9. Surface water resources

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9.1 Introduction

9.1.1 Overview

This chapter describes the surface water characteristics of the Fitzroy Basin and subcatchments associated with the Lower Fitzroy River Infrastructure Project (Project). The assessment addresses how flood plains and surface water resources may be impacted by the Project, and where applicable identifies methods by which these impacts can be avoided, mitigated or otherwise managed.

Together with assessments presented in Chapter 10 Groundwater resources and Chapter 11 Water quality and supported by material included at Appendix P, this chapter addresses the following terms of reference (ToR) for the draft environmental impact statement (EIS):

- Flood plain management as per Part B, Sections 5.8 – 5.9
- Water resources as per Part B Sections 5.92 – 5.94 and Part B, Sections 5.102 - 5.108.

An Integrated Quantity Quality Model (IQQM) Yield Assessment report is provided under separate cover to the Department of Natural Resources and Mines (DNRM), the Department of Energy and Water Supply (DEWS) and the Department of Science, Information Technology, Innovation and the Arts (DSITIA). Results are summarised herein.

A table cross-referencing the ToR requirements is provided in Appendix B. Where appropriate management measures relating to surface water resources are used to inform the environmental management plan (EMP) contained in Chapter 23.

9.1.2 Regulatory framework

9.1.2.1 Overview

Legislation, plans, policies and strategies governing and guiding the protection, use and management of surface water resources in relation to the Project include the following as summarised:

- *Environmental Protection Act 1994* (Qld) (EP Act)
  - Environmental Protection Regulation 2008 (EP Regulation)
  - Environmental Protection (Water) Policy 2009 (EPP Water).
- *Water Act 2000* (Qld) (Water Act)
  - Water Resource (Fitzroy Basin) Plan 2011 (Fitzroy WRP)
  - Fitzroy Basin Resource Operations Plan (as amended October 2011 and as amended September 2014) (Fitzroy ROP)
- The *Water Supply (Safety and Reliability) Act 2008* (Qld)
- Central Queensland Regional Water Supply Strategy (CQRWSS)

Chapter 3 Legislation and project approvals and Appendix P provide further detail, as applicable.

9.1.2.2 Water Resource (Fitzroy Basin) Plan 2011

Figure 9-1 shows the Fitzroy WRP plan area relative to the Project.

The Fitzroy WRP seeks to achieve general and specific outcomes for the sustainable management of water. The outcomes relate to providing:

- Security for water users and licence holders through the establishment of water allocation security objectives (WASOs). WASOs define the performance that water users can expect from their allocations. The Fitzroy WRP defines WASO performance indicators for supplemented and unsupplemented water allocations within water supply schemes and water management areas, respectively
- Environmental water for aquatic ecosystems through the establishment of environmental flow objectives (EFOs). EFOs are the flows considered necessary to sustain a healthy environment. The Fitzroy WRP defines EFOs that specifically relate to flow-based performance indicators.

Performance indicators for WASOs and EFOs are defined at nodes within the Fitzroy WRP plan area. In relation to the Project, surface water Node 0 (at the Fitzroy Barrage, 59.6 km AMTD) and Node 1 (on the Fitzroy River immediately downstream of the existing Eden Bann Weir, 141.2 km AMTD) (Figure 9-1) are applicable.

Unallocated water within the Fitzroy WRP plan area is divided into a strategic reserve, strategic water infrastructure reserve and general reserve. For the Project, unallocated water held as the strategic water infrastructure reserve may be granted for water infrastructure on the Fitzroy River (nominally 76,000 ML) (Section 9.2.5). However, the Fitzroy WRP requires that decisions made about the allocation and management of water in the plan area must be consistent with WASOs and EFOs.

Water allocation security objectives

In the Fitzroy WRP, the WASO performance indicators for supplemented water in the Lower Fitzroy Water Supply Scheme and Fitzroy Barrage Water Supply Scheme for water allocation in the high priority group are:

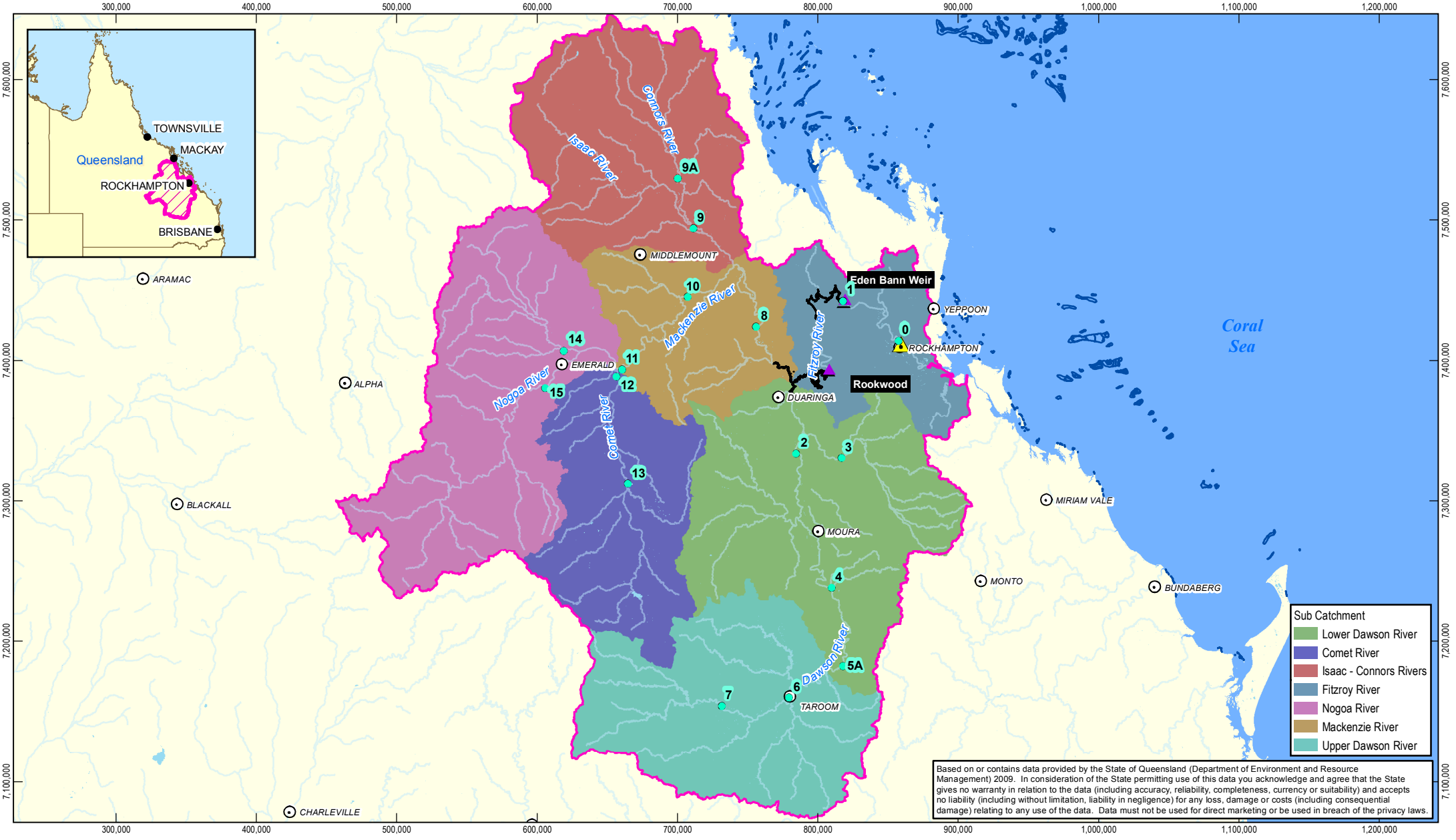
- The annual supplemented water sharing index is to be at least 94 per cent
- The monthly supplemented water sharing index is to be at least 98 per cent.

For water allocations in the medium priority group, the performance indicator is based on the monthly supplemented water sharing index that must be at least 82 per cent.

WASOs for water allocations per water allocation group in the Fitzroy Water Management Area are listed in Table 9-1. The Fitzroy WRP states that the annual volume probability is to be at least the percentage stated for the group in Table 9-1.

Table 9-1 Unsupplemented water allocation security objectives

Water allocation group	Flow conditions for water allocation	Annual volume probability (%)
Class 5A	2,592 ML/day passing flow	61
Class 5B	4,320 ML/day passing flow	73
Class 6C	No flow conditions, and 9 ML/day passing flow	95
Class 7D	260 ML/day passing flow	93



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Kilometres

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

N

LEGEND

- Weir Location
- Fitzroy Barrage
- Waterway (Major)
- Waterway (Minor)
- Fitzroy Catchment
- Lakes
- Impoundment area
- Surface water nodes

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Fitzroy WRP plan area

Figure 9-1

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Environmental flow objectives

EFOs are specified at nodes within the Fitzroy WRP plan area. EFOs relevant to the Project are reported only at Node 0 (Figure 9-1).

The performance indicators for the EFOs specified in the Fitzroy WRP are:

- For assessing periods of low flow (the seasonal base flow) as defined in Table 9-2. It is important to note that the Fitzroy WRP states that these values 'should be' met indicating aspirational targets, rather than mandated minimum requirements
- For assessing periods of medium to high flow as per Table 9-3. EFOs listed are mandatory requirements as indicated by the statement in the Fitzroy WRP of 'is to be at least' or 'is to be not more than'
- For assessing the first post-winter flow (FPWF) event as per Table 9-4. EFOs listed are mandatory requirements under the Fitzroy WRP.

Table 9-2 Seasonal base flow objectives

Water flow season	Objective
January to April	88%
May to August	57%
September to December	47%
Node 0 base flow: 288 ML/day	

Table 9-3 Medium to high flow objectives

Performance indicator	Objective
Mean annual flow in the simulation period, expressed as a percentage of the mean annual flow for the pre-development flow pattern, is to be at least	77%
Median annual flow ratio in the simulation period, expressed a as percentage, is to be at least	58%
Annual proportional flow deviation is to be not more than a factor of	2.5
Mean wet season flow in the simulation period, expressed as a percentage of the wet season flow for the pre-development flow pattern, is to be at least	80%
Four per cent daily exceedance duration flow in the simulation period, expressed as a percentage of the four per cent daily exceedance duration flow for the pre-development flow pattern, is to be at least	74%
Ten per cent daily exceedance duration flow in the simulation period, expressed as a percentage of the ten per cent daily exceedance duration flow for the pre-development flow pattern, is to be at least	55%
Two year daily flow volume in the simulation period, expressed as a percentage of the two year daily flow volume for the pre-development flow pattern, is to be at least	75%
Five year daily flow volume in the simulation period, expressed as a percentage of the two year daily flow volume for the pre-development flow pattern, is to be at least	87%
Twenty year daily flow volume in the simulation period, expressed as a percentage of the two year daily flow volume for the pre-development flow pattern, is to be at least	88%

Table 9-4 First post-winter flow event objectives

Performance indicator	Objective
Number of FPWF events in the simulation period expressed as a percentage of the number of post w inter-flow years in the period is to be at least	80%
Number of five-week lag events in the simulation period expressed as a percentage of the number of post w inter-flow years in the period is to be at least	60%
Number of two-week lag events in the simulation period expressed as a percentage of the number of five-w eek lag events in the period is to be at least	70%
Average volume ratios for the post-w inter flow years in the simulation period is to be at least	70%
Average of the peak flow ratios for the post-w inter flow years in the simulation period is to be at least	Not applicable
Number of two-times base flow events in the simulation period expressed as a percentage of the number of post w inter-flow years in the period is to be at least	70%
Number of five-times base flow events in the simulation period expressed as a percentage of the number of post w inter-flow years in the period is to be at least	70%

9.1.2.3 Fitzroy Basin Resource Operations Plan

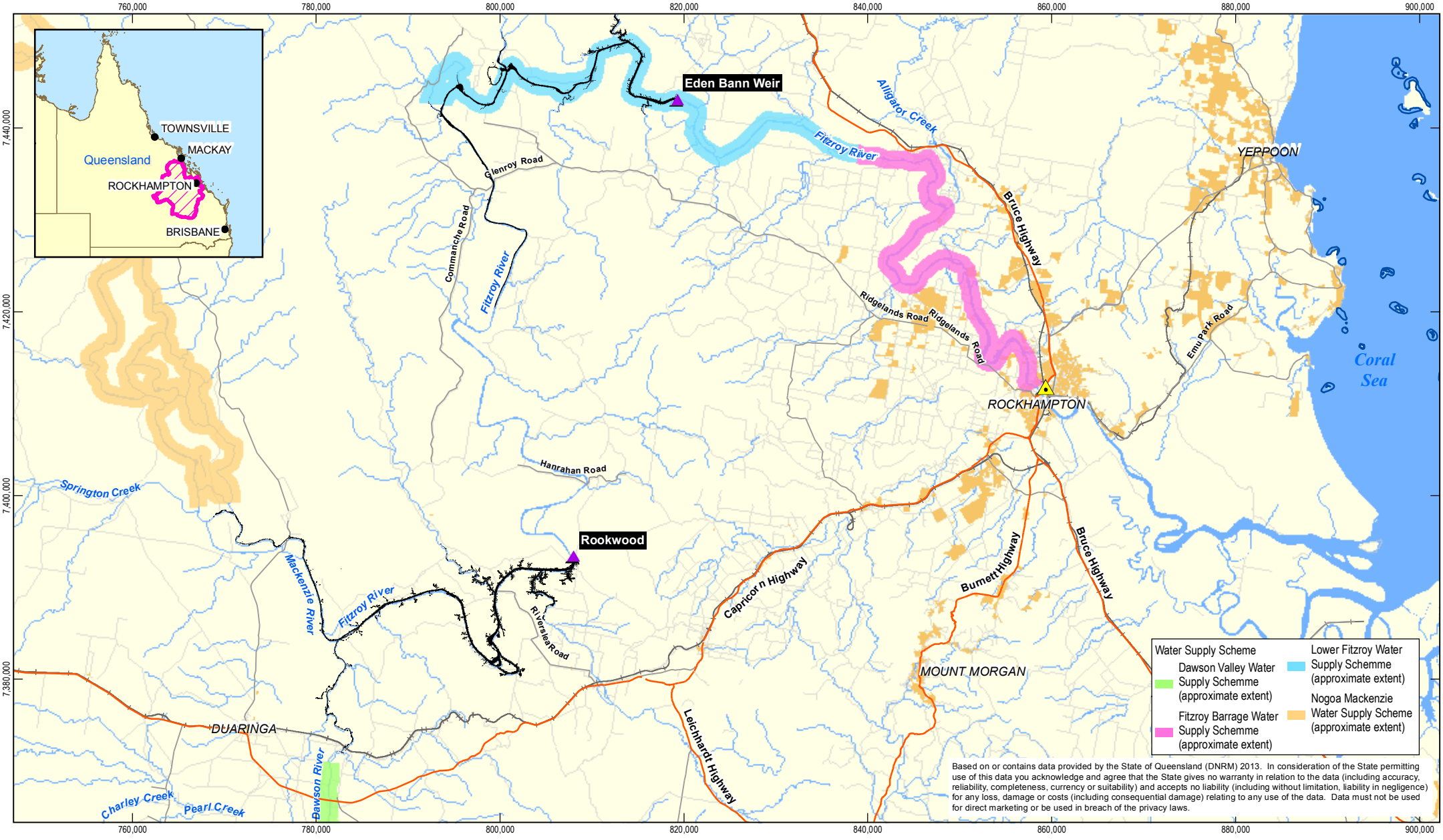
The Fitzroy ROP implements the Fitzroy WRP and defines the rules for allocation and management of water in order to achieve WASOs and EFOs. In this regard, the Fitzroy ROP specifically deals with the management arrangements for supplemented water supply schemes and associated infrastructure, and those for unsupplemented water in water management areas:

- Supplemented water is managed through water supply schemes. Relative to the Project, the Lower Fitzroy (supported by the existing Eden Bann Weir storage) and the Fitzroy Barrage (supported by the Fitzroy Barrage storage) water supply schemes are applicable as shown on Figure 9-2
- Unsupplemented water is managed by the State in water management areas. The Fitzroy Water, Nogoa Mackenzie and Dawson Valley management areas (Figure 9-3) are applicable to the Project
- The geographic location from which water can be taken under a water allocation is specified as a zone and shown on Figure 9-4.

The Fitzroy WRP reserves a nominal volume of supplemented water allocations (76,000 ML) for strategic water infrastructure on the Fitzroy River as the strategic water infrastructure reserve. The Project is recognised as strategic water infrastructure to which water allocations may be granted. The Fitzroy ROP specifies that submissions to make unallocated water available from the strategic water infrastructure reserve on the Fitzroy River may be made as follows:

- Gladstone Area Water Board (GAWB): up to 30,000 ML of the reserve for urban and industrial water supplies
- Local government authority: up to 4,000 ML of the reserve for urban water supplies for the Capricorn Coast.

The Fitzroy ROP does not specify the intended use of the remaining 42,000 ML and nominates that any person or entity may make a submission in this regard.



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Kilometres

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

N

LEGEND

- Weir Location
- Fitzroy Barrage
- Highway
- Major Road
- Streets (Local)
- Fitzroy Basin
- Urbanised Area
- Impoundment area
- Waterway

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Supplemented water supply schemes relative to the Project

Figure 9-2

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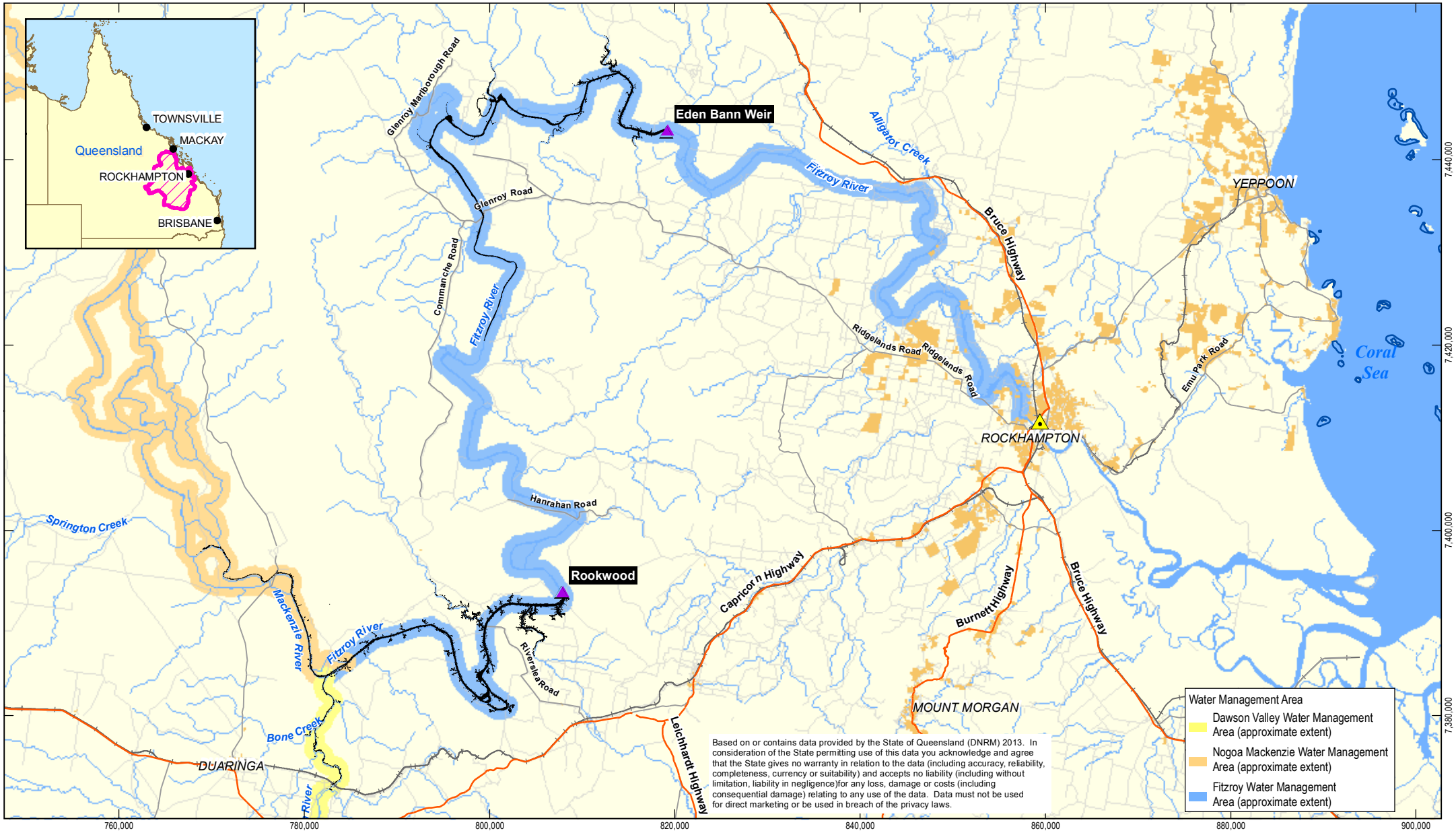

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Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Weir
- Location
- Fitzroy Barrage
- Highway
- Major Road
- Streets (Local)
- Fitzroy Basin
- Urbanised Area
- Impoundment area
- Waterway

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Existing unsupplemented water management areas relative to the project

Figure 9-3

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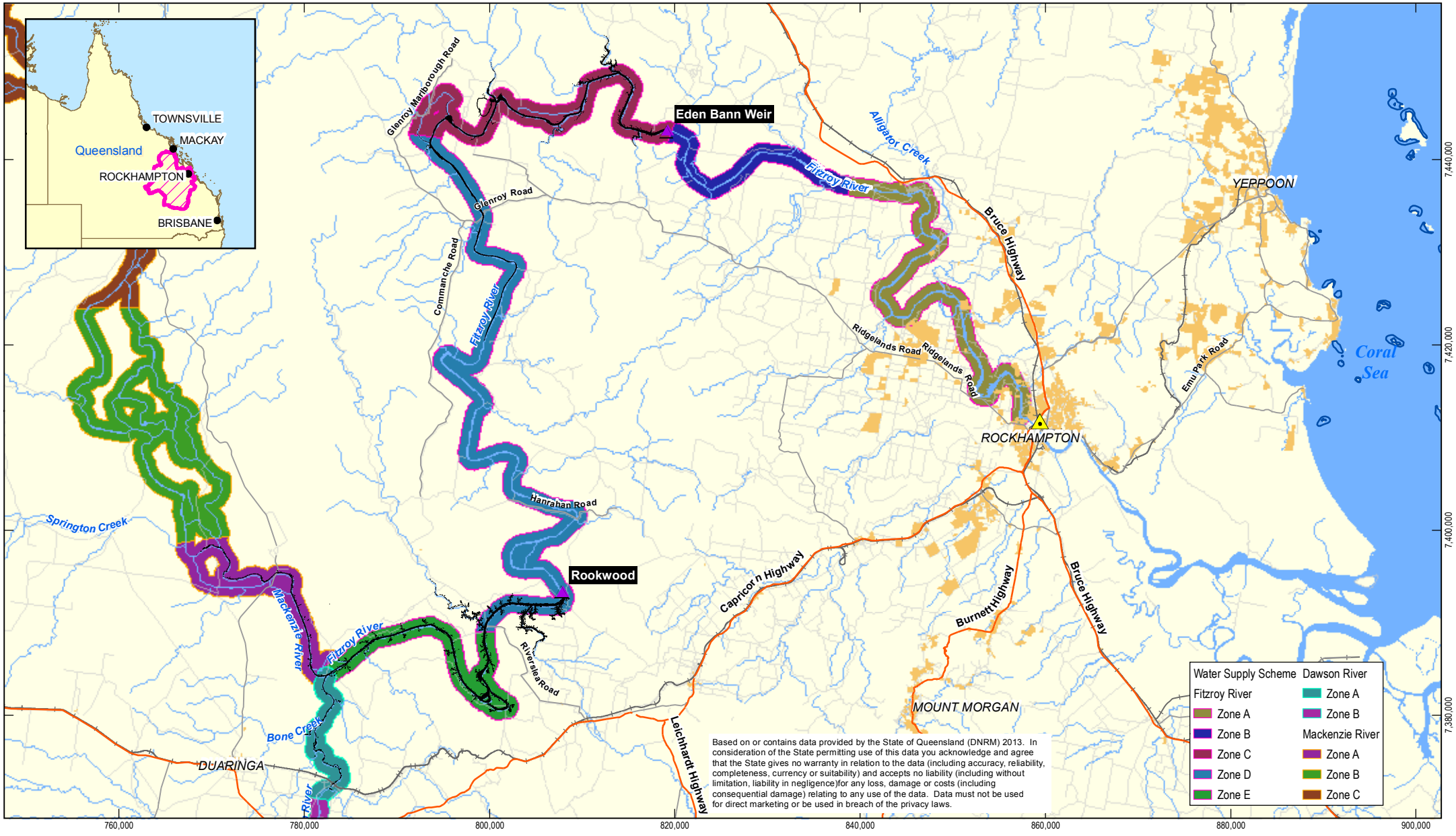

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Kilometres

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

N

LEGEND

- Weir
- Location
- Fitzroy Barrage
- Highway
- Major Road
- Streets (Local)
- Fitzroy Basin
- Urbanised Area
- Impoundment area
- Waterway

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Existing water allocation zones relative to the Project

Figure 9-4

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9.1.3 Approach and methodology

9.1.3.1 Overview

In order to develop an understanding of the existing surface water characteristics, the potential impacts and associated management and mitigation measures for surface water resources that may be affected by the Project, the following general assessment approach was adopted:

- Undertake surface water modelling to quantify the available yield using the IQQM (Section 9.1.3.2)
- Describe the existing environment with regard to surface water resources, including at the catchment scale, and locally within the Fitzroy, lower Dawson and lower Mackenzie rivers (as applicable). This included:
  - Identifying and defining Fitzroy Basin and subcatchment characteristics
  - Describing the existing surface drainage patterns, flows, and history of flooding (including extent, levels and frequency)
  - Describing existing water uses.
- Assess the potential impacts of the Project on the surface water resources, surface drainage patterns, flows, flooding and existing users
- Identify appropriate management and mitigation measures to avoid, minimise and/or mitigate the potential impacts.

A number of different methodologies and approaches have been used to determine the potential impacts associated with the Project as summarised below and described in further detail in Appendix P.

9.1.3.2 Yield modelling

The Project yield is assessed using the IQQM. IQQM is a computer program with associated statistical analysis and reporting programs developed by DNRM and DSITIA. The IQQM simulates daily stream flows, flow management, storages, releases, in-stream infrastructure, water diversions, water demands and other hydrologic events in the Fitzroy WRP area.

The modelling approach and outcomes detailed in the below documents were also reviewed with respect to the IQQM methodology and consistency in goals:

- Fitzroy Basin Draft Water Resource Plan Environmental Assessment – Stage 1 Background Report (DERM 2009) provides a summary of the basic water resource management profile, environmental provisions and the previous planning strategies and water monitoring programs for the Fitzroy Basin
- Fitzroy Basin Draft Water Resource Plan Environmental Assessment – Stage 2 Assessment Report (DERM 2010) details the outcomes of technical ecological assessments (including ecological risk assessments and climate change analyses) and reviews of the previous Fitzroy WRP and Fitzroy ROP.

For the purposes of the Project, the IQQM is specifically used to determine Project yields and whether the proposed water extraction is consistent with the Fitzroy WRP WASOs and EFOs for surface water.

Appendix P provides a detailed methodology. The approach adopted by the Project for yield modelling is summarised as follows:

- The IQQM for the Fitzroy Basin (IQQM (CAS2134)) was obtained from the Queensland Government (DSITIA) for use under licence
- IQQM (CAS2134) nodal parameters were assessed and agreed with DNRM and DSITIA and augmented to develop IQQM-Project
- The 'existing case' was simulated to include all existing water storage infrastructure within the Nogoa/Fitzroy system. Specifically with relevance to the Project, this included the Fitzroy Barrage and Eden Bann Weir (Stage 1). In-flow data from the Mackenzie and Dawson rivers also accounted for the presence of proposed water storage infrastructure, namely Connors River Dam and Nathan Dam, respectively. These storages are included so as to conservatively represent the potential yield for the Project
- Project staging options or development scenarios were identified as described in Table 9-5
- High priority water yield estimates (theoretical yields) were determined (existing case and Project scenarios)
- IQQM-Project also run with the high priority yield capped at 76,000 ML/a (capped yield); this aligns with the supplemented water nominal volume stated in the Fitzroy WRP for water infrastructure on the Fitzroy River (strategic water infrastructure reserve)
- Post-processing of the theoretical and capped yield model runs (IQQM-Project) was completed to assess compliance with the requirements of the Fitzroy WRP (WASOs and EFOs) or at least such that there is no worsening of the existing situation (existing case). Compliance results criteria are presented as shown in Table 9-6
- A third party review of results and findings.

Additional medium priority water availability was not assessed for the Project as securing medium priority water is not the primary Project objective. Existing water sharing rules for medium priority groups in the IQQM-Project were unchanged and in accordance with the Fitzroy ROP. Post-processing assessment of compliance with the requirements of the Fitzroy WRP WASOs for medium priority users is presented.

Chapter 4 Climate, natural hazards and climate change provides an overview of climate change projections. Climate change sensitivities have however not been included within yield modelling undertaken to date. It is proposed that once a Project trigger is realised, further yield modelling will be undertaken to develop a robust business case and inform augmentation of the Fitzroy ROP. Climate change scenarios will be included at this time. Given that Project development is to be staged in response to actual demand triggers, this allows for business case development on available yield and demand and other constraints, such as potential climate change impacts, to be reviewed as near to development commencement as possible.

Table 9-5 Project development scenarios

Development scenario	Description
Eden Bann Weir Stage 1 (EB1)	The existing environment or base case, that is the system as it currently operates, including existing water storages (Fitzroy Barrage and EB1) and the proposed Connors River and Nathan dams and assumed full utilisation of all existing and proposed water entitlements
Eden Bann Weir Stage 2 (EB2)	The existing Eden Bann Weir (EB1) raised to a new fixed crest at full supply level (FSL) 18.2 m Australian Height Datum (AHD)
Eden Bann Weir Stage 3 (EB3)	The addition 2 m high gates to EB2 raising the weir to FSL 20.2 m AHD
Rookwood Weir Stage 1 (RW1) + EB1	A greenfield weir development to a fixed crest at FSL 45.5 m AHD
RW1 +EB2	A greenfield weir development to a fixed crest at FSL 45.5 m AHD plus a raised Eden Bann Weir to FSL 18.2 m AHD.
RW1 + EB3	A greenfield weir development to a fixed crest at FSL 45.5 m AHD plus Eden Bann Weir with 2 m high gates to FSL 20.2 m AHD.
Rookwood Weir Stage 2 (RW2) + EB1	The addition of 3.5 m gates to RW1 raising the weir to FSL 49.0 m AHD
RW2 + EB2	The addition of 3.5 m gates to RW1 and a raise to EB1
RW2 + EB3	The addition of 3.5 m gates to RW1 and the addition of 2 m gates to EB2

Table 9-6 IQQM-Project compliance reporting criteria

Key	Compliance criteria
	All Fitzroy WRP objectives are achieved
	Fitzroy WRP non-mandatory objectives are not achieved and the Project achieves at least the same results as the existing case
	Fitzroy WRP non-mandatory objectives are not achieved and the Project achieves results of less than the existing case
	Fitzroy WRP mandatory objectives are not achieved

9.1.3.3 Stream flow hydrology

Flow characterisation

To characterise flows within the Fitzroy, Mackenzie and Dawson rivers (as reflective of flows in the Project area) (Section 9.2.2) flow data from four stream gauging stations (Figure 9-5) was analysed for an historic period and a nominated 'current' period (2000 to 2009) (Appendix P):

- The Gap (130 005A)
- Riverslea (130 003B)
- Coolmaringa (130 105A)
- Beckers (130 322A).

For each gauging station, the following information was prepared to inform discussion on stream flow characteristics in the Project area:

- Hydrographs presenting flow discharges and the longer term variability in flows (as total annual flow)
- Flow duration curves summarising the range and distribution of flows
- The average total monthly flow (ML) reflecting the seasonal variability in flow.

Flow analysis

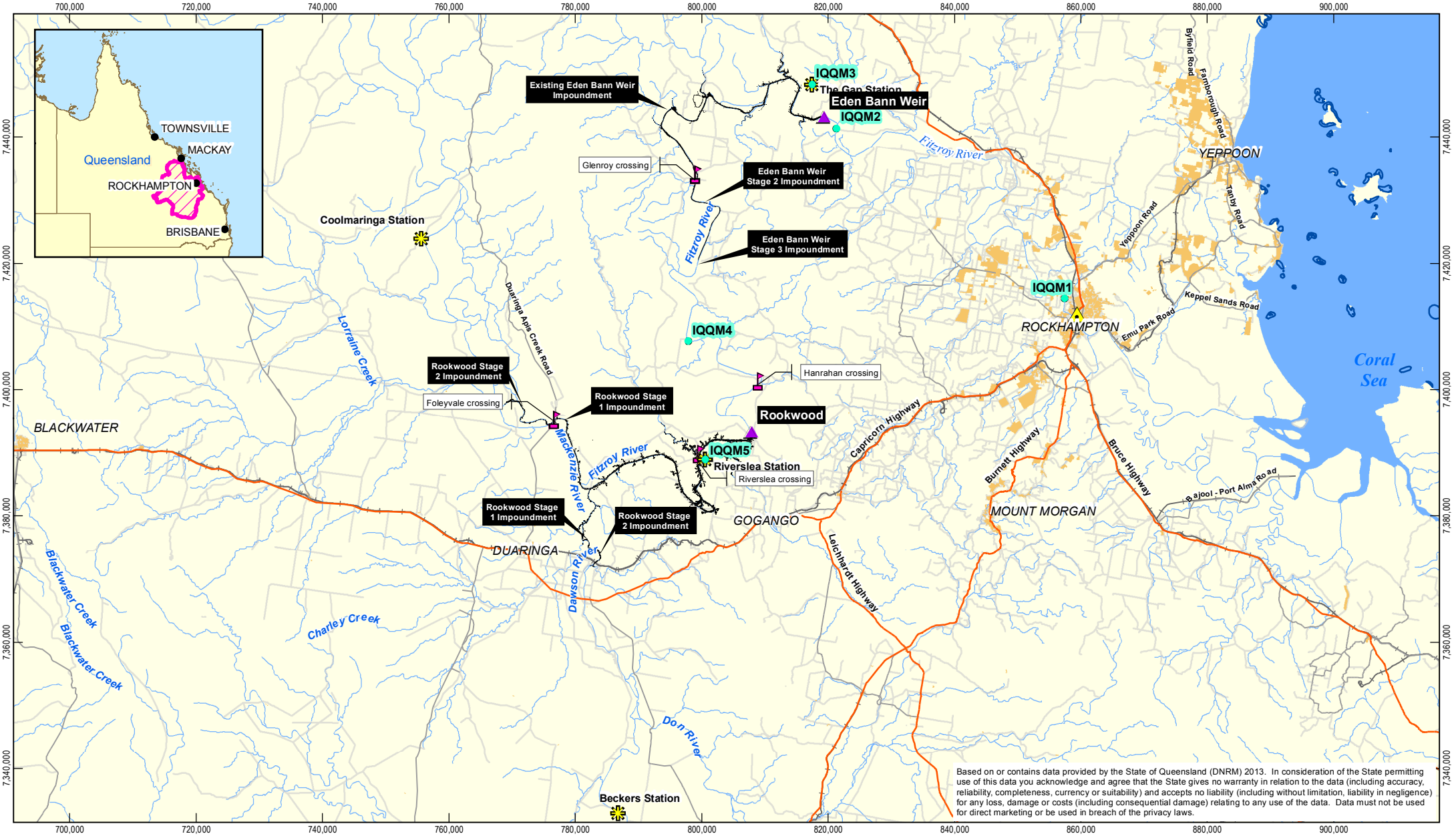
The IQQM-Project was used to predict potential changes to flow regimes at five locations (Figure 9-5) within and downstream of the Project areas, as described in Table 9-7, as a result of implementing selected development scenarios (Table 9-5).

Hydrographs were developed to illustrate pre- and post-development flows (Appendix P).

Flow duration curves were generated for each location comparing development scenarios to the existing case (EB1) over the entire time series (Appendix P).

Table 9-7 Flow analysis data locations

Reference	Assessment location	Description
IQQM1	End of system	Located downstream of the Fitzroy Barrage and representative of the marine/estuarine environment. Approximately concurrent with Node 0.
IQQM2	Wattlebank	Downstream of the existing Eden Bann Weir.
IQQM3	The Gap	Located at the gauging station on the Fitzroy River (142.1 km AMTD), approximately 1 km upstream of the existing Eden Bann Weir; within the current impoundment.
IQQM4	-	An area downstream of the proposed Rookwood Weir but upstream of the existing Eden Bann Weir impoundment.
IQQM5	Riverslea	At the Riverslea gauging station located on the Fitzroy River at 276 km AMTD within an unregulated stretch of the river approximately 11 km upstream of the proposed Rookwood Weir.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
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N

LEGEND

- Weir Location
- River Crossing
- Fitzroy Barrage
- Highway
- Major Road
- Streets (Local)
- Railway
- Waterway
- Fitzroy Basin
- Urbanised Area
- Impoundment Area
- Flow assessment locations
- Stream Gauges

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Gauging stations and flow assessment locations within and near to Project areas

Figure 9-5

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Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Places, Waterways (2007); Sunwater: Waterways, Weir Locations - 2008; DNRM: Railways, Roads, Fitzroy River Delta, Stream Gauges - 2010;
GHD: Impoundment Area, Crossings (2012), Flow assessment locations - 2014. Created by: MS *See Appendix for disclaimers and copyrights.

In addition, statistical analysis was undertaken for the following selected development scenarios at the end of the system (IQQM1) to determine impacts on the marine/estuarine environment and flows to the Great Barrier Reef World Heritage Area (GBRWHA):

- Existing case (existing Eden Bann Weir Stage 1)
- Eden Bann Weir Stage 2
- Rookwood Weir Stage 1 and the existing Eden Bann Weir Stage 1
- Rookwood Weir Stage 2 and Eden Bann Weir Stage 3.

Detailed methodology with regard to the statistical analysis is provided in Appendix P.

9.1.3.4 Flood hydrology

Flood hydrological investigations were undertaken to estimate peak flow rates along the Fitzroy River at various locations including at the Eden Bann Weir and the proposed Rookwood Weir site. This included:

- Making use of existing and available hydrological information, that is, SunWater (2008a) flood hydrology study, and DNRM water level and rainfall data from stream gauging stations located on the Fitzroy River
- Undertaking a flood frequency analysis
- Developing a flood hydrology model (URBS), including model calibration, design flood estimation and potential climate change impacts.

A detailed methodology for the hydrological studies is provided at Appendix P.

9.1.3.5 Hydraulic modelling

Hydraulic modelling was undertaken for the Project in relation to development at Eden Bann Weir and construction of Rookwood Weir to predict the extent of upstream afflux and comprised the following:

- Development of a one-dimensional (1D) MIKE 11 hydraulic mode for the Fitzroy River and its contributing tributaries from downstream of the Mackenzie and Dawson Rivers confluence to approximately 15 km downstream of the existing Eden Ban Weir;
- Calibration of the 1D model using historical flood events;
- Development of a two-dimensional (2D) MIKE 21 hydraulic model for the lower Mackenzie and Dawson Rivers areas and confluence;
- Assessment of a range of design flood events (namely, 1 in 2, 5, 10, 20, 50 and 100 Average Exceedance Probability[1] (AEP) events) to estimate the influence of the Project on existing peak flood levels, and as influenced by potential climate change factors.

A detailed hydraulic model methodology is provided at Appendix P.

[1] The AEP is the probability of an event occurring in any one year. For example, the 1 in 2 AEP event has a 50 per cent chance of occurring in any one year, while a 1 in 100 AEP event has a one per cent chance of happening in any one year.

9.2 Existing environment

9.2.1 Catchment characteristics

9.2.1.1 The Fitzroy basin

The Fitzroy Basin 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. It consists of six major subcatchments, namely: Isaac Connors; Nogoa; Comet; Mackenzie; Dawson; and Fitzroy as shown in Figure 9-1.

Strongly seasonal climatic factors heavily influence flows within the Fitzroy Basin, 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 from approximately May to October. Mean annual rainfall is generally higher in the eastern parts of the Fitzroy Basin (800 – 1000 mm), and slightly lower inland to the west (600 mm) (Johnston et al., 2008). Severe flooding occurs within the Fitzroy Basin 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 climate that the Fitzroy Basin is exposed to. Climatic conditions are described further is Chapter 4 Climate, natural hazards and climate change.

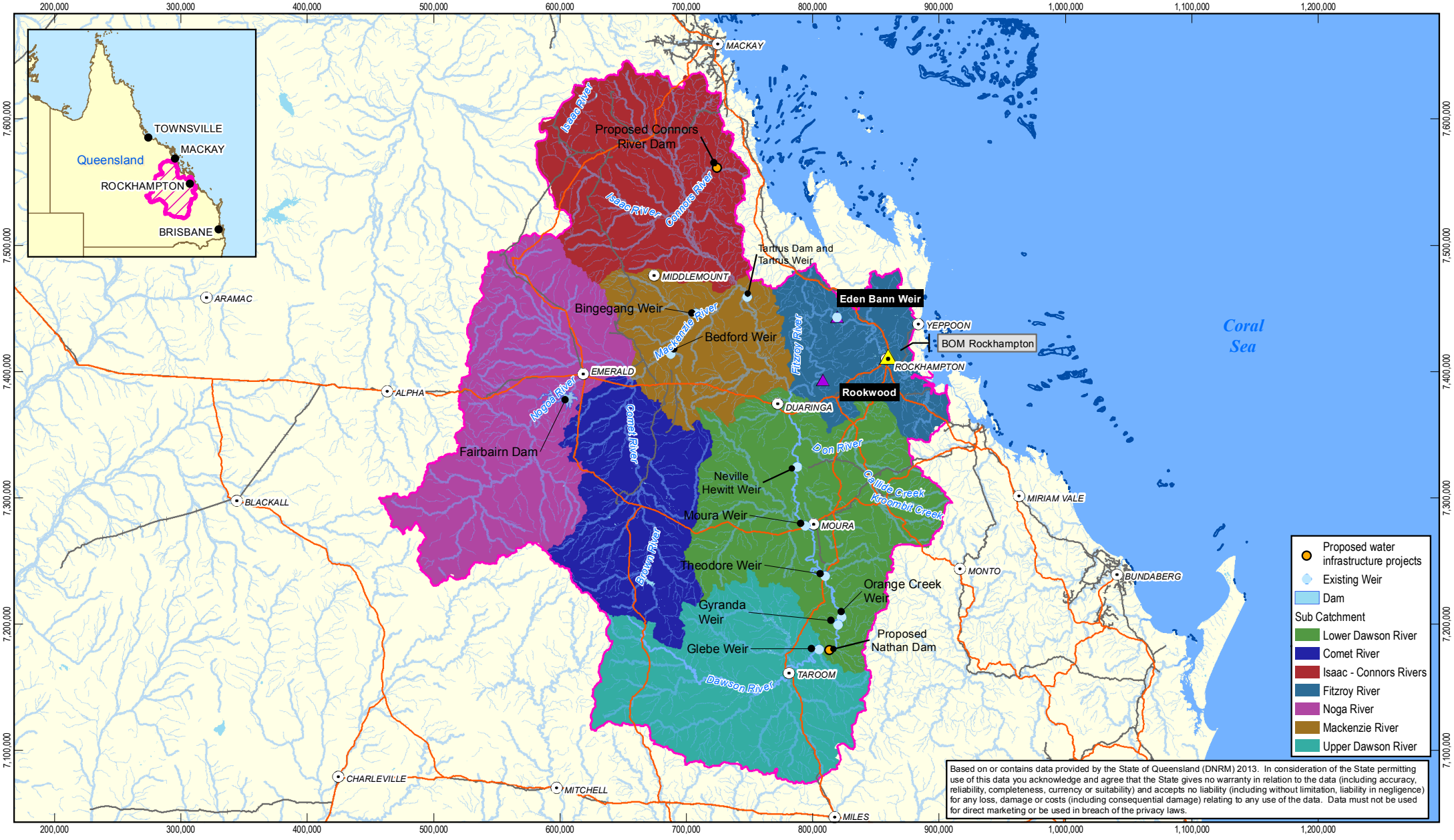
Although sparsely populated, large tracts of land within the Fitzroy Basin have been modified for human land use practices. Agricultural production accounts for almost 90 per cent of land use within the Fitzroy Basin (Johnston et al., 2008). Of this, 81.7 per cent is livestock grazing (Johnston et al., 2008). Other notable land uses within the Fitzroy Basin include State Forest (6.65 per cent), nature conservation (4.54 per cent) and mining (0.38 per cent) (Johnston et al. 2008). Mining occurs throughout the Fitzroy Basin, with existing mining activities concentrated in the northern and western parts of the Basin. As of 2008, approximately 55 mines (45 of which were coal mines) and 20 medium-to-large quarries were located in the central Queensland region, of which a large number occur within the Fitzroy Basin.

In order to support human activities (i.e. agriculture, mining, industry, urban centres) in a climatically-variable system, rivers within the Fitzroy Basin have been heavily regulated with five dams (large and small), 11 weirs and a large tidal barrage. These include Fairbairn Dam, Glebe Weir, Gyranda Weir, Orange Creek Weir, Theodore Weir, Moura Weir, Neville Hewitt Weir, Bedford Weir, Bingegang Weir, Tartrus Weir, Eden Bann Weir and the Fitzroy Barrage (Marsden and Power, 2007). Within the Basin, Nathan Dam is proposed on the Dawson River and Connors River Dam is proposed on the Connors River, along with the Project.

Figure 9-6 shows the locations of existing and proposed water storage infrastructure with the Fitzroy Basin.

The aquatic ecosystems within the Fitzroy Basin are host to a range of aquatic flora and fauna species, several of which are endemic to the area. The Basin supports high native freshwater fish diversity.

The proposed infrastructure developments associated with the Project are located on the Fitzroy River, within the Fitzroy subcatchment in the east of the Fitzroy Basin. The impoundment associated with construction of Rookwood Weir will inundate the lower reaches of the Mackenzie and Dawson Rivers, within the (lower) Mackenzie and (lower) Dawson subcatchments respectively.



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Kilometres

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

N

LEGEND

- Weir Location
- Fitzroy Barrage
- Waterway (Major)
- Waterway (Minor)
- Highways (National)
- Railway
- Fitzroy Catchment
- Lakes

Gladstone Area Water Board, SunWater
Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision A
Date 26 Sep 2014

Existing and Proposed Water Storage Infrastructure in the Fitzroy Basin

Figure 9-6

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9.2.1.2 The Fitzroy subcatchment

The Fitzroy subcatchment is dominated by the Fitzroy River that forms from the confluence of the Mackenzie and Dawson Rivers (at 310 km AMTD), and flows out to the GBRWHA. Between Eden Bann Weir and the Mackenzie / Dawson confluence, the Fitzroy River is considered a 9th order stream (Queensland Government Regional Ecosystem Mapping Version 6).

The Fitzroy River passes through the city of Rockhampton which lies 59 km from the river mouth. The Rockhampton Regional Council (RRC) local government area is a growing residential area, with significant rural and rural residential areas, and some commercial and industrial land uses. The area encompasses over 18,300 km^2 and includes national parks, state forests, coastline and islands. The main urban centre is Rockhampton. There are numerous small towns along the coast.

Two water storage infrastructure developments occur within the Fitzroy subcatchment; Eden Bann Weir (at 141.2 km AMTD); and the Fitzroy Barrage (at 59 km AMTD) which is located in Rockhampton. The Fitzroy Barrage forms a barrier between the freshwater and tidal reaches of the Fitzroy River. Agriculture (particularly cattle grazing) is the major non-urban land use in the subcatchment. Power generation and tourism are also some of the important industries in the area.

The Fitzroy River traverses through flat-to-undulating country for a distance of 310 km from its formation at the confluence of the Dawson and Mackenzie Rivers to Keppel Bay in the GBRWHA. In unimpounded reaches, the Fitzroy River is generally a wide, slow flowing river typified by long, relatively deep pools interspersed with narrower, faster flowing riffles and runs. In the impounded reaches upstream of Eden Bann Weir and the Fitzroy Barrage, the river is wide and deep with little flow for most of the year (excluding flow events in the wet season). As with all rivers in the Fitzroy Basin, the Fitzroy River is susceptible to seasonal high flow events during the wet season, and occasional flooding in instances where intensive rainfall events occur within and up-stream of the Fitzroy subcatchment.

Upstream of Rockhampton, land use is dominated by cattle grazing. Land clearing has occurred extensively where agricultural production occurs adjacent to the Fitzroy River. However, fringing woodland and alluvial floodplain vegetation has been retained along much of the river (including where agricultural activities are practiced). Rocky hills and ranges which are unsuitable for grazing also retain relatively larger, better connected patches of woodland vegetation.

Figure 9-7 shows typical landscapes along and adjacent to the Fitzroy River, at the Fitzroy Barrage, and at the existing Eden Bann Weir and proposed Rookwood Weir sites. Figure 9-8 shows surface water resources relative to Eden Bann Weir. Figure 9-9 shows surface water resources relative to the proposed Rookwood Weir site.

Figure 9-7 Typical landscapes associated with the Fitzroy River

Fitzroy River

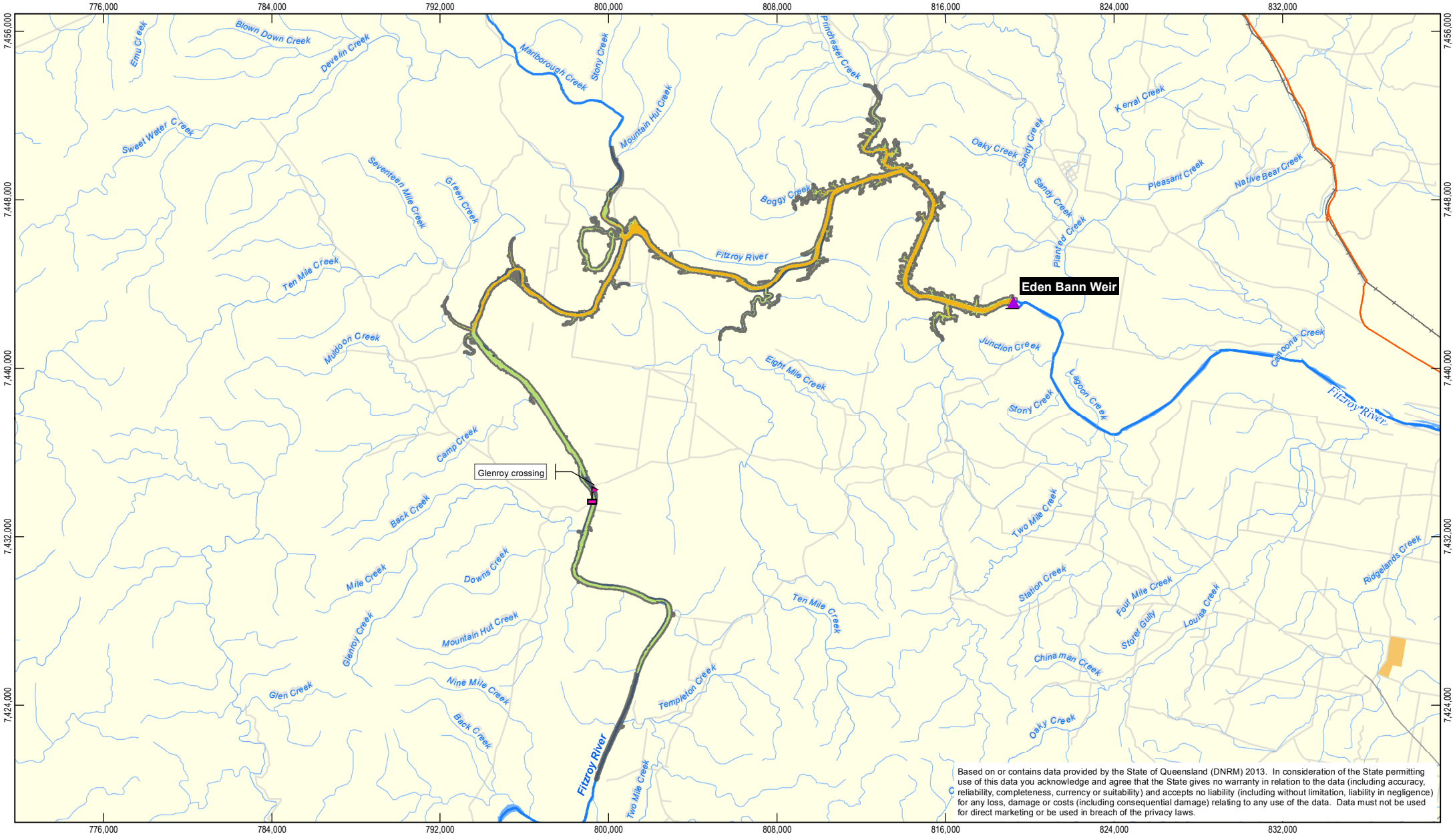
Fitzroy River

Fitzroy Barrage impoundment

Fitzroy Barrage impoundment

Existing Eden Bann Weir impoundment

Proposed Rookwood Weir site



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Kilometres

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

N

LEGEND

- Weir Location
- River Crossing
- Highway
- Major Road
- Streets (Local)
- Railway
- Waterway
- Urbanised Area
- Existing impoundment
- Stage 2 impoundment
- Stage 3 impoundment

Gladstone Area Water Board, SunWater
Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision A
Date 11 Aug 2014

Eden Bann Weir surface water resources

Figure 9-8

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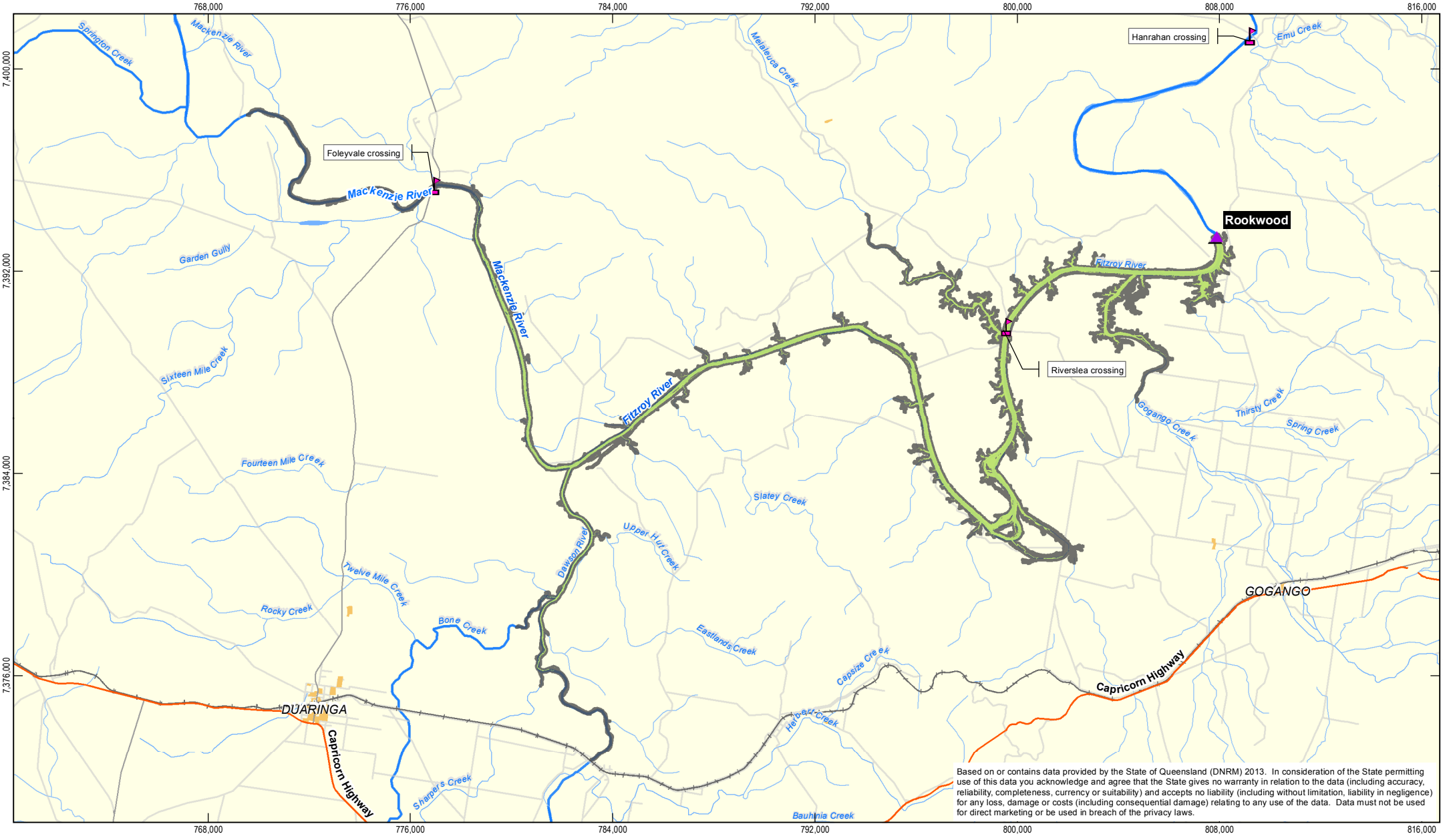
Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Places, Waterways (2007); Sunwater: Waterways, Weir Locations - 2008; DNRM: Railways, Roads - 2010;
GHD: Impoundment Area, Crossings (2012). Created by: MS *See Appendix for disclaimers and copyrights.



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Kilometres

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

N

LEGEND

- Weir Location
- River Crossing
- Highway
- Major Road
- Streets (Local)
- Railway
- Waterway
- Urbanised Area
- Stage 1 impoundment
- Stage 2 impoundment

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SunWater Making Water Work

Gladstone Area Water Board, SunWater
Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision A
Date 11 Aug 2014

Rookwood Weir surface water resources

Figure 9-9

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Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Places, Waterways (2007); Sunwater: Waterways, Weir Locations - 2008; DNRM: Railways, Roads - 2010;
GHD: Impoundment Area, Crossings (2012). Created by: MS *See Appendix for disclaimers and copyrights.

9.2.1.3 The Dawson subcatchment

The Dawson subcatchment dominates the south eastern part of the Fitzroy Basin. The Dawson River originates in the Carnarvon and Expedition Ranges north of Injune, from where it flows to the south east towards Taroom before changing to a northerly course until it meets the Mackenzie River (forming the Fitzroy River) (Figure 9-6). Cattle grazing is the dominant land use within the subcatchment. Five weirs occur on the Dawson River, including Glebe Weir, Gyranda Weir, Theodore Weir, Moura Weir and Neville Hewitt Weir (Figure 9-6). Neville Hewitt Weir is the first infrastructure on the Dawson River located above the confluence (at approximately 82.6 km AMTD) and is not within the Project's footprint. Nathan Dam is proposed on the Dawson River at 315.3 km AMTD. The Don River is the most notable tributary of the Dawson River. In its lower reaches (i.e. within the project footprint), the Dawson River is considered an 8th order stream.

The lower reaches of the Dawson River meander in a northerly direction towards the confluence with the Mackenzie River, where the Fitzroy River is formed. In its lower reaches, the Dawson River is generally a narrow river with relatively steep banks in places. The width of the river increases towards the Mackenzie River confluence. In the dry season, the waterway is characterised by a series of pool-riffle-run sequences, which become isolated towards the end of the dry season into a series of discrete pools. Evidence of large wet season flows is prevalent along the lower reaches of the river, namely through the presence of flood debris (including very large eucalyptus trees), and channel gouging.

The landscape adjacent to the lower reaches of Dawson River is predominantly flat. Land use is dominated by agricultural practices, particularly cattle grazing and cropping (i.e. wheat). While woodland vegetation in the riparian zone and adjacent alluvial floodplain has been retained in many places, significant tracts of land behind this vegetated buffer have been cleared (either partially or completely) to facilitate agricultural production. In many places, cattle have access to the Dawson River.

Figure 9-10 shows typical landscapes along and adjacent to the Dawson River in the lower parts of the Dawson subcatchment.

9.2.1.4 The Mackenzie subcatchment

The Mackenzie subcatchment occurs in the central part of the Fitzroy Basin. The Mackenzie River forms from the confluence of the Nogoa and Comet Rivers (Figure 9-6). Water storage infrastructure along the Mackenzie River includes Bedford Weir, Bingegang Weir and Tartrus Weir (Figure 9-6). Tartrus Weir is the first infrastructure on the Mackenzie River located above the confluence (approximately 428.6 km AMTD) and is not within the Project's footprint. Located upstream of the Mackenzie River confluence on the Nogoa River is Fairbairn Dam (Queensland's second largest lake with a capacity of approximately 1.3 million ML). Water is extracted from these storages for crop irrigation, coal mining, and urban consumption. In the lower reaches agricultural production (grazing and irrigated cropping) is the main land use and the landscape has been substantially modified through land clearing to accommodate cattle grazing.

Figure 9-11 shows typical landscapes along and adjacent to the Mackenzie River within the Project footprint.

In its lower reaches (within the project footprint), the Mackenzie River is considered a 9th order stream and follows a roughly south-easterly course before meeting the Dawson River at 310.3 km AMTD. The river is wide and deep in places, however like the lower Dawson River, shallower, narrower sections are typified by pool-riffle-run sequences. Lack of inflows and evaporation during the dry season isolate deeper pools. As with all rivers in the Fitzroy Basin, flooding occurs in the Mackenzie River in response to localised and upstream inflows from heavy rainfall events.

Figure 9-10 Typical landscapes associated with the lower Dawson River

Figure 9-11 Typical landscapes associated with the lower Mackenzie River

9.2.2 Stream flow hydrology

Flows within the Fitzroy, Mackenzie and Dawson rivers have been characterised below. Hydrographs, flow duration curves and average annual total flows are presented in Appendix P.

Rainfall in the Fitzroy Basin is highly variable. However rainfall generally decreases with increasing distance from the coast along with topographical influences. High rainfall events are generally associated with monsoonal conditions or tropical cyclones in summer along with thunderstorms, with thunderstorms occurring more frequently in inland parts of the Fitzroy Basin (Keane 2004). Winter rainfall generally results from cold fronts and upper trough systems. This variable rainfall and subsequent runoff influence flows in river systems within the Fitzroy Basin and its subcatchments, including the Fitzroy, Mackenzie and Dawson rivers (Keane 2004). Prolonged dry conditions and drought are also characteristic features of the region. Chapter 4 Climate, natural hazards and climate change provides further detail on climatic characteristics of the Project area.

Flows in the Mackenzie River (and subsequently the Fitzroy River) are erratic and largely driven by cyclonic action, severe storms and tropical low pressure systems characteristic of the north of the Fitzroy Basin. These highly variable and unpredictable flows are clearly shown in hydrographs (Appendix P). Historically total annual flows range from almost zero to 22,500,000 ML. Peak flows generally coincide with extreme weather events, in particular flood events that occurred during the recording period in 1978, 1983, 1991 and 2008 (Section 9.2.3). Extended periods of low flows reflect prolonged droughts as experienced during the period 2001 to 2007.

While the Dawson River also exhibits variable flows, the order of magnitude is much reduced (between zero and 5,000,000 ML annually). This is as a result of drivers associated with less extreme climatic events in the subcatchments that feed the Dawson subcatchment much further to the west within the Fitzroy Basin. The Dawson River itself is also classified as a lower order stream than the Mackenzie and Fitzroy rivers. Further its gauge at Beckers receives flows from a catchment of only 40,500 km^2 in extent compared to catchments of 76,645 km^2, 131,385 km^2 and 135,757 km^2 associated with the Coolmaringa, Riverslea and The Gap gauges, respectively.

Drought conditions (experienced in central-north Queensland during the period 2000 to 2007) impact the inter-annual variability of flow and the long-term sustainability of flow with prolonged periods of below average annual flow.

The relative position of flow duration curves reflects differences in the magnitude of flow (Appendix P). Where climatic conditions are more or less similar between river systems, the magnitude of flow is primarily determined by the size of the respective catchment. As discussed above, the Fitzroy River and Mackenzie River gauges have the larger catchment areas and subsequently greater flows compared to the Dawson River gauge. This is evident where the stream flows in the Fitzroy River appear similar to those of the Mackenzie River with The Gap, Riverslea and Coolmaringa gauging stations recording around 80 per cent of the days as having flows greater than 10 ML and ten per cent of days with flows above 10,000 ML. Noticeably, flows on the Dawson River are lower overall with only 50 per cent of days reaching flows greater than 10 ML per day.

The shape of the flow duration curves and thus the distribution and range of flows is controlled by catchment characteristics such as land use, geology and topography, as well as variations in local climatic conditions. A consistency in shape suggests a general similarity in catchment and climatic conditions. Deviations from the general shape (for example a truncation of low flows at The Gap) are likely to be the result of the gauge being drowned out by inundation from storage behind the existing Eden Bann Weir which prevents the measurement of low flows. The upper reaches of the Fitzroy River

(at Riverslea) and the lower reaches of the Mackenzie River (at Coolmaringa) present around 95 per cent of days with flows between 1 ML and 10 ML per day compared to the Fitzroy River at the Gap where only 80-81 per cent of flows are between 1 ML and 10 ML per day.

Records for the period 1999 – 2009 reflect considerably lower daily flows with only 65 per cent to 70 per cent of days having flow greater than 10 ML on the Mackenzie and upper Fitzroy rivers. Similarly daily flows in the lower Dawson River at Beckers are also reduced with in the order of 40 per cent of daily flows being 10 ML. This is consistent with drought conditions experienced across the region during this period and reflected in the records at all the selected gauging stations. Flow duration curve shape is maintained again reflecting the influence of the catchments on the flows at the selected gauging stations, albeit that daily flows are significantly reduced.

In general average monthly flow volumes show a consistent seasonal pattern of high summer flows and low winter flows on the Fitzroy and Mackenzie Rivers, peaking at around 1,200,000 ML per month and 900,000 ML per month, respectively and falling to almost zero flow in the winter months. This seasonality in flow is less marked on the Dawson River and may reflect differences in localised climatic conditions. The Dawson subcatchment does not typically experience regular intense rainfall events associated with cyclones and is rather susceptible to severe thunderstorms particularly during the summer months. Flows are markedly reduced (with the peak at around 120,000 ML monthly); possibly attributed to the climatic conditions and the smaller catchment area associated with the Beckers gauging station.

During drought conditions, wet season flows in all catchments appear to have been sustained at a similar magnitude to those occurring in the historic period but over a shorter period of the season, whilst dry season flows generally decrease throughout the season.

9.2.3 Flooding

The Fitzroy Basin is described as having an immense size and fan-like shape which is capable of producing severe flooding following heavy rainfall events (BoM 2011). Major floods can result from flows in either the Dawson or the Connors-Mackenzie Rivers. Significant flooding in the Rockhampton area can also occur from heavy rain in the local area below Riverslea, which is upstream of the proposed Rookwood Weir site.

The Fitzroy River at Rockhampton has a long and well-documented history of flooding with flood records dating back to 1859. The highest recorded flood occurred in February 1918 and reached 10.11 m on the Rockhampton gauge. In 2010/2011 the Fitzroy River reached 9.20 m on the Rockhampton gauge (BoM 2011) (Chapter 4 Climate, natural hazards and climate change and Appendix P). Flooding in January 2013 associated with ex-tropical cyclone Oswald recorded the ninth highest levels on record (8.6 m) at the Rockhampton gauge (BoM 2013). While moderate to heavy rainfall was recorded in the Connors River catchment in association with tropical cyclone Ita in April 2014 river level downstream in the Fitzroy system were reported to be well below minor flood levels and not recorded (BoM 2014).

A summary of significant flood events is provided in Appendix P. Hydrologic and hydraulic modelling and analysis is also presented in Appendix P.

In general the flood extents for the current 1 in 2 year AEP event are largely contained within the river banks. Anabranch flows develop during the 1 in 5 year AEP event. Flooding starts becoming quite extensive across the river floodplains and anabranches start to run full during a 1 in 20 year AEP event, and become flooded during a 1 in 50 year AEP event.

9.2.4 Fluvial processes and morphology

The Fitzroy River is located in the eastern part of the Fitzroy Basin and drains the catchment to the Fitzroy estuary and into Keppel Bay. The Fitzroy River forms at the confluence of the Dawson and Mackenzie rivers in the east of the catchment. The Fitzroy River drains the Nogoa River (in the far west), the Comet River (draining the south-central part and joins the Nogoa River to form the Mackenzie River); the Mackenzie River (from the Isaac Connor systems draining north); the Dawson River (joining the Mackenzie River and draining the southern part of the catchment with the Don and Dee rivers as major tributaries). A total of eight named creeks join the Fitzroy, Dawson and Mackenzie Rivers within the Rookwood Weir Project footprint. The largest of these are Gogango Creek and Melaleuca Creek on the Fitzroy River. Eleven named creeks flow into the Fitzroy River within the Eden Bann Weir Project footprint. For the most part, rivers in the Fitzroy Basin are low gradient streams incised into the landscape (Douglas et al 2005). Small floods (1 in 2 year AEP event) remain within the river bed and banks however larger events (1 in 20 year AEP event and above) that cause overbank flows connect the rivers to adjacent floodplains.

As described by Keane (2004), approximately 130 km of Fitzroy River downstream of the confluence of the Mackenzie and Dawson rivers has a remarkably uniform and deeply incised channel. The riverbed is in the order of 150 m to 200 m wide with banks 25 m high. The channel meanders through undulating to relatively level country. River banks within the Project footprint are generally moderately stable and contain a relatively large amount of overhanging vegetation. Substrates are predominately gravel, pebble, cobble with smaller areas of clay/silts, sands and bedrock.

The meandering nature of the Fitzroy River suggests that the river course is determined by the underlying geology from the New England Fold Belt which dominates the eastern part of the Fitzroy Basin (Douglas et al 2005) as described in Chapter 5 Land. Areas along the Mackenzie and Dawson rivers are dominated by the Duaringa and Biloela formations. Relatively straight (3 km to 7 km long) sections of river are followed by sharp angular bends, usually where higher resistant country is encountered as is evidenced in Figure 9-12. During high flows, water is contained within the riverbanks while during low flows the channel consists of long pools separated by short riffle zones. With moderate to high flows, the river maintains a uniform gradient of 0.2 m fall per kilometre of river length (Keane 2004).

Downstream of the proposed Rookwood Weir site and within the existing Eden Bann Weir impoundment, the Fitzroy River passes through rugged coastal ranges dominated by serpentinite and volcanic rocks of the Marlborough Block. At The Gap (between 143 km and 149 km AMTD), the channel is bordered on both sides by rugged ranges (reaching between 250 m and 300 m heights) (Keane 2004).

The Fitzroy River within the existing Eden Bann Weir impoundment is deep, wide and slow-flowing. The river bed substrate is generally clay/silt with smaller amounts of gravel and sand. The river banks are generally stable to moderately stable and on average 7 m high. Upstream of the Eden Bann Weir impoundment the river exists as a series of pool-riffle-run sequences. The river channel is generally narrower than the impounded area and water depth and velocity vary from deep, slow-moving conditions in the natural pools to shallow and fast-flowing conditions in the riffle zones. Substrates within the natural river channel vary from soft clay/slits and sands to harder gravel, pebble, cobble and bedrock. The river banks are generally moderately stable and contain a relatively larger amount of overhanging vegetation than the impounded area.

Figure 9-12 Fitzroy River aerial overview

Downstream of Eden Bann Weir the river traverses cleared grazing land. Channel width is increased and bank heights are reduced creating a defined and continuous floodplain until about Yaamba at which point the Fitzroy Barrage impoundment is encountered.

Flood flows in the Fitzroy River contain a high level of suspended sediment (Chapter 11 Water quality).When flow is captured in a storage or areas where flow velocity reduces (for example river bends) the sediment drops out as silt and sand. As a consequence of the high velocity flows in the Fitzroy River during flood events, deposited silt is remobilised in subsequent floods (Keane 2004). Anecdotal evidence from local landholders report sand banks in excess of 5 m being deposited in one flood event and removed in the next.

Joo et al. (2005) estimates the mean annual sediment load in the Fitzroy River (as recorded at The Gap and thus exported past Rockhampton into the Fitzroy River estuary) at 3.1 Mt/a, with most of this sediment coming from the Nogoa and Comet subcatchments. Of the four major tributaries of the Fitzroy River, the Nogoa River has the highest sediment load, followed by the Comet, Isaac and then the Dawson subcatchments with a combined catchment area of is 103,771 km^2 (76% of the Fitzroy catchment area). The Mackenzie River receives water and sediment from the Nogoa, Comet and Isaac subcatchments and the total suspended solids concentrations appear diluted by flows from the Isaac subcatchment

Within the Fitzroy Basin, sheet wash (62 per cent) and rill erosion (24 per cent) processes dominate gully and river bank erosion (12 per cent); nationally, 40 per cent of sediment is delivered to streams from hillslope erosion, 34 per cent from gully erosion and 26 per cent from streambank erosion (ANRA 2002). Similarly, Dougall et al (2006) through the SedNet model concluded that hillslope erosion was the dominant source of suspended sediments making up around 50 per cent of the total contribution with gully and bank erosion contributing 29 per cent and 21 per cent, respectively.

9.2.5 Water users and future reservations

The Fitzroy Basin is a highly regulated system with a number of existing water storages as shown on Figure 9-6. Water supply is managed through allocations from supplemented and/or unsupplemented supplies as regulated by the Fitzroy WRP and Fitzroy ROP. Geographical zones have been defined to determine the location of a water allocation within a particular reach of river (Figure 9-4), namely (as relevant to the Project) Zones A through E for the Fitzroy River, Zone A for the Dawson River and Zone A for the Mackenzie River.

9.2.5.1 Supplemented water supplies

In the Project area, supplemented water is supplied from water supply schemes as described in Table 9-8 and shown in Figure 9-2.

Table 9-8 Supplemented water allocations

Water Supply Scheme	Description	Water allocation (ML/a)	
		Medium priority	High priority
Lower Fitzroy	The scheme comprises zones Fitzroy B and Fitzroy C and extends on the Fitzroy River from the upstream limit of Eden Bann Weir (183.4 km AMTD) to the upstream limit of the Fitzroy Barrage (115.0 km AMTD). The existing Eden Bann Weir supports the supply scheme. A resource operations license (ROL) is held by SunWater Limited for Eden Bann Weir. In the order of 94 per cent of the high priority allocation from the scheme is allocated to Stanwell Corporation Limited for the Stanwell Power Station	3,101	25,520
Fitzroy Barrage	The scheme (zone Fitzroy A) extends on the Fitzroy River from the upstream limit of the Fitzroy Barrage to the Fitzroy Barrage (AMTD 59.6 km) at Rockhampton. The RRC holds a ROL for the Fitzroy Barrage, which is operated by Fitzroy River Water (a business unit of RRC). All high priority water from the supply scheme is allocated to RRC. The Lower Fitzroy Water Supply Scheme, based on Eden Bann Weir, and the Fitzroy Barrage Water Supply Scheme, based on the Fitzroy Barrage, operate in conjunction with each other.	12,335*[1]	50,000
Nogoa Mackenzie	The scheme comprises the Mackenzie A zone and extends from the upstream limit of Fairbairn Dam (AMTD 737.5 km) on the Nogoa River to the Comet River junction (AMTD 611.5 km); and on the Mackenzie River from the Comet River junction to the Springton Creek junction (AMTD 339.3 km). The supply scheme extent falls outside of the Project area. The upper limit of inundation associated with Rookwood Weir Stage 2 is predicted to reach 335 km AMTD on the Mackenzie River.	190,925	44,398
Dawson Valley	The scheme (within the Dawson A zone), particularly the lower Dawson sub-scheme that extends from the effective upstream limit of Neville Hewitt Weir (AMTD 113 km) to the downstream limit of Boolburra waterhole (AMTD 18.37 km), which is near Duaringa, on the Dawson River. The supply scheme extent falls outside of the Project area. The upper limit of Rookwood Weir Stage 2 is predicted to reach 16 km AMTD on the Dawson River.	56,358*[2]	5,579

*[1]Includes 575 ML granted to Rockhampton City Council under Section 6.2.6 of Chapter 6 of the Fitzroy ROP.

*[2]Includes 'medium A' priority and 'medium' priority interim water allocations.

Source Fitzroy ROP (January 2004, Amended October 2011 (revision 3)).

Water supplied under a water allocation may only be used for the purpose stated on that water allocation as follows:

- 'Agriculture' is the nominated purpose for those existing authorisations that are primarily used for agricultural purposes. This nominated purpose is largely associated with medium priority allocations, although there are some agricultural high priority allocations across the supply schemes, mostly from the Nogoa Mackenzie Water Supply Scheme.
- 'Distribution loss' is the nominated purpose for water allocations for distribution losses associated with the following infrastructure (all as high priority allocations):
  - The Stanwell Pipeline distribution losses for the Lower Fitzroy Water Supply Scheme
  - The Theodore and Gibber Gunyah channel systems for the Dawson Valley Water Supply Scheme
  - The Selma and Weemah channel systems and Blackwater pipeline for the Nogoa Mackenzie Water Supply Scheme
- 'Any' is the nominated purpose for all other uses of water, comprising both medium and high priority allocations.

9.2.5.2 Unsupplemented water supplies

Unsupplemented water in the Project area is managed within the Fitzroy Water Management Area (covering the Fitzroy River from the Dawson and Mackenzie Rivers' confluence to the Fitzroy Barrage) and the lower reaches of the Dawson Valley and Nogoa Mackenzie Water Management Areas (extending to the confluence of the Dawson and Mackenzie Rivers within the impoundment area associated with the proposed Rookwood Weir (Figure 9-3):

- The Fitzroy Water Management Area covering the Fitzroy River from the Dawson River junction to the Fitzroy Barrage and overlaps both the Lower Fitzroy and Fitzroy Barrage water supply schemes. These unsupplemented water arrangements refer to taking water under high stream flow conditions (water harvesting) within the bounds of the both the water supply schemes and to taking any water upstream of the Eden Bann Weir impoundment.
- The Dawson Valley Water Management Area that covers the Dawson River from the Glebe Weir impoundment to the Fitzroy River junction and overlaps with the Dawson Valley Water Supply Scheme.
- The Nogoa Mackenzie Water Management Area covering the Nogoa and Mackenzie rivers from the Fairbairn Dam impoundment to the Dawson River junction and overlaps with the Nogoa Mackenzie Water Supply Scheme.

Where water management areas overlap with water supply schemes, the unsupplemented water management arrangements generally allow for the taking of water under high stream flow conditions (water harvesting) within the bounds of the water supply scheme and for the taking of any water upstream or downstream of water supply scheme limits. An unsupplemented water allocation is described in terms of volume (volumetric limit and nominal value), location, the purpose for which water may be taken, the maximum rate for taking water and the flow conditions under which it may be taken.

All of the Eden Bann Weir Project area falls within the Fitzroy Water Management Area, as does the proposed Rookwood Weir site and a large portion of the associated impoundment. The upper limits of the Rookwood Weir Project area extend into the lower reaches of the Dawson Valley and Nogoa water management areas on the Dawson and Mackenzie rivers, respectively.

Flow conditions under which unsupplemented water may be taken is defined for a number of water allocation groups within the Fitzroy Water Management Area as described in Table 9-9.

Table 9-9 Fitzroy Water Management Area water allocation groups

Location	Zone (Fitzroy)	Water allocation group	Flow conditions
Fitzroy River from the Dawson Junction to the Fitzroy Barrage	A, B, C, D, E	Class 5A	2,592 ML/d passing flow
		Class 5B	4,320 ML/d passing flow
Fitzroy River from the Dawson River junction to the upstream limit of Eden Bann Weir	D and E	Class 6C	No flow condition 9 ML/d passing flow
		Class 7D	260 ML/d passing flow

Water harvesting authorisations on the Fitzroy River (all zones) have been converted to water allocations (total volumetric limit of approximately 46,000 ML and a total maximum rate for taking water of about 7.5 m^3/s). All other authorisations (that is those other than for water harvesting) upstream of the Eden Bann Weir impoundment (within Zones Fitzroy D and E) have been converted to water allocations (total volumetric limit of about 12,300 ML).

9.2.5.3 Unallocated water

The Fitzroy WRP identifies that a nominal volume of 76,000 ML is available for strategic water infrastructure on the Fitzroy River as supplemented water allocations from the strategic water infrastructure reserve. The Project is recognised as strategic water infrastructure to which allocations may be granted.

The Fitzroy ROP specifