LOWER FITZROY RIVER
INFRASTRUCTURE PROJECT

Appendix J

Eden Bann Weir Baseline Aquatic Fauna Report

SunWater
MAKING WATER WORK

Gladstone Area Water Board

Gladstone Area Water Board and SunWater

Lower Fitzroy River Infrastructure Project

Eden Bann Weir Baseline Aquatic Fauna Report

June 2015

Executive summary

An aquatic ecology study was conducted for the proposed raising of Eden Bann Weir. The study aims to provide sufficient baseline information to enable identification and assessment of the potential impacts of the Lower Fitzroy River Infrastructure Project on the existing environmental values of the Fitzroy River upstream and downstream of Eden Bann Weir. Data for the study was collected from literature reviews and seasonal field surveys to achieve this objective.

The literature review included a study of relevant scientific and grey literature, database searches, and previously prepared technical reports. Field surveys were conducted to supplement the findings from the desktop assessments. Surveys were conducted in wet and dry seasons to document seasonal changes in the ecosystems. Habitat assessments were undertaken at accessible sites representing major aquatic habitats throughout the Project footprint. These were selected on the basis of digital topography, aerial photographs, access and safety constraints and field reconnaissance. The results of habitat assessments, combined with an aerial overflight of the study area, provided the basis for the assessment of the likely ecological values of these habitats.

The aquatic ecological assessment aims to describe aquatic fauna present or likely to be present in the Project footprint, as well as the environmental values of the aquatic system. These may encompass habitat composition and conditions, stream geomorphology and characteristics, presence or absence of macrophytes and adjacent land use. Findings of these searches and surveys inform the impact assessment on aquatic fauna, identifying potential impacts that construction and operation of Eden Bann Weir may have on environmental values such as species diversity, habitat, nesting habits and movement behaviour. Management measures have then been developed to avoid, minimise or mitigate these impacts.

Upstream of the existing weir, the dominant aquatic habitat type is the impounded pool. The linear extent of this habitat type varies seasonally, and is also dependent on operation of the storage. Upstream of the impounded pool habitat, and downstream of Eden Bann Weir to the upper limit of the Fitzroy Barrage impoundment, in-stream habitats are dominated by seasonally-dynamic recurring pool-riffle-run sequences. These sequences represent the natural hydrological and geomorphologic regime of the rivers in the study area.

Through habitat assessments, variable water velocity, depth, bank characteristics, in-stream habitat features (woody debris, macrophytes) and stream substrate were observed within and between the in-channel aquatic habitat types of the Project footprint. Seasonal variability markedly alters the characteristics and linear extent of these habitats – a regime to which the aquatic species of the Fitzroy Basin catchment are adapted. The less variable, more homogenising influence of the impoundment upstream of Eden Bann Weir somewhat dampens the seasonal temporal variability in habitat characteristics and extent immediately upstream of the existing weir.

A number of creeks and off-stream water bodies provide further aquatic habitat beyond the main channel of the Fitzroy River. Creek habitats in the proposed Project footprint were observed to provide a high abundance of microhabitat resources such as overhanging vegetation and in-stream woody debris and rocks. These habitats potentially provide resources for an array of aquatic species, including small cryptic fish species, freshwater turtles and juvenile crocodiles. It was also observed that areas where cattle access to the river was currently prevented tended to produce a highly quality of marginal aquatic habitats, though this was not quantifiably assessed.

Off-stream water bodies were not readily accessible during the field surveys; however, one large off-stream water body west of Marlborough Creek was assessed. It was assessed that this water body had good coverage, excellent bank and vegetative stability and fair streamside cover. These water bodies have been identified as important reservoirs of fish biomass, nursery habitat for juvenile fish, and provide potential habitat for crocodiles and long-necked turtles.

Desktop reviews and field surveys undertaken to inform this baseline assessment of the aquatic ecology within and downstream of the Eden Bann Weir Project footprint revealed that 34 fish species, seven aquatic reptiles (six turtles, one crocodile), one aquatic mammal, 86 macroinvertebrate taxa and 105 macrophytes have the potential to occur within the Project footprint, based on previous records from the study area and the results of field surveys. Of particular note are conservation significant species which were confirmed present during field surveys, or are known / predicted to occur based on a review of relevant literature. These include the Fitzroy River turtle, white-throated snapping turtle, estuarine crocodile, southern saratoga, leathery grunter, golden perch and the platypus.

Overall, the general characteristics of aquatic habitats within the Eden Bann Weir Project footprint, and the aquatic species they support, appear to represent a continuum of habitats downstream to the Fitzroy Barrage, and are not unique in the values and resources they provide in the context of the wider study area. Aquatic habitats (and the species they support) within and downstream of the Eden Bann Weir Project footprint have been impacted and altered by human processes occurring at the local to catchment-wide scale. Such impacts include degradation of riparian habitats by livestock, changes to water quality (agriculture and mining) and disruption to natural flow regimes and connectivity of aquatic systems. Notably, the aquatic habitats up and downstream of Eden Bann Weir are influenced by the operations of the existing structure.

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Acronym	Term
AHD	Australian Height Datum
AusRivAS	Australia Rivers Assessment System
BoM	Australian Bureau of Metrology
DEEDI	Department of Employment, Economic Development and Innovation
DEHP	Department of Environment and Heritage Protection
DERM	Department of Environment and Resource Management
DEWHA	Department of Environment, Water, Heritage and the Arts
DNRW	Department of Natural Resources and Water
EIS	Environmental Impact Statement
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
FSL	Full Supply Level
GHD	GHD Pty Ltd
NC Act	*Nature Conservation Act 1992*

1. Introduction

1.1 Project overview

The Lower Fitzroy River Infrastructure Project (Project) comprises the construction and operation of a raised Eden Bann Weir and/or a new weir at Rookwood on the Fitzroy River, Central Queensland to facilitate capture and storage of all high priority unallocated water (76,000 ML/a) in the Fitzroy system. The Fitzroy River forms at the confluence of the Mackenzie (flowing from the north) and Dawson (flowing from the south) Rivers. The Fitzroy River flows out into the Coral Sea including the Great Barrier Reef World Heritage Area and Marine Park, some 300 km downstream. The Fitzroy River passes through the city of Rockhampton which lies approximately 59 km from the river mouth.

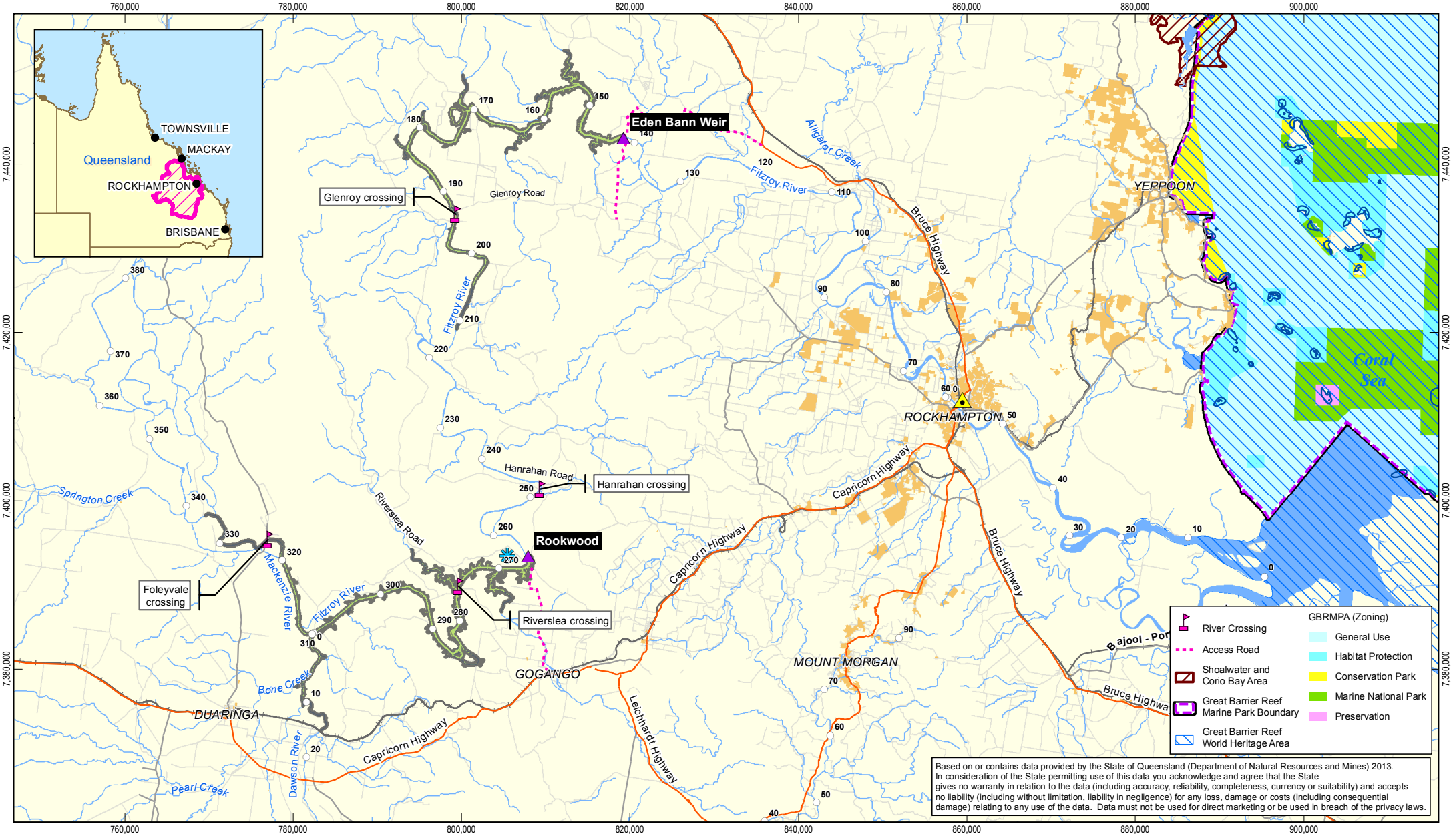
Key Project components include the following:

- Eden Bann Weir
  - Eden Bann Weir Stage 2 – a raise of the existing Eden Bann Weir to a full supply level (FSL) 18.2 m Australian Height Datum (AHD) and associated impoundment of the Fitzroy River.
  - Eden Bann Weir Stage 3 – the addition of 2 m high flap gates to achieve FSL 20.2 m AHD and associated impoundment of the Fitzroy River.
- Rookwood Weir
  - Rookwood Weir Stage 1 – a new build to FSL 45.5 m AHD, saddle dams and associated impoundment of the Fitzroy, Mackenzie and Dawson Rivers.
  - Rookwood Weir Stage 2 – the addition of 3.5 m high flap gates to achieve FSL 49.0 m AHD and associated impoundment of the Fitzroy, Mackenzie and Dawson Rivers.
  - Any combination of the above.
- Fish passage infrastructure and turtle passage infrastructure, namely fish locks and a turtle bypass, respectively, at each weir.

Other infrastructure components associated with the Project include:

- Augmentation to and construction of access roads (public and private) to and from the weir sites for construction and operations 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.
- Relocation of existing and/or installation of new gauging stations
- Removal and decommissioning of existing low level causeways and culverts at river crossings described above.
- Water supply for construction will be sourced directly from nearby rivers and creeks and will not require the construction of additional water supply infrastructure.

The location of Project components is shown on Figure 1-1.



1:600,000 (at A4)

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

Gladstone Area Water Board, SunWater
Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision J
Date 01 Aug 2014

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

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

The development of weir infrastructure (and associated works), the resultant storage of water (inundation of the river bed and banks) and the transfer of water between storages through 'run of river' methods on the Fitzroy River comprise the scope of the Project. Abstraction, transmission and distribution to end users are not considered as part of the proposed Project and are subject to their own environmental investigations.

1.2 Report context

In accordance with the Program of Works Notification (No 3) 2007, the investigations and studies for the Project commenced in late 2008 with most technical studies and reporting being undertaken in 2009. At that time, the target completion date for final development of a Project Business Case was 2009- 2010. It was however acknowledged that this would be dependent on the urgency associated with drought conditions in the region.

Since 2009, Central Queensland has experienced above average rainfalls and water supply infrastructure in the region has been operating at capacity. This has resulted in extended Project timeframes. Furthermore, the State had commissioned a number of investigations and assessments prior to 2008 which were used as a basis for the current environmental impact statement (EIS). Consequently, the EIS reporting spans a change of Government and subsequent reconfiguration of government departments. Names as were applicable to the specific reference are therefore used and not referenced as 'former', 'prior' or 'the then'.

The Eden Bann Weir baseline aquatic fauna assessment commenced in 2009. Relevant and applicable updates have been made to the present (2014) as appropriate and necessary.

2. Aquatic assessment scope, approach and methodology

2.1 Assessment aim and scope

The aim of the aquatic ecology study was to provide sufficient baseline information to enable identification and assessment of the potential impacts of the Project on the existing environmental values of the Fitzroy River and lower sections of the Mackenzie and Dawson rivers.

The study area in relation to aquatic ecology values was broad. It included areas upstream of the Rookwood Weir site; downstream of the Rookwood Weir site to the existing Eden Bann Weir impoundment; downstream of the existing Eden Bann Weir and downstream reaches of the Fitzroy River to the Fitzroy Barrage. The estuarine environment immediately downstream of the Fitzroy Barrage and the marine environment into Keppel Bay are discussed in Volume 2, Chapter 7 Existing environment and indirect impacts are assessed in Volume 2, Chapters 8 through 11.

Project footprints comprise the Eden Bann Weir site (and immediate downstream reaches) and associated impoundment; reaches between Eden Bann Weir and the Rookwood Weir site; the Rookwood Weir site itself and associated impoundment along with river crossing locations.

To achieve this objective, desktop and literature reviews were conducted for the study area to provide information on aquatic habitats and species occurring or predicted to occur. The literature review included a study of relevant scientific and grey literature, database searches, and previously prepared technical reports.

Wet and dry season field surveys were conducted within the Project footprints to supplement and ground-truth findings from the desktop assessments and, where possible, fill any knowledge gaps.

Results of the desktop and literature reviews and field surveys specific to the Eden Bann Weir Project footprint along with values of the aquatic environment downstream to the Fitzroy Barrage are presented herein (unless otherwise stated). Aquatic values for the Rookwood Weir Project footprint (that is upstream of the Eden Bann Weir Project footprint) are described in Appendix K.

The distribution and extent of aquatic habitats downstream of Eden Bann Weir were primarily assessed through a desktop analysis of aerial photography. An aerial overflight of the study area, in conjunction with the results of aquatic habitat assessments within the Project footprint, were used to assess the likely ecological values of these habitats. Information gathered from the literature review regarding potential aquatic fauna species assemblages and utilisation of downstream habitats was reviewed.

The scope of the aquatic ecological assessment was as follows:

- Describe the aquatic fauna present or likely to be present within the Project footprint including:
  - Diversity of fish, turtles, crocodiles, macroinvertebrates and other aquatic fauna (i.e. platypus)
  - Species which are poorly known but suspected of being threatened
  - The existence of conservation significant or otherwise noteworthy species or communities, including discussion regarding species range, habitat, breeding, recruitment, feeding and movement requirements, and the current level of protection
  - Habitat requirements for aquatic fauna including movement, foraging and breeding requirements
  - The existence and habitat utilisation of introduced species.
- Describe the environmental values of the aquatic system in terms of:
  - The integrity of ecological processes, including habitat composition, structure and function (particularly for conservation significant species)
  - Stream geomorphology, including channel width, channel depth, substrate and bank height
  - Stream characteristics (e.g. pool, impounded pool, riffle etc.)
  - General condition of riparian habitats, including bank vegetative stability and streamside cover
  - Presence / absence of aquatic macrophytes
  - Adjacent land use.

Baseline findings and conditions have informed the preparation of an impact assessment that:

- Identifies and assesses potential impacts that construction and operation of a raised Eden Bann Weir may have on the aquatic environmental values upstream and downstream of the structure
- Outlines strategies and management recommendations to avoid, minimise and / or mitigate these potential impacts.

2.2 Nomenclature

Scientific names for aquatic species are consistent with those used in the following sources:

- A Field Guide to the Freshwater Fishes of Australia (Allen et al. 2003)
- Freshwater Fishes of North-Eastern Australia (Pusey et al. 2004)
- A Field Guide to Reptiles of Queensland (Wilson 2005)
- A Complete Guide to Reptiles of Australia (Wilson and Swan 2008)
- Australian Freshwater Turtles (Cann 1998)
- Mayfly Nymphs of Australia. A Guide to Genera. No. 7. (Dean and Suter 1996)
- The Mammals of Australia (Van Dyck and Strahan 2008).

2.3 Literature review

To inform field surveys, a literature review was conducted to document the known aquatic environmental values within the study area and to also identify any conservation significant species that have been historically recorded or have the potential to occur within the study area. This review underpinned the description of the baseline aquatic environmental values of the Project footprint presented here. The literature review included searches of:

- The former Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Environmental Reporting Tool (now the EPBC Act Protected Matters Search Tool) to identify species and / or their habitat listed under the EPBC Act, that are predicted to occur within the Project footprint area and downstream to the Fitzroy Barrage, and also to identify invasive species of national significance. The search area was defined by a 2 km buffer following the Fitzroy River
- The former Queensland Department of Environment and Resource Management (DERM) (now the Department of Environment and Heritage Protection (DEHP)) Wildlife Online Database to identify fauna species that have been historically recorded in or surrounding the Project footprints, including threatened species listed under the Queensland *Nature Conservation Act 1992* (NC Act). Records (in 2009) were returned for a search area within a 10 km radius of the Eden Bann Weir. Additional searches were undertaken in 2013 as reported in Volume 1, Chapter 7 Aquatic ecology
- The Essential Habitat Mapping Database (Version 3.0, 2009) to identify essential habitats within the Project footprint, or in the vicinity of the Project footprints
- The DEWHA EPBC Act Environmental Reporting Tool (now the EPBC Act Protected Matters Search Tool) to identify any Nationally Important Wetlands (recorded in the Directory of Important Wetlands in Australia) that occur specifically within the Project footprint and within the wider study area. The search area was defined by a 2 km buffer following the Fitzroy River
- The Queensland Museum's Specimen Database to obtain a record of aquatic vertebrates previously recorded in the study area in general and within the Project footprint specifically. Data is stored for discrete regions on the Queensland Museum database, and as such, a "search rectangle" encompassing the area around the Eden Bann Weir, and upstream to the maximum proposed impoundment extent was queried for aquatic fauna species records. The coordinates of the search rectangle were as follows: 150° 7', -22° 59' (top right corner) and 149° 48', -23° 41' (bottom left corner)
- Threatened species profiles and field guides
- Previous studies and reports[1] conducted in the region, including (but not limited to):
  - Impact assessment of modified water infrastructure (Fitzroy Barrage) on the Fitzroy River saltwater crocodile – Potential implications and proposed mitigation measures for saltwater crocodiles (*Crocodylus porosus*) (Britton 2007a)
  - Proposal for raising Eden Bann Weir and construction of Rookwood Weir – An assessment of the potential implications and proposed mitigation measures for saltwater crocodiles (*Crocodylus porosus*) (Britton 2007b)

[1] Not all material referenced is publically available having been produced as "commercial in confidence".

- Proposal for raising Eden Bann Weir and construction of Rookwood Weir – An assessment of the potential requirements for fish passage (Marsden and Power, 2007)
- Assessment of potential implications of modified water infrastructure on Fitzroy River fish passage and the fishway (Earth Tech 2007)
- Do fish locks have potential in tropical rivers? (Stuart et al. 2007)
- The assessment of Eden Bann Weir Fishlock, Fitzroy River, Queensland (Long and Meager 2000)
- Freshwater fishes of the Fitzroy Basin catchment, Central Queensland (Berghuis and Long 1999)
- Lower Fitzroy weirs discussion paper on fishway facilities for raised Eden Bann Weir (SunWater 2008a)
- Proposal for raising Eden Bann Weir and construction of Rookwood Weir – An assessment of the potential implications and mitigation measures for Fitzroy turtles (*Elseya albagula* and *Rheodytes leukops*) (Limpus et al. 2007)
- Fitzroy River Water, Modified Water Infrastructure EIS and Management Plan: Turtles (*Rheodytes leukops* and *Elseya albagula*) (frc environmental 2007)
- Lower Fitzroy Weirs discussion paper on turtle passage facilities for raised Eden Bann Weir and Rookwood (SunWater 2008b)
- Lower Fitzroy Weirs literature review and gap analysis (frc environmental 2008).

Further to this list, a wide range of studies focussing on various aspects of the aquatic ecology of the study area, and of the ecology of species known to occur in the study area, were sourced from the scientific literature and other relevant material and reviewed.

2.4 Field survey

2.4.1 Overview

Field surveys were conducted in order to ground-truth information acquired through the literature review regarding species and communities expected to occur within the Project footprint, and to verify the likely occurrence of EPBC Act and NC Act listed aquatic fauna species. Verification was based on direct and indirect (e.g. suitable habitat) observations. Where possible, given the limitations and constraints on the field studies outlined in Section 2.4.2, attempts were made to fill knowledge gaps identified through the literature review, including those highlighted by frc environmental (2008) in their literature review and gap analysis.

Areas of focus for the field survey effort included:

- Assessments of aquatic habitat characteristics and values throughout the Project footprint
- Assessment and mapping of potential turtle nesting banks throughout the Project footprint, including ranking of potential value
- Fish trapping to sample species diversity in impounded habitats to be impacted by increased inundation, as a supplement to information acquired through the literature review
- Opportunistic recordings of conservation significant fauna (including Fitzroy River turtle, estuarine crocodile and platypus)
- Macroinvertebrate sampling within the Project footprint. Macroinvertebrate sampling was also undertaken in downstream reaches of Fitzroy Barrage to supplement information acquired through the literature review.

Surveys were conducted in the wet and dry season (refer to Section 2.4.4) to document seasonal changes in aquatic fauna assemblages, habitat condition and utilisation. Survey timing and design considered seasonal variation and the ecology of targeted threatened species.

A summary of the literature reviewed and the study approach / field survey effort is provided in Table 2-1.

2.4.2 Constraints and limitations

As specified in Section 2.1, the aim of this assessment was to provide sufficient information to inform the assessment of impacts and identification of appropriate mitigation measures. As such, habitat assessments and fauna trapping efforts were focussed on providing information that would:

- Ground-truth and supplement existing information on the ecological values of the Project footprint
- Assist in filling knowledge gaps revealed during the literature review
- Fulfil the assessment scope outlined in Section 2.1.

There were three main limitations that influenced field survey methodologies and effort:

- Flooding and wet weather access. On several field survey occasions (namely during the wet season aquatic fauna survey – 13/14 February 2009), field effort and accessibility was severely limited by flood activity. For example, macroinvertebrates were not able to be sampled via kick-sampling and standard Australian Rivers Assessment System (AusRivAS 2001) methodology as was intended, due to safety concerns associated with trying to access suitable substrate in flood conditions. For this reason, artificial substrates were deployed as surrogate measures (Section 3.4.6). The use of colonisation of artificial substrates to infer macro invertebrate assemblage structure does have associated limitations, however, this approach provided data which would otherwise not have been obtainable.

  Flooding events and heavy rainfall leading up to and during the wet season fauna trapping survey (13/14 February 2009), restricted road access and created significant difficulties in launching and retrieving the survey boat from the one accessible launch site. In the wet season survey, a number of propeller blades (both on boats and spares) were broken attempting to traverse rapidly flowing shallow sections of the Fitzroy River. Therefore only four fish trapping sites within the impoundment were able to be established safely. Flooding and high flows also resulted in high turbidity in the Fitzroy River, thereby limiting survey options for freshwater turtles reliant on visual detection (dip-netting).
- Dry weather access. Due to the large size of the Project footprint and study area, and the relative paucity of vehicle access points, boat travel was the most expedient form of transport with which to establish and access survey sites. However, in the dry season the ability to traverse by boat was hampered by the lack of water in the river (particularly in shallow runs and riffles), snags and submerged structures. As a result, the assessment of the Fitzroy River downstream of the Rookwood Weir site to the upstream limit of the Eden Bann Weir Project footprint was undertaken via aerial photography analysis (refer to Section 2.4.8 - aquatic habitat segment analysis).

- Safety concerns and requirements. The occurrence of estuarine crocodiles in the Eden Bann Weir Project footprint represented a safety concern when conducting aquatic habitat assessments and fauna trapping. Therefore activities that involved wading in the river, such as seine netting, backpack electrofishing, snorkelling for turtles and in-stream macroinvertebrate sampling (kick-sampling) were not undertaken. Access to very remote areas, requiring long travel times over unsealed roads was also not undertaken for safety reasons, however, the use of boats as a mode of transportation was implemented (albeit with its own limitations) in an attempt to circumvent this.

In addition, landholder permission was required to access launching sites and riparian habitats throughout the Project footprint, and while in most cases this was granted, where it was not, survey could not be undertaken.

The field survey approach employed in this assessment (considering access limitations) did not attempt to sample all potential species, or all available habitats, that may occur within the Project footprint over the duration of the study. Rather, the approach allowed for the sampling of species that may have been poorly described in the literature, confirmation of the presence of conservation significant species (and/or their habitats), and the description of the general aquatic habitat values based on assessments of representative habitat types at a number of locations in the Eden Bann Weir Project footprint. Despite limitations, given the body of literature reviewed and coverage achieved it is considered that sufficient baseline data was attained to provide a valid description of existing aquatic ecology values.

2.4.3 Animal ethics and approvals

Aquatic fauna surveys were conducted under Section 52 of the *Animal Care and Protection Act 2001* (General Fisheries Permit - 113990) and supported by the former Queensland Department of Employment, Economic Development and Innovation (DEEDI) animal ethics committee (CA 2008/07/280).

2.4.4 Timing of field surveys

Wet and dry season field surveys were conducted in order to document seasonal changes in the ecosystems within the Project footprint. A reconnaissance of the study area was undertaken on 20 January 2009 (aerial overflight) and subsequent wet season surveys were conducted between 28 January and 2 February 2009 (habitat assessments) and 13 to 14 February 2009 (aquatic fauna trapping). The dry season survey for aquatic fauna was undertaken between 12 and 14 July 2009. Turtle nesting bank surveys were also conducted between 15 and 18 December 2008 in addition to during the wet and dry season surveys (refer to Section 2.4.10).

2.4.5 Climatic conditions

Climatic data was sourced from the Australian Bureau of Meteorology (BoM), recorded at the Rockhampton Airport weather station (039083) (BoM 2009). This data is considered to be indicative of the general climatic conditions in the study area, yet it does not necessarily represent the precise meteorological conditions prevailing at survey sites when the field surveys were undertaken due to the separation distance from the sites to the Bureau of Meteorology station (approximately 60 km).

Table 2-1 Summary of literature reviewed and study approach / field survey effort

Parameter	Information in literature to inform impacts	References	Current knowledge gaps	Field effort	Study approach and field effort
Freshwater turtles (including conservation significant Fitzroy River turtle)	• Species diversity • Distribution in catchment • Aquatic habitat requirements • Breeding ecology • Threatening processes	Key reference Limpus et al. 2007 Other references Cann 1998 Clark 2008 Clark et al. 2008 frc environmental 2007 frc environmental 2008 Gordos 2004 Gordos et al. 2003a,b Gordos et al. 2007 Hamann et al. 2007 Legler and Cann 1980 Legler and Georges 1993 Limpus et al. 2006 Mathie and Franklin 2006 Priest 1997 Priest and Franklin 2002 Rogers 2000 SunWater 2008b Thomson et al. 2006 Tucker 2000 Tucker et al. 2001 Venz et al. 2002	• Specific nesting bank requirements • Nesting bank locations (including locations of any aggregated nesting sites) • Movement behaviours	• Aquatic habitat assessments • Opportunistic recordings of species (including conservation significant species) • Identification, assessment and mapping of potential nesting banks for conservation significant turtles	A significant body of literature on freshwater turtles of the Fitzroy Basin catchment exists. This includes a comprehensive assessment for the Project undertaken by DERM (Limpus et al.) in 2007. This assessment drew on a number of previous studies and included detailed field assessments within the proposed inundation areas of a raised Eden Bann Weir and the proposed weir at Rookwood. In light of the availability of information on species diversity, distribution in the Fitzroy Basin catchment and aquatic habitat requirements, trapping in the Project footprint was not deemed necessary. Given that potential nesting banks are poorly known from the Project footprint, that these habitats are likely to be impacted by the proposed raising of Eden Bann Weir, and that lack of recruitment has been cited as a major threat to these species' (Limpus et al. 2007), targeted surveys for the Fitzroy River turtle and white-throated snapping turtle focussed on the identification, assessment and mapping of potential turtle nesting in the Project footprint. Due to the difficulty in trapping the Fitzroy River turtle and white-throated snapping turtle, the distribution and abundance of these species within the Project footprint and study area was assessed based on the results of the past surveys detailed above. Where insufficient information was available, species occurrence was assessed based on habitat suitability.
Estuarine crocodile	• Distribution in catchment • Relative abundance in catchment • Aquatic habitat requirements • Breeding ecology • Threatening processes	Key references Britton 2007a Britton 2007b Other references DERM 2009 Environmental Protection Agency 2007 frc environmental 2008 Walsh and Whitehead 1993	• Movement behaviours • Recruitment into population	• Aquatic habitat assessments • Opportunistic recordings of crocodiles (including characteristic slides on banks) • Opportunistic recordings of crocodile nests	Two comprehensive studies were undertaken to describe potential impacts (and associated mitigation measures) on estuarine crocodiles from water infrastructure development on the Fitzroy River (Britton 2007a; Britton 2007b). These studies provide a thorough description of estuarine crocodile populations (including abundance) and habitat utilisation in the Fitzroy River (including the Eden Bann Weir Project footprint), based upon the results of detailed field assessments. Given the amount of information on estuarine crocodile ecology in the Fitzroy River, specific targeted field surveys were not deemed necessary for this species. Habitat assessments documented potentially suitable habitat, while opportunistic recordings were noted.

Parameter	Information in literature to inform impacts	References	Current knowledge gaps	Field effort	Study approach and field effort
Fish	• Species diversity in catchment • General habitat preferences of fish species • Barriers to movement in the Fitzroy River / use of fish passage devices	<u>Key references</u> Berghuis and Long 1999 Long and Meager 2000 Marsden and Power 2007 Pusey et al. 2004 Stuart et al. 2007 <u>Other references</u> Allen et al. 2003 DEEDI 2009 Earth Tech 2007 frc environmental 2008 Heindenreich and Broadfoot 2001 Long 2000 Stuart and Mallen-Cooper 1999 Stuart 1997 SunWater 2008a	• Species assemblages in specific aquatic habitat types	• Aquatic habitat assessments • Fish sampling in margins of Eden Bann Weir impoundment	The fish diversity of the Fitzroy Basin catchment has been studied in detail in a number of other studies. In particular, the impacts of movement barriers on fish in the system has received notable attention, including a specific study on potential requirements for fish passage relating to the raising of Eden Bann Weir and the construction of the proposed weir at Rookwood (Marsden and Power 2007). Habitat preferences for fish species in the Fitzroy Basin catchment is generally well-described, based on the volume of sampling that has occurred throughout the catchment, including various aquatic habitats in the Fitzroy River. A number of constraints during EIS surveys limited both wet and dry season fish sampling in the Eden Bann Weir Project footprint (refer Section 2.4.2). Fish sampling in accessible parts of the Project footprint (namely within the existing Eden Bann Weir impoundment) was undertaken to characterise species assemblages at the margins of the impoundment. Likely species assemblages in other in-stream and off-stream aquatic habitat types were derived based on an analysis of the individual ecology of species, information contained within the literature, and from an extrapolation of results obtained from downstream fish sampling (i.e. between Eden Bann Weir and the Fitzroy Barrage).
Platypus	• Occurrence in the Dawson, Mackenzie and Fitzroy rivers	<u>References</u> Fish et al. 2001 frc environmental 2008 Gardner and Serena 1995 Grant and Temple-Smith 1998 Otley et al. 2000 Serena et al. 1998	• Distribution and abundance in the Dawson, Mackenzie and Fitzroy Rivers	• Aquatic habitat assessments • Opportunistic recordings	Platypus are known to occur in the study area. A general characterisation of potentially suitable habitats for the platypus (based on the known ecology of the species from the literature) was ascertained through aquatic habitat assessments. Targeted searches for this species were not undertaken, although any opportunistic recordings of this species were noted.
Macroinvertebrates	• General characterisation of diversity of macroinvetrebrate taxa in the study area • Non-occurrence of listed threatened species in the study area	<u>References</u> Duivenvoorden et al. 2000 Duivenvoorden and Roberts 1997 frc environmental 2008	• Description of species assemblages occurring in specific aquatic habitat types within the Eden Bann Weir Project footprint • Habitat requirements of key species	• Non-systematic deployment of artificial substrates in various aquatic habitat types throughout study area to supplement existing information about macorinvertebrate diversity in study area	Macro-invertebrate sampling in the Eden Bann Weir Project footprint was severely limited by several constraints (refer to Section 2.4.2). Where possible, sampling was undertaken through deployment of artificial substrates, to contribute additional information regarding the general diversity of macro-invertebrates in the study area. It is recognised that there are limitations associated with the use of colonisation of artificial substrates to infer macro-invertebrate assemblage structure, however, this approach provided data which would otherwise not have been obtainable. As no threatened aquatic macro-invertebrates were identified from the literature review, a general characterisation of macro-invertebrate diversity from the literature (and supplemented, where possible, by field data) was considered sufficient to inform potential impacts on these animals from the Project.
Macrophytes	• General description of macrophytes known to occur in the study area • Pest species known to occur in study area	<u>References</u> Duivenvoorden 1992 Noble et al. 1997 frc environmental 2008 Houston and Duivenvoorden 2002	• Species presence, diversity and distribution in various aquatic habitat types • Temporal patterns in macrophyte distribution	• Aquatic habitat assessments	The presence of macrophytes was noted during aquatic habitat assessments throughout the Eden Bann Weir Project footprint. A general description of macrophytes was recorded, however species-level identification was not undertaken. As the primary aim of recording macrophyte presence / absence and general characteristics was to inform potential value to aquatic fauna (i.e. provision of shelter and foraging resources), species level identification was deemed unnecessary at the environmental impact assessment level.

