 1985). The incubation period is dependent upon environmental conditions with hatching generally occurring during summer (November-March) (C. Limpus, 2011).

Field surveys indicate that the annual breeding rate of the Fitzroy River turtle is generally high with close to 100 % of adult females nesting each year. Breeding rates are however thought to be negatively influenced by habitat degradation and poor health of individuals (C. Limpus, 2011).

All located nests have been on river sandbanks 1 to 4 m above water level. Nests have been found up to 15 m from water on flat sandbanks (Cann, 1998). There is insufficient evidence available on species specific nesting requirements to accurately describe optimal nesting bank conditions; however, banks with a relatively steep slope, low density of ground/understorey vegetation and partial shade cover appear to be preferred (C. Limpus, 2011).

Respiratory physiology and diving behaviour

The Fitzroy River turtle is one of a unique group of Australian freshwater turtles that can extract oxygen from both the air and the water. This feature is most fully developed in the Fitzroy River turtle, with laboratory studies demonstrating that up to 70% of its oxygen requirements can be obtained from the water (Franklin, 2000).

The ability to respire aquatically allows the Fitzroy River turtle to remain underwater for a longer period of time than a primarily air-breathing species and field studies have logged a maximum voluntary dive time of almost 4 days (average time submerged 88.6 minutes) (M. Gordos & Franklin, 2002). Gordos, et al. (2003) recorded the Fitzroy River turtle surfacing frequency increased significantly during the daylight hours in autumn and summer, with peak levels normally occurring around dawn and dusk. This was attributed to periods of increased activity (possibly associated with foraging) during the daylight hours. No consistent diel surfacing trend was recorded for the turtles in winter or spring (Matthew A Gordos, Franklin, & Limpus, 2003). Gordos, et al. (2003) also found that individuals generally remained at depths >1 m throughout the day where the effects of diel fluctuations in water temperature and aquatic partial pressure of oxygen (PO_2) level was considered to be negligible.

The ability of the Fitzroy River turtle to respire aquatically allows this species to inhabit fast -flowing riffle zones from which primarily air-breathing species are excluded. High water velocities within riffle zones make surfacing for air energetically expensive and dangerous. The ability of the Fitzroy River turtle to respire aquatically reduces the need to surface within a high velocity environment. The Fitzroy River turtle is also uniquely negatively buoyant, which allows the turtle to easily maintain its position on the river bottom. The ability of the Fitzroy River turtle to inhabit riffle zones provides them with access to an abundance and diversity of food resources (M A Gordos, 2004).

Diet

The Fitzroy River turtle has a unique foraging technique of ‘scrape feeding’ whereby the species uses the horny sheaths of the upper jaw to scrape the surface of the substrate, particularly submerged logs and rocks. This method of foraging primarily captures slow moving benthic invertebrates, invertebrate eggs, aquatic insects, freshwater sponges and algae (Legler & Cann, 1980).

Movement biology

Studies to date suggest that home range size is relatively small (up to four ha) with local movement generally occurring between riffle zones and adjacent pools (Tucker et al., 2001). It is unknown how far turtles may migrate or whether traditional breeding sites are utilised. Movement over land is only known to occur between adjacent pools. The habitat and movement requirements of hatchling turtles are unknown.

An investigation using radio telemetry to track adult Fitzroy River turtles found that home range margins and the core areas of activity for both sexes impinge on riffle zones year-round (Tucker et al., 2001). The turtles remained within 300 m of riffle zones, even during base flows, and then retreated to deeper sections of pools as the riffle zones became ephemeral or dried completely.

Population status and key threatening processes

The population of Fitzroy River turtle within the catchment is comprised primarily of adults (Colin J. Limpus, Limpus, & Hamann, 2002). The absence of hatchling and juvenile turtles within the population has also been observed in recent surveys conducted within the Connors and Mackenzie Rivers. Nest predation rates of close to 100% are thought to be responsible for the lack of recruitment into the population (C. Limpus, 2011). The bias in favour of adult turtles within the catchment indicates that low recruitment of hatchlings has been occurring over many decades.

At the current rates of recruitment, the population of Fitzroy River turtles within the catchment is not considered sustainable (C. Limpus, 2011). Other threatening processes include:

- Loss of habitat
- Alteration of natural flow regime
- Movement barriers
- Physical injury and mortality
- Poor water quality.

3.1.1.2 White-throated snapping turtle (*Elseya albagula*) literature review

Description

The white-throated snapping turtle is one of Australia's largest freshwater turtle species, with carapace lengths up to 42 cm in females and 30 cm in males (Thomson, Georges, & Limpus, 2006) (Thomson, et al., 2006). Adults are large and heavily built, with a large, robust head. Adult females commonly have irregular white or cream markings on the side and under surfaces of the head and neck. Males are easily distinguished from mature females by their much larger tail. Hatchlings and small juveniles have strongly serrated shell margins (Thomson, et al., 2006). The carapace of this species is broadly oval, but is blunt at the front. The carapace is dark brown to black in colour and smooth. The plastron is heavily stained in adults, appearing black over the true base colour of yellow to cream (Thomson, et al., 2006).

Distribution and habitat

The white-throated snapping turtle occurs throughout the Fitzroy, Burnett and Mary River catchments, with an area of occupancy of an estimated less than 500 km^2 (Threatened Species Scientific Committee, 2014).

The white-throated snapping turtle is a habitat specialist (Todd et al., 2013). Within the river system it prefers clear, flowing, well-oxygenated waters. It prefers waters with complex subsurface structure in the form of log tangles, undercut banks, and irregular rocky substrata. It is typically absent or rare in standing waters impounded by dams or weirs, unless associated with free-flowing streams.

The white-throated snapping turtle has not been recorded where there are no permanent pools during the dry season and has not been recorded inhabiting ephemeral water bodies away from main watercourses, indicating that it has a limited capacity to cross dry paddocks or follow dry streambeds for extended distances (Threatened Species Scientific Committee, 2014).

Reproductive biology and nesting habitat

The white-throated snapping turtle has an extended breeding season that occurs between March and September. Once they reach sexual maturity (at least 18 years of age) female turtles are thought to breed annually.

Breeding occurs during the dry season, when many individuals do not necessarily have access to flowing water habitat with its higher quality food availability (C. Limpus, 2011). However, the species appears to employ embryonic diapause, which delays embryonic development so that hatching occurs when environmental conditions are suitable (Hamann & National Parks and Wildlife Service, 2007).

The species aggregates at certain sites to nest and may nest in the same general area of a riverbank across a decade or more. Compared to most other freshwater turtles, it has an extended nesting

season of around 7 months. In the Fitzroy River catchment, the species aggregates to breed during May to December (C. Limpus, 2011).

Almost all nesting occurs on alluvial sand-loam banks deposited by floodwaters, which are often reworked with each significant flooding event (C. Limpus, 2008). Nests may occur in loose or compact soils, under a closed canopy or with less than 50% canopy cover, with a dense covering of grasses or with low or no vegetation (C. Limpus, 2011).

In the Fitzroy catchment, nests are constructed on average at 17 m (with a range of 1-86 m) from the water's edge (C. Limpus, 2011). Nests are shallow, with a mean depth of 23 cm, and most nesting occurs on sloped banks with an average slope of 27 degrees.

Respiratory physiology and diving behaviour

The species is one of a number of freshwater turtles in Australia which can absorb oxygen from both the air and water, through active ventilation of the cloacal bursae (FitzGibbon & Franklin, 2010). Adults may obtain up to 40-60% of their total oxygen requirements from aquatic respiration, but in hatchlings this may be up to 100%, with younger turtles having a higher reliance on aquatic respiration than adults (FitzGibbon & Franklin, 2010). A maximum submerged dive time of greater than 3 hours has been recorded in this species (M. A. Gordos, Hamann, Schauble, Limpus, & Franklin, 2007), with water depth and temperature significantly influencing dive duration (Storey, Kayes, De Vries, & Franklin, 2008).

Diet

The white-throated snapping turtle is a benthic foraging species. It is primarily herbivorous, feeding on fruit and buds of riparian vegetation that fall on the water (such as *Livistona*, *Ficus*, *Syzygium* and *Castanospermum australe*), leaves and stems of terrestrial plants, tree roots, filamentous algae (including *Mougeotia* and *Spirogyra*), and instream macrophytes (such as *Vallisneria*, *Schoenoplectus* and *Nitella*) (Armstrong & Booth, 2005). The species changes its diet from being largely carnivorous (feeding on benthic invertebrates) when young, to largely herbivorous as it gets older. Animal material forms a small part of the diet of adults and includes freshwater sponges, carrion, cane toads and insect larvae (Thomson et al., 2006).

