LOWER FITZROY RIVER
INFRASTRUCTURE PROJECT

Appendix L

Fitzroy River turtle (*Rheodytes leukops*)

SunWater
MAKING WATER WORK

Gladstone Area Water Board

Gladstone Area Water Board and Sun Water

Lower Fitzroy River Infrastructure Project

Fitzroy River turtle (*Rheodytes leukops*) technical report

June 2015

Acronyms

Acronym	Definition
ADH	Australian height datum
AMTD	Adopted middle thread distance
ANZECC	Australian and New Zealand Environment and Conservation
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AusRivAS	Queensland Australian River Assessment System
CFD	Computational fluid dynamics
cm	centimetres
DEHP	Department of Environment and Heritage Protection
DERM	Department of Environment and Resource Management
DNRW	Department of Natural Resources and Water
EIS	Environmental impact statement
EMP	Environmental management plan
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
FSL	Full supply level (elevation in m AHD)
ha	hectare
IECA	International Erosion Control Association
km	Kilometres
m	Metre
ML/a	Mega litre per annum
mm	millimetres
N	Number of turtles
NC Act	Nature Conservation Act 1992 (Queensland)
PIT	Passive integrated transponder
RCC	Roller compacted concrete
ROP	Fitzroy Basin Resource Operations Plan 2004
ToR	Terms of reference
WRP	*Water Resource (Fitzroy Basin) Plan 2011*

Executive Summary

The Fitzroy River turtle (*Rheodytes leukops*) is listed as vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the Queensland *Nature Conservation Act 1992*. The Fitzroy River turtle is endemic to the Fitzroy Basin catchment and the species is known to occur within the footprints of the Lower Fitzroy River Infrastructure Project (Project). The Project, proposed by Gladstone Area Water Board and SunWater Limited, includes construction and operational activities to raise the existing Eden Bann Weir and/or to establish a new weir at Rookwood on the Fitzroy River, Central Queensland.

A targeted investigation into the population of Fitzroy River turtle within the Project footprints was undertaken as a component of the environmental impact assessment. This investigation included a population assessment (Limpus et al. 2011a), nesting habitat survey, aquatic habitat assessment, habitat segment analysis and literature review. Background information on the species was collected including: distribution and habitat, population structure, reproductive biology and nesting requirements, respiratory physiology and diving behaviour, diet, movement biology and threatening processes. Potential impacts of Project construction, commissioning and operation were then identified and assessed against the Matters of National Environmental Significance Significant impact guidelines 1.1.

The Fitzroy River turtle is a specialist species that is endemic to the Fitzroy Basin catchment. The species inhabits flowing riverine habitats, including pool-riffle-run sequences. Important habitat for the species occurs within the Project footprint at Glenroy crossing, Redbank crossing, Marlborough Creek and upstream of Boolburra rail crossing. Nesting is generally restricted to alluvial sand/loam banks with a relatively steep slope, low density of ground/understorey vegetation and partial shade cover. Important nesting habitat occurs at Alligator Creek located within the upper reaches of the Fitzroy Barrage impoundment (approximately 40 km downstream of the Project footprint). This area supports the largest known Fitzroy River turtle nesting aggregation. Within the Project footprints, isolated nests of the Fitzroy River turtle have been historically recorded at Glenroy and Redbank crossings. Isolated turtle nesting activity was also identified at six nesting banks within the Rookwood Weir Project footprint during field surveys. Two additional banks, one within the Rookwood Weir Project footprint and one within the Eden Bann Project footprint, were identified as being highly suitable for Fitzroy River turtle nesting.

The ecology of the Fitzroy River turtle is influenced by the species' ability to respire aquatically, which allows the turtle to remain submerged underwater for long periods. Benefits of aquatic respiration include: increased time available for foraging and breeding, reduced exposure to predation, reduced energy expenditure and habitation of fast-flowing riffle zones. The home range size of the Fitzroy River turtle is relatively small, however, large scale movements are thought to occur for the purpose of dispersal, courtship, nesting and repositioning following flood displacement.

The biggest threat to the survival of the Fitzroy River turtle is the lack of recruitment into the population. Predation of nesting banks by feral animals, goannas and water rats and trampling of nests by cattle results in extremely poor survival of egg clutches. The bias in favour of adult turtles within the Fitzroy Basin 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. Additional threatening processes include: loss of habitat; alteration of natural flow regime; movement barriers; physical injury and mortality; and poor water quality.

In the absence of suitable management, the construction and operation of weir infrastructure at Eden Bann Weir and Rookwood Weir has the potential to exacerbate the existing threatening processes occurring throughout the Fitzroy Basin catchment.

Construction of the Project will result in the permanent loss of Fitzroy River turtle habitat within the Rookwood Weir construction footprint and river crossing construction areas. The area of habitat to be impacted is relatively small in size in relation to that available within the immediate area and as such the loss of habitat is not considered significant.

Additional impacts to the Fitzroy River turtle that may occur as a result of Project construction activities include: the degradation of habitat, increased injury and mortality, and the restriction of turtle movement. These impacts will be localised, restricted to the duration of the construction period and primarily managed through the Project construction environmental management plan. Key mitigation measures to be implemented will include: pre-clearance surveys, turtle and nest relocation, and flow diversion/maintenance.

Project commissioning will result in the inundation of 113 km of Fitzroy River turtle habitat. The conversion of natural creeks and pool-riffle run sequences into impounded habitat will reduce the suitability of the habitat for the Fitzroy River turtle. The area of permanent occupancy of the Fitzroy River turtle is predicted to decrease, however, the species is expected to persist in the shallow water margins and upstream reaches of the impoundments.

A total of 5.71 ha of Fitzroy River turtle nesting habitat (historical, confirmed and high potential) will be inundated during Project commissioning. Suitable nesting habitat for the Fitzroy River turtle is expected to persist in the upper reaches of the impoundments and the existence of aggregated nesting in the upper reaches of the Fitzroy River Barrage and the Tartrus Weir impoundment, demonstrate that the species has the ability to colonise new habitat where suitable conditions do occur. While the establishment and success of Fitzroy River turtle nesting within the Project footprints is unable to be assured, the implementation of a Weed Management Plan and Feral Animal Control Program will assist in increasing the quality of potential nesting habitat for the Fitzroy River turtle and the potential for successful recruitment of hatchlings into the population. These management strategies will directly target the key existing threatening process acting on the species and if successful will increase hatchling recruitment above existing levels. Due to the specific nesting requirements of the species and the extremely high nest predation rates throughout the catchment, the loss of Fitzroy River turtle nesting habitat within the Project footprint is considered a significant impact of the Project.

Operational activities that have the potential to impact the Fitzroy River turtle include: in-stream barrier operation and alteration of the flow regime. Minimising the potential risk of turtle injury and mortality and maintaining upstream and downstream turtle movement, have been key management objectives through the Project design phase. Design features that have typically responsible for high levels of turtle injury and mortality in the. A specifically designed turtle passage facility (turtle ramp) will be constructed at Eden Bann past have been completely avoided in the Project design thereby substantially reducing the risk to turtles Weir and Rookwood Weir to mitigate the potential impacts of the Project on

turtle movement and population fragmentation. As turtle movement is currently restricted at Eden Bann Weir as result of the existing weir, provision of the turtle ramp will improve the movement of turtles past this structure and restore the connectivity of the population in this region.

The operation of weirs is predicted to result in a change to the downstream flow regime. Water flows are predicted to increase during the dry season resulting in a decrease in the frequency and duration of no flow periods. The operation of the weirs is also likely to result in a reduction in the frequency and magnitude of small – medium downstream flood flows. The increase in flows during the dry season has the potential to improve the quality of Fitzroy River turtle habitat downstream by reducing the duration and severity of pool isolation and prolonging the presence of flowing riffles zones and runs. An alteration in the magnitude and timing of downstream flows does, however, have the potential to impact Fitzroy River turtle nesting. The operation strategy of the weirs will be dictated by the objectives set in the *Water Resource (Fitzroy Basin) Plan 2011* and subordinate Fitzroy Basin Resource Operation Plan 2004, inclusive of environmental flow objectives. The operational strategy will aim to minimise environmental impacts as a results of the water infrastructure and will mimic natural flow conditions as much as possible. Ongoing monitoring of Fitzroy River turtle nesting habitat downstream of the Project footprints will identify potential impacts from changes in flow regime and allow for adaptive management.

Operation phase impacts associated with changes in water quality and an increase in predator abundance have the potential to exacerbate existing threats to the species. Various management plans will be implemented to improve the quality of Fitzroy River turtle aquatic and nesting habitat remaining within the Project footprints.

A Species Management Program for the Fitzroy River turtle (Volume 3 Appendix M) describes measures to be implemented to avoid, and if this is not possible, minimise the potential impacts of the Project on the species and provides a framework for the management of the species throughout the life of the Project.

Overall, the assessment of Project impacts against the Matters of National Environmental Significance Significant impact guidelines 1.1, identified that the Project is likely to have a residual impact on the Fitzroy River turtle during Project operations. Offsets are required under the EPBC Act Environmental Offset Policy. The protection and management of turtle nests has been selected as the proposed offset for the Project. The protection and management of nests will target Project specific impacts as well as address the key processes currently threatening the survival of the species throughout the catchment. These actions will reduce nest predation, increase population recruitment and promote the recovery of the species. Ongoing monitoring of the Fitzroy River turtle population within, upstream and downstream of the Project footprints during Project operation will identify potential impacts to the species and allow for adaptive management.

Table of contents

Table index

Figure index

Appendices

1. Introduction

1.1 Overview

The Fitzroy River turtle (*Rheodytes leukops*) is listed as vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Queensland *Nature Conservation Act 1992* (NC Act). The Fitzroy River turtle is endemic to the Fitzroy Basin catchment and the species is known to occur within the footprints of the Lower Fitzroy River Infrastructure Project (Project). The Project, proposed by Gladstone Area Water Board and SunWater Limited, includes construction and operational activities to raise the existing Eden Bann Weir and to establish a new weir at Rookwood on the Fitzroy River, Central Queensland.

This Fitzroy River turtle technical report has been prepared as a component of the environmental impact statement (EIS). Background information on the existing population of Fitzroy River turtle within the Project footprints is discussed including distribution and habitat, population structure, reproductive biology and nesting requirements, respiratory physiology and diving behaviour, diet, movement biology and threatening processes. The potential impacts of Project (construction and operation) on the species are identified and assessed against the Matters of National Environmental Significance Significant impact guidelines 1.1 (DoE 2013). The management actions proposed have been developed to avoid, and if this is not possible, mitigate Project specific impacts as well as address the key processes currently threatening the survival of the species throughout the catchment. Where impacts are unavoidable and assessed as being significant residual impacts offsets are proposed.

In relation to the Fitzroy River turtle this report addresses the following under the terms of reference (ToR):

- Part B, Sections 5.76 – 5.81 as described in Appendix A
- Part C, Section 1.46 and Appendix 3 as described in Appendix A

Further information relevant to the Fitzroy River turtle is provided in the following sections of the EIS:

- Volume 1, Chapter 7 Aquatic fauna
- Volume 1, Chapter 22 Offsets
- Volume 2, Chapter 14 Offsets
- Volume 3 Appendix J and Volume 3 Appendix K (aquatic fauna baseline reports including approach and survey methodology)
- Volume 3 Appendix M (Species Management Program for the Fitzroy River turtle.

1.2 Project description

The Project includes construction and operational activities to raise the existing Eden Bann Weir and establish a new weir at Rookwood on the Fitzroy River, Central Queensland to capture and store unallocated but available high priority water. A detailed description of the Project is provided in Volume 1, Chapter 2 Project description of the EIS.

Key Project components include a combination of:

- Eden Bann Weir
  - Eden Bann Weir Stage 2 (EB2) – a raise of the existing Eden Bann Weir. The existing Eden Bann Weir is located at 141.2 kilometres (km) adopted middle thread distance

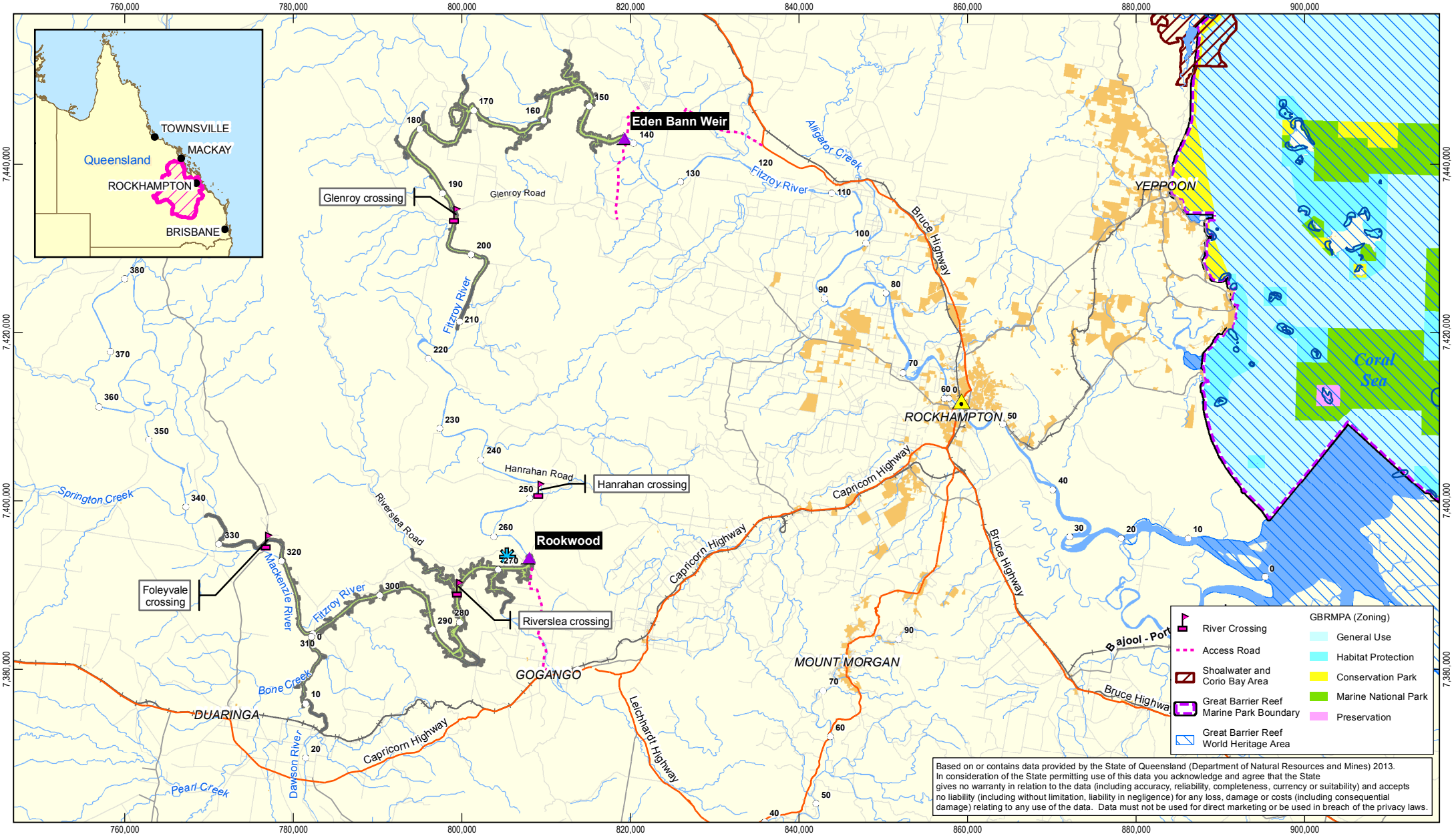
(AMTD), and has a full supply level of 14.5 metres (m) Australian Height Datum (AHD). The existing impoundment extends to 184 km AMTD (approximately 43 km). Raising the weir to FSL 18.2 m for a Stage 2 build extends the impoundment of the Fitzroy River to approximately 205 km AMTD, an additional 21 km.

  - Eden Bann Weir Stage 3 (EB3) – the addition of 2 m high flap gates to achieve FSL 20.2 m AHD and associated impoundment of the Fitzroy River to approximately 211 km AMTD, an additional 6 km.

- Rookwood Weir
  - Rookwood Weir Stage 1 (RW1) – a new build at 265.3 km AMTD to FSL 45.5 m AHD (15.5 m above the river bed level), saddle dams and associated impoundment of the Fitzroy, Mackenzie (to 322 km AMTD) and Dawson (to 10 km AMTD) rivers. Total inundation length of 61 km
  - Rookwood Weir Stage 2 (RW2) – the addition of 3.5 m high flap gates to achieve FSL 49.0 m AHD and associated impoundment of the Fitzroy, Mackenzie (335 km AMTD) and Dawson Rivers (15 km AMTD), an additional 25 km of inundation (combined for the Mackenzie and Dawson rivers).
- Fish locks and a turtle bypass at each weir.
- Other components associated with the Project include:
- Augmentation to and construction of access roads (public and private) to and from the weir sites for construction, operation and upgrades to intersections
- Construction of low level bridges in areas upstream of weir infrastructure impacted by the impoundments, specifically at Glenroy, Riverslea and Foleyvale crossings
- Installation of culverts at Hanrahan Crossing downstream of Rookwood Weir to facilitate access during operation releases
- Removal and decommissioning of existing low level causeways and culverts at river crossings described above
- Resource extraction of construction materials (gravel and sand) from within the river bed and banks (subject to separate environmental assessment and approval).

Figure 1-1 shows the Project location.

Operationally the Project comprises the maintenance and management of the weir infrastructure, private access roads and impoundments, inclusive of a flood buffer. Water releases will be made through 'run of river' methods and no water distribution infrastructure (pipeline or channels) is required. Water releases will be made to satisfy environmental and water security objectives in accordance with the Water Resource (Fitzroy Basin) Plan 2011 (Fitzroy WRP). Operating regimes will be developed and implemented through the Fitzroy Basin Resource Operations Plan 2004 (as augmented) (Fitzroy ROP).



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0 5 10 15 20

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- AMTD (km)
- Weir Location
- Fitzroy Barrage
- Saddle dams
- Highway
- Major Road
- Streets (Local)
- Access Road
- Fitzroy Basin
- Urbanised Area
- Rookwood Weir Stage 1 impoundment
- Rookwood Weir Stage 2 impoundment
- Eden Bann Weir Stage 2 impoundment
- Eden Bann Weir Stage 3 impoundment

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Gladstone Area Water Board

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Project locality plan

Figure 1-1

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

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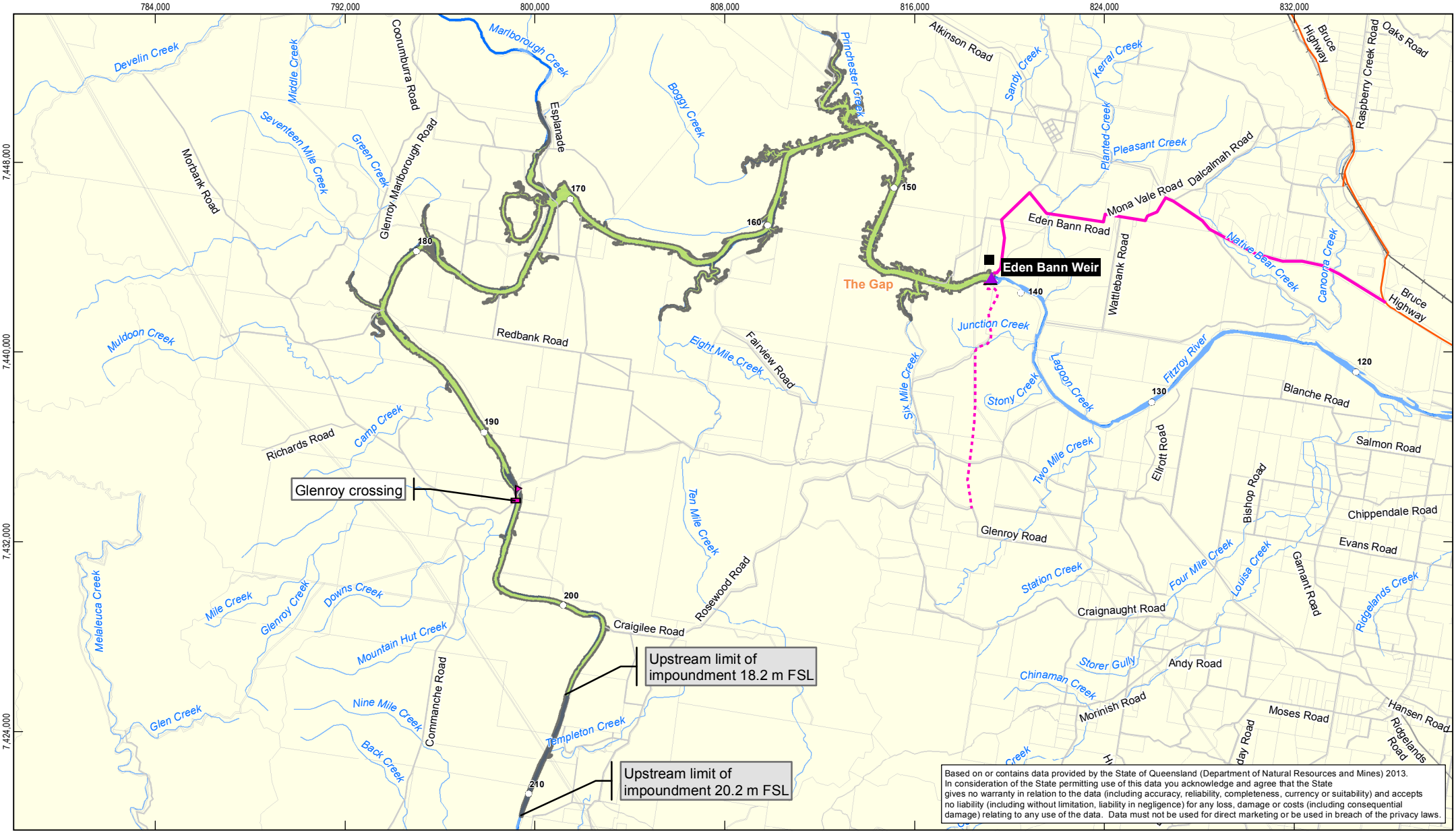
Project construction is expected to be staged, with sequencing and timing dependant on supply/demand balance and drought conditions. Construction is scheduled over a two-year period, allowing for the majority of construction activities to be undertaken over two dry seasons. Impoundment is expected to occur within a single wet season given average river flow conditions during which commissioning will take place.

For the purpose of this report the following locality descriptions apply:

- Study area - the Fitzroy River, lower reaches of the Mackenzie River and lower reaches of the Dawson River (Figure 1-1)
- Eden Bann Weir Project footprint – the Eden Bann Weir construction area, weir infrastructure areas (including weir wall, abutments, spillway, fish and turtle passage infrastructure, control room, amenities) and impoundment including aquatic and terrestrial (riparian) habitats potentially impacted by the Project. Figure 1-2 shows the location of Eden Bann Weir infrastructure and impoundment extents at full supply levels. The Eden Bann Weir construction area is shown on Figure 1-3
- Rookwood Weir Project footprint - the Rookwood Weir construction area, weir infrastructure areas (including weir wall, abutments, spillway, fish and turtle passage infrastructure, control room, amenities, saddle dams) and impoundment including aquatic and terrestrial (riparian) habitats potentially impacted by the Project. Figure 1-4 shows the location of Rookwood Weir infrastructure and impoundment extents at full supply levels. The Rookwood Weir construction area is shown on Figure 1-5
- River crossings – low level bridges and causeways that require upgrades to accommodate raised water levels (Figure 1-2 and Figure 1-4). The Glenroy crossing construction area is show in Figure 1-6.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

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LEGEND

- AMTD (km)
- Weir Location
- Fitzroy Barrage
- Highway
- Major Road
- Streets (Local)
- Waterway
- Fitzroy Basin
- Property Boundary
- Eden Bann Weir Stage 2 impoundment
- Eden Bann Weir Stage 3 impoundment
- Homestead
- River Crossing
- Proposed Access Road
- Existing Access Road

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Eden Bann Weir Project footprint

Figure 1-2

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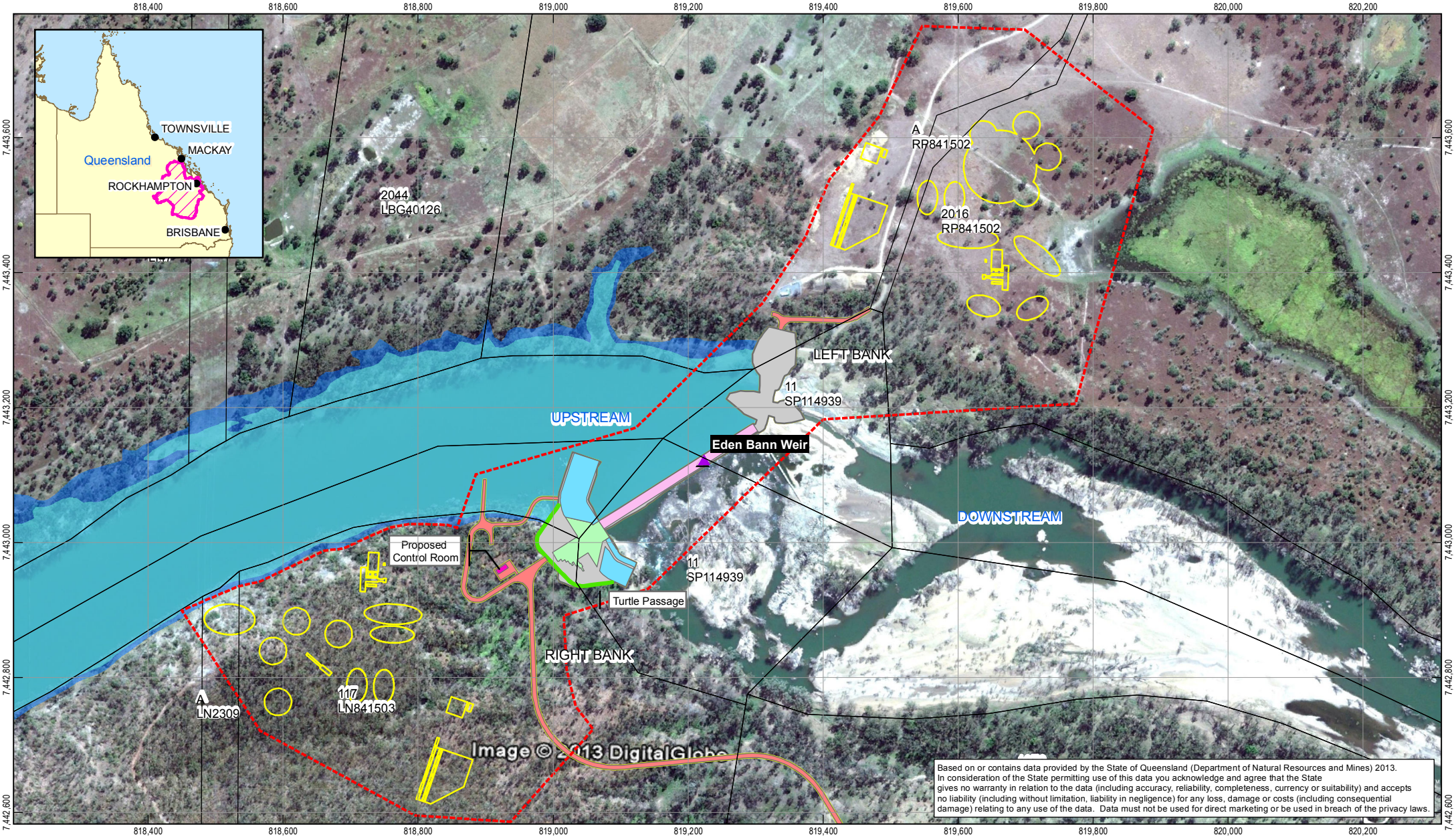

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Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Weir Location
- Fitzroy Basin
- Access Roads
- Channel
- Outlet works and fishway
- Proposed Control Room
- Proposed Spillway
- Turtle Passage
- Eden Bann Weir Proposed Structure
- Construction Footprints
- Construction Area
- Eden Bann Weir Stage 2 impoundment
- Eden Bann Weir Stage 3 impoundment

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Job Number 41-20736
Revision B
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Eden Bann Weir construction area

Figure 1-3

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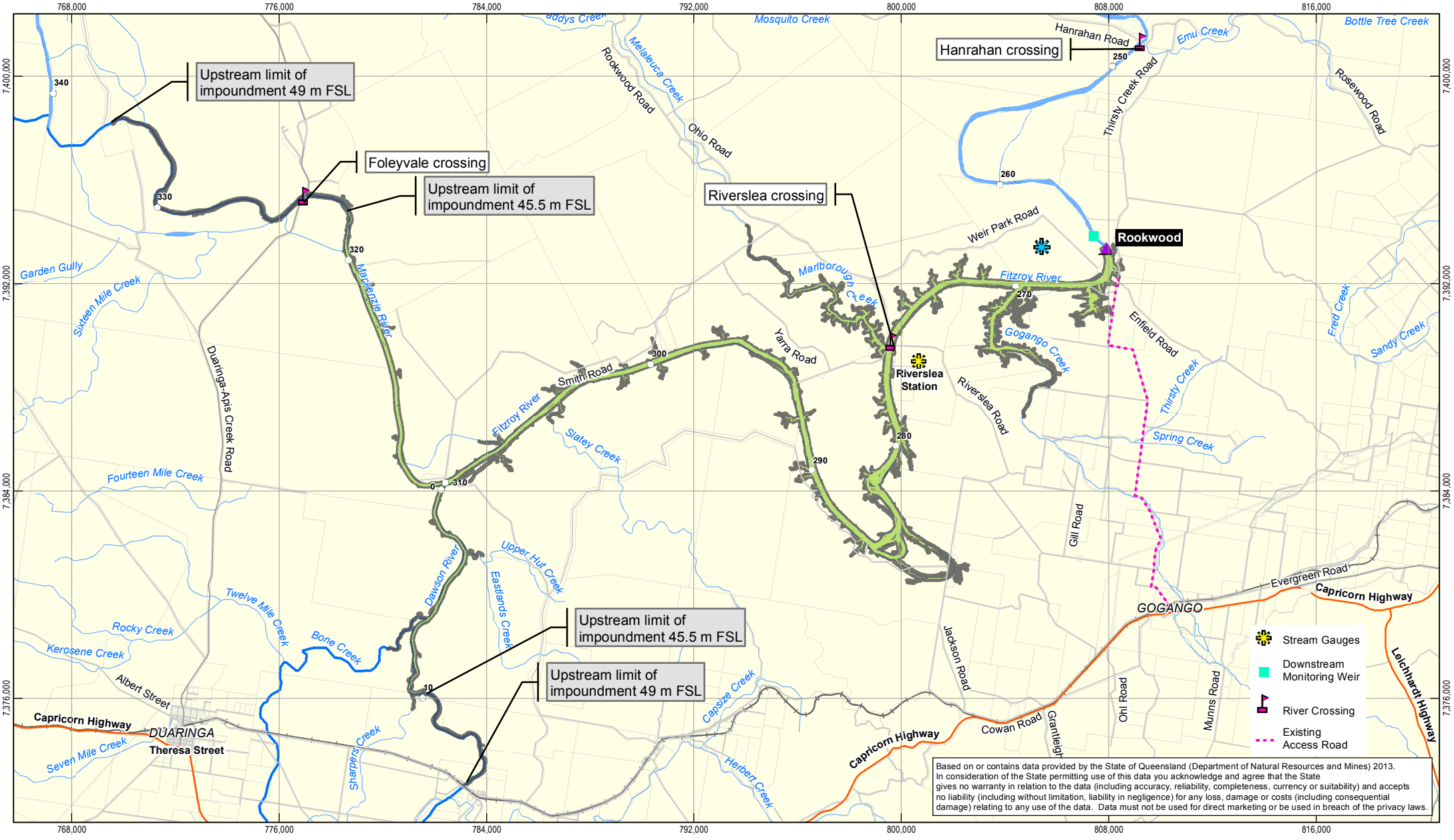

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- AMTD (km)
- Weir Location
- Fitzroy Barrage
- Saddle dams
- Highway
- Major Road
- Streets (Local)
- Railway
- Waterway
- Fitzroy Basin
- Property Boundary
- Rookwood Weir Stage 1 impoundment
- Rookwood Weir Stage 2 impoundment

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Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision B
Date 05 Aug 2014

Rookwood Weir Project footprint

Figure 1-4

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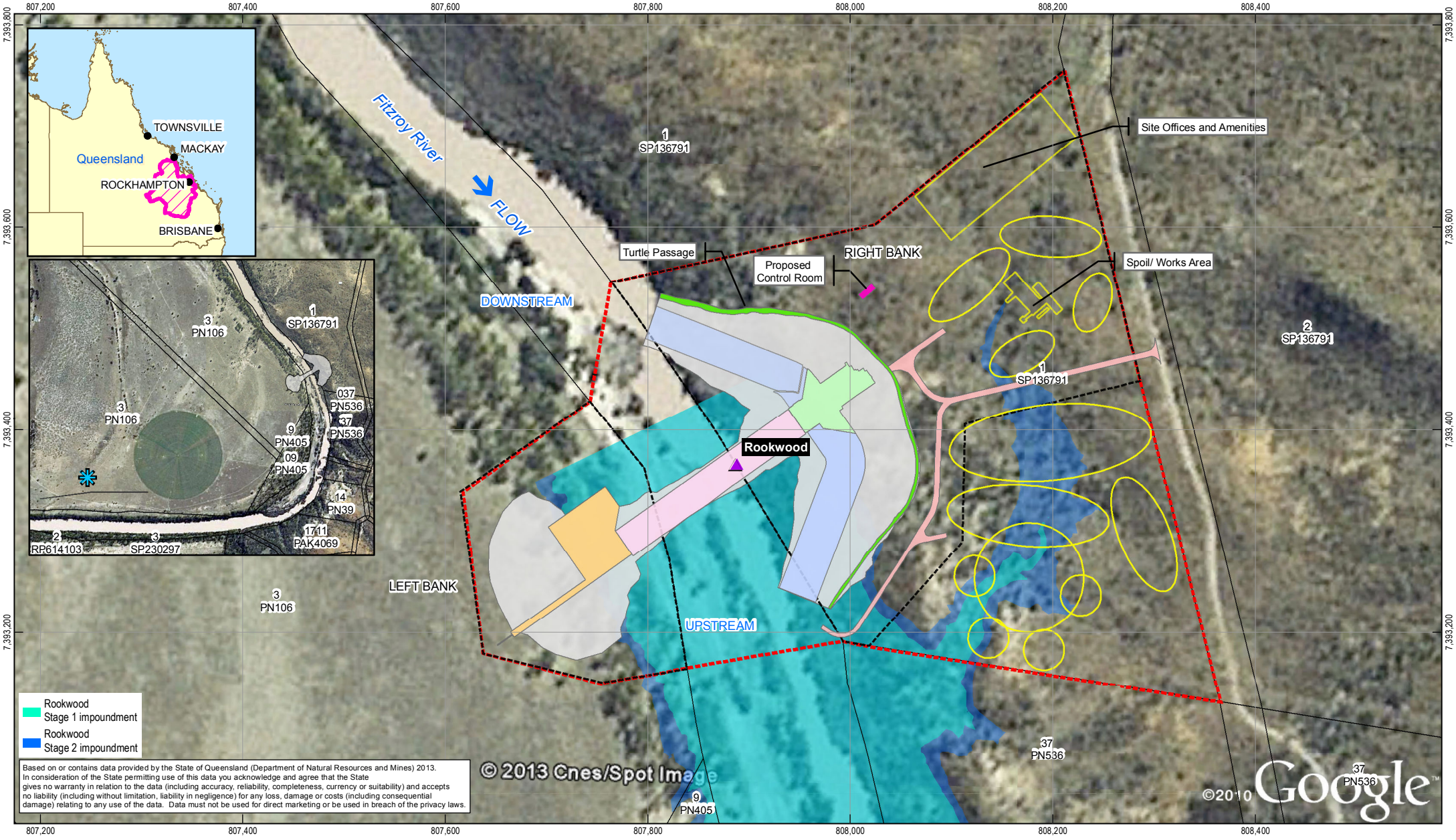

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0 50 100 150 200

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Weir Location
- Fitzroy Basin
- Construction Area
- Proposed Property Acquisition Boundary
- Rookwood Weir proposed structure
- Construction Site Facilities
- Abutement, Wide Rock filled mattress
- Access Roads
- Channel
- Outlet works and fishway
- Proposed Control Room
- Spillway
- Turtle Passage
- Saddle Dam

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Rookwood Weir construction area

Figure 1-5

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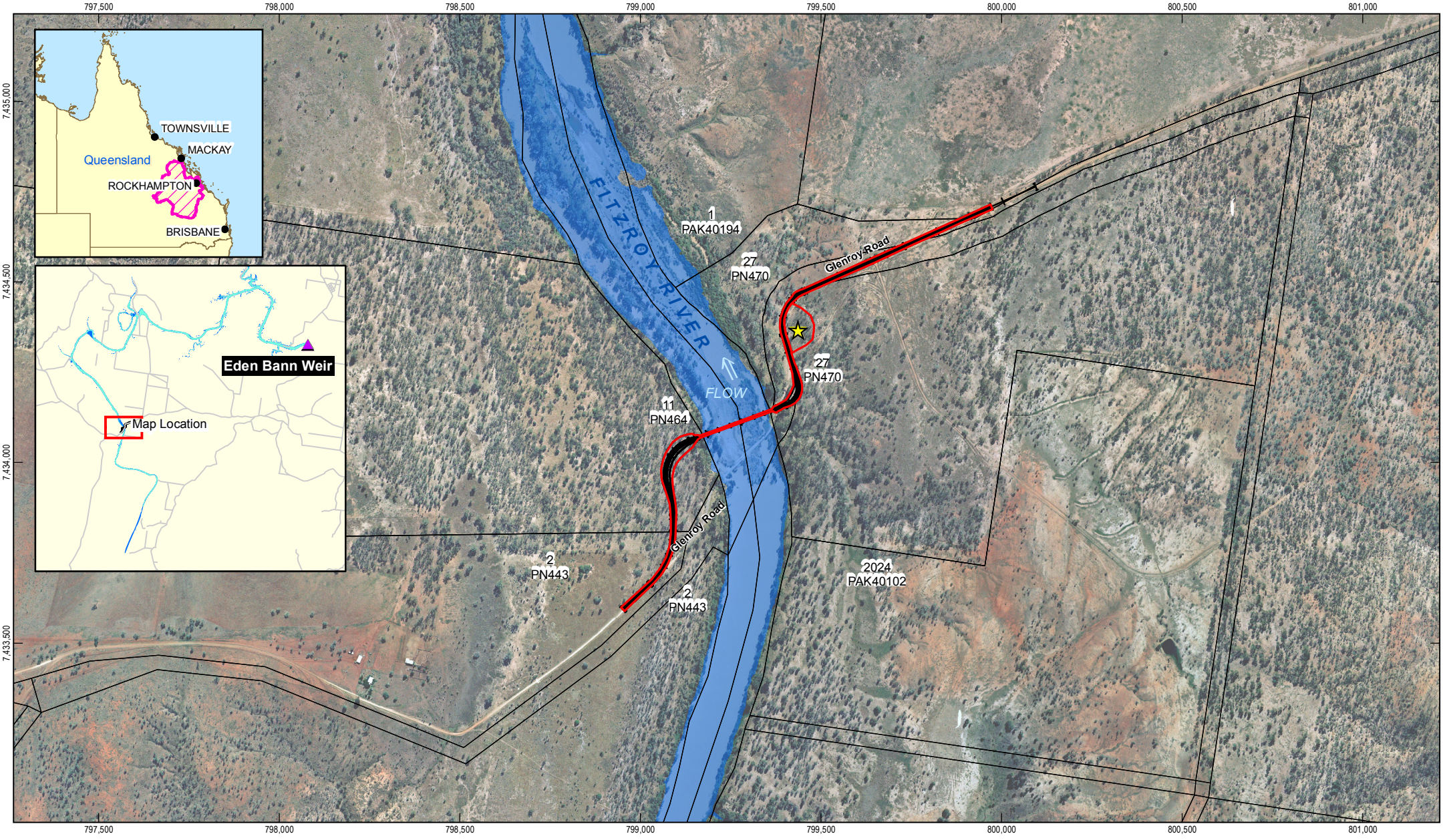

1:14,000 (at A4)

0 500

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Weir Location
- Fitzroy Basin
- Construction Corridor
- Eden Bann Weir Impoundment (Stage 3)
- Property Boundary
- Indicative Site Compound
- Bridge Infrastructure

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Glenroy crossing construction area

Figure 1-6

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1.3 Project existing environment

1.3.1 Fitzroy Basin catchment

The Fitzroy Basin catchment is the largest catchment on the eastern seaboard of Australia, and is second only to the Murray-Darling Basin as Australia's largest catchment. The catchment extends over an area of approximately 142,000 square kilometres of Central and Eastern Queensland about the Tropic of Capricorn and drains into the Great Barrier Reef World Heritage Area. Six major sub-catchments occur, namely: Isaac/Connors; Nogoa; Comet; Mackenzie; Dawson; and Fitzroy.

The Project footprints are located within the lower Dawson, lower Mackenzie and Fitzroy River sub-catchments.

Strongly seasonal climatic factors heavily influence flows within the Fitzroy Basin catchment, with the sub-tropical climate fostering the majority of rainfall during the wet season (approximately November to April). Severe flooding occasionally occurs as a result of intensive rainfall events. Prolonged dry seasons (generally May to October) and drought are also characteristic features of the highly variable and unpredictable nature of the climate. Mean annual discharge from the catchment is 5 million ML, however flows can be as low as 100, 000 ML in dry years (Department of Natural Resources and Water (DNRW) 2008).

Although sparsely populated, large tracts of land within the Fitzroy Basin catchment have been modified for human land use practices, principally agriculture, which accounts for almost 90 per cent of catchment land use (Johnston et al. 2008). Of this agricultural use, 81.7 per cent is livestock grazing (Johnston et al. 2008). Other notable land uses within the Fitzroy Basin catchment include State Forest (6.65 per cent), nature conservation (4.54 per cent) and mining (0.38 per cent) (Johnston et al. 2008).

Past and present land use practices throughout the catchment have had a significant influence on water quality. Most notably, historic vegetation clearing for agricultural production has greatly increased the sediment load entering the river as a result of increased erosion and runoff. Such runoff has increased the introduction of nutrients and dissolved metals and raised salinity levels in waterways, thereby causing alterations to the chemical composition of the water. Water quality conditions within the catchment are discussed further in Chapter 11.

Major water infrastructure has been constructed at a number of sites along rivers within the Fitzroy Basin catchment in order to meet irrigation, urban and industrial demands. Infrastructure includes:

- Mackenzie-Nogoa sub-catchment - Tartrus Weir; Bingegang Weir; Bedford Weir; Fairbairn Dam
- Dawson sub-catchment - Neville Hewitt Weir; Moura Weir; Theodore Weir; Orange Creek Weir; Gyranda Weir; Glebe Weir
- Fitzroy River - Eden Bann Weir; Fitzroy Barrage

1.3.2 Eden Bann Weir site characteristics

Eden Bann Weir is located on the Fitzroy River at 141.2 km AMTD. The upstream limit of the impoundment associated with the proposed raising of the structure to Stage 3 is at approximately 211 km AMTD.

The terrestrial environment upstream of Eden Bann Weir along the Fitzroy River contains a high proportion of remnant vegetation cover. The landscape is a mix of rugged ranges, low undulating hills and alluvial plains. Lowland areas are predominantly cleared for grazing. However large areas of woodland vegetation persist on low rocky hills and uncleared alluvial plains. The river is wide and slow-flowing within the proposed impoundment area, with a series of sand banks vegetated with *Melaleuca spp*. occurring. The riparian fringe is generally narrow adjacent to grazing areas and wider and more extensively vegetated adjacent to rocky hills. A series of creeks join the river between the Eden Bann Weir and Glenroy crossing. The creeks generally have more natural, complex riparian vegetation.

The Fitzroy River currently impounded (Figure 1-7) upstream of Eden Bann Weir is deep, wide and slow-flowing. The river bed substrate is generally clay/slit with smaller amounts of gravel and sand. The abundance and diversity of macrophytes is reduced and those that do occur are generally restricted to the shallow margins. The river banks are generally stable to moderately stable and on average approximately 7 m high. The riparian zone has been partially inundated and in many cases the river connects directly to the terrestrial vegetation on the flood plain. The inundated riparian vegetation that remains along the margins appears in relatively good condition in the upstream reaches but deteriorates in health downstream, with only dead stags remaining adjacent to the spillway.

Figure 1-7 Typical aquatic habitats within the Project footprints

Upstream of the Eden Bann impoundment, the Fitzroy River exists as a series of pool-riffle-run sequences (Figure 1-7). The river channel is generally narrower than the impounded pool and water depth and velocity varies from deep, slow-moving conditions in the pools habitats to shallow and fast-flowing conditions in the riffle zones. Substrates within the natural river channel vary from soft clay/silts and sands to harder gravel, pebble, cobble and bedrock. Macrophyte abundance and diversity is generally higher than that of the impoundment with the greatest quantities occurring within the creeks, riffle zones and off-stream billabongs. The river banks within this section of the Project footprint are generally moderately stable and contain a relatively larger amount of overhanging vegetation than the impoundment. The riparian zone ranges in width from narrow highly degraded strips to wide sections of well-developed large growth vegetation that joins directly to the terrestrial vegetation behind.

Based on the assessment of aerial photography and field survey observations (Volume 3 Appendix J), the impoundment created as a result of the existing Eden Bann Weir is the dominant aquatic habitat type in this section of the Fitzroy River (approximately 40 per cent of the main river channel in the Eden Bann Weir Project footprint; Section 3.2). Upstream of the existing impoundment, pools are the most abundant aquatic habitat, accounting for approximately 34 per cent of the main river channel within the Project footprint. Riffle and run habitats represent approximately five per cent and approximately 13 per cent of the main river channel respectively[1] (Section 3.2). Off-stream billabongs occur in linear depressions within the riparian zone, typically 20 – 50 m from the rivers' edge. Billabongs vary in size from small ephemeral ponds to large permanent to semi-permanent water bodies. There are a number of creeks joining the river channel upstream of Eden Bann Weir, the largest of these being Marlborough Creek.

1.3.3 Rookwood Weir site characteristics

The proposed Rookwood Weir is located on the Fitzroy River at 265.3 km ATMD. The impoundment associated with the proposed Rookwood Weir Stage 2 extends approximately 337 km AMTD into the Mackenzie River and approximately 15 km AMTD into the Dawson River.

These sections of the Fitzroy, Mackenzie and Dawson Rivers are generally more narrow and dynamic than the Fitzroy River further downstream which has been altered as a result of impoundments (namely, Eden Bann Weir and the Fitzroy Barrage). There are no existing weirs or other water storage infrastructure within the Rookwood Weir Project footprint. Consequently, it retains many of the features of a natural riverine system and contains a greater diversity of lotic habitats. The river banks within the Project footprint are generally moderately stable and contain a relatively larger amount of overhanging vegetation. The riparian zone ranges in width from narrow highly degraded strips to wide sections of well-developed large growth vegetation that joins directly to the terrestrial vegetation extending out onto the floodplain. Land use adjacent to the Rookwood Weir Project footprint is dominated by low density pastoral grazing land and cropping. The landscape is predominantly flat and has been extensively cleared for grazing. However, low undulating

[1] As habitat boundaries (e.g. the difference between a riffle and a run, the extent of the weir pool) vary between seasons, the percentages of each habitat type within the Project footprint provide an example of aquatic habitat extent at the time of assessment only. These values are likely to fluctuate substantially in response to seasonal variability in water flows and management of the storage.

rocky hills and uncleared alluvial plains occur in places and retain remnants of native woodland vegetation.

The river channel is less defined than areas downstream, with greater seasonal changes in river flow attributable to the lack of anthropogenic regulation of the system. Open riverine sections (pools) are interspersed with more confined sections of riffles and runs (Figure 1-7). Water depth and velocity vary from deep, slow-moving conditions in the pool habitats to shallow and fast-flowing conditions in the riffle zones. Substrates are predominately gravel, pebble, cobble with smaller areas of clay / slits, sands and bedrock. Macrophyte abundance and diversity is greatest within the creeks, riffle zones and off-stream billabongs. Attached, filamentous and floating algae occur occasionally throughout the Rookwood Weir Project footprint.

Pool habitat is the most extensive aquatic habitat type, covering a total stream length of approximately 46 km (approximately 47 per cent of the main river channel within the Project footprint; Section 3.2). The riffle and run habitats that connect the pools cover a total length of approximately 21 km (approximately 22 per cent) and approximately 29 km (approximately 30 per cent), respectively (Section 3.2). Off-stream billabongs occur in linear depressions within the riparian zone, typically 20 – 50 m from the rivers' edge. Billabongs are relatively abundant and vary in size from small ephemeral ponds to large permanent to semi-permanent water bodies. There are several creeks joining the Fitzroy River in the Rookwood Weir Project footprint. The largest of these are Gogango Creek and Melaleuca Creek on the Fitzroy River.

2. Methodology

2.1 Overview

The aquatic ecological assessment undertaken for the EIS (Volume 1, Chapter 7 Aquatic fauna) included a targeted investigation into the population of Fitzroy River turtle within the Project footprints. This investigation included:

- Targeted population assessment (Limpus et al. 2011a)
- Targeted nesting habitat survey
- Aquatic habitat assessment
- Habitat segment analysis
- Literature review
- External consultation.

2.2 Targeted population assessment

An assessment of freshwater turtle populations within the Fitzroy Basin catchment was conducted by the Department of Environment and Resource Management (DERM) in 2007, specifically focusing on the proposal for raising Eden Bann Weir and constructing a new weir at Rookwood (Limpus et al. 2011a). The DERM assessment involved field studies and sampled an extensive range of habitats throughout the Fitzroy Basin catchment including: isolated spring fed pools, farm dams, backwaters, weir pools and natural river habitats. The field surveys involved a combination of:

- Snorkelling
- Dip netting
- Trapping
- Seine netting
- Muddling
- Nesting habitat surveys.

Data collected included:

- Turtle abundance, diversity and density
- Distribution and habitats
- Life history parameters (sex, age, maturity, reproductive status,)
- Mortality and injury
- Nesting characteristics.

Surveys were in accordance with the Commonwealth Department of the Environment survey guidelines for threatened reptiles (Commonwealth of Australia 2011). Survey findings were made available to the Project and no additional trapping for the Fitzroy River turtle was undertaken. Additional distribution and abundance surveys for the species were not undertaken due to the difficulty in safe turtle capture success.

The Fitzroy River turtle is difficult to survey as the species rarely enters baited traps. Hand capture via snorkelling, muddling or dip netting is the most effective method of capture however these techniques are generally limited within the Fitzroy Basin catchment due to high turbidity levels (Commonwealth of Australia 2011; Limpus et al. 2011a). Seine netting may also be an effective capture method, however the abundance of in-stream woody debris generally limits suitability in many habitats (Limpus et al. 2011a). Furthermore, both snorkelling and seine netting were not considered due to the health and safety risks associated with the potential occurrence of estuarine crocodiles.

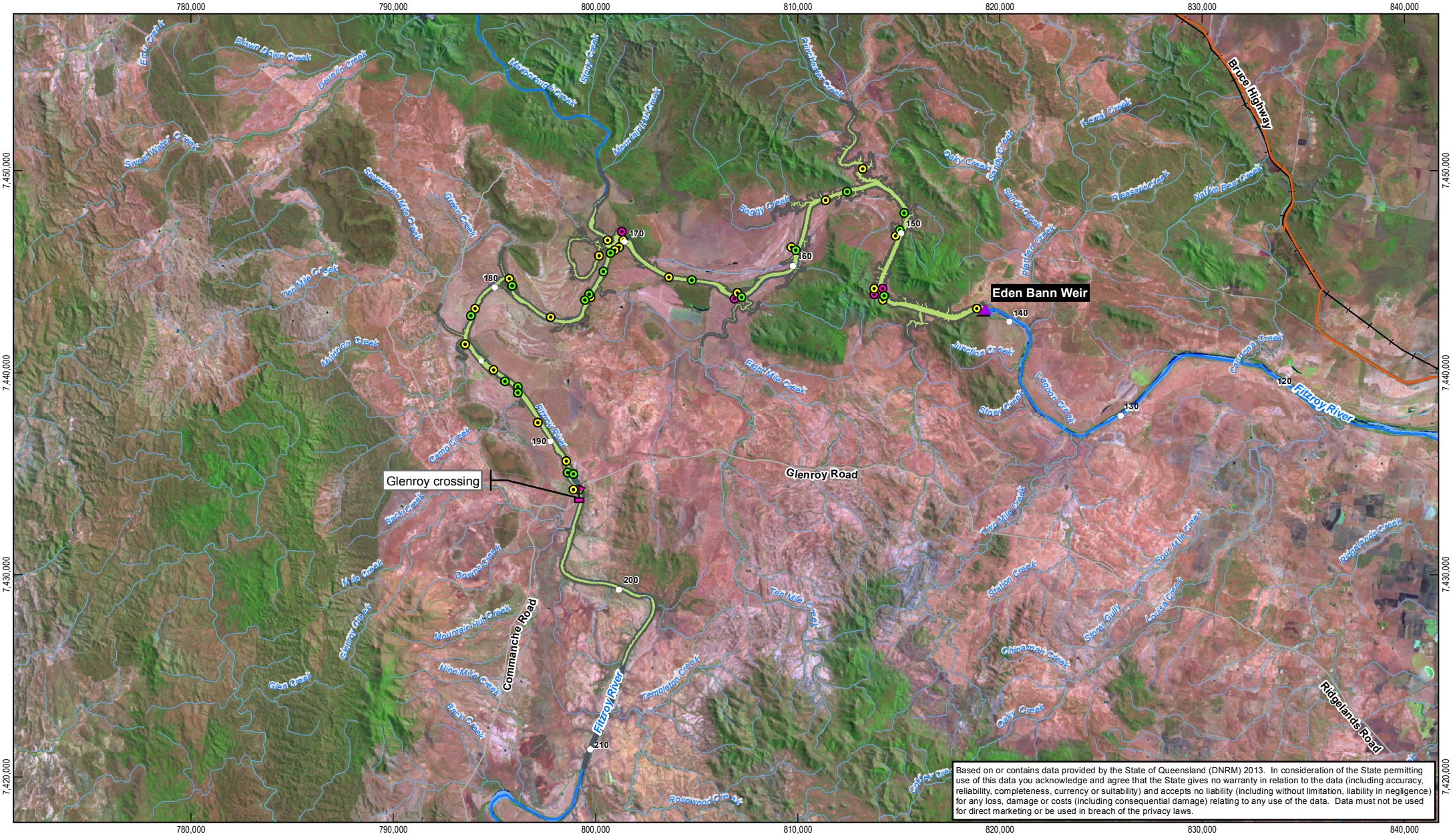
Incidental observations of turtles, including those caught in the fish fyke nets, were however, recorded and identified. Assessment of Fitzroy River turtle habitat suitability provided additional information to inform the risks associated with the Project.

2.3 Targeted nesting habitat surveys

Where access permitted, stream bank margins throughout the Project footprints were assessed for potential Fitzroy River turtle nesting habitat. Surveys were conducted in December 2008 to coincide with late nesting/hatching of the Fitzroy River turtle and in July 2009 to coincide with the nesting season of the white-throated snapping turtle (*Elseya albagula*). Accessible potential nesting habitats (i.e. those comprising sand and/or loam banks (Figure 2-1; Figure 2-2 and Figure 2-3) were identified and the following parameters recorded:

- Bank length
- Bank width
- Approximate slope
- Substrate type
- Per cent vegetation cover
- Evidence of turtle activity and nesting
- Evidence of disturbance (e.g. from cattle and pigs).

Figure 2-1 Targeted nesting habitat survey site



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0 2.5 5 7.5 10

Kilometres

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

N

LEGEND

- AMTD (km)
- Weir Location
- River Crossing
- Highway
- Minor Road
- Railway
- Watercourse (Major)
- Watercourse (Minor)
- Waterway
- Eden Bann Weir Stage 2 impoundment
- Eden Bann Weir Stage 3 impoundment
- Aquatic Fauna Trapping Site
- Turtle Nesting Bank Survey Site
- Habitat Assessment Site

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Eden Bann Weir aquatic ecology footprint and aquatic survey sites

Figure 2-2

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Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Waterways, State (2007); Sunwater: Waterways, Weir Locations - 2008; DNRM: Roads - 2010, Railways - 2010, Imagery/2005; GHD Fauna Survey - 2009. Created by: MS

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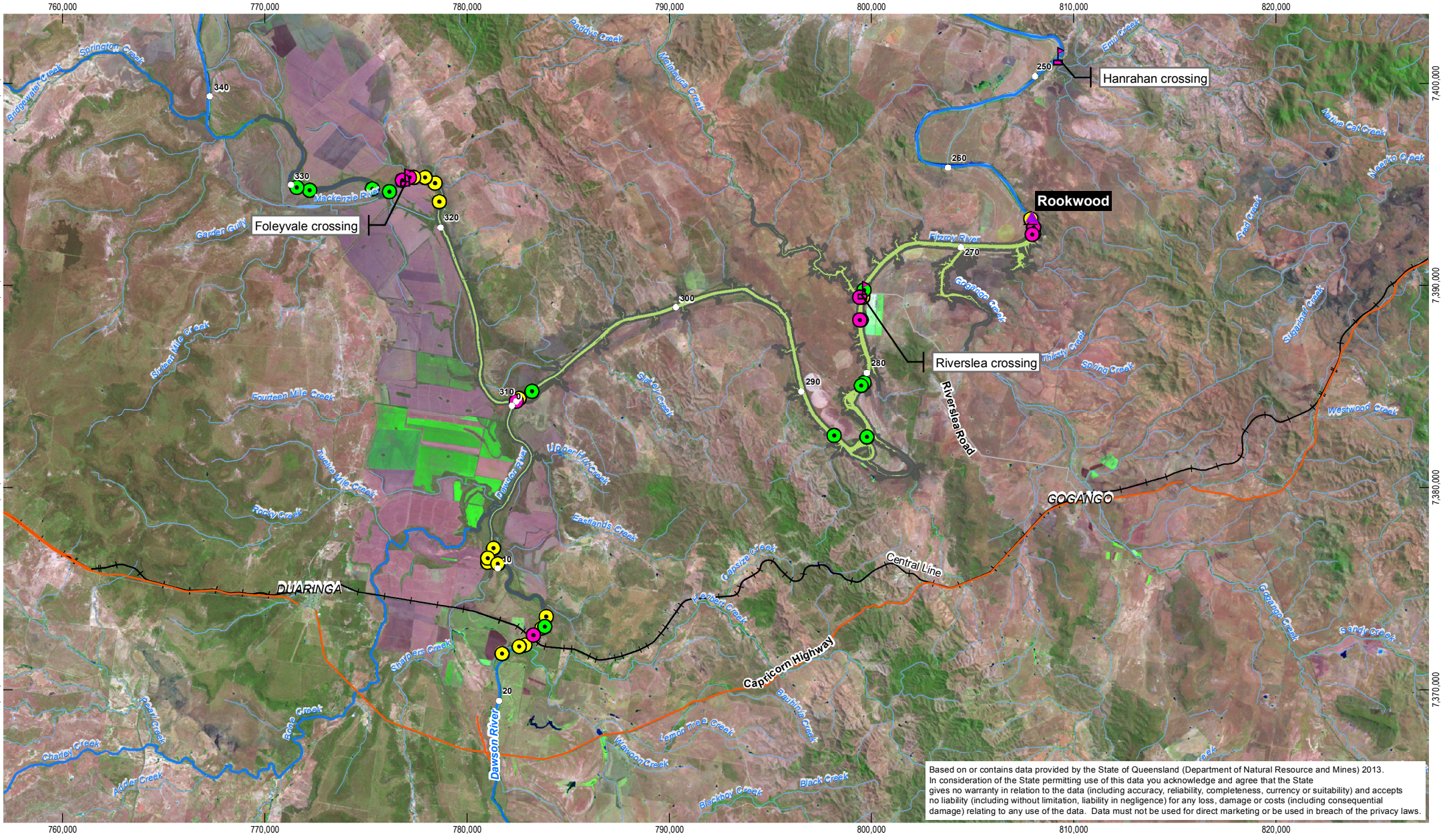

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- AMTD (km)
- Weir Location
- River Crossing
- Highway
- Minor Road
- Railway
- Rookwood Weir Stage 1 impoundment
- Rookwood Weir Stage 2 impoundment
- Watercourse (Major)
- Watercourse (Minor)
- Waterway
- Aquatic Fauna trapping site
- Habitat and Turtle Nesting Bank survey site
- Turtle Nesting Bank survey site

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Gladstone Area Water Board, SunWater Lower Fitzroy River Infrastructure Project

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Rookwood aquatic ecology footprint and aquatic survey sites Figure 2-3

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Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Waterways, State (2007); Sunwater: Waterways, Weir Locations - 2008; DNRM: Roads - 2010, Railways - 2010, Imagery/2005; GHD Fauna Survey - 2009. Created by IH, MS

In the absence of nesting habitat survey guidelines, nesting habitat surveys were conducted in accordance with standard DERM methodology (Limpus et al. 2011a) and as discussed with DEHP's Chief Scientist, Aquatic Threatened Species Division, Dr Col Limpus. Potential nesting banks were examined for signs of nesting (which included the presence of turtle tracks, diggings and predated egg shells) using single strip transects parallel to the water's edge. Transect length and width varied according to bank morphology. Nest locations were described in relation to distance and height from the water.

Based on an assessment of nesting bank slope, substrate type and vegetation cover, each sand/loam bank identified was assigned a broad nesting habitat suitability rating as follows:

- Low – nesting banks with a relatively low gradient slope and/or predominantly unsuitable substrate (e.g. gravel)
- Medium – nesting banks with a relatively medium to steep slope, predominantly sand/loam substrate and/or medium to high vegetation cover
- High – nesting banks with a relatively steep slope, sand/loam substrate and low vegetation cover
- Confirmed – nesting banks in which direct evidence of turtle nesting was observed (e.g. predated egg shell)
- Historical - nesting banks in which direct evidence of turtle nesting has been confirmed in previous studies.

The nesting suitability ratings were selected based on current data available on the optimal nesting conditions for the Fitzroy River turtle. It is important to note that the classification of a bank as potential turtle nesting habitat does not guarantee that turtle nesting does/will occur in that area. Turtle nesting may also occur in areas not identified as potential habitat, however, the occurrence of this is expected to be low. Nesting bank conditions are also subject to change over time, for example as a result of flooding events, and as such the suitability of the habitat for turtle nesting may vary. Mapped nest location points may represent a series of adjacent nesting banks.

The direct impact to nesting habitat as a result of the Project was then calculated based on the area of historical, confirmed and high potential turtle nesting habitat that will be impounded within the Project footprints. Nesting banks with high suitability but no nesting activity were included in the calculation due to the difficulty in detecting nests and the relatively low survey effort undertaken in the Project footprints. Nesting banks with a high suitability ranking are considered to provide optimal nesting conditions for the Fitzroy River turtle. Fitzroy River turtles generally nest approximately 5 m from the water's edge (Limpus et al. 2011a). As such, the area of each historical, confirmed and high potential nesting bank that will be impacted by the Project was estimated by multiplying the length of bank by 5 m. This calculation is considered to provide an estimate of potentially suitable nesting habitat that will be impounded as a result of the Project. To date, only isolated nests of the Fitzroy River turtle have been recorded in the Project footprints (Section 3.2) and as such, calculating the area of potential nesting habitat to be impacted is considered a conservative estimate of the actual impact to Fitzroy River turtle nesting.

2.4 Nesting bank availability analysis

In order to determine the potential availability of nesting banks for the active protection of nests within the impoundment, nesting bank elevation data was compared to daily water levels during the nesting season.

Daily flow versus storage data was extracted from the Integrated Quantity Quality Model (IQQM) for a number of development scenarios (EB2, EB3, RW1, RW2 and a combined EB3 and RW2) at IQQM nodes representing Eden Bann Weir and Rookwood Weir. This comprised over 100 years of daily simulated data for the four months between 1 September and 30 December (nesting period). The storage capacity curves for the 100 year dataset provide daily water level in the weirs as simulated by the IQQM. As a general rule, water levels declined from September through to the end of December however a number of large inflows are encountered during December which could inundate nesting banks within the impoundment. Detailed IQQM methodology is provided in Volume 3 Appendix P.

As described in Section 2.3, potential nesting habitat within the Project footprint was identified during field surveys and assigned suitability ratings based on an assessment of nesting bank slope, substrate type and vegetation cover. Identified sites were mapped as location points where each point could represent a series of adjacent nesting banks. The boundaries of these sites were digitised using satellite imagery based on discernible preferred nesting bank conditions (sand/loam banks, low density ground/understorey vegetation and partial shade cover) as defined in Section 2.3. For each nesting bank polygon elevation data was extracted using 10 m interpolated digital elevation model surface data. This data was compared to full supply levels and daily water levels during the nesting season to determine the potential availability of each nesting bank during this period.

For the purpose of identifying potential offset sites, satellite imagery was used to determine potential nesting habitat upstream (50 km upstream of the upper extent of the Rookwood Weir impoundment), downstream (to the Fitzroy Barrage impoundment) and between the Eden Bann Weir and Rookwood Weir impoundment areas. Potential nesting habitat was determined using the same discernible preferred nesting bank conditions described above. Potential sites identified through this process have not been field verified and further investigation would be required to determine suitability to meet offset requirements.

2.5 Aquatic habitats

2.5.1 Habitat assessment

Habitat assessments were undertaken at accessible sites representing major aquatic habitats throughout the Project footprints (Figure 2-2 and Figure 2-3). Each survey site was identified in relation to habitat type and the following parameters recorded:

- Stream channel and bank morphology (e.g. channel width, depth and bank height)
- Bank profile
- Substrate description (e.g. bedrock, gravel, sand or silt)
- Presence of plant material (e.g. aquatic plants, algae and submerged logs)
- Riparian vegetation description (e.g. width and length of stream side vegetation, overhanging and native vegetation)

- Adjacent land use
- Water velocity (e.g. deep and shallow areas)
- Position in relation to existing or proposed impoundment.

Creek and off-stream water body habitats were assessed where access permitted. Where these habitats could not be accessed in the field, a desktop approach to assessing the spatial distribution/extent of these habitat types was undertaken. Specifically, this involved an assessment of Queensland Government's Wetland*Info* Mapping Service in conjunction with satellite imagery of the study area.

Habitat characteristics of each survey site were assessed from excellent to poor according to criteria of the Queensland Australian River Assessment System (AusRivAS) River Bioassessment Program from which a sub sample of habitat variables relevant to the Project were selected (AusRivAS 2001).

2.5.2 Habitat segment analysis

In the absence of being able to access all habitats, habitat segment analysis was utilised to assess the extent of aquatic habitats, within and downstream of the Project footprints.

The distribution and linear extent of aquatic habitat types within the Project footprints were quantified and mapped from aerial photographs, and where possible, verified in the field. Habitat boundaries were subsequently estimated based on the visual characteristics observed. For example, based on observations within the Eden Bann Weir Project footprint, the Eden Bann Weir impoundment habitat was mapped to only extend approximately 30 km upstream rather than the entire length of the maximum weir impoundment (approximately 43 km).

The extent of each habitat type within the main river channel in the Project footprints was then calculated based on the percentage of river length covered by each habitat (off-stream water bodies and adjoining creeks not included). As habitat boundaries (e.g. the difference between a riffle and a run) vary between seasons, the percentages of each habitat type within the Project footprint provide an example of aquatic habitat extent. These values are likely to fluctuate substantially in response to seasonal variability in water flows. Habitat quality was inferred to be similar to that of the aquatic habitats assessed within the Project footprints, given the similarity of surrounding land uses up and downstream.

2.5.3 Aquatic habitat calculation

Aquatic habitat types included in the calculation of aquatic habitat within the Project footprint consist of pool, riffle, run habitats and creeks adjoining the main river. Aquatic habitat already impacted by the existing Eden Bann Weir impoundment was excluded for the purpose of quantifying the area of aquatic habitat within the Project footprint. Off-stream water bodies (palustrine wetlands) outside of the river channel bed and banks are excluded from the assessment as the Project is not expected to adversely impact off-stream wetland connectivity with the river, or adversely alter the seasonality, duration, frequency and volume of water entering and leaving the off-stream water bodies. While sand banks within the river channel are utilised by aquatic species, impacts on these habitats have been assessed separately (Section 4.2.6 and Appendix B).

The Fitzroy River transports a substantial sediment load during periods of flood with high erosion and deposition rates which change the river and its boundaries overtime.

Elsewhere in the EIS, cadastral boundaries have been used to define the extent of watercourse areas and adjacent landholdings however this was considered inappropriate for determining areas of aquatic habitat as land title boundaries in some cases are over 100 years old and the physical river channel as well as survey techniques and legislation defining watercourse boundaries have changed in that time. There was found to be no existing watercourse data that was suitable in terms of accuracy for use in calculating aquatic habitat. Cadastral data, Queensland land use mapping program data and regional ecosystem mapping data proved highly inaccurate when overlayed on satellite imagery as these mapped watercourse boundaries included land outside of the river channel, rocky outcrops in the river channel and sand banks.

In the absence of suitable GIS data, aquatic habitat was manually digitised using satellite imagery (Digital Globe World View 2, July 2010) based on the discernible boundaries of water within the river channel (excluding rock and sand banks) between the upper limit of the existing and proposed Eden Bann Weir impoundment and within the proposed Rookwood Weir impoundment. The digitised data was then cross-checked against river bed level cross-section data at 81 locations. The cross-section data was available from the hydraulic model developed for the Project as described in Volume 1 Chapter 9 Surface water resources. Land survey cross-sections which enable calibration of the hydraulic model were used to validate the river width determined by the digitised river channel polygon. The cross-sections distinctly show where the river channel is and what profile the channel takes. The average difference between the digitised width and cross-section width is –0.9 m which is considered to show good correlation.

Water levels in the system fluctuate seasonally, as such July was considered the most appropriate time to represent near to stable water levels early in the dry season that are not influenced by wet season flood flows. While satellite imagery for other months was not available for use, aerial imagery captured in August and September 2009 was also assessed showing an average decrease in river width of 6 m at cross-sections when compared to the July 2010 data. The Fitzroy River is susceptible to seasonal high flow events during the wet season (approximately November to April), and occasional flooding in instances where intensive rainfall events occur within and up-stream of the Fitzroy subcatchment (Volume 1 Chapter 9 Surface water resources). As such, the use of imagery captured during the wet season would not be representative of normal channel flow conditions.

While the Fitzroy River turtle is often referred to as a riffle zone specialist, the species also inhabit pools, runs and creeks. However, deep water areas (> 5 m) of pools are largely uninhabitable to the turtle species due to lower dissolved oxygen concentrations, limited light penetration and relatively cooler temperatures. Currently there is limited information available on depth profiles to be able to exclude deep water habitat that would not be utilised by the Fitzroy River turtle. As such, the inclusion of pool habitat in the calculation of impacted Fitzroy River turtle aquatic habitat is considered conservative.

2.6 Literature review

Additional information on the Fitzroy River turtle population with the Fitzroy Basin catchment and specifically the Project footprints was obtained through a detailed literature review. Past studies (published and unpublished) undertaken throughout the catchment (and in nearby catchments) that were used to inform this assessment include:

- Stomach flushing: a technique for chelonian dietary studies (Legler 1977)

- A new genus and species of Chelid turtle from Queensland, Australia (Legler and Cann 1980)
- Australian freshwater turtles (Cann 1998)
- Cumulative effects of dams and weirs on freshwater turtles: Fitzroy, Kolan, Burnett and Mary Catchments. DERM study 1997-1999 (Tucker 2000)
- Home ranges of Fitzroy River turtles (*Rheodytes leukops*) overlap riffle zones: potential concerns related to river regulation (Tucker et al. 2001)
- Fauna of the Dawson River Floodplain – An assessment of fauna downstream of the proposed Nathan Dam (Venz et al. 2002)
- Diving behaviour of two Australian bimodally respiring turtles, *Rheodytes leukops* and *Emydura macquarii*, in a natural setting (Gordos and Franklin 2002)
- Seasonal changes in the diving performance of the bimodally respiring freshwater turtle *Rheodytes leukops* in a natural setting (Gordos et al. 2003)
- Impact of dams and weirs on freshwater turtles - Fairbairn Dam (Limpus et al. 2006)
- Fitzroy River Water, Modified Water Infrastructure EIS and Management Plan: Turtles (*Rheodytes leukops* and *Elseya albagula*) (frc environmental 2007)
- Connors River Dam Fitzroy River turtle survey August 2012 (frc environmental 2010)
- Connors River Dam Fitzroy River turtle survey (frc environmental 2011)
- Connors River Dam and Pipeline Project EIS, supplementary EIS, Coordinator-General's report and Australian Government's approval (SKM 2010; SKM 2011; CoG 2012)
- Survey of Freshwater turtle populations and nesting habitat, Tartrus Weir Turtleway Project. September – December 2011 (Limpus et al. 2011b)
- Nathan Dam and Pipeline Project, Fitzroy River turtle survey September – October 2012 (frc environmental 2012)
- Nathan Dam and Pipeline Project EIS (SKM 2012).

2.7 External consultation

Throughout the aquatic ecological impact assessment phase of the Project, external expert advice was garnered to guide the development of mitigation strategies for freshwater turtles, and the Fitzroy River turtle in particular. This included a review of literature and discussions with the Department of Environment and Heritage Protection's (DEHP) Chief Scientist, Aquatic Threatened Species Division, Dr Col Limpus. Information was specifically used to provide input into survey design, impact identification and development of appropriate mitigation measures.

3. Species overview

3.1 Description

The Fitzroy River turtle (Figure 3-1) has a maximum straight carapace (shell) length of 260 millimetres (mm). The carapace is broadly oval and medium to dark brown in colour. The plastron, or underside of the shell, varies from pale yellow to cream. Tubercles are present on the neck and orange markings can be seen on the sides of the neck and throat of large males. The Fitzroy River turtle has a distinctive white ring around its eye. The feet are fully webbed and five claws are present on each forelimb. The shell of hatchlings turtles is serrated along the back edge and the ring around the eye is metallic silver-blue (Cogger 2000; Wilson and Swan 2003; Latta and Latta 2005; Limpus et al. 2011a).

Figure 3-1 Fitzroy River turtle identified at the Fitzroy River Barrage fish ladder (October 2008)

3.2 Distribution and habitat

The Fitzroy River turtle is endemic to the Fitzroy Basin catchment with the species' distribution extending from the Fitzroy Barrage to at least Glebe Weir (at 326.2 km AMTD) on the Dawson River, and within the lower reaches of the Nogoa River and upper reaches of the Connors River (in the vicinity of the proposed Connors River Dam at 95.7 km AMTD) (Table 3-1). Important habitat areas relevant to the Project footprint (Leger and Cann 1980; Cann 1998; Limpus et al. 2011a) are listed below and illustrated in Figure 3-2:

- Glenroy crossing – essential habitat and type locality[2] within the Eden Bann Weir Project footprint, upstream of the existing impoundment
- Redbank crossing – type locality within the Eden Bann Weir Project footprint, upstream of the existing impoundment
- Marlborough Creek – essential habitat just upstream of Eden Bann Weir Project footprint
- Between Boolburra rail crossing and the Capricorn Highway – essential habitat just upstream of Rookwood Weir Project footprint
- Alligator Creek – important nesting habitat within the Fitzroy River Barrage impoundment, downstream of Eden Bann Weir Project footprint.

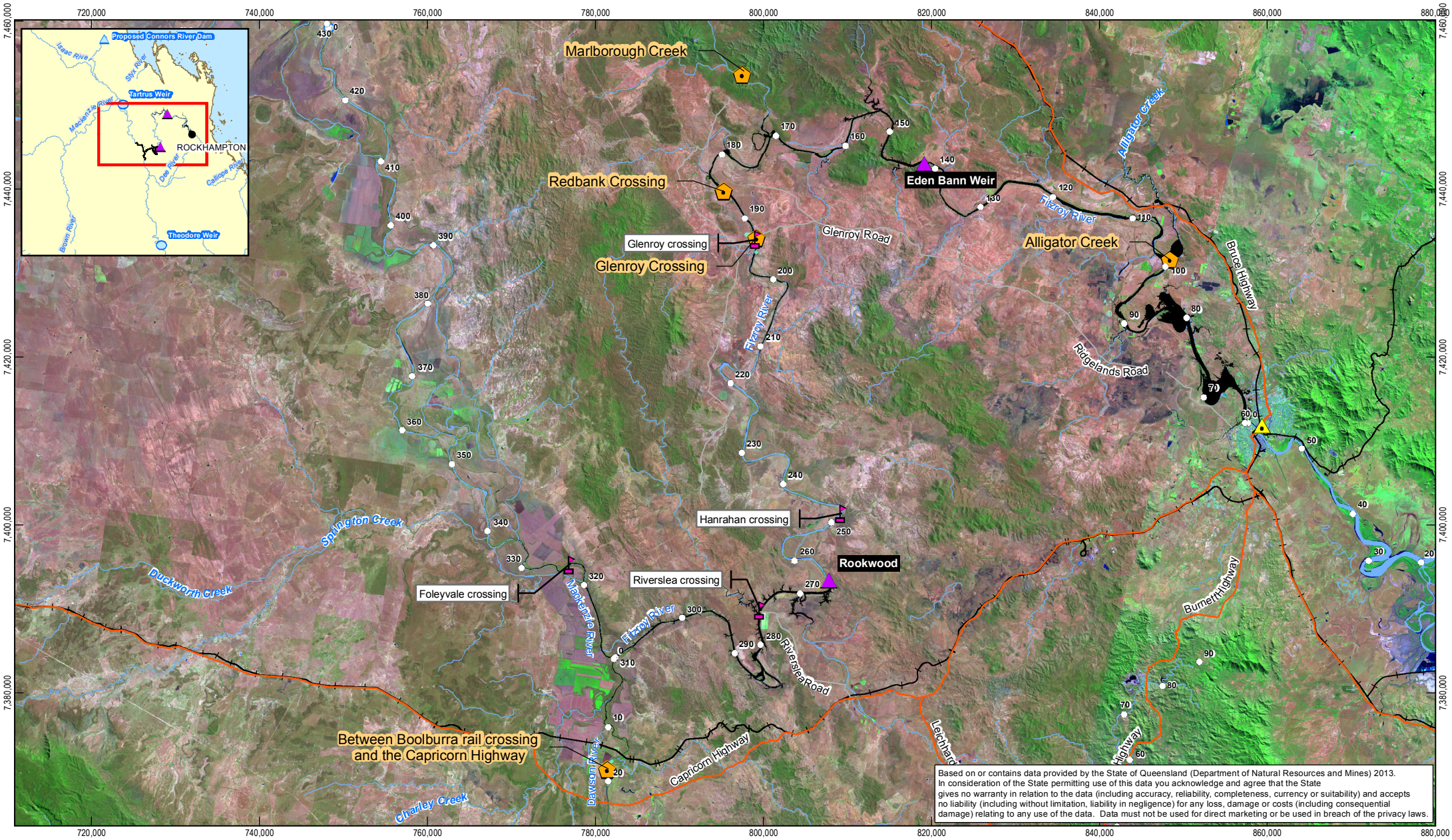
Table 3-1 Known distribution of the Fitzroy River turtle

Known distribution within the catchment		Abundance and survey reference (N = number of turtles)
Project footprint	Marlborough Creek – Fitzroy River	N = 6 - Limpus et al. 2011a N = 8 - Gordos and Franklin, 2002; Gordos et al. 2003 Confirmed record - Cann 1998
	Redbank crossing – Fitzroy River	N = 2 deceased - Limpus et al. 2011a N = 38 - Legler and Cann 1980 N = 8 - Legler 1977 N = 2 nests - Legler and Cann 1980
	Glenroy crossing– Fitzroy River	N = 13 live; 14 deceased - Limpus et al. 2011a N = 11 - Tucker et al. 2001 Confirmed nesting - Limpus et al. 2011a Confirmed record - Legler and Cann 1980
	Rookwood Weir site – Fitzroy River	N = 3 deceased - Limpus et al. 2011a
	Foleyvale crossing – Mackenzie River	N = 1 deceased - Limpus et al. 2011a
Downstream of Eden Bann Weir Project footprint	Fitzroy Barrage impoundment	N = 1 – Project EIS surveys
	Alligator Creek junction – Fitzroy River	N = 4* live; 3* deceased - Limpus et al. 2011a N = 10 confirmed nesting banks - Limpus et al. 2011a
	Wattlebank Control Weir – Fitzroy River	N = 5 - frc 2007
Upstream of Rookwood Weir	Windah Creek – Fitzroy River	Confirmed record - Legler and Cann 1980
	Gainesford – Dawson River	Confirmed record - Legler and Cann 1980

[2] Type locality is the location where a holotype (i.e. the specimen on which the original description of a species is based) was found.

Known distribution within the catchment		Abundance and survey reference (N = number of turtles)
Project footprint	Downstream of Theodore Weir – Dawson River	N = 118 - Limpus et al. 2011a
	Glebe Weir – Dawson River	N = 1 – C. Dr Col Limpus pers comm.
	Duck ponds – Nogoa River	Confirmed record - Limpus et al. 2011a
	Cardowan irrigation farm – Connors River	N > 12 - Limpus et al. 2011a
	Cardowan irrigation farm – Connors River	N = 2 nests - Limpus et al. 2011a
	Connors River	N = 16 - Gordos et al. 2003
	Downstream of the proposed Connors River Dam – Connors River	N = 16 – frc 2010 N = 182 – frc 2011
	Downstream of Tartrus Weir – Mackenzie River	N = 78* – Limpus et al. 2011 N = 92 nests - Limpus et al. 2011
	Tartrus Weir impoundment – Isaac River	N = 17 nests - Limpus et al. 2011 N = 1 - Limpus et al. 2011

* Cumulative total from multiple survey events.



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0 10 20

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- AMTD (km)
- Weir Location
- Fitzroy Barrage
- River Crossing
- Highway
- Minor Road
- Waterway
- Railway
- Impoundment Area
- Fitzroy river turtle important habitat areas
- Essential Habitat fitzroy river turtle
- Existing weir
- Proposed Connors River Dam

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Fitzroy River turtle important habitat areas

Figure 3-2

G:\41\20736\GIS\Projects\MXD\900_Baseline Terrestrial Fauna Report\4120736_913_Fitzroy_Turtle_Nesting_Habitat_A3_Rev_E.mxd

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

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The Fitzroy River turtle is considered to be a specialist species that inhabits freshwater habitats within the river channel. The ability of the Fitzroy River turtle to respire aquatically (Section 3.5) allows this species to inhabit fast-flowing riffle zones from which primarily air-breathing species are excluded (Gordos 2004). While riffle zones are considered particularly important habitat, the species also inhabits pools, runs and creeks. Foraging in these habitats is generally associated with in-stream debris such as fallen logs. 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 (Limpus et al. 2011a).

The Fitzroy River turtle is also known to inhabit modified habitats associated with in-stream infrastructure. While the deep water areas (> 5 m) of impoundments are largely uninhabitable to the turtle species due to very low oxygen levels, little or no light penetration and cold temperatures, suitable habitat can occur within the shallow littoral habitats along the perimeter of the storage, the shallow upstream margins and within pool habitats immediately downstream. The two highest abundances of Fitzroy River turtle ever recorded within the catchment have occurred within the plunge pool below Theodore Weir (Table 3-1; Limpus et al. 2011a) and within the dissipater pool below Tartrus Weir (Table 3-1; Limpus et al. 2011b). The largest known nesting aggregation for the Fitzroy River turtle also occurs in the upper reaches of the Fitzroy Barrage impoundment (downstream of the Project footprint) and the species has been recorded within the impounded waters of Neville Hewitt Weir, Tartrus Weir and the Fitzroy River Barrage (Limpus et al. 2011a).

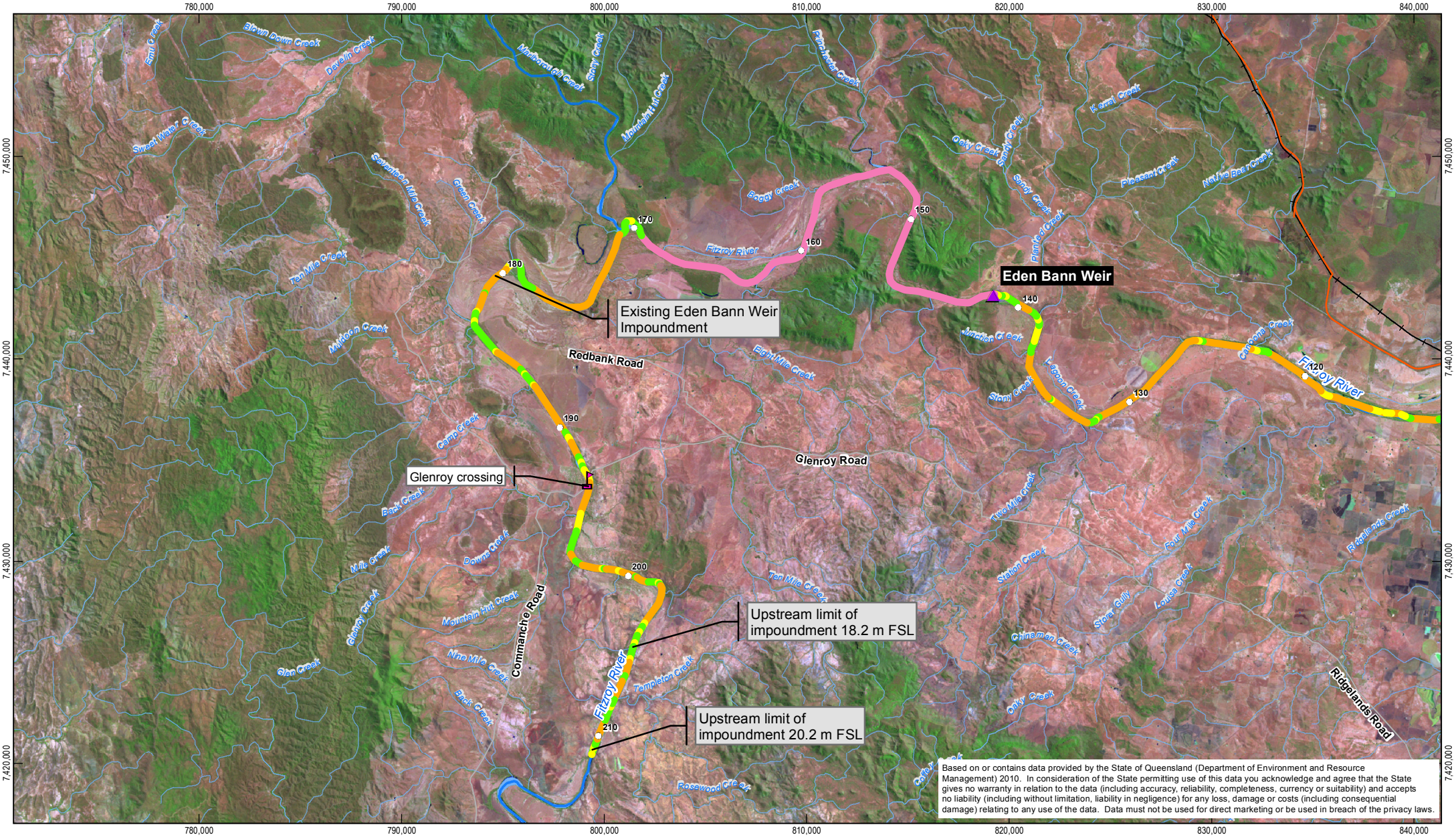
The Fitzroy River turtle is not known to occur in off-stream habitats such as farm dams, billabongs, or flood plains (Limpus et al. 2011a). The specific habitat requirements of hatchling turtles are unknown.

Based on the assessment of aerial photography and field survey observations (as discussed in Section 2 and Chapter 7 Aquatic fauna), the linear extent of various in-channel[3] aquatic habitat types within the Project footprints is provided in Table 3-2. The spatial distribution of in-channel aquatic habitats, as determined through the analysis, is illustrated in Figure 3-3 and Figure 3-4.

Table 3-2 Linear extent of in-channel aquatic habitats within the Project footprint

	Linear extent of habitat in Rookwood Weir Project footprint (km)	% linear extent of habitat in Rookwood Weir Project footprint	Linear extent of habitat in Eden Bann Weir Project footprint (km)	% linear extent of habitat in Eden Bann Weir Project footprint
Impounded pool	0	0	27.8	39.77
Pool	37.6	43.27	23.9	34.19
Run	29.1	33.49	13.1	18.74
Riffle	20.2	23.25	5.1	7.3
Total	86.9 km	100%	69.9 km	100%

[3] In-channel refers to habitats within the mainstream of the Dawson, Mackenzie and Fitzroy rivers. It excludes adjoining creeks and off-stream water bodies.



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1:250,000 (at A4)

0 2.5 5 7.5 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

Legend

- AMTD (km)
- Weir Location
- River Crossing
- Watercourse (Major)
- Watercourse (Minor)
- Highway
- Minor Road
- Railway
- Waterway
- Aquatic Habitat
- Impounded Pool
- Pool
- Riffle
- Run

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Revision B
Date 05 Aug 2014

Spatial distribution of in-channel aquatic habitats within and downstream of the Eden Bann Weir Project footprint

Figure 3-3

G:\41\20736\GIS\Projects\MXD\900_Baseline Terrestrial Fauna Report\4120736_911_Eden_Bann_Aquatic_Habitats_Rev_B.mxd

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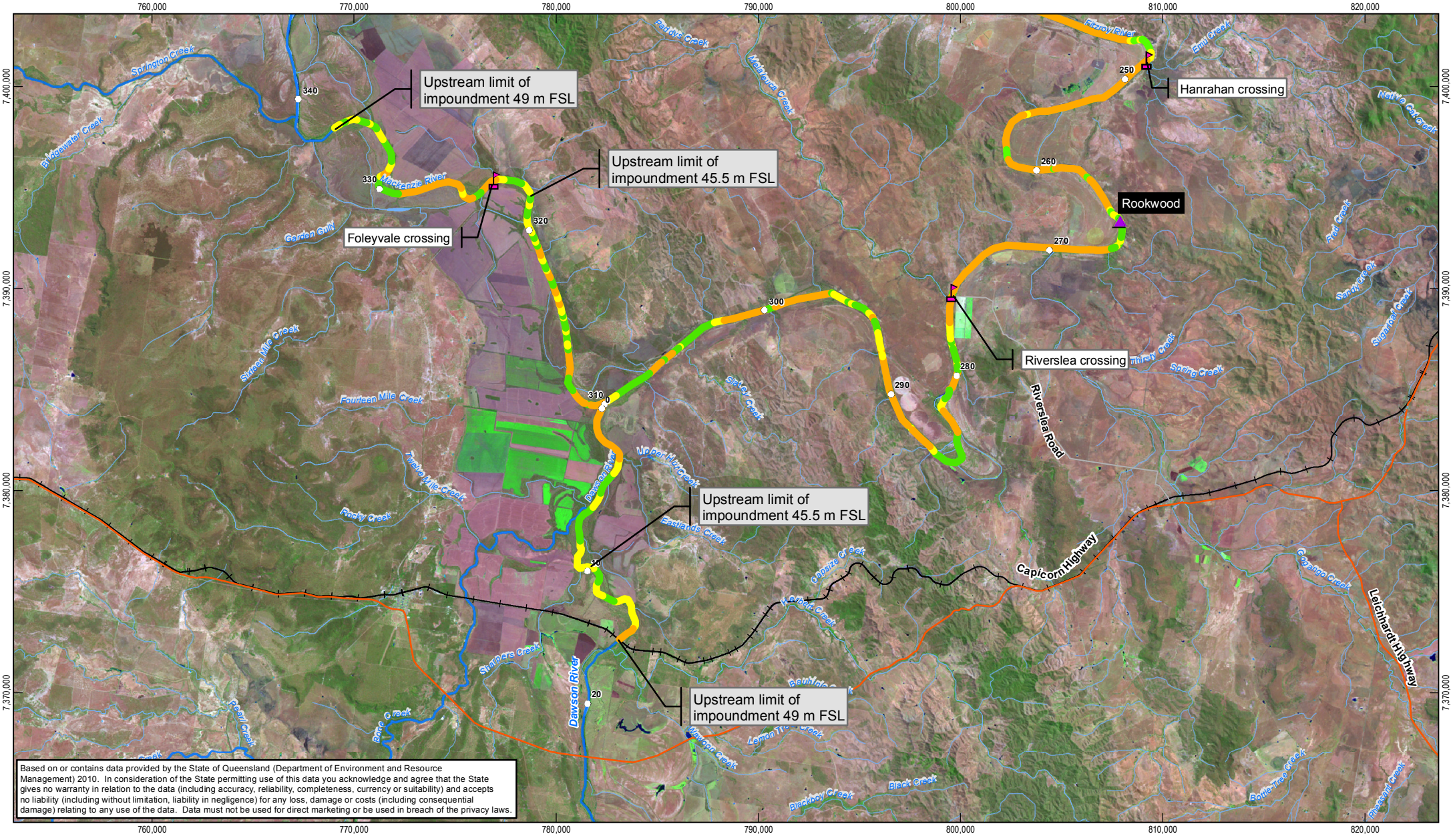
Data Source: GHD: Fauna Survey/2009; © Copyright Commonwealth of Australia (Geoscience Australia): Waterways, State (2007); Sunwater: Waterways, Weir Locations - 2008; DERM: Roads - 2010, Railways - 2010, Imagery - 2005. Created by: MS.



1:250,000 (at A4)

0 2.5 5 7.5 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

Legend

- AMTD (km)
- Weir Location
- River Crossing
- Highway
- Minor Road
- Railway
- Waterway
- Watercourse (Major)
- Watercourse (Minor)
- Aquatic Habitats
  - Pool
  - Riffle
  - Run

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Spatial distribution of in-channel aquatic habitats within and downstream of the Rookwood Weir Project footprint

Figure 3-4

G:\41\20736\GIS\Projects\MXD\900_Baseline Terrestrial Fauna Report\4120736_914_Rookwood_Aquatic Habitats_Rev_C.mxd

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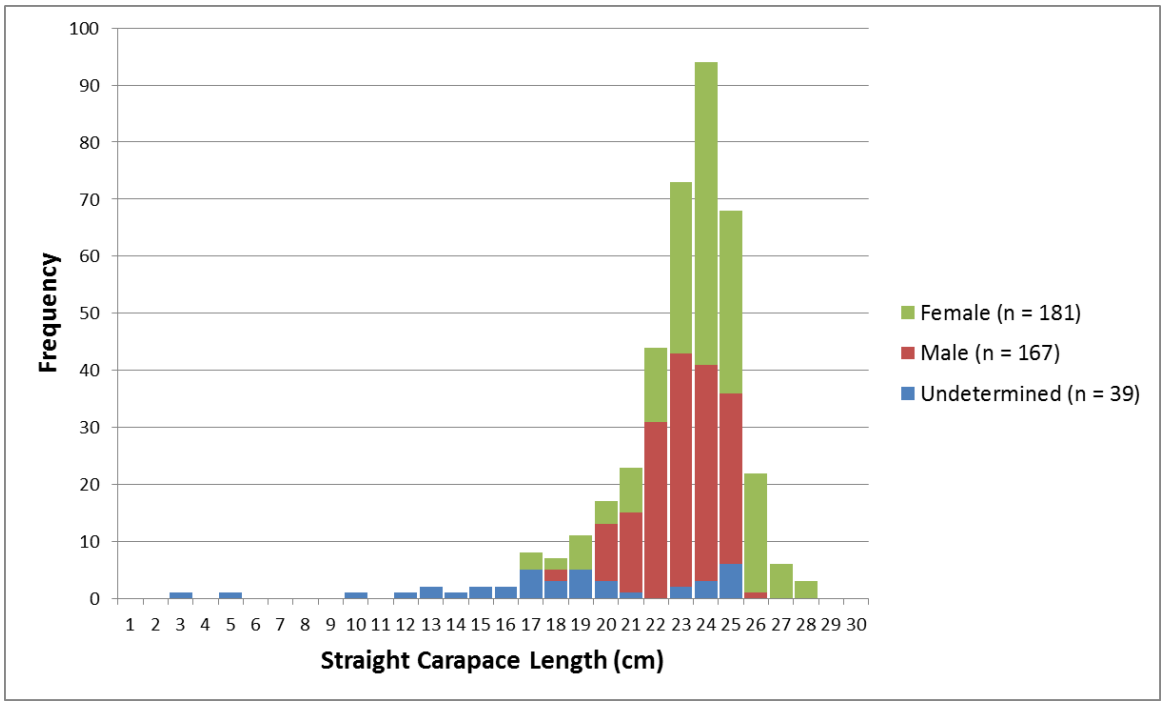
3.3 Population structure

The population of Fitzroy River turtle within the catchment is comprised primarily of adults (Limpus et al 2007; Limpus et al. 2011b). Mature males and females, with a straight carapace (shell) length of greater than 22 centimetres (cm) in females and 21 cm in males, dominate the catchment wide size frequency distribution (Figure 3-5). Of the 387 individuals captured throughout the catchment in 2007, 181 were females, compared to 167 males. Very few hatchling or juvenile turtles were recorded.

The absence of hatchling and juvenile turtles within the population has also been observed in recent surveys conducted within the Connors and Mackenzie rivers (frc 2011, Limpus et al. 2011b). Nest predation rates of close to 100 per cent are thought to be responsible for the lack of recruitment into the population (Section 3.8; Limpus et al. 2011a; DERM 2008). The bias in favour of adult turtles within the catchment indicates that low recruitment of hatchlings has been occurring over many decades (Limpus et al. 2011a).

Figure 3-5 Size frequency distribution of Fitzroy River turtle within the Fitzroy Basin catchment



Source: Limpus et al. 2011a

3.4 Reproductive biology and nesting habitats

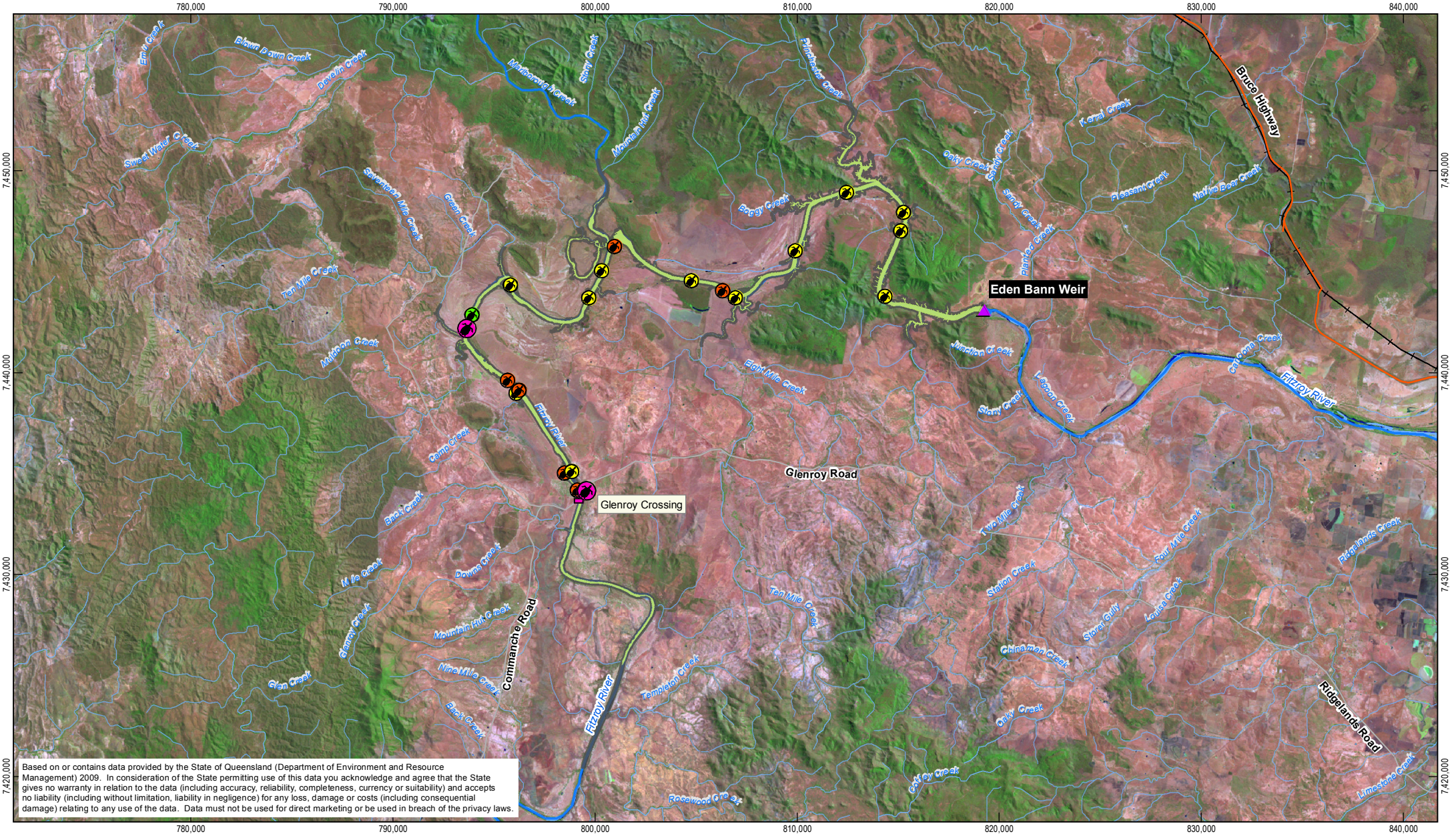
The Fitzroy River turtle reaches sexual maturity at around 15-20 years old (Limpus et al. 2011a). The breeding cycle for an adult female is approximately one year and each female can lay two or more egg clutches per year during spring (September-November). The incubation period is dependent upon environmental conditions with hatching generally occurring during summer (November-March) (Limpus et al. 2011a; Limpus et al. 2011b). Field surveys indicate that the annual breeding rate of the Fitzroy River turtle is generally high with close to 100 per cent of adult females nesting each year (Limpus et al. 2011a; Limpus et al. 2011b). Breeding rates are however thought to be negatively influenced by habitat degradation and poor health of individuals (Limpus et al. 2011a).

Nesting is generally restricted to alluvial sand/loam banks which are deposited during flood events (Figure 3-6). 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 (Limpus et al. 2011a). Nesting generally occurs approximately 5 m from the water's edge (Limpus et al. 2011a; Hamann et al. 2007). The Fitzroy River turtle has demonstrated adaptability to fluctuations in nesting habitat conditions following natural events such as flooding (Dr Col Limpus pers comm.).

Figure 3-6 Potential turtle nesting habitat in Rookwood Weir Project footprint (left) and Eden Bann Weir Project footprint (right)

Important nesting habitat is found at Alligator Creek located within the upper reaches of the Fitzroy Barrage impoundment (40 km downstream of Eden Bann Weir at approximately 100 km AMTD). This area supports the largest known Fitzroy River turtle nesting aggregation. Additional nesting aggregations have also been recorded immediately downstream of Tartrus Weir on the Mackenzie River and within the upper reaches of the Tartrus Weir impoundment on the Isaac River (Limpus et al. 2011b).

Within the Project footprints, isolated nests of the Fitzroy River turtle have been historically recorded at Glenroy and Redbank crossings. Turtle nesting activity was also identified at six nesting banks within the Rookwood Weir Project footprint during field surveys. Predated egg shell from five of these banks was identified as potential Fitzroy River turtle. Two nests recorded at the Rookwood Weir site were confirmed as white-throated snapping turtle. Due to the similarity in nesting bank requirements between the Fitzroy River turtle and the white-throated snapping turtle, the Rookwood Weir site is considered to provide highly suitable habitat for Fitzroy River turtle nesting. Two additional banks, one within the Rookwood Weir Project footprint and one within the Eden Bann Project footprint, were identified as being highly suitable (although unconfirmed) for Fitzroy River turtle nesting. The location of potential Fitzroy River turtle nesting sites within the Eden Bann Weir Project footprint and Rookwood Weir Project footprint are shown in Figure 3-7 and Figure 3-8, respectively.



1:250,000 (at A4)

0 2.5 5 7.5 10

Kilometres

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

N

LEGEND

- Weir Location
- River Crossing
- Highway
- Minor Road
- Waterway
- Waterway
- Railway
- Eden Bann Weir Stage 2 impoundment
- Eden Bann Weir Stage 3 impoundment
- High Potential Turtle Nesting Suitability
- Medium Potential Turtle Nesting Suitability
- Low Potential Turtle Nesting Suitability
- Historical Turtle Nesting Site

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Location of potential turtle nesting banks within the Eden Bann Weir Project footprint

Figure 3-7

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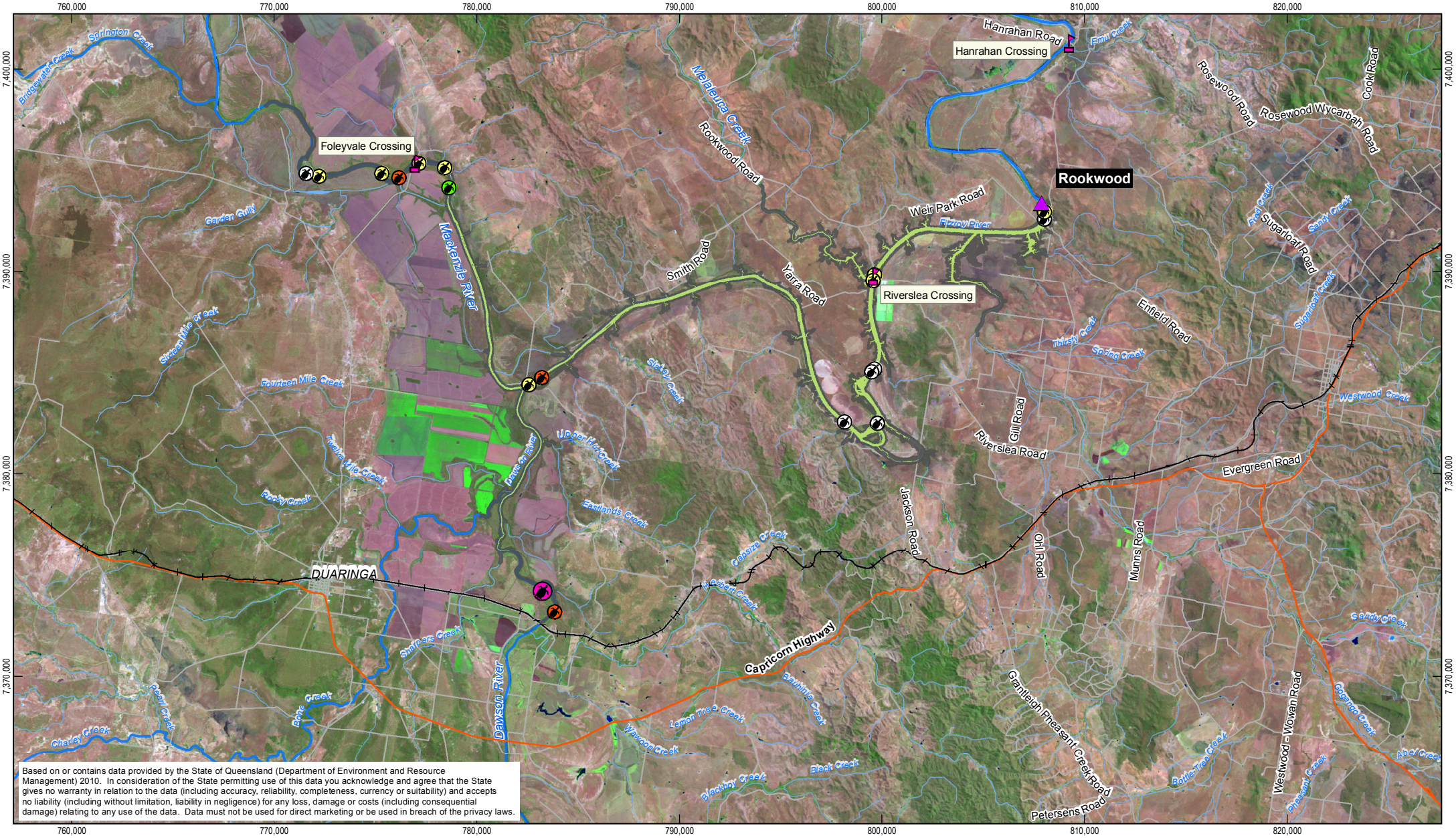
G:\41\20736\GIS\Projects\MXD\900_Baseline Terrestrial Fauna Report\4120736_910_Eden_Bann_Potential_Turtle_Nesting_Sites_Rev_D_Fig4.mxd

Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Waterways, State (2007); Sunwater: Waterways, Weir Locations - 2008; DNRM: Roads - 2010, Railways - 2010, DERM - Imagery/2005; GHD: Fauna Survey - 2009. Created by AJ



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1:250,000 (at A4)

0 2.5 5 7.5 10

Kilometres

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

N

LEGEND

- Weir Location
- River Crossing
- Railway
- Highway
- Minor Road
- Waterway
- Watercourse (Major)
- Watercourse (Minor)
- Rookwood Weir Stage 1 impoundment
- Rookwood Weir Stage 2 impoundment
- Confirmed Turtle Nesting Site
- Historical Turtle Nesting Site
- High Potential Turtle Nesting Suitability
- Medium Potential Turtle Nesting Suitability
- Low Potential Turtle Nesting Suitability

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Location of potential turtle nesting banks within the Rookwood Weir Project footprint

Figure 3-8

G:\41\20736\GIS\Projects\MXD\900_Baseline Terrestrial Fauna Report\4120736_913_Rookwood_Potential_Turtle_Nesting_Sites_Rev_D.mxd

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The nesting habitats within the Project footprint and throughout the Fitzroy Basin catchment are impacted by adjacent land use practices and in general are highly disturbed. Degradation from cattle, pigs and weeds is widespread reducing the suitability of habitat for turtle nesting in many areas. Where nesting does occur, extreme levels of nest predation, close to 100 per cent, result in little to no recruitment of hatchlings into the population (Limpus et al. 2011a; Limpus et al. 2011b). As a consequence the quality of nesting habitat within the Project footprint is considered to be low/poor.

3.5 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. Aerial respiration is achieved via the lungs at the water's surface, whilst aquatic respiration occurs underwater via gill like structures in the cloaca (Priest and Franklin 2002). 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. The Fitzroy River turtle can support at least 70 per cent of its oxygen requirements from the water, which allows this species to remain submerged underwater for days or weeks at a time (Priest 1997; Gordos et al. 2003). Benefits of aquatic respiration include increased time available for foraging and breeding, reduced exposure to predation, reduced energy expenditure and habitation of fast-flowing riffle zones (Gordos 2004; Clark 2008). Due to their high surface area-to-volume ratio, hatchling turtles have a relatively high reliance on aquatic respiration (compared to adults) and this is considered particularly beneficial for predator avoidance (Clark et al. 2008). Successful aquatic respiration in freshwater turtles is dependent upon a range of environmental conditions such as water temperature and dissolved oxygen levels. Changes in these conditions can influence the amount of oxygen the turtle can extract from the water and can, therefore, direct influence the ecological behaviour of the species (Clark 2008).

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 (Gordos 2004). 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 (Gordos 2004). 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 (Gordos 2004).

3.6 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, sponges and algae (Leger and Cann 1980; Rogers 2000; Tucker et al. 2001; Limpus et al. 2011a). Food resources for the Fitzroy River turtle can often be in short supply within natural pools and impounded habitats. Access to highly productive riffle zones or flowing shallow water margins assist in the accumulation of fat reserves that are utilised by the species for breeding during the dry season (Limpus et al. 2011a).

3.7 Movement biology

Little is known about the movement patterns of the Fitzroy River turtle. Studies to date suggest that home range size is relatively small (up to four hectares (ha)) with local movement generally occurring between riffle zones and adjacent pools. Large scale movements in the order of tens of kilometres may potentially occur for the purpose of dispersal, courtship and repositioning following flood displacement (Tucker et al. 2001). Upstream and downstream migrations may also occur during the nesting season as individuals move to traditional nesting areas (Dr Col Limpus pers comm.). Initial research on the movement behaviour of freshwaters turtles has also discovered that some male turtles may undertake upstream and/or downstream movements to attend breeding aggregations (Dr Col Limpus, pers comm.). 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.

Existing infrastructure within the Fitzroy Basin catchment has reduced the connectivity of the Fitzroy River turtle habitat by restricting the upstream and downstream movement of turtles past in-stream structures. As a result, the population of Fitzroy River turtles within the Fitzroy, Dawson and Mackenzie sub-catchments is now fragmented into the twelve separate habitat areas located between each storage. Existing infrastructure currently impacting turtle movement and the percentage of impoundment within each river is detailed in Table 3-3.

Table 3-3 Current level of impoundment of main rivers relative to the Project

River	Existing infrastructure	Length of river (km AMTD)	Level of impoundment (km AMTD)	Percentage %
Dawson River	Neville Hewitt Weir, Moura Weir, Theodore Weir, Orange Creek Weir, Gyranda Weir, Glebe Weir	356. 5	125.2	35%
Nogoa and Mackenzie Rivers	Tartrus Weir, Bingegang Weir, Bedford Weir, Fairbairn Dam	427.2	143.7	34%
Fitzroy River	Eden Bann Weir, Fitzroy Barrage	250.7	97.6	39%

Rainfall is thought to act as a trigger for the movement of the Fitzroy River turtle and individuals have been observed attempting to move past impoundments during rainfall and small flow events (Limpus et al. 2011a; Limpus et al. 2011b). Fishways, such as vertical slots and mechanical locks are not traditionally designed to accommodate freshwater turtles and as a result, have relatively low, to no, success at facilitating turtle passage (Hamann et al. 2007; Limpus et al. 2011a). Anecdotal observations of turtle behaviour at dams and weirs have revealed that turtles attempt to move upstream by climbing in-stream structures such as the spillway face and abutments (Dr Col Limpus pers comm.). A recent study by Limpus et al. (2011), recorded evidence of the Fitzroy River turtle attempting to move upstream by climbing the concrete structures at Tartrus Weir, on the Dawson River,

at night. During higher flow conditions, the species was observed attempting to climb past the wall via the river bank (Limpus et al. 2011b).

3.8 Population status and key threatening processes

The biggest threat to the survival of the Fitzroy River turtle is the lack of recruitment into the population (Limpus et al. 2011a; DERM 2008). Predation of nesting banks by feral animals, goannas and water rats and trampling of nests by cattle results in extremely poor survival of egg clutches. The bias in favour of adult turtles within the Fitzroy Basin catchment indicates that low recruitment of hatchlings has been occurring over many decades (Limpus et al. 2011a). At the current rates of recruitment, the population of Fitzroy River turtles within the catchment is not considered sustainable (Limpus et al. 2011a).

Other threatening processes include:

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

The potential impacts on the Fitzroy River turtle that may arise as a result of the Project are likely to be analogous to those caused by the processes which are currently affecting the species throughout the Fitzroy Basin catchment. These processes and their associated impacts on the Fitzroy River turtle at a catchment scale are discussed further in Table 3-4.

Table 3-4 Existing threatening processes acting on Fitzroy River turtle in the Fitzroy River catchment

Existing threatening process	Description	Impact of threatening processes on the Fitzroy River turtle
Nest predation	Freshwater turtles within the Fitzroy Basin catchment have extremely high nest predation rates with close to 100 per cent of clutches predated each season (Limpus et. 2007; DERM 2008; Limpus et al 2011). The high mortality of eggs has led to little to no recruitment of hatchlings into the population over the last decade. The population of Fitzroy River turtles is now primarily comprised of adult individuals. The key predators of freshwater turtle nests include: foxes, dogs, pigs, cats, goannas and water rats. Trampling of nests by cattle has also contributed to the low level of recruitment (Limpus et al. 2011a; DERM 2008).	• Low population recruitment • Disruption to population age structure.
Loss of habitat	The natural pool-riffle-run sequences within the Fitzroy Basin catchment provide preferential habitat for the Fitzroy River turtle. The construction of impoundments throughout the catchment has inundated a large proportion of these natural habitats. The conversion of the heterogeneous lotic habitat into homogeneous lentic habitat has resulted in the loss of turtle foraging, sheltering and nesting habitat (Limpus et al. 2011a; DERM 2008).	• Reduction in heterogeneity of aquatic habitats • Decrease in foraging and sheltering resources • Increase in competition from generalist species • Decrease in availability of nesting habitat.
Alteration of natural flow regime	The construction of in-stream storage infrastructure and water extraction within the Fitzroy Basin catchment has altered the natural flow regime of the system. Flows within the impoundments are reduced to zero or slow flowing conditions (excluding flooding events) while, downstream conditions vary according to operational releases. The reduction in flows within impoundments has resulted in a change in aquatic habitat conditions including water quality and the diversity and abundance of foraging resources (e.g. macrophytes, macroinvertebrates, benthic invertebrates). Operational water releases that increase water levels downstream during the turtle nesting season may inundate turtle nests.	• Alteration of habitat • Reduction in foraging resources • Inundation of turtle nests.
Movement barriers	In-stream infrastructure and resulting impoundments within the Fitzroy Basin catchment have created physical barriers that inhibit the upstream and downstream movement of turtles. Whilst the home range size of the Fitzroy River turtle is generally relatively small, individuals are thought to undertake long-distance migrations for the purpose of dispersal, courtship and nesting, and repositioning following flood displacement. Restriction of long-distance movement can lead to a disruption in reproductive behaviours and the creation of genetically isolated populations (Limpus et al. 2011a).	• Restriction of long-distance movement • Disruption to reproductive behaviours (e.g. courtship and nesting) • Fragmentation of populations.

Existing threatening process	Description	Impact of threatening processes on the Fitzroy River turtle
Physical injury and mortality	The structural and operational design of in-stream infrastructure and impoundments has resulted in high levels of turtle injury and mortality. Specifically, mortalities are known to occur as a result of entrapment on trash screens, contact with hard structures during spilling events and during water discharge (Limpus et al. 2011a). Turtle injury and mortality has also increased as a result of human recreation activities with causes of turtle injury and mortality including crab trap drowning, fish hook injuries and boat strikes (Limpus et al. 2011a).	• Decline in turtle health • Decrease in population size.
Poor water quality	Land use practices in the Fitzroy Basin, such as agriculture and mining, have led to various pressures being placed on the aquatic ecosystems and species that occur in the waterways of the Basin. Of particular concern is the deterioration of water quality due to excess sediments, nutrients, dissolved salts and agrochemical and metal concentrations (Johnston et al., 2008). The reduction ns water quality within the catchment has led to the degradation of turtle habitat and food resources and may be responsible for a reduction in turtle heath (Limpus et al. 2011a; DERM, 2008). Increased run-off from agricultural/pastoral lands has also increased the levels of toxic chemicals within the Fitzroy Basin catchment. Whilst the chemicals are currently below guideline levels, their effect on the health of freshwater turtles is unknown. Bimodally respiring species are likely to be more sensitive to toxic chemicals than primarily air-breathing species (Limpus et al. 2011a; DERM 2008). Changes in water quality conditions, particularly reduced oxygen levels, may reduce aquatic respiration and dive duration in turtles. Alteration of respiratory physiology and diving behaviour may lead to a reduction in foraging and breeding rates, and increase in predation levels, particularly in hatchlings (Clark 2008). An increase in predation levels of hatchlings is likely to compound the extremely high rates of nest predation currently occurring throughout the catchment.	• Degradation of habitat – reduction in the diversity and abundance of food resources • Alteration of respiratory physiology and diving behaviour – potential reduction in turtle health and increase in predation levels.

4. Potential impacts

4.1 Overview

The augmentation/construction and operation of weir infrastructure at Eden Bann Weir and Rookwood Weir has the potential to exacerbate the existing threatening processes to the Fitzroy River turtle throughout the Fitzroy Basin catchment.

Construction activities are expected to occur over at least two consecutive dry seasons. Impoundment is expected to occur within a single wet season during which commissioning will take place (Volume 1, Chapter 9 Surface water resources). Construction and commissioning activities which have the potential to impact on the Fitzroy River turtle, if not mitigated appropriately include:

- Loss of vegetation and excavation within the bed and banks
- Vehicle and plant movement to, from and around the construction sites
- Storage or spillage of potentially hazardous materials
- Construction within the waterway
- Resource extraction
- Flow diversion/control
- Commissioning -water capture and storage behind the weir

Operation activities which may have the potential to impact the Fitzroy River turtle, if not mitigated appropriately include:

- In-stream barrier operation
- Altered flow regimes (including management of storage)

The specific impacts of weir construction and operation on the Fitzroy River turtle are discussed in Sections 4.2 and 4.3 below. Within the discussion, relevant mitigation and management strategies that may avoid, reduce or minimise these impacts are presented. Management actions that are likely to result in a residual benefit to the species and/or target existing threatening processes are also discussed.

A species management program (SMP) for the Fitzroy River turtle (Volume 3 Appendix M) describes measures to be implemented to avoid, and if this is not possible, minimise the potential impacts of the Project on the species and provides a framework for the management of the species throughout the life of the Project. The SMP will be implemented together with the Project construction environmental management plan and operational environmental management plan (Chapter 23 Environmental management plan)

Unavoidable impacts are expected to remain in relation to commissioning activities (Section 4.2). These residual impacts are considered significant and offsets are proposed (Section 5 and Chapter 22 Offsets).

4.2 Construction and commissioning phase impacts

4.2.1 Loss of aquatic and nesting habitat

4.2.1.1 Potential impact

Project construction will require the removal of vegetation, excavation of the bed and banks and resource extraction within the weir construction footprints. Construction works within the Eden Bann Weir construction footprint will occur within the existing impoundment and modified habitat immediately downstream. These areas provide limited resources for the Fitzroy River turtle and no potential nesting habitat is known to occur. Minimal impact to Fitzroy River turtle habitat is expected to occur as a result of Eden Bann Weir construction activities.

Aquatic habitat within the Rookwood Weir construction footprint includes pool-riffle-run sequences that are known to be utilised by the Fitzroy River turtle. Habitat to be lost as a result of construction activities (in the order of 4 ha) is, however, considered relatively small in size compared to the availability of similar habitat upstream and downstream of the site. While the area is considered to be suitable habitat for Fitzroy River turtle nesting (based on confirmed presence of nesting of the white-throated snapping turtle (*Elseya albagula*), a species with similar habitat preferences) aggregated nesting is not known to occur at the site. The predicted loss of habitat is not expected to have a significant impact on the Fitzroy River turtle.

Additional loss of aquatic and nesting habitat has the potential to occur within the river crossing construction areas. Glenroy Crossing is a known important habitat areas for the species. The construction area at all river crossing sites will be kept to the minimum amount necessary in order to minimise impact to turtle aquatic and nesting habitat. Due to the relatively small area of habitat to be impacted at these sites and the availability of suitable habitat upstream and downstream of the construction works, impacts to the Fitzroy River turtle are not expected to be significant. Resource extraction (aggregate) for use in construction will be sourced from excavations within the construction footprints and future inundation areas where ever possible, to avoid additional impact to turtle habitat. Acquisition of materials will not occur in important habitat areas or from historical, confirmed or high potential turtle nesting habitats.

4.2.1.2 Mitigation measures

- The construction schedule of river crossing construction at Glenroy Crossing will be designed to avoid construction works that may impact on turtle habitat during the peak turtle nesting and hatching season (September to March)
- The construction footprints areas will be kept to the minimum amount necessary and be co-located within existing disturbed areas
- The construction footprints will be clearly marked with construction tape to prevent disturbance and/or destruction of turtle habitat in adjacent areas
- Resource extraction will not occur in important habitat areas (e.g. mapped essential habitat) or from historical, confirmed or high potential turtle nesting habitat
- All construction personnel will be informed of environmental responsibility with respect to the Fitzroy River turtle. Site inductions will include information on the location of important habitat and potential nesting habitat to prevent disturbance

and/or destruction of these areas. Management actions relevant to the protection of turtle aquatic and nesting habitat will be discussed and responsible persons identified.

4.2.2 Degradation of habitat

4.2.2.1 Potential impact

Construction activities within the construction footprints have the potential to result in the degradation of Fitzroy River turtle habitat immediately downstream of the sites. Habitat degradation may occur as a result of:

- Sedimentation and erosion
- Increased weed and pest species
- Light, noise and vibration disturbance
- Spillage of hazardous materials
- Flow diversion and control.

Unmitigated these impacts may have a localised effect on the Fitzroy River turtle by reducing habitat value (e.g. amount of refuges, microhabitats and food availability) within the immediate downstream area and disrupting turtle behaviours. Reduced water quality may decrease reliance on aquatic respiration leading to a change in diving behaviour. The potential ecological consequences to the species may include a temporary and localised decrease in turtle abundance, reduction in turtle health and disruption to turtle breeding. The impacts are however, primarily restricted to the habitat areas immediately downstream of the Rookwood Weir construction footprint and Glenroy crossing construction area. As construction will primarily occur during the dry season, dissemination of impacts downstream will be limited. Standard environmental management practises, including the implementation of construction environmental management plans (e.g. Drainage, Erosion and Sediment Control Plan, Waste and Hazardous Materials Management Plan, Animal Control Plan) are considered sufficient such that no significant impact to the Fitzroy River turtle is expected.

4.2.2.2 Mitigation measures

- Water flows downstream of the construction footprints will be maintained. A flow diversion strategy will be implemented at the Rookwood Weir site while the existing fish lock at Eden Bann Weir will remain in operation during construction of the right bank. Flows will be maintained within the natural river channel at river crossing construction areas (Volume 1, Chapter 2 Project description)
- Weir construction will be primarily undertaken over two consecutive dry seasons when flows within the river are low and natural/existing conditions will be maintained for as long as possible
- Night lighting will be minimised where practicable. No lighting shall be placed in the vicinity of a confirmed nesting habitat adjacent to the construction footprints. Any lighting installed will be designed and mounted so that no spill over light occurs within these habitat areas (such as directional lighting with protective guards) (Volume 1, Chapter 5 Land)

- A Weed Management Plan will be developed and implemented and will include the following control techniques specific to the protection of Fitzroy River turtle habitat:
  - Existing aquatic weeds within the construction footprints will be removed prior to construction activities
  - Vehicles, plant and equipment will be cleaned prior to entering site to prevent the introduction of weeds to potential nesting areas
  - Key personnel on site will be capable of identifying terrestrial and aquatic weed species and preventing their spread and translocation. During an initial site inspection, weeds will be identified and flagged and recorded in the site register. Weeds will be treated to prevent spread.
- A Feral Animal Control Program will be developed and implemented by construction personal or in collaboration with local council, community groups and landholders. Management actions will be in accordance with the Project EMP and may include culling, baiting and trapping of pigs, foxes, wild dogs and feral cats
- A Drainage, Erosion and Sediment Control Plan will be developed and implemented. Management actions will be in accordance with the Best Practice Erosion and Sediment Control Guidelines (International Erosion Control Association (IECA) 2008)
- A Water Quality Management Plan will be developed and implemented in accordance with the Project construction EMP. Water quality parameters particularly important for the Fitzroy River turtle, i.e. turbidity, temperature, oxygen levels, toxic chemical, will be monitored as part of the Project Water Quality Monitoring Program. The Project Water Quality Monitoring Program will include pre, during and post construction monitoring in accordance with the Australian Guidelines for Water Quality Monitoring and Reporting (Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000)
- A Waste and Hazardous Materials Management Plan will be developed and implemented. Management actions will be in accordance with Australian Standards (Hazardous Material Management Programme)
- Aquatic habitats immediately upstream and downstream of the construction footprints will be monitored for signs of degradation as a result of the construction phase activities and turtles relocated if conditions deteriorate to threshold levels (to be confirmed) in isolated pools.

4.2.3 Increased injury and mortality

4.2.3.1 Potential impact

Turtles or turtle nests residing within the construction footprints may experience direct injury and/or mortality. Similarly, turtles moving upstream or downstream within these areas are at risk of being trapped or injured in the active construction zones. Construction activities may also foster greater utilisation of the area by introduced animals. The incorrect disposal of rubbish and other refuse may encourage introduced species (including pigs, dogs, foxes, and cats) to the area, which in turn may increase predation pressure on turtle nests leading to an increased injury/mortality rate for the species.

4.2.3.2 Mitigation measures

- Prior to initial construction works, all river banks within the construction footprints will be surveyed by a suitably trained and qualified ecologist, during the peak nesting (September to November) and hatching (November to March) season. Pre-clearance surveys will occur during and immediately following rainfall events and will involve systematically searching banks for direct and indirect evidence of turtle nesting and hatchlings. Surveys will be repeated throughout the construction period for any new disturbance scheduled to occur during the nesting and hatching season
- If Fitzroy River turtle nesting is confirmed to be present within the construction footprints and construction is not scheduled to commence until after the hatching season (November to March), then the area will be mapped and clearly marked in the field and on construction plans. Nest protection mesh will be secured over nests to provide predator protection
- If construction works are scheduled to commence prior to the end of the hatching period (November to March), a suitably trained and qualified fauna spotter/catcher will relocate the eggs to a suitable area using techniques approved by DEHP. Exclusion fencing will be erected along the nesting bank/s to prevent further nesting within the construction footprints
- Prior to any initial or new disturbance to aquatic habitat within the construction footprints, all impact areas will be inspected by a suitably trained and qualified fauna/spotter for the presence of the Fitzroy River turtle. Pre-clearance surveys for the Fitzroy River turtle will be undertaken immediately prior to disturbance works and will include survey techniques suitable for the species (i.e. seine netting, dip netting, snorkelling, muddling, spotlighting). If the Fitzroy River turtle is located, the species will be captured and relocated. Relevant measures will be implemented to exclude turtle access to active constructions areas (e.g. erection of exclusion fencing/netting, bund walls)
- A fauna spotter/catcher will be located on site during all works that have the potential to cause injury or mortality to turtles located in the area. The fauna spotter/catcher will identify, capture and relocate turtles and/or turtle nests as required to avoid direct impact
- All habitat remaining within the construction footprints, from which turtles are not excluded, will be inspected daily for the presence of the Fitzroy River turtle or during nesting season, it's nests
- If injury occurs, injured turtles will be immediately removed and taken to a qualified veterinary or wildlife carer for treatment. Suitable veterinarians and wildlife carers in nearby areas and Rockhampton will be identified and commercial arrangements established to guarantee the financial costs of treatment and rehabilitation
- All construction personnel will be informed of environmental responsibility with respect to minimising the risk of turtle injury or mortality. Site inductions will include information on the identification of the Fitzroy River turtle, location of any confirmed nesting habitat areas within or adjacent to the construction footprint and relevant management actions
- Resource extraction will not occur in important habitat areas or from historical, confirmed or high potential turtle nesting habitat

- A Feral Animal Control Program will be developed and implemented.

4.2.4 Restriction of movement

4.2.4.1 Potential impact

Water flow within the construction footprints may be impacted during the construction period and upstream and downstream movement of turtles temporarily restricted within the Rookwood Weir construction footprint. Turtle passage is currently restricted at Eden Bann Weir as a result of the existing structure. Construction activities will primarily occur during the dry season when flows are reduced and the river exists as a series of isolated pools. Long-distance movement of turtles during this period is likely to be low, however, some localised movement may occur as isolated pools in adjacent areas naturally dry out or become increasingly degraded as a result of low water levels. Water flows and the movement of turtles is not expected to be impacted at river crossing construction areas.

4.2.4.2 Mitigation measures

- Weir construction will be primarily undertaken during two consecutive dry seasons when long-distance movement of turtles is likely to be low
- A flow diversion strategy will maintain flows at the Rookwood Weir site and provide safe turtle movement during construction phase flow events
- The existing fish lock at Eden Bann Weir will remain in operation during construction on the right bank to maintain flows. During this time, the turtle passage facility (Section 4.3.1) will be constructed. The turtle passage facility will provide safe turtle movement past the Eden Bann construction footprint when construction works move to the left bank
- Existing low level causeways at river crossings will remain in situ during bridge construction to facilitate water flow and maintain turtle movement. The existing low level causeways will be decommissioned once bridge construction is complete.

4.2.5 Alteration of aquatic habitats

4.2.5.1 Potential impact

Approximately 282 ha and 660 ha of aquatic habitat is estimated to be impacted by the additional impoundment area at Eden Bann Weir and Rookwood Weir, respectively, assuming maximum development at each site. Currently approximately 36 per cent of the Fitzroy, Dawson and Mackenzie sub-catchments have been impounded as a result of in-stream water infrastructure (Table 3-3). The Project will result in the inundation of an additional 113 km, increasing the area of impacted habitat within the sub-catchment by approximately 10 per cent. Specifically, the commissioning of the raised Eden Bann Weir is expected to inundate an additional 27 km of pool-riffle-run habitat, while Rookwood Weir will inundate approximately 86 km. The lower reaches of the 19 named creeks (and smaller unnamed creeks), and the connectivity and hydrology of the 55 off-stream water bodies within 1 km of the Project footprints are also likely to experience varying degrees of alteration.

The conversion of natural habitats (i.e. pool-riffle-run sequences) into a large impounded pool habitat will result in the loss of heterogeneous lotic habitat utilised by the Fitzroy River turtle. Of particular importance is the loss of riffle zone habitat, flowing shallow-water

habitat and micro-habitats (e.g. in-stream debris) which provide foraging and sheltering resources.

The impounded habitat created as a result of the weirs will be generally characterised by a deep, wide river channel, slow to zero flow, poor quality clay/silt substrate, low density of in-stream debris and low density of overhanging riparian vegetation. The deep water areas (> 5 m) that dominate the weir pool habitat are expected to be largely avoided by the Fitzroy River turtle due to very low oxygen levels, little or no light penetration and colder temperatures. The open water pelagic zones are likely to provide transient habitat, however, the low abundance of micro-habitats and food resources will generally limit permanent habitat suitability. A comparative study between natural and impounded habitats by Tucker (2000) found that turtle biodiversity was reduced within impoundments with a decline in specialist species, such as the Fitzroy River turtle, and an increase in generalist species, such as the Krefft's River turtle (*Emydura signata*). Tucker associated this reduction in turtle biodiversity with a change in foraging resources, reduction in micro-habitats and change in water quality (Tucker 2000).

Since the publication of Tucker's report in 2000, additional surveys within impounded habitats have identified that pool-riffle-run sequences are not critical to the survival of the Fitzroy River turtle and that the species can persist within impounded habitats (Limpus et al. 2007). It is expected that the Eden Bann Weir and Rookwood Weir impoundments will provide suitable habitat for the Fitzroy River turtle within the shallow littoral habitats along the perimeter of the storage and the shallow upstream margins. In comparison to the deep water areas of the impoundments, these habitats will contain improved water quality conditions and a higher diversity and abundance of in-stream micro-habitats (e.g. fallen logs and root mats) and food resources such as sponges and macroinvertebrates. The availability of suitable Fitzroy River turtle habitat within the Eden Bann Weir and Rookwood Weir impoundments is expected to fluctuate over time in accordance with storage operation and the associated level of impoundment. Operationally it is intended that weir storages will remain impounded for approximately eight months of the year with draw down occurring in the drier period.

Due to the overall reduction in turtle resources within the Eden Bann Weir and Rookwood Weir impoundments, the carrying capacity of these habitats is expected to be lower than that of the un-impounded pool-riffle-run sequences (Limpus et al. 2007). This has the potential to lead to a long-term decrease in the size of the Fitzroy River turtle population and also reduce the overall area of occupancy of the species. These impacts are considered significant and offsets are proposed (Section 5; Volume 1, Chapter 22 Offsets and Volume 2, Chapter 14).

4.2.5.2 Mitigation measures

- Riparian vegetation within the impoundments prior to inundation will not take place and large woody debris will be retained
- The re-establishment of turtle aquatic habitat within the impoundment will be encouraged through the following actions:
  - Avoiding rapid drawdowns of the storage area and controlling water levels to allow for the stabilisation of aquatic habitat around the margins of the impoundment
  - Rehabilitating and restoring areas impacted by scouring, erosion and slumping

- Promoting the natural regeneration of trees and shrubs
- Controlling introduced weeds and feral animals in accordance with the Project Weed Management Plan and Feral Animal Control Program.

4.2.6 Inundation of nesting habitat

4.2.6.1 Potential impact

Nesting is primarily restricted to alluvial sand/loam banks with a relatively steep slope and low vegetation cover. Fitzroy River turtle nesting habitat throughout the Fitzroy Basin catchment is impacted by adjacent land use practices and is, in general, highly disturbed. Degradation from cattle, pigs and weeds is widespread reducing the suitability of habitat for turtle nesting in many areas. Where nesting does occur, extreme levels of nest predation, close to 100 per cent, result in little to no recruitment of hatchlings into the population (Limpus et al. 2011a; Limpus et al. 2011b).

Within the Fitzroy Basin catchment, important nesting habitat occurs at Alligator Creek within the upper reaches of the Fitzroy Barrage impoundment (downstream of the Project footprint), immediately downstream of Tartrus Weir on the Mackenzie River (upstream of the Project footprint) and within the upper reaches of the Tartrus Weir impoundment on the Isaac River (upstream of the Project footprint) (Limpus et al. 2011b). Outside these areas, including within the Project footprints, isolated nesting occurs.

As described in Section 2.4, nesting bank elevation data was compared to daily water levels in the impoundments during the nesting season to determine the potential availability of nesting banks for active protection of nests during this period. The assessment showed that during a wet year there is no possibility of protecting nests within the impoundment. In dry years there is the potential to protect nests at some locations but an inflow that inundates all nesting banks could occur at any time. As a result, the Project will result in the inundation of known and potential Fitzroy River turtle nesting habitat within the Project footprints during commissioning. Nesting habitat to be impacted will include:

- Three historical nesting banks at Redbank crossing, Glenroy crossing and Boolburra Rail crossing
- Six confirmed nesting banks between 266 and 329 km AMTD within the Rookwood Weir Project footprint
- Two high potential nesting banks at 182 km AMTD (Eden Bann Weir Project footprint) and 321 km AMTD (Rookwood Weir Project footprint).

Some water storages, such as Ben Anderson Barrage on the Burnett River, are able to manage water levels within the impoundments during nesting periods through regulated inflows from upstream storages (for example Paradise Dam releases) to prevent nest inundation within the impoundment. At the proposed Rookwood Weir, there are no such structures upstream from which regulated releases can be made to maintain a nominated water level within the proposed impoundment. Similarly, while there is potential for the proposed Rookwood Weir to regulate flows to Eden Bann Weir to some degree, given the nature and operation of weir storages and reliance on natural inflows this ability would be limited and are likely to be superseded by naturally occurring high river flows that overtop the spillway. As such, the Project cannot feasibly manage water levels to a nominated level in order to effectively avoid or minimise impacts on existing nesting habitat within the proposed impoundments.

The loss of nesting habitat within the Project footprints has the potential to disrupt the breeding cycle of the species by restricting nesting to sub-optimal habitats and reducing reproductive success. Due to the specific nesting requirements of the species and the extremely high nest predation rates throughout the catchment, the loss of any Fitzroy River turtle nesting habitat within the Project footprint is considered significant in the absence of mitigation and offsetting measures. The maximum total area of nesting habitat impacted by the Project (Eden Bann Weir Stage 3 and Rookwood Weir Stage 2) has been calculated as 5.71 ha.

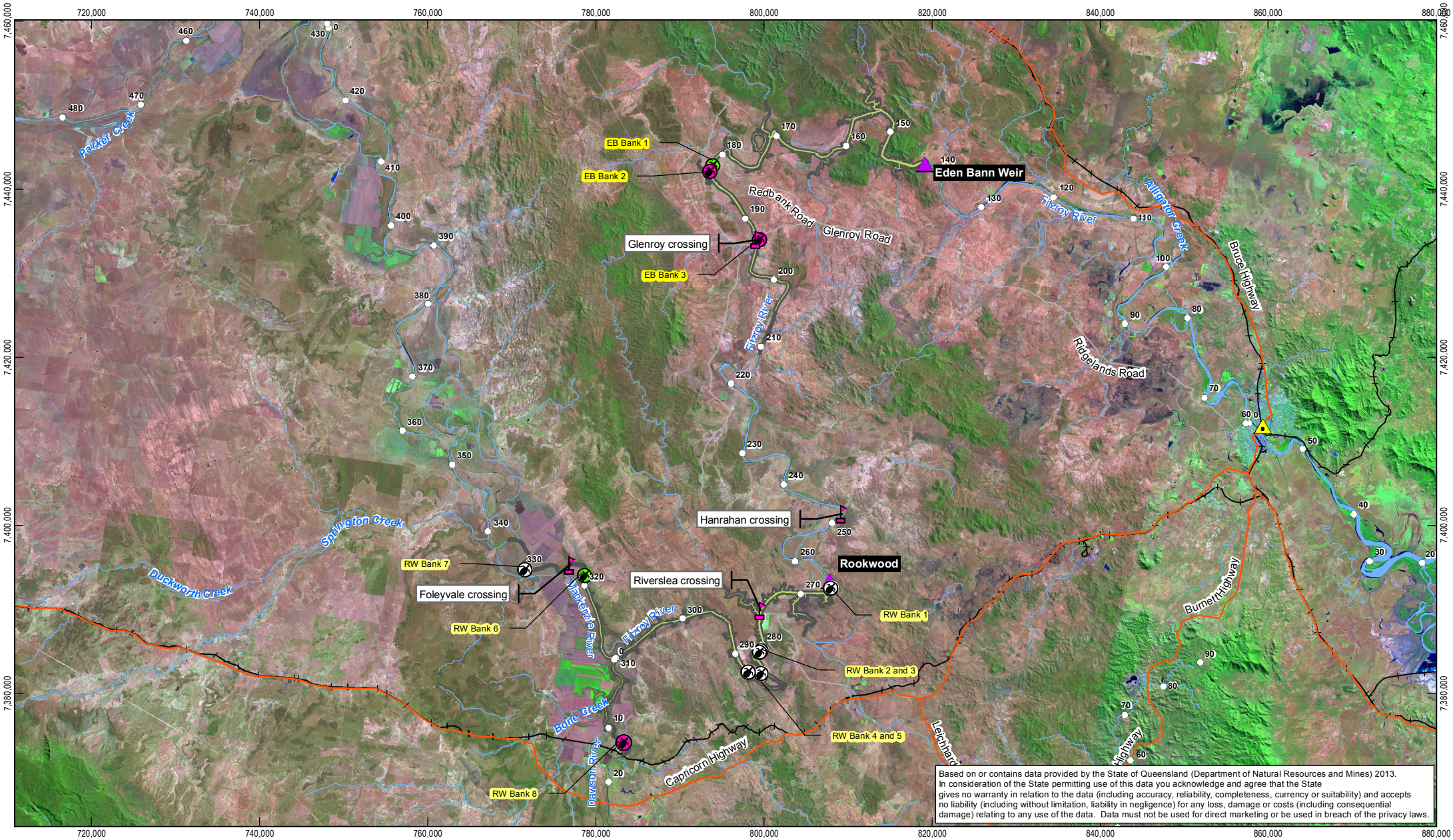
Table 4-1 details the area of impact to each nesting bank shown on Figure 4-1 while inundation extents at each location are illustrated in Appendix B. Based on studies undertaken for this assessment, there are three sites within the upper reaches of the Rookwood Weir impoundment where potential nesting habitat would remain above the full supply level (Table 4-1). These could be suitable offset sites particularly the confirmed nesting site on the Mackenzie River (329 km AMTD). These sites require field validation to confirm their suitability.

Table 4-1 Area of impact to historical, confirmed and high potential nesting habitats

Nesting bank location	Nesting bank suitability	Area of impact Eden Bann Weir		Area of impact Rookwood Weir	
		Stage 2 (ha)	Stage 3 (ha)*	Stage 1 (ha)	Stage 2 (ha)*
Eden Bann Weir Project footprint					
EB Bank 1 Fitzroy River 182 km AMTD	High potential	0.33 ha (complete inundation of nesting habitat)	0.33 ha (complete inundation of nesting habitat)	Not applicable	Not applicable
EB Bank 2 Redbank crossing – Fitzroy River 183 km AMTD	Historical	1.45 ha (complete inundation of nesting habitat)	1.45 ha (complete inundation of nesting habitat)	Not applicable	Not applicable
EB Bank 3 Glenroy crossing – Fitzroy River 193 km AMTD	Historical	0 substantial nesting habitat remains above FSL	1.4 ha (complete inundation of nesting habitat)	Not applicable	Not applicable
Rookwood Weir Project footprint					
RW Bank 1 Fitzroy River 266 km AMTD	Confirmed	Not applicable	Not applicable	0.33 ha (complete inundation of nesting habitat)	0.33 ha (complete inundation of nesting habitat)
RW Banks 2 and 3 Fitzroy River 280.5 km AMTD	Confirmed	Not applicable	Not applicable	1 ha (complete inundation of nesting habitat)	1 ha (complete inundation of nesting habitat)
RW Banks 4 and 5 Fitzroy River 284 km AMTD	Confirmed	Not applicable	Not applicable	1.2 ha (complete inundation of nesting habitat)	1.2 ha (complete inundation of nesting habitat)

Nesting bank location	Nesting bank suitability	Area of impact Eden Bann Weir		Area of impact Rookwood Weir	
		Stage 2 (ha)	Stage 3 (ha)*	Stage 1 (ha)	Stage 2 (ha)*
RW Bank 6 Mackenzie River 321 km AMTD	High potential	Not applicable	Not applicable	0	0 substantial nesting habitat remains above FSL
RW Bank 7 Mackenzie River 329 km AMTD	Confirmed	Not applicable	Not applicable	0	0 substantial nesting habitat remains above FSL
RW Bank 8 Rail crossing Dawson River 15 km AMTD	Historical	Not applicable	Not applicable	0	0 substantial nesting habitat remains above FSL
Total		1.78 ha	**3.18 ha**	2.53 ha	**2.53 ha**
Maximum impact area					**5.71 ha**

*Values for Eden Bann Weir Stage 3 and Rookwood Weir Stage 2 are cumulative and are not in addition to the areas affected by Eden Bann Weir Stage 2 and Rookwood Weir Stage 1, respectively.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

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LEGEND

- AMTD (km)
- Weir Location
- Fitzroy Barrage
- River Crossing
- Highway
- Minor Road
- Waterway
- Railway
- Historical turtle nesting site
- Confirmed turtle nesting site
- High Potential Turtle Nesting Suitability
- Rookwood Weir Stage 1 impoundment
- Rookwood Weir Stage 2 impoundment
- Eden Bann Weir Stage 2 impoundment
- Eden Bann Weir Stage 3 impoundment

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Gladstone Area Water Board, SunWater
Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision C
Date 05 Aug 2014

Location of historical, confirmed and high potential nesting habitat within the Project footprints

Figure 4-1

G:\41\20736\GIS\Projects\MXD\900_Baseline Terrestrial Fauna Report\4120736_915_Nesting_both_weir_Rev_A.mxd

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

Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Waterways, State (2007); Sunwater: Waterways, Weir Locations - 2008; DNRM: Roads - 2010, Railways - 2010, Imagery/2005, Essential Habitat /2008. Created by: MS

Suitable nesting habitat for the Fitzroy River turtle is expected to persist in the upper reaches of the impoundments with potential nesting habitat remaining above the full supply level within the Rookwood Weir Project footprint (Table 4-1 and Appendix B). Suitable nesting habitat is also expected to be naturally created in flood deposition areas over time. The existence of aggregated nesting in the upper reaches of the Fitzroy River Barrage and the Tartrus Weir impoundment, demonstrate that the species has the ability to colonise new habitat where suitable conditions occur. The Fitzroy River turtle has also demonstrated adaptability to fluctuations in nesting habitat conditions following natural events such as flooding (Dr Col Limpus pers comm.). While the establishment and success of Fitzroy River turtle nesting within the Project footprints is unable to be assured, the implementation of a Weed Management Plan and Feral Animal Control Program will assist in increasing the quality of potential nesting habitat for Fitzroy River turtle nesting and the potential for successful recruitment of hatchlings into the population. These management strategies will directly target the key existing threatening process acting on the species and if successful will increase hatchling recruitment above existing levels.

Overall, residual impacts to Fitzroy River turtle nesting are expected as a result of the Project and offsets are proposed (Section 5; Volume 1, Chapter 22 Offsets and Volume 2, Chapter 14 Offsets).

4.2.6.2 Mitigation measures

- The re-establishment of turtle nesting habitat within the impoundment will be encouraged through the following actions:
  - Avoiding rapid drawdowns of the storage area to allow for the re-establishment of nesting habitat around the margins of the impoundment
  - Rehabilitating and restoring areas impacted by scouring, erosion and slumping.
- A Weed Management Plan will be developed and implemented for the Project. The management plan will detail the control and treatment of introduced weeds that may negatively impact habitat quality
- A Feral Animal Control Program will be developed and implemented for the Project.

4.3 Operational phase impacts

4.3.1 Creation of movement barriers and fragmentation of the population

4.3.1.1 Potential impact

The connectivity of the Fitzroy River turtle population within the Fitzroy Basin catchment is currently restricted as a result of existing in-stream infrastructure. The Project will create an additional physical barrier (Rookwood Weir) that may further restrict turtle movement and increase population fragmentation.

The home range size of the Fitzroy River turtle is generally relatively small with the movement of individuals occurring between riffle zones and adjacent pools within a local area (Tucker et al. 2001). The requirement for the Fitzroy River turtle to undertake long distance migrations has not been thoroughly investigated, however, initial observations suggest upstream and downstream movement may occur for the purposes of nesting and courtship migrations, repositioning following flood displacement, and dispersal (Dr Col Limpus pers comm.).

Monitoring of Fitzroy River turtle nesting at Alligator Creek has observed large numbers of females returning to the same nesting habitat every year (Dr Col Limpus pers comm.). It is unknown how far females may migrate to this traditional area, however, survey of the population indicates an immigration of females into the immediate area is occurring for the purpose of nesting (Dr Col Limpus pers com.). Initial research on the movement behaviour of freshwater turtles in the Burnett catchment has discovered that male turtles may undertake upstream and/or downstream movements to attend breeding aggregations (Dr Col Limpus, pers. Com). Restriction of turtle movement as a result of the Project therefore has the potential to disrupt the breeding cycle of the species and may inhibit nesting in traditional areas.

Upstream and downstream movements may also be undertaken by the Fitzroy River turtle in association with flooding events. Upstream movement of turtles into refuge habitat (e.g. creeks and backwaters) is thought to occur as the river rises (Dr Col Limpus pers comm.). Some individuals are, however, inevitably carried downstream. Approximately 40 freshwater turtles from a variety of species were observed below the Fitzroy River Barrage following a spilling event in 2008. At this time a Fitzroy River turtle was recorded attempting to move upstream through the vertical slot fishway at the barrage. Similar attempts at upstream movement following flood displacement have been observed in a number of other catchments including the Burnett and Mary catchments (Dr Col Limpus pers comm.).

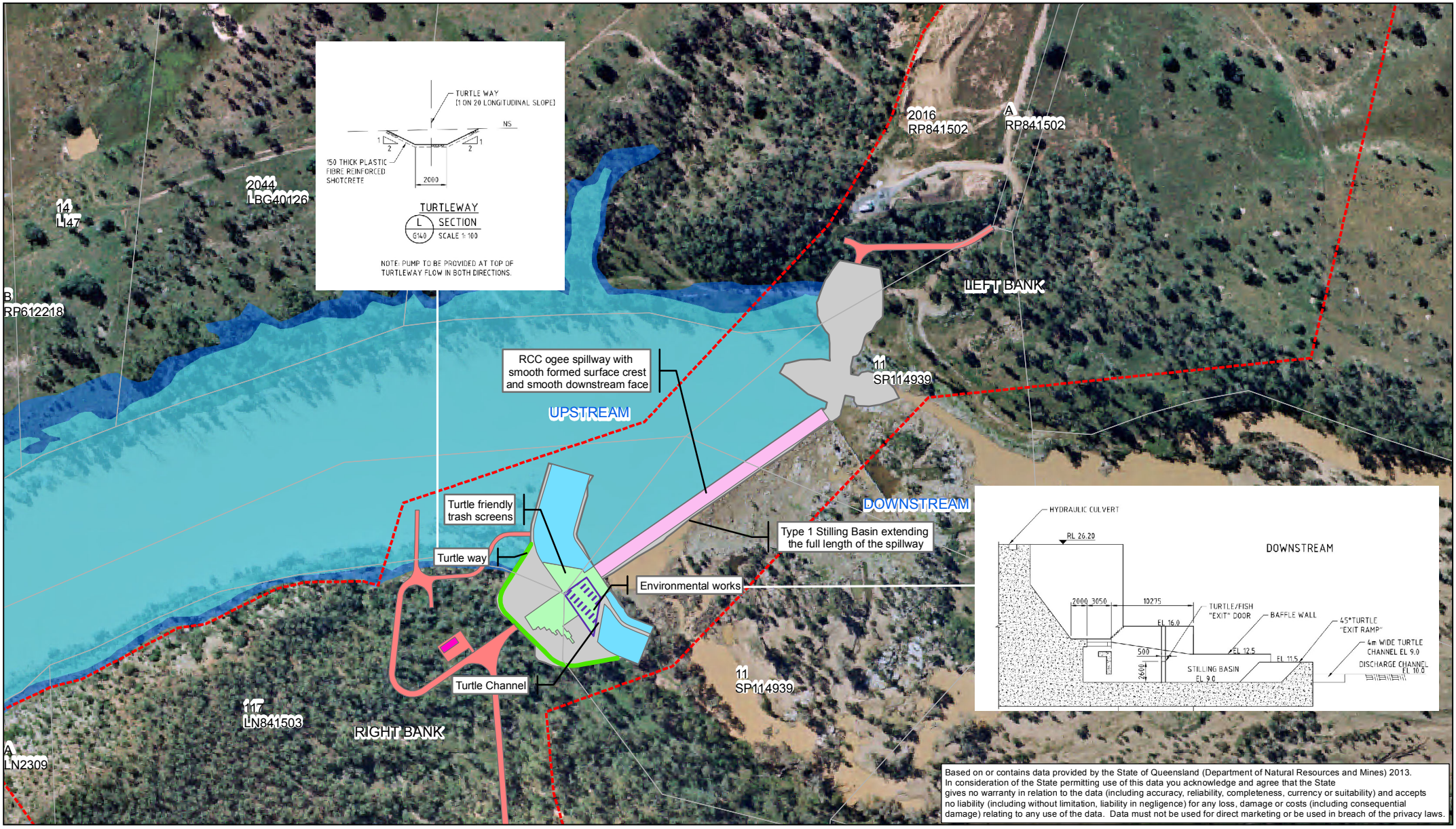
The movement behaviour of hatchling and juvenile Fitzroy River turtles is unknown, however, dispersal is a requirement in any population in order to maintain genetic diversity. A long-term decrease in dispersal migrations within the catchment may cause a reduction in gene flow resulting in the formation of genetically isolated populations. A restriction of dispersal migrations may also result in physically isolated populations becoming threatened with localised extinction due to a lack of immigration from neighbouring areas (Tucker 2000; Bunn and Arthington 2002).

A specifically designed turtle passage facility (turtle ramp) will be constructed at Eden Bann Weir and Rookwood Weir to mitigate the potential impacts discussed above. As turtle movement is currently restricted at Eden Bann as result of the existing weir, provision of the turtle ramp will improve the movement of turtles past this structure and restore the connectivity of the population in this region. A turtle ramp has been selected as the turtle passage design based on expert knowledge of turtle movement capabilities and evidence of turtle behaviour at existing structures. Fishways, such as vertical slots and mechanical locks, have not been designed to accommodate freshwater turtles and as a result, have relatively low, to no, success at facilitating turtle passage (Hamann et al. 2007; Limpus et al. 2011a). Anecdotal observations of turtle behaviour at dams and weirs have revealed that turtles attempt to move upstream by climbing in-stream structures such as the spillway face and abutments during rainfall and small flow events (Limpus et al. 2011a; Limpus et al. 2011b). A recent study by Limpus et al. 2011, recorded evidence of the Fitzroy River turtle attempting to move upstream by climbing the concrete structures of Tartrus Weir at night. During higher flow conditions, the turtle was observed attempting to climb past the wall via the river bank (Limpus et al. 2011b).

The existing low level causeways at Glenroy, Riverslea and Foleyvale crossings are low, dark structures not conducive to turtle passage. New bridges will better facilitate the movement of turtles at these locations.

4.3.1.2 Mitigation measures

- A species specific and Project specific turtle passage facility (turtle ramp) is currently designed to concept level for each weir. The turtle ramps are shown in Figure 4-2 and Figure 4-3 for Eden Bann Weir and Rookwood Weir, respectively. Specific design features currently include:
  - Provides for both upstream and downstream passage
  - Provides passage in all headwater/tailwater conditions from dead storage up to drown out of the weirs
  - Provides passage on the bank adjacent to the main river channel
  - Entry and exit points sloped and located at the river margins where turtles can assess them at low velocity conditions
  - Slope suitable for turtle climbing, not more than 45° at any point
  - Width of 2 m
  - A shotcrete or roughened concrete lined channel to provide a roughened surface for climbing
  - Small attraction flow maintained by a pump
  - Mesh grid cover to provide natural light where the ramp passes through the abutment of the weir.
- Discussions with DEHP will be held during the detailed design phase to further refine the design of the turtle ramp at each weir from concept through to detailed design. Design features identified to date for further consideration include:
  - Locations and numbers of resting pools (at least every 15 m and with a minimum depth of 0.5 m) and provision of shade and shelter along the ramp
  - Specific protection measures for hatchling and juvenile turtles (shelter along the ramp)
  - Measures to facilitate monitoring (active and passive). This may include pit tag scanners, remote sensing cameras, trap attachment points and turtle trapping facilities
  - Options to decrease the length of the turtle passage. Options to reduce length may include increasing the slope of the ramp or adding steps (maximum step height of 0.02 m)
  - Options to facilitate downstream passage
  - Ability to modify the turtle ramp in terms of structure, operation and monitoring.
- The turtle ramps will be constructed at the weirs in accordance with detailed design. Their operability will be maintained through:
  - Undertaking regular inspections, cleaning and maintenance including following spill events
  - Inspecting and maintaining the attraction flow pump
  - Inspecting and maintaining the plastic fibre reinforced shotcrete on the turtle ramp.



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Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Access Roads
- Channel
- Outlet works and fishway
- Proposed Control Room
- Proposed Spillway
- Environmental Outlet Works
- Turtle Ramp
- Eden Bann Weir Proposed Structure
- Property Boundary
- Construction Area
- Eden Bann Weir Stage 2 impoundment
- Eden Bann Weir Stage 3 impoundment

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Gladstone Area Water Board, SunWater
Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision A
Date 05 Aug 2014

Eden Bann Weir general arrangement with turtle protection design features and turtle ramp

Figure 4-2

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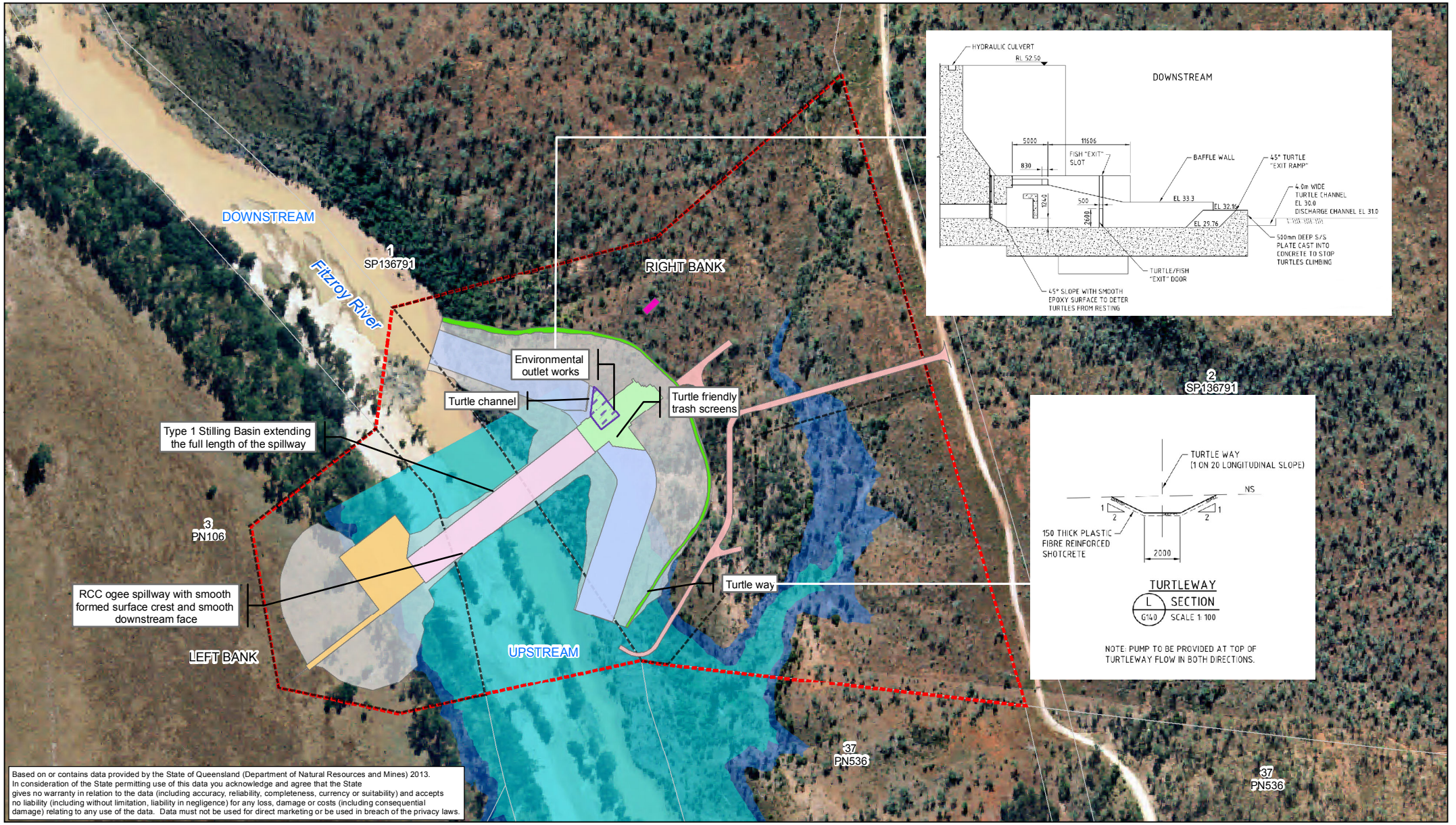

1:5,000 (at A4)

0 50 100 150 200

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Property Boundary
- Construction Area
- Proposed Property Acquisition Boundary
- Rookwood Weir proposed structure
- Abutement, Wide Rock filled mattress
- Access Roads
- Channel
- Outlet works and fishway
- Proposed Control Room
- Spillway
- Turtle Ramp
- Turtle Passage
- Rookwood Stage 1 impoundment
- Rookwood Stage 2 impoundment

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Gladstone Area Water Board

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Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision A
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Rookwood Weir general arrangement with turtle protection design features and turtle ramp

Figure 4-3

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- A monitoring program will be developed and implemented to evaluate the performance of the turtle ramps at each weir. The monitoring program will be developed in consultation with DEHP and will include a procedure for corrective action
- Design of the Glenroy, Riverslea and Foleyvale river crossings have been upgraded to a bridge design

Culverts at Hanrahan crossing have been designed at various sizes to facilitate movement under a range of flow conditions.

4.3.2 Increased injury and mortality

4.3.2.1 Potential impact

Injury and mortality of freshwater turtles is often prevalent at water infrastructure as result of site-specific design. The majority of injuries and mortalities occur as a result of:

- Contact with spillway steps (i.e. stepped spillways) as turtle move downstream over the infrastructure during spilling events
- Contact with hard structures (e.g. dissipater teeth) in the turbulence of the downstream pool
- Drowning in the turbulence of the downstream pool during high flow events
- Insufficient water depth within the downstream pool over the full length of the spillway, resulting in contact with the concrete surface when turtles move downstream over the spillway (during low flow spilling events and when the impoundment is at FSL)
- Sudden release of high velocity water during regulated flow discharges resulting in turtles being projected again hard structures when congregating around outlet works
- Impingement against trash screens on the upstream side of the impoundment (Dr Col Limpus pers comm.).

Turtle injury and mortality also has the potential to occur as a result of recreational activities associated with impoundments. Many turtles caught during recreational fishing are released without stainless steel hooks being removed. These hooks can prevent turtles feeding, leading to prolonged injury and mortality. Lost or discarded crab traps are also responsible for a large number of turtle drownings each year. During drought conditions when impoundment waters are low, incidence of boat/propeller strikes increases leading to turtle injuries and mortalities (Tucker 2000; Hamann et al. 2007; Limpus et al. 2011a).

The design process undertaken for the Project, including consultation with DEHP, has considered options and measures to minimise risk of turtle injury and mortality at Eden Bann and Rookwood Weirs. The key design features responsible for high levels of turtle injury and mortality described above (i.e. stepped spillway, dissipater teeth, high turbulence, insufficient pool length and depth, high velocity trash screens) have been completely avoided in Project design thereby substantially reducing the risk to turtles. Additional mitigation strategies will be implemented in the operation of the structure to further reduce the potential risk of turtle injury and mortality. Recreational activities within the impoundments will not be encouraged or facilitated. As such, risk of injury or mortality through recreational activities is considered to be negligible.

4.3.2.2 Mitigation measures

- The structural components of the weirs and associated works are designed (concept/preliminary design level) to avoid/minimise risks of turtle injury and mortality. Specific design features of Eden Bann Weir and Rookwood Weir are detailed in Figure 4-2 and Figure 4-3, respectively, and include:
  - A roller compacted concrete (RCC) ogee spillway to provide a smooth formed surface finish at the crest of the weir in the spillway section
  - A smooth downstream face of the spillway section
  - Type 1 stilling basin to minimise exposure to extreme turbulence and the presence of hard structures (i.e. dissipater teeth) that turtles can collide with
  - Stilling basin that extends the full length of the spillway to prevent turtles being projected against hard concrete during spilling events
  - Spillway gates have been designed such that when they close the shape mirrors that of the ogee crest. This limits turtle entrapment at the edge or under gates
  - Outlet works and fishway gates that close to prevent turtles aggregating in areas of intermittent high velocity water flow
  - Outlet works and fishway gates that prevent turtles from being crushed when closing
  - Sloped (45 degree) ramp to allow turtles to exit the environmental flow outlet area
  - Channel downstream of the environmental flow area to build tailwater and prevent turtles landing on hard concrete when exiting this area
  - A sloped entrance to the environmental flow gates lined with slippery substrate to prevent turtles accessing the area immediately in front of the gates during no flow periods
  - Smooth stainless steel plates to discourage turtles from climbing into unsafe locations
  - Slot in environmental flow area baffle wall to allow turtles to exit the area
  - Trash screens to prevent turtles entering the outlet works from the impoundment or being trapped by high water pressures on the upstream side of the outlet works
  - Trash screens have been designed so that the water pressure on the face of the screen will not trap turtles
  - Trash screens that allow for turtles to grip and climb.
- Discussions with DEHP will be held during the detailed design phase to further refine the turtle protection design features and identify any additional options for minimising the potential for turtle injury and mortality. Design features identified to date for further consideration include:
  - A section of the internal wall of the low flow outlet chamber to be sloped and have a roughened surface to allow turtles to exit this area
  - Sloping or increasing the surface area of the trash screens to decrease velocities so that turtles can readily surface. This will be dependent on maintenance considerations such as screen cleaning
  - Slope trash screens so sweeping velocities push turtles towards the surface

  - Measures to prevent turtles climbing the ogee crest of the spillway when the impoundment is at FSL and no flow is occurring into the stilling basin area. This may include a slippery surface such that turtles cannot congregate on the crest
  - Computational fluid dynamics (CFD) modelling of turbulence conditions in the stilling basin to be undertaken and design modified (if required) to provide hydraulic flow paths that allow turtles to escape extreme turbulence locations
  - CFD modelling of trash screen velocities to assess suitability for turtles
  - Subject to occupational health and safety legislation and dam safety regulations design features to facilitate access to weir infrastructure for monitoring of turtle populations.
- These design features and those described in the existing Project concept design will be applied in the detailed design and delivered during Project construction to mitigate risk of injury or mortality from poor infrastructure design
- The weir operating strategy will avoid/minimise risk of turtle injury and mortality. Specific operational actions will include:
  - Controlling the flow of water through release values to provide gradual increments in water release volume (DEHP recommend 10 % changes in total outlet valve aperture per half hour period)
  - During planned releases, increase water release during dawn and dusk periods when turtles are more likely to be away from weir infrastructure
  - Operate the flood gate next to the fishway independently and initiate the gate opening sequence with this gate to build tailwater in the stilling basin.
- Recreational activities within the impoundment will not be encouraged or facilitated.

4.3.3 Changes in downstream flow regime

4.3.3.1 Potential impact

The operation of weirs is predicted to result in a change to the downstream flow regime between the weir and upper inundation limit of the preceding impoundment. Aquatic habitats between Rookwood Weir and the upper limit of the proposed Eden Bann Weir Project footprint that will potentially be impacted by operations of the proposed weir comprise 54 km of pool-riffle-run habitat, six named creeks and eight off-stream water bodies (within 1 km of the Fitzroy River between the Rookwood Weir site and the upper limit of the Eden Bann Project footprint). Aquatic habitats between Eden Bann Weir and the upper limit of the Fitzroy River Barrage impoundment that are currently subject to downstream impacts, and which will continue to be impacted post-raising of the weir, comprise 26.2 km of pool-riffle-run habitat, 13 named creeks and 32 off-stream water bodies (within 1 km of the Fitzroy River between Eden Bann Weir and Fitzroy Barrage).

The operation strategy of the impoundments will be dictated by the Environmental Flow Objectives, ROP and the demand. The timing and quantity of releases downstream is likely to vary significantly between seasons with the dry winter period expected to trigger the highest demand for water resources downstream. As a result, water flows downstream will increase during the dry season and the frequency and duration of no flow periods will decrease. The increase in flows during the dry season has the potential to improve the quality of Fitzroy River turtle habitat downstream by reducing the duration and severity of pool isolation and prolonging the presence of flowing riffles zones and runs. The increase in

habitat availability during the dry season will provide additional resources for the turtle during times when conditions are limiting. The diversity and abundance of food resources, such as macroinvertebrates, is likely change with a potential increase in species that prefer flowing conditions and a reduction in species that prefer slow flowing and ephemeral habitats.

The operation of the proposed weirs is also likely to result in a reduction in the frequency and magnitude of small – medium downstream flood flows. Flood flows entering the impoundment are likely to be captured and stored until the weir reaches FSL. This will result in the reduction of flows downstream and is most likely to occur at the start of summer when the storage is predicted to be at a minimum. Once the weir reaches FSL, downstream flows will increase however the magnitude of the events will be reduced compared to existing conditions.

Fitzroy River turtle nesting habitats located downstream of the Project footprints may be impacted as a result of the changes in water flows. Nesting banks naturally change over time with substrates being eroded and redeposited under different flow conditions. A reduction in small - medium downstream flood flows may decrease erosion of potential nesting banks in some areas, while the overall reduction in water flows may disrupt the natural rejuvenation of banks in others, potentially reducing their suitability for nesting. Changes to downstream water flows may also lead to an increase in macrophytes along stream margins which may prevent access to nesting areas (Tucker 2000; Hamann et al. 2007). Large flood flows, > 9000 m^3/second (weir drown-out) will, however, not be affected by the proposed infrastructure, and as such, sufficient sediment transport is expected to occur to maintain downstream nesting habitats and the high flows will remove macrophytes that may have become established.

Operational water releases that result in increased water levels during the Fitzroy River turtle nesting periods could also lead to the inundation of nests downstream (Cann 1998). Based on the predicted demand triggers, there is expected to be an increase in downstream flows during the dry season with peak water releases occurring immediately prior to the pre-summer floods. An increase in water flows during early September is unlikely to affect nests of the Fitzroy River turtle, as the releases are likely to have commenced prior to the peak laying period and therefore eggs will be laid above the water line and not drowned. Early nesting of these species during August may be affected by inundation. Nesting habitats that remain within the impoundments (Section –) may also be impacted by fluctuations in water level (i.e. associated with seasonal flooding and management of the storage). A rapid increase in water storage level may inundate turtle nests if flooding occurs following nesting, while periods of low water level will result in the disconnection of nesting banks from the water's edge (Cann 1998).

4.3.3.2 Mitigation measures

- The operation strategy of the weirs will be dictated by the Environmental Flow Objectives in the WRP and ROP. These objectives will aim to minimise environmental impacts as a results of the water infrastructure and will mimic natural flow conditions as much as possible
- Subject to compliance with the WRP and ROP, water release volumes and timing will be controlled to minimise the inundation of turtle nests downstream of the weir during nesting season

- As part of the operational phase Turtle Monitoring Program (Section 4.4), important nesting habitats downstream of the Project footprint (i.e. Alligator Creek) will be monitored for signs of degradation as a result of changes in the downstream flow regime.

4.3.4 Habitat degradation associated with changes in water quality

4.3.4.1 Potential impact

Changes in environmental conditions such as reduced water flows, temperature stratification, increased water depth, decreased aquatic oxygen levels and increased nutrient levels are known to occur with conversion of riverine habitat to impounded water (Bodie 2001; Arthington 2003). As discussed in Section 4.2.5, the changes in water quality conditions that will occur within deep water areas of the impoundment will result in the degradation of habitat to the point where the Fitzroy River turtle is not expected to permanently inhabit the area. Where the species does persist, habitat degradation is expected to result in a change in the diversity and abundance of resources for the species. In particular there is expected to be an increase in macroinvertebrate, macrophyte, and fish species that prefer slow-flowing conditions and a decrease in specialist species such as those found in rocky substrates and flowing waters. The change in environmental conditions also has the potential to influence the physiology and behaviour of the Fitzroy River turtle. For example, the behaviour of the Fitzroy River turtle is largely influenced by its ability to extract oxygen from the water (aquatic respiration) which is in turn dependent upon environmental conditions (Gordos 2004). Changes in water quality such as reduced oxygen levels and increased water temperature are known to decrease a turtle's ability to respire aquatically (Clark 2008). By decreasing aquatic respiration, the amount of time the turtle can spend underwater is reduced and surfacing frequency increases. These changes in diving behaviour have the potential to result in reduced time available for foraging, increased energy expenditure during surfacing and increased predation levels. The increased predation levels associated with an increase in surfacing frequency are thought to be especially threatening to hatchling and juvenile turtles which have a higher reliance on aquatic respiration than adults and have a larger range of predators than adults as a result of their smaller body size (Clark 2008). Mitigation measures will be implemented to improve water quality conditions within the littoral margins and upper reaches of the Eden Bann Weir and Rookwood Weir impoundments.

Changes in water quality will primarily occur within the impoundments, however, downstream habitats may also be affected due to the release of poor water quality (Tucker 2000; Hamann et al. 2007; Limpus et al. 2011a). The mitigation measures proposed to avoid the degradation of water quality downstream (e.g. multi-level off-takes, selective withdrawal outlets), have the potential to benefit the Fitzroy River turtle by improving the quality of habitat downstream during the dry season (Section 4.3.3).

4.3.1.2 Mitigation measures

- An operations Water Quality Management Plan will be developed and implemented in accordance with the Project EMP. Specific management actions will include:
  - Including multi-level off-takes in weir design
  - Using selective withdrawal outlets to select water of most appropriate quality for downstream release

  - Manipulating flows to prevent the build-up of blue-green algae or to disperse blooms.
- A Weed Management Plan will be developed and implemented for the Project. The management plan will detail the control and treatment of introduced aquatic weeds that may negatively impact water quality
- A Feral Animal Control Program will be developed and implemented for the Project or in collaboration with local council, community groups and landholders. Specific measures may include the control of pigs which cause degradation to aquatic habitat and water quality
- An operations phase Drainage, Erosion and Sediment Control Plan will be developed and implemented. Management actions will be in accordance with the Best Practice Erosion and Sediment Control Guidelines (IECA 2008).

4.3.5 Increased predation

4.3.5.1 Potential impact

The Project is likely to result in an increase in the abundance of predators within the Eden Bann Weir and Rookwood Weir impoundments, potentially resulting in an increase in predation of the Fitzroy River turtle and its nests. The creation of impounded pool habitat is expected to increase the availability of suitable habitat for large predatory fish (such as long-finned eels and golden perch) and the estuarine crocodile. An increase in abundance of these species within the impoundments, either through natural immigration or stocking for recreational purposes (fish species only), may result in a direct increase in the predation of turtles (Tucker 2000; Hamann et al. 2007; Limpus et al. 2011a). As discussed in Section 4.3.4, the Fitzroy River turtle may also be more susceptible to predation within the impoundments as a result of changes to water quality and the associated impact on turtle physiology and behaviour.

The greatest threat to the survival of the Fitzroy River turtle is the lack of hatchling recruitment in the population as a result of nest predation (Section 3.8). The increase in permanent water resource availability associated with the weir impoundments may increase the abundance of terrestrial predators such as feral pigs, water rats and goannas, thereby further increasing predation pressure on nesting habitat remaining within the Project footprints. Nesting habitat located within the impoundment may also be subject to increased rates of trampling by cattle with river margins more accessible.

4.3.5.2 Mitigation measures

- Large predatory fish species (i.e. barramundi) will not be stocked within the impoundment
- A Feral Animal Control Program will be developed and implemented for the Project.

4.4 Monitoring

In addition to the mitigation measures detailed above, the following monitoring will be undertaken as a component of the species management for the Project.

- All turtles captured during pre-construction surveys will be tagged with passive integrated transponder (PIT) tags, carapace notching and numbered monel metal foot tags. Morphometric measurements, age and sexual maturity, and evidence of

injury and disease will also be recorded. All personnel involved in tagging and biological data collection activities will be suitably qualified, trained and hold the appropriate permits

- Prior to the completion of construction, a baseline survey of Fitzroy River turtle populations within the impoundment and immediately downstream (within 5 km) will be undertaken. Turtles will be tagged with PIT tags, carapace notching and numbered monel metal foot tags. Parameters recorded will include:
  - Morphometric measurements
  - Age and sexual maturity
  - Estimates of annual nesting and recruitment
  - Evidence of injury, mortality and disease
  - Known or likely nesting areas, including microhabitats
  - Estimates of predation and other losses of eggs at nesting sites.
- The Project footprints will be monitored in accordance with the Project Weed Management Plan, Feral Animal Control Plan, Sediment and Erosion Control Plan, Water Management Program and Hazardous Waste Management Plan
- An operational phase Turtle Monitoring Program will be developed and implemented in consultation with DEHP. Monitoring requirements detailed in the mitigation measures described in Sections 4.2 and 4.3 will form a component of the Turtle Monitoring Program. The monitoring program will be undertaken annually for a period of five years and will include areas upstream of the inundation area, within the impoundment and downstream of the weirs. The monitoring program will include targeted surveys (day and night sampling) during the turtle nesting (September to November) and hatching (November to March) seasons, as well as event based sampling.

5. Assessment of significance

The Fitzroy River turtle is endemic to the Fitzroy Basin catchment with the species' distribution extending from the Fitzroy Barrage to the upper reaches of the Dawson, Nogoa and Connors Rivers. To date the majority of individuals and aggregated nesting habitats have been recorded in the middle to lower reaches of the catchment, within which the Project footprints are located. Important habitat for the species is present within both the Eden Bann Weir and Rookwood Weir Project footprints and the largest known nesting aggregation for the species occurs downstream (within the upper limits of the Fitzroy River Barrage impoundment). Due to the proportion of the species' habitat in which the Project is located and the significance of habitats within and downstream, the Project footprint is considered to support an important population of the Fitzroy River turtle. An assessment of the potential impacts on the Fitzroy River turtle against the *Matters of National Environmental Significance Significant impact guidelines 1.1* is provided in Table 5-1.

The Project footprints are considered to support an important population of the Fitzroy River turtle. As such, the assessment of significance has identified that the Project is likely to have a residual impact on the Fitzroy River turtle during operations (Table 5-1). Offsets are required under the EPBC Act Environmental Offset Policy. The protection and management of turtle nests has been selected as the proposed offset for the Project. The protection and management of nests will target Project specific impacts as well as address the key processes currently threatening the survival of the species throughout the catchment. These actions will reduce nest predation, increase population recruitment and promote the recovery of the species. Details of the proposed offset for the Fitzroy River turtle is provided in the Project Offset Strategy (Volume 1 Chapter 22).

Table 5-1 Significance of impact on the Fitzroy River turtle

Significance criterion	Assessment
An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	
Lead to long-term decrease in the size of an important population of a species	The Project has the potential to exacerbate the existing long-term decrease in the size of an important population of Fitzroy River turtle through the inundation of pool-riffle-run habitat. Suitable habitat for the Fitzroy River turtle is expected to remain within the shallow littoral habitats along the perimeter of the impoundments and within the shallow upstream margins. Due to the overall loss of habitat and the decrease in habitat resources within the impoundments, the carrying capacity of these habitats is expected to be reduced. A potential long-term decrease in the size of the Fitzroy River turtle population within the Project footprints may result.
Reduce the area of occupancy of an important population	The Project is expected to reduce the area of Fitzroy River turtle occupancy within the deep water areas of the impoundments. Deep water areas (areas > 5 m depth) are expected to be largely avoided by the species due to reduced oxygen levels, little or no light penetration and colder temperatures. The open water pelagic zones are likely to provide transient habitat, however, the low abundance of micro-habitats and food resources within these areas will generally limit permanent habitat availability and suitability. In general, suitable habitat for the Fitzroy River turtle is expected to remain within the shallow littoral habitats along the perimeter of the impoundment and within the shallow upstream margins.

Significance criterion	Assessment
Fragment an existing important population into two or more populations	The Project has the potential to fragment the existing population of Fitzroy River turtles within the catchment by physically inhibiting upstream and downstream movement of turtles past the weir infrastructure. The home range extent of the Fitzroy River turtle is generally relatively small, however, individuals are thought to make long distance migrations for nesting and courtship, dispersal and reposition following flood displacement. Turtle movement is currently restricted at Eden Bann Weir and at other impoundments throughout the catchment. Turtle passage facilities (turtle ramps) will be constructed at both Eden Bann Weir and Rookwood Weir to maintain turtle movement and prevent fragmentation of populations.
Adversely affect habitat critical to the survival of a species	The Project will inundate pool-riffle-run sequences and nesting habitats within the Eden Bann Weir and Rookwood Weir Project footprints. Although considered preferred habitat, pool-riffle-run sequences are not critical to the survival of the species. The shallow margins and upstream reaches of the impoundment are expected to contain suitable habitat for the Fitzroy River turtle and the presence of this species within existing impoundments substantiates this expectation. Due to the overall reduction in habitat resources within the Eden Bann Weir and Rookwood Weir impoundments, the carrying capacity of these habitats is, however, expected to be reduced. The Eden Bann Weir and Rookwood Weir Project footprints support isolated nesting of the Fitzroy River turtle (no aggregated nest sites) and confirmed and high potential nesting habitat will be inundated by the impoundments. Due to the specific nesting requirements of the species and the extremely high nest predation rates throughout the catchment, the loss of Fitzroy River turtle nesting habitat within the Project footprint is considered significant. Implementation of a Weed Management Plan and Feral Animal Control Program will assist in increasing the quality of potential nesting habitat for Fitzroy River turtle nesting and the potential for successful recruitment of hatchlings into the population. These management strategies will directly target the key existing threatening process acting on the species and if successful will increase hatchling recruitment above existing levels.
Disrupt the breeding cycle of an important population	The inundation of Fitzroy River turtle nesting habitat within the Project footprints during commissioning is considered a significant impact of the Project. Loss of nesting habitat has the potential to disrupt the breeding cycle of the species by restricting nesting to sub-optimal habitats and reducing reproductive success. These impacts have the potential to result in a further reduction in population recruitment, thereby exacerbating the main threatening processes currently impacting the species in the Project footprint and throughout the Fitzroy catchment. Implementation of a Weed Management Plan and Feral Animal Control Program will assist in increasing the quality of potential nesting habitat for Fitzroy River turtle nesting and the potential for successful recruitment of hatchlings into the population. These management strategies will directly target the key existing threatening process acting on the species and if successful will increase hatchling recruitment above existing levels.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The Project will result in the inundation of 113 km of natural river habitat. The quality of habitat within the deep water benthic areas and open water pelagic habitats is likely to be unsuitable for permanent habitation by the species. The Fitzroy River turtle is expected to persist in the shallow littoral margins and upstream reaches, however, due to the overall decrease in habitat resources, the carrying capacity of these habitats is expected to be reduced. Impacts to the availability and quality of habitats downstream of the Project footprints are expected to be suitably managed such that the species is unlikely to decline in these areas.

Significance criterion	Assessment
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	An increase in the diversity and abundance of invasive flora and fauna species as a result of Project construction and operation is expected to be suitably managed through mitigation such that impacts to the Fitzroy River turtle are not expected.
Introduce disease that may cause the species to decline	The construction and operation of the Project is not expected to introduce disease that may cause the Fitzroy River turtle to decline.
Interfere substantially with the recovery of the species	The population of Fitzroy River turtle is currently impacted by a number of existing threatening processes, the key factor being extremely high nest predation rates. At the current rate of recruitment, the population of Fitzroy River turtles within the catchment is not considered sustainable. The management actions proposed for the Project, particularly the implementation of a predator control program and provision of turtle ramps, will minimise additional impact and promote the recovery of the species.

6. Conclusion

The Eden Bann Weir and Rookwood Weir Project footprints, located within the lower Dawson, lower Mackenzie and Fitzroy River sub-catchments, support an important population of the vulnerable Fitzroy River turtle.

The Fitzroy River turtle is a specialist species that is endemic to the Fitzroy Basin catchment. The species inhabits flowing riverine habitats, including pool-riffle-run sequences, with nesting occurring on steep sandy banks. The ecology of the Fitzroy River turtle is influenced by the species' ability to respire aquatically, which allows the turtle to remain submerged underwater for long periods. The Fitzroy River turtle is currently under threat from extremely high nest predation and the current rate of hatchling recruitment into the population is not considered sustainable.

Construction of the Project will result in the permanent loss of Fitzroy River turtle habitat within the Rookwood Weir construction footprint and the river crossing construction areas. This habitat includes important and historical nesting habitat at Glenroy crossing and high potential nesting habitat within the Rookwood Weir construction footprint. The construction area at these locations will be kept to the minimum amount necessary and, as such, the loss of Fitzroy River turtle habitat will be relatively small in size in relation that available within the immediate area and is not considered significant.

Additional impacts to the Fitzroy River turtle that may occur as a result of Project construction activities include: the degradation of habitat, increased injury and mortality, and the restriction of turtle movement. These impacts will be localised, restricted to the duration of the construction period and primarily managed through the Project construction EMP. Key mitigation measures to be implemented will included: pre-clearance surveys, turtle and nest relocation, and flow diversion/maintenance.

Project commissioning will result in the inundation of 113 km of Fitzroy River turtle habitat. This area includes known important aquatic habitat areas including Glenroy crossing, Redbank crossing, Marlborough Creek and upstream of Boolburra rail crossing. Glenroy and Redbank crossings represent historically significant habitat for the species within the catchment. The conversion of natural creeks and pool-riffle run sequences into impounded habitat will reduce the suitability of the habitat for the Fitzroy River turtle. The area of permanent occupancy of the Fitzroy River turtle is predicted to decrease, however, the species is expected to persist in the shallow water margins and upstream reaches of the impoundment. This expectation is substantiated by the habitation of the species within existing impoundments, such as the Fitzroy River Barrage, in which the largest known nesting aggregation of the species occurs. Due to the overall reduction in turtle resources within the Eden Bann Weir and Rookwood Weir impoundments, the carrying capacity of these habitats is expected to be lower than that of the un-impounded pool-riffle-run sequences. This impact has the potential to lead to a long-term decrease in the size of the Fitzroy River turtle population and also reduce the overall area of occupancy of the species. These impacts are considered significant and offsets are proposed.

Fitzroy River turtle nesting habitat that will be impacted by the Project (5.71 ha) includes: three historical, six confirmed and two high potential nesting habitats. These habitats will be partially to completely inundated during Project commissioning. The quality of the nesting habitat within the Project footprints is currently relatively low as a result of high rates of nest predation and the degradation of banks by introduced weeds, pests and cattle. No

aggregated nesting habitat occurs within the Project footprints. Suitable nesting habitat for the Fitzroy River turtle is expected to persist in the upper reaches of the impoundments and the existence of aggregated nesting in the upper reaches of the Fitzroy River Barrage and the Tartrus Weir impoundment, demonstrate that the species has the ability to colonise new habitat where suitable conditions do occur. The implementation of a Weed Management Plan and Feral Animal Control Program will assist in increasing the quality of potential nesting habitat for Fitzroy River turtle nesting and the potential for successful recruitment of hatchlings within the Project footprints. The establishment and success of Fitzroy River turtle nesting in these areas is, however, unable to be assured. Due to the specific nesting requirements of the species and the extremely high nest predation rates throughout the catchment, the loss of Fitzroy River turtle nesting habitat within the Project footprint is considered a significant impact of the Project.

Operational activities that have the potential to impact the Fitzroy River turtle include: in-stream barrier operation and alteration of the flow regime. Minimising the potential risk of turtle injury and mortality and maintaining upstream and downstream turtle movement, have been key management objectives through the Project design phase. Design features responsible for high levels of turtle injury and mortality, such as a stepped spillway, dissipater teeth, high turbulence in the downstream pool, insufficient water depth and length of the downstream pool and high velocity trash screens, have been completely avoided in Project design thereby substantially reducing the risk to turtles. Additional design features have been developed and in association with management actions in the operational strategy, the risk of turtle injury and mortality is reduced.

A specifically designed turtle passage facility (turtle ramp) will also be constructed at Eden Bann Weir and Rookwood Weir to mitigate the potential impacts of the Project on turtle movement and population fragmentation. Although the home range size of the Fitzroy River turtle is relatively small, large scale movements are thought to occur for the purpose of dispersal, courtship, nesting and repositioning following flood displacement. Upstream and downstream movement past the weirs during Project operation will avoid and/or minimise disruptions to the breeding cycle of the species, the creation of genetically isolated populations and the potential for localised extinction. As turtle movement is currently restricted at Eden Bann as result of the existing weir, provision of the turtle ramp will improve the movement of turtles past this structure and restore the connectivity of the population in this region.

The operation of weirs is predicted to result in a change to the downstream flow regime. Water flows are predicted to increase during the dry season resulting in a decrease in the frequency and duration of no flow periods. The operation of the weirs is also likely to result in a reduction in the frequency and magnitude of small – medium downstream flood flows. Large flood flows, > 9000 m^3/second (weir drown-out) will not be affected by the proposed infrastructure. The increase in flows during the dry season has the potential to improve the quality of Fitzroy River turtle habitat downstream by reducing the duration and severity of pool isolation and prolonging the presence of flowing riffles zones and runs. An alteration in the magnitude and timing of downstream flows does, however, have the potential to impact Fitzroy River turtle nesting. An increased in water levels during the Fitzroy River turtle nesting season could lead to the inundation of nests downstream, while a decrease in flow magnitude may impact the rejuvenation of nesting habitat decreasing nesting suitability. The operation strategy of the weirs will be dictated by the Environmental Flow Objectives set in the WRP and ROP. The operation strategy will aim to minimise environmental

impacts as a results of the water infrastructure and will mimic natural flow conditions as much as possible.

Operation phase impacts associated with changes in water quality and an increase in predator abundance, have the potential to exacerbate existing threats to the species. Various management plans will be implemented to improve the quality of Fitzroy River turtle aquatic and nesting habitat remaining within the Project footprints.

Overall, the assessment of Project impacts against the *Matters of National Environmental Significance Significant impact guidelines 1.1*, identified that the Project is likely to have a residual impact on the Fitzroy River turtle during Project operations. Offsets are required under the EPBC Act Environmental Offset Policy. The protection and management of turtle nests has been selected as the proposed offset for the Project. The protection and management of nests will target Project specific impacts as well as address the key processes currently threatening the survival of the species throughout the catchment. These actions will reduce nest predation, increase population recruitment and promote the recovery of the species.

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Appendices

Appendix A – Terms of reference requirements

A1 – Terms of reference Part B, Section 5.76 – 5.81 Fauna – turtles

A2 – Terms of reference Part C, Appendix 3. Specific information on the Fitzroy River turtle which is required to be included in the EIS

A1 – Terms of reference Part B, Sections 5.76 – 5.81: Fauna - turtles

ToR	Report section
Describe the turtle species that may be using the Fitzroy River (catchment), and its tributaries in proximity to the proposed development area.	Section 3 Other turtle species are discussed in the Volume 1, Chapter 7 Aquatic ecology
Monitor turtle nesting along beaches near the proposed project area for the duration of the turtle nesting seasons, for turtle species occurring in the area.	Section 2.3 Section 3.4
Undertake a desktop review of information on the turtle communities of the study area, particularly the Fitzroy river, broad-shelled, eastern snake-necked, Krefft's river, saw-shelled and white-throated snapping turtles, paying specific attention to any anecdotal or recorded information on turtle populations frequenting the area and any known nesting sites.	Section 2.5.3 Other turtle species are discussed in the Volume 1, Chapter 7 Aquatic ecology
Conduct ecological risk assessment modelling for turtles, paying particular attention to the impacts of the flow regime on nesting banks.	Section 4.3.3 Modelling discussed in the Volume 1, Chapter 9 Surface water resources
A complete analysis of the species is required and should include:	
Likely historic range including the locations of nesting sites, the types of living/foraging habitats, and total range length.	Section 3.2 Section 3.4
Analysis of the percentage loss of these components of the historic range.	Section 4.2.5 Section –
Measures of habitat fragmentation (length of habitats inundated, number of fragments removed).	Section 3.7 Section 4.3.1
Current population structure (male/female ratios, age classes, female reproductive health), assessment of health status of individuals, nest sites remaining and measures of quality of remaining habitat.	Section 3.3 Section 3.4 Section 3.8
Refer to studies of the turtle population and consult DEHP on historical data for the area, particularly in relation to previously conducted nesting surveys.	Section 2.2 Section 2.5.3 Section 2.7
An analysis should include measures to either provide additional suitable nesting sites or upgrade the suitability/security of existing nesting sites.	Section 4.3 Section 5 Offsets are discussed in Volume 1, Chapter 22
The proponent shall use this information to establish the basis for recommendations in relation to the most appropriate management measures to be adopted to minimise this risk of turtle injury or death.	Section 4.2.3 Section —

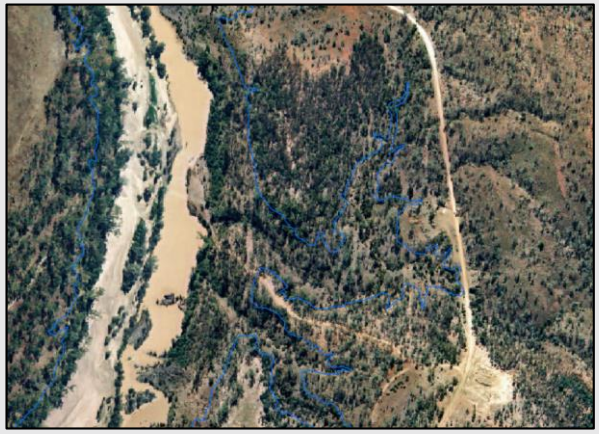
A2 – Terms of reference Part C, Appendix 3: Specific information on the Fitzroy River turtle which is required to be included in the EIS

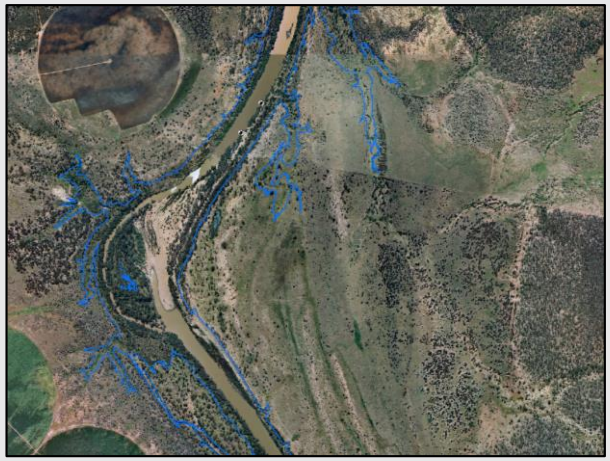
ToR	Report section
Baseline information - using up to date information, provide the following information on the Fitzroy River Turtle (*Rheodytes leukops*). Information should include but not limited to:	
A discussion of the current population status of the Fitzroy River Turtle	Section 3.8
A discussion of the life history traits and habitat preferences of the Fitzroy River Turtle in the Fitzroy catchment	Section 3.2 Section 3.3 Section 3.4 Section 3.5
Provide a description of all current and known threats to the Fitzroy River Turtle	Section 3.8
Outline the current population structure of the Fitzroy River Turtle including size-frequency distributions	Section 3.3
Outline the availability and extent of suitable habitat for the Fitzroy River Turtle in the Fitzroy catchment	Section 3.2 Section 3.4
Outline the importance of the population of Fitzroy River Turtle in the lower Fitzroy River compared with other areas of the Fitzroy Basin	Section 5
Discuss and provide an analysis of the connectivity of habitat for the Fitzroy River Turtle in the Fitzroy basin	Section 3.7
Outline the availability of nesting sites for the Fitzroy River Turtle and provide information on the current reproductive success	Section 3.4
Discuss and provide evidence of the potential for the Fitzroy River Turtle to persist in impounded waters	Section 3.2
Discussion of relevant impacts - provide and assessment of all potential and likely impacts to the Fitzroy River Turtle (*Rheodytes leukops*) during construction, operation and all stages of the proposed action. Information must include but not be limited to:	
A discussion of the success of recruitment and the long-term persistence of the Fitzroy River Turtle in impounded waters	Section 3.2 Section 3.4 Section 3.8 Section 4.2.5 Section –
Discuss the ability for all age cohorts of the Fitzroy River Turtle to persist in impounded waters	Section 4.2.5 Section 4.3
Detail the likely changes to flow regimes in the Fitzroy River below the proposed Rookwood Weir and the Eden Bann Weir during inundation, operation and all stages of the project	Section 4.3.3
The total area of nesting and riffle/pool habitat (in hectares) which is likely to the inundated or impacted during filling and operation of all stages of the proposed action	Section –

ToR	Report section
Discuss the potential for the proposed action to fragment habitat for the Fitzroy River Turtle. The discussion should consider the impact of existing barriers in the catchment to the species	Section 4.3.1
Discuss the potential and likely impacts of changes to flow regimes to riffle/pool habitat between the Rookwood and Eden Bann Weirs and below the Eden Bann Weir and how these are likely to impact the Fitzroy River Turtle	Section 4.3.3
Discuss the impacts of barriers in the Fitzroy basin to the genetic exchange and long term survival of the species	Section 4.3.1
Include information and discuss the potential for mitigation measures to reduce potential impact on the Fitzroy River Turtle	Section 4 Section 5
Discuss using relevant examples, the likelihood that the species will use turtle passage devices over barriers	Section 3.7 Section 4.3.1

Appendix B – Inundation extents of nesting habitat impacted by the Project

Location	Nesting bank status	Project impact	
		Eden Bann Weir Stage 2	Eden Bann Weir Stage 3
EB Bank 1 Fitzroy River 182 km AMTD	High potential	 Nesting within 5 m over 650 m length = 0.33 ha	 Nesting within 5 m over 650 m length = 0.33 ha
EB Bank 2 Redbank – Fitzroy River 183 km AMTD	Historical	 Nesting within 5 m over 2900 m length = 1.45ha	 Nesting within 5 m over 2900 m length = 1.45ha

Location	Nesting bank status	Project impact	
EB Bank 3 Glenroy crossing – Fitzroy River 193 km AMTD	Historical	 Minimal impact from inundation	 Nesting within 5 m over 2800 m length (both sides of bank) = 1.4 ha
		Rookwood Weir Stage 1	Rookwood Weir Stage 2
RW Bank 1 Fitzroy River 266 km AMTD	Confirmed for white-throated snapping turtle High potential for Fitzroy River turtle	 Nesting within 5 m over 650 m length (right bank, left bank not suitable) = 0.33 ha	 Nesting within 5 m over 650 m length (right bank, left bank not suitable) = 0.33 ha

Location	Nesting bank status	Project impact	
RW Banks 2 and 3 Fitzroy River 280.5 km AMTD	Confirmed	 Nesting within 5 m over 2000 m length (right bank) = 1 ha	 Nesting within 5 m over 2000 m length (right bank) = 1 ha
RW Banks 4 and 5 Fitzroy River 284 km AMTD	Confirmed	 Nesting within 5 m over 900+700+800 m length (left bank) = 1.2 ha	 Nesting within 5 m over 900+700+800 m length (left bank) = 1.2 ha

Location	Nesting bank status	Project impact	
RW Bank 6 Mackenzie River 321 km AMTD	High potential	 No impact from inundation	 Minimal impact from maximum inundation
RW Bank 7 Mackenzie River 329 km AMTD	Confirmed	 No impact from inundation	 Minimal impact from maximum inundation

Location	Nesting bank status	Project impact	
RW Bank 8 Rail crossing Dawson River 15 km AMTD	Historical	 No impact from inundation	 Minimal impact from maximum inundation

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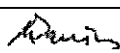
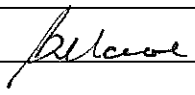
2	K Hryczyszyn	G Squires		L Delaere		05/06/2015

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