

10. Groundwater resources

Table of contents

10. Groundwater resources	i
10.1 Introduction	10-1
10.1.1 Overview	10-1
10.1.2 Regulatory framework	10-1
10.1.3 Approach and methodology	10-1
10.2 Existing environment	10-2
10.2.1 Geology and hydrogeology	10-2
10.2.1.1 Alluvial aquifers	10-3
10.2.1.2 Tertiary sediment aquifers	10-3
10.2.1.3 Gogango overfold aquifers	10-3
10.2.1.4 Groundwater levels, flow and water quality	10-4
10.2.2 Groundwater resource allocation	10-6
10.2.3 Groundwater dependent ecosystems	10-11
10.3 Potential impacts and mitigation measures	10-12
10.3.1 Construction	10-12
10.3.2 Operations	10-15
10.3.2.1 Upstream impacts	10-15
10.3.2.2 Downstream impacts	10-17
10.4 Summary	10-18

Table index

Table 10-1 Groundwater chemistry zones within the Project area	10-5
Table 10-2 Registered bores within proximity to the Project footprint	10-8

Figure index

Figure 10-1 Fitzroy and Highlands groundwater management areas	10-7
Figure 10-2 Eden Bann Weir - registered bores	10-9
Figure 10-3 Rookwood Weir - registered bores	10-10
Figure 10-4 Eden Bann Weir groundwater dependent ecosystems	10-13
Figure 10-5 Rookwood Weir groundwater dependent ecosystems	10-14

10.1 Introduction

10.1.1 Overview

This chapter describes the groundwater resources in the Fitzroy Basin, focusing on the area potentially affected by the Lower Fitzroy River Infrastructure Project (Project). The assessment addresses how groundwater resources may be impacted by the Project and identifies methods by which these impacts may be avoided, mitigated or otherwise managed.

Together with Chapter 11 Water quality, this assessment addresses Part B, Sections 5.93 – 5.131, and Sections 5.114 – 5.117 of the terms of reference (ToR) for the environmental impact statement (EIS) as applicable. A table cross-referencing the ToR requirements is provided in Appendix B. This chapter may be read in conjunction with Chapter 9 Surface water resources and Chapter 23 Environmental management plan.

10.1.2 Regulatory framework

The legislation, policies and strategies relevant to the management of groundwater resources are as follows.

- *Water Act 2000* (Qld); subordinate legislation and plans
 - Water Resource (Fitzroy Basin) Plan 2011 (Fitzroy WRP)
 - Fitzroy Basin Resource Operations Plan (Fitzroy ROP)
- *Environmental Protection Act 1994* (Qld) (EP Act) and subordinate regulation and policy
 - Environmental Protection Regulation 2008
 - Environmental Protection (Water) Policy 2009 (Water EPP)
- Australian National Water Quality Management Strategy (NWQMS) and subordinate guidelines
 - Australian and New Zealand Guidelines for Fresh and Marine Water Quality
 - Queensland Water Quality Guidelines
 - Guidelines for Water Quality Protection in Australia
- Central Queensland Regional Water Supply Strategy (CQRWSS).

Further detail is provided in Chapter 3 Legislation and project approvals.

10.1.3 Approach and methodology

The study area for the groundwater assessment is defined by the Fitzroy WRP Groundwater management area (GMA). The following approach was taken to describe the groundwater resources of the Project area and the potential impact of the Project on these resources:

- Identify and describe the groundwater resources of the Project area
- Identify and describe groundwater uses in the Project area
- Identify Project activities and/or components with the potential to impact on groundwater resources or uses upstream and downstream of the weirs
- Assess potential impacts of identified activities
- Develop measures to manage potential impacts to groundwater as necessary and applicable.

Project specific groundwater monitoring has not been undertaken due to the limited impacts predicted from the Project on groundwater. A study conducted by Raymond and McNeil (2011) to determine the regional chemistry of groundwater in the Fitzroy Basin and the Hydrogeological Investigation of the Fitzroy River Sub-Catchment, Central Queensland, Australia (as part of the National Action Plan for Salinity and Water Quality) (Pearce and Hansen 2006) have been reviewed. Surface water and groundwater data available for the region was collated to establish groundwater chemistry zones (Chapter 11 Water quality).

10.2 Existing environment

10.2.1 Geology and hydrogeology

The existing Eden Bann Weir is situated on the Wattlebank Granodiorite intruded into the Princhester Serpentinities on either side of the Fitzroy River. The foundation conditions at the proposed Rookwood Weir site are relatively complex, comprising Holocene to Tertiary poorly to well consolidated alluvial deposits, underlain by Permian sedimentary rocks on the left bank and volcanic rocks under the river channel and right bank.

The geology at the Eden Bann and Rookwood weir sites is described further in Chapter 5 Land.

Pearce and Hansen (2006) has been reviewed to summarise the hydrogeology of the Fitzroy River sub-catchment extending from Gogango in the south-west, to Marlborough in the northwest, and from Raglan in the south-east, to Rossmoya and Barmoya regions in the northeast. Pearce and Hansen (2006) is used to describe hydrogeological units within the Fitzroy River sub-basin and relative to the Project areas. The Fitzroy River sub-catchment is defined by nine hydrogeological units, comprising alluvial sediments, Tertiary sediments and seven fractured rock hydrogeological units, overlain by extensive Quaternary alluvial deposits, as follows:

- Yarrol Province
- Wandilla Province
- Connors-Auburn Province
- Gogango Overfold Zone
- Bowen Basin
- Permo-triassic intrusives
- Mulgildie Basin.

The serpentines of the Yarra Fault system, a formation within the Wandilla Province hydrogeological unit, are mapped in the areas adjacent to the existing Eden Bann Weir and associated impoundment. The serpentines are uniformly massive and hard with groundwater supplies contained in unconfined fractured rock aquifers. Bores are typically shallow (on average 30 m depth) with yields ranging from 0.12 l/s to 4 l/s. Groundwater quality is reported as good (Pearce and Hansen 2006); with total dissolved solids ranging between 350 mg/l and 650 mg/l. Transmissivities range from 7m²/d to 70 m²/d (Pearce 1976).

The Gogango Overfold Zone and Bowen Basin hydrogeological units dominate the remaining (existing and proposed) areas adjacent to the Eden Bann Weir impoundment area and the proposed Rookwood Weir site and associated impoundment. While the Connors-Auburn Province, Gogango Overfold Zone and Bowen Basin are separate tectonostratigraphic units with regard to hydrogeology they effectively form a single hydrogeological unit. They comprise highly

fractured and sheared rocks with low porosity. Groundwater resources are contained within the fracture zones and have highly variable yields and water quality (Pearce and Hansen 2006).

These hydrogeological units are overlain by Quaternary sediments that form unconfined alluvial aquifers.

Tertiary sediments are found in the vicinity of Glenroy Crossing (upstream within the proposed Eden Bann Weir impoundment and south-west of the proposed Rookwood Weir in the vicinity of Gogango).

10.2.1.1 Alluvial aquifers

Alluvial deposits are associated with the Quaternary drainage system in the Fitzroy River sub-catchment. The deposits become more extensive across broad floodplains in the eastern part of the sub-catchment, downstream of the Project area. The most reliable aquifers are often located closest to the main river systems. Within the alluvial aquifer system, the majority of bores are confined to the area between Yaamba and Rockhampton and to the southwest of Rockhampton towards Bouldercombe and Stanwell, downstream of the Project areas. Alluvial aquifers are also exploited locally in the Bajool - Raglan region and Gogango district in the southeast and southwest of the sub-catchment respectively. Along the Fitzroy River and relative to the Project areas, the depth to the base of the alluvium is typically between 20 m and 35 m.

The alluvium is composed of unconsolidated coarse clastic sand and gravel with varying amounts of clay. The main groundwater aquifer is typically contained in a quartzes gravel layer that is up to 10 m deep although in areas where the alluvium is thickest several gravel layers are sometimes present. Quaternary sediments associated with broad floodplains in the east of the sub-catchment are often more clayey and contain isolated sand bodies that yield limited groundwater supplies. The alluvial aquifers are typically unconfined.

10.2.1.2 Tertiary sediment aquifers

Extensive Tertiary sediment deposits have developed in numerous, small fault controlled basins throughout the Fitzroy River sub-catchment. The most extensive Tertiary sediment deposits occur in the Biloela Basin in the southwest of the subcatchment. The Biloela Formation contains fluviolacustrine deposits that are composed of semi-consolidated to consolidated claystone, mudstone, siltstone and minor sandstone with the occasional peat layer and gravel bed. Groundwater resources in the Biloela Formation typically yield limited supplies and often have poor quality. Tertiary sediments in other basins, particularly the buried Rossmoya, Yaamba and Casuarina Basins, remain largely unexplored due to poor groundwater potential and the availability of more accessible and reliable groundwater resources in overlying alluvial aquifers.

10.2.1.3 Gogango overfold aquifers

The Gogango Overfold Zone is composed of fractured and sheared sedimentary and volcanic successions that are considered equivalents of the Bowen Basin. Data coverage across the Gogango Overfold Aquifers is erratic and bores are often located in lower lying areas. The greatest concentration of bores is in the Gogango area south of the Fitzroy River.

Groundwater supplies in the Gogango Overfold Aquifers are contained in weathered, fractured zones that often reach depths of approximately 25 m but can be up to 50 m in depth. The most reliable groundwater supplies occur in lower lying areas. More elevated regions typically produce unreliable bores.

10.2.1.4 Groundwater levels, flow and water quality

Publically available groundwater level data for alluvial aquifers is essentially confined to alluvium associated with the Fitzroy River between Yaamba and Rockhampton, and Neerkol Creek between Stanwell and Rockhampton (all downstream of the Project area) with limited data points at Marlborough (north to north-west of the existing Eden Bann Weir impoundment), Gogango (south of the proposed Rookwood Weir impoundment) and near Raglan (further afield, south-east of the Project). Pearce and Hansen (2006) report that there is a relatively flat hydraulic gradient and that, as expected, groundwater flow in alluvial aquifers essentially follows the surface drainage gradient. Although not definitive, there are indications that groundwater level gradients in alluvial aquifers possibly become steeper with distance from the Fitzroy River. Within the Fitzroy River sub-catchment the depth to groundwater level is typically between 5 m and 15 m below ground surface in the alluvium although there are a significant number of bores that have groundwater levels that are shallower than 5 m below ground surface.

Groundwater levels are influenced by a number of factors including rainfall, groundwater extraction from production bores and groundwater flow. Pearce and Hansen (2006) indicate that both rainfall and groundwater extraction from private bores both have long term effects on groundwater level behaviour. Groundwater level trends in general mimic residual rainfall trends (Pearce and Hansen 2006). Groundwater level trends within fractured rock aquifers respond to rainfall events within a couple of months and the magnitude of the response is up to three metres. While not definitive, the trends also indicate that rate and magnitude of this response appears to be faster and greater in areas where the groundwater levels are shallower. Water tables generally follow topographic features indicating that the dominant recharge source is from direct infiltration of rainfall.

Within the fractured rock aquifers Pearce and Hansen (2006) report that groundwater flow is primarily towards the Fitzroy River from topographic highs and then possibly down gradient along the Fitzroy River. Groundwater flow gradients are relatively flat in lower lying areas and become steeper with increasing elevation. The depth to groundwater level for fractured rock aquifers is quite variable ranging from less than 5 m to over 40 m below ground surface.

Information on groundwater levels in proximity to Eden Bann Weir and the proposed Rookwood Weir site is limited. A review of borehole logs and associated pre-construction one off groundwater level data for Eden Bann Weir (GHD 2011a) and for Rookwood Weir (GHD 2011b) obtained as part of the site investigations for each weir site (undertaken within and on the banks of the river channel), in conjunction with knowledge of the typical characteristics of the Fitzroy River, does however indicate the following:

- At both Eden Bann Weir and the proposed Rookwood Weir sites the groundwater table typically lies at or close to the bed of the river channel, depending on the flow condition of the river and time since last significant rainfall and river flow event, given:
 - Under conditions of low/no flow in the river, depth to groundwater beneath the river channel at Eden Bann Weir was measured between around 0.5 m and 3 m below ground surface (elevations between around 8.5 m and 14 m AHD) during the site investigations conducted within the river channel (GHD, 2011a).
 - Under conditions of low/no flow in the river, depth to groundwater beneath the river channel at Rookwood Weir was measured at less than 0.5 m to around 6 m below ground surface (elevations between around 31 and 34 m AHD) during the site investigations conducted within the river channel (GHD, 2011b)

- In dry conditions (i.e. intermittent low flow/no flow in the river upstream and downstream of any impounded reaches) the groundwater table within the river channel ‘windows’ in the topographic lows within the river bed and expresses as surface water pools.
- A downward hydraulic gradient from the river (by virtue of the pressure head of the surface water when the river is flowing/within the impounded section of the river being higher than that of the groundwater) to the underlying groundwater table is therefore indicated at both weir sites. The underlying unconfined alluvial (predominantly sand and gravel with silts and clays) and fractured rock aquifers can therefore be recharged via seepage from the river through the river bed when the river is flowing and also beneath inundated reaches of the river. Recharge of groundwater almost certainly occurs through the bed of the river channel upstream and downstream of the weir structures given the similarities in the mapped geology
- No significant contribution of groundwater to surface water flow is therefore anticipated.

A review of groundwater data from registered bores within 5 km of the Project areas (Queensland Groundwater Database 2009 and 2013) reveals the following:

- Vicinity of Eden Bann Weir site
 - Groundwater bores within 5 km of the Eden Bann Weir Project area produce variable yields in general (up to 6.3 litres per second), with groundwater occurrence in fractured zones in the plutonic and volcanic rocks
 - Standing water level is on average 12 m below ground level with potable water quality (electrical conductivity (EC) range is between 700 µS/cm and 2,600 µS/cm).
- Vicinity of Rookwood Weir site
 - Groundwater bores in proximity to the proposed Rookwood Weir site Project area produce variable yields in general (up to 2.4 litres per second), with groundwater occurrence in fractured bedrock and unconsolidated sediments (alluvium)
 - Standing water level is on average 10 m below ground level with potable to brackish water quality (EC range is between 600 µS/cm and 7,200 µS/cm).

The Queensland Government study, Regional Chemistry of the Fitzroy Basin Groundwater (Raymond and McNeil 2011) divides the Fitzroy Basin into 44 discrete chemistry zones. Three of these zones are traversed by the Project area as summarised in Table 10-1.

Table 10-1 Groundwater chemistry zones within the Project area

No.	Name	Cations	Anions	Salinity	Electrical conductivity (µS/cm)			
					Depth	20 th percentile	50 th percentile	80 th percentile
14	Prospect Fitzroy	Na	HCO ₃	Low - moderate	Shallow	1,006	1,619	2,765
					Deep	756	1,420	2,150
22	Fitzroy	Balanced	Cl	Moderate	Shallow	1,403	2,220	3,722
					Deep	1,507	2,735	5,279
34	Isaac Dawson	Na	Cl	Saline	Shallow	498	2,150	8,910
					Deep	3,419	6,100	16,000

Pearce and Hansen (2006) report that groundwater quality across the Fitzroy River sub-catchment is generally in the fresh to slightly saline range with median EC within the alluvial aquifers of 2,380 $\mu\text{S}/\text{cm}$. Median EC within the Gogango Overfold aquifers is 4,080 $\mu\text{S}/\text{cm}$.

Pearce and Hansen (2006) conclude that poor quality groundwater occurs in specific locations rather than specific aquifers, namely alluvial flats and adjacent flanking areas in the Barmoya - Rossmoya district, Raglan district, between Yaamba and Rockhampton, the Ridgeland Granodiorite, and alluvial and Tertiary sediments in the Gogango district. All districts are located outside of the Project area. Yaamba and Rockhampton are located downstream of the existing Eden Bann Weir; the Ridgeland district is located downstream and south-east of the Eden Bann Weir Project area and the Gogango district is located south of the proposed Rookwood Weir site and inundation area.

However, poor quality groundwater in the Gogango district is related to aquifer characteristics. Poor quality, slightly to moderately saline groundwater in this area is contained in fractured rock aquifers of the Gogango Overfold Zone, Tertiary sediments or alluvial aquifers adjacent to Tertiary sediments. Fractured rock aquifers of the Gogango Overfold Zone in the northwest of the sub-catchment also contains slightly to moderately saline groundwater.

Although data is limited, groundwater quality typically experiences minimal changes over time (Pearce and Hansen 2006). Representative monitoring bores from alluvial aquifers associated with alluvial deposits of the Fitzroy River near Yaamba (downstream of the Project and the existing Eden Bann Weir and impoundment, and upstream of the existing Fitzroy Barrage and impoundment) show no significant variations or fluctuations in groundwater quality. The majority of alluvial aquifer monitoring bores near Stanwell show some fluctuations in groundwater quality but no significant overall trends of increasing or decreasing EC and total dissolved solids.

10.2.2 Groundwater resource allocation

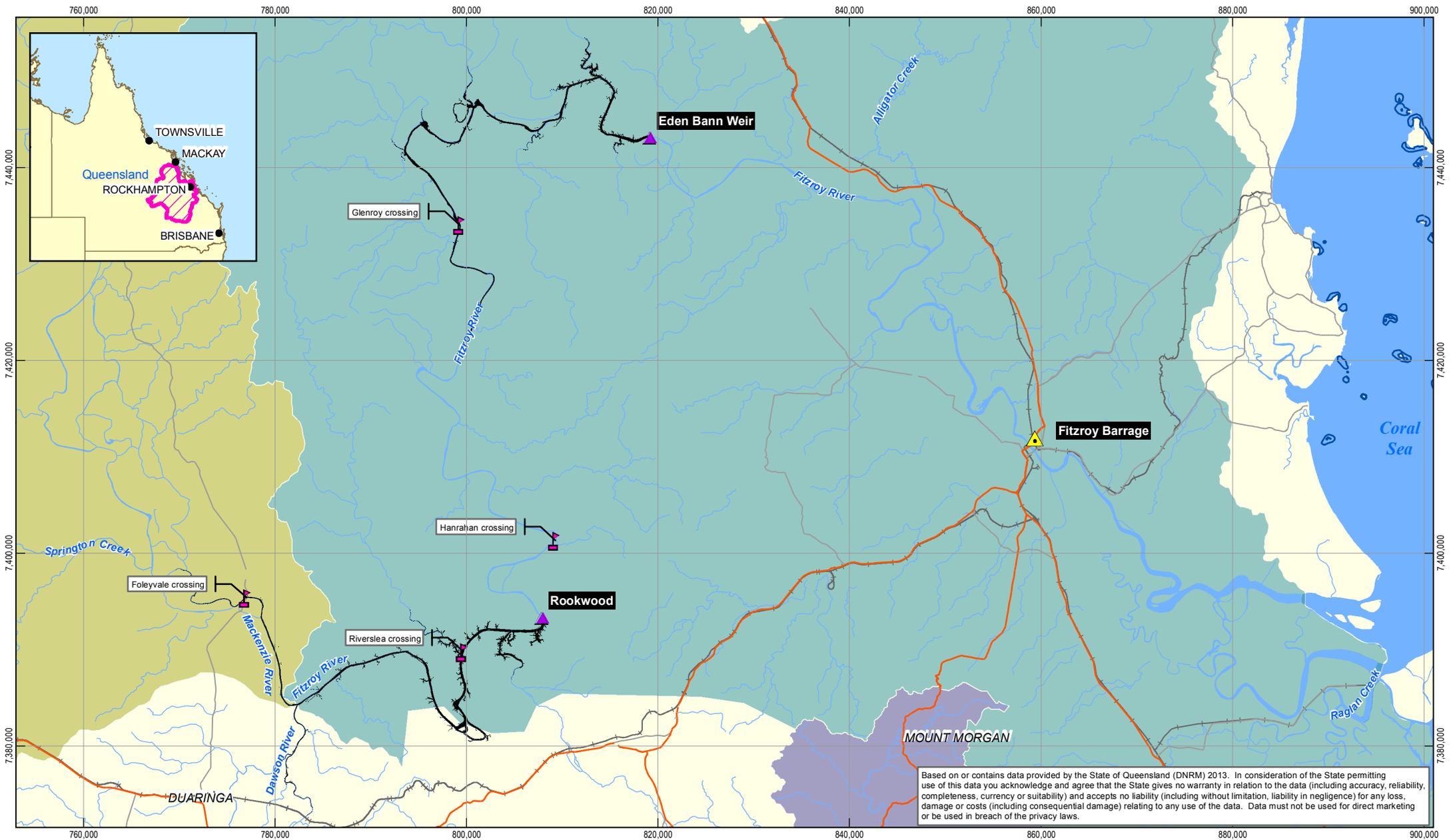
The Fitzroy WRP and Fitzroy ROP manage the use and allocation of water resources, including groundwater, in the plan area. The plan area, defined in the Fitzroy WRP, comprises five groundwater management areas (GMAs). The primary GMA relevant to the Project is the Fitzroy GMA shown on Figure 10-1. A small section of the Highlands GMA is relevant to the upper reaches of the inundation associated with Rookwood Weir at the junction with the Mackenzie and Dawson rivers. No sub-areas are defined for the Fitzroy GMA. The Sandy Creek alluvium sub-area defined for the Highlands GMA is not within the Project area.

The Fitzroy GMA comprises:

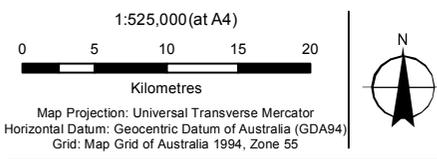
- Fitzroy Groundwater Unit 1, containing the aquifers of the recent (mainly Holocene) coastal deposits
- Fitzroy Groundwater Unit 2, containing all sub-artesian aquifers within the Fitzroy GMA other than the aquifers included in Fitzroy Groundwater Unit 1.

The Highlands GMA comprises:

- Highlands Groundwater Unit 1, containing the aquifers of the Quaternary alluvium, and is defined by the Sandy Creek Alluvium groundwater sub-area
- Highlands Groundwater Unit 2, containing all subartesian aquifers within the Highlands GMA other than the aquifers included in Highlands Groundwater Unit 1



Based on or contains data provided by the State of Queensland (DNRM) 2013. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws.



LEGEND	
	Weir Location
	Fitzroy Barrage
	River Crossing
	Highway
	Major Road
	Railway
	Inundation Zone
	Waterway
	Fitzroy Basin
	Callide GMA
	Fitzroy GMA
	Highlands GMA
	Groundwater Management Areas



Gladstone Area Water Board, SunWater
 Lower Fitzroy River Infrastructure Project

Job Number: 41-20736
 Revision: B
 Date: 02 Oct 2014

Fitzroy WRP groundwater management areas

Figure 10-1

Unallocated groundwater in the plan area is divided into a strategic reserve and a general reserve. The Fitzroy WRP specifies that unallocated water held as a strategic reserve may only be granted if the water is to be taken for a State purpose (a project of State or regional significance) or an Indigenous purpose. Unallocated water held as a general reserve may be granted for any purpose.

As per schedule 8 of the Fitzroy WRP, the strategic reserve for groundwater that may be granted in the Fitzroy GMA is 500 ML/a. The general reserve for groundwater that may be granted in the Fitzroy GMA totals 22,000 ML/a comprising 20,000 ML/a for Fitzroy Groundwater Unit 1 and 2,000 ML/a for Fitzroy Groundwater Unit 2. Schedule 8 of the Fitzroy WRP defines the strategic reserve for groundwater that may be granted from the Highlands GMA (excluding the Sandy Creek Alluvium sub-area) as 3,000 ML/a. Nominally 7,000 ML/a may be granted from the Highlands GMA general reserve (excluding the Sandy Creek Alluvium groundwater sub-area).

Under the Fitzroy WRP, certain GMAs are further divided into groundwater management units, representing aquifers with more targeted groundwater management requirements, specifically the Upper Callide, Lower Callide and Prospect Creek groundwater sub-areas and the Callide Valley Water Supply Scheme, all outside of the Project area. Targeted management requirements are not defined for the Fitzroy and Highland GMAs.

Specific ecological outcomes are similarly not defined for the Fitzroy and Highland GMAs. At present, the Fitzroy WRP sets environmental flow objectives for groundwater only in the Callide GMA. There are no environmental flow objectives for groundwater in the Fitzroy and Highlands GMAs.

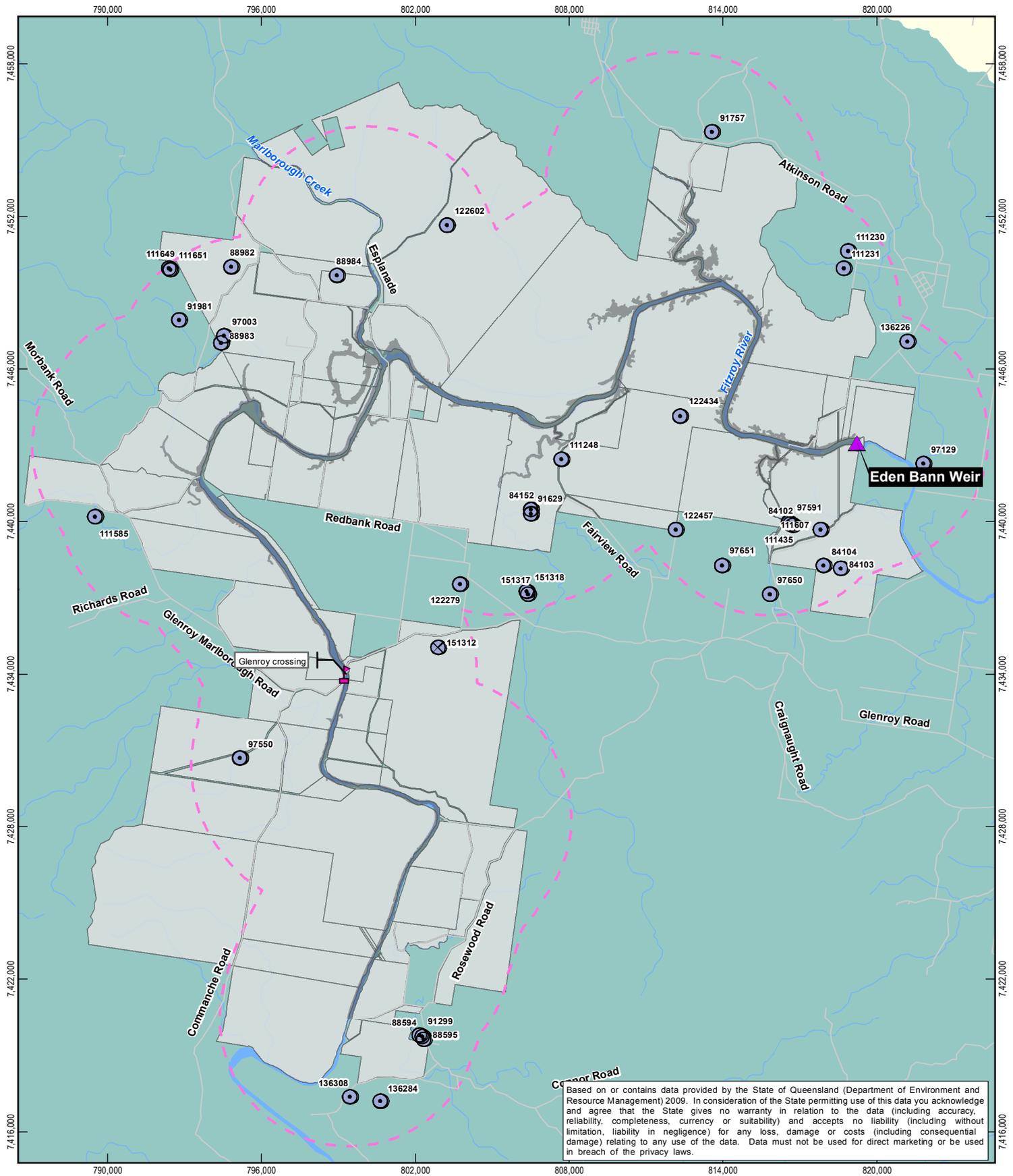
Figure 10-2 and Figure 10-3 show the location of registered groundwater bores within 5 km of the Project footprint for the Eden Bann Weir and the Rookwood Weir sites, respectively.

The number of registered bores within 5 km of the Project footprint and distance to the nearest registered bores is shown in Table 10-2.

Table 10-2 Registered bores within proximity to the Project footprint

Registered bores	Eden Bann Weir 5 km Project footprint	Rookwood Weir 5 km Project footprint
No. of registered bores within 5 km	37	66
No. of registered bores on subject lots	21	28
No. of registered bores within the proposed impoundment	0	1 (RN 88940)
Distance to nearest registered bore from the proposed impoundment	400 m (RN 111248)	0 m (RN 88940)
Distance to nearest registered bore from the weir construction area	2.5 km (RN 97129)	250 m (RN 15128)

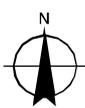
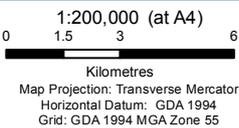
Source: DNRM 2013



Based on or contains data provided by the State of Queensland (Department of Environment and Resource Management) 2009. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws.

LEGEND

- Weir Location
- River Crossing
- Secondary Roads
- Waterway
- Impoundment (Stage 3)
- Registered Bores: Abandoned and Destroyed
- Registered Bores: Existing
- Groundwater Bores: Water Supply
- Groundwater Management Areas: Fitzroy GMA
- 5km Buffer
- Subject lots

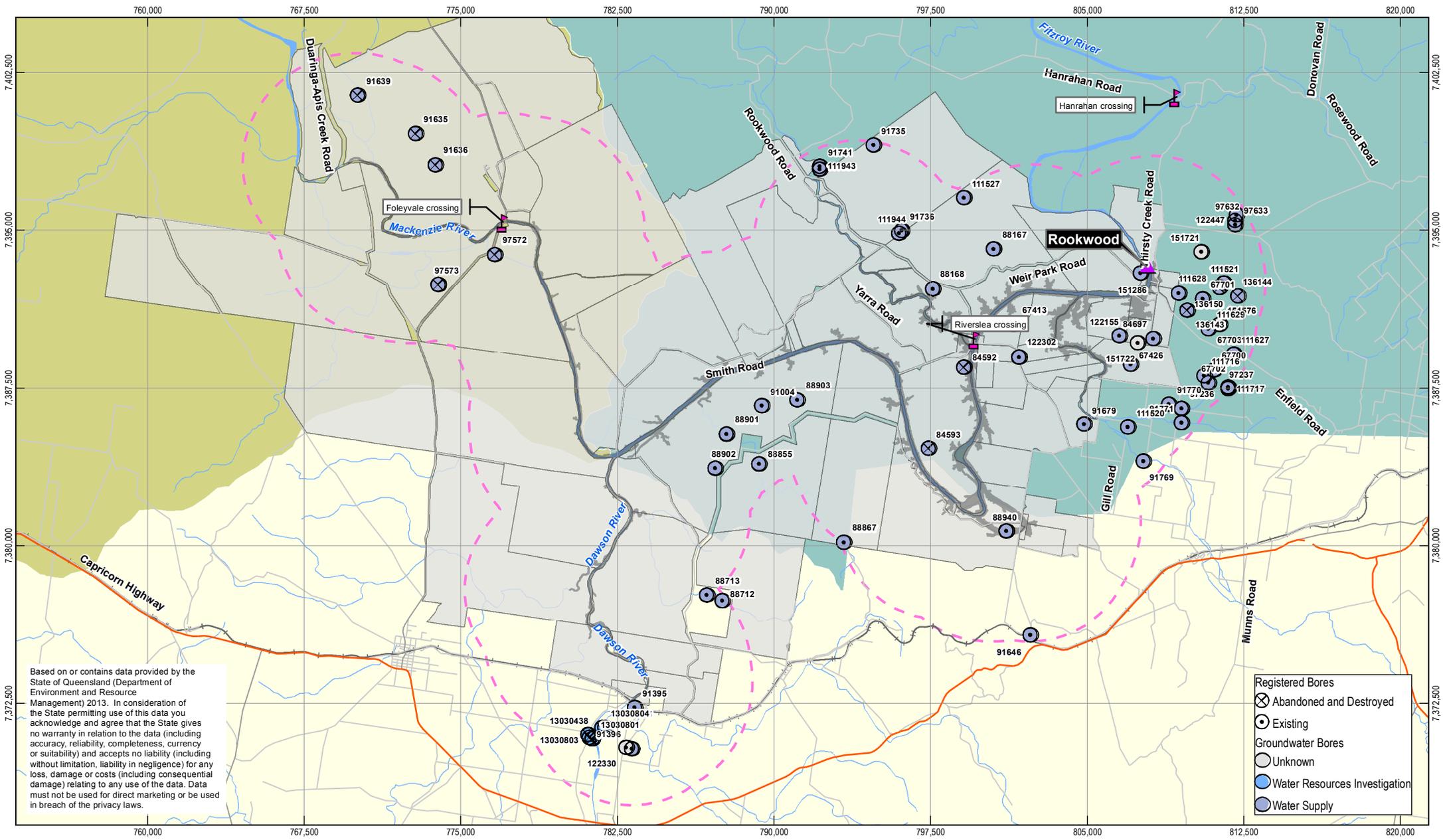


Gladstone Area Water Board, Sunwater
Lower Fitzroy River Infrastructure Project

Job Number | 41-20736
Revision | D
Date | 02 Oct 2014

**Eden Bann Weir
– registered bores**

Figure 10-2



Based on or contains data provided by the State of Queensland (Department of Environment and Resource Management) 2013. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws.

Registered Bores	⊗ Abandoned and Destroyed
	⊙ Existing
Groundwater Bores	○ Unknown
	● Water Resources Investigation
	● Water Supply

1:240,000 (at A4)

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



LEGEND

Weir	Major Road	Groundwater Management Areas	5km Buffer
Location	Secondary Roads	Callide GMA	Subject lots
River Crossing	Railway	Fitzroy GMA	
Highway	Waterway	Highlands GMA	
	Impoundment (Stage 2)		

GHD
CLIENTS | PEOPLE | PERFORMANCE

Gladstone Area Water Board, SunWater
Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision B
Date 02 Oct 2014

**Rookwood Weir
- registered bores**

Figure 10-3

Gladstone Area Water Board
SunWater
Making Water Work

Registered bores within 5 km of the Eden Bann Weir Project area comprise the following:

- Thirty-six existing bores are registered for water supply
- One water supply bore is registered as 'Abandoned and Destroyed'.

Registered bores within 5 km of the Rookwood Weir Project footprint comprise the following:

- Forty-five existing bores are registered for water supply
- Three existing bores do not have a defined facility role
- Eleven water supply bores are registered as 'Abandoned and Destroyed'
- Six water resource investigation bores are registered as 'Abandoned and Destroyed'.

One bore registered as 'Abandoned and Destroyed' does not have a defined facility role.

No registered bores are located within the proposed Eden Bann Weir impoundment. One registered bore (RN 88940) is located within the proposed Rookwood Weir impoundment (Stage 1 and Stage 2). RN 88940 is described as a sub-artesian facility, with a water supply role and a maximum yield of 3.8 litres per second. There is no standing water level information for this bore. The Queensland Groundwater Database (2009 and 2013) indicates that for bores within 5 km of both the Eden Bann Weir and Rookwood Weir Project areas groundwater water supply is for stock and domestic use.

DNRM's groundwater level monitoring network does not include the Fitzroy sub-catchment as groundwater use is limited. Within the Fitzroy Basin, alluvial aquifers supporting major uses of groundwater are found in the Don, Dee and Callide Valleys, Boyne Valley, Isaac Catchment, and Sandy Creek/Neerkol Creek (Gracemere). None of these intercept the area potentially affected by the Project.

Local salinity problems in streams are found in the Wowan area of the Don River, Bell Creek and Prospect Creek in the Callide Valley, and creeks north of Theodore to Lonesome Creek. The salinity is associated with groundwater migration as a result of rising water tables, attributed partly to extensive land clearing in the surrounding areas and partly to overuse of groundwater supplies. As above, none of these streams are located in proximity to the Project area. As discussed in Chapter 11 Water quality salinity levels within the Fitzroy, lower Mackenzie and Dawson rivers is not considered problematic and largely influenced by the naturally saline and alkaline geology of the region. Temporary elevated salinity levels in rivers have been recorded in association with mine dewatering activities elsewhere in the Fitzroy Basin.

10.2.3 Groundwater dependent ecosystems

The Atlas of Groundwater Dependent Ecosystems (BoM 2013a) maps groundwater dependent ecosystems (GDEs) across Australia. BoM (2013b) defines GDEs as 'natural ecosystems that require access to groundwater to meet all or some of their water requirements on a permanent or intermittent basis, so as to maintain their communities of plants and animals, ecosystem processes and ecosystem services'. Eamus et al. (2006) identifies three key classes of GDEs, these include:

- Aquifer and subterranean ecosystems which contain stygofauna. These include karstic, fractured rock, alluvial aquifers and the zones of saturated sediments within floodplains and river beds
- Ecosystems dependent on the surface expression of groundwater, including base flow rivers, streams, wetlands, some floodplains, mound springs and estuarine seagrass beds
- Ecosystems dependent on the subsurface presence of groundwater. These fringing terrestrial ecosystems, such as *Eucalyptus camaldulensis* forests and banksia woodlands, access groundwater resources via their roots in the non-saturated zone located above the water table. Relative

dependency of these communities on groundwater is significantly reduced where depths of groundwater exceed 10 metres (Eamus et al. 2006).

The Atlas of Groundwater Dependent Ecosystems (BoM 2013a) identifies rivers, springs and wetlands associated with the Fitzroy, Dawson and Mackenzie rivers as GDEs reliant on the expression of groundwater. Consistent with Pearce and Hansen (2006) indicating that groundwater flows are towards the Fitzroy River and groundwater flow in alluvial aquifers essentially follows the surface drainage gradients, Figure 10-4 shows that for the Eden Bann Weir Project area there is a high potential for groundwater interaction with rivers, springs and wetlands. For the proposed Rookwood Weir Project area Figure 10-5 shows there is a moderate potential for groundwater interaction with rivers, springs and wetlands.

Fringing riparian and floodplain ecosystems, dominated by eucalypts can contain a number of plant species largely dependent on the availability of groundwater resources to maintain viable populations (Eamus et al. 2006; Hatton and Evans, 1997). Potential GDEs dependent on the subsurface presence of groundwater identified within the Eden Bann Weir and Rookwood Weir Project areas include riparian vegetation dominated by *Eucalyptus camaldulensis*, *E. tereticornis* and *E. coolabah*, consistent with Regional Ecosystems 11.3.25, 11.3.4 and 11.3.3.

The nearest subterranean GDE recorded on Queensland Government Wetland Info GDE mapping is approximately 35 km east of Eden Bann Weir (Queensland Government 2013).

10.3 Potential impacts and mitigation measures

Surface waters (such as rivers) commonly interact with groundwater systems. Surface water bodies, such as rivers, may receive groundwater inflows from groundwater systems impacting on water levels and water quality within the system. Conversely, surface water systems also have the potential to recharge groundwater areas and influence groundwater quality.

Extraction of water from rivers can potentially reduce groundwater levels and polluted surface water systems have the potential to pollute groundwater systems. The converse is also true; extraction of groundwater may result in reduced surface water flows and polluted groundwater may cause pollution of surface water systems.

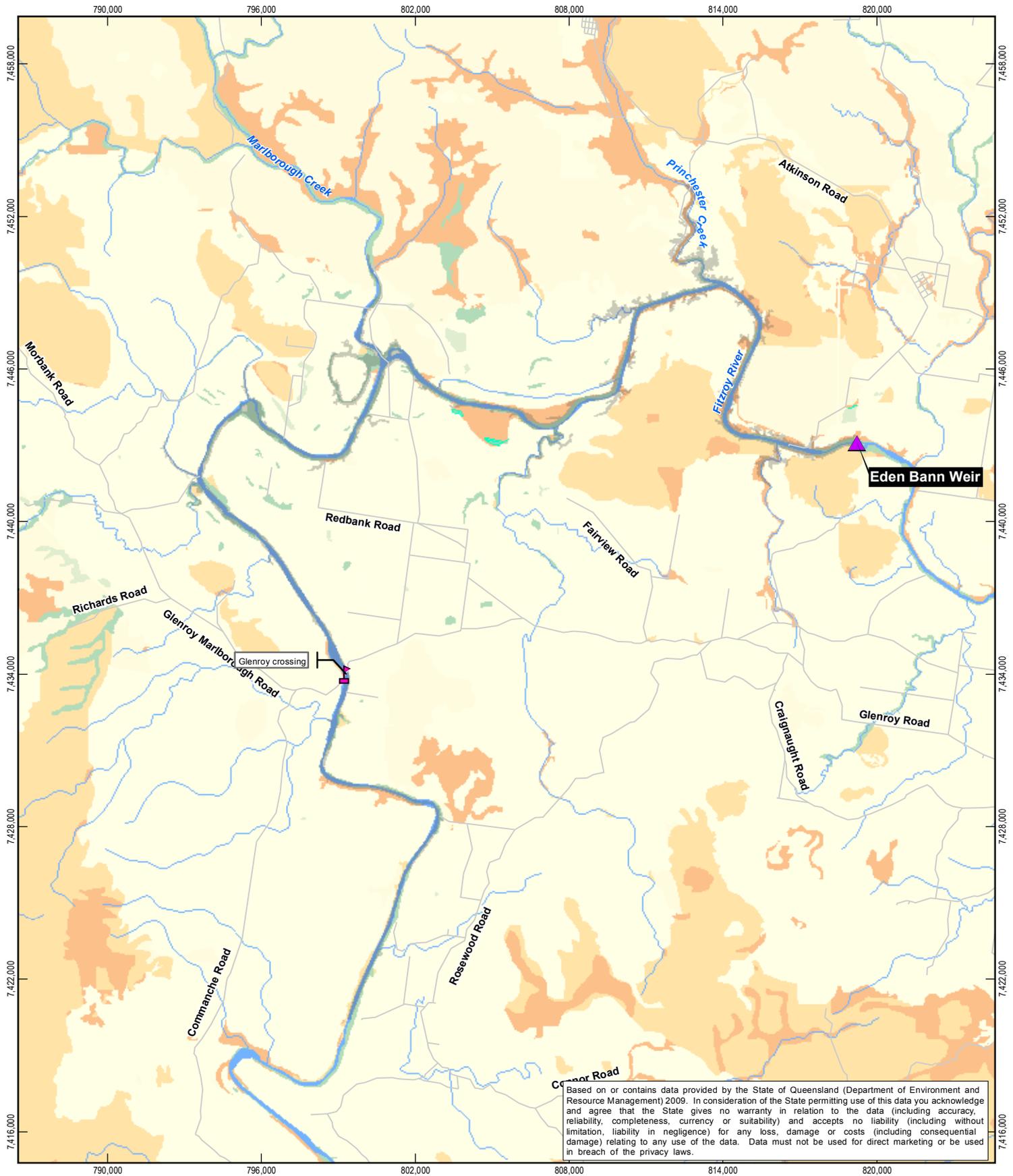
10.3.1 Construction

Construction activities associated with the Project are detailed in Chapter 2 Project description. Activities with the potential to impact on groundwater resources or uses include the following:

- Dewatering of excavations
- Extraction of surface water
- In-stream diversion of surface water.

A number of potential construction material extraction areas have been identified in close proximity to the weir construction areas. Subject to further sampling and investigations, separate assessment and approval of these areas will be sought and they are not included for assessment within the EIS.

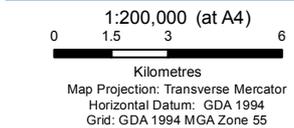
Dewatering of excavations will take place during drier periods in accordance with the construction phases as described in Chapter 2 Project description. As described in Chapter 2 Project description, excavations are likely to be contained within the shallower, alluvial aquifers. Groundwater in the Project areas is considered moderate in terms of water quality (section 10.2.1), with the 50th percentile EC in the order of 2220 $\mu\text{S}/\text{cm}$ (Table 10-1) (median in the order of 2,380 $\mu\text{S}/\text{cm}$ (Pearce and Hansen 2006)).



Based on or contains data provided by the State of Queensland (Department of Environment and Resource Management) 2009. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws.

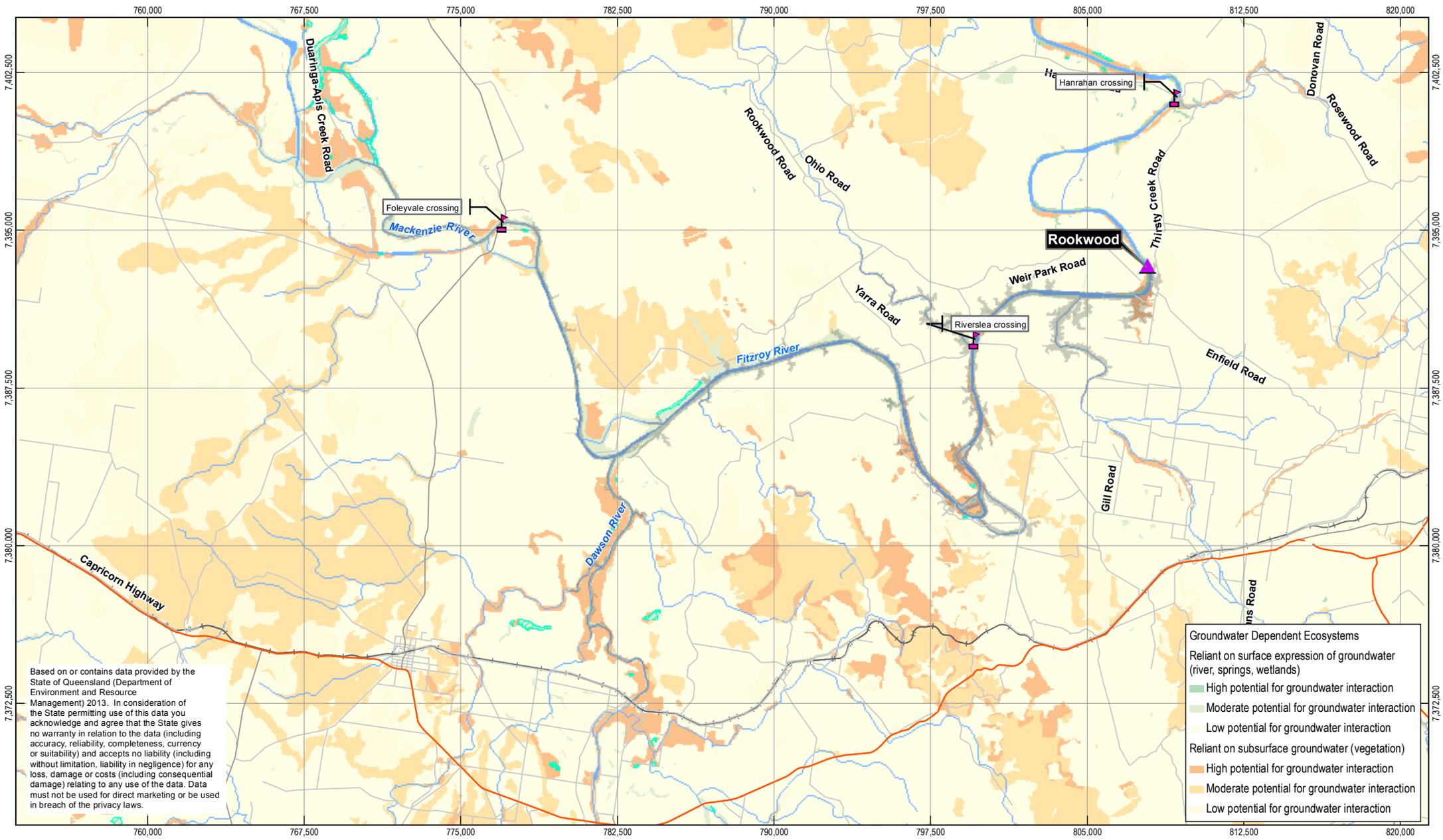
LEGEND

- ▲ Weir
- Location
- ▬ River Crossing
- Secondary Roads
- ▬ Impoundment (Stage 3)
- ▬ Waterway
- ▬ High Ecological Significance Wetlands
- ▬ Groundwater Dependent Ecosystems
- ▬ Reliant on surface expression of groundwater (river, springs, wetlands)
- ▬ High potential for groundwater interaction
- ▬ Moderate potential for groundwater interaction
- ▬ Low potential for groundwater interaction
- ▬ Reliant on subsurface groundwater (vegetation)
- ▬ High potential for groundwater interaction
- ▬ Moderate potential for groundwater interaction
- ▬ Low potential for groundwater interaction



Gladstone Area Water Board, Sunwater
 Lower Fitzroy River Infrastructure Project
 Job Number 41-20736
 Revision A
 Date 30 Oct 2014

Eden Bann Weir groundwater dependent ecosystems **Figure 10-4**



Based on or contains data provided by the State of Queensland (Department of Environment and Resource Management) 2013. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws.

Groundwater Dependent Ecosystems

Reliant on surface expression of groundwater (river, springs, wetlands)

- High potential for groundwater interaction
- Moderate potential for groundwater interaction
- Low potential for groundwater interaction

Reliant on subsurface groundwater (vegetation)

- High potential for groundwater interaction
- Moderate potential for groundwater interaction
- Low potential for groundwater interaction

1:240,000 (at A4)

0 1.5 3 4.5 6 7.5
Kilometres

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



LEGEND

- Weir Location
- River Crossing
- Highway
- Major Road
- Secondary Roads
- Railway
- Waterway
- Impoundment (Stage 2)
- High Ecological Significance Wetlands

GHD
CLIENTS | PEOPLE | PERFORMANCE

SunWater
Making Water Work

Gladstone Area Water Board

Gladstone Area Water Board, SunWater
Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision A
Date 30 Oct 2014

Rookwood Weir groundwater dependent ecosystems **Figure 10-5**

G:\41\20736\GIS\Projects\MXD\200_Report\4120736_357_rev_a.mxd
 Copyright: This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was produced. Unauthorised use of this document in any way is prohibited. © 2014.
 © 2014. While GHD has taken care to ensure the accuracy of this product, GHD, DNRM, SUNWATER, GA and BOM make no representations or warranties about its accuracy, completeness or suitability for any particular purpose. GHD, DNRM, SUNWATER and GA cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.
 Data Sources: © Copyright Commonwealth of Australia (Geoscience Australia); Waterways (2007); Sunwater: Waterways, Weir Locations - 2008; DERM: Roads - 2010, HES Wetlands - 2012; BOM: GDE - 2013. Created by: MS

Groundwater extracted as part of this dewatering will be stored temporarily in a sediment basin and released to the existing channel of the Fitzroy River once it is demonstrated that the water quality is suitable for release. It is considered that recharge is likely due to the proximity of the point of release and the point of groundwater extraction. It is not expected that drawdown as a result of dewatering will be significant.

Water supply for the Project will be achieved through surface water extraction immediately upstream of the construction site (Chapter 2 Project description). Surface water will be extracted in accordance with a permit acquired under the *Water Act 2000* (Qld) and will therefore be consistent with the environmental flow objectives of the Fitzroy WRP. Groundwater extraction is not proposed for the purpose of water supply. It is considered that drawdown as a result of the extraction of surface water will not be significant.

The construction of the Project will involve diversion of surface water within existing channels and will not require the impoundment of water within a watercourse. As surface water will be diverted within the existing channel, this activity is not expected to affect groundwater recharge.

Groundwater quality has the potential to be impacted by unsuitable storage and spillage of chemicals, fuels and waste products during construction. With appropriate management measures in place and compliance with relevant guidelines (as described in the Chapter 23 Environmental management plan), it is considered that the potential for groundwater contamination is negligible.

Construction of the Project will not directly impact groundwater infrastructure as there are no registered bores within the construction areas. There is low potential for groundwater drawdown as a result of construction the Project. As such, no indirect impacts on groundwater infrastructure (reduced availability) are expected.

The construction phase is anticipated to have very little effect on groundwater dependant ecosystems within the area, due to the established low potential for drawdown associated with construction of the Project.

10.3.2 Operations

Groundwater impacts during operations can be broadly divided into two categories:

- Upstream impacts: Impacts caused by inundation of river bed and bank areas upstream of the proposed weirs. Inundation has the potential to cause damage to GDEs and impact water users through inundation of groundwater infrastructure
- Downstream impacts: Impacts caused by altered river flow regimes. A reduced river flow has the potential to reduce groundwater recharge and therefore groundwater levels which has the potential to impact GDEs and other groundwater users.

10.3.2.1 Upstream impacts

Salinisation

There are a number of mechanisms by which groundwater salinisation could occur as a result of the inundation. These include:

- Increased recharge leading to leaching of saline soil water towards fresher groundwater
- Rising water tables causing groundwater to be mixed with more saline soil water.

It is not expected that groundwater salinisation will occur for the following reasons:

- There are no known existing outbreaks of salinity in the Project Area. It is noted that Eden Bann Weir was constructed in 1994 (some 20 years ago) and there is no evidence of salinisation associated with the impoundment
- There will be no vegetation clearing which could lead to salinisation
- No salinity outbreaks are expected as a result of inundation of the water storage areas
- Groundwater flows within the Fitzroy River-sub-catchment trends towards flows into the Fitzroy River.

During operations, the inundation area and immediate surrounds will be monitored to detect any instances of erosion, salinity, or other landscape instability so that any necessary remedial work can be arranged.

Groundwater infrastructure

The operation of the proposed Rookwood Weir (Stage 1 and Stage 2) will result in the inundation of one existing bore (Section 10.2.2). Consultation with the landholder will be undertaken to enter into an agreement on measures to restore the loss of supply or provision of alternative compensatory measures as agreed between the parties as relevant and applicable.

No existing groundwater bores will be directly impacted as a result of raising Eden Bann Weir.

Local groundwater levels and recharge

Inundation as a result of the Project will increase from the existing (Stage 1) 670 ha to 1,690 ha at Eden Bann Weir (Stage 3) and will cover 1,930 ha at Rookwood Weir (Stage 2).

Given the downward gradient from surface water to groundwater and presence of the impounded water, recharge to the underlying alluvium and fractured bedrock aquifers beneath the two inundated reaches is anticipated to increase in comparison to existing conditions and localised groundwater levels (i.e. beneath and in the immediate vicinity of the channel) are anticipated to rise as a result. At Eden Bann Weir there is the potential for the localised groundwater levels to increase to around 20.2 m AHD (gated spillway level, Stage 3) and at Rookwood Weir to increase to around 49 m AHD (gated spillway level, Stage 2), however these levels remain well below the respective river bank elevations of between around 25 m and 30 m AHD at Eden Bann Weir and around 56 to 58 m AHD at Rookwood Weir. Such groundwater levels are unlikely to be maintained for any significant length of time however, as the stored water behind the weirs is gradually released throughout the year.

Groundwater dependant ecosystems

The increase in inundation and likely associated rise in the groundwater table beneath and in the immediate vicinity of the river channel (discussed in the above paragraph) could potentially lead to waterlogging of the root zone in the riparian area outside of the inundated zone and associated dieback.

Potential GDEs dependent on the subsurface presence of groundwater identified within the Eden Bann Weir and Rookwood Weir Project areas include riparian vegetation dominated by *Eucalyptus camaldulensis*, *E. tereticornis* and *E. coolabah*, consistent with Regional Ecosystems 11.3.25, 11.3.4 and 11.3.3.

Riparian vegetation and GDEs inundated within the bed and banks of the Fitzroy, Mackenzie and Dawson rivers will be subject to dieback. The increase in inundation and likely associated rise in the groundwater table beneath and in the immediate vicinity of the river channel (discussed in the above

subsection) could potentially lead to waterlogging of the root zone of the riparian area outside of the inundated zone and associated dieback.

Upstream of the proposed Rookwood Weir Stage 2 impoundment (at 334 km AMTD) there is a Great Barrier Reef wetland protection area/wetland of high ecological significance located between 100 m and 350 m from the upstream limit on the Mackenzie River (Figure 10-5). This wetland is not listed as a GDE on the Queensland Government Wetland Info. For the proposed Rookwood Weir Project area Figure 10-5 shows there is a moderate potential for groundwater interaction with rivers, springs and wetlands. The Stage 2 Rookwood Weir impoundment is not expected to inundate the identified wetland areas. Any rise in the groundwater table associated with the impoundment is anticipated to be minimal at and in the vicinity of the upstream limit of the impoundment, as the surface water level and hence hydraulic gradient to the underlying strata should not be significantly different to pre-construction conditions. No significant impact to the Great Barrier Reef wetland protection area is therefore anticipated.

10.3.2.2 Downstream impacts

Local groundwater levels and recharge

Flow in the river is the predominant mechanism for the recharge of groundwater and for the maintenance of groundwater levels and flows in the immediate vicinity of the Fitzroy River. Given that no significant differences between pre and post-development modelled flows are predicted downstream of Eden Bann Weir and Rookwood Weir (Chapter 9 Surface water resources), no significant reduction in the existing groundwater levels or in the existing recharge to groundwater provided by the Fitzroy River channel downstream of the structures is anticipated. This is supported by the following:

- Analysis of modelled flows for locations upstream, within and downstream of the Project (IQQM1 end of system, IQQM2 at Wattlebank (downstream of Eden Bann Weir), IQQM3 The Gap (~1 km upstream of Eden Bann Weir), IQQM4 (downstream of Rookwood Weir and upstream of Eden Bann Weir impoundment) and OQQM5 at Riverslea (~11 km upstream of Rookwood Weir)) predicts no significant differences between the current modelled flow regimes (with the existing Eden Bann Weir (base case)) and the projected flow regimes for any of the proposed additional infrastructure (Eden Bann Weir Stage 2 and Stage 3, Rookwood Weir Stage 1 and Stage 2). The results of the modelling are discussed in detail in Chapter 9 Surface Water Resources and the hydrographs and flow duration curves are presented in Appendix P. For the final development scenario (completed Eden Bann Stage 3 and Rookwood Weir Stage 2) at IQQM4 (downstream of Rookwood Weir) and at IQQM2 (Wattlebank downstream of Eden Bann Weir):
 - The hydrographs of modelled streamflow show no significant difference in the pattern of monthly flows for the final development scenario in comparison to the existing scenario (base case).
 - The flow duration curves of modelled streamflow under the final development scenario show flows are maintained for longer in comparison to the existing (base case) scenario. The flow duration curves for IQQM4 (downstream of Rookwood Weir) predict just under 90% of days with flows greater than 100ML/day under the final development scenario in comparison to around 65% of days under the existing scenario (base case). The flow duration curves for IQQM2 (Wattlebank downstream of Eden Bann Weir) predict just over 90% of days with flows greater than 100ML/day under the final development scenario in comparison to around 70% of days under the existing scenario (base case).
- Release of water from the Eden Bann Weir and the proposed Rookwood Weir will be made in accordance with environmental flow objectives (EFOs) and water allocation security objectives (WASOs) defined in the Fitzroy ROP. Environmental flow objectives will be established to maintain

base flow (a daily release) and first wet season flow, among other flow characteristics. Water releases are designed to mimic the natural system and therefore assist in maintaining recharge to groundwater downstream. The environmental flow objectives will be set in accordance with the Fitzroy WRP, and in consultation with the Department of Environment and Heritage Protection and the Department of natural Resources and Mines. It is therefore considered that the Fitzroy ROP will achieve the general ecological outcomes under Clause 14 of the Fitzroy WRP, including the maintenance of groundwater recharge beneath the river channel.

The potential for a reduction in groundwater levels at existing registered bores located downstream of the weirs as a result of the Project is considered negligible.

Groundwater dependant ecosystems

The nearest subterranean GDE recorded on Queensland Government Wetland Info GDE mapping is approximately 35 km east of Eden Bann Weir (Queensland Government 2013). Figure 10-4 shows that downstream of the Eden Bann Weir and Rookwood Weir there is a high potential for groundwater interaction in relation to rivers, springs and wetlands and in relation to vegetation reliant on sub surface groundwater. There are also potential GDEs associated with riparian vegetation dominated by *Eucalyptus camaldulensis*, *E. tereticornis* and *E. coolabah*, consistent with Regional Ecosystems 11.3.25, 11.3.4 and 11.3.3.

It is demonstrated that environmental flows will be maintained and no significant reduction in the existing groundwater levels or in the existing recharge to groundwater provided by the Fitzroy River channel downstream of Eden Bann Weir or Rookwood Weir is anticipated. No significant impacts to potential GDEs downstream of either structure are therefore anticipated.

10.4 Summary

Impacts on groundwater levels and recharge to groundwater as a result of the Project construction and operation are considered likely to be negligible. Groundwater beneath and in the near vicinity of the Fitzroy River will continue to be recharged via seepage through the river channel bed, as flows will be maintained during construction and operational water releases are designed to mimic the natural system as far as possible, whilst direct infiltration of rainfall remains the predominant recharge mechanism away from the river. An increase in recharge and groundwater levels is possible beneath and in the immediate vicinity of the impoundments. However, the volume of additional recharge to the system overall is not expected to be significantly different to existing conditions given the volumes of water within the river system are essentially remaining the same as pre-development conditions.

Groundwater quality within the Fitzroy River sub-catchment is slightly to moderately saline. It is not expected that groundwater salinisation will occur as a result of the Project.

The potential for a reduction in groundwater levels at existing registered bores located downstream of the weirs as a result of the Project is considered negligible due to the maintenance of environmental flow objectives of the Fitzroy WRP and hence maintenance of aquifer recharge beneath and in the immediate vicinity of the river as a result.

The Project will have negligible effects on groundwater dependant ecosystems outside of the bed and banks of the Fitzroy, Mackenzie and Dawson rivers' inundation areas.

In relation to effects on groundwater infrastructure a single bore will be inundated at Rookwood Weir Stage 1 and Stage 2 in association with the operation of the Project.