Movement biology

During the day, the white-throated snapping turtle is generally found in deep pools (> 6 m) either upstream or downstream from a riffle zone. At night the turtle moves into the shallow riffle zones (M. A. Gordos et al., 2007).

The home range of the white-throated snapping turtle is generally less than 500 m and is usually restricted to the one pool. During dry periods turtles may move into deeper pools which function as a dry season refuge. On the onset of the wet season, they may move into riffle zones to access the abundant food resources in this habitat type. Movements may also be associated with reproduction, with aggregations occurring adjacent to nesting banks at breeding time (C. Limpus, 2011). The habitat and movement pattern of hatchling turtles is largely unknown.

Population status and key threatening processes

The remaining populations of the white-throated snapping turtle within the Fitzroy, Burnett and Mary River catchments consist primarily of ageing adults with very low recruitment to the adult breeding population. Abundant evidence of nesting can be found in all three catchments; however almost 100% of eggs are predated on by native and exotic predators, or lost to trampling by stock (Hamann & National Parks and Wildlife Service, 2007).

The lack of hatchling and juvenile turtles within the population suggests that there has been very little recruitment into the population over the last decade (< 2%) (Hamann & National Parks and Wildlife Service, 2007). In the Fitzroy River system, it is estimated that 0.5% of adults are new recruits to the breeding population. However, the occurrence of the largest known nesting aggregation in the upper reaches of the Fitzroy Barrage impoundment does indicate that successful breeding can occur within the flowing margins of impounded habitats.

Other threats to the species include the loss of high quality habitat through increased water infrastructure development and large-scale land use practices (cattle grazing, agriculture).

3.1.2 Fish Passage Assessment

3.1.2.1 Fitzroy Basin

The Fitzroy Basin has a catchment area of approximately 142,000 km^2, extending from the Carnarvon Gorge National Park in the west to Rockhampton on the central Queensland coast (Bureau of Meteorology, 2018). With more than 20,000 km of waterways, the Fitzroy Basin is the largest drainage basin in Queensland. Within the basin six major sub-basins occur: Comet, Dawson, Mackenzie, Isaac, Nogoa and Fitzroy. Formed by the confluence of the Mackenzie and Dawson rivers, the Fitzroy River flows east through the City of Rockhampton in Queensland, and discharges flow from the catchment into the Great Barrier Reef World Heritage Area.

Stream flows within the Fitzroy Basin catchment are highly variable and strongly influenced by seasonal climatic factors (Yu, Joo, & Carroll, 2013). The region is characterised by a tropical to sub-tropical climate, with the Tropic of Capricorn running across the geographical centre of the basin. Majority of rainfall and therefore flow occurs during the distinct wet season (approximately November to April), largely due to tropical monsoon influence and degenerated tropical cyclones (Yu et al., 2013). Historically, a number of large flooding events near the Fitzroy River have occurred after intense rainfall periods. However, rainfall across the region is variable and evaporation rates are high, so prolonged dry periods are also common. Most rivers and creeks are dry from May to October, with only the lower reaches of the Fitzroy River being generally perennial (Bureau of Meteorology, 2018).

3.1.2.2 Project Waterways

The Project Area is mapped as containing five waterways under the *Fisheries Act 1994* (refer to Figure 3). Mapped waterways are categorised based on the level of risk of adverse impact on fish movement that is likely from barrier works. The data layer uses a traffic light colour scheme to indicate risk, with green being least risk and red being highest risk, for self-assessable works. Two other colours are used—purple for higher order waterways and grey for tidal areas. These generally require approval assessment. However, where the barriers are bed-level, works on purple waterways may be self-assessable. Where the works are temporary, works on purple or grey waterways may be self-assessable. The waterways intersected by the alignment and their risk rating are outlined below:

- Fitzroy River (Purple)
- Limestone Creek (Red)
- Lion Creek – two crossings (Ridgelands Road and Nine Mile Road) (Purple)
- Scrubby Creek (Purple)
- Unnamed creek – tributary of the Fitzroy River (Green).

There are also a number of local tributaries which drain local runoff to the Fitzroy River. These local tributaries, which typically have main channel widths of 10 m to 20 m and main channel depths of less than 4 m, include:

- Alligator Creek
- Limestone Creek
- Etna Creek
- Ramsay Creek
- Splitters Creek
- Lion Creek
- Moores Creek
- Frenchmans Creek and Thozets Creek
- Neerkol Creek
- Scrubby Creek
- Gavial Creek.

3.1.2.3 Hydrology

In relation to fish passage characteristics, the hydrology of the Fitzroy Basin is thought to consist of non-perennial flows resulting in a fragmented chain of waterholes during the dry season (Marsden, 2017). Construction and operation of dams and weirs across the catchment has transformed the flow regime of many of the streams from intermittent to perennial or near perennial with subsequent ecological implications. Natural flow regimes of supplemented streams have changed from high annual summer flows and no/low flow conditions in winter to medium to low flows through the year.

3.1.2.4 Migratory Patterns and the Requirement for Fish Passage

At some point in their lifecycle all freshwater fish will migrate. The temporal and spatial scale of migration varies, as does the reason for doing so. Migration can enable fish to fulfil a life cycle stage, move between feeding and breeding areas, locate suitable habitat, find refuge and/or disperse from refuge.

The life-cycle characteristics of a fish will govern their migration behaviours and patterns (Kapitzke, 2010). These characteristics include seasonality (time of year), direction of movement (upstream or downstream), life-stage of the fish (adult or juvenile). There are five generalised patterns of fish migration in riverine systems described below:

- *Potamodromous* adult or juvenile fish migrate wholly within freshwater
- *Diadromous* fish complete migration between marine and freshwater habitats. Fish within this category can fall into either of the following sub-categories
    - *Catadromous* fish develop in freshwater and once adult, migrate downstream to spawn at sea
    - *Anadromous* fish develop in saline conditions and migrate upstream to spawn in freshwater, (uncommon in Queensland)
- *Amphidromous* fish migrate between freshwater and marine, but not for the purpose of reproduction.

Barriers can impede all forms of connectivity between populations including longitudinal migrations and lateral connections between river and floodplain habitats (Humphries & Walker, 2013). The restriction and prevention of fish migration may have a number of negative ecological implications, including restricting a species' ability to breed, disperse and recruit, alter population structures, alter species assemblages and trophic interactions. Obstructions to movement can also lead to declines and localised extinctions of species whose life cycle requirements include an obligate migration or where access to essential habitat and foraging resources becomes limiting.

3.1.2.5 Fish Communities and Species

The fish assemblage within the Fitzroy River is one of the most biodiverse in tropical eastern Australia, including a variety of freshwater and estuarine/freshwater species. Within the Fitzroy River a large diversity of fish species move upstream all year round when flow is available. Recent modifications including the construction of a new cone fishway next to the vertical slot fishway on the Fitzroy Barrage has significantly increased the passage of small fish, with estimated fish passage rates of 3.8 million fish per year and possibly the highest number of fish migrating through a fishway in Australia (Marsden, 2017).

Studies on fish assemblage in the Fitzroy catchment have been completed and confirm the presence of least 30 fish species. These species are likely to occur within and adjacent to the Project Area (listed in Table 5 below).

Table 5 Fish species known from the Fitzroy catchment (consolidated list from ALA records and references cited in Marsden, 2017)

Scientific Name	Common Names	Lagoon Record	Fitzroy Catchment	Migration[1]
Ambassis agassizii	Agassiz's Glassfish / olive perchlet		✓	P
Amniataba percoides	Banded grunter	Yeppen	✓	P
Anguilla reinhardtii	Long fined eel	Yeppen	✓	C
Arrhamphus sclerolepis	Snub nosed garfish		✓	P
*Carassius auratus**	Goldfish		✓	P
Craterocephalus stercusmuscarum	Line-eye / fly speckled hardyhead	Crescent Yeppen	✓	P
*Gambusia holbrooki**	Mosquito fish		✓	P
Glossamia aprion	Flabby/mouth almighty	Yeppen	✓	P
Hypseleotris compressa	Empire Gudgeon		✓	A
Hypseleotris klunzingeri	Western carp gudgeon		✓	P
Hypseleotris sp.	Midgey's carp gudgeon		✓	P
Lates calcarifer	Barramundi	Yeppen		C
Macquaria ambigua	Golden Perch		✓	P
Megalops cyprinoides	Oxeye herring		✓	C
Melanotaenia splendida splendida	Northern sunfish / eastern rainbowfish		✓	P
Morgurnda adspersa	Trout Gudgeon / purple spotted gudgeon		✓	P
Mugil cephalus	Striped mullet		✓	C
Nematalosa erebi	Bony herring		✓	A
Neosilurus ater	Black catfish		✓	P
Neosilurus hyrtlii	Moony		✓	P
Notesthes robusta	Bullrout		✓	C
Ophisternon sp	Swamp eel		✓	C
Oxyeleotris lineolatus	Loter / sleepy gudgeon		✓	P
Philyponodon grandiceps	Flathead gudgeon		✓	P
Porochilus rendahli	Rendahl's catfish		✓	A
Pseudomugil signifier	Pacific Blue Eye		✓	A
Sclereopages leichardti	Saratoga		✓	P
Scortum hillii	Leathery grunter	Yeppen	✓	P
Strongylura kreffti	Longtom	Yeppen	✓	A
Tandanus tandanus	Freshwater catfish		✓	P

[1]: Migration patterns including P (Potamodromous), D (Diadromous), C (Catadromous) and A (Amphidromous).

*: Exotic species

3.2 Field Results

3.2.1 Survey Timing and Climatic Conditions

Field assessments were conducted between 10 and 14 June, 2019. Weather conditions experienced consisted of warm and cool nights. A review of the daily weather observations sourced from the Bureau of Meteorology (BOM) Rockhampton Aero (station 039083), determined that the minimum and maximum temperature during the survey were 11.9°C and 28.2°C respectively. The BOM reported a total of zero mm of rainfall during the survey period, however 161.6 mm fell in the six week period prior to the survey. Winds were from the southeast, averaging 26 km/h whilst relative humidity at 9 am averaged 74% (Bureau of Meteorology, 2019).

3.2.2 Water Quality

A range of physico-chemical parameters were recorded during the field survey including temperature, electrical conductivity, dissolved oxygen (DO) (in mg/L and % saturation), pH and turbidity. At locations where water depth exceeded 1 m, data was recorded from the bottom and surface of the water column. To determine if changes in water quality may change significantly during the diurnal cycle water quality was also taken at several times during the day where possible. Results from the physico-chemical water quality assessment at turtle survey sites and fish habitat assessment sites are provided in Table 6.

Physical and chemical stressors can cause serious degradation of aquatic ecosystems when values are too high or too low. The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* provides a series of environmental values (EVs) and water quality objectives (WQOs) for different waterways of Queensland. WQOs are numerical values to assess risk of adverse effects due to nutrients, biodegradable organic matter and pH for slightly to moderately disturbed and highly disturbed ecosystems in different geographic locations.

The alignment falls within the Fitzroy South / Central Tributaries sub-catchment as mapped in *WQ1035 - Fitzroy River Sub-basin Environmental Values and Water Quality Objectives* (DES, 2011). The alignment crosses areas mapped as moderately disturbed Fitzroy River Sub-basin fresh waters as well as high ecological value (HEV) palustrine wetlands (mapping unit HEVa2085).

Where trigger values for moderately disturbed systems have been exceeded or do not fall within the specified range (for pH, electrical conductivity, turbidity and DO % saturation), an asterix is associated with the value. There is insufficient data to provide triggers for HEV palustrine wetlands (DES, 2011) and an asterix has been associated with the sample value if it exceeds the triggers for moderately disturbed waters instead.

All lagoons showed elevated electrical conductivity values with respect to the WQO (445 µS/cm during baseflow or 250 µS/cm during high flow). The tributary of the Fitzroy River recorded 3122 µS/cm and Limestone Creek recorded 2855 µS/cm. The Fitzroy River is generally relatively saline, influenced by catchment geology, low flow periods (where conductivity would be higher) and if the system receives saline groundwater inputs. The tributary of the Fitzroy River (55.5% saturation) and Limestone Creek (37.6% saturation) also both recorded the lowest DO % saturation readings which significantly exceeded the trigger range of 85 – 110% saturation.

Other exceedances which were recorded were only slightly outside of trigger values with the exception of the turbidity (173.3 NTU) in the Fitzroy River being significantly beyond the WQO (50 NTU) for moderately disturbed Fitzroy River sub-basin fresh waters. Rivers of this magnitude experience highly variable turbidity values dependent on degree of catchment modification and seasonal rainfall runoff. Approximately 160 mm had fallen within the six week period prior to the survey. This would have increased flow in the local watercourses, elevating turbidity values from resuspension of sediment. Most rivers within Central and Northern Queensland experience exceedances of similar turbidity WQOs. These recordings are not of concern for the Fitzroy River. Turbidity values for Pink Lily Lagoon (19-100 NTU) are elevated with respect to the WQO (50 NTU).

Table 6 Results of physico-chemical water quality assessment

Site	Waterway/Lagoon	Time	Parameter					
			Temperature (°C)	Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	pH	Turbidity (NTU)
Fish Habitat Assessment Sites								
FHA1	Lion Creek	11:15	Risk of estuarine crocodile too high to take water quality measurements at time of sampling					
FHA2	Lion Creek	12:10	Dry at time of sampling					
FHA3	Scrubby Creek	15:30	Dry at time of sampling					
FHA4	Fitzroy River	09:30	19.2	255	7.77	84.2*	7.8	173.3*
FHA5	Fitzroy River (tributary)	10:30	18.4	3122*	5.16	55.5*	7.9	4.2
FHA6	Limestone Creek	13:00	18.0	2855*	3.53	37.6*	7.8	5.8
Turtle Survey Site								
Dunganweate Lagoon		06:30 (bottom – 2.4 m)	18.9	607*	9.03	97.4	7.6	11.6
		06:30 (surface (0.3 m)	18.9	606*	8.57	92.3	8.0	11.9
		12:15 (bottom – 2.4 m)	19.6	581*	9.37	102.3	8.1	15.5
		12:15 (surface – 0.3 m)	19.3	576*	9.14	99.3	8.1	17.5
Fitzroy River		06:30	17.7	262	7.82	82.3*	8.4	148.7*

Site	Waterway/Lagoon	Time	Parameter					
			Temperature (°C)	Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	pH	Turbidity (NTU)
		09:30	19.2	255	7.77	84.2*	7.8	173.3*
Nelson Lagoon		09:00	19.6	703	9.23	100.3	8.1	43.5
Pink Lily Lagoon		06:50 (bottom – 1.6 m)	19.5	619	7.93	86.8	7.9	91.7*
		06:50 (surface – 0.3 m)	19.6	616*	7.87	86.1	8.4	93.9*
		14:00 (bottom – 1.5 m)	20.8	682*	9.1	102.0	8.5	96.5*
		14:00 (surface 0.3 m)	20.3	659*	9.58	106.2	8.6*	100.5*

*Symbolises an exceedance of trigger values for physico-chemical parameters for moderately disturbed Fitzroy River Sub-basin fresh waters as per the Queensland Water Quality Guidelines.

3.2.3 Threatened Turtle Assessment

3.2.3.1 Habitat Assessment

Habitat descriptions and suitability for each threatened turtle species are detailed below. Potential habitat for these species is displayed in Figure 4.

3.2.3.1.1 Pink Lily Lagoon

Table 7 Pink Lily Lagoon threatened turtle assessment

Pink Lily Lagoon
Habitat Description
Pink Lily Lagoon is a permanent, isolated water body in the north of the Project Area, which lies within the floodplain of the Fitzroy River. The adjacent land uses within the Project Area are predominantly suburban housing and cattle grazing. At the time of survey, the lagoon was separated into two distinct pools (which are connected when sufficient water is present). Both pools were characterised by shallow sloping, black cracking clay banks with depths reaching up to 1.6 m in the centre of the large pool and only 0.4 m in the small pool. Riparian vegetation was limited to vegetated margins dominated by *Persicaria orientalis* and *Urochloa mutica* which retreat and encroach dependent on the water level. No submerged, floating or emergent macrophytes were recorded and no undercut banks were available. Snags and woody debris were limited to occasional inundated stags and fence posts on the western edge of the lagoon. Periphyton was observed in the water column however no filamentous algae was present. The substrate consisted of 100% silts and clay.
Habitat Suitability for White-throated Snapping Turtle
Unsuitable for foraging, nesting or dispersal The habitat in Pink Lily Lagoon represented poor quality habitat for this species. The white-throated snapping turtle is a habitat specialist which prefers clear, flowing, well-oxygenated water with complex subsurface structure. Pink Lily Lagoon provides a highly turbid, lacustrine environment with no undercut banks, log tangles or irregular rocky substrata recorded. The banks of the lagoon consisted of black cracking clacks, unsuitable for nesting. Although some food sources are likely present including insect larvae and cane toads, primary food sources for adult turtles (i.e. riparian vegetation, filamentous algae, freshwater sponges and instream macrophytes) were not recorded. The species has limited capacity to cross dry paddocks or streambeds and as such would only be present if stranded after a major flood event which connected the lagoon to the Fitzroy River. Due to the lagoon's isolation from suitable habitat, limited foraging resources and unsuitable nesting habitat, the white-throated snapping turtle is considered unlikely to occur.
Habitat Suitability for Fitzroy River Turtle
Unsuitable for foraging, nesting or dispersal Preferred habitat for the Fitzroy River turtle includes high water clarity, flowing water, riffle zones and complex sheltering habitat such as undercut banks, root mats, logs and rocks. Pink Lily Lagoon did not provide any of these habitat features. The species requires river sandbanks to nest showing preference for relatively steep slopes and low density of ground vegetation and partial shade. This habitat was not present and the lagoon was heavily used by watering cattle which present a major risk of nest trampling. Substrate and complex surfaces suitable for scrape feeding were limited to rare woody debris, with no rocks, log tangles or sponges recorded. Local movement generally occurs between riffle zones and adjacent pools and movement over land is only known to occur between adjacent pools. Riffle zones seem to provide important habitat with one study showing that turtles remained within 300 m of riffle zones, even during base flows, and then retreated to deeper sections of pools as the riffle zones became ephemeral or dried completely (Tucker, et al., 2001).

Pink Lily Lagoon

Due to the isolated nature of the lagoon, lack of accessibility to riffle zones and lack of sandy banks and complex feeding habitat, this species is unlikely to occur within Pink Lily Lagoon.

Pink Lily Lagoon

3.2.3.1.2 Dunganweate Lagoon

Table 8 Dunganweate Lagoon threatened turtle assessment

Dunganweate Lagoon
Habitat Description
Dunganweate Lagoon is moderate sized wetland with an elongated crescent shaped permanent waterbody which is recharged by the Neerkol catchment system. It is located within a disturbed and heavily grazed landscape with riparian vegetation largely absent. The waterbody had moderately sloping banks which are dominated by clay soils with occasional rocks or sand patches. The lagoon was the deepest within the Project Area with a maximum depth of 2.8 m recorded. Dense patches of the emergent aquatic macrophyte, *Nelumbo nucifera* (lotus) were present covering less 10% of the lagoon and small amounts of ribbonweed (*Vallisneria sp.*) was also recorded in shallow margins. Occasional woody debris was present primarily associated with a disused timber ramp. Some algae and detritus was observed on and surrounding the woody debris and dense stands of macrophytes. The water was well oxygenated with readings typically above 97% saturation and 9.0 mg/L. Turbidity was also significantly lower than Pink Lily Lagoon.
Habitat Suitability for White-throated Snapping Turtle
Unsuitable for nesting or dispersal. Marginal foraging habitat Dunganweate Lagoon did provide some microhabitat features consistent with white-throated snapping turtle preferences. These include well oxygenated water and some availability of woody debris and emergent macrophytes. Some foraging resources are available however the lack of defined riparian zone, tree roots or filamentous algae does limit the foraging potential for this species. Although some sand was recorded in the banks of the lagoon, it was not sufficient for nesting purposes and cattle pugging covered almost 100% of the bank. The species has limited capacity to cross dry paddocks or streambeds and as such would only be present if stranded after a major flood event which connected the lagoon to the Fitzroy River. Due to the lagoon's isolation from suitable habitat, limited foraging resources and unsuitable nesting habitat, the white-throated snapping turtle is considered unlikely to occur.
Habitat Suitability for Fitzroy River Turtle
Unsuitable for nesting or dispersal. Marginal foraging habitat Marginal foraging habitat values were available for the Fitzroy River turtle however the lagoon was lacking flowing water, riffle zones, suitable sandy banks for nesting and had minimal complex sheltering habitat. The species requires river sandbanks to nest showing preference for relatively steep slopes and low density of ground vegetation and partial shade. Suitable nesting habitat was absent at this lagoon. Some substrate and complex surfaces suitable for scrape feeding were present with occasional rocks and woody debris associated with the disused timber ramp. Log tangles and sponges were absent. The lagoon is disconnected from potential habitat in the Fitzroy River and is not within overland migration distance. Due to the isolated nature of the lagoon, lack of accessibility to riffle zones and lack of nesting habitat and complex feeding habitat, this species is unlikely to occur within Dunganweate Lagoon.

Dunganweate Lagoon

3.2.3.1.3 Nelson Lagoon

Table 9 Nelson Lagoon threatened turtle assessment

Nelson Lagoon
Habitat Description
Nelson Lagoon is a small permanent waterbody located directly south of Dunganweate Lagoon. The wetland is within heavily disturbed grazing habitat where vegetation is dominated by open *Eucalyptus tereticornis* woodland. The lagoon is recharged by the Neerkol catchment system and is likely connected to Dunganweate Lagoon during flood events. The geology was characterised by black cracking clays in shallow sloping banks and substrate composed of 100% clay. At the time of survey the lagoon reached depths of up to 1 m. The water had high oxygen levels (100.3% saturation) and was moderately turbid (43.5 NTU). No aquatic macrophytes or complex structure was recorded. Some woody debris is present in the form of narrow, inundated stags.
Habitat Suitability for White-throated Snapping Turtle
Unsuitable for foraging, nesting or dispersal Habitat in Nelson Lagoon was not suitable to support a population of white-throated snapping turtle. Foraging resources were very limited with no defined riparian zone, tree roots or filamentous algae. Nesting habitat was absent with heavily pugged clays in the banks. The species has limited capacity to cross dry paddocks or streambeds and as such would only be present if stranded after a major flood event which connected the lagoon to the Fitzroy River. Due to the lagoon's isolation from suitable habitat, limited foraging resources and unsuitable nesting habitat, the white-throated snapping turtle is considered unlikely to occur.
Habitat Suitability for Fitzroy River Turtle
Unsuitable for foraging, nesting or dispersal Preferred habitat for the Fitzroy River turtle includes high water clarity, flowing water, riffle zones and complex sheltering habitat such as undercut banks, root mats, logs and rocks. None of these habitat features were available in Nelson Lagoon. The species requires river sandbanks to nest showing preference for relatively steep slopes and low density of ground vegetation and partial shade. Banks were composed of cracking black clays with no defined riparian zone, unsuitable for breeding for this species. Substrate and complex surfaces suitable for scrape feeding were limited to rare woody debris, with no rocks, log tangles or sponges recorded. The lagoon is disconnected from potential habitat in the Fitzroy River and is not within overland migration distance. Due to the isolated nature of the lagoon, lack of accessibility to riffle zones and lack of sandy banks and complex feeding habitat, this species is unlikely to occur within Nelson Lagoon.

Nelson Lagoon

3.2.3.1.4 Fitzroy River

Table 10 Fitzroy River threatened turtle assessment

Fitzroy River
Habitat Description
Within the Project Area the Fitzroy River is a large permanently inundated 9th order river with wetted width approximately 250 m across. At this location it is above tidal influence with electrical conductivity reading between 255 and 262 microsiemens µS/cm. The bedform features at this section of the river include backwaters and a very large, structurally diverse pool, which runs after flow. No riffle habitat is available. The riparian zone on both northern and southern banks are well developed with large native trees species such as *Eucalyptus tereticornis* and *Melaleuca leucadendra* observed. The riparian zone provides shading to the edges of the channel where undercut banks, root tangles, woody debris and macrophytes are present. On the southern bank the macrophyte community was dominated by the exotic species *Eichhornia crassipes, Hymenachne amplexicaulis* and *Salvinia molesta*. Adjacent the northern bank, macrophyte composition was also 100% exotic and dominated by *Pistia stratiotes* and *Eichhornia crassipes.* The river was experiencing low flow conditions at the time of the survey and banks were approximately 0.7 m – 1 m above the water surface. The northern bank consisted of loamy soils and was vegetated with exotic grass species. The southern bank was heavily vegetated with very little exposed soil.
Habitat Suitability for White-throated Snapping Turtle
Potential foraging and dispersal habitat The Fitzroy River provides a highly connected and structurally diverse habitat. Undercut banks, root tangles, woody debris, riparian vegetation and macrophytes all provide complex sheltering and foraging habitat. The species does shows preference for clear, flowing water in riffle habitat or adjacent pools. This habitat was not recorded however the species is known from the Fitzroy River and it may provide dispersal opportunities. Although alluvial, loamy soils dominate the banks, ground vegetation cover is high, providing very marginal nesting opportunities. Despite lack of riffle zones and high quality nesting habitat, the Fitzroy River within the Project Area does provide potential foraging and dispersal habitat for the species.
Habitat Suitability for Fitzroy River Turtle
Potential foraging and dispersal habitat Undercut banks, root tangles, woody debris, riparian vegetation and macrophytes are all preferred sheltering and foraging habitat features. The species also shows preference for reaches of high water clarity and riffle zones and nests are have all been located on river sandbanks 1 to 4 m above the water level. This habitat was not recorded however the species is known from the Fitzroy River and the Project Area may provide dispersal and foraging opportunities.

Fitzroy River

3.2.3.1.5 Limestone Creek

Table 11 Limestone Creek threatened turtle assessment

Limestone Creek
Habitat Description
Limestone Creek is an ephemeral, third order waterway which is characterised by a series of large shallow pools separated in the dry season by dry cobbled reaches of varying width. The areas surrounding Limestone Creek have been historically cleared or thinned of native vegetation and subject to agricultural and land development practices (AECOM, 2017). However, much of the riparian vegetation within the Project Area does meet remnant status with RE 11.3.25a mapped by AECOM (2017) surrounding Limestone Creek. The riparian vegetation was primarily open forest of *Eucalyptus raveretiana* (black ironbox) and *Melaleuca fluviatilis* (river tea tree) over *Casuarina cunninghamiana* (river she-oak) and the exotic species, *Leucaena leucocephala* (leucaena). The riparian weed *Ruellia simplex* (Mexican petunia) was common in the ground layer. Downstream of the Bruce Highway crossing, the bankfull width was up to 50 m and bank height between 2 m and 5 m. No flow was recorded at the time of the survey and the stream landform consisted of a series of disconnected pools, with one extending for several hundred metres with a width of between 0.5 m and 12 m and up to 3 m depth. The water column varied from algae rich and almost entirely covered in scum, to very low turbidity with stands of submerged and floating macrophytes such as *Potamageton sp.* (pondweed), *Myriophyllum sp.* (water milfoil) and *Nymphaea sp.* (water lily). Submerged woody debris was common and emergent woody debris suitable for turtle basking was also noted at several locations. The substrate was primarily dominated by cobble and several isolated pools were connected by narrow, cobbled stream bed which would form small reaches of shallow riffle zones during times of flow. Surrounding the bridge at the Bruce Highway crossing, the stream bedform and vegetation community has been highly impacted and construction work was being undertaken at the time of survey. Vegetation consists almost exclusively of invasive, weed species including *Rinicus communis* (castor oil plant), *Ruellia simplex* (Mexican petunia) and *Megathyrsus maximus* (guinea grass). Alteration to the stream channel has resulted in an unnaturally raised bedform that disconnects the upper reaches from the downstream environment and the Fitzroy River except for in very high flow conditions. Some physico-chemical water quality parameters at Limestone Creek were below trigger values for slightly to moderately disturbed lowland streams in tropical Australia. These included high electrical conductivity and low DO levels.
Habitat Suitability for White-throated Snapping Turtle
Marginal foraging habitat. Unsuitable for nesting or dispersal Some marginal habitat for white-throated snapping turtle existed in the clear pools downstream from the Bruce Highway crossing (Figure 4). Although no flowing water was recorded in Limestone Creek, the large pool within the Project Area reached depths of 2.5 m and provided complex structure in the form of undercut banks and submerged woody debris. Plant material from dense riparian vegetation and instream macrophytes was abundant and the substrate is favourable for epifaunal colonisation which may provide suitable feeding resources. Gordos, et al. (2007) found that white-throated snapping turtle was generally found in pools >6 m, significantly deeper than any available pools. Further, the species shows preference for clear, flowing, highly oxygenated water. Although clear, no flow was recorded at this location and DO % saturation was significantly below trigger values for moderately disturbed Fitzroy River sub-basin fresh waters. Some cobbled areas upstream may develop into riffle zones during high flow, but no nesting habitat was available adjacent in the stream reach. As such this habitat was considered to be marginal for foraging only.

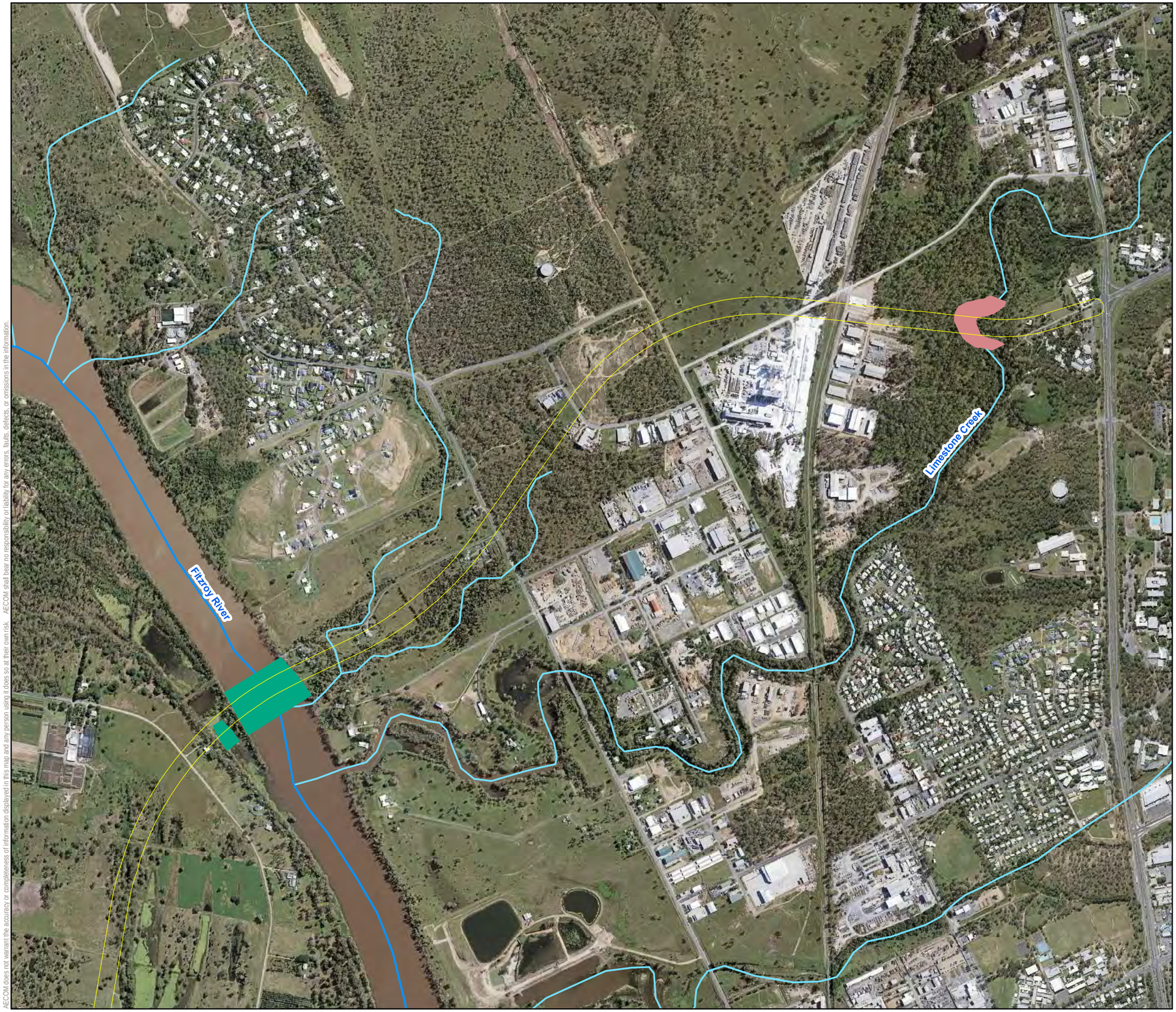
Limestone Creek

Habitat Suitability for Fitzroy River Turtle

Marginal foraging habitat. Unsuitable for nesting or dispersal

Marginal foraging habitat exists for Fitzroy River turtle in the large pool downstream from the Bruce Highway crossing. In this pool water depth reached up to approximately 2.5 m with large stands of floating and submerged macrophytes. Submerged woody debris is abundant in some areas providing potential feeding resources and riparian species associated with Fitzroy River turtle habitat are common in the riparian zone. Several sections of dry, cobbled streambed both upstream and downstream have the potential to form productive riffle zones in periods of high flow, which are favoured habitat for this species. Dissolved oxygen at this location was low and may be limiting for this species. No suitable nesting habitat was identified and upstream habitat is of generally low quality. As such habitat is considered to be marginal for foraging only.

Limestone Creek



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DATUM GDA 1994, PROJECTION MGA ZONE XX

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Metres

1:12,500 (when printed at A3)

LEGEND

- Project Area

White-throated Snapping Turtle and Fitzroy River Turtle Habitat

- Marginal Foraging Habitat
- Potential Foraging and Dispersal Habitat

Watercourses

- Non Perennial
- Perennial

Data sources:
Base Data: (c) State of Queensland (Department of Natural Resources, Mines and Energy) 2019,
Baseline Roads and Tracks, Railway Network.
Aecom 2019, Corridor and RRR Data

ROCKHAMPTON RING ROAD

THREATENED TURTLE POTENTIAL HABITAT

PROJECT ID	60593305
CREATED BY	MCKEEJ2
LAST MODIFIED	12-Aug-2019
VERSION	<version number>

Figure 4

A3 size

Filename: O:\Bus_Lines\Environment\IAP\NR\7. NR Technical QLD\7.6 Mapping\MXD Working\60593305_AquaticRRingRoad_F4_PotentialTurtleHabitat.mxd

3.2.3.2 Live Capture and Release Trapping

During the five day survey a total of 433 individual turtles were captured, positively identified and released without harm. These turtles were all of the same species, Krefft's river turtle (*Emydura macquarii krefftii*) (Plate 1). The species is listed as Least Concern under the NC Act and is not listed as threatened under the EPBC Act.

After identifying to species level, each individual was sexed. Due to innate difficulties in sexing juvenile specimens, young turtles of both sexes were classified collectively as juveniles. Capture rates in Pink Lily Lagoon were highest with some traps units resulting in captures of over 40 individuals. There was evidence of successful recruitment in both Pink Lily and Dunganweate Lagoon with juveniles captured at both locations.

No target turtle species were captured during live capture and release trapping.

Table 12 Turtle species identified within Project Area

Species		Number identified[1]									Total
Scientific Name	Common Name	Pink Lily Lagoon (20 trap units)			Dunganweate Lagoon (5 trap units)			Fitzroy River (5 trap units)			
		M	F	J	M	F	J	M	F	J	
Emydura macquarii krefftii	Krefft's river turtle	81	131	128	31	37	4	11	10	-	
Total		340			72			21			433

[1] M = male; F = female; J = juvenile.

Plate 1 Large female Krefft's river turtle captured in the Fitzroy River

3.2.3.3 Active Searches for Turtle Signs

Over the course of the survey, a minimum of 300 m of the bank from each waterbody was traversed whilst completing active searches for turtle signs. No signs of Fitzroy River turtle or white-throated snapping turtle were encountered. As sandy banks suitable for nesting were not present, no active nests, no tracks to and from the water and no broken eggshells were present.

3.2.3.4 Targeted and Opportunistic Observation

No individuals were positively recorded during targeted and opportunistic observation. Several Krefft's river turtle were observed basking in shallow water in Pink Lily Lagoon and on timber structures in Dunganweate Lagoon. However, neither of the target species were recorded.

3.2.4 Fish Passage Assessment

The primary aquatic environments sensitive to impacts from the Project include the Fitzroy River, Lion Creek at Ridgelands Road and Limestone Creek. At the time of survey, two waterways were dry (Lion Creek at Nine Mile Road and Scrubby Creek) and fish passage was highly restricted at the tributary of the Fitzroy River. A brief description of the habitat available at each waterway is provided below and locations of each site are shown on Figure 3. Representative habitat at each site is shown in Plate 2 to Plate 7.

Fitzroy River (site FHA4)

Within the Project Area the Fitzroy River is characterised by a large channel, with wetted width approximately 250 m. The bedform features at this section of the river include backwaters and a very large, structurally diverse pool, which runs after flow. No riffle habitat was present. The Fitzroy River presents excellent opportunities for fish passage with no unrestricted passage throughout all seasons. Complex instream habitat is abundant with undercut banks, large woody debris, root tangles, deep water and macrophytes, trailing bank vegetation and some stream channel shading adjacent the bank edges.

Lion Creek at Ridgelands Road (site FHA1)

Where the alignment crosses Lion Creek at Ridgelands Road permanent water is present providing fish passage. There was no flow at the time of assessment, with bedform consisting of one large pool with maximum wetted width of 15 m. The riparian vegetation consisted of *Eucalyptus tereticornis* and *Melaleuca leucadendra* woodland with limited cover in the shrub layer and high infestation of exotic grass species in the ground layer. The water column was highly turbid and some areas were clogged with exotic macrophytes such as *Eichhornia crassipes, Hymenachne amplexicaulis* and *Azolla sp.* Fish passage was partly restricted at this location due to the infestation of emergent macrophytes, however microhabitat features such as submerged logs, instream cover, trailing bank vegetation and macrophytes did provide suitable habitat for a number of native and exotic fish species.

Limestone Creek (site FHA6)

At Limestone Creek a large, deep (up to 2.5 m) pool is present with no flow at the time of survey. The riparian vegetation was open forest of *Eucalyptus raveretiana* (black ironbox) and *Melaleuca fluviatilis* over *Leucaena leucocephala* and *Casuarina cunninghamiana* (river she-oak) which provided shade to approximately 80% of the stream channel. Some emergent macrophytes (i.e. *Typha orientalis*) and floating macrophytes (i.e. *Nymphaea sp.*) were present. Percentage cover of macrophytes was low in much of the main channel; however, at the western end of the reach, point bars had developed which were infested with exotic macrophytes. Very large woody debris was also present at these point bars as a result of fallen canopy trees. These habitat features result in moderately restricted fish passage at this location. The stream provided high value habitat for some fish species with relatively high structural diversity in the form of undercut banks, trailing bank vegetation, large woody debris and macrophytes.

Lion Creek at Nine Mile Road (site FHA2)

At FHA2, Lion Creek is a highly ephemeral system in a landscape which has been severely degraded by historical clearing, thinning and grazing. The riparian habitat consisted of open woodland dominated by *Eucalyptus coolabah* with no defined shrub layer and a grassy understorey. The channel was dry at the time of survey providing no opportunity for fish passage. During summer surveys only a very small, shallow pool was present.

The bed and bank material was dominated by silts and clay, however a small amount of cobble (approximately 5%) was present. The channel is highly uniform with no complex instream habitat available. During times of periodic inundation this area would not represent high value habitat for fish.

Scrubby Creek (site FHA3)

At this location Scrubby Creek is intersected by a small bridge on the Capricorn Highway. This reach was extremely disturbed due to impacts associated with the road and bridge construction works as well as grazing and clearing in the adjacent land parcels. The riparian zone is highly modified with large trees absent but *Corymbia tessellaris, Eucalyptus tereticornis, Lysiphyllum hookeri* and *Acacia salicina,* collectively provide 10-15% cover in a low canopy (<10 m) downstream of the crossing. Exotic species represented almost 100% of the ground cover with *Urochloa mutica* completely clogging the channel downstream of the crossing. Directly upstream, the riparian vegetation is sparser with canopy and shrub layer almost absent and exotic grasses dominating the ground layer.

The channel has been modified through rock reinforcement and re-sectioned downstream to allow farm vehicles to cross the channel. Banks were moderately unstable with areas of erosion evident and high erosion potential during floods. The creek was dry at the time of sampling and no fish passage would be possible during base or low flow conditions. During large flow events moderately restricted passage of fish is likely. Instream habitat is uniform and of low value.

Tributary of the Fitzroy River (site FHA5)

This tributary of the Fitzroy River is characterised by very small, shallow, disconnected pools with high water clarity a mix of bedrock, boulders, cobble and fines in the substrate and banks. Pools rarely exceeded 1 m in width and 10 cm depth. The conductivity at this location was 3122 µS/cm, much higher than the reading at the main channel (255 µS/cm). This difference suggests that electrical conductivity may be influenced by the geology at this location and the high reading at FHA5 may create an inhospitable environment for some freshwater fish species.

The riparian zone has experienced historical thinning however regrowth vegetation provided approximately 30% canopy cover and has helped to stabilise the moderately steep banks. Dominant species include *Eucalyptus coolabah, Melaleuca leucadendra* and *Melaleuca bracteata.* Macrophytes were limited to *Typha orientalis* which was present in approximately 50% of the reach.

Although water was present during the survey, the disconnected pools did not provide fish passage and it is expected that during high flow passage would still be moderately restricted. Some habitat features were present including occasional woody debris, macrophytes and trailing bank vegetation; however habitat value is limited to small bodied fish which may persist in very small, shallow pools with high electrical conductivity.

Plate 2 Fitzroy River at FHA4

Plate 3 Lion Creek at Ridgelands Road (FHA1)

Plate 4 Limestone Creek at FHA6

Plate 5 Lion Creek near Nine Mile Road (FHA2)

Plate 6 Scrubby Creek at FHA3

Plate 7 Tributary of the Fitzroy River at FHA5

4.0 Potential Impacts and Mitigations

The construction and operational phase of the Project has the potential to result in temporary impacts to the aquatic environment surrounding crossings at waterways and lagoons. Temporary impacts include a reduction in the extent and complexity of some aquatic habitat, potential for increased pollution, some impacts to water quality and creation of barriers to fish movement which can potentially impede the fulfilment of life history strategies. It is expected that with appropriate mitigation measures that these impacts would be limited to the construction period after which the biotic ecosystem components (including algae, detritus, macrophytes, macroinvertebrates, fish etc.) would be re-established.

General mitigation measures will be implemented for the Project including an Environmental Management Plan (Planning) EMP(P) and Erosion and Sediment Control Plan ESCP in accordance with specification MRTS51 Environmental Management and MRTS52 Erosion and Sediment Control. All rehabilitation works will be undertaken in accordance with specification MRTS16 Landscape and Revegetation Works. Site inductions to be undertaken by all people working / entering the Project Area.

Additional mitigation measures are discussed below in Sections 4.1 and 4.2.

4.1 Threatened Turtles

4.1.1 Loss or Degradation of Habitat

4.1.2 Direct Habitat Loss

During the construction phase of the Project, removal of riparian vegetation surrounding waterways and lagoons and excavation within and adjacent the Project Area will occur. The lagoons and waterways were not found to provide suitable nesting habitat for either Fitzroy River turtle or white-throated snapping turtle. However, the Fitzroy River is likely to provide some dispersal opportunities for both species, and marginal foraging habitat was observed in the Fitzroy River and Limestone Creek.

Instream construction works can change the complexity of aquatic habitat in a range of ways such as removal of macrophyte communities, altering the natural state of algae and detritus and clearing of instream woody debris. This in turn can modify fish and macroinvertebrate communities which may provide a food resource. Further, loss of riparian vegetation overhanging riverine habitat, can lead to a reduction in fruit as food for adult white-throated snapping turtle (C.J. Limpus et al., 2011). Clearing of instream woody debris can also reduce the availability of refuge and basking locations for turtles.

Where bridge construction is proposed to occur at the Fitzroy River crossing, the channel is approximately 250 m wide. Undercut banks, root tangles and clumped macrophytes provide some sheltering and foraging opportunities directly adjacent the banks of the river which may be impacted during construction. However, this habitat is considered to be only marginal and is widely available in the adjacent banks. Bridge construction is not anticipated to result in barriers to movement and the Fitzroy River is also highly connected to higher value habitat upstream and as such dispersal opportunities for either turtle species are not expected to be impacted.

At Limestone Creek some marginal foraging habitat for both species exists in the large, clear pool within the Project Area. Although no flowing water was recorded in Limestone Creek, the large pool within the Project Area reached depths of 2.5 m and provided complex structure in the form of undercut banks and submerged woody debris. Plant material from dense riparian vegetation and instream macrophytes were abundant and the substrate is favourable for epifaunal colonisation which may provide suitable feeding resources. A single span bridge is proposed to be constructed over Limestone Creek at this location, however this will still require removal of riparian vegetation and complex instream structure such as woody debris, undercut banks and root tangles.

Mitigation Measures:

The following mitigation measures are proposed to minimise potential impacts:

- No-go zones will be clearly identified to avoid unauthorised disturbance of areas of sensitive vegetation and habitat adjacent to the Project area that will be retained; such as riparian zones associated with waterways and wetlands and other threatened species and migratory species habitat
- Rehabilitation works will be undertaken in accordance with TMR specification for Landscape and Revegetation Works and include a revegetation strategy
- Retain and / or reinstate complex instream habitat values wherever possible (i.e. undercut banks, woody debris, log tangles, native macrophytes) at Limestone Creek and the Fitzroy River crossings.

4.1.3 Habitat Degradation

Construction activities have the potential to impact on aquatic habitats within and adjacent the Project Area and in the downstream environment. Such impacts include but are not limited to:

- Alteration of natural flow regimes
- Erosion and sedimentation
- Reduction in water quality
- Exacerbation of weed and pest species
- Construction related light and noise impacts.

Changes to the natural flow regime can result in homogenising the natural run-riffle-pool sequence. Usually alteration of a flow regime results in an increase in lentic habitat, which can reduce the availability of riffle and run that can provide important habitat units for both target species. The Project is not expected to alter the natural flow regime, with no major modification of channel banks or permanent instream barriers required.

Changes in water quality can occur due to increased sedimentation, pollution and run-off. The primary potential impact to the target turtle species would be a reduction in oxygen during the construction phase. As both species are able to perform facultative aquatic respiration, a temporary reduction in dissolved oxygen levels could negate the benefits of this adaptation such as increased foraging time and reduced exposure to predators. Therefore, a reduction in dissolved oxygen could directly impact the preferred ecological behaviours.

Potential changes to water quality can be managed through standard environmental management practices and controls such as implementing an erosion and sediment control plan and water quality management plan. A reduction in water quality in Limestone Creek may occur as a result of Project activities which could reduce the suitability of this habitat for the target species. Water quality at this location is already compromised, with low readings of dissolved oxygen and high readings of electrical conductivity recorded. Where marginal foraging and dispersal habitat was found to be present in the Fitzroy River, the magnitude of changes to water quality is not expected to be significant, due to the volume of water present compared to the works proposed.

Construction activities generally have the potential to result in the proliferation of riparian and aquatic weeds. Aquatic weeds can have a range of environmental impacts including competing with native species and reducing biodiversity; reducing flow capacity of drainage networks; and when too dense may significantly impact the under-surface ecosystem, causing oxygen depletion potentially leading to aquatic species mortality. Aquatic weeds which form dense mats and reduce flow capacity (i.e. *Hymenachne amplexicaulis* and *Eichhornia crassipes*) were already established along the banks of the Fitzroy River. At Limestone Creek some aquatic weeds were observed, however they had not yet proliferated to the point they were likely to significantly deplete oxygen in the water or reduce flow capacity.

Proliferation of weeds has not been identified as a key threat to either target turtle species. However innate issues with weed proliferation may lead to indirect impacts on turtles. For example, infestation

of dense macrophytes may cause cessation of flow leading to reduced oxygenation of the water and impeding cloacal respiration. Spread of aquatic weeds should be managed through appropriate mitigation measures to reduce this potential risk.

Temporary construction noise and light impacts are expected within the Project Area. Noise impacts can result in reduced foraging behaviour and increased risk of predation by visual predators due to increased background noise. Light pollution has the potential to affect nocturnal nesting behaviour. Due to the lack of viable nesting and foraging habitat within the Project Areas, impacts from increased noise, activity or light associated with construction activities are considered to be minimal.

Mitigation Measures:

The following mitigation measures are proposed to minimise potential impacts:

- Construction in areas mapped as potential habitat for threatened turtles should be limited to daylight hours whenever practical at Limestone Creek and the Fitzroy River crossings
- Implement an appropriate Weed and Pest Management Plan for the Project (this should include the control of aquatic weeds and pests)
- Design will consider minimising instream impacts and inclusion of suitable design measures for mitigating and/ or treating pollutants in accordance with TMR design standards
- Develop and implement a water quality monitoring program to establish baseline conditions and monitor water quality changes during construction phase of the Project.

4.1.4 Barriers to Movement

Obstruction of migration within rivers has been identified as a threat to the white-throated snapping turtle as the species is known to migrate tens of kilometres up or down streams to aggregate at traditional nesting sites (C.J. Limpus et al., 2011).

Upstream and downstream movement of turtles could be temporarily constrained during the construction period. Potential impacts to turtle passage will be limited to crossings at Limestone Creek and the Fitzroy River. Turtle passage is already limited at Limestone Creek during the dry season where the creek forms a series of disconnected pools. During this period, turtle movements are likely to be localised and as such construction during the dry season is recommended to occur in this area if practicable.

The Fitzroy River provides the higher value dispersal pathway within the Project alignment. Bridge abutments are unlikely to impede turtle movement during operation. Maximising the retention of suitable in-river and riparian habitat should be considered during design.

Mitigation Measures:

The following mitigation measure is proposed to minimise potential impacts:

- Design and construction of bridge, culvert and drainage works will seek to minimise barriers to turtle movement by maintaining stream flow and in-river habitat in the Fitzroy River and Limestone Creek.

4.1.5 Nest Predation and Trampling

Nest predation by native and exotic predators and trampling of nests by stock is considered one of the key threatening process for both target turtle species. Given the current land use and topography, pastoral animals are unlikely to have access to the banks of the Fitzroy River and Limestone Creek. However, feral pig (*Sus scrofa*) is present within the area and known to destroy turtle nests and predate on eggs. The surrounding riparian zone also provides suitable habitat for monitor lizards of the genus *Varanus* which are known predators of turtle nests.

Most lagoons within the Project Area are within cattle grazing properties and are used by livestock for watering. Severe pugging was recorded in the banks of several lagoons. Given the existing livestock use and the lack of high quality nesting habitat for either turtle species it is highly unlikely the Project will exacerbate impacts on nest predation or trampling.

Mitigation Measures:

- Implement an appropriate Weed and Pest Management Plan for the Project (this should include the control of aquatic weeds and pests).

4.2 Fish Passage

The construction of barriers to waterways can impede upstream or downstream fish migrations which are required as a part of natural lifecycles to:

- Move between feeding and breeding habitats (i.e. catadromous adult fish migrate from freshwater habitat to estuaries where they breed. Adults and post-larvae migrate back to freshwater, riverine habitat post breeding)
- Find refuge during dry season and droughts and disperse from refuge areas once connections are reformed during the wet season or flow events
- Locate breeding partners.

A waterway barrier is any form of infrastructure built on a waterway that impedes flow or connectivity. This includes permanent structures (i.e. dams, weirs, culverts and bed-level road crossings) and temporary installations (e.g. temporary workspaces, silt curtains and litter booms). Under the *Fisheries Act 1994* and *Planning Act 2016,* 'waterway barrier works' include the construction, raising or replacement of such structures, and also some maintenance works.

There are six waterway crossings within the Project Area where new bridges or changes to existing bridges are proposed. Although bridges are typically designed to provide adequate fish passage, impacts to fish are still associated with the construction of such structures. Potential impacts on fish habitat and passage include the following.

- Changes to hydrology which can result in reduced fish passage and migration due to change in instream habitat and water velocities
- Reduction in water quality which can impact on health and survivorship.

Hydrology

The replacement of and construction of new bridges and additional hardstand has the potential to impact on the current hydrological regime of the creeks and rivers within and adjacent to the Project Area. Impacted services may also require relocation which will entail further necessary excavation works and placement of impermeable structures.

Hydraulic impacts such as additional hardstand and structures can influence afflux (change flood levels) and flow velocities. This can cause scouring of waterways and structures, which can homogenise instream habitat and lead to greater or lesser inundation on neighbouring properties during a high rainfall or flood event. This change in velocities can also hinder the ability of small bodied fish species to migrate within a waterway. Further, during construction, the taking of water for construction activities may be necessary. This can have temporary impacts (e.g. changes in water level and flow) on the natural hydrology of creeks and reduce the availability of suitable habitat or the ability of fish to disperse to favourable habitat.

Water Quality

As previously described the Project has the potential to impact on water quality at waterway crossings as a result of increased sediment loads and stormwater runoff entering the surface water systems during the construction and operational phases. This presents and increased risk of contaminants entering natural waters as a result of:

- Construction activities, including:
  - chemical surface coating
  - abrasive or water blasting
  - bitumen spraying

- Wear and tear from vehicles, brakes and other mechanical components
- Accidental spill
- Wear and tear of the road surface, shoulder and verge
- Maintenance practice such as herbicide use, mowing, road surface cleaning or reparation
- Change in slope/gradient on waterways and embankments/cuttings.

An increase in sedimentation and contaminants can alter the equilibrium of physical and chemical parameters in the waterbody which are necessary for fish health and survival. For example, oxygen in the water body may be depleted through decay of some hydrocarbons or by increased sedimentation smothering of oxygen producing macrophytes. An increase in sedimentation may also result in reduction of light penetration in water bodies. This can clog the gills of fish and can hinder the ability of some visual aquatic predators to locate prey, as well as reducing the photosynthetic ability of native aquatic plants.

The concentration of heavy metals in waterbodies may increase from vehicle wear during the construction phase, normal operation or as the result of an unintentional spills or traffic accidents. Heavy metals can bio-accumulate in the food chain and cause adverse health effects, and in some cases fish mortality.

Impacts to water quality should be controlled through the following mitigation measures.

Mitigation Measures:

The following mitigation measures are proposed to minimise potential impacts:

- Design and construction of bridges, culverts and drainage works will seek to minimise impacts to fish passage, migration and movement barriers where possible. Consideration should be given to specific DAF requirements under the Accepted Development Requirements (ADR) for operational works that are water way barrier works (DAF, 2018)
- Design will consider minimising instream impacts and inclusion of suitable design measures for mitigating and/ or treating pollutants in accordance with TMR design standards
- Develop and implement a water quality monitoring program to establish baseline conditions and monitor water quality changes during construction phase of the Project
- Rehabilitation works will be undertaken in accordance with TMR specification for Landscape and Revegetation Works and include a revegetation strategy
- Implement an appropriate Weed and Pest Management Plan for the Project (this should include the control of aquatic weeds and pests)
- Develop and implement an ESCP for the Project.

5.0 Conclusion

AECOM undertook an aquatic ecology investigation for the BC phase of the Project. This included two components run concurrently, a targeted survey aimed at establishing the presence or potential presence of two threatened turtle species, white-throated snapping turtle (*Elseya albagula*) and Fitzroy River turtle (*Rheodytes leukops*), and a physical assessment of waterways within the alignment to understand the suitability of mapped waterways as habitat for potential fish passage.

Threatened Turtles

To determine presence/absence of the target species, a range of survey methods were employed including, live capture and release trapping, habitat assessment, active searches for turtle signs and targeted and opportunistic observations. Live capture and release trapping did not result in the capture of any target turtle species however 433 individual Krefft's river turtle (*Emydura macquarii krefftii*) were caught. Krefft's river turtle were captured at all three trapping locations, with the highest catch per unit effort recorded in Pink Lily Lagoon.

Habitat assessments determined that potential foraging and dispersal habitat was available for both species in the Fitzroy River and marginal foraging habitat was present in Limestone Creek. No suitable nesting habitat for either species was present within or directly adjacent the Project Area.

It was concluded that the lagoons did not provide high value foraging, dispersal or nesting habitat which could support a population of either species. Further due to their isolation from the Fitzroy River it is considered unlikely that an individual or population would exist in any of the lagoons unless stranded during a large flood event.

Potential impacts to turtle habitat in the Fitzroy River and Limestone Creek include construction works instream and in riparian habitats and changes to water quality. Instream construction works can change the complexity of aquatic habitat in a range of ways such as removal of macrophyte communities, altering the natural state of algae and detritus and clearing of instream woody debris. This in turn can modify fish and macroinvertebrate communities which may provide a food resource. Further, loss of riparian vegetation overhanging riverine habitat, can lead to a reduction in fruit as food for adult white-throated snapping turtle (C.J. Limpus et al., 2011). Changes in water quality due to increased sedimentation, pollution and run-off may also impact habitat value. The primary potential impact to the target turtle species would be a reduction in oxygen during the construction phase. As both species are able to perform facultative aquatic respiration, a temporary reduction in dissolved oxygen levels could negate the benefits of this adaptation such as increased foraging time and reduced exposure to predators. It must be noted that at one location (Limestone Creek) where marginal foraging habitat was located, dissolved oxygen levels were already below trigger levels for slightly to moderately disturbed systems.

This assessment determined that given the availability of only marginal habitat for threatened turtle species, the bridge design spanning higher value waterways and the mitigation measures proposed, the Project is highly unlikely to significantly impact threatened turtle species.

Fish Passage

As part of the technical investigations for the Project, an aquatic assessment was undertaken at all water course crossings within the Project Area in order to determine aquatic habitat values relevant for waterway barrier works and fish passages. No live capture and release of fish species was conducted during this survey.

This assessment determined that the primary aquatic environments sensitive to impacts from the Project include the Fitzroy River, Lion Creek at Ridgelands Road and Limestone Creek. The Fitzroy River provides the highest value fish habitat and is characterised in the Project Area by a large, permanent river, providing excellent fish passage, with a high diversity of fish species with a range of migration strategies. Large permanent pools with a range of instream habitat characteristics were also noted at Lion Creek at Ridgelands Road and Limestone Creek.

At the time of survey, two waterways were dry (Lion Creek at Nine Mile Road and Scrubby Creek) and fish passage was highly restricted at the tributary of the Fitzroy River. Lion Creek at Nine Mile Road and Scrubby Creek were both highly degraded systems which are unlikely to provide fish passage outside of very large flow events. The channel in both systems is homogenised and would not provide complex in stream habitat during such events. The tributary of the Fitzroy River was reduced to several very small, shallow pools with high electrical conductivity that were found to be disconnected from the main channel. Fish passage is likely to be afforded during flow events and some instream habitat features such as macrophytes, rocky substrate and high riparian vegetation cover were noted at the time of survey.

Potential impacts to fish passage and general habitat health are primarily associated with potential changes to hydrology and reduction in water quality. Changes to hydrology can result in reduced fish passage and migration due to change in instream habitat and water velocities. An increase in sedimentation and contaminants can alter the equilibrium of physical and chemical parameters in the waterbody which are necessary for fish health and survival. Through bridge design and management measures to reduce impacts to water quality as a result of the Project, fish passage is not expected to be compromised within the Project Area.

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