Parameter	Information in literature to inform impacts	References	Current knowledge gaps	Field effort	Study approach and field effort
Aquatic habitats	• Potential utilisation by aquatic fauna, including threatened species	References All references related to aquatic ecology of study area	• Distribution and extent of aquatic habitats • General characteristics of aquatic habitats • Values of aquatic habitats for fauna	• Aquatic habitat assessments and field observations • Aerial overflight of study area	Habitat assessments were undertaken at accessible sites representing major aquatic habitats throughout the Project footprint. Creek and off-stream water body habitats were assessed where access permitted. Where these habitats could not be accessed in the field (refer to limitations Section 2.4.2), a desktop approach to assessing the spatial distribution / extent of these habitat types was undertaken. Specifically, this involved an assessment of the Queensland Government's Wetland*Info* Mapping service in conjunction with satellite imagery of the study area. 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 Eden Bann Weir Project footprint. The distribution and linear extent of aquatic habitat types within and downstream of the Project footprint was quantified and mapped from aerial photographs, and where possible, verified in the field (including during the reconnaissance aerial overflight).
Upstream and downstream habitats	• Potential utilisation by aquatic fauna, including threatened species	References All references related to aquatic ecology of study area	• Distribution and extent of aquatic habitats • Values of aquatic habitats for fauna	• Aquatic habitat assessments within Project footprint • Aerial overflight of study area	The distribution and extent of aquatic habitats within and downstream of the Project footprint was primarily assessed through a desktop analysis of aerial photography. An aerial overflight of the study area, in conjunction with the results of aquatic habitat assessments in the Eden Bann Weir Project footprint was used to infer the likely ecological values of these habitats. Information from the literature about potential aquatic fauna species assemblages and utilisation of upstream and downstream habitats was reviewed. Habitats upstream of the Project footprint, which are predicted to suffer minimal impacts from the proposed weir, were inferred to be similar to those described within the Project footprint (based on aerial photo interpretation, field observations and literature reviews), and were not specifically addressed. However, upstream and downstream habitats of significant values identified in the literature reviews are discussed in subsequent sections of this report. As construction of a weir at Rookwood would impact aquatic habitats upstream of the Eden Bann Weir impoundment, this section of the Fitzroy River is described in the Rookwood Weir Baseline Aquatic Fauna Report.

2.4.6 Site selection

Aquatic survey sites (for habitat assessments, turtle nesting bank surveys and aquatic fauna trapping) were selected based on a review of digital topography, georeferenced aerial photographs, streambed geology, road and boat access, safety constraints and field reconnaissance, including an aerial overflight. Site selection was also influenced by logistical constraints associated with boat operation. These included safety concerns in fast-flowing waters (wet season) and low water levels preventing boat access (dry season) and the potential presence of estuarine crocodiles in the Project footprint (Section 2.4.2).

Habitat assessments were conducted at sites representing major aquatic habitats within the study area. These were defined as:

- **Impounded pool** (impounded water upstream of existing Eden Bann Weir): generally non-flowing, typically deep water impounded within the bed and banks of a river upstream of a weir; distinct from a 'natural' pool in an unregulated river. Water depth and linear extent of the impounded pool is variable, and dependent on operations of the infrastructure, climatic factors (rainfall / evaporation) and extraction by adjacent land users
- **Pools**: zones of relatively deep, still or very slow flowing water over variable substrates (i.e. silt, sand, stony or rocky) that occur naturally within the riverine environment (as opposed to upstream of man-made structures) (AusRivAS 2001). This aquatic habitat type occurs in the main channel, and may become isolated into a series of discrete water holes during dry conditions when flow ceases and water levels drop. The low (or zero) velocity of water flow differentiates a pool habitat from a faster flowing run habitat (AusRivAS 2001)
- **Riffles**: shallow (<0.3 m), fast-flowing (>0.2 m/s) water over a stony bed (AusRivAS 2001)
- **Runs**: relatively deep, fast flowing unbroken water over a sandy, stony or rocky bed (AusRivAS 2001). These habitats may occur immediately upstream and downstream of a riffle zone. Fast flowing water during high flow / flood conditions may result in the conversion of generally sluggish pool habitats and generally shallow riffle habitats into runs (AusRivAS 2001)
- **Off-stream water bodies** including:
  - Palustrine wetlands (vegetated swamps, billabongs), oxbow lakes, and farm dams in the floodplain adjacent to the main channel[2]
  - Flood-runners / secondary channels within the bed and banks (i.e. including the riparian zone)
- **Creeks**: small tributaries adjoining the main river channel that persist for varying distances across the adjacent floodplain and beyond. This does not include minor drainage lines that may only flow intermittently after rainfall.

Where possible, sites for deployment of nets and traps were selected to sample aquatic fauna in each of the habitat types, and in locations that allowed safe operation and had suitable structures (e.g. projecting branches or roots for attachment). Where appropriate, trapping sites were coincident with those of habitat assessments, but this was not always possible. For example, traps could not be deployed in areas with very fast flows due to the risk of trap loss and subsequent wildlife entrapment.

[2] For the purposes of this assessment, off-stream water bodies within 1 km of the main channel and adjoining creeks were considered.

Turtle nesting bank surveys were conducted at targeted sites based on the current knowledge of species preferences for particular substrate, slope, elevation and vegetation cover (refer to Section 2.4.10). Locations of habitat assessment, turtle nesting bank surveys and fauna trapping sites are provided in Figure 2-1.

2.4.7 Aquatic habitat assessments

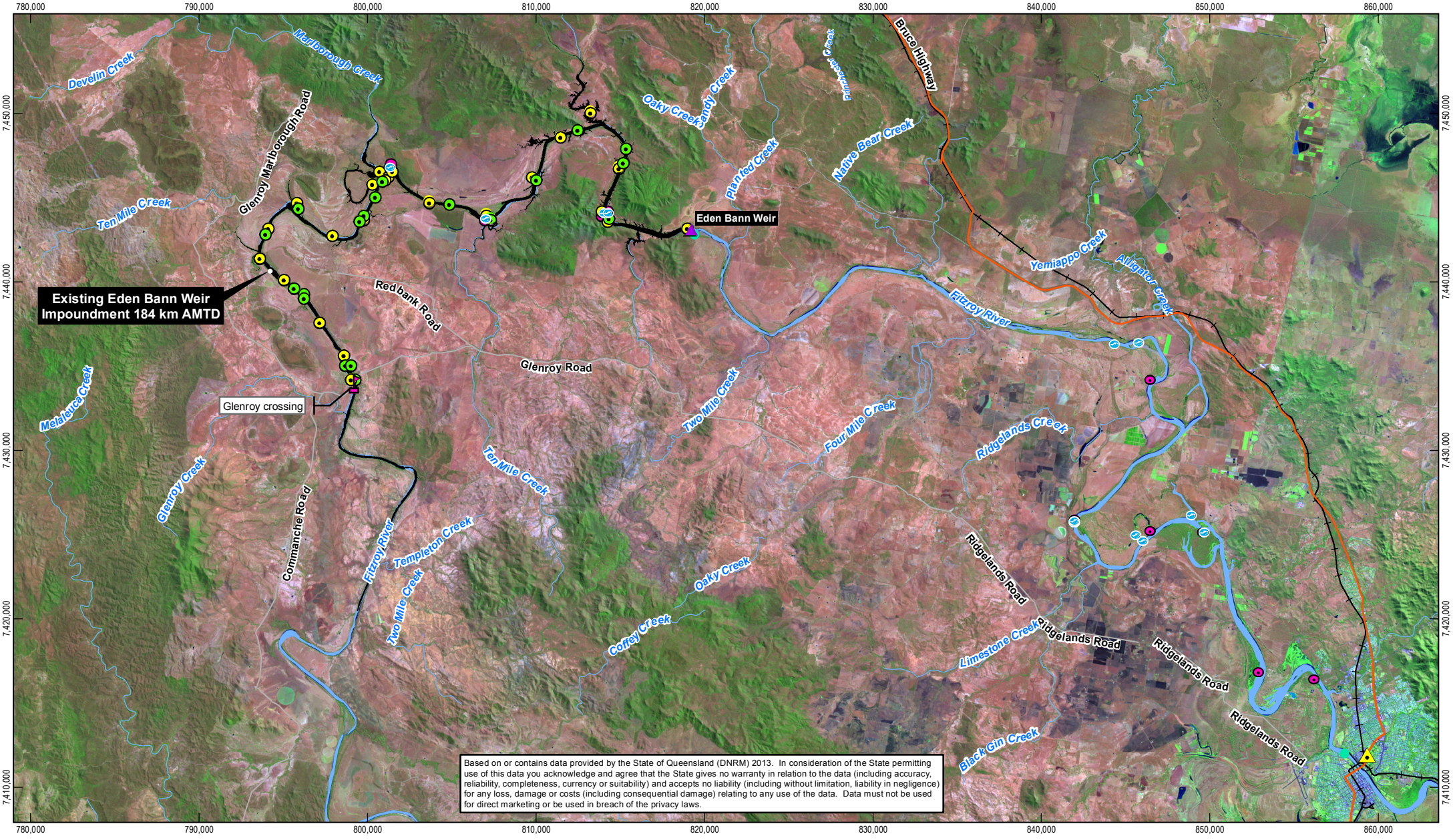
Habitat assessments were undertaken at accessible sites representing major aquatic habitats throughout the Project footprint. Each survey site was identified in relation to habitat type described above in section 2.4.6 and the following parameters recorded:

- 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 (refer to limitations Section 2.4.2), a desktop approach to assessing the spatial distribution / extent of these habitat types was undertaken. Specifically, this involved an assessment of the 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 AusRivAS River Bioassessment Program from which a sub sample of habitat variables relevant to the Project were selected (Table 2-2).

A summary of the aquatic habitat assessment survey sites is provided in Table 2-3 below.



1:300,000 (at A4)

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

- Weir Location
- Fitzroy Barrage
- River Crossing
- Highway
- Minor Road
- Railway
- Impoundment Area
- Waterway
- Aquatic Fauna Trapping Site (GHD)
- Turtle Nesting Bank Survey Site (GHD)
- Habitat Assessment Site (GHD)
- Macroinvertebrate articial substrate sites (GHD)
- Principal study sites (Limpus et al 2011)

GHD
CLIENTS | PEOPLE | PERFORMANCE

Gladstone Area Water Board

SunWater
Making Water Work

Gladstone Area Water Board, SunWater
Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision C
Date 19 Aug 2014

Eden Bann Weir Aquatic Ecology Footprint and Aquatic Survey Sites

Figure 2-1

G:\41\20736\GIS\Projects\MXD\900_Baseline Terrestrial Fauna Report\4120736_909_Eden_Bann_Survey_Sites_Rev_C.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

Table 2-2 AusRiVAS River Bioassessment Program habitat variables and criteria rankings

Habitat variable	Excellent	Good	Fair	Poor
1. Bottom Substrate / Available cover	> 50% rubble, gravel, submerged logs, undercut banks, or other stable habitat.	30-50% rubble, gravel or other stable habitat.	10-30% rubble, gravel or other stable habitat.	<10% rubble, gravel or other stable habitat. Lack of habitat is obvious.
2. Bank Stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%.	Moderately stable. Infrequent small areas of erosion. Side slopes up to 40% on some banks.	Moderately unstable. Moderate frequency and size of erosion areas. Side slopes up to 60% on some banks.	Unstable. Many eroded areas. Side slopes >60% are common. Exposed 'raw' areas frequent along straight sections and bends.
3. Bank Vegetative Stability	Over 80% of the streambank covered by vegetation or boulders and cobble.	50-79% of the streambank covered by vegetation, gravel or larger material.	25-49% of the streambank covered by vegetation, gravel or larger material.	<25% of the streambank covered by vegetation, gravel or larger material.
4. Streamside Cover	Dominant vegetation is of tree form.	Dominant vegetation is shrub form.	Dominant vegetation is grass, sedge, ferns.	Over 50% of stream bank has no vegetation and dominant material is soil, rock, bridge materials or culverts.

Table 2-3 Summary of aquatic habitat assessment survey sites

Sampling site name	Coordinate	Site location	Aquatic habitat type at time of survey	Sampling period*
EBA1	-23.174 , 149.922	Glenroy Crossing	Riffle	Wet
EBA2	-23.161 , 149.916	Downstream of Glenroy Crossing	Run	Wet
EBA3	-23.144 , 149.902	Between Glenroy Crossing and Redbank Crossing	Run	Wet
EBA4	-23.121 , 149.880	Between Glenroy Crossing and Redbank Crossing	Run	Wet
EBA5	-23.110 , 149.866	Between Glenroy Crossing and Redbank Crossing	Run	Wet
EBA6	-23.094 , 149.871	Downstream of Redbank Crossing	Run	Wet
EBA7	-23.080 , 149.887	Between Redbank Crossing and Marlborough Creek	Run	Wet
EBA8	-23.099 , 149.909	Between Redbank Crossing and Marlborough Creek	Run	Wet
EBA9	-23.088 , 149.926	Just upstream of Marlborough Creek	Run	Wet
EBA10	-23.062 , 149.934	Marlborough Creek	Creek	Wet

Sampling site name	Coordinate	Site location	Aquatic habitat type at time of survey	Sampling period*
EBA11	-23.065 , 149.937	Small creek just upstream of Marlborough Creek	Creek	Wet
EBA12	-23.069 , 149.930	Adjacent to Marlborough Creek	Off-stream water body (billabong)	Wet
EBA13	-23.065 , 149.937	Just downstream of Marlborough Creek	Run	Wet
EBA14	-23.060 , 149.941	Between Marlborough Creek and Princhester Creek	Run / Riffle	Wet / Dry
EBA15	-23.078 , 149.964	Between Marlborough Creek and Princhester Creek	Impounded pool	Wet
EBA16	-23.087 , 149.997	Between Marlborough Creek and Princhester Creek	Impounded pool / Run	Wet / Dry
EBA17	-23.065 , 150.026	Between Marlborough Creek and Princhester Creek	Impounded pool	Wet
EBA18	-23.042 , 150.039	Between Marlborough Creek and Princhester Creek	Impounded pool	Wet
EBA19	-23.028 , 150.056	Princhester Creek	Impounded lower reaches of creek	Wet
EBA20	-23.055 , 150.075	Between Princhester Creek and Eden Bann Weir	Impounded pool	Wet
EBA21	-23.082 , 150.066	Between Princhester Creek and Eden Bann Weir	Impounded pool / Impounded pool	Wet / Dry
EBA22	-23.089 , 150.113	Between Princhester Creek and Eden Bann Weir	Impounded pool	Wet
EBA23	-23.085 , 150.067	Between Princhester Creek and Eden Bann Weir	Impounded pool / Impounded pool	Wet / Dry

*Wet: surveys conducted late January / early February 2009; Dry: surveys conducted July 2009

2.4.8 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, upstream and downstream of the Eden Bann Weir Project footprint.

The distribution and linear extent of aquatic habitat types within the Project footprint (i.e. upstream of Eden Bann Weir) as well as downstream, were quantified and mapped from aerial photographs, and where possible, verified in the field (within Project footprint during field studies and during the reconnaissance aerial overflight). Habitat boundaries were estimated based on the visual characteristics observed.

The extent of each habitat type in the main river channel within and downstream of the Eden Bann Weir Project footprint was then calculated based on the percentage of river length covered by each habitat (off-stream water bodies and adjoining creeks were 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 and management of the storage.

Habitat quality downstream to the Fitzroy Barrage was inferred to be similar to that of the aquatic habitats assessed within the Project footprint, given the similarity of surrounding land uses.

2.4.9 Fish

Prior to field investigations, a literature review was performed in order to catalogue previously recorded fish diversity of the Project footprint, the study area and the Fitzroy Basin catchment. Wet and dry season field surveys, using fyke nets and small collapsible baited traps, were undertaken in order to confirm and supplement the information acquired from the literature review, and also to reveal the potential presence of any cryptic and / or uncommon species in the existing Eden Bann Weir impoundment.

Fish species in the main stream were surveyed using single wing fyke nets, with the cod *end anchored to* projections (such as logs and branches) protruding from the water at the stream bank, allowing any inadvertently captured turtles and platypus access to the surface. Fyke nets were deployed by boat to allow the wing panel to be deployed 10-15 m into the stream, perpendicular to the bank. The nets were also positioned in locations away from the main flow of the river to prevent the wing panel from being displaced or damaged. At each site, a minimum of two fyke nets were deployed in the afternoon, left overnight, and checked the following morning.

Small collapsible baited traps were deployed along the margins within the existing Eden Bann Weir impoundment to sample small, cryptic fish and macroinvertebrate species that were less likely to be captured in fyke nets. Traps were baited with dry cat biscuits (prawn and sardine) and tied to overhanging or emergent vegetation or structure (such as logs) with a corner of the trap above the surface. This enabled small turtles to breathe in the unlikely event that they were caught in the trap. Three or four bait traps were deployed at the same location as the fyke nets, thereby allowing different microhabitats to be sampled within the same lotic habitat. These traps were also left overnight and checked the following morning.

Flooding on the Fitzroy River during wet season sampling resulted in the loss of a number of baited traps. At one site, the presence of an estuarine crocodile prevented the retrieval of baited traps. During the dry season, the use of baited traps was abandoned due to safety concern encountered in the wet season. A summary of fish sampling effort is provided in Table 2-4

In all netting / trapping operations captured fish and macroinvertebrates were placed in a bucket of water and identified to species level. The number of individuals of each species level was recorded and all individuals were subsequently returned live to the water body. Turtles captured during fish sampling were immediately removed from the net and identified to the species level. The sex, size and age class of each turtle was also recorded, and the presence of tags from previous captures by DERM was also determined, before being returned to the water.

Table 2-4 Summary of fish sampling effort in Eden Bann Weir Project footprint

Sampling site	Coordinates	Habitat sampled	Date	Number of fyke nets	Number of baited traps
Wet season					
EBA14	-23.058, 149.941	Eden Bann Weir impoundment on bend, just downstream of Marlborough Creek	13/02/2009-14/02/2009	3	3 (all traps washed away in flood – river rose 2 m overnight)
EBA16	-23.087, 149.997	Eden Bann Weir impoundment on bend, just upstream of Eight Mile Creek	13/02/2009-14/02/2009	2	3
EBA21	-23.082, 150.066	Eden Bann Weir impoundment (first bend upstream of weir)	13/02/2009-14/02/2009	2	4 (2 abandoned due to presence of crocodile)
EBA23	-23.082, 150.066	Eden Bann Weir impoundment (first bend upstream of weir) – opposite bank to EBA21	13/02/2009-14/02/2009	3	4
Dry season					
EBA14	-23.058, 149.941	Eden Bann Weir impoundment on bend, just downstream of Marlborough Creek	13/07/2009 – 14/07/2009	3	No bait traps used in dry season due to safety concerns (crocodiles)
EBA16	-23.087, 149.997	Eden Bann Weir impoundment on bend, just upstream of Eight Mile Creek	13/07/2009 – 14/07/2009	2	No bait traps used in dry season due to safety concerns (crocodiles)
EBA21	-23.082, 150.066	Eden Bann Weir impoundment (first bend upstream of weir)	12/07/2009 – 13/07/2009	2	No bait traps used in dry season due to safety concerns (crocodiles)
EBA23	-23.082, 150.066	Eden Bann Weir impoundment (first bend upstream of weir) – opposite bank to EBA21	12/07/2009 – 13/07/2009	3	No bait traps used in dry season due to safety concerns (crocodiles)

2.4.10 Freshwater turtles

An assessment of freshwater turtle populations within the Fitzroy Basin catchment was conducted by DERM in 2007, specifically focusing on the proposal for raising Eden Bann Weir and constructing a new weir at Rookwood (Limpus et al. 2007). The DERM assessment (Limpus et al. 2007) involved field studies, as well as a review of the results of past studies undertaken throughout the catchment (and in nearby catchments) since 1997. Past studies included:

- Cumulative effects of dams and weirs on freshwater turtles: Fitzroy, Kolan, Burnett and Mary Catchments. DERM study 1997-1999 (Tucker 2000)

- Fauna of the Dawson River Floodplain – An assessment of fauna downstream of the proposed Nathan Dam (Venz et al. 2002)
- Management plan for the conservation of *Elseya albagula* in the Burnett River Catchment (Hamann et al. 2007)
- Impact of dams and weirs on freshwater turtles - Fairbairn Dam (Limpus et al. 2006)
- DERM surveys for Fitzroy River turtle (*Rheodytes leukops)* and white-throated snapping turtle (*Elseya albagula*)
- Data from turtle biologists who have conducted research on freshwater turtles of the Fitzroy River:
  - Queensland University: Dr Matt Gordos PhD thesis (Gordos 2004)
  - Toni Priest BSc Hon thesis (Priest 1997)
  - Central Queensland University: Dr John Parmenter
  - Carl Glen (unpublished Central Queensland University project).

An additional turtle survey focussing on the Fitzroy River turtle and white-throated snapping turtle was undertaken for Project by frc environmental in 2007 (frc environmental 2007).

Combined, these studies 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. Data collected included turtle abundance and diversity, distribution and aquatic habitats, life history parameters and nesting habitats (Limpus et al. 2007). Due to the amount of information available on freshwater turtles in the Fitzroy Basin catchment, trapping for turtle species was not undertaken within the Project footprint as part of this assessment. Incidental observations of turtles, including those caught in the fish fkye nets, were however, recorded and identified as described in Section 2.4.9.

The distribution and abundance of the Fitzroy River turtle and white-throated snapping turtle within the Project footprint was assessed based on the results of the past surveys detailed above. Where it was deemed that insufficient information was available to inform the risks associated with the Project to the Fitzroy River turtle and white-throated snapping turtle, occurrence of these species was instead assessed based on habitat suitability using targeted nesting bank surveys. Additional distribution and abundance surveys of these species were not undertaken as part of this assessment due to the difficulty in safe turtle capture success. Populations of these species, particularly the Fitzroy River turtle, are difficult to survey as they rarely enter baited traps. Hand capture via snorkelling 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 (Limpus et al. 2007). Seine netting may also be an effective capture method, however, in potential habitats for survey the abundance of in-stream woody debris generally limits suitability in many habitats (Limpus et al. 2007). Furthermore, both snorkelling and seine netting were not considered due to the potential occurrence of estuarine crocodiles.

Nesting bank surveys

Where access permitted, stream bank margins throughout the Project footprint were assessed for potential Fitzroy River turtle and white-throated snapping turtle nesting habitat. Accessible potential nesting areas (i.e. those comprising sand and / or loam banks) (Plate 2-1) were identified and the following parameters recorded:

- Bank length
- Bank width

- Approximate slope
- Substrate type
- Percent vegetation cover
- Evidence of turtle activity and nesting
- Evidence of disturbance (e.g. from cattle and pigs).

Potential nesting banks were examined for signs of nesting (which included the presence of turtle tracks, diggings and predated egg shells) using a single strip transect parallel to the waters edge (as per standard DERM methodology (Limpus et al. 2007) and as discussed with the DEHP's Senior Principal Conservation Officer Dr Col Limpus). Transects varied in length and width according to bank morphology. Nest locations were described in relation to distance and height from water. Predated egg shell was also collected for identification by DERM.

Table 2-5 lists the locations of targeted turtle nesting bank surveys as performed within and upstream of the existing Eden Bann Weir impoundment.

Plate 2-1 Potential turtle nesting bank surveyed during field assessments

Table 2-5 Summary of targeted turtle nesting bank survey sites

Sampling site name	Coordinates	Site location
NB1	-23.085 , 150.067	Between Eden Bann Weir and Princhester Creek
NB2	-23.055 , 150.075	Between Eden Bann Weir and Princhester Creek
NB3	-23.047 , 150.077	Between Eden Bann Weir and Princhester Creek
NB4	-23.038 , 150.049	Just upstream of Princhester Creek
NB5	-23.079 , 149.975	Between Princhester Creek and Marlborough Creek
NB6	-23.087, 149.997	Between Princhester Creek and Marlborough Creek

Sampling site name	Coordinates	Site location
NB7	-23.088 , 149.926	Between Princhester Creek and Marlborough Creek
NB8	-23.065 , 150.025	Between Princhester Creek and Marlborough Creek
NB9	-23.065 , 149.937	Just upstream of Marlborough Creek
NB10	-23.076 , 149.932	Just upstream of Marlborough Creek
NB11	-23.088 , 149.926	Just upstream of Marlborough Creek
NB12	-23.083 , 149.888	Between Marlborough Creek and Redbank Crossing
NB13	-23.126 , 149.886	Redbank Crossing
NB14	-23.130 , 149.893	Between Glenroy Crossing and Redbank Crossing
NB15	-23.130 , 149.892	Between Glenroy Crossing and Redbank Crossing
NB16	-23.097 , 149.869	Between Glenroy Crossing and Redbank Crossing
NB17	-23.167 , 149.919	Just downstream of Glenroy Crossing
NB18	-23.166 , 149.918	Glenroy Crossing
NB19	-23.174 , 149.922	Glenroy Crossing

Based on an assessment of nesting bank slope, substrate type and vegetation cover, each sand / loam bank identified was assigned a broad nesting suitability rating. Four nesting suitability categories were utilised:

- **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, predominately 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).

The nesting suitability ratings were selected based on current data available on the optimal nesting conditions of both the Fitzroy River turtle and the white-throated snapping 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 these areas are considered to be of low quality and unlikely to support large numbers or achieve high nesting success. All incidental observations of turtle nesting were subsequently recorded.

2.4.11 Crocodiles

A review of the literature indicated that estuarine crocodiles (*Crocodylus porosus*) occur in relatively high numbers in the impoundment upstream of Eden Bann Weir compared with other parts of the study area. Any opportunistic crocodile sightings as well as any signs of crocodile presence (e.g. characteristic slides on sand banks), were subsequently recorded.

2.4.12 Other fauna

The platypus (*O. anatinus*) is known to occur within the Fitzroy Basin catchment (Grant and Temple-Smith 1998). A general characterisation of potentially suitable habitats for the platypus (based on the known ecology of the species from the literature) was ascertained through aquatic habitat assessments. Any opportunistic observations of this species were subsequently recorded. Other fauna that utilise aquatic habitats, including water birds, amphibians, eastern water dragon (*Physignathus lesuerii*) and water rat (*Hydromys chrysogaster*) were not considered in this aquatic assessment.

2.4.13 Macroinvertebrates

Information on macroinvertebrate assemblages in the Fitzroy River system was acquired from a review of the literature and supplemented by the results of field studies. Literature reviews were verified by opportunistic sampling for large macroinvertebrates during fish trapping whilst small and cryptic macroinvertebrates were sampled by deploying artificial substrates at locations within the Eden Bann Weir Project footprint, Rookwood Weir Project footprint and in downstream reaches to the Fitzroy Barrage as presented in Table 2-6. Artificial substrates were utilised at the time of the surveys, due to the inability to undertake kick-sampling as a result of flooding and other logistical and safety concerns (Section 2.4.2).

The artificial substrates were 'rock basket' substrates based upon De Pauw et al. (1986) substrates. The substrates were approximately 2500 cm^3 in volume, made of an open mesh and filled with plastic potato / orange bags and rocks to the size of half a house brick. These substrates were placed into the water at depths no greater than five metres and allowed to be colonised for three to six weeks. Variation in duration of substrate colonisation was related to logistical issues associated with retrieving the samples. Five substrates were deployed at each survey site.

The substrates were collected into a 250 µm sweep net and rinsed, then placed into suitable sample jars and preserved with 70% ethanol. Samples were identified using a stereoscope and keys listed in Hawking (2000). Individuals from every sample jar were identified to family level and preserved in individual vials containing 90% ethanol.

Within the Eden Bann Weir Project footprint, artificial substrates were deployed at two sites in the Eden Bann Weir impoundment in the wet season and four sites in the dry season. Artificial substrates were also deployed throughout the broader study area, including sites upstream of the Fitzroy Barrage (six during the wet, and three during the dry season) and one site in the Rookwood Weir Project footprint (wet season only).

2.4.14 Macrophytes

A review of the literature provided baseline information on the aquatic plant assemblages typically encountered in the Fitzroy Basin catchment. Marcophytes were infrequently encountered throughout the Project footprint during field studies. If present, aquatic plant assemblages were recorded at locations in which habitat assessments were performed. While not identifying macrophytes to species level, a general description of the plants, including whether they were emergent, submergent or floating was noted.

Table 2-6 Description of artificial substrate locations

Site name	River	Site location	Site coordinate	Aquatic habitat type	Season sampled
FBA1	Fitzroy River	Creek adjoining Fitzroy Barrage weir pool between Fitzroy Barrage and Alligator Creek	-23.237, 150.409	Creek adjoining Fitzroy Barrage impounded pool	Dry
FBA2	Fitzroy River	Creek adjoining Fitzroy Barrage weir pool between Fitzroy Barrage and Alligator Creek	-23.251, 150.381	Creek adjoining Fitzroy Barrage impounded pool	Dry
FBA3	Alligator Creek	Alligator Creek	-23.246, 150.417	Creek	Dry
FBA6	Fitzroy River	Fitzroy Barrage impoundment between Fitzroy Barrage and Alligator Creek	-23.242, 150.342	Impounded pool	Wet
FBA6A	Fitzroy River	Fitzroy Barrage impoundment between Fitzroy Barrage and Alligator Creek	-23.242, 150.342	Impounded pool	Wet
FBA9	Fitzroy River	Fitzroy River between Fitzroy Barrage impoundment and Eden Bann Weir	-23.146, 150.362	Pool	Wet
FBA10	Fitzroy River	Fitzroy River between Fitzroy Barrage impoundment and Eden Bann Weir	-23.145, 150.376	Impounded pool	Wet
FBA11	Fitzroy River	Off-stream billabong adjacent to Fitzroy Barrage Impoundment	-23.248, 150.377	Off-stream water body	Wet
FBA13	Fitzroy River	Fitzroy Barrage impoundment between Fitzroy Barrage and Alligator Creek	-23.241, 150.342	Impounded pool	Wet
EBA14	Fitzroy River	Eden Bann Weir impoundment on bend, just downstream of Marlborough Creek	-23.058, 149.941	Impounded pool	Dry
EBA16	Fitzroy River	Eden Bann Weir impoundment on bend, just upstream of Eight Mile Creek	-23.087, 149.997	Impounded pool	Dry
EBA21	Fitzroy River	Eden Bann Weir impoundment (first bend upstream of weir)	-23.082, 150.066	Impounded pool / Impounded pool	Wet / Dry
EBA23	Fitzroy River	Eden Bann Weir impoundment (first bend upstream of weir) – opposite bank to EBA21	-23.082, 150.066	Impounded pool / Impounded pool	Wet / Dry
Riverslea	Fitzroy River	Upstream of Riverslea Crossing	-23.578, 149.934	Pool	Wet

2.4.15 Summary of aquatic survey effort

The following survey effort was conducted within the Eden Bann Weir Project footprint:

- 23 habitat assessments (23 wet season, 4 replicated in dry season)
- 19 targeted turtle nesting bank surveys (19 wet season)
- 20 fyke trap nights (10 wet season; 10 dry season)
- 14 baited trap nights (14 wet season)
- Artificial substrates throughout entire study area including six sites within Eden Bann Weir Project footprint (two sites in the wet season, and four sites in the dry season).

The survey effort employed in this assessment sought to combine existing information with data and observations recorded from field studies, in the context of the assessment objectives and identified limitations. Most importantly, this methodology allowed for the characteristics, value and spatial distribution of aquatic habitat types to be described, such that the loss / alteration of these habitats due to raising Eden Bann Weir could be assessed. Furthermore, the assessment considered a large amount of existing information on aquatic species in the Fitzroy Basin catchment, including previously prepared reports that have investigated the potential impacts of raising Eden Bann Weir and / or constructing a weir at Rookwood on conservation significant aquatic species (namely the Fitzroy River turtle and estuarine crocodile). The baseline environmental values detailed in these reports, and other studies relating to the aquatic fauna and flora of the Fitzroy Basin catchment (including comparative studies of riverine and weir environments), were ground-truthed and supplemented through the implementation of the survey effort outlined above. As a result of this combined desktop and field based assessment approach, the risks associated with raising Eden Bann Weir on aquatic habitats and species (most notably, conservation significant fauna known or predicted to occur within the Project footprint) have been identified, thereby allowing for a thorough assessment of potential impacts and the development of appropriate migration strategies.

2.5 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 natural aquatic habitat within the Project footprint.

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. The digitised data was then cross-checked against river bed level cross-section data at 23 locations. The cross-section data was available from the hydraulic model developed for the Project as described in 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 (Chapter 9 Surface water resources). As such, the use of imagery captured during the wet season would not be representative of flow conditions.

3. Aquatic ecology existing environmental values

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. It extends over an area of approximately 142,000 km^2 of Central and Eastern Queensland about the Tropic of Capricorn, and drains into the Great Barrier Reef World Heritage Area. It consists of six major sub-catchments, namely:

- Isaac / Connors
- Nogoa
- Comet
- Mackenzie
- Dawson
- Fitzroy.

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). The warm, wet season is generally interspersed with long, dry periods during the dry season (approximately May to October). Mean annual rainfall is generally higher in eastern parts of the catchment (800 – 1000 mm), and slightly lower inland to the west (600 mm) (Johnston et al. 2008). Total evaporation within the Fitzroy Basin catchment significantly exceeds rainfall, thereby resulting in prevailing dry conditions and variable stream flow (Marsden and Power 2007). Severe flooding occasionally occurs within the Fitzroy Basin catchment as a result of intensive rainfall events associated with severe storms, cyclones and tropical low pressure systems. Prolonged dry conditions and drought are also characteristic features of the highly variable and unpredictable nature of the Fitzroy Basin catchment climate is exposed to. 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% of catchment land use (Johnston et al. 2008). Of this agricultural use, 81.7% is livestock grazing (Johnston et al. 2008). Other notable land uses within the Fitzroy Basin catchment include State Forest (6.65%), nature conservation (4.54%) and mining (0.38%) (Johnston et al. 2008). Although only a comparatively small component of land use, existing mining activities within the Fitzroy Basin catchment are concentrated in the northern and western parts of the catchment. As of 2008, 85% of the state's operational coal mines were located in the Fitzroy Basin catchment (Johnston et al. 2008).

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 system**: Tartrus Weir, Bingegang Weir, Bedford Weir, Fairbairn Dam
- **Dawson River**: Neville Hewitt Weir, Moura Weir, Theodore Weir, Orange Creek Weir, Gyranda Weir, Glebe Weir
- **Fitzroy River**: Eden Bann Weir, Fitzroy Barrage.

The freshwater fish community within the Fitzroy Basin catchment contains a unique combination of semi-arid / temperate and tropical / sub-tropical species, including two endemic species (southern saratoga (*Scleropages leichardti*) and leathery grunter (*Scortum hillii*)), and one endemic sub-species (golden perch (*Macquaria ambigua oriens*)) (Stuart et al. 2007).

The Fitzroy Basin catchment supports one of the highest diversities of freshwater turtles in Australia, with six species occurring throughout the catchment, including two regionally endemic species (Fitzroy River turtle and white-throated snapping turtle). The Fitzroy River turtle is listed as 'Vulnerable' under the NC Act and the EPBC Act. Other conservation significant species occurring within the Fitzroy Basin catchment include the estuarine crocodile, listed as 'Vulnerable' under the NC Act and 'Migratory' and 'Marine' under the EPBC Act (Britton 2007a; Britton 2007b), and the platypus (*Ornithorhynchus anatinus*) which is protected under the NC Act as a 'Special Least Concern' species.

3.2 Field survey climatic conditions

3.2.1 Wet season

Conditions during the initial wet season habitat assessment survey (28 January - 2 February 2009), were generally warm and dry. Temperatures ranged between 21.9ºC and 31.3ºC with averages of 22.9ºC (min) and 30.2ºC (max). Days were generally cloudy with moderate relative humidity (average 60% recorded at 3 pm). Total rainfall during the survey period was 3.4 mm. Forty-one millimetres of rain was recorded in the two-week period prior to the surveys while 131.6 mm of rain fell in the two months prior (December 2008 and January 2009). During the wet season aquatic fauna trapping survey (13-14 February 2009) the temperature did not drop below 22.8ºC, and the maximum recorded temperature was 31.5ºC. Conditions were overcast and humid, with 37.4 mm of rain recorded and an average relative humidity (at 3 pm) of 73%. In the two weeks prior to the survey 123 mm of rainfall was recorded, including 87.4 mm on February 11.

3.2.2 Dry season

Conditions during the dry season survey (12 - 14 July 2009) were typified by warm days, and cool to mild nights. Temperatures ranged between 7.5ºC and 26.6ºC with averages of 8.7ºC (min) and 26.1ºC (max). Days were generally clear (i.e. little cloud cover) with high relative humidity in the mornings (average 74.3 % recorded at 9 am) and low relative humidity in the afternoons (average 33.3 % recorded at 3 pm). No rainfall was recorded during the survey period, nor in the two-week period prior to the surveys, however 16.8 mm of rain occurred in the two months prior (13 May 2009 and 12 July 2009).

3.3 Aquatic habitats

3.3.1 Overview

Approximately 282 ha of natural (not impounded) aquatic habitat occurs within the Eden Bann Weir Project footprint. Six main aquatic habitat types occur within the Project footprint upstream of Eden Bann Weir and within reaches downstream to the Fitzroy Barrage. Aerial photograph interpretation informed a description of the linear extent of these habitat types within and downstream of the Eden Bann Weir Project footprint (aquatic habitat segment analysis). Based on the aquatic habitat segment analysis, field observation based habitat assessments, and information acquired from the literature review, the general characteristics and features of these aquatic habitat types were determined.

3.3.2 Aquatic habitat segment analysis

Based on the assessment of aerial photography and field survey observations (as discussed in Section 2.4), the linear extent of various in-channel[3] aquatic habitat types in the Project footprint area and downstream to the Fitzroy Barrage was determined[4]. The results of this analysis are provided below in Table 3-1 and Figure 3-1. The spatial distribution of in-channel aquatic habitats, as determined through the analysis, is provided in Figure 3-2.

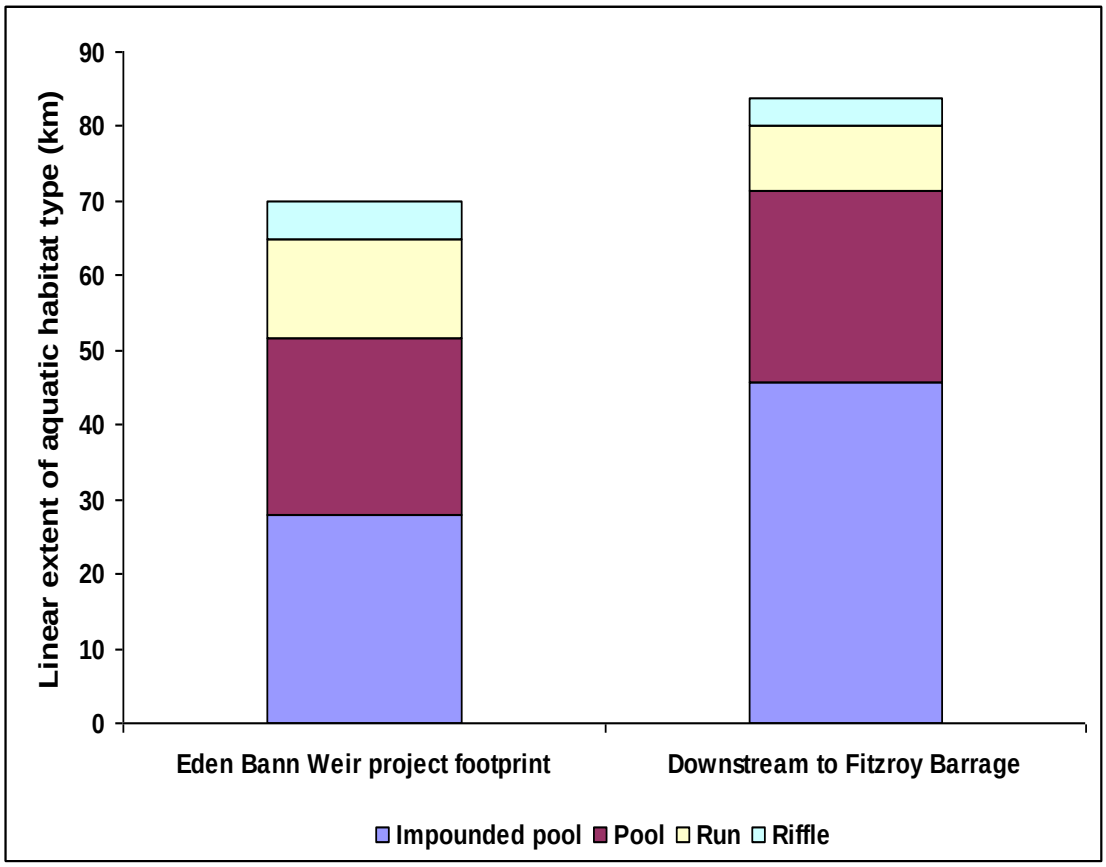
Table 3-1 Linear extent of in-channel aquatic habitats within and downstream of Eden Bann Weir Project footprint

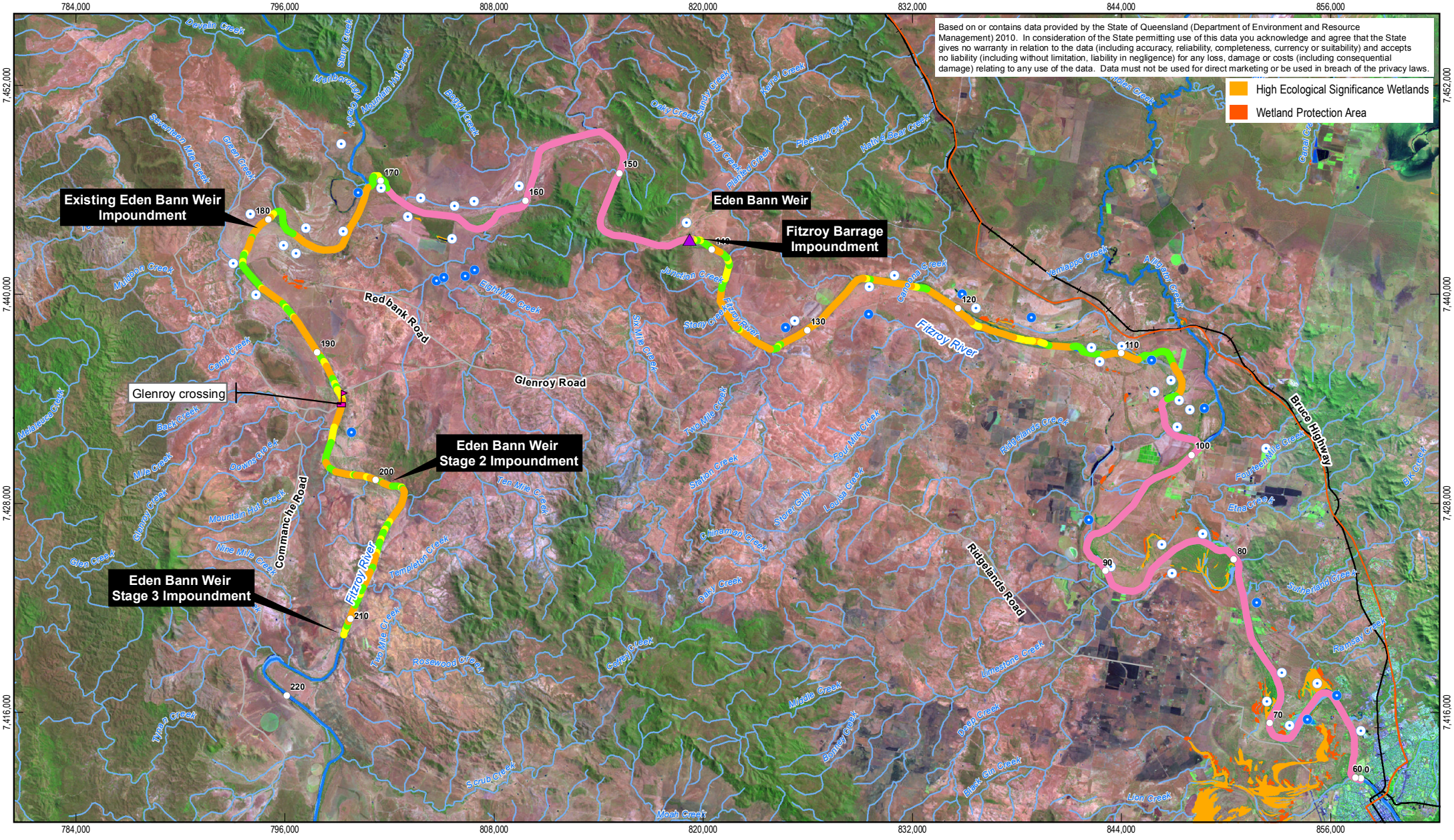
Habitat type	Linear extent of habitat in Eden Bann Weir Project footprint (km)	% linear extent of habitat in Eden Bann Weir Project footprint	Linear extent of habitat downstream of Eden Bann Weir Project footprint (to Fitzroy Barrage) (km)	% linear extent of habitat downstream of Eden Bann Weir Project footprint (to Fitzroy Barrage)
Impounded pool	27.8	39.77	45.8	54.59
Pool	23.9	34.19	25.5	30.39
Run	13.1	18.74	8.9	10.61
Riffle	5.1	7.3	3.7	4.41
Total	69.9 km	100%	83.9 km	100%

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

[4] Habitat boundaries were estimated based on visual characteristics observed. As habitat boundaries (e.g. the difference between a riffle and a run) vary substantially between seasons, the percentages of each habitat type within and downstream of 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 and management of the storage (refer to Section 2.4.8).

Figure 3-1 Linear extent of in-channel aquatic habitats within and downstream of Eden Bann Weir Project footprint





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Lower Fitzroy River Infrastructure Project

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

Figure 3-2

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

3.3.3 Impounded pools

General characteristics

Impounded pool habitats are defined as generally non-flowing, typically deep water impounded within the bed and banks of a river upstream of a weir. The depth and linear extent of this habitat type is variable, and dependent on local to catchment-wide climatic factors as well as operations of the infrastructure.

Within the Project footprint, the following characteristics of impounded pool habitat were identified based on eight aquatic habitat assessments:

- Average stream width approximately 172.5 m (range 120-250 m)
- Average channel depth approximately 8.7 m (6.5-10 m)
- Average bank height approximately 7.8 m (3-20 m)
- Typical substrate: clay / silt (<0.006 mm)
- Logs and coarse-woody debris occurred at the margins of the impoundment at all but one site, and were plentiful at two sites
- Aquatic macrophytes were encountered occasionally (four of eight sites) – these were generally attached to the substrate rather than free floating
- Water was not flowing.

As described in Section 2.4.7, the habitat characteristics of the impounded pool habitat was assessed from excellent to poor according to the AusRivAS River Bioassessment Program (Table 3-2).

Table 3-2 Habitat characteristic ratings of impounded pool habitats

Habitat assessment site	Bottom substrate / available cover		Bank stability		Bank vegetative stability		Streamside cover	
	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank
EBA15	Poor	Poor	Excellent	Excellent	Good	Excellent	Fair	Fair
EBA16	Poor	Poor	Excellent	Good	Excellent	Excellent	Fair	Fair
EBA17	Poor	Poor	Good	Excellent	Good	Good	Fair	Fair
EBA18	Poor	Poor	Fair	Fair	Fair	Fair	Fair	Fair
EBA20	Good	Fair	Excellent	Good	Excellent	Excellent	Good	Fair
EBA21	Fair	Poor	Good	Excellent	Excellent	Excellent	Fair	Good
EBA22	Good	Good	Excellent	Excellent	Excellent	Excellent	Fair	Good
EBA23	Fair	Fair	Good	Good	Good	Good	Fair	Fair

Assessment of the habitat characteristics within the Eden Bann Weir Project footprint revealed that bottom substrate / available cover within the impounded pool habitat was generally fair, with habitat features such as submerged logs and rocks, largely confined to the margins of the impounded pool habitat. Bank stability and bank vegetative stability were ranked as being *good – excellent* with few areas of exposed/unstable banks. Whilst high grass/weed cover on the river banks served to stabilise banks, the low abundance of trees and shrubs resulted in 13 of the 16 banks assessed, receiving a *poor* streamside covering rating (Table 3-2).

While not quantifiably assessed, a notable field observation throughout the Eden Bann Weir Project footprint (and indeed the entire study area) was that the quality of marginal aquatic habitats (in terms of likely value for fauna) was higher where cattle access to the river was prevented or restricted. This observation not only applies to the impounded pool habitat, but to all aquatic habitats, including off-stream water bodies and adjoining creeks.

Spatial distribution and extent of habitat

Impounded pool habitat occurs in the Fitzroy River (and the lower reaches of adjoining creeks) upstream of Eden Bann Weir. While the maximum impoundment extent of the existing structure is 184 km adopted middle thread distance (approximately 43 km upstream of the weir), field observations and aquatic habitat segment analysis indicated that the impounded pool habitat does not necessarily extend upstream as far as this. Aquatic habitat assessments and aerial photograph interpretation indicated that the impounded pool habitat prevails upstream from Eden Bann Weir to approximately Marlborough Creek (28 km upstream). It is important to note that this conclusion is based on observations made at the time of survey, and may, therefore, be subject to variation in response to the highly variable and seasonal climatic factors for the catchment.

Downstream of Eden Bann Weir, the impounded pool habitat created by water contained within the Fitzroy Barrage is the most dominant aquatic habitat type (approximately 54.6 per cent). Based on the aquatic habitat segment analysis, this habitat extends 45.8 km upstream.

3.3.4 Pools

General characteristics

Pool habitats are defined as relatively deep, still / very slow flowing water over variable substrates (i.e. silt, sand, stone or rock) that occur naturally within the riverine environment (as opposed to upstream of man-made structures) (AusRivAS 2001). This aquatic habitat type occurs in the main river channel, and may become isolated into a series of discrete water holes during dry conditions when flow ceases and water levels drop. The low (or zero) velocity of water flow differentiates a pool habitat from a faster flowing run habitat (AusRivAS 2001).

During the wet season surveys, the pool habitats that normally occur within the Project footprint during the dry season, were converted to run habitats due to the level and flow of water within the Fitzroy River. These habitats within and upstream of the Project footprint could not be accessed for assessment during the dry season (refer to Section 2.4.2) and as a result aquatic habitat assessments could not be undertaken for this habitat type. Observations from the broader study area (i.e. upstream of the Rookwood Weir site) indicated that, like the impounded pool habitat, the most significant habitat features of pools are concentrated along the margins of the waterway. The provision of a variety of habitat resources and microhabitats due to the presence of undercut banks, woody debris, macrophytes, variable substrates, and overhanging and inundated riparian vegetation, has the potential to support a diversity of aquatic fauna, including freshwater turtles, fish, platypus and macroinvertebrates.

Spatial distribution and extent of habitat

The spatial distribution and extent of pool habitat within the Project footprint was assessed from aerial photographs. This assessment revealed that pools are the second most dominant aquatic habitat type within the Eden Bann Weir Project footprint (total linear extent of 23.9 km; 34.19 % of habitat). The pool habitats are typically interspersed by riffle and / or run habitats. Based on the habitat segment analysis, the largest pool in the Eden Bann Weir Project footprint extends upstream of Marlborough Creek (for a length of approximately 6.8 km).

Aquatic habitat segment analysis indicated that pools are also the second most dominant habitat type downstream of the Project footprint (total linear extent of 25.5 km; 30.39% of habitat between Fitzroy Barrage and Eden Bann Weir).

3.3.5 Runs

General characteristics

Run habitats are defined as relatively deep, flowing, unbroken water over a sandy, stony or rocky bed (AusRivAS 2001). These habitats may occur immediately upstream and downstream of a riffle zone. Fast flowing water during high flow / flood conditions may result in the conversion of sluggish pool habitats and shallow riffle habitats into runs (AusRivAS 2001).

Within the Project footprint, the following characteristics of run habitats were identified based on ten aquatic habitat assessments:

- Average stream width approximately 113.5 m (range 60-200 m)
- Average channel depth approximately 4.15 m (3-6 m)
- Average bank height approximately 5.8 m (2-13.5 m)
- Typical substrate: clay / silt (<0.006 mm), some sites also had a combination of clay / silt and sand (2-0.006 mm)
- Logs and coarse-woody debris occurred at the margins of run habitats at seven of ten sites, and were plentiful at one site
- Aquatic macrophytes were absent at all sites assessed
- Water velocity was generally slow to moderate at the time of habitat assessments.

As described in Section 2.4.7, the habitat characteristics of the run habitats were assessed from excellent to poor according to the AusRivAS River Bioassessment Program. The results of this assessment are provided in Table 3-3 and summarised below.

Table 3-3 Habitat characteristic ratings of run habitats

Habitat assessment site	Bottom substrate / available cover		Bank stability		Bank vegetative stability		Streamside cover	
	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank
EBA2	Poor	Poor	Good	Good	Excellent	Excellent	Fair	Fair
EBA3	Poor	Poor	Excellent	Excellent	Excellent	Excellent	Excellent	Fair
EBA4	Poor	Poor	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
EBA5	Poor	Poor	Good	Good	Excellent	Excellent	Excellent	Excellent
EBA6	Poor	Poor	Excellent	Good	Excellent	Good	Excellent	Fair
EBA7	Poor	Poor	Poor	Excellent	Fair	Excellent	Fair	Fair
EBA8	Poor	Poor	Good	Good	Excellent	Excellent	Fair	Fair
EBA9	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Fair	Good
EBA13	Poor	Poor	Fair	Poor	Poor	Poor	Poor	Poor
EBA14	Poor	Poor	Good	Excellent	Excellent	Excellent	Excellent	Fair

Habitat assessments and field observations showed that run habitats were typically shallow and narrower in comparison to the downstream impounded pool habitat within the Eden Bann Weir Project footprint. While bottom substrate / available cover was generally ranked as being *poor*, bank vegetative stability was typically *excellent* along the riparian zone of run habitats. Bank stability and streamside cover were variable, and rankings are likely to reflect site specific land uses (i.e. intensity of cattle grazing) in the riparian zone adjacent to run habitats. As for the impounded pool habitat, habitat complexity was greatest at the margins of run habitats. In the wet season these habitats provide a linkage between slower-flowing (typically wider and deeper) pool habitats.

As water flow decreases during the dry season, it is likely that the run habitats assessed in the field would revert to pool habitats. The general characteristics outlined above for run habitats within the Eden Bann Weir Project footprint (excluding flow) are therefore considered to be applicable to natural pool habitats within the Project footprint also.

Spatial distribution and extent of habitat

Based on the aquatic habitat segment analysis, runs occur frequently in the Eden Bann Weir Project footprint upstream of the impounded pool habitat. They are generally short in length, and are often, although not always, associated with riffles (i.e. upstream and /or downstream of riffles). A total of 13.1 km of run habitat was mapped as occurring within the Eden Bann Weir Project footprint, accounting for 18.7 % of in-channel habitat. Upstream of the mapped impounded pool habitat, runs constitute approximately 31.1% of in-channel aquatic habitats.

Between Eden Bann Weir and Fitzroy Barrage, the aquatic habitat segment analysis indicated that run habitats extended for a combined total of 8.9 km, representing 10.6 % of the downstream reach of the Fitzroy River between the two structures.

3.3.6 Riffles

General characteristics

Riffle habitats are defined as shallow (<0.3 m), fast-flowing (>0.2 m/s) reaches over a stony bed (AusRivAS 2001). The unique combination of shallow, fast flowing water that is (relatively) highly oxygenated and flows over a hard substrate, differentiates this habitat type from pool and run habitats.

The one riffle habitat assessed[5] in the Eden Bann Weir Project footprint featured:

- A substrate dominated by cobble (256-64 mm), gravel (16-2 mm) and pebbles (64-16 mm)
- Plentiful woody debris in the margins
- Attached macrophytes
- Fast flowing water.

As described in Section 2.4.7, the habitat characteristics of the riffle habitat was assessed from excellent to poor according to the AusRivAS River Bioassessment Program. The results of this assessment are provided in Table 3-4

Table 3-4 Habitat characteristic ratings of riffle habitat

Habitat assessment site	Bottom substrate / available cover		Bank stability		Bank vegetative stability		Streamside cover	
	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank
EBA1	Excellent	Excellent	Fair	Excellent	Good	Excellent	Fair	Excellent

The riffle zone assessed in the Eden Bann Weir Project footprint was typical of this aquatic habitat type throughout the study area (i.e. riffles assessed upstream of the Rookwood Weir site). Namely, these habitats tended to occur immediately downstream of runs, and were narrow, shallow and featured a rocky substrate. Aquatic macrophytes were infrequently observed within riffle zone habitats.

Spatial distribution and extent of habitat

Riffle habitats account for 7.3% of the Eden Bann Weir Project footprint, as determined by the aquatic habitat segment analysis. These habitats were mapped as extending from 100 m to 900 m in length. The total combined length of riffle habitats in the Eden Bann Weir Project footprint was determined to be 5.1 km. Between Eden Bann Weir and Fitzroy Barrage, 3.7 km of riffle habitat was identified, accounting for 4.4% of the linear extent of in-channel habitats between the two infrastructures.

[5] Constraints associated with accessing riffle habitats in the Eden Bann Weir Project footprint prevented further riffles from being assessed.

3.3.7 Off-stream water bodies

For the purposes of this assessment, off-stream water bodies were defined as palustrine wetlands (i.e. vegetated swamps, billabongs), oxbow lakes, and farm dams (i.e. lacustrine habitats) in the floodplain adjacent to the main channel[6] of the Fitzroy River within the Eden Bann Weir Project footprint. Access severely hampered assessment of this habitat type, however, one large off-stream water body to the west of Marlborough Creek was assessed. The results of the AusRivAS River Bioassessment Program assessment for this off-stream water body habitat are provided in Table 3-5 and summarised below.

Table 3-5 Habitat characteristic ratings of the off-stream water body habitat

Habitat assessment site	Bottom substrate / available cover		Bank stability		Bank vegetative stability		Streamside cover	
	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank
EBA12	Good	Good	Excellent	Excellent	Excellent	Excellent	Fair	Fair

Macrophytes and woody debris were prevalent in the off-stream water body assessed, which constituted a good bottom substrate / available cover rating. The wide, shallow body of water was observed to have *excellent* bank stability and bank vegetative stability, while streamside cover was assessed as being *fair*.

Spatial distribution of habitats

An analysis of satellite imagery and the Queensland Government's Wetland*Info* maps informed the location of off-stream water body habitats within and downstream of the Eden Bann Weir Project footprint. A total of 32 off-stream water bodies were identified within 1 km of the Fitzroy River and adjoining creeks downstream of the Eden Bann Weir Project footprint (comprising 22 palustrine wetlands and 10 lacustrine wetlands). Within 1 km of the Eden Bann Weir Project footprint, 18 palustrine habitats and six lacustrine wetlands were identified. The location of the off-stream water body habitats are presented in Figure 3-2.

The Fitzroy River floodplain, which extends to the north west of Rockhampton (approximate centre is 11 km North West of Rockhampton) is listed as a Nationally Important Wetland Site and features in the Directory of Important Wetlands (DEWHA 2008). This wetland comprises a complex of water bodies including the Fitzroy River and associated floodplain wetlands to the north, west and south of Rockhampton (DEWHA 2008).This corresponds in part with the inundation zone of the Fitzroy Barrage. The site is recognised to be important for water birds, and provides foraging and breeding resources for common, threatened and migratory species (DEWHA 2008).

3.3.8 Creeks

Creek habitats include small tributaries adjoining the main river channel that persist for varying distances across the adjacent floodplain and beyond (refer to Section 2.4.6). The variable geomorphology of these habitats (i.e. depth, width, length), adjacent land use and proximity to water infrastructure, varies the characteristics and potential fauna habitat values these waterways feature.

[6] For the purposes of this assessment, off-stream water bodies within 1 km of the main channel and the lower reaches of adjoining creeks were considered.

Habitat assessments were undertaken at three creek habitats in the Eden Bann Weir Project footprint. The following general characteristics of creek habitats were identified from these assessments:

- Average width: 20 m (range 15 m-25 m)
- Average depth: 2.2 m (range 1 m -4 m)
- Average bank height: 3.5 m (range 1.5 m – 7 m)
- Typical substrate: clay / silt, although one site (EBA10 had cobble / gravel / pebbles / clay and silt)
- Woody debris was present at all three sites assessed
- Macrophytes were noted from one of three sites.

As described in Section 2.4.7, the habitat characteristics of the creek habitats were assessed from excellent to poor according to the AusRivAS River Bioassessment Program. The results of this assessment are provided in Table 3-6 and summarised below.

Table 3-6 Habitat characteristic ratings of the creek habitats

Habitat assessment site	Bottom substrate / available cover		Bank stability		Bank vegetative stability		Streamside cover	
	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank
EBA10	Good	Good	Excellent	Excellent	Excellent	Good	Good	Poor
EB11	Poor	Poor	Excellent	Excellent	Excellent	Excellent	Fair	Fair
EBA19	Poor	Poor	Excellent	Excellent	Excellent	Excellent	Fair	Fair

Creek habitats assessed were variable, although general findings from the habitat assessments were that these shallow, narrow adjoining waterways had *excellent* bank stability and bank vegetative stability, supported *fair* streamside cover, yet provided *poor* bottom substrate / available cover. The results of the bottom substrate / available cover assessment at the specific habitat assessment sites, were representative of that observed throughout the wider study area. In general, the observed creek habitats often supported notable in-stream cover and structure in the form of woody debris, (inundated and overhanging vegetation), and also supported more macrophytes (especially floating and emergent) when compared with the main stream of the Fitzroy River.

Spatial distribution of habitats

An analysis of satellite imagery and the Queensland Government's Wetland*Info* mapping service highlighted the location of creek habitats[7] within and downstream of the Eden Bann Weir Project footprint. A total of 13 named creeks join the Fitzroy River between the Fitzroy Barrage and Eden Bann Weir, whilst eleven named creeks flow into the Fitzroy River within the Eden Bann Weir Project footprint. Table 3-7 presents the locations of all named creeks and Figure 3-2 illustrates the locations of the major creeks.

[7] Only named creeks were selected for this study. Small, ephemeral unnamed creeks and drainage lines were not considered.

Table 3-7 Location of named creeks downstream of and within Eden Bann Weir Project footprint

Creek name	Location of junction with Fitzroy River	Tributaries of creek		
Downstream of Eden Bann Weir Project footprint				
Lion Creek	-23.360, 150.491	Gudman Creek		
Ramsay Creek	-23.314, 150.477			
Etna Creek	-23.240, 150.410	Four Mile Creek		
Limestone Creek	-23.263, 150.355	Black Gin Creek	Deep Creek	
Alligator Creek	-23.190, 150.403	Yemiappo Creek	Duck Holes Creek	Bills Creek
Ridgelands Creek	-23.182, 150.384			
Lousia Creek	-23.135, 150.287	Four Mile Creek	Chinaman Creek	
Canoona Creek	-23.109, 150.243	Native Bear Creek		
Two Mile Creek	-23.145, 150.159	Station Creek		
Lagoon Creek	-23.141, 150.155			
Stony Creek	-23.129, 150.137			
Junction Creek	-23.115, 150.133			
Planted Creek	-23.098, 150.138	Sandy Creek	Kerral Creek	Pleasant Creek
Eden Bann Weir Project footprint				
Six Mile Creek	-23.091, 150.085			
Princhester Creek	-23.034, 150.063	Cabbage Tree Creek	Two Mile Creek	
Boggy Creek	-23.044, 150.031			
Eight Mile Creek	-23.086, 150.001	Ten Mile Creek		
Marlborough Creek	-23.065, 149.935	Mountain Hut Creek	#Numerous	
Green Creek	-23.079, 149.885			
Seventeen Mile Creek	-23.106, 149.865			
Muldoon Creek	-23.109, 149.866			
Camp Creek	-23.134, 149.894			
Glenroy Creek	-23.192, 149.918	Downs Creek	Mile Creek	Back Creek
Templeton Creek	-23.274, 149.938	Two Mile Creek		

3.3.9 Upstream habitats

Upstream aquatic habitats (in-channel, adjoining and off-stream) were assessed as being similar to those described within the Project footprint (based on aerial photo interpretation, field observations from the study area and literature reviews). As the landscape (i.e. topography, gradient) and adjacent human land use along the Fitzroy River upstream of the Project footprint is similar to that within the Eden Bann Weir Project footprint, it is likely that the aquatic habitat types, and the general characteristics of these habitats (including value to fauna) would persist upstream of the Project footprint. Subsequent sections of this report discuss some upstream habitats that literature reviews identified as having significant values (i.e. known populations of habitat for conservation significant fauna).

3.3.10 Habitat dynamics

Aquatic habitats in the Fitzroy River are highly dynamic. The temporal distribution and spatial extent of aquatic habitat types are related to fluctuating water levels driven by factors including climate (i.e. rainfall or lack thereof with the Fitzroy River sub-catchment and upstream catchments); management of water storages (i.e. such as Eden Bann Weir and the Fitzroy Barrage); extraction of water from waterways by adjacent land holders; evaporation and ground seepage. Due to the highly unpredictable nature of these individual factors, and the combined influence of the variable interactions of these factors, aquatic habitat distribution and extent is in a constant state of flux. A generalised description of the typical dynamics of the system, as observed in the field (both within the Eden Bann Weir Project footprint, and throughout the wider study area), and as described in the literature, is outlined below, and summarised in Table 3-8. Examples of aquatic habitat diversity by season are provided in Table 3-9.

During and post wet season – approximately November to April

During periods of high rainfall (i.e. during and post-wet season), the linear extent of the impounded pool habitat upstream of Eden Bann Weir is at its greatest. Unregulated reaches of the Fitzroy River primarily exist as a deep fast-flowing channel (run habitat) in which in-channel aquatic habitats such as pools and riffles are inundated as a result of a significant increase in water depth and velocity. This was evident upstream of the impounded pool habitat within the Eden Bann Weir Project footprint during wet season field surveys. Depending of localised rainfall patterns, creek habitats may increase in depth and width as flow rates increase. Off-stream water body habitats such as billabongs may also be inundated during flooding events as river levels rise above bank height (observed downstream of the Eden Bann Weir during wet season surveys). This periodic flooding is important for off-stream water bodies to recharge water levels, provide flushing and allow for biological connectivity with the main stream.

Dry and pre-wet season – approximately April to October

As flows decline following the wet season, the river channel is transformed into a series of pool-riffle-run sequences. These sequences were prevalent upstream of the Eden Bann Weir impoundment and upstream of the Rookwood Weir site during dry season field surveys. Off-stream water bodies lose connection with the main channel, and, unless recharged by groundwater (or unseasonal rainfall), begin to recede. As the dry season persists, many of the riffle and run habitats dry out and much of the river exists as a series of isolated non-flowing pools (Limpus et al. 2007; Marsden and Power 2007). These isolated pools act as refuge for aquatic fauna during the dry season (Limpus et al. 2007).

Table 3-8 Typical dynamics of aquatic habitats in the study area

Habitat type	Wet season and post-wet	Dry-season	Pre-wet
Impounded pool	Linear extent maximised	Linear extent dependent on management of storage – draw-down reduces length of impounded pool habitat. Other factors including extraction by adjacent land users, evaporation and ground seepage influence extent of habitat	Linear extent dependent on management of storage – draw-down reduces length of impounded pool habitat. Other factors including extraction by adjacent land users, evaporation and ground seepage influence extent of habitat
Pool	Flowing water converts pools to runs	Predominant habitat type	Likely to become isolated as lack of run-off and water level in river channel declines (evaporation, ground seepage, extraction)
Run	Predominant aquatic habitat type upstream of impounded pool	Flowing water that links deeper natural pools	May dry out, or become narrower and shallower
Riffle	Drowned out due to increased water level in river (i.e. runs)	Where stream bed geomorphology is suitable (rocky substrate), shallow water between natural pools (often preceded and immediately followed by runs)	Dry out
Off-stream water body	Recharge through rainfall and flooding	Water levels decrease, unless water body is recharged by groundwater (or unseasonal rainfall)	Water levels decrease to the point where habitats may dry out completely, unless water body is recharged by groundwater (or unseasonal rainfall) – also dependent on size and depth of water body
Creek	Increased depth and flow – dependent on rainfall within creek catchment. Lower reaches may also be inundated by flood waters moving downstream along the main river channel	Reduced rate of flow and depth due to lack of runoff	Reduced rate of flow and depth – creek may become series of isolated pools

Table 3-9 Examples of wet and dry season aquatic habitat dynamics in the Eden Bann Weir Project footprint

Wet season	 Impounded pool upstream of Eden Bann Weir (February 2009)	 Run habitat upstream of impounded pool (February 2009)	 Run habitat upstream of impounded pool (February 2009)
Dry season	 Impounded pool upstream of Eden Bann Weir (August 2009)	 Pool habitat (August 2009)	 Greatly reduced impounded pool immediately upstream of Eden Bann Weir (November 2009)

3.4 Aquatic fauna and flora

3.4.1 Overview

Aquatic species recorded or predicted to occur in the study area include: 34 fish species, seven reptiles, one mammal, 86 taxa of macroinvertebrates and 105 species of macrophytes[8]. Desktop surveys and field assessments identified a number of threatened and other conservation significant species that occur in the Project footprint, have been previously recorded in the study area, or are predicted to occur based on bioclimatic modeling. Fauna species considered as rare, threatened with extinction, or as having high conservation value, are protected under both Commonwealth and State legislation. At the national level, fauna are protected under the EPBC Act. Within Queensland, rare and threatened fauna are listed under the NC Act and its subordinate legislation (namely the *Nature Conservation (Wildlife) Regulation 2006*). At a regional level, priority conservation significant fauna have been identified in the 'Back on Track' prioritisation framework for conservation management of Queensland's wildlife in the Fitzroy Natural Resource Management area. While this tool has no legislative power, it outlines management and recovery actions for selected priority species. The habitat preference of each conservation significant species and their likely occurrence within the Project footprint and wider study area is discussed in the relevant sections below.

Table 3-10 summarises the total number of aquatic fauna and flora species recorded according to information source or survey method. Full desktop database search results are presented in Appendix A.

3.4.2 Fish

Species diversity

A total of 34 fish species have been previously recorded in the study area (i.e. the lower Dawson, lower Mackenzie and Fitzroy Rivers). The species recorded include two endemic species, the southern saratoga (*Scleropages leichardti*) and the leathery grunter (*Scortum hillii*), and one endemic subspecies of golden perch (*Macquaria ambigua oriens*). Table 3-11 details the fish species data attained during wet and dry season field surveys, as well as previous records from various studies reported in Marsden and Power (2007).

An additional six fish species, i.e. pacific short-finned eel (*Anguilla obscura)*; freshwater mullet (*Myxus petardi*); striped gudgeon (*Gobiomorphus australis*); Marjorie's hardyhead (*Craterocephalus marjoriae*); guppy (*Poecilia reticulata*) and silver perch (*Bidyanus bidyanus*), have been recorded in the broader Fitzroy Basin catchment and although not observed in the study area to date, these species have the potential to occur. The silver perch, which was recorded in the Fitzroy Basin catchment by Berghuis and Long (1999), was also listed as 'Vulnerable' in 1996 on the IUCN (International Union for the Conservation of Nature) Red List of Threatened Species. A native of the Murray-Darling system, the silver perch is likely to have been introduced into the Fitzroy Basin catchment, where it does not naturally occur. It is not known to occur within the Eden Bann Weir Project footprint.

The Fitzroy Basin catchment has a relatively low diversity of introduced / pest fish species with only three species (i.e. mosquitofish, goldfish and guppy) known to occur throughout the system.

[8] 105 species of macrophyte previously recorded within the broader Fitzroy Basin catchment

Table 3-10 Total number of fauna species predicted to occur or recorded in the study area

	DEWHA Environmental Reporting Tool (predicted to occur)	DERM Wildlife Online Database (historically recorded)	Queensland Museum Specimen Database (historically recorded)	Previous studies (historically recorded)	Field surveys (recorded within Project footprint)
Species Diversity	-	24 fish 5 reptiles	2 reptiles	34 fish 7 reptiles 1 mammal (predicted to occur) 86 macroinvertebrate taxa 105 macrophytes	10 fish 3 reptiles 59 macroinvertebrate taxa (from study area)
EPBC Act, NC Act Threatened Species	1 reptile	3 reptiles	1 reptile	3 reptiles	2 reptiles
EPBC Act Marine and / or Migratory Species	1 reptile	1 reptile	-	1 reptile	1 reptile
Endemic / Range Restricted Species	1 reptile	2 fish 2 reptiles	1 reptile	3 fish 2 reptiles	1 reptile
Introduced / Pest Species	-	-	-	3 fish	-

Table 3-11 Fish species known to occur within the study area based on current study and past reports

Family	Species	Project footprint		Past reports (study area)					
		Wet season survey	Dry season survey	Stuart et al. 2007	Marsden and Power 2007	Heindenreich and Broadfoot 2001	Long and Meager 2000	Berghuis and Long 1999	Stuart 1997
Catadromous									
Anguillidae	long-finned eel (*Anguilla reinhardtii*)	✓	✓	✓	✓	✓	✓		✓
Centropomidae	barramundi (*Lates calcarifer*)			✓	✓	✓			✓
Scorpaenidae	bullrout (*Notesthes robusta*)								✓
Synbranchidae	swamp eel (*Ophisternon* spp.)					✓			
Amphidromous									
Ariidae	blue catfish (*Arius graeffei*)	✓	✓	✓	✓	✓	✓	✓	✓
Belonidae	freshwater longtom (*Strongylura krefftii*)			✓	✓	✓	✓	✓	✓
Gobiidae	speckled goby (*Redigobius bikolanus*)	✓			✓				
Hemiramphidae	snub-nosed garfish (*Arrhamphys sclerolepis*)			✓		✓	✓		✓
Megalopidae	oxeye herring (*Megalops cyprinoides*)							✓	✓
Mugilidae	sea mullet (*Mugil cephalus*)								✓
Potamodromous									
Apogonidae	mouth almighty (*Glossamia aprion*)			✓	✓	✓	✓	✓	✓

Family	Species	Project footprint		Past reports (study area)					
		Wet season survey	Dry season survey	Stuart et al. 2007	Marsden and Pow er 2007	Heindenreich and Broadfoot 2001	Long and Meager 2000	Berghuis and Long 1999	Stuart 1997
Atherinidae	fly-specked hardyhead (*Craterocephalus stercusmuscarum*)				✓	✓		✓	✓
Chandidae	Agassiz's glassfish (*Ambassis agassizii*)			✓		✓	✓	✓	✓
Clupeidae	bony bream (*Nematalosa erebi*)	✓		✓	✓	✓	✓	✓	✓
Cyprinidae	goldfish* (*Carassius auratus*)				✓				
Eleotridae	empire gudgeon (*Hypseleotris compressa*)				✓			✓	✓
Eleotridae	flathead gudgeon (*Philypnodon grandiceps*)	✓							
Eleotridae	Midgley's carp gudgeon (*Hypseleotris* species 1)		✓			✓		✓	✓
Eleotridae	purple-spotted gudgeon (*Mogurnda adspersa*)					✓			
Eleotridae	sleepy cod (*Oxyeleotris lineolata*)	✓	✓	✓	✓	✓	✓	✓	✓
Eleotridae	w estern carp gudgeon (*Hypseleotris klunzingeri*)		✓		✓	✓			✓
Melanotaeniidae	eastern rainbow fish (*Melanotaenia splendida splendida*)			✓	✓	✓	✓	✓	✓
Osteoglossidae	southern saratoga1 (*Scleropages leichardti)*			✓	✓	✓	✓	✓	

Family	Species	Project footprint		Past reports (study area)					
		Wet season survey	Dry season survey	Stuart et al. 2007	Marsden and Power 2007	Heindenreich and Broadfoot 2001	Long and Meager 2000	Berghuis and Long 1999	Stuart 1997
Percichthyidae	golden perch2 (*Macquaria ambigua oriens*)			✓	✓	✓	✓	✓	✓
Plotosidae	black catfish (*Neosilurus ater*)					✓	✓		
Plotosidae	freshwater catfish (*Tandanus tandanus*)	✓		✓	✓	✓	✓	✓	
Plotosidae	Hyrtl's tandan (*Neosilurus hyrtlii*)	✓		✓	✓	✓	✓	✓	
Plotosidae	Rendahl's catfish (*Porochilus rendahli*)			✓					✓
Poeciliidae	mosquitofish* (*Gambusia holbrooki*)				✓	✓			✓
Pseudomugilidae	Pacific blue-eye (*Pseudomugil signifier*)							✓	
Terapontida	barred grunter (*Amniataba percoides*)			✓	✓	✓	✓	✓	✓
Terapontidae	leathery grunter1 (*Scortum hillii*)			✓	✓	✓	✓	✓	✓
Terapontidae	sooty grunter (*Hephaestus fuliginosus*)				✓	✓			
Terapontidae	spangled perch (*Leiopotherapon unicolor*)			✓	✓	✓	✓		✓

[1] endemic species; [2] endemic sub-species; * introduced species

The information in this table incorporates wet and dry season field data and a summary of previous records from various studies reported in Marsden and Power (2007)

The highly invasive and destructive European carp (*Cprinus caripio*), has been recorded in a lagoon adjacent to Tartrus Weir on the Mackenzie River (Limpus et al. 2001) upstream of the Project area..

A total of ten fish species were recorded during wet and dry season field surveys within the Eden Bann Weir Project footprint (Table 5-12), all of which were common freshwater species previously recorded in the area. No conservation significant species were encountered during the field survey program. The blue catfish (*Arius graeffei*) was the most commonly recorded large fish species in both seasons, and was particularly prevalent during wet season surveys. The western carp gudgeon (*Hypseleotris klunzingeri*) was not recorded during wet season surveys, however it was a common capture in the dry season.

Table 3-12 Wet and dry season fish captures in the Eden Bann Weir Project footprint

Site name	EBA14	EBA16	EBA21	EBA23
Habitat type sampled	Run	Impounded pool	Impounded pool	Impounded pool
Wet season				
blue catfish (*Arius graeffei*)	20	44	7	15
Hyrtl's tandan (*Neosilurus hyrtlii*) (Plate 3-1)	2			3
freshwater catfish (*Tandanus tandanus*)	2	1	2	1
speckled goby (*Redigobius bikolanus*)	1			
sleepy cod (*Oxyeleotris lineolata*) (Plate 3-2)		1		1
flathead gudgeon (*Philypnodon grandiceps*)			5	1
long-finned eel (*Anguilla reinhardtii*)			1	
bony bream (*Nematalosa erebi*)				5
Dry season				
blue catfish (*Arius graeffei*)		1	2	
sleepy cod (*Oxyeleotris lineolata*)	1			
long-finned eel (*Anguilla reinhardtii*)			1	
Western carp gudgeon (*Hypseletotris klunzingeri*)	18	1	4	5
Midgley's carp gudgeon (*Hypseleotris* species 1)	2			

Plate 3-1 Hyrtl's tandan (*Neosilurus hyrtlii*)

Plate 3-2 Sleepy cod (*Oxyeleotris lineolata*)

Ecology

A species specific description of the ecology of all 41 species known and predicted to occur in the study area (including habitat preferences, dietary requirements and movement behaviour), is provided in Table 5-13, while a broad summary is detailed below.

Habitat preferences

Fish species in the Fitzroy Basin catchment have adapted to the highly dynamic and variable nature of this system (Long 2000), represented by the specific foraging, breeding and sheltering preferences of the species that occur. A review of the ecology of fish species known to occur within the Fitzroy Basin catchment revealed that most species prefer (or are tolerant of) the still or slow flowing conditions that are present in pool habitats (Pusey et al. 2004; Allen et al. 2003; Marsden and Power 2007). The relatively deep water areas within large pools provide habitat for larger-bodied pelagic (e.g. freshwater longtom, southern saratoga and golden perch) and benthic (e.g. freshwater catfish and Rendahl's catfish) species, while the shallow water margins are preferred by smaller bodied species such as western carp gudgeon, eastern rainbowfish and fly-specked hardyhead. Whilst generalist species such as the long-finned eel, striped gudgeon and barred grunter are known to inhabit the fast-flowing conditions of riffles and runs, few species in the Fitzroy Basin catchment are specifically adapted to these habitats. Species that are known to prefer flowing conditions include Marjorie's hardyhead, silver perch, and sooty grunter. None of these species were recorded during wet and dry season surveys, however the sooty grunter had been previously recorded in the study area (Table 3-11 and Table 3-12).

Foraging and breeding in the majority of fish species is associated with in-stream microhabitats in the form of fallen logs, undercut banks, root masses, complex substrates (i.e. cobble) and macrophytes. Creeks and off-stream water bodies such as floodplains and billabongs generally contain a high diversity of in-stream microhabitats and as a result provide habitat for a range of species including spangled perch, black catfish, southern saratoga, eastern rainbowfish and purple-spotted gudgeon. Off-stream water bodies also provide breeding and nursery habitat for fish species. The breeding season of a number of species (i.e. barramundi, long-finned eel, oxeye herring, spangled perch, eastern rainbowfish and empire gudgeon) is known to occur during the wet season when flows within the river are increased and off-stream water bodies are connected to the river system, facilitating access to these microhabitat environments (Reynolds 1983; Pusey et al. 2004; Stuart 1999; Stuart and Berghuis 1997).

Field surveys conducted within the Project footprint confirmed the general habitat preferences detailed from the literature review. The assemblage of species caught (Table 3-12) indicates that the impounded pool habitat provides resources for predominantly benthic species (i.e. sleepy cod, blue catfish, freshwater catfish), cryptic small-bodied species (i.e. western carp gudgeon, Midgley's carp gudgeon, flathead gudgeon) and habitat generalists (i.e. bony bream, Hyrtl's tandan). Off-stream waterbody habitats downstream of Eden Bann Weir support predominantly small-bodied native fish including Agassiz's glassfish, Midgley's carp gudgeon, fly-speckled hardyhead, purple-spotted gudgeon, spangled perch and eastern rainbow fish.

The Fitzroy Basin catchment is a highly regulated system and much of the natural aquatic habitat has been inundated as a result of weir / dam operations. Long (2000) investigated the impact of such river regulation on the spatial and temporal trends in fish habitat utilisation. Specifically, Long (2000) compared species diversity and abundance in weir and riverine environments in the Dawson River. Of the 19 species caught during the two year study, 16 were caught in both the weir and riverine habitats (Long 2000).

A notable finding of Long's study was that while species diversity between weir and riverine habitats was similar, the relative abundance of most species inhabiting these environments (as deduced from catch rates) differed. This difference was not consistent across species. For example:

- Golden perch: number caught in riverine environments twice that of weirs
- Leathery grunter: number caught in riverine environments five times that of weirs
- Hyrtl's tandan: number caught in riverine environments half that of weirs
- Spangled perch: number caught in riverine environments eight times that of weirs
- Eel-tailed catfish (freshwater catfish): number caught in riverine environments twice that of weirs.

Bony bream, the most commonly encountered species at all sites in Long's study (2000), were equally as prevalent in weir environments as riverine habitats. This species has been documented to increase in numbers in modified waterways of the Murray-Darling Basin, in spite of river regulation (Long 2000; Puckridge and Walker 1990). The bony bream is an important prey item for higher level consumers (Pusey et al. 2004) such as larger predatory fish, piscavorous birds and crocodiles, and as such, this species is an important component of aquatic trophic systems within impounded habitats.

Table 3-13 Ecology of the fish species in the Fitzroy Basin catchment

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Catadromous					
Anguillidae	long-finned eel (*Anguilla reinhardtii*)	500-3000 mm	Prefers high gradients, shallow depths and high velocities in riffles and runs however will inhabit lakes, swamps, flood plains and impoundments. Adults most commonly occur around 100 km upstream of the river month while juveniles are generally found at lower elevations. Oceanic waters are required for breeding.	Omnivorous - juveniles and sub-adults predominantly take invertebrate prey, whilst adults feed on fish, aquatic and terrestrial invertebrates and vegetation matter	Adults – catadromous, migrate from sea from late summer to autumn for spawning. Also move within the river for habitat and dispersal. Passage between freshwater and saltwater habitats are an obligatory component of the species' life history. Juveniles (elvers) – migrate from the sea to coastal rivers during spring – summer. Rising flows and increasing water temperature are suspected cues for movement.
Anguillidae	Pacific short-finned eel (*Anguilla obscura*)	Maximum 1100 mm, more commonly encountered up to approximately 600 mm.	Lower reaches of rivers and brackish coastal lagoons. Also known to occur in streams, swamps and impoundments. Juveniles commonly occur in estuarine areas. Oceanic waters are required for breeding.	Omnivorous - juveniles and sub-adults predominantly take invertebrate prey, whilst adults feed on fish, aquatic and terrestrial invertebrates and vegetation matter	Catadromous - passage between freshwater and saltwater habitats are an obligatory component of the species' life history. Downstream migration thought to peak during summer and autumn months (November – May). Rising flows and increasing water temperature are suspected cues for movement.
Centropomidae	barramundi (*Lates calcarifer*)	Maximum 1800 mm, more commonly encountered up to approximately 1200 mm.	Variety of freshwater, brackish and coastal habitats. Prefers areas with submerged logs and rock ledges. River mouths are required for breeding. Floodplain habitats are highly important for larvae.	Carnivorous - feed on micro- and macro-invertebrates and fish	Adults – catadromous, migrate from the river to the sea to spawn. Passage between freshwater and saltwater habitats are an obligatory component of the species' life history. Juveniles move upstream from estuarine nursery habitats for dispersal. Peak movement occurs from October – December. Rising flows and increasing water temperature are suspected cues for movement.

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Mugilidae	freshwater mullet (*Myxus petardi*)	Maximum 800 mm, more commonly encountered between 300-400 mm.	Prefers gently flowing rivers channels. Estuarine and oceanic habitats are required for breeding.	Largely herbivorous with algae and other plant material constituting the bulk of the diet	Catadromous - passage between freshwater and saltwater habitats are an obligatory component of the species' life history. Spawns in estuaries and the sea, peaking in February.
Scorpaenidae	bullrout (*Notesthes robusta*)	Up to 300 mm	Occurs in still or slow-flowing waters, often associated with underwater structures such as vegetation and logs. Estuarine habitats required for breeding.	Carnivorous – a benthic ambush predator. Aquatic insects and crustaceans are the primary prey items for this species	Catadromous - passage between freshwater and saltwater habitats are an obligatory component of the species' life history. Spawns in estuarine waters during winter months (May to September). Peak upstream movement in the Fitzroy River has been recorded between July and November. Low flows and cooler temperatures are suspected cues for movement.
Synbranchidae	swamp eel (*Ophisternon* spp.)	Up to 600 mm	Well-vegetated backwaters of estuarine and lower freshwater reaches of rivers. Habitats will an abundance of leaf litter and overhanging riparian vegetation are preferred.	Feeding biology poorly known – probably carnivorous, with fish and aquatic macroinvertebrates dominating the diet	Catadromous - passage between freshwater and saltwater habitats are an obligatory component of the species' life history.
Amphidromous					
Ariidae	blue catfish (*Arius graeffei*)	Up to 600 mm	Variety of habitats including coastal marine waters, estuaries, and freshwater rivers. Also known to inhabit impoundments.	Omnivorous generalist feeder, bulk of diet comprising invertebrate prey.	Amphidromous – although adults can complete entire life cycle in river. Rising flows and increasing water temperature are suspected cues for movement.

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Belonidae	freshwater longtom (*Strongylura krefftii*)	Commonly 300 – 400 mm (up to 800 mm)	Various freshwater habitats including rivers, creeks and lagoons. Occurs in still and slow flowing water. A pelagic species that often ambushes prey on the surface.	Carnivorous ambush predator – small fish are the major prey item	Amphidromous - predominantly a freshwater species that rarely occurs in the marine estuarine environments. As spawning is thought to occur in freshwater, does not necessarily need access to marine environment as part of life history requirements. Spawning thought to occur during northern Australian wet season (November – April). Increasing water temperature is a suspected cue for movement.
Eleotridae	striped gudgeon (*Gobiomorphus australis*)	Maximum 180 mm, more commonly up to 120 mm	Adults - various freshwater habitats from still, muddy pools to swiftly-flowing streams. Habitats with an abundance of in-stream debris and overhanging riparian vegetation are preferred. Larvae/juveniles inhabit estuarine habitats. Hard surfaces such as logs and rocks are required for oviposition.	Aquatic macroinvertebrates are the primary food source for this species	Possibly amphidromous. Spawning occurs in freshwater (late summer and autumn) and larvae are carried downstream to estuarine habitats. Juvenile fish are thought to migrate upstream during spring.
Gobiidae	speckled goby (*Redigobius bikolanus*)	Uncommon above 40 mm	Broad range of habitat use including brackish and estuarine habitats, and freshwater rivers and streams. Thought to prefer open, sunny habitats over heavily vegetated areas.	Predominantly carnivorous with aquatic insects the major food source	Amphidromous – eggs and larvae develop in downstream reaches of rivers with adults migrating upstream.
Hemiramphidae	snub-nosed garfish (*Arrhamphys sclerolepis*)	Maximum 400 mm, more commonly encountered between 150-200 mm.	Prefers shallow habitats in coastal and estuarine waters, lower reaches of freshwater systems, and freshwater impoundments. A pelagic species.	Predominantly herbivorous, with filamentous algae representing a principle food source	Amphidromous – thought to breed in estuaries under natural conditions, but capable of completing entire life-cycle in freshwater impoundments. Increasing water temperature is a suspected cue for movement.

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Megalopidae	oxeye herring (*Megalops cyprinoides*)	Maximum 1300 mm, more commonly encountered up to 500 mm	Occurs in coastal, estuarine and freshwater habitats. Juvenile fish may utilise smaller backwaters branching off larger rivers. Habitats with an abundance of macrophytes are preferred. Estuarine and near-shore oceanic habitats required for breeding.	Predominantly carnivorous, taking small fish, aquatic and terrestrial insects and crustaceans	Amphidromous - spawning occurs in estuarine and near-shore coastal environments. Juvenile tarpon move upstream post-metamorphous. Passage between freshwater and saltwater habitats is not considered essential for the species' life cycle. Adults migrate to marine environments to breed between December and March. Juveniles migrate upstream into freshwater habitats between January and May. Increasing water temperature is a suspected cue for movement.
Mugilidae	sea mullet (*Mugil cephalus*)	Up to 750 mm	Occurs in freshwater habitats and tends to avoid fast flowing waters, with a preference for shallow waters with a soft benthos. Oceanic waters are required for breeding.	Omnivorous, with algae and detritus the core components of the diet of this species	Amphidromous – spawning occurs in the marine environment passage between freshwater and saltwater habitats, an obligatory component of this species' life history. Spawning occurs in the sea – adults migrate in large schools to river mouths and adjacent coastlines during winter months. Juvenile fish migrate up rivers during spring / summer months. 1 -2 year old fish occasionally make non-spawning related migrations to the marine environment.
Potamodromous					
Apogonidae	mouth almighty (*Glossamia aprion*)	Up to 180 mm	Most habitats with a preference for shallow well-vegetated margins. Is tolerant of a variety of environmental conditions.	Largely carnivorous taking aquatic invertebrates and small fish.	Potamodromous – a freshwater species that does not require access to estuarine or marine environment at any stage of life cycle. Increasing water temperature suspected as a cue for movement.

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Atherinidae	fly-specked hardyhead (*Craterocephalus stercusmuscarum*)	Maximum 80 mm, more commonly encountered between 50-60 mm.	Occurs in a variety of habitats including flood plains, billabongs, brackish estuaries and impoundments. Prefers slow-flowing areas dominated by aquatic vegetation and gravel substrates. Aquatic root masses may be important for spawning.	Feeds on small aquatic invertebrates and algae	Potamodromous - entire life-cycle (including spawning) occurs in freshwater. Increasing water temperature is a suspected cue for movement.
Atherinidae	Marjorie's hardyhead (*Craterocephalus marjoriae*)	Up to 85 mm	Occurs in clear, flowing shallow water in streams and creeks. Aquatic vegetation and sandy or gravel substrates are preferred by this species. Aquatic macrophytes and submerged marginal vegetation are preferred habitat for spawning.	Omnivorous feeding on small aquatic invertebrates and algae	Potamodromous - a freshwater species that does not require access to estuarine or marine environment at any stage of life cycle. Movement behaviour poorly understood although not thought to undertake large movements. August to April represents periods of increased movement. Increasing water temperature is a suspected cue for movement.
Chandidae	Agassiz's glassfish (*Ambassis agassizii*)	Up to 75 mm	Occurs in well-vegetated areas in rivers, creeks, swamps and ponds, generally in areas of little or no flow Macrophytes and submerged marginal vegetation preferred for spawning.	Largely carnivorous – microcrustaceans and small aquatic insects the major prey items	Potamodromous - adults and juveniles move upstream (September-February) for habitat and dispersal, possibly in response to flooding. A freshwater species that does not require access to estuarine or marine environment at any stage of life cycle. Rising flows and increasing water temperature are suspected cues for movement.
Clupeidae	bony bream (*Nematalosa erebi*)	Maximum 470 mm, more commonly encountered between 150-200 mm	Prefers shallow waters with little or no flow, in creeks, streams and rivers. Is tolerant of a range of environmental conditions including high turbidity.	Omnivorous – detritus a major component of the diet	Potamodromous – adults and juveniles move upstream for dispersal. A freshwater species that does not require access to estuarine or marine environment at any stage of life cycle. Increasing water temperature is a suspected cue for movement.

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Cyprinidae	goldfish* (*Carassius auratus*)	Seldom greater than 200 mm	Occurs in still and slow-flowing freshwater environments. Capable of withstanding high temperatures and low dissolved oxygen levels.	Omnivorous – detritus, plant matter and aquatic insects form the bulk of the diet of this species	Potamodromous
Eleotridae	Empire gudgeon (*Hypseleotris compressa*)	Attains a size of 120 mm	Occurs in lower reaches of rivers, occasionally estuarine waters. Prefers still or slow-flowing waters with underwater structure. Oviposition likely to occur on aquatic macrophytes, rocks and woody debris.	Omnivorous – feeds on small invertebrate prey and vegetation matter	Potamodromous - a predominantly freshwater species where access to estuarine or marine environments is not an essential component of the life history. Upstream migrations for spawning and juvenile dispersal occur in late spring and early summer. Rising flows and increasing water temperature are suspected cues for movement.
Eleotridae	flathead gudgeon (*Philypnodon grandiceps*)	Maximum 120 mm, more commonly encountered up to 80 mm	Predominantly found in freshwater habitats (creeks, rivers, billabongs) with little or no flow, and underwater structure (vegetation, undercut banks, logs). Also occurs in brackish tidal environments. Rocks and woody debris are required for oviposition.	Predominantly carnivorous, with aquatic insects a favoured food item	Potamodromous - a predominantly freshwater species where access to estuarine or marine environments is not an essential component of the life history. May move in response to periods of peak flow (August to April). Rising flows and increasing water temperature are suspected cues for movement.
Eleotridae	Midgley's carp gudgeon (*Hypseleotris* species 1)	Up to 60 mm	Occurs in streams, creeks, swamps, wetlands and ponds boasting underwater structure such as aquatic vegetation, rocks and logs. Hard surfaces near the substrate are preferred for oviposition.	Predominantly carnivorous, with aquatic insects a favoured food item	Potamodromous - a freshwater species that does not require access to estuarine or marine environment at any stage of life cycle. Spawning peaks between September and January. Increased water temperature and day length are suspected cues for movement.

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Eleotridae	purple-spotted gudgeon (*Mogurnda adspersa*)	Up to 120 mm	Avoids areas of high water flow. Seeks out aquatic vegetation in slow-flowing parts of rivers and streams, often with rocky substrate. Also occurs in still water bodies including billabongs. Aquatic macrophytes, rocks and woody debris required for oviposition.	Predominantly carnivorous, with aquatic insects a favoured food item	Potamodromous - a freshwater species that does not require access to estuarine or marine environment at any stage of life cycle. Increasing water temperature suspected as a cue for movement.
Eleotridae	sleepy cod (*Oxyeleotris lineolata*)	Maximum 500 mm, more commonly encountered up to 200 mm	Prefers slow-flowing water amongst submerged structure (vegetation, timber) in rivers, creeks, lagoons and billabongs. Also tolerant of turbid conditions. Large woody debris required for spawning.	Predominantly carnivorous, with aquatic insects a favoured food item	Potamodromous – does not make substantial migrations and does not require access to estuarine or marine environments at any stage of life cycle. Rising flows associated with rainfall and increasing water temperature is a suspected cue for movement.
Eleotridae	western carp gudgeon (*Hypseleotris klunzingeri*)	Rarely exceeds 45 mm	Avoids areas of high water flow. Seeks out aquatic vegetation in slow-flowing parts of rivers and streams. Also occurs in still water bodies such as lakes and impoundments. Aquatic macrophytes, submerged marginal vegetation and woody debris may be important for oviposition.	Predominantly carnivorous, with aquatic insects a favoured food item	Potamodromous - a freshwater species that does not require access to estuarine or marine environments at any stage of life cycle. May move upstream to spawn during the wet season. Increased water temperature and day length are suspected cues for movement.

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Melanotaeniidae	eastern rainbow fish (*Melanotaenia splendida splendida*)	Maximum 140 mm, more commonly encountered up to 80 mm	A habitat generalist that occurs in a wide array of still to slow-flowing freshwater habitats, including creeks, swamps, wetlands, rivers and impoundments. Aquatic vegetation and root masses preferred for oviposition.	Omnivorous – algae and aquatic invertebrates the major component of this species' diet	Potamodromous – a freshwater species that does not require access to estuarine or marine environments at any stage of life cycle. Recorded moving upstream of the Fitzroy Barrage throughout the year, particularly between November and April. The number of fish recorded ascending the Fitzroy Barrage was low. Rising flows and increasing water temperature are suspected cues for movement.
Osteoglossidae	southern saratoga1 (*Scleropages leichardti*)	Maximum 1000 mm, more commonly encountered up to 550 mm	Occurs in Billabongs, large pools, impoundments and slow-flowing rivers and streams. Submerged structure and turbid waters are favoured by this species.	A pelagic carnivorous predator that takes insects, crustaceans, fish and frogs	Potamodromous - strictly a freshwater species – unknown whether migration occurs within freshwater systems.
Percichthyidae	golden perch2 (*Macquaria ambigua oriens*)	Maximum 760 mm, more commonly encountered up to 400 mm	Inhabits rivers, creeks, billabongs and lakes. Favours deeper, slow-flowing, turbid habitats with an abundance of in-stream debris and shade.	Carnivorous – primarily preys on aquatic invertebrates and small fish	Potamodromous - a freshwater species that does not require access to estuarine or marine environments at any stage of life cycle. Movement recorded in the Fitzroy River (through the Fitzroy Barrage) during spring and summer months. Spawning and recruitment triggered by increased flows and water temperatures above 23° C.
Plotosidae	black catfish (*Neosilurus ater*)	Maximum 470 mm, more commonly encountered up to 250 mm.	A benthic species that prefers fast-flowing waters in streams and rivers. Also occurs in wetlands, pools, and slow-flowing tributaries and side-channels of rivers.	Omnivorous, although diet dominated by aquatic invertebrates	Potamodromous – a freshwater species that does not require access to estuarine or marine environments at any stage of life cycle. Migrations upstream thought to coincide with spawning at the outset of the wet season (January-February). Downstream migration of adults and juveniles post-spawning is poorly understood. Rising flows and increasing water temperature are suspected cues for movement.

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Plotosidae	freshwater catfish (*Tandanus tandanus*)	Maximum 900 mm, more commonly encountered up to 450 mm	Prefers slow flowing streams, also lakes and impoundments. A benthic species that generally favours sandy or gravel substrates. Gravel substrate required for spawning.	Omnivorous, although diet dominated by aquatic invertebrates	Potamodromous - a generally sedentary freshwater species that does not require access to estuarine or marine environment at any stage of life cycle. May be territorial. Rising flows is a suspected cue for movement.
Plotosidae	Hyrtl's tandan (*Neosilurus hyrtlii*)	Maximum 340 mm, more commonly encountered up to 200 mm.	Occurs in most freshwater habitats above estuarine reaches. Tributary streams and gravel substrates may be important for spawning.	Omnivorous, although diet dominated by aquatic invertebrates	Potamodromous – upstream migrations from dry season refugia thought to coincide with spawning. Movement in the Fitzroy River system greatest between November and March. Rising flows suspected as cue for movement.
Plotosidae	Rendahl's catfish (*Porochilus rendahli*)	Up to 240 mm	A benthic species inhabiting river channels and tributaries. Usually associated with muddy substrates. Tolerant of turbid water.	Omnivorous, although diet dominated by aquatic invertebrates	Potamodromous – adults migrate downstream to spawn in flooded lowland lagoons. Upstream migration of adults and juveniles coincident with the start of the dry season.
Poeciliidae	guppy* (*Poecilia reticulata*)	Females up to 60 mm, males up to 30 mm	Prefers still and slow-flowing water. Predominantly shoal around the margins of water bodies, amongst aquatic and overhanging bankside vegetation.	Omnivorous	Potamodromous
Poeciliidae	mosquitofish* (*Gambusia holbrooki*)	Females to 60 mm, males to 35 mm	Occurs in shallow, warm waters with little or no flow. Generally occurs along margins of stream bank.	Omnivorous	Potamodromous

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Pseudomugilidae	Pacific blue-eye (*Pseudomugil signifer*)	Up to 70 mm	Marine to freshwater environments. Usually frequents habitats boasting submerged structure, but may also occur in pools and clear streams. Shallow, flowing water is favoured by this species. Breeding can occur in freshwater and saltwater habitats.	Omnivorous, although diet dominated by aquatic invertebrates	Potamodromous - although this species is known to utilise estuarine and marine environments, access to saline habitats is not obligatory for survival. Increasing water temperature is a suspected cue for movement.
Terapontidae	barred grunter (*Amniataba percoides*)	Maximum 180 mm, more commonly encountered up to 120 mm	Benthic species that occurs in still to fast-flowing water. Tolerant of highly variable temperature, turbidity and pH.	Omnivorous, although diet dominated by aquatic invertebrates	Potamodromous – thought to move downstream in the wet season into lowland floodplains. Access to saline habitats is not obligatory for population viability in this species. Recorded moving through Eden Bann Weir between April and January (concentrated during dry season). Upstream movement beyond the Fitzroy Barrage peaks between September and November. Movements associated with spawning correspond with increasing water temperatures and possibly increased day length.
Terapontidae	leathery grunter1 (*Scortum hillii*)	Maximum 350 mm, more commonly encountered up to 250 mm	Flowing streams and still water bodies. Tolerant of turbid conditions and temperatures up to 35 °C. Also found in estuarine environments.	Freshwater mussels and algae constitute the two major food items for this species	Potamodromous – a predominantly freshwater species that migrates upstream to spawn during the wet season.
Terapontidae	silver perch (*Bidyanus bidyanus*)	Maximum size of 400 mm	In riverine environments prefers areas of faster flow (often below riffle zones, weirs etc). Also occurs in still habitats such as lakes and reservoirs.	Omnivorous – feeds on aquatic invertebrates and algae	Potamodromous – a freshwater species that does not require access to estuarine or marine environment at any stage of life cycle. Upstream spawning migration occurs in spring (September – January). Rising flows and increasing water temperature are suspected as cues for movement.

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Terapontidae	sooty grunter (*Hephaestus fuliginosus*)	Up to 450 mm	Occurs in large flowing waterways, particularly the upstream reaches of rivers. Prefers habitats boasting aquatic vegetation on a sandy or rocky substrate. Fast-flowing habitats may be important for spawning.	Omnivorous – feeds on aquatic invertebrates, algae and aquatic and terrestrial vegetation	Potamodromous - a freshwater species that does not require access to estuarine or marine environments at any stage of life cycle. May migrate between wet season (August – February) spawning grounds (upstream in rapids) and dry season refugia.
Terapontidae	spangled perch (*Leiopotherapon unicolor*)	Up to 300 mm	A generalist species that occurs in most permanent and temporary freshwater habitats including billabongs, impoundments, rivers and streams. Highly tolerant of environmental variability Non-flowing, shallow habitats with soft substrate are preferred for spawning.	Omnivorous – feeds on aquatic invertebrates, algae and aquatic and terrestrial vegetation	Potamodromous – depending on locality, moves upstream or downstream within the freshwater environment to spawn. Spawning migrations coincide with the wet season (October – April). This species may also undertake substantial movements away from dry season habitats as they recede. Rising flows and increasing water temperature are suspected cues for movement.

Ecological information in table sourced from Pusey et al. (2004); Allen et al. (2003); Marsden and Power (2007); [1] endemic species; [2] endemic sub-species; * introduced species

Movement behaviour and hydrological requirements

Fish species within the Fitzroy Basin catchment regularly move among spawning, feeding and refuge habitats. Movement behaviours can be classified into one of three groups:

- Catadromous: fish that spend the majority of their lives in freshwater, but migrate to the sea to breed
- Amphidromous: fish that move between freshwater and estuarine/marine environments at defined periods of their life cycle, but not for the purposes of reproduction
- Potamodromous: fish that carry out their entire life cycle within the freshwater environment.

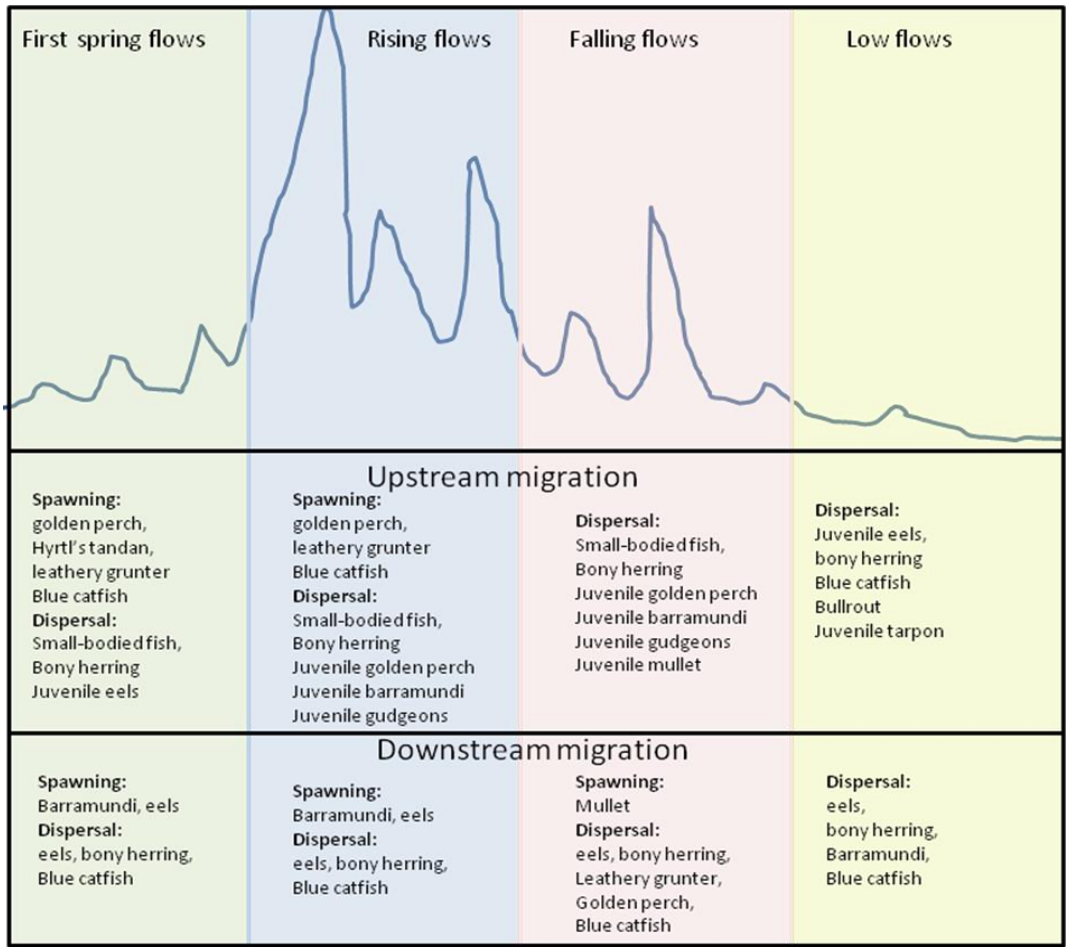
Fish species diversity recorded in the Project footprint was dominated by potamodromous species (83%) with a small number of amphidromous species also recorded (17%). No catadromous species were captured during the field surveys however four catadromous species (i.e. long-finned eel, barramundi, bullrout and swamp eel) have been previously recorded in the study area.

The Fitzroy system is typical of many dry tropical rivers in northern Australia where local fish migration is strongly associated with hydrological changes (Hogan et al. 1997; Renfree and Marsden 2006). Other factors or combinations of environmental factors which stimulate migration include water temperature, day length, food availability, fish biomass and water chemistry. The hydrological cue, however, is recognised as one of the most important for influencing tropical river fish communities and their migrations (Baran 2006; Sheaves et al. 2007). Hydrology can be divided into a number of different, but related, factors including: variation in river height, variation in discharge, turbidity, and first rainfalls of the (pre)-wet season.

Golden perch is highlighted as the species most sensitive to high flow and flood migration triggers (Stuart and Mallen-Cooper 1999; Mallen-Cooper and Edwards 1991; Marsden and Power 2007). Nevertheless, the majority of species that inhabit the Fitzroy Basin catchment demonstrate a strong migratory tie to large flood events (>120,000 ML/d) and many others respond to increased flows (Stuart and Mallen-Cooper 1999; Mallen-Cooper and Edwards 1991; Marsden and Power 2007). A migration model demonstrating the temporal relationship between migratory behaviour of fish in the Fitzroy River system and river flow is provided in Figure 3-3.

As shown in Figure 3-3 the first post winter flood is likely to trigger spawning and dispersal migrations for a number of species and these are likely to continue during summer flows (Marsden and Power 2007). For catadromous fish (e.g. barramundi and eels), high flows and floods are especially important for spawning migrations to downstream estuarine and marine waters. Barramundi have shown increased recruitment and strong year-classes associated with high flows when fish can migrate laterally into off-stream water bodies (Staunton-Smith et al. 2004). Low flow events are important for upstream dispersal migrations of several juvenile fish species including sea mullet, leathery grunter, Hyrtl's tandan and empire gudgeon (Marsden and Power 2007).

Figure 3-3 Relationship between fish migration and flow in the Fitzroy River



Source: modified from Marsden and Power 2007

Fish migration at high flows is well known to the Aboriginal people who constructed the Brewarrina fish traps to collect migratory golden perch and other fishes during flow events on the Darling system (Dargin 1976). These observations are supported by state fisheries agency surveys of the Darling and Murray systems during flooding when large numbers of golden perch were migrating upstream at weirs (Mallen-Cooper and Edwards 1991, Harris et al. 1992, Mallen-Cooper 1996). In the Australian tropics, state fisheries agency studies that have also collected large numbers of fish at high flows include Hogan et al. (1997) (flows of more than 127,000 ML/d) and Renfree and Marsden (2006) in the fishway on the Burdekin system at Clare Weir where large numbers of fish (comprising 27 species were collected during the study) (flows of 60,000 ML/d).

On the Fitzroy River at Eden Bann Weir, large numbers of fish were collected migrating at flows of 35,000 plus ML/d (higher flows could not be sampled due to safety considerations) (Stuart et al. 2007). Observations of considerable numbers of fish in the rock pools below the weir, after high flow events, indicated that there had been migration during flood events (Stuart et al. 2007). Fish species most noted to migrate on high flows were golden perch, blue catfish and leathery grunter.

At the Fitzroy Barrage, fish (primarily catfish species and long-finned eels) were collected on major flow events (more than 197, 000 ML/d (exceeded 0.5 per cent of the time)) before the fishway drowned-out and sampling was suspended (Stuart and Mallen-Cooper 1999). These represent some of the highest flows ever sampled because these conditions usually present insurmountable safety hazards to field staff.

For catadromous fish, high flows and floods are especially important for downstream migration, often over weirs on their journey to estuarine and marine waters for spawning. Barramundi have shown increased recruitment and strong year-classes associated with high flows when fish migrate laterally into connected floodplains (Staunton-Smith et al. 2004). Hence, catadromous fish have evolved a migration strategy to take advantage of flooding.

In the order of 30 per cent of species in the Fitzroy River migrate strongly on large floods (defined as being more than 120,000 ML/d) and many others respond to increasing flows as shown in Table 3-14.

Table 3-14 Sensitivity of fish migration to hydrology

Fish species	Flood migration	First spring flow migration	Maximum discharge when observed (where available)
Diadromous			
Long-finned eel	✓	✓	+195,757 ML/d (+2265 m^3/s)[1, 3]
Swamp eel			127,457 ML/d (1475 m^3/s)[1]
Bullrout			6,937 ML/d (80 m^3/s)[3]
Barramundi	✓	✓	127,457 ML/d (1475 m^3/s)[1]
Blue catfish	✓	✓	195,757 ML/d (2265 m^3/s)[1]
Striped mullet	✓		127,457 ML/d (1475 m^3/s)[1]
Oxeye herring			127,457 ML/d (1475 m^3/s)[1]
Freshwater longtom			660 ML/d (8 m^3/s)[1]
Snub-nosed garfish			660 ML/d (8 m^3/s)[1]
Potamodromous			
Spangled perch	✓	✓	127,457 ML/d (1475 m^3/s)[1]
Sooty grunter			660 ML/d (8 m^3/s)[1]
Banded grunter	✓	✓	127,457 ML/d (1475 m^3/s)[1]
Leathery grunter	✓	✓	+195,757 ML/d* (+2265 m^3/s)[3, 5]
Golden perch	✓	✓	119,581 ML/d (1384 m^3/s)[2, 3, 5]
Bony herring	✓	✓	127,457 ML/d (1475 m^3/s)[1, 3, 5]
Fly-specked hardyhead			65,466 ML/d (758 m^3/s)[1]
Olive perchlet			65,466 ML/d (758 m^3/s)[1]
Rendahl's catfish		✓	
Hyrtl's tandan	✓	✓	195,757 ML/d (2265 m^3/s)[3]
Black catfish	✓		127,457 ML/d (1475 m^3/s)[1]
Mouth almighty			65,466 ML/d (758 m^3/s)[1]
Eastern rainbowfish			119,581 ML/d (1384 m^3/s)[1, 3, 5]

Fish species	Flood migration	First spring flow migration	Maximum discharge when observed (where available)
Sleepy cod			127,457 ML/d (1475 m^3/s)[1, 5]
Empire gudgeon			127,457 ML/d (1475 m^3/s)[1, 4]
Purple-spotted gudgeon			65,466 ML/d (758 m^3/s)[1]
Midgley's carp gudgeon		✓	
Western carp gudgeon		✓	
Eel-tail catfish		✓	

*=small numbers

References: [1] Hogan et al. 1997; [2] Mallen-Cooper and Edwards 1991; [3] Stuart and Mallen-Cooper 1999; [4] Renfree and Marsden 2006; [5] Marsden and Power 2007.

Hydrological requirements for key large-bodies fish species are summarised:

- Golden perch

  Golden perch from the Fitzroy basin are a genetically and morphologically distinct sub-species from the southern population. The species is distributed widely throughout the sub-catchments and has been observed moving through the fishways at the Fitzroy Barrage (Stuart 1997), Eden Bann (Stuart et al. 2007) and other weirs (Marsden and Power 2007).

  Migratory requirements include the need to migrate upstream and downstream to breed (Reynolds 1983; Pusey et al. 2004; O'Çonnor et al. 2005). The flood recruitment model has been proposed in the past as the main mechanism for recruitment for golden perch in the Murray-Darling Basin but they can also recruit during rising flows within the river channel (Lake 1967; Mallen-Cooper and Stuart 2003). In the Fitzroy River system, there is strong recruitment in years associated with high flows and floods in late spring and summer (Roberts et al. 2008). The degree of river regulation can also depress recruitment patterns. This strategy potentially allows larvae to benefit from the floodplain at times of maximum inundation, and maximum exposure to larval food supplies (O'Connor et al. 2003)

  Migration often occurs in the spring and summer months but has also been recorded after flow events in autumn and winter (Stuart and Berghuis 1999; pers. com. Dawson River Fish Stocking Group). This indicates that migrations are most likely temperature independent and more driven by opportunistic flow events (Marsden & Power 2007).Migration is triggered by environmental cues such as temperature and flow events but is not necessarily restricted to initial or periods of high flow (Marsden and Power 2007). This species has been witnessed moving through the Fitzroy River barrage over a wide range of flows (Stuart 1997). It has been determined that 1.83 m/s is an appropriate water velocity in fishways for an adult golden perch (Mallen-Cooper 1994).

- Barramundi

  Barramundi spawn in saltwater and the juveniles often migrate upstream into freshwater (Mallen-Cooper 1992). Juveniles move upstream on high flow events preferably on the tail of the hydrograph, at least three days after the peak flow but they can also move upstream opportunistically at lower flows (Marsden and Power 2007).

  Barramundi generally move during spring and summer with sub-adult fish (100-400 mm) forming the majority of migrating fish (Stuart 1999, Renfree and Marsden 2006). Individuals will still continue migrations throughout the cooler months but in lower numbers (Marsden

and Power 2007). There is limited fish movement when water temperature is below 22.5°C. In other rivers, upstream movement has not been recorded at low flows. In the Fitzroy River movement has been observed at a range of flows up to about 8,000 ML/day (Pusey, Kennard and Arthington 2004). Juvenile barramundi (43 mm) have been recorded moving through laboratory fishways with a swimming speed of 0.66 m/s (Mallen-Cooper 1992). This is thought to be a conservative estimate of barramundi swimming speed due to the low water temperature used in the experiment. Within the Fitzroy River, barramundi were observed negotiating a fishway with a maximum water velocity of 1.4 m/s (Stuart 1997). Barramundi can also pass barriers and obstacles during a period of drown-out (Marsden and Power 2007).

- Long-finned eel

  Long-finned eels are catadromous with adults migrating downstream on a variety of flows in order to breed at sea. Migration downstream occurs in autumn with the onset of cooler weather. As movement occurs under a variety of flow conditions, this movement is most likely temperature dependent (Stuart and Berghuis 1999). Elders (50-100 mm) migrate upstream during high flow events in spring and summer. This movement is protracted as individuals must allow time to acclimate to reduced salinity upstream (Pusey, Kennard and Arthington 2004). Within the freshwater environment, fish are thought to exhibit limited local movement (Pusey et al. 2004).

  Long-finned eels have been recorded above Tartrus Weir, on which no fishway is present. This occurrence might be explained by the fact long-finned eels have been demonstrated to migrate past barriers of a similar size to Tartrus Weir (Marsden and Power 2007). This species has been observed climbing obstacles and travelling short distances over damp ground. Several researchers have advocated the inclusion of roughened substrate on fishways in order to enable climbing (friction with substrate) (Langdon and Collins 2000; Stuart and Berghuis 2002). The swimming ability of this species (0.32-0.75 m/s) may be below that necessary to negotiate the high velocities frequently observed in fishways (Langdon and Collins 2000).

- Stripped mullet

  Striped mullet are amphidromous moving downstream during autumn as part of their annual migration to spawning grounds in the sea (Stuart and Berghuis 1999, Stuart 1999). These downstream migrations are triggered by specific water temperature conditions. They migrate downstream in the autumn with the onset of cooler weather and on a variety of flows (Stuart and Berghuis 1999). The juveniles then disperse upstream during spring and summer (Power and Marsden 2006). The juveniles utilise low flows to undertake dispersal migrations and have been recorded migrating on low flows through a fishway on Raglan Creek, indicating the importance of passage at that time (Power and Marsden 2006). Fish under 40 mm have been observed negotiating the Fitzroy Barrage and Burnett vertical-slot fishways which have a maximum water velocity of 1.4 m/s (Stuart and Mallen-Cooper 1999; Stuart and Berghuis 2002).

- Saratoga

  The saratoga is endemic to the Fitzroy River system. While there is limited knowledge of the movement biology of this species, it is present throughout the upper Fitzroy, Dawson and Mackenzie rivers and is not considered to be migratory (Merrick and Schmida 1984). Local

anglers have reported large numbers of saratoga congregating below the Neville Hewitt Weir during flow events (pers. com. Dawson River Fish Stocking Group). This anecdotal evidence indicates this species may undertake facultative migrations. One saratoga has been collected in the Eden Bann Weir fish lock (Stuart et al. 2007).

- Fort-tailed catfish

  Fork-tailed catfish are an amphidromous species. They reproduce in freshwater and in estuarine waters and movement may be stimulated by various conditions (Pusey et al. 2004). Individuals have been recorded moving through Eden Bann Weir's fish lock, reaching peak numbers at the top of each flow event throughout the summer months (Stuart and Berghuis 1997), while lower numbers occur on flow peaks throughout the rest of the year (Stuart 1999; Marsden and Power 2007). At the Kolan River Barrage, the species has been observed migrating upstream in flows up to 5500 ML/d (Broadfoot, Berghuis and Heidenreich 2000). Movement at high flows has also been observed at the Fitzroy Barrage (1.6 per cent exceedence). Movement is greatly reduced in the colder winter months.

- Leathery grunter

  The leathery grunter is endemic to the Fitzroy Basin. Upstream migration has been documented prior to spawning suggesting the species is potamodromous (Merrick and Schmida 1984). Sampling at barriers within the Fitzroy catchment indicate the first flood of spring as being a major migration cue for the species (Stuart et al. 2007).This species undertakes upstream migrations coinciding with summer rainfall prior to spawning. Anecdotal reports suggest that the numerous barriers on the Fitzroy-Dawson river systems prevent upstream migration necessary for reproduction (Marsden and Power 2007).

- Sleepy cod

  It does not appear as though this species undertakes substantial migrations (Pusey, Kennard and Arthington 2004). Only five and 21 individuals have been observed moving through the Fitzroy Barrage and Eden Bann Weir fishway, respectively. A small number have also been recorded at the Clare Weir fishway in the Burdekin system (Renfree and Marsden 2006). It is expected that this species moves in response to changing abundance of prey fish rather than a need to migrate.

- Oxeye herring

  A small number of oxeye herring have been detected ascending the Fitzroy River Barrage during March and April only (Kowarsky and Ross 1981) and they have also been found in the Burnett Barrage fishway. It is believed that this species undertakes downstream spawning migrations. There is debate as to whether adults return upstream after spawning (Pusey et al. 2004). This species has been recorded attempting to ascend Clare Weir fishway on the Burdekin River under flow conditions (65,466 ML/d – 127,467ML/d).

Hydrological requirements for key small-bodied fish species are summarised:

- Fly speckled hardyhead

  The movement pattern of the fly speckled hardyhead is described as facultative potamodromy. Access to estuarine areas is not a necessary component of the life cycle. The species is abundant in streams that are periodically disconnected during low flow. Therefore the species has the ability to survive in isolated pools and rapidly recolonise previously dry stretches (Pusey et al. 2004). Within the Fitzroy River, upstream migration

peaks in early summer with low fish movement occurring for the remainder of the year. There are few records of this species undertaking downstream movement (Stuart 1997). The environmental cue for movement is unknown however elevated flows are a likely stimulus (Pusey et al. 2004). The fly speckled hardyhead has been recorded moving through a fishway at flows of 18,305 ML/d. This flow is exceeded 10 per cent of the time in the Fitzroy River (Stuart 1997). The species has difficulty ascending pool-weir type fishways and has been observed in large numbers immediately downstream of obstructions (Pusey et al. 2004).

- Eastern rainbowfish

  The eastern rainbowfish is a potamodromous species. Adults migrate upstream in order to spawn. During high flow events the species undertakes dispersal migration (Pusey et al. 2004). Eastern rainbowfish have been observed in low numbers moving through fishways on the Fitzroy River at low flows (Stuart 1997). The highest rate of movement has been recorded from November to April.

- Hyrtl's tandan

  The Hyrtl's tandan is a potamodromous species. Adults migrate upstream to spawn, and then disperse downstream (Pusey et al. 2004). Individuals have been observed moving upstream through fishways on the Fitzroy River. Movement occurs between November and March under most flow conditions. Small fish (<150 mm) only moved upstream during low flow conditions (18 ML/d) (Stuart 1997). At Eden Bann Weir, there has been a strong migration response of Hyrtl's tandan to the first rising flows of spring and this has also been observed elsewhere (A. Berghuis, pers. comm.).

- Midgleys carp gudgeon

  Midgleys carp gudgeon has been observed moving upstream in a tributary of the Fitzroy River (Wager 1997). Upstream migration may occur after being displaced from a flow event or as dispersal movements when flow conditions allow.

- Empire gudgeon

  The species is described as facultative potamodromous or semi-amphidromous. The species engage in a facultative mass dispersal phase and mass upstream migrations (Renfree and Marsden 2006). It is unclear whether empire gudgeon undertake migration for spawning or simply recolonising freshwater (Pusey et al. 2004). They have the ability to breed in freshwater. They have been observed entering the Fitzroy Barrage fishway on a wide variety of flows (18-18,305 ML/d) (flows are exceeded about 82 per cent to 8 per cent of the time respectively) (Stuart 1997). Upstream migration usually takes place in spring and summer, particularly on large flow events. They have the ability to swim at a velocity of 1 m/s (Hogan, Graham and Vallance 1997).

Barriers such as weirs compromise the ability of fish to freely move downstream and upstream within the freshwater environment or between the freshwater and estuarine / marine environment. A vertical-slot fishway at the Fitzroy Barrage and a fish lock at Eden Bann Weir facilitate up- and downstream movement of many fish species. The vertical slot-fishway at Fitzroy Barrage represents a successful upgrade to the 'weir-and-pool' fishway originally constructed. However the smallest fish species, and small size-classes (i.e. immature and juveniles) of larger species are often unable to negotiate the structure, likely as a result of their inability to swim against the high velocity water flow at the downstream entrance of the fishway (Stuart and Mallen-Cooper 1999).

During low flows, the Eden Bann Weir fish lock has been recorded to successfully pass a broad size range (35 – 710 mm long) of species however passage efficiency is reduced at high flows due to a reduced attraction of the fishway entrance (Long and Meager 2000; Stuart et al. 2007).

Conservation significant species

While no fish species listed as threatened under the EPBC Act or NC Act were identified from the literature review and field studies as occurring / potentially occurring in the Fitzroy Basin catchment (including the Project footprint), the following species are considered conservation significant due to their restricted geographic range.

- **Southern saratoga (*Scleropages leichardti*) –** the southern saratoga is endemic to the Fitzroy Basin catchment. As it has a restricted natural geographic range (the species has been stocked in waterways of South East Queensland), is endemic and generally uncommon, and is a unique remnant of a primitive group of fish, the southern saratoga is considered to have important local conservation values. This species prefers slow flowing pools and backwaters, and is tolerant of turbid conditions (Allen et al. 2003). Pool and creek habitats within the Project footprint represent potentially suitable habitat, and while no southern saratoga were encountered during wet and dry season surveys, the species is known to occur in the study area and is likely to occur in the Project footprint.
- **Leathery grunter (*Scortum hillii)*** – the leathery grunter is endemic to the Fitzroy Basin catchment. As it has a restricted natural geographic range, is endemic and relatively uncommon, the leathery grunter is considered to have important local conservation values. It prefers flowing waters where it feeds near the benthos (particularly on mussels and algae), however it also inhabits still areas, and is tolerant of turbid conditions (Allen et al. 2003). Pool and run habitats within the Project footprint are likely to provide suitable habitat for this species. No leathery grunter were recorded during wet and dry season surveys in the Project footprint, however due to the availability of suitable habitat, and the fact that the species has been previously recorded in the study area, it is considered likely to occur.
- **Golden perch (*Macquaria ambigua oriens*) –** this sub-species of the golden perch is endemic to the Fitzroy Basin catchment with relatively secure populations (Marsden and Power 2007). The golden perch occurs in a variety of aquatic habitats, but shows a preference for slow-flowing turbid habitats with an abundance of in-stream debris. While no golden perch were recorded during wet and dry season surveys in the Project footprint, the availability of suitable habitat and its known presence in the study area indicate that it is likely to occur within the Project footprint.
- **Ornate rainbowfish (*Rhadinocentrus ornatus*) –** due to its restricted distribution and habitat degradation, the ornate rainbowfish has been identified as high priority under the 'Back on Track' prioritisation framework for conservation management of Queensland's wildlife within the Fitzroy Natural Resource Management area (DERM 2008). This species is typically associated with waterways in coastal lowland wallum and rainforest ecosystems, as well as coastal sand islands (Pusey et al. 2004). The ornate rainbowfish was not recorded during wet and dry season surveys, and has not been previously recorded in the study area. Due to the lack of suitable habitat, it is unlikely to occur in the Project footprint.

Recreationally and commercially important fish species

Species with significant fisheries values previously recorded upstream of Eden Bann Weir include the barramundi (*Lates calcarifer*), a species that is a key target of the Queensland East Coast Inshore Fin Fish Fishery (DEEDI 2009). While commercial net fishing does not occur within the Project footprint, the life-history traits of the barramundi include utilisation of both freshwater and saltwater habitats. As such, barramundi occurring upstream of Eden Bann Weir should be considered a potential component of the downstream commercial fishery. Other commercially-important catadromous / amphidromous species known to occur above Eden Bann Weir include sea mullet (*Mugil cephalus*) and long-finned eel (*Anguilla reinhardtii*). Important recreational species recorded in the study area include barramundi, southern saratoga, golden perch, blue catfish (*Arius graeffei*), freshwater catfish (*Tandanus tandanus*), sleepy cod (*Oxyeleotris lineolata*), oxeye herring (*Megalops cyprinoides*) and snub-nosed garfish (*Arrhamphus sclerolepis*).

3.4.3 Freshwater turtles

Species diversity

The Fitzroy Basin catchment supports one of the highest diversities of freshwater turtles in Australia, including two regionally endemic, conservation significant species. Turtle species that inhabit the Fitzroy River include:

- Fitzroy River turtle (*Rheodytes leukops*)
- White-throated snapping turtle (*Elseya albagula*)
- Saw-shelled turtle (*Elseya latisternum*)
- Krefft's river turtle (*Emydura krefftii*)
- Broad-shelled river turtle (*Chelodina expansa*)
- Eastern snake-necked turtle (*Chelodina longicollis*).

The Fitzroy River turtle is endemic to the Fitzroy Basin catchment and is listed as 'Vulnerable' under the EPBC Act and the NC Act. The white-throated snapping turtle is endemic to the Fitzroy, Burnett and Mary river catchments and is listed as least concern under the NC Act and is ranked as high priority under DEHP's Back on Track framework. The white-throated snapping turtle has been nominated for threatened species status under the NC Act and the EPBC Act (Limpus et al 2011a) and is included in the Australian Government's Department of the Environment's Finalised Priority Assessment List for the period commencing 1 October 2013. The Threatened Species Scientific Committee will provide advice on the nomination by 30 March 2016. The white-throated snapping turtle has been previously recorded within the Project footprints.

All turtle species listed above, excluding the eastern snake-necked turtle, have previously been recorded within the Eden Bann Weir Project footprint. The eastern snake-necked turtle primarily inhabits ephemeral off-stream water bodies such as billabongs and farm dams (Limpus et al. 2007). Within the broader study area, this species has been recorded within the upper Fitzroy River and the lower reaches of the Dawson River. The known distribution of all turtle species within the Fitzroy Basin catchment is detailed in Table 3-15.

Table 3-15 Known distribution of freshwater turtles within the Fitzroy Basin catchment

Turtle species	Known distribution within the catchment		Survey reference
Fitzroy River turtle	Project footprint	Marlborough Creek – Fitzroy River	Cann 1998 N = 6 - Limpus et al. 2007 N = 8 - Gordos and Franklin 2002; Gordos et al. 2003
		Redbank Crossing – Fitzroy River	N = 2 deceased - Limpus et al. 2007 N = 38 - Legler and Cann 1980 N = 2 nests - Legler and Cann 1980 N = 8 - Legler 1977
		Glenroy Crossing – Fitzroy River	N = 11 - Tucker et al. 2001 N = 13 live, 14 deceased - Limpus et al. 2007 N = confirmed nesting - Limpus et al. 2007 Legler and Cann 1980
	Downstream of Project footprint	Fitzroy River Impoundment (N = 1)	This study
		Alligator Creek junction – Fitzroy River	N = 4* live, 3 * deceased - Limpus et al. 2007 N = 10 confirmed nesting banks - Limpus et al. 2007
		Wattlebank Control Weir – Fitzroy River	N = 5 - frc, 2007
	Upstream of Project footprint	Rookwood Weir site – Fitzroy River	N = 3 deceased - Limpus et al. 2007
		Windah Creek – Fitzroy River	Legler and Cann 1980
		Foleyvale Crossing – Mackenzie River	N = 1 = Limpus et al. 2007
		Gainesford – Dawson River	Legler and Cann 1980
		Theodore Weir – Dawson River	N = 118 - Limpus et al. 2007
		Duck ponds – Nogoa River	Limpus et al. 2007
		Cardowan irrigation farm – Connors River	N > 12 - Limpus et al. 2007 N = 2 nests - Limpus et al. 2007
		Connors River	N = 16 - Gordos et al. 2003 N = 182 – frc environmental 2011

Turtle species	Known distribution within the catchment		Survey reference
		Connors River Dam	N = 7 captured, 9 sighted – frc environmental 2010a
		Nathan Dam and surrounds	N = 1 nest – frc environmental 2010b
		Tartus Weir	N = 81 – Limpus et al 2011
White-throated snapping turtle	Project footprint	Eden Bann Weir – Fitzroy River	N = 22 live, 1 deceased - Limpus et al. 2007 N = 1 - This study
		Marlborough Creek – Fitzroy River	N = 15 - Limpus et al. 2007
		Redbank Crossing – Fitzroy River	N > 10 - Limpus et al. 2007 Legler and Cann 1980
		Glenroy Crossing – Fitzroy River (N = 36 live; 2 deceased)	N = 36 live, 2 deceased - Limpus et al. 2007
	Downstream of Project footprint	Fitzroy Barrage Impoundment – Fitzroy River	N = 5 - frc, 2007 N = 2 - This study
		Alligator Creek junction – Fitzroy River	N = 83* live – 2 decreased - Limpus et al. 2007 N = 13 - frc, 2007 N = 56 - Hamann et al. 2007
		Alligator Creek to Wattlebank Control Weir – Fitzroy River (N = 11)	N = 11 - frc, 2007
		Wattlebank Control Weir – Fitzroy River (N = 8)	N = 8 - frc, 2007
	Upstream of Project footprint	Rookwood Weir site	N = 2 - Limpus et al. 2007 N = 2 nests - This study
		Riverslea Crossing – Fitzroy River	N = 1 - Limpus et al. 2007 N = 1 - This study
		Foleyvale Crossing – Mackenzie River	N = 1 deceased - Limpus et al. 2007 N =1 - This study
		Boolburra Crossing – Dawson River	N = 1 nest - Limpus et al. 2007
		Gainesford – Dawson River	Legler and Cann 1980
		Theodore Weir – Dawson River	N = 20 - Limpus et al. 2007
		Glebe Weir – Dawson River	N > 4 deceased - Limpus et al. 2007

Turtle species	Known distribution within the catchment		Survey reference
		Callide Dam – Callide Creek	Limpus et al. 2007
		Hutton Creek (Warndoo Station spring fed pools) – Dawson River	N = 1 - Limpus et al. 2007
		Hutton Creek (Korcha Station spring fed pools) – Dawson River	N > 1 - Limpus et al. 2007
		Cardowan irrigation farm – Connors River	N = 28 - Limpus et al. 2007
		Connors River Dam site – Connors River	N = 2 - Summarised in SKM 2010 N = 9 - frc environmental 2010a
		Connors River Dam Site – Cattle Creek and Collaroy Creek	N = 1 – SKM 2007
		Duck ponds – Nogoa River	Limpus et al. 2007
		Tartus Weir	N = 40 – Limpus et al. 2011
		Nathan Dam and surrounds	N = 3 – SKM 2012 N = 2 - frc environmental 2010b N = 1 - frc environmental 2012
Saw-shelled turtle	Project footprint	Marlborough Creek – Fitzroy River	N = 26 - Limpus et al. 2007
		Glenroy Crossing – Fitzroy River	N = 1 live, 2 deceased - Limpus et al. 2007
	Downstream of Project footprint	No records	
	Upstream of Project footprint	Foleyvale Crossing – Mackenzie River	N =1 - Limpus et al. 2007
		Theodore Weir – Dawson River	N = 22 - Limpus et al. 2007
		Glebe Weir – Dawson River	N = 2 deceased - Limpus et al. 2007
		Hutton Creek (Korcha Station spring fed pools) – Dawson River	N =1 deceased - Limpus et al. 2007
		Carnarvon Creek	N = 47 - Limpus et al. 2007
		Cardowan irrigation farm – Connors River	N =1 - Limpus et al. 2007
		Connors River Dam site – Connors River	N = 4 - Summarised in SKM 2010
		Cattle Creek	N = 1 – SKM 2007
		Collaroy Creek	N = 1 – SKM 2007
		Tartus Weir	N = 5 – Limpus et al. 2011

Turtle species	Known distribution within the catchment		Survey reference
Krefft's river turtle	Project footprint	Eden Bann Weir – Fitzroy River	N = 89 live, 2 deceased - Limpus et al. 2007 N = 14 - This study
		Marlborough Creek – Fitzroy River	N = 6 - Limpus et al. 2007
		Redbank Crossing – Fitzroy River	N > 66 - Limpus et al. 2007 Legler and Cann 1980
		Glenroy Crossing – Fitzroy River	N = 199 live, 6 deceased - Limpus et al. 2007
	Downstream of Project footprint	Fitzroy Barrage Impoundment – Fitzroy River	N = 92 - This study
		Alligator Creek junction – Fitzroy River	N 451* live, 6 deceased - Limpus et al. 2007
	Upstream of Project footprint	Rookwood Weir site (N = 43)	N = 43 - Limpus et al. 2007
		Riverslea Crossing – Fitzroy River	N = 7 - Limpus et al. 2007 N = 6 - This study
		Fitzroy – Mackenzie – Dawson Confluence (N =1)	N =1 - This study
		Foleyvale Crossing – Mackenzie River	N = 43 - Limpus et al. 2007 N = 15 - This study
		Boolburra Crossing – Dawson River	N =2 deceased - Limpus et al. 2007 N = 1 - This study
		Gainesford – Dawson River	Legler and Cann 1980
		Theodore Weir – Dawson River	N = 93 - Limpus et al. 2007
		Glebe Weir – Dawson River	N ≈ 100 deceased - Limpus et al. 2007
		Hutton Creek (Warndoo Station spring fed pools) – Dawson River	N = 17 live, 8 deceased - Limpus et al. 2007
		Hutton Creek (Korcha Station spring fed pools) – Dawson River	N ≈ 12 - Limpus et al. 2007
		Callide Dam – Callide Creek	N = 657 - Limpus et al. 2007
		Bedford Weir – Mackenzie River	N = 109 - Limpus et al. 2007
		Fairbairn Dam – Nogoa River	N = 500 live, 179 deceased - Limpus et al. 2007
		Cardowan irrigation farm – Connors River	N = 67 - Limpus et al. 2007
		Connors River Dam site – Connors River	N = 33 – frc environmental 2011

Turtle species	Known distribution within the catchment		Survey reference
		Funnel Creek – Connors River	N = 2 - SKM 2010
		Murray Creek	N = 6 – SKM 2007
		Connors River	N = 1 SKM 2007
		Cattle Creek	N = 8 SKM 2007
		Collaroy Creek	N = 5 SKM 2007
		Sandy Creek	N = 9 SKM 2007
		Nathan Dam and surrounds	N = 32 - SKM 2012 N = 8 – frc environmental 2010 b N = 12 frc environmental 2012
		Tartus Weir	N = 235 – Limpus et al. 2011
Broad-shelled river turtle	Project footprint	Eden Bann Weir – Fitzroy River	N = 1 - Limpus et al. 2007
		Eden Bann Weir – Fitzroy River	N = 1 nest - This study
		Redbank Crossing – Fitzroy River	N = 1 deceased - Limpus et al. 2007
		Glenroy Crossing – Fitzroy River	N = 3 live, 1 deceased - Limpus et al. 2007
		Glenroy Crossing – Fitzroy River	Legler and Cann 1980
	Downstream of Project footprint	Fitzroy Barrage Impoundment	N > 1 - This study
		Gavial Creek floodplain billabong – Fitzroy River	N = 24 - Limpus et al. 2007
		Alligator Creek junction – Fitzroy River	N = 9* live, 1 deceased - Limpus et al. 2007
	Upstream of Project footprint	Boolburra Crossing – Dawson River	N =1 deceased - Limpus et al. 2007
		Theodore Weir – Dawson River	N = 3 - Limpus et al. 2007
		Glebe Weir – Dawson River	N > 5 deceased - Limpus et al. 2007
		Hutton Creek (Warndoo Station spring fed pools) – Dawson River (anecdotal evidence)	Limpus et al. 2007
		Duck ponds – Nogoa River	Limpus et al. 2007
		Fairbairn Dam – Nogoa River	N = 2 live, 5 deceased - Limpus et al. 2007
		Nathan Dam and surrounds	N = 1 - SKM 2012

Turtle species	Known distribution within the catchment		Survey reference
			N = 1 frc environmental 2010 b
		Broad-shelled long necked turtle	N = 1 – Limpus et al. 2011
Eastern long-necked turtle	Project footprint	No records	
	Downstream of Project footprint	Alligator Creek junction – Fitzroy River	N = 11* - Limpus et al. 2007
	Upstream of Project footprint	Capricorn Highway Crossing – Dawson River	N = 1 - This study
		Theodore Weir – Dawson River	Limpus et al. 2007
		Glebe Weir – Dawson River	N = 1 deceased - Limpus et al. 2007
		Hutton Creek (Crowman and Oakwell Station dams) – Dawson River	N = 26 live, 17 deceased - Limpus et al. 2007
		Hutton Creek (Korcha Station spring fed pools) – Dawson River	N > 2 - Limpus et al. 2007
		Callide Dam – Callide Creek	Limpus et al. 2007
		Connors River Dam site – Connors River	N = 1 - Summarised in SKM 2010
		Nathan Dam and surrounds	N = 1 - SKM 2012 N = 1 – frc environmental 2010 b
		Tartus Weir	N = 3 – Limpus et al 2011

* cumulative total from multiple survey events

Ecology

A species specific description of the ecology, including habitat preferences, nesting behaviour, respiratory physiology, dietary requirements, and movement behaviours of the six turtle species recorded within the Fitzroy Basin catchment is provided in Table 3-16 while a broad summary is detailed below.

Aquatic habitats

Habitat preferences vary considerably between turtle species and range from ephemeral waterholes and pools to fast-flowing riffle zones and structurally complex tributaries. The Krefft's river turtle is the most generalist species occurring in all freshwater habitats throughout the Fitzroy Basin catchment excluding isolated farm dams (Limpus et al. 2007). This species was the most widespread and abundant species encountered within the Project footprint during DERM surveys (Limpus et al. 2007).

The saw-shelled turtle is thought to occur in low abundance throughout the Fitzroy Basin catchment with a higher number of individuals occurring in the flowing streams of the upper catchment than the larger riverine habitats of the lower catchment (Limpus et al. 2007). Within the Project footprint, this species has been recorded at Marlborough Creek and Glenroy Crossing (Table 3-15). The broad-shelled river turtle is primarily known to occur in the slow flowing riverine reaches, impoundments and billabongs of the middle and lower catchment (Limpus et al. 2007). A small number of individuals have been recorded within the Eden Bann Weir and at Redbank and Glenroy Crossings (Table 3-15). The eastern snake-necked turtle is known to occur in the Dawson River Catchment and the lower Fitzroy River Catchment. This species is primarily encountered in off-stream ephemeral water bodies such as swamps, lagoons, man-made dams and billabongs (Limpus et al. 2007). To date this species has not been recorded within the Project footprint but it is considered likely to occur in the off-stream habitats in the area.

The Fitzroy River turtle and the white-throated snapping turtle are specialist species that inhabit the natural permanent riverine habitats of the Fitzroy Basin catchment. Riffle zones are considered particularly important habitat for these species, however individuals may also inhabit run, pool, creek and impounded habitats that support an abundance of undercut banks, submerged roots and fallen trees (Limpus et al. 2007). The aquatic habitats of these species within the Project footprint are further discussed below.

Nesting habitats

Nesting by the Krefft's river turtle, saw-shelled turtle, broad-shelled river turtle and eastern snake-necked turtle can occur in a variety of river bank substrates from hard clays and grass covered banks to soft sands (Cann 1998; Limpus et al. 2007). The majority of nesting occurs close to the waters edge (5 - 50 m), however, the broad-shelled river turtle and eastern snake-necked turtle have been observed nesting up to 1 km from river banks.

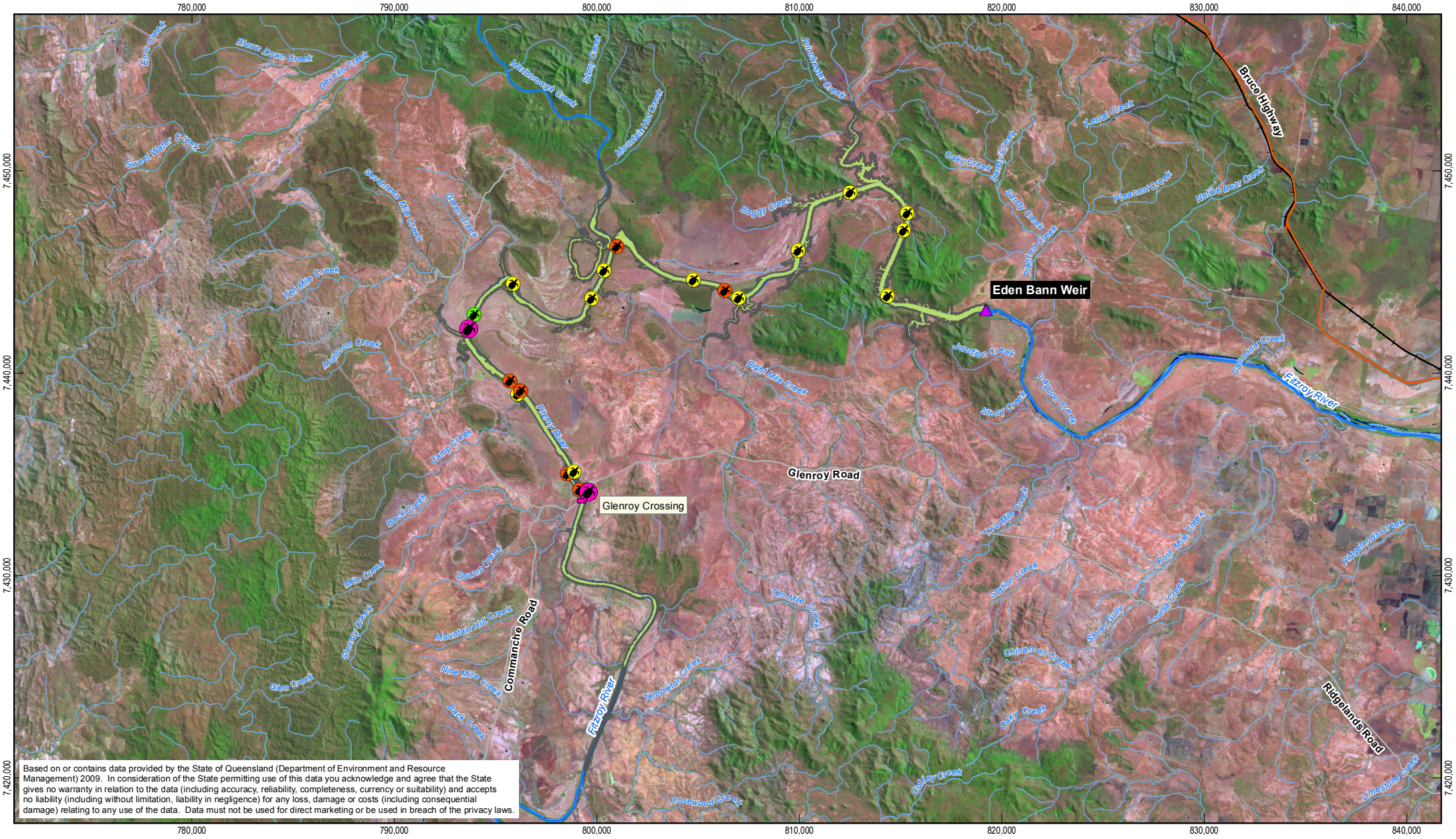
In comparison to these species, the preferred nesting habitat of the Fitzroy River turtle and white-throated snapping turtle is more specific with nesting primarily occurring in alluvial sand / loam banks that occur in depositional areas (Plate 3-3) (Limpus et al. 2007; Hamann et al. 2007). These banks generally form at the river's edge and extend back into the immediate riparian zone, however islands are also known to occur in places.

Plate 3-3 Potential turtle nesting bank in Eden Bann Weir Project footprint

There is insufficient evidence available on species specific nesting requirements to accurately describe optimal nesting bank conditions for the Fitzroy River turtle and white-throated snapping turtle, however, banks with a relatively steep slope (~27˚ elevation), low density of ground / understorey vegetation and shade cover appear to be preferred (Limpus et al. 2007). Nesting generally occurs approximately 5-6 m from the water's edge in both species, however, nesting by the white-throated snapping turtle has been recorded up to 60 m from the water edges (Limpus et al. 2007; Hamann et al. 2007).

The largest nesting aggregation for the Fitzroy River turtle and white-throated snapping turtle occurs at Alligator Creek, located within the upper reaches of the Fitzroy Barrage impoundment (downstream of the Project footprint). Outside the aggregated nesting area at Alligator Creek, only isolated nests of both species have been observed (Limpus et al. 2007). Within the Eden Bann Weir Project footprint, Fitzroy River turtle nesting has been historically recorded at Glenroy and Redbank Crossings (Figure 3-4). No evidence of Fitzroy River turtle or white-throated snapping turtle nesting was observed during the current surveys, however, one broad-shelled river turtle nest and a number of degraded unidentified nests were incidentally recorded immediately below the Eden Bann Weir. Potential nesting habitat degradation from pigs and cattle was evident throughout the Project footprint.

Overall the occurrence of suitable turtle nesting habitat for the Fitzroy River turtle and white-throated snapping turtle is relatively limited within the Eden Bann Weir Project footprint. Field surveys identified 19 potential nesting bank habitat areas, eighteen of which were considered to have low – medium suitability for turtle nesting and the remaining site was assessed as having high nesting suitability (Figure 5-5.) It is important to note that the classification of a bank as potential turtle nesting habitat does not guarantee turtle nesting does/will occur in that area. Turtle nesting may also occur in areas not identified as potential habitat, however these areas are considered to be of low quality and unlikely to support large numbers or achieve high nesting success. Note: mapped nest location points may represent a series of adjacent nesting banks.



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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Gladstone Area Water Board, SunWater
Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision D
Date 01 Aug 2014

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

Figure 3-4

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Level 9, 145 Ann St Brisbane QLD 4000 T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com.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, DERM - Imagery/2005; GHD: Fauna Survey - 2009. Created by AJ

Movement behaviour

Very little is known about the long-term movement requirements of freshwater turtles in the Fitzroy Basin catchment. Home ranges are thought to be generally small, however movements in the scale of tens of kilometres have been recorded in some species (Limpus et al. 2007; Hamann et al. 2007). Migrations are generally associated with courtship, nesting, dispersal and repositioning following flood displacement. The broad-shelled river turtle and eastern snake-necked turtle are also known to undertake overland migrations in response to nesting and habitat degradation (e.g. drying of ephemeral pools) (Limpus et al. 2007).

Within the Fitzroy Basin catchment, long-distance movement of turtles is significantly compromised as a result of eighteen major water infrastructures that occur within the catchment. These structures can physically inhibit the upstream and downstream movement of turtles throughout the catchment. Although some of the dams and weirs within the Fitzroy Basin catchment contain fishways, these structures have not been designed to accommodate freshwater turtles and as a result, have relatively low, to no, success at facilitating turtle passage (Limpus et al. 2007).

Conservation significant species

Fitzroy River turtle

The Fitzroy River turtle is endemic to the Fitzroy Basin catchment and is thought to inhabit the permanent freshwater riverine habitats from the Fitzroy Barrage to the upper reaches of the Dawson, Nogoa and Connors Rivers (Limpus et al. 2007) (Table 3-15). Within the Project footprint, the Fitzroy River turtle has been recorded at Marlborough Creek, Redbank Crossing and Glenroy Crossing. Redbank Crossing and Glenroy Crossing are considered particularly important habitats as they contain the type localities[9] for the species. Detailed information on the Fitzroy River turtle is provided in Appendix L Fitzroy River turtle (*Rheodytes leukops*).

White-throated snapping turtle

The white-throated snapping turtle (Plate 3-4) occurs throughout the Fitzroy, Burnett and Mary River Catchments. Like the Fitzroy River turtle, the white-throated snapping turtle inhabits permanent waters within flowing streams and is not thought to occur within farm dams, ephemeral swamplands or brackish waters (Hamann et al. 2007). Within the Project footprint, this species has been recorded from within the Eden Bann Weir, Marlborough Creek, Redbank Crossing and Glenroy Crossing (Table 3-15). An individual was opportunistically observed just upstream of Eden Bann Weir impoundment during wet season surveys for this study.

[9] Type locality refers to the place/s where the holotype or type specimen was collected

Plate 3-4 White-throated snapping turtle captured in the Fitzroy Barrage impoundment (July 2009)

The white-throated snapping turtle is one of Australia's largest turtle species with adult females weighing up to 9 kg. As for the Fitzroy River turtle, the white-throated snapping turtle can also respire aquatically, with turtles obtaining ~40-60% of their oxygen requirements from the water (Mathie and Franklin 2006). This species inhabits permanent flowing reaches of the river that are characterised by steep sides, a sand-gravel substrate and an abundance of underwater refuge (e.g. rocks, logs and undercut banks) (Hamann et al. 2007). During the day, the white-throated snapping turtle is generally found in deep pools (>6 m) either up- or downstream from a riffle zone, whereas at night the turtle moves into the shallow riffle zones (Gordos et al. 2007; Hamann et al. 2007). Due to the relatively high abundance of overhanging vegetation and macrophytes within creeks, these habitats are often utilised by this species for foraging and sheltering. During the dry season, the white-throated snapping turtle are restricted to the less productive slow moving pools where they compete for limited resources with other turtle species and aquatic fauna. Juvenile white-throated snapping turtle are carnivorous, while adult turtles are primarily herbivorous, feeding on fruit and leaves of riparian vegetation and aquatic macrophytes (Rogers 2000).

The white-throated snapping turtle is also known to inhabit impounded pools with individuals recorded within the Fitzroy Barrage, Eden Bann Weir, Theodore Weir, Glebe Weir and Callide Dam (Table 3-15). Due to a shortage of foraging and sheltering resources within impounded habitat, the carrying capacity of this species is expected to be lower in these areas than in the natural pool-riffle-run sequences (Limpus et al. 2007). The occurrence of the largest known nesting aggregation in the upper reaches of the Fitzroy Barrage impoundment does however indicate that successful breeding can occur within the flowing margins of impounded habitats.

The home range of the white-throated snapping turtle is generally less than 500 m and is usually restricted to the one pool. On occasions the turtle has been known to move large distances (10 – 55 km) in association with dispersal, courtship and nesting and repositioning following flood

displacement (Hamann et al. 2007). Movement over land is generally only known to occur between adjacent pools. Rainfall is a suggested cue for turtle movement with individuals observed attempting to move past impoundments during rainfall and small flow events (Hamann et al. 2007; Limpus et al. 2007). The habitat and movement pattern of hatchling turtles is largely unknown.

The white-throated snapping turtle has an extended breeding season that occurs between March and September. Once they reach sexual maturity (at least 18 years of age) female turtles are thought to breed annually. Nesting occurs from autumn through to early spring with hatching generally occurring in early summer after an embryonic diapause over the winter months (Hamann et al. 2007). Nesting in the white-throated snapping turtle is generally restricted to sand / loam alluvial deposits (see nesting habitats above). The location of potential turtle nesting sites within the Project footprint is shown in Figure 3-4. Predation of nests by foxes, goannas, feral cats, and water rats is extremely high, indicated by the lack of hatchling and juvenile turtles within the population which suggests that there has been very little recruitment into the population over the last decade (<2 per cent) (Hamann et al. 2007).

Table 3-16 Ecology of freshwater turtle species in the Fitzroy Basin catchment

Species	Adult size (mm)	Habitat	Nesting behaviour	Respiratory physiology	Diet	Type of movement
Fitzroy River turtle **Rheodytes leukops** 	240-260	Endemic to the natural permanent riverine habitats of the Fitzroy Basin catchment Utilises fast-flowing riffle zones however will also occur in slow moving or non-flowing permanent pools Areas with an abundance of submerged logs, undercut banks and tree trunks are preferred Does not occur in off-stream water bodies separated from the flowing stream (e.g. ephemeral billabongs)	Nesting generally occurs on sand and loam banks between September and October Nesting aggregations can occur at traditional nesting banks	High reliance on aquatic respiration Well developed cloacal bursae allows the Fitzroy River turtle to extract at least 70% of its oxygen requirements from the water As a result, this species can remain submerged underwater for weeks at a time	Specialist forager - the Fitzroy River turtle has a unique foraging technique of 'scrape feeding' whereby the turtle uses the horny sheaths of the upper jaw to scrape the surface of the substrate This method of foraging primarily produces slow moving benthic invertebrates, invertebrate eggs, aquatic insects, sponges and algae	Home range size thought to be relatively small (up to 4 ha) Large scale movement may occur for dispersal, courtship and nesting and repositioning following flooding events Migrations may be triggered by rainfall Movement over land only known to occur over very short distances between adjacent pools
White-throated snapping turtle **Elseya albagula** 	320-450	Occurs throughout the catchment in the permanent freshwater reaches Flowing habitats with suitable shelter and refuges are preferred Does not occur in off-stream water bodies separated from the flowing stream (e.g. ephemeral billabongs)	Nesting primarily occurs on sand and loam banks between March and September Nesting aggregations can occur at traditional nesting banks	Medium reliance on aquatic respiration The white-throated snapping turtle can extract 40-60% of its oxygen requirements from the water	Primarily herbivorous – adult turtles primarily feed on aquatic macrophytes (including Vallesnaria leaves and filamentous algae) and fruit and leaves from riparian vegetation Small amounts of animal material will be consumed including terrestrial and aquatic insects Juveniles are primarily carnivorous	Home range size thought to be relatively small (500 m) but some individuals known to move larger distances (10 – 55 km) Large scale movement may occur for dispersal, courtship and nesting and repositioning following flooding events Migrations may be triggered by rainfall Movement over land generally only known to occur over very short distances between adjacent pools

Species	Adult size (mm)	Habitat	Nesting behaviour	Respiratory physiology	Diet	Type of movement
Saw-shelled turtle **Elseya latisternum** 	200-300	Inhabits flowing areas in the upper catchment Is most abundant in small tributaries off the main river channel Prefers areas with abundant fallen logs, submerged rocks and undercut banks	Nesting is thought to occur on the river banks during late spring-summer	Medium – low reliance on aquatic respiration The saw-shelled turtle can extract 10-30% of its oxygen requirements from the water	Opportunistically omnivorous – adult turtles feed on crustaceans, frogs, aquatic and terrestrial insects and aquatic plants Juvenile turtles are primarily carnivorous	Home range size unknown Large scale movement may occur for dispersal, courtship and nesting and repositioning following flooding events Migrations may be triggered by rainfall Movement over land only known to occur over very short distances between adjacent pools
Krefft's river turtle **Emydura krefftii** 	210-350	Inhabits all freshwater habitats throughout the catchment except isolated farm dams	Extended nesting season occurs during spring and summer	Medium – low reliance on aquatic respiration The Krefft's river turtle can extract 10-30% of its oxygen requirements from the water	Opportunistically omnivorous – variable diet including gastropods, bivales, terrestrial and aquatic insects, aquatic macrophytes, algae and sponge	Home range size unknown Large scale movement may occur for dispersal, courtship and nesting and repositioning following flooding events Migrations may be triggered by rainfall May move short distances overland
Broad-shelled river turtle **Chelodina expansa** 	350-480	Recorded in slow flowing riverine reaches, impoundments and billabongs in the lower and middle reaches of the Fitzroy River Catchment Turbid areas with abundant debris and submerged roots are preferred	Nesting is thought to occur on the river banks during March-September Nesting may occur up to 1 km from the waters edge	Low reliance on aquatic respiration No specialisation of cloacal bursae Very little oxygen extracted from the water	Carnivorous – ambush predator feeding on small fish and crustaceans	Home range size unknown Large scale movement may occur for dispersal, courtship and nesting and repositioning following flooding events Migrations may be triggered by rainfall May move long distances overland

Species	Adult size (mm)	Habitat	Nesting behaviour	Respiratory physiology	Diet	Type of movement
Eastern snake-necked turtle Chelodina longicollis 	190-260	Most abundant in shallow ephemeral water bodies such as swamps, lagoons, man-made dams and billabongs Within the Fitzroy River Catchment, this species occurs within the Dawson Catchment and the lower Fitzroy River	Nesting is thought to occur in firm substrates during summer Nesting may occur up to 500 m from the waters edge	Low reliance on aquatic respiration No specialisation of cloacal bursae Very little oxygen extracted from the water	Opportunistically carnivorous –thought to primarily feed on aquatic insects and crustaceans however plankton, nekton, benthic macroinvertebrates and carrion may also be consumed	Home range size unknown Large scale movement may occur for dispersal, courtship and nesting and repositioning following flooding events Migrations may be triggered by rainfall Undertake long distance overland migrations for nesting and dispersal

Ecological information in table sourced from: Preist 1997; Cann 1998; Gordos 2004; Mathie and Franklin 2006; Limpus et al. 2007; Hamann et al. 2007; Rogers 2000

3.4.4 Crocodiles

The estuarine crocodile (*Crocodylus porosus*) is listed as 'Marine' and 'Migratory' under the EPBC Act and 'Vulnerable' under the NC Act. The Fitzroy River is at the southern distribution limit for the estuarine crocodile and as such population abundance is naturally low throughout the area. The construction of impoundments on the Fitzroy River has however increased the availability of suitable habitat for this species and anecdotal evidence suggests abundance has increased within the local area. The construction of Eden Bann Weir in 1994 and the resultant alteration to the hydrological system of the Fitzroy River upstream are thought to have benefited the species due to the creation of more habitat (more linear shoreline and deeper water), and thus greater access to resources (Britton 2007b).

A 2007 study commissioned by the former Queensland Department of Natural Resources and Water on the distribution and abundance of crocodiles upstream of Eden Bann Weir and upstream of the proposed Rookwood Weir site observed 43 non-hatchling crocodiles (Britton 2007b). Based on the results of this study, the density of crocodiles upstream of Eden Bann Weir was estimated to be 0.7 crocodiles / km (Britton 2007b). Two crocodile nests were observed upstream of Eden Bann Weir, although both had experienced significant disturbance (one was flooded and one was destroyed by feral pigs (*Sus scrofa*) (Britton 2007b)). Despite the abundance of food and suitable habitat (for foraging and shelter), the propensity for seasonal flooding of nests in conjunction with low recruitment from other populations are thought to restrict the growth of the population upstream of Eden Bann Weir (Britton 2007b).

During wet and dry season field surveys upstream of Eden Bann Weir, opportunistic sightings of estuarine crocodiles were recorded (Table 3-17). Five crocodile sightings were made during the wet season (this may represent repeat sightings of two individuals). Three estuarine crocodiles were seen in the dry season.

Typically, crocodiles were observed on the bank, however they generally moved into the water upon approach of the survey boat. A large crocodile (approximately 3.5 metres) was observed approaching the survey boat during nocturnal spotlighting. Crocodile slides were observed at numerous locations upstream of Eden Bann Weir (Plate 3-5). All crocodile and crocodile slide sightings were within the existing weir pool area upstream of Eden Bann Weir.

Table 3-17 Location of crocodile sightings in Eden Bann Weir during aquatic surveys

Location	Approximate size	Notes
Wet Season		
Eden Bann Weir pool (first bend upstream of weir)	3.5 m	Observed at night in water whilst spotlighting
Eden Bann Weir pool (first bend upstream of weir)	3.5 m	Observed during day in water (possibly same crocodile as above)
Just downstream of Marlborough Creek	2.5 m	Observed in water (same individual seen 3 times during survey)
Dry Season		
Eden Bann Weir pool (200 m downstream from first bend upstream of weir)	3.5 m	Observed during day on bank
Eden Bann Weir pool (400 m upstream from first bend upstream of weir)	3 m	Observed during day on bank
Just downstream of Marlborough Creek	4.5 m	Observed during day on bank

Plate 3-5 Crocodile slide observed on sand bank within Eden Bann Weir Project footprint

Ecology

Growing up to 7 metres in length, the estuarine crocodile is the apex predator of tropical Australia's inland and coastal waters. This species ranges from Gladstone in southern Queensland across the top half of the country to north-west Western Australia, as well as southeast Asia. Whilst it is usually associated with tidal coastal and estuarine environments, it often occurs well inland (hundreds of kilometres) in freshwater habitats (such as rivers, creeks, swamps and billabongs) along large drainages. The physiology of this species allows it to readily move between salt- and freshwater environments.

Breeding peaks during October and November, with nesting occurring from December to April. Eggs are laid in a mound of vegetation and soil, which is constructed within close proximity of a permanent water body (DERM 2009). The nest is usually constructed amongst vegetation (grasses, *Melaleucas*, mangroves in tidal areas) well above the water level. Females aggressively defend their nest against predators such as pigs and goannas. Embryo development is heavily dependent on temperature, with average internal nest temperatures of approximately 32°C producing predominantly male young, and temperatures slightly above or below 32°C resulting in relatively more females (DERM 2009).

Dispersal in estuarine crocodiles is generally related to access to resources and / or excessive competition where crocodiles occur at high densities. Whilst large male crocodiles may dominate particular home ranges, overlapping home ranges of a number of adult crocodiles are not uncommon (EPA 2007). Estuarine crocodiles are faithful to their home range, and although individuals are known to undertake natural migrations of hundreds of kilometres, translocated "problem" crocodiles have been recorded moving almost 300 kilometres from the point of their release back to the river system in which they were originally captured (Walsh and Whitehead 1993).

Seasonal migrations from lotic habitats to ephemeral swamps and billabongs occur during the wet season, as these temporary water bodies are generally rich in food resources (EPA 2007). Estuarine crocodiles are opportunistic ambush predators. Juveniles take insects, crustaceans and small fish, whilst adult crocodiles consume fish, turtles, birds and mammals (including macropods, livestock, feral pigs). Adult crocodiles will also readily scavenge carrion.

3.4.5 Platypus

The platypus (*Ornithorhynchus anatinus*) is listed as 'Special Least Concern' wildlife under the NC Act. 'Special Least Concern' wildlife are those species considered as having inherent value and potential importance for the maintenance of ecosystem processes. 'Special Least Concern' fauna are also considered a source of genetic information integral to an understanding of the evolution of the Australian biota and a genetic resource of potential benefit to society. These species are also considered culturally significant. No platypus were observed during wet and dry season field surveys, however platypus are known to occur in the Fitzroy River system (Grant and Temple-Smith 1998). Although no records were found in the literature for the species in the Eden Bann Weir Project footprint, a single record does exist within the study area (DERM Wildlife Online Database), specifically in the lower Dawson River (recorded in March 2000).

Platypus occupy a wide range of aquatic habitats, are tolerant of degraded systems, and show notable adaptability (Grant and Temple-Smith 1998). Potentially suitable aquatic habitat for platypus, as described by Grant and Temple-Smith (1998), occurs throughout the Eden Bann Weir Project footprint, both within the margins of the impounded pool habitat, and in upstream pool habitats. However the spatial utilisation of habitat is expected to be restricted to reaches of the Fitzroy River (and adjoining creeks) that support necessary resources for burrowing (i.e. earthen banks consolidated by the roots of riparian vegetation, overhanging vegetation, undercut banks (Grant and Temple-Smith 1998)). As described in Section 3.3, the variability in riparian habitats in the Project footprint is heavily influenced by adjacent land use, most notably cattle grazing in the riparian zone.

Based on observations in the Project footprint, it is inferred that where riparian habitats have been degraded by cattle, suitable platypus burrowing habitat is unlikely to be prevalent, and thus the species is likely to be limited in abundance or absent. Bank vegetative stability (a measure of the percentage of bank covered by vegetation and other habitat features such as boulders) was variable in the impounded pool habitat (see habitat assessments summarised in Section 3.3), with rankings ranging from *fair* to *excellent*. Run habitats received rankings of *poor* to *excellent* for bank vegetative stability (Section 3.3.5), while in the three creek habitats assessed, *excellent* rankings were given in five out of six instances (i.e. two banks per site). It is predicted that the lower reaches of creek habitats may provide potentially suitable burrowing habitat for platypus, based on these observations.

Ecology

Platypus *are* distributed along Australia's east coast (including Tasmania). *The species* inhabit lotic and lentic freshwater habitats, with a preference for areas that have steep, well vegetated banks. Shelter and nesting occur in a burrow constructed in the river bank just above the *water* level *with an* entrance to the burrow usually concealed by overhanging vegetation or an undercut bank. Burrows used for nesting tend to be longer and more elaborate than those used for shelter (Van Dyck and Strahan 2008).

Whilst largely solitary, a number of platypus may occur within a relatively small area (i.e. the same pool in a river). Platypus show fidelity to home ranges (up to several kilometres of river). Once established in a home range, platypus may undertake daily foraging movements of several kilometres (Gardner and Serena 1995). Platypus are capable of limited overland movement (Fish et al. 2001). A study of movement behaviour in Tasmania recorded platypus moving up to 1.5 km overland (Otley et al. 2000). Serena et al. (1998) speculated that platypus may occasionally undertake overland movements to bypass natural obstacles in river systems such as waterfalls and strong rapids.

Benthic aquatic invertebrates constitute the significant majority of the platypus prey. Prey is sifted from amongst the streambed sediments through the use of their unique bill, and / or taken from the water column, and subsequently chewed on the surface. The platypus is most active at dawn and dusk, although they may occasionally forage during the day and at night.

3.4.6 Macroinvertebrates

Diversity

A total of 4270 individuals from 59 families of macroinvertebrates were collected from artificial substrates deployed at locations presented in Figure 2-1 relative to the Eden Bann Weir Project footprint and areas upstream at Riverslea Crossing associated with the proposed Rookwood Weir during the wet season and 233 individuals from 28 families during the dry season. The most dominant families across all the sites combined were:

- Diptera, Chironominae (non-biting midge, Plate 3-6) - Chironominae are a subfamily of Chironomidae. Chironominae can be simple detritivores, omnivores or carnivores that feed on a mixture of algae and bacteria in soft sediments. They are found in a variety of water sources and most genera are relatively tolerant to pollution
- Diptera, Tanypodinae (non-biting midge) - Tanypodinae are a subfamily of Chironomidae. Tanypodinae are predators that also feed on some algae, bacteria and diatoms in their early larval stages. They are found in a variety of water sources and most genera are relatively tolerant to pollution
- Ephemeroptera, Baetidae (mayfly, Plate 3-7) - Baetidae is the second most diverse family of mayflies in Australia. They have a worldwide distribution and like all mayflies are excellent indicators for environmental monitoring due to their intolerance for poor water quality and habitat degradation. They are algal feeders and are more diverse in cooler, flowing waters of southern Australia but also occur in lowland systems and wetlands of northern Australia
- Ephemeroptera, Caenidae (mayfly, Plate 3-8) - Caenidae inhabit slow-flowing streams and are often found on bark, logs and rocks in streams, wetlands and pools. They are detritivores and herbivores. Most mayflies are pollution intolerant and are frequently used as an indicator group for environmental monitoring programs (Dean and Suter 1996)
- Ephemeroptera, Leptophlebiidae (mayfly, Plate 3-9) -Leptophlebiidae is the most diverse family of mayflies in Australia. They have a worldwide distribution and like all mayflies are excellent indicators for environmental monitoring due to their intolerance for poor water quality and habitat degradation. They are algal and detrital feeders and occur across Australia
- Gastropoda, Hydrobiidae - Hydrobiidae are small dextrally coiled snails that occur across Australia. They occupy a diverse range of habitats and little is known about their biology.

They can occur in huge quantities but have very restricted habitat tolerances. One genus of this family is an introduced pest from New Zealand, however this genus was not noted during this study

- Ostracoda (seed shrimps) - Ostracoda look like small freshwater mussels but are in fact small multi-segmented crustaceans. They are herbivores and detritivores, filter feeding by generating a current through their shell with their legs. This order is very common and has 11 families that occur in Australia
- Gastropoda, Thiaridae (sculptured snails, Plate 3-10) - Thiaridae are ornately sculptured snails. They are asexual reproducers and as such can rapidly produce large populations from a single animal
- Furthermore, fish trapping (fyke and bait traps) within the Eden Bann Weir Project footprint revealed the presence of two species belonging to the order Decapoda. Freshwater shrimp (*Paratya australiensis*, family: Atyidae) were recorded from two sites in the dry season, and a freshwater (*Macrobrachium spp., family: Palaemonidae)* was also recorded at one site in the wet season.

Several studies have characterised the macroinvertebrate diversity of the Fitzroy Basin catchment. Data collected by the former Department of Natural Resources and Water and summarised by frc environmental (2008) from three sites in the lower Fitzroy Basin catchment (Mackenzie River at Tartrus Weir headwater (1997), Dawson River at Boolburra Crossing (1998, 2001), Fitzroy River at Wattlebank (1994-1996)) returned 66 macroinvertebrate taxa. The Duivenvoorden and Roberts (1997) study investigating macroinvertebrate assemblages from the major drainages of the Fitzroy Basin catchment recorded over 70 families, with the most prevalent taxa including:

- Coleopteran (beetles)
- Diptera (flies)
- Ephemeroptera (mayflies)
- Hemiptera (sucking bugs)
- Odonata (dragon and damsel flies)
- Trichoptera (caddis flies)
- Bivalvia (mussels)
- Gastropoda (snails)
- Decapoda (shrimps and crayfish)
- Isopoda (shrimp-like taxa).

As well as sampling riverine habitats, Duivenvoorden and Roberts (1997) investigated macroinvertebrate assemblages in off-stream wetland habitats and lower order adjoining streams. The off-stream habitats sampled had relatively high macroinvertebrate diversity (> 30 species), and relative abundance at these sites was also observed to be higher. The results obtained in creek habitats were similar to off-stream water bodies, excluding a creek site in a semi-urban landscape (Duivenvoorden and Roberts 1997).

Plate 3-6 Diptera, Chironominae

Plate 3-7 Ephemeroptera, Baetidae

Plate 3-8 Ephemeroptera, Caenidae

Plate 3-9 Ephemeroptera, Leptophebiidae

Plate 3-10 Gastropoda, Thiaridae

A study of macroinvertebrate diversity in the Dawson River between 1997 and 1999 returned 86 taxa from four sites (Duivenvoorden et al. 2000). Taxa numbers per site showed statistically significant temporal variability (Duivenvoorden et al. 2000). Spatial variability was also shown to be statistically significant – most notably, there was a statistically significant difference in taxa richness between impounded sites and riverine sites (Duivenvoorden et al. 2000). A major conclusion of the study was that macroinvertebrate populations at impounded sites had fewer taxa, appeared to be generally lower in abundance and featured fewer pollution sensitive taxa when compared with riverine sites (Duivenvoorden et al. 2000). The impacts of rapid water level fluctuations within weir environments on food and habitat availability were hypothesised as a potential explanation for this observed spatial trend (Duivenvoorden et al. 2000). The loss of more specialist taxa, which are less tolerant of sudden habitat changes (i.e. due to water level fluctuations), was thought to account for observed temporal variability in macroinvertebrate assemblages, and may have contributed towards the lower taxon richness in weir environments (Duivenvoorden et al. 2000). The relatively lower numbers of taxa sensitive to poor water quality (namely Ephemeropteran and Trichopteran) was also speculated to be a reflection of the modified and highly variable aquatic environment within impounded pool habitats (Duivenvoorden et al. 2000).

As a result of the limitations encountered in assessing macroinvertebrates in the study area (as described in Section 2.4.2), sampling in this study did not seek to identify temporal and spatial trends in taxa diversity / abundance, nor did it attempt to quantify differences in macroinvertebrate habitat utilisation. The studies summarised above provide a snapshot of macroinvertebrate taxa richness in the Fitzroy Basin catchment, and the results obtained in this investigation provide additional information about macroinvertebrate diversity in the study area. The prevalence of Diptera, Ephemeroptera and Gastropoda recorded in this study corresponds with previous studies which have recorded these taxa from the Fitzroy Basin catchment (i.e. Duivenvoorden and Roberts 1997; Duivenvoorden et al. 2000). The results of the study undertaken by Duivenvoorden et al. (2000) provide information about the potential impacts of weirs on macroinvertebrate assemblages in the Fitzroy Basin catchment, which will contribute towards assessing the impacts of raising Eden Bann Weir on these animals.

3.4.7 Macrophytes

Diversity

One hundred and five species of macrophytes have been previously recorded in the Fitzroy Basin catchment (Duivenvoorden 1992). At the time of survey (1989-1991), the most commonly recorded species were from the genera *Persicaria*, *Cyperus*, *Juncus* and *Potamogeton*. The diversity of macrophytes species recorded at each survey site at any one time was relatively low (average two – five species), however extreme climatic events (e.g. severe flooding followed by drought) were observed to notably impact temporal macrophyte species diversity (Duivenvoorden 1992). These results are consistent with localised studies in the Mackenzie and Dawson Rivers which recorded a maximum of 11 and 10 macrophyte species per site, respectively (Duivenvoorden 1997). The macophytes species recorded within the Mackenzie River were predominately desiccation-resistant, emergent species located high on the bank (Duivenvoorden 1997). Common macrophyte genera recorded on the Dawson River included: *Azolla, Cyperus, Lomandra, Ludwigia, Muelenbecia, Persicaria, Polygonum, Rumex* and *Spirodela* (Duivenvoorden 1995).

Habitat assessments and field observations revealed that macrophytes were uncommon in riverine (i.e. in-channel) habitats within the Eden Bann Weir Project footprint. Of 19 sites in which habitat assessments were undertaken, macrophytes were recorded from only five (four of which were within the impounded pool). Unlike the main channel, creeks and off-stream water bodies were observed to support more notable macrophyte assemblages. Floating and emergent macrophytes were particularly prevalent (Plate 3-11). Such assemblages are likely to be dynamic and ephemeral. Macrophytes in creeks are likely to be flushed into the main channel and washed downstream during seasonal flood events in the wet season, followed by a period of reestablishment during the dry season when flows from these waterways are low. Recruitment into off-stream water bodies is likely to occur as a result of flooding from the main channel during the wet season, followed by a period of establishment in the dry season.

Plate 3-11 Floating and emergent macrophytes on a large off-stream water body (left), and along the margins of an adjoining creek

The generally low diversity and abundance of macrophytes in the Fitzroy Basin catchment has been related to factors including the highly variable climate, and its influence on the hydrology of the system, high turbidity levels and cattle grazing / degradation in marginal and riparian habitats (Nergus 2007). Fluctuating water levels in impoundments and turbidity were cited as potential explanations for an observed lack of submerged macrophytes upstream of weirs on the Dawson River (Duivenvoorden et al. 2000). Macrophyte species commonly found in impounded habitats include: *Nymphaea gigantea*, *Nymphoides indica, Azolla pinnata*, *Potamogeton crispus*, *Hydrilla verticillata*, *Myriophyllum verrucosum*, *Vallisneria gigantea, Ludwigia peploides* and *Polygonum attenuatum* (Duivenvoorden 1992).

Weed and pest species

Salvinia *(Salvinia molesta*) is an exotic weed that can rapidly infest waterways and severely degrade aquatic ecosystems. It is a declared Weed of National Significance, and is listed as a Class 2 Declared Plant under the Queensland *Land Protection (Pest and Stock Route Management) Act 2002*. This species has been recorded downstream of Eden Bann Weir (within the Fitzroy Barrage) (Limpus et al. 2007), and is predicted to occur (by DEWHA Environmental Reporting Tool) upstream of Eden Bann Weir based on bioclimatic modelling.

The replacement of native aquatic vegetation by the exotic semi-aquatic grass *Hymenachne amplexicaulis* has markedly altered the ecology of waterways adjoining the Fitzroy River. Like salvinia, this species is a declared Weed of National Significance, and is listed as a Class 2

Declared Plant under the *Land Protection (Pest and Stock Route Management) Act 2002*. Where this highly invasive species has replaced native aquatic vegetation in quieter backwaters (e.g. creeks, off-stream water bodies etc.), macroinvertebrate assemblages were found to be different, with a decline in several orders (Houston and Duivenvoorden 2002).

Algae

Algae diversity is relatively low within the Fitzroy Basin catchment with a total of 52 species previously recorded (Noble et al. 1997). Potentially toxic blue-green algae blooms are known to occur throughout the Fitzroy Basin catchment in response to high pH, high nutrients and low flows (Noble et al. 1997). Since, October 2007, only low levels of blue-green algae have been recorded from the existing Eden Bann Weir impoundment (frc environmental 2008; Volume 1, Chapter 11 Water quality).

4. Summary

Aquatic habitats within and downstream of the Eden Bann Weir Project footprint were assessed through a combination of field surveys, literature reviews and aerial photograph interpretation. Upstream of the existing weir, the dominant aquatic habitat type is the impounded pool. The linear extent of this habitat type varies seasonally, and is also dependent on operation of the storage. Upstream of the impounded pool habitat, and downstream of Eden Bann Weir to the upper limit of the Fitzroy Barrage impoundment, in-stream habitats are dominated by seasonally-dynamic recurring pool-riffle-run sequences. These sequences represent the natural hydrological and geomorphologic regime of the rivers in the study area.

Through habitat assessments, variable water velocity, depth, bank characteristics, in-stream habitat features (woody debris, macrophytes) and stream substrate were observed within and between the in-channel aquatic habitat types of the Project footprint. Seasonal variability markedly alters the characteristics and linear extent of these habitats – a natural regime to which the aquatic species of the Fitzroy Basin catchment are adapted. The less variable, more homogenising influence of the impoundment upstream of Eden Bann Weir somewhat dampens the seasonal temporal variability in habitat characteristics and extent immediately upstream of the existing weir.

A number of creeks and off-stream water bodies provide further aquatic habitat beyond the main channel of the Fitzroy River. Creek habitats in the Project footprint were observed to provide a high abundance of microhabitat resources such as overhanging vegetation and in-stream woody debris. These habitats potentially provide resources for an array of aquatic species, including small cryptic fish species, freshwater turtles and juvenile crocodiles. Off-stream water bodies have been identified as important reservoirs of fish biomass, nursery habitat for juvenile fish, and provide potential habitat for crocodiles and long-necked turtles.

Desktop and field surveys undertaken to inform this baseline assessment of the aquatic ecology within and downstream of the Eden Bann Weir Project footprint revealed that 34 fish species, seven aquatic reptiles (six turtles, one crocodile), one aquatic mammal, 86 macroinvertebrate taxa and 105 macrophytes have the potential to occur within the Project footprint, based on previous records from the study area and the results of field surveys. Of particular note are conservation significant species which were confirmed present during field surveys, or are known / predicted to occur based on a review of relevant literature. These include:

- Fitzroy River turtle - known to occur in within the Eden Bann Weir Project footprint. Important habitat for this species occurs at Redbank Crossing (type locality), Glenroy Crossing (type locality and essential habitat) and Marlborough Creek (essential habitat). Fitzroy River turtle nesting has been historically recorded within the Project footprint. Alligator Creek, located downstream of the Project footprint, has been identified as an important nesting habitat for this species
- Estuarine crocodile –known to occur within and downstream of the Eden Bann Weir. Eight sightings of crocodiles were observed during the GHD field surveys. Eden Bann Weir impoundment is considered important habitat for the species in the Fitzroy River
- Southern saratoga – known to occur in the study area and predicted to occur in the Project footprint due to availability of suitable habitat
- Leathery grunter - known to occur in the study area and predicted to occur in the Project footprint due to availability of suitable habitat

- Golden perch - known to occur in the study area and predicted to occur in the Project footprint due to availability of suitable habitat
- Platypus - known to occur in the study area and predicted to occur in the Project footprint due to availability of suitable habitat.

Overall the general characteristics of aquatic habitats within the Eden Bann Weir Project footprint, and the aquatic species they support, appear to represent a continuum of habitats downstream to the Fitzroy Barrage, and are not unique in the values and resources they provide in the context of the wider study area. Aquatic habitats (and the species they support) within and downstream of the Eden Bann Weir Project footprint have been impacted and altered by human processes occurring at the local to catchment-wide scale. Such impacts include degradation of riparian habitats by livestock, changes to water quality (agriculture and mining) and disruption to natural flow regimes and connectivity of aquatic systems. Notably, the aquatic habitats up and downstream of Eden Bann Weir are influenced by the operations of the existing structure. In this context, the potential impacts of raising Eden Bann Weir on the baseline aquatic values outlined in this assessment have been identified.

5. References

Allen, GR, Midgley, SH and Allen, M 2003, '*Field Guide to the Freshwater Fishes of Australia'*, Perth, Western Australian Museum.

Australian Bureau of Meteorology (BoM) 2009, '*Latest Weather Observations for Rockhampton'*, Australian Bureau of Meteorology, retrieved 21 August, 2009, from <http://www.bom.gov.au/products/IDQ60801/IDQ60801.94374.shtml>.

Baran, E 2006, '*Fish migration triggers in the Lower Mekong Basin and other tropical freshwater systems'*, MRC Technical Paper No. 14. Mekong River Commission.

Berghuis, AP & Long, PE 1999, '*Freshwater fishes of the Fitzroy Catchment, Central Queensland*', *Proceedings of the Royal Society of Queensland*, vol. 108, pp. 13-25.

Britton, A 2007a, *'Impact assessment of modified water infrastructure (Fitzroy Barrage) on the Fitzroy River saltwater crocodile – Potential implications and proposed mitigation measures for saltwater crocodiles (Crocodylus porosus)'*, Commercial-in-confidence report prepared for the Department of Natural Resources and Water, Queensland.

Britton, A 2007b, *'Proposal for raising Eden Bann Weir and construction of Rookwood Weir – An assessment of the potential implications and proposed mitigation measures for saltwater crocodiles (Crocodylus porosus)'*, Commercial-in-confidence report prepared for the Department of Natural Resources and Water, Queensland.

Broadfoot, CD, Berghuis AP, and Heidenreich, MJ 2000, *Assessment of the Kolan River barrage vertical-slot fishway*. Queensland Department of Primary Industries Report for the Department of Natural Resources State Water Projects.

Cann, J 1998, '*Australian freshwater turtles'*, Beaumont Publishing Pty Ltd, Singapore.

Clark, NJ 2008, '*The diving physiological ecology of Australian freshwater turtle hatchlings'*, PhD Thesis, University of Queensland, Brisbane.

Clark, NJ, Gordos, MA & Franklin, CE 2008, *'Diving behaviour, aquatic respiration, and blood respiratory properties: a comparison of hatchling and juvenile Australian turtles'*, *Journal of Zoology*, vol. 275, pp. 399–406.

De Pauw, M, Roels, D & Fontoura, AP 1986, *'Use of artificial substrates for standardized sampling of macroinvertebrates in the assessment of water quality by the Belgian Biotic Index', Hydrobilogia*, vol. 133, pp. 237-258.

Dean, JC and Suter, PJ 1996, '*Mayfly nymphs of Australia. A guide to genera. No. 7',* Albury: Cooperative Research Centre for Freshwater Ecology iii 82 pp.

Department of Employment, Economic Development and Innovation (DEEDI) 2009, '*East Coast Inshore Fin Fish Fishery*, Department of Employment, Economic Development and Innovation', retrieved 11 September, 2009, from <http://www.dpi.qld.gov.au/cps/rde/dpi/hs.xsl/28_14415_ENA_HTML.htm>.

Department of Environment and Resource Management (DERM) 2009, '*Estuarine Crocodile*,' Department of Environment and Resource Management, retrieved 11 September, 2009, from <http://www.epa.qld.gov.au/nature_conservation/wildlife/living_with_wildlife/crocodiles/estuarine_crocodile.html>.

Department of Environment and Resource Management (DERM) 2008, *'Fitzroy NRM Region 'Back on Track' Biodiversity Action Plan*,' Department of Environment and Resource Management, Queensland.

Department of Environment, Water, Heritage and the Arts (DEWHA) 2008, '*Directory of Important Wetlands in Australia – Information Sheet: Fitzroy River Floodplain – QLD013*,' Department of Environment, Water, Heritage and the Arts, retrieved 1 March, 2010, from <http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW&doiw_refcodelist=QLD013>.

Department of Natural Resources and Water (DNRW) 2006, '*Central Queensland Regional Water Supply Strategy'*, Rockhampton, Queensland Government.

Department of Natural Resources and Water (DNRW) 2008, '*Fitzroy Basin draft water resource plan information report*,' Department of Natural Resources and Water, Queensland.

Duivenvoorden, LJ, Hamilton, DR, Price, MD & Attard, TB 2000, '*Temporal Variation of Macroinvertebrate Communities of impounded and riverine sites in Central Queensland'*, in RM Noble (ed.), *River Health in the Fitzroy Catchment: Community Ownership*, Department of Natural Resources, Rockhampton, Queensland.

Duivenvoorden, LJ & Roberts, DT 1997, '*Aquatic Invertebrates'*, in RM Noble, Duivenvoorden, LJ, Rummenie, SK, Long, PE & Fabbro, LD, *Downstream Effects of Land Use in the Fitzroy Catchment*, Department of Natural Resources, Queensland.

Duivenvoorden, L 1995, '*Biological and ecological data (excluding fisheries) on the Dawson River system with particular reference to the proposed Nathan Dam*,' Report prepared for Centre for Land Water and Resource Development.

Duivenvoorden, LJ 1992, '*Aquatic macrophytes of the Fitzroy River Catchment'*, in LJ Duivenvoorden, Yule, D, Fairweather, L & Lawrie, G (eds), *Proceedings of the Fitzroy Catchment Symposium*, University of Central Queensland, Rockhampton, Queensland.

Earth Tech 2007, '*Assessment of potential implications of modified water infrastructure on Fitzroy River fish passage & the Fishway'*, Report prepared for Fitzroy River Water.

Environmental Protection Agency (EPA) 2007, '*Draft Management program for Crocodylus porosus in Queensland 2007-2017*', Environmental Protection Agency, retrieved September, 2009, from <http://www.epa.qld.gov.au/register/p02075aa.pdf>.

Fish, FE, Frappell, PB, Baudinette, RV & Macfarlane, PM 2001, *'Energetics of terrestrial locomotion of the platypus* Ornithorhynchus anatinus', The Journal of Experimental Biology, vol. 204, pp. 797-803.

frc environmental 2008, '*Lower Fitzroy Weirs Literature Review and Gap Analysis'*, report prepared for SunWater.

frc environmental 2007, '*Modified Water Infrastructure EIS & Management Plan: Turtles (Rheodytes leukops & Elseya albagula)*,' report prepared for Fitzroy River Water.

frc environmental 2010a, Connors River Dam Fitzroy River Turtle Survey, August 2010, Wellington Point, pp 27

frc environmental 2010b, Nathan Dam Fitzroy River Turtle Distribution, Reproductive Condition and Nesting Survey, 2010, Wellington Point, pp 24

frc environmental 2012, Nathan Dam and Pipeline Project: Fitzroy River Turtle Survey September – October 2012, Wellington Point, pp 31

Gardner, JL & Serena, M 1995, '*Spatial organisation and movement patterns of adult male platypus,* Ornithorhynchus anatinus *(*Monotremata*:* Ornithorhynchidae)', Australian Journal of Zoology, vol. 43, pp. 91-103.

Gordos, MA, Hamann, M, Schauble, CS, Limpus, CJ, & Franklin, CE 2007, '*Diving behaviour of Elseya albagula from a naturally flowing and hydrologically altered habitat',* Journal of Zoology, vol. 272, pp. 458-469.

Gordos, MA 2004, '*Diving physiological ecology of the bimodally respiring freshwater turtle, Rheodytes leukops'.* PhD Thesis, University of Queensland. Brisbane.

Gordos, MA, Franklin, CE & Limpus, CJ 2003a, '*Seasonal changes in the diel surfacing behaviour of the bimodally respiring turtle* Rheodytes leukops'*.* Canadian Journal of Zoology, vol. 81, pp. 1614-1622.

Gordos, MA, Franklin, CE & Limpus, CJ 2003b, '*Seasonal changes in the diving performance of the bimodally respiring freshwater turtle Rheodytes leukops in a natural setting'*. Canadian Journal of Zoology. vol. 81, pp. 617-625.

Grant, TR & Temple-Smith, PD 1998, '*Field biology of the platypus (Ornithorhynchus anatinus): historical and current perspectives*', Philosophical Transactions of the Royal Society B: Biological Sciences, vol. 353, pp. 1081-1091.

Hamann, M, Schauble, CS, Limpus, DJ, Emerick, SP, and Limpus, CJ 2007, '*Management plan for the conservation of Elseya sp. (Burnett River) in the Burnett River Catchment'*, Queensland Environmental Protection Agency.

Hawking, JH 2000, '*Key to Keys. A guide to keys and zoological information to identify invertebrates from Australian inland waters',* Identification Guide No. 2 2nd Edition, Cooperative Research Centre for Freshwater Ecology.

Heindenreich, M & Broadfoot, C 2001, '*Migratory Fish Communities and Fish Passage options at Tartrus Weir, Mackenzie River*,' Department of Primary Industries, Queensland.

Hogan, A, Graham, P, & Vallance, T 1997, *'Redesign of the Clare Weir Fishway: Identification of fish movement'* in Proceedings of the Second National Fishway Technical Workshop, Rockhampton.

Houston, WA & Duivenvoorden, LJ 2002, '*Replacement of littoral native vegetation with the ponded pasture grass* Hymenachne amplexicalus*: Effects on plant, macroinvertebrate and fish biodiversity in backwaters in the Fitzroy River, Central Queensland, Australia'*, Marine and Freshwater Research, vol. 53, pp. 1235-1244.

Johnston, N, Peck, G, Ford, P, Dougall, C & Carroll, C 2008, '*Fitzroy Basin Water Quality Improvement Report,'* Fitzroy Basin Association Inc., December 2008.

Kowarsky, J and Ross, AH 1981, *Fish movement upstream through a central Queensland (Fitzroy River) coastal fishway*. Australian Journal of Marine and Freshwater Research, 32, pp 93-109.

Lake JS. 1967. *Rearing experiments with five species of Australian freshwater fishes. I. Inducement to spawning*. Australian Journal of Marine and Freshwater Research 18, pp 155–173.

Langdon, SA and Collins, AL 2000, *Quantification of the maximal swimming performance of Australasian glass eel, Anguilla australis and Anguilla reinhardtii, using hydraulic flume swimming chambers.* New Zealand Journal of Marine and Freshwater Research, 34, pp. 629-636.

Legler, JM & Georges, A 1993, '*Family Chelidae'* in CJ Glasby, Ross, GJB & Beesley, PL (eds) *Fauna of Australia vol 2A*, Australian Government Publishing Service, Canberra.

Legler, JM & Cann, J 1980, '*A new genus and species of Chelid turtle from Queensland, Australia*', Contributions to the Science and Natural History Museum Los Angeles County, vol. 324, pp. 1-18.

Legler, JM 1977, *'Stomach flushing: a technique for chelonian dietary studies'*, Herpetologica, vol. 33, pp. 281-284.

Limpus, DJ, Hodge, WJ & Limpus, CJ, 2006, *'Impacts of dams and weirs on freshwater turtle: Fairbairn Dam',* Queensland Environmental Protection Agency, Queensland.

Limpus, CJ, Limpus, DJ, Parmenter, CJ, Hodge, J, Forrest, MJ, & McLachlan, J 2007, '*Proposal for raising Eden Bann Weir and construction of Rookwood Weir – an assessment of the potential implications and mitigation measures for Fitzroy Turtles*,' Commercial-in-confidence report prepared for the Department of Infrastructure, Queensland.

Limpus, CJ., Limpus, DJ., Hollier, C., Savige, M., McAllister, D. 2011, Survey of freshwater turtle populations and nesting habitat – Tartus Weir Turtle Population Project September – December 2011, Department of Environment and Heritage Protection, Queensland Government, pp 32

Long, P & Meager, M 2000, '*The assessment of Eden Bann Weir fishlock, Fitzroy River, Queensland'*, Department of Primary Industries, Queensland.

Long, PE 2000, *'Fish communities in the Dawson River – Weir and Riverine Environments'* in RM Noble (ed.), *River Health in the Fitzroy Catchment: Community Ownership*, Department of Natural Resources, Rockhampton, Queensland.

Mallen-Cooper, M 1992, *Swimming Ability of Juvenile Australian Bass, Macquaria novemaculeata (Steindachner) , and Juvenile Barramundi, Lates calcarifer (Bloch), in an Experimental Vertical-slot Fishway,* Australian Journal of Freshwater Research, 43, pp. 823-34.

Mallen-Cooper, M 1994, *Swimming Ability of adult golden perch, Macquaria ambigua (Percichthyidae), and adult silver perch, Bidyanus bidyanus (Teraponidae) , in an experimental vertical-slot fishway*, Australian Journal of Freshwater Research, 45, pp. 191-198.

Mallen-Cooper, M. & Edwards, E 1991, '*Fish passage through the main weir at Menindee lakes during the flood of September 1990*,' NSW Fisheries Research Institute Report.

Marsden, T & Power, T 2007, '*Proposal for raising Eden Bann Weir and construction of Rookwood Weir – An assessment of the potential requirements for fish passage'*, Commercial-in-confidence report prepared for the Department of Natural Resources and Water, Queensland.

Mathie, NJ & Franklin, CE 2006, *'The influence of body size on the diving behaviour and physiology of the bimodally respiring turtle* Elseya albagula', Journal of Comparative Physiology B, vol. 176 pp. 739-747.

Nergus, P 2007, '*National Action Plan for Salinity and Water Quality State-Level Investment Project Water Quality Information Summary for the Fitzroy Region*,' Report prepared for Department of Natural Resources and Water, Queensland.

Noble, RM, Duivenvoorden, LJ, Rummenie, SK, Long, PE & Fabbro, LD 1997, '*Downstream Effects of Land Use in the Fitzroy Catchment*,' Department of Natural Resources, Queensland.

O'Connor, J, O'Mahony, D, and O'Mahony, J 2003, Downstream movements of adult Murray-Darling fish species, Arthur Rylah Institute of Environmental Research, Heidelberg, Victoria. Project Report. Agriculture, Fisheries and Forestry Australia, Canberra.

O'Connor, J. P., O'Mahony, D. J., and O'Mahony, J. M. 2005, Movements of Macquaria ambigua, in the Murray River, south-eastern Australia. Journal of Fish Biology 66, 392-403.

Otley, HM, Munks, SA & Hindell, MA 2000, *'Activity patterns, movements and burrows of platypuses (*Ornithorhynchus anatinus*) in a sub-alpine Tasmanian lake'*, Australian Journal of Zoology, vol. 48, pp. 701-713.

Priest, TE & Franklin, CE 2002, '*Effects of water temperature and oxygen levels on the diving behaviour of two freshwater turtles:* Rheodytes leukops *and* Emydura macquarii', Journal of Herpetology, vol. 36, pp. 55-561.

Priest, T 1997, '*Bimodal respiration and diving behaviour of the Fitzroy River turtle Rheodytes leukops*'. BSc Honours Thesis, University of Queensland, Brisbane.

Puckridge, JT & Walker, KF 1990, *'Reproductive biology and larval development of gizzard shad,* Nematolosa erebi *(*Gunther*) (*Dorosomatinae*:* Teleostei*), in the Murray River, South Australia'*, Australian Journal of Marine and Freshwater Research, vol. 41, pp. 695-712.

Pusey, B, Kennard, M & Arthington, A 2004, '*Freshwater Fishes of North-Eastern Australia*', CSIRO Publishing, Collingwood.

Queensland Australian River Assessment System *(AusRivAS)* 2001, '*Sampling and Processing Manual'*, Report Prepared for Queensland Department of Natural Resources and Mines, August 2001.

Renfree, M & Marsden,T 2006, '*Clare Weir Fishlock Monitoring, Post-construction Report*,' Queensland Department of Primary Industries – Fisheries Service, Mackay.

Reynolds, LM 1983, '*Migration patterns of five fish species in the Murray-Darling River system'.* Australian Journal of Marine and Freshwater Research. vol 34, pp. 857- 871.

Roberts, D., Duivenvoorden, L., and Stuart, I. (2009). *Factors influencing recruitment patterns of golden perch (Macquaria ambigua oriens) within a hydrologically variable and regulated Australian tropical river system.* Ecology of Freshwater Fish 17, 577-589.

Rogers, VM 2000, '*Dietary ecology including dietary resources partitioning of four species of chelid turtle in a tributary of the Fitzroy River, central Queensland',* BSc Honours Thesis, Central Queensland University, Rockhampton.

Serena, M, Thomas, JL, Williams, GA & Officer, RCE 1998, *'Use of stream and river habitats by the platypus,* Ornithorhynchus anatinus*, in an urban fringe environment'*, Australian Journal of Zoology, vol. 46: pp. 267-282.

Sheaves, M, Johnston, R, Molony, B & Shepard, G. 2007, '*The effect of impoundments on the structure and function of fish fauna in a highly regulated dry tropics estuary'*. Estuaries and Coasts, vol 30, pp. 507-517.

Sinclair Knight Merz (SKM) 2010, *'Connors River Dam and Pipelines Environmental Impact Statement'*, SunWater.

SKM 2007, Appendix E-6.0 Connors River Dam aquatic flora and fauna dry season field survey (frc environmental, December 2007), pp 86

SKM 2012, Nathan Dam and Pipelines Project EIS

Staunton-Smith, J, Robbins JB, Mayer, DG, Sellin, M.J & Halliday, IA 2004, '*Does the quantity and timing of fresh water flowing into a dry tropical estuary affect year-class strength of barramundi (*Lates calcarifer*)?'*. Marine and Freshwater Research, vol. 55, pp. 787.

Stuart, IG 1997, '*Assessment of a Modified Vertical-Slot Fishway, Fitzroy River, Queensland'*, Department of Primary Industries and Fisheries, Bundaberg, Queensland.

Stuart, IG, & Berghuis, AP 1997, '*Assessment of Eden Bann Weir Fishlock Fitzroy River, Queensland,.'* Project Report, Queensland Department of Primary Industries and Fisheries, Bundaberg.

Stuart, IG & Mallen-Cooper, M 1999, '*An assessment of the effectiveness of a vertical-slot fishway for non-salmonid fish at a tidal barrier on a large tropical/subtropical river',* Regulated Rivers Research and Management, vol.15, pp. 575-590.

Stuart, IG, Berghuis, AP, Long, PE & Mallen-Cooper, M 2007, '*Do fish locks have potential in tropical rivers?',* River Research and Applications, vol. 23, pp. 269-286.

SunWater 2008a, '*Lower Fitzroy weirs discussion paper on fishway facilities for raised Eden Bann Weir*,' SunWater.

SunWater 2008b, '*Lower Fitzroy weirs discussion paper on turtle passage facilities for raised Eden Bann Weir and Rookwood'*, SunWater.

Thomson, S, Georges, A, & Limpus, CJ 2006, *'A new species of freshwater turtle in the Genus Elseya (Testundines: Chelidae) from Central Coastal Queensland, Australia'*, Chelonian Conservation and Biology, vol. 5, pp. 74-86.

Tucker, AD, Limpus, CJ, Priest, TE, Cay, J, Glen, C & Guarino, F 2001, *'Home ranges of Fitzroy River turtles (Rheodytes leukops) overlap riffle zones: potential concerns related to river regulation'.* Biological Conservation, vol 102, pp 171-181.

Tucker, AD 2000, '*Cumulative effects of dams and weirs on freshwater turtles: Fitzroy, Kolan, Burnett and Mary Catchments*.' Report prepared for Queensland Department of Natural Resources.

Van Dyck, S & Strahan, R 2008, '*The Mammals of Australia*.' 3rd edn, Reed New Holland, Sydney.

Venz, M, Mathieson, M & Schulz, M 2002, '*Fauna of the Dawson River Floodplain – an assessment of fauna downstream of the proposed Nathan Dam*,' Queensland Environmental Protection Agency.

Walsh, B & Whitehead, PJ 1993, '*Problem crocodiles (Crocodylus porosus) at Nhulunbuy, Northern Territory, Australia: An assessment of relocation as a management strategy*', Wildlife Research, vol. 20, pp. 127-135.

Wager, R 1997, *Aquatic biota assessment*. Comet River proposal. Impact assessment study, proposed Starlee Dam site Rolleston, Central Queensland.

Wilson, S 2005, '*A Field Guide to Reptiles of Queensland*,' Reed New Holland, Sydney.

Wilson, S & Swan, G 2008, '*A Complete Guide to Reptiles of Australia*,' Reed New Holland, Sydney.

Appendices

Appendix A – Eden Bann Weir aquatic desktop search results

DEWHA Environmental Report Tool

DERM Wildlife Online

Queensland Museum

Environmental Reporting Tool

You are here: Environment Home > ERIN > ERT

5 March 2009 10:32

Database Report

This report includes places of national environmental significance that are registered in the Department of the Environment and Water Resources' databases, for the selected area. The information presented here has been provided by a range of groups across Australia, and the accuracy and resolution varies.

Search Type: Line

Buffer: 2 km

Coordinates: -23.08957367,150.1164517, -23.08915314,150.1146644, -23.09347328,150.1064628, -23.08786377,150.0702041, -23.0813826,150.0654548, -23.04636368,150.0788329, -23.03397795,150.0626948, -23.04297241,150.032225, -23.07404312,150.0248855, -23.07620224,150.013224, -23.08440384,150.004164, -23.08786377,149.9959624, -23.08181366,149.9877647, -23.07965263,149.9730819, -23.07361397,149.9523643, -23.06325325,149.9445937, -23.06365483,149.9340405, -23.09606346,149.9225829, -23.09822258,149.9079154, -23.08527359,149.8884834, -23.08095345,149.8880523, -23.07879242,149.8850349, -23.08656296,149.8742431, -23.10685333,149.8656142, -23.11634239,149.8746741, -23.12757286,149.8915046, -23.17591271,149.9234451, -23.20267281,149.9143851, -23.21303352,149.9169753, -23.21432289,149.9320853, -23.220373,149.9502128, -23.21907219,149.9562553, -23.22598251,149.9592727, -23.24195274,149.9497741, -23.29029259,149.9299224, -23.31274399,149.9234451

Report Contents: Summary >> Details >> Caveat >> Acknowledgment

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Biodiversity

Threatened Species:	26
Migratory Species:	18
Listed Marine Species:	17
Invasive Species:	13
Whales and Other Cetaceans:	None
Threatened Ecological Communities:	2

Heritage

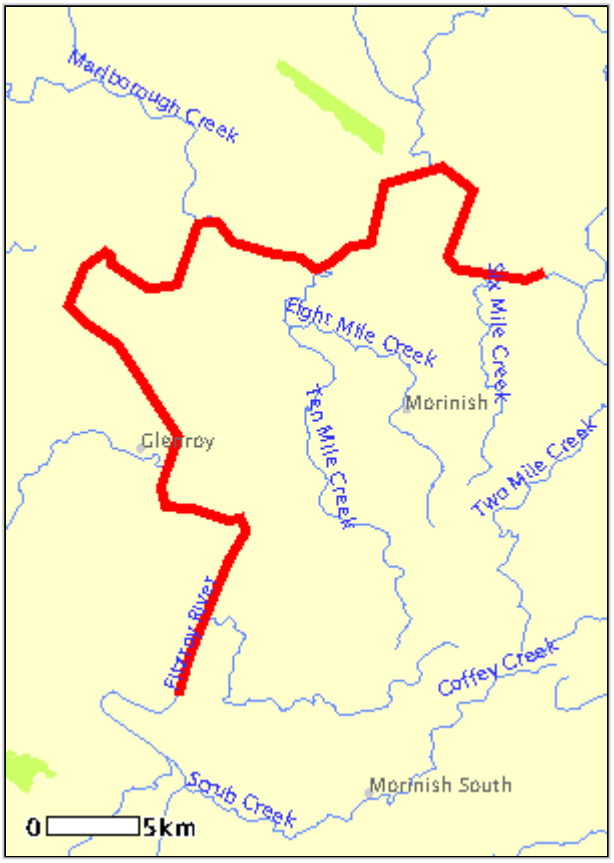
World Heritage Properties:	None
Australian Heritage Sites:	None

Wetlands

Ramsar sites: (Internationally important)	1
Nationally Important Wetlands:	None

National Pollutant Inventory

Reporting Facilities:	None



Airsheds:	None
Catchments:	None

Protected Areas

Reserves and Conservation Areas:	1
Regional Forest Agreements:	None

Biodiversity

Threatened Species [Dataset Information]	Status	Comments
Birds		
Erythrotriorchis radiatus Red Goshawk	Vulnerable	Species or species habitat likely to occur within area
Geophaps scripta scripta Squatter Pigeon (southern)	Vulnerable	Species or species habitat likely to occur within area
Neochmia ruficauda ruficauda Star Finch (eastern), Star Finch (southern)	Endangered	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe	Vulnerable	Species or species habitat may occur within area
Turnix melanogaster Black-breasted Button-quail	Vulnerable	Species or species habitat likely to occur within area
Mammals		
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll	Endangered	Species or species habitat may occur within area
Nyctophilus timoriensis (South-eastern form)	Vulnerable	Species or species habitat may occur

Eastern Long-eared Bat		within area
Reptiles		
Denisonia maculata Ornamental Snake	Vulnerable	Species or species habitat likely to occur within area
Egernia rugosa Yakka Skink	Vulnerable	Species or species habitat likely to occur within area
Furina dunmalli Dunmall's Snake	Vulnerable	Species or species habitat may occur within area
Paradelma orientalis Brigalow Scaly-foot	Vulnerable	Species or species habitat likely to occur within area
Rheodytes leukops Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle	Vulnerable	Species or species habitat may occur within area
Plants		
Capparis thozetiana	Vulnerable	Species or species habitat likely to occur within area
Corymbia xanthope	Vulnerable	Species or species habitat likely to occur within area
Cycas megacarpa	Endangered	Species or species habitat likely to occur within area
Cycas ophiolitica	Endangered	Species or species habitat likely to occur within area
Dichanthium queenslandicum King Blue-grass	Vulnerable	Species or species habitat likely to occur within area
Digitaria porrecta Finger Panic Grass	Endangered	Species or species habitat likely to occur within area
Hakea trineura Three-veined Hakea	Vulnerable	Species or species habitat likely to occur within area
Leucopogon cuspidatus	Vulnerable	Species or species habitat likely to occur within area
Marsdenia brevifolia	Vulnerable	Species or species habitat likely to occur within area
Neoroepera buxifolia	Vulnerable	Species or species habitat likely to occur within area
Parsonsia larcomensis	Vulnerable	Species or species habitat likely to occur within area
Pimelea leptospermoides	Vulnerable	Species or species habitat likely to occur within area
Pultenaea setulosa	Vulnerable	Species or species habitat likely to occur within area
Migratory Species [Dataset Information]	Status	Comments
Migratory Terrestrial Species		
Birds		
Haliaeetus leucogaster White-bellied Sea-Eagle	Migratory	Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail	Migratory	Species or species habitat may occur within area
Hirundo rustica Barn Swallow	Migratory	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater	Migratory	Species or species habitat may occur within area

Monarcha melanopsis Black-faced Monarch	Migratory	Species or species habitat may occur within area
Monarcha trivirgatus Spectacled Monarch	Migratory	Breeding likely to occur within area
Myiagra cyanoleuca Satin Flycatcher	Migratory	Species or species habitat likely to occur within area
Rhipidura rufifrons Rufous Fantail	Migratory	Breeding may occur within area

Migratory Wetland Species

Birds

Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe	Migratory	Species or species habitat may occur within area
Nettapus coromandelianus albipennis Australian Cotton Pygmy-goose	Migratory	Species or species habitat may occur within area
Numenius minutus Little Curlew, Little Whimbrel	Migratory	Species or species habitat may occur within area
Rostratula benghalensis s. lat. Painted Snipe	Migratory	Species or species habitat may occur within area

Migratory Marine Birds

Apus pacificus Fork-tailed Swift	Migratory	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area

Migratory Marine Species

Reptiles

Crocodylus porosus Estuarine Crocodile, Salt-water Crocodile	Migratory	Species or species habitat likely to occur within area

Listed Marine Species [Dataset Information]	Status	Comments

Birds

Anseranas semipalmata Magpie Goose	Listed - overfly marine area	Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift	Listed - overfly marine area	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Listed - overfly marine area	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Listed - overfly marine area	Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe	Listed - overfly marine area	Species or species habitat may occur within area

Haliaeetus leucogaster White-bellied Sea-Eagle	Listed	Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail	Listed - overfly marine area	Species or species habitat may occur within area
Hirundo rustica Barn Swallow	Listed - overfly marine area	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater	Listed - overfly marine area	Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch	Listed - overfly marine area	Species or species habitat may occur within area
Monarcha trivirgatus Spectacled Monarch	Listed - overfly marine area	Breeding likely to occur within area
Myiagra cyanoleuca Satin Flycatcher	Listed - overfly marine area	Species or species habitat likely to occur within area
Nettapus coromandelianus albipennis Australian Cotton Pygmy-goose	Listed - overfly marine area	Species or species habitat may occur within area
Numenius minutus Little Curlew, Little Whimbrel	Listed - overfly marine area	Species or species habitat may occur within area
Rhipidura rufifrons Rufous Fantail	Listed - overfly marine area	Breeding may occur within area
Rostratula benghalensis s. lat. Painted Snipe	Listed - overfly marine area	Species or species habitat may occur within area

Reptiles

Crocodylus porosus Estuarine Crocodile, Salt-water Crocodile	Listed	Species or species habitat likely to occur within area

Invasive Species [Dataset Information]	Status	Comments
Selected Invasive Species: Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.		

Mammals

Capra hircus Goat	Feral	Species or species habitat may occur within area
Felis catus Cat, House Cat, Domestic Cat	Feral	Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit	Feral	Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox	Feral	Species or species habitat likely to occur within area

Plants

Acacia nilotica subsp. *indica* Prickly Acacia	WoNS	Species or species habitat may occur within area
Alternanthera philoxeroides Alligator Weed	WoNS	Species or species habitat may occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda	WoNS	Species or species habitat likely to occur within area
Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass	WoNS	Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage	WoNS	Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean	WoNS	Species or species habitat may occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed	WoNS	Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba	WoNS	Species or species habitat may occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed	WoNS	Species or species habitat may occur within area
Threatened Ecological Communities [Dataset Information]	Status	Comments
Brigalow (*Acacia harpophylla* dominant and co-dominant)	Endangered	Community known to occur within area
Weeping Myall Woodlands	Endangered	Community likely to occur within area
Wetlands		
Wetlands of International Importance (Ramsar sites) [Dataset Information]		
SHOALWATER AND CORIO BAYS AREA		Within same catchment as Ramsar site
Other		
Reserves and Conservation Areas [Dataset Information]		
Princhester Conservation Park, QLD		

Caveat

The information presented here has been drawn from a range of sources, compiled for a variety of purposes. Details of the coverage of each dataset are included in the metadata [Dataset Information] links above.

Acknowledgment

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- New South Wales National Parks and Wildlife Service
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- Department of Primary Industries, Water and Environment, Tasmania
- Department of Environment and Heritage, South Australia Planning SA
- Parks and Wildlife Commission of the Northern Territory
- Environmental Protection Agency, Queensland

- Birds Australia
- Australian Bird and Bat Banding Scheme
- Australian National Wildlife Collection
- Natural history museums of Australia
- Queensland Herbarium
- National Herbarium of NSW
- Royal Botanic Gardens and National Herbarium of Victoria
- Tasmanian Herbarium
- State Herbarium of South Australia
- Northern Territory Herbarium
- Western Australian Herbarium
- Australian National Herbarium, Atherton and Canberra
- University of New England
- Other groups and individuals

ANUCliM Version 1.8, Centre for Resource and Environmental Studies, Australian National University was used extensively for the production of draft maps of species distribution. The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Environmental Reporting Tool

You are here: Environment Home > ERIN > ERT

5 March 2009 10:09

Database Report

This report includes places of national environmental significance that are registered in the Department of the Environment and Water Resources' databases, for the selected area. The information presented here has been provided by a range of groups across Australia, and the accuracy and resolution varies.

Search Type: Line

Buffer: 2 km

Coordinates: -23.36177313,150.4984877, -23.36065277,150.4936355, -23.33993324,150.4949325, -23.31421903,150.4773588, -23.33777222,150.462992, -23.34252342,150.4530624, -23.33518395,150.446585, -23.3231028,150.4526351, -23.30884226,150.450801, -23.24474753,150.4229381, -23.23979363,150.4004043, -23.2505835,150.3827041, -23.26094231,150.3775237, -23.26655373,150.3719123, -23.2648333,150.3581031, -23.24972328,150.3429931, -23.23850235,150.342562, -23.23634323,150.3524955, -23.22296318,150.3676055, -23.20440277,150.3909019, -23.18972382,150.4047225, -23.18368324,150.3852943, -23.16728386,150.3844321, -23.16598305,150.3900436, -23.15951332,150.393492, -23.15303406,150.3904746, -23.14181313,150.3831351, -23.14742264,150.3706229, -23.14397224,150.359835, -23.14526352,150.342562, -23.14224228,150.3373855, -23.13793358,150.2963851, -23.13318237,150.2812751, -23.11289391,150.2514938, -23.10901245,150.2337936, -23.10901245,150.2113441, -23.12541374,150.1953719, -23.14656242,150.1630042, -23.13275322,150.1418555, -23.11850342,150.1336539, -23.10037407,150.1396926, -23.09260353,150.1293319, -23.08957367,150.1164517

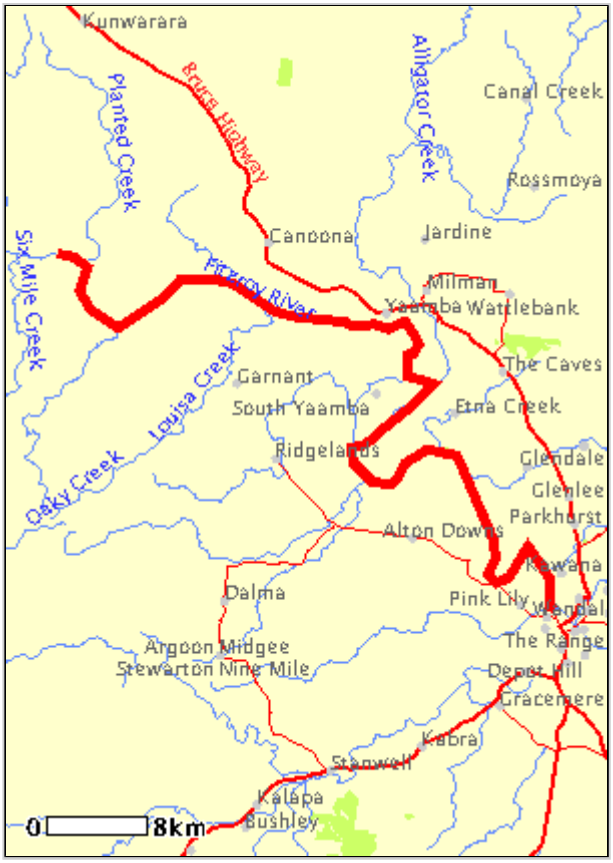
Report Contents: Summary >> Details >> Caveat >> Acknowledgment

Biodiversity

Threatened Species:	24
Migratory Species:	18
Listed Marine Species:	17
Invasive Species:	13
Whales and Other Cetaceans:	None
Threatened Ecological Communities:	3

Heritage

World Heritage Properties:	None



Australian Heritage Sites:	5

Wetlands

Ramsar sites: **(Internationally important)**	1
Nationally Important Wetlands:	2

National Pollutant Inventory

Reporting Facilities:	14
Airsheds:	None
Catchments:	None

Protected Areas

Reserves and Conservation Areas:	1
Regional Forest Agreements:	None

Biodiversity

Threatened Species [Dataset Information]	Status	Comments
Birds		
Erythrotriorchis radiatus Red Goshawk	Vulnerable	Species or species habitat likely to occur within area
Geophaps scripta scripta Squatter Pigeon (southern)	Vulnerable	Species or species habitat likely to occur within area

Neochmia ruficauda ruficauda Star Finch (eastern), Star Finch (southern)	Endangered	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe	Vulnerable	Species or species habitat may occur within area
Turnix melanogaster Black-breasted Button-quail	Vulnerable	Species or species habitat likely to occur within area
Mammals		
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll	Endangered	Species or species habitat may occur within area
Nyctophilus timoriensis (South-eastern form) Eastern Long-eared Bat	Vulnerable	Species or species habitat may occur within area
Reptiles		
Denisonia maculata Ornamental Snake	Vulnerable	Species or species habitat likely to occur within area
Egernia rugosa Yakka Skink	Vulnerable	Species or species habitat likely to occur within area
Furina dunmalli Dunmall's Snake	Vulnerable	Species or species habitat may occur within area
Rheodytes leukops Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle	Vulnerable	Species or species habitat may occur within area
Plants		
Capparis thozetiana	Vulnerable	Species or species habitat likely to occur within area
Corymbia xanthope	Vulnerable	Species or species habitat likely to occur within area
Cycas megacarpa	Endangered	Species or species habitat known to occur within area
Cycas ophiolitica	Endangered	Species or species habitat likely to occur within area
Eucalyptus raveretiana Black Ironbox	Vulnerable	Species or species habitat likely to occur within area
Hakea trineura Three-veined Hakea	Vulnerable	Species or species habitat likely to occur within area
Leucopogon cuspidatus	Vulnerable	Species or species habitat likely to occur within area
Marsdenia brevifolia	Vulnerable	Species or species habitat likely to occur within area
Neoroepera buxifolia	Vulnerable	Species or species habitat likely to occur within area
Parsonsia larcomensis	Vulnerable	Species or species habitat likely to occur within area
Pimelea leptospermoides	Vulnerable	Species or species habitat likely to occur within area

Pultenaea setulosa	Vulnerable	Species or species habitat likely to occur within area
Migratory Species [Dataset Information]	Status	Comments
Migratory Terrestrial Species		
Birds		
Haliaeetus leucogaster White-bellied Sea-Eagle	Migratory	Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail	Migratory	Species or species habitat may occur within area
Hirundo rustica Barn Swallow	Migratory	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater	Migratory	Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch	Migratory	Breeding may occur within area
Monarcha trivirgatus Spectacled Monarch	Migratory	Breeding likely to occur within area
Myiagra cyanoleuca Satin Flycatcher	Migratory	Species or species habitat likely to occur within area
Rhipidura rufifrons Rufous Fantail	Migratory	Breeding may occur within area
Migratory Wetland Species		
Birds		
Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe	Migratory	Species or species habitat may occur within area
Nettapus coromandelianus albipennis Australian Cotton Pygmy-goose	Migratory	Species or species habitat may occur within area
Numenius minutus Little Curlew, Little Whimbrel	Migratory	Species or species habitat may occur within area
Rostratula benghalensis s. lat. Painted Snipe	Migratory	Species or species habitat may occur within area
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift	Migratory	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area
Migratory Marine Species		
Reptiles		
Crocodylus porosus Estuarine Crocodile, Salt-water Crocodile	Migratory	Species or species habitat likely to occur within area

Listed Marine Species [Dataset Information]	Status	Comments
Birds		
Anseranas semipalmata Magpie Goose	Listed - overfly marine area	Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift	Listed - overfly marine area	Species or species habitat may occur within area
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Rostratula benghalensis s. lat. Painted Snipe	Listed - overfly marine area	Species or species habitat may occur within area
Reptiles		
Crocodylus porosus Estuarine Crocodile, Salt-water Crocodile	Listed	Species or species habitat likely to occur within area

Invasive Species [Dataset Information]	Status	Comments
Selected Invasive Species: Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit,		

2001.

Mammals

Capra hircus Goat	Feral	Species or species habitat may occur within area
Felis catus Cat, House Cat, Domestic Cat	Feral	Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit	Feral	Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox	Feral	Species or species habitat likely to occur within area

Plants

Acacia nilotica subsp. *indica* Prickly Acacia	WoNS	Species or species habitat may occur within area
Alternanthera philoxeroides Alligator Weed	WoNS	Species or species habitat may occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda	WoNS	Species or species habitat likely to occur within area
Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass	WoNS	Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage	WoNS	Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean	WoNS	Species or species habitat may occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed	WoNS	Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba	WoNS	Species or species habitat may occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed	WoNS	Species or species habitat may occur within area

Threatened Ecological Communities [Dataset Information]	Status	Comments
Brigalow (*Acacia harpophylla* dominant and co-dominant)	Endangered	Community known to occur within area
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	Endangered	Community likely to occur within area
Weeping Myall Woodlands	Endangered	Community likely to occur within area

Heritage

Australian Heritage Sites [Dataset Information]
Note that not all Indigenous sites may be listed.

Historic

Alexandra Bridge QLD

Archer Park Railway Station (former) QLD

Glenmore Homestead Complex (former) QLD

House QLD

Tobruk House QLD

Wetlands

Wetlands of International Importance (Ramsar sites) [Dataset Information]

SHOALWATER AND CORIO BAYS AREA	Within same catchment as Ramsar site

Nationally Important Wetland Sites [Dataset Information]

Fitzroy River Delta, QLD

Fitzroy River Floodplain, QLD

National Pollutant Inventory

Reporting Facility [Dataset Information]	Top Substance	Source

Substance emissions are ranked on a scale of 1-100: 1=lowest; 100=highest. Rankings are shown as: =0-25; =26-50; =51-75; =76-100.

ALINTA ASSET MANAGEMENT P/L (Fitzroy River (1) Valve KP 93.311 (MLV) (Queensland Gas Pipeline), ROCKHAMPTON QLD)	Total Volatile Organic Compounds [Low]	Main Line Valve
ALINTA ASSET MANAGEMENT P/L (Fitzroy River (2) Valve KP 93.688 (MLV) (Queensland Gas Pipeline), ROCKHAMPTON QLD)	Total Volatile Organic Compounds [Low]	Main Line Valve
ALINTA ASSET MANAGEMENT P/L (Origin South Offtake Meter Station KP 90.625 (Queensland Gas Pipeline), ROCKHAMPTON QLD)	Total Volatile Organic Compounds [Low]	Natural Gas Metering
BP AUSTRALIA PTY LTD (AIR BP ROCKHAMPTON AIRPORT, ROCKHAMPTON QLD)	Total Volatile Organic Compounds [Low]	Bulk petroleum storage facility
Central Queensland Petroleum Pty Ltd (Rockhampton Depot, Rockhampton QLD)	Cumene (1-methylethylbenzene) [Low]	Petroleum Product Wholesaling
Country Bake (Regal Bakeries Pty Ltd) - Goodman Fielder Limited (Rockhampton QLD)	Carbon monoxide [Low]	Plant Bakery
FITZROY RIVER WATER (Glenmore Water Treatment Plant, ROCKHAMPTON QLD)	Chlorine [Low]	Treatment and Processing of potable water
KALININ INVESTMENTS P/L (Sungold, ROCKHAMPTON QLD)	Total Volatile Organic Compounds	Hydrocarbon storage and distribution

	[Low]	
ROCKHAMPTON CITY COUNCIL (Jardine Park Landfill (Closed), ROCKHAMPTON QLD)	Chlorine [Low]	Closed Municipal Landfill Facility
ROCKHAMPTON CITY COUNCIL (Jardine Street Landfill (Closed), ROCKHAMPTON QLD)	Chlorine [Low]	Closed Municipal Landfill Facility
ROCKHAMPTON CITY COUNCIL (Ski Gardens Landfill (Closed), ROCKHAMPTON QLD)	Acrylonitrile (2-propenenitrile) [Low]	Closed Municipal Landfill Facility
ROCKHAMPTON CITY COUNCIL (Victoria Park Landfill (Closed), ROCKHAMPTON QLD)	Chlorine [Low]	Closed Municipal Landfill Facility
ROCKHAMPTON CITY COUNCIL (West Rockhampton Landfill (Closed), ROCKHAMPTON QLD)	Chlorine [Low]	Closed Municipal Landfill Facility
ROCKHAMPTON CITY COUNCIL (West Rockhampton Sewage Treatment Plant, ROCKHAMPTON QLD)	Total Phosphorus [Low]	Treatment of municipal wastewater. Trickling filter (secondary treatment) servicing south west side of Rockhampton

Other

Reserves and Conservation Areas [Dataset Information]

Long Island Bend Conservation Park, QLD

Caveat

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- Tasmanian Herbarium

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DERM Wildlife Online Database			
Scientific Name	**Common Name**	**NC Act Status**	**EPBC Act Status**
Reptiles			
Crocodylus porosus	estuarine crocodile	V	Mig
Chelodina longicollis	eastern snake-necked turtle		
Elseya albagula	southern snapping turtle	#	
Emydura macquarii krefftii	Krefft's river turtle		
Rheodytes leukops	Fitzroy River turtle	V	V
Fish			
Ambassis agassizii	Agassiz's glassfish		
Amniataba percoides	barred grunter		
Anguilla reinhardtii	longfin eel		
Arius graeffei	blue catfish		
Arius leptaspis	boofhead catfish		
Arrhamphus sclerolepis	snubnose garfish		
Craterocephalus marjoriae	silverstreak hardyhead		
Craterocephalus stercusmuscarum	flyspecked hardyhead		
Glossamia aprion	mouth almighty		
Hypseleotris galii	firetail gudgeon		
Hypseleotris species 1	Midgley's carp gudgeon		
Leiopotherapon unicolor	spangled perch		
Macquaria ambigua	golden perch		
Megalops cyprinoides	oxeye herring		
Melanotaenia splendida splendida	eastern rainbowfish		
Mugil cephalus	sea mullet		
Nematalosa erebi	bony bream		
Neosilurus hyrtlii	Hyrtl's catfish		
Oxyeleotris lineolata	sleepy cod		
Philypnodon grandiceps	flathead gudgeon		
Pseudomugil signifer	Pacific blue eye		
Redigobius bikolanus	speckled goby		
Scortum hillii	leathery grunter		
Tandanus tandanus	freshwater catfish		

Queensland Museum Database			
Scientific Name	**Common Name**	**NC Act Status**	**EPBC Act Status**
Emydura macquarii krefftii	Krefft's river turtle		
Rheodytes leukops	Fitzroy River turtle	V	V

#Has been recommended for listing as 'Endangered' under NC Act

GHD

145 Ann Street Brisbane QLD 4000
GPO Box 668 Brisbane QLD 4001
T: (07) 3316 3000 F: (07) 3316 3333 E: bnemail@ghd.com

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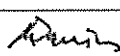
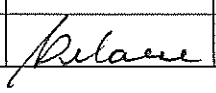
Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	N Clark J Simmonds	G Squires	On file	L Delaere	On file	01/08/2014
1	-	G Squires	On file	L Delaere	On file	18/08/2014
2	-	G Squires		L Delaere		05/06/2015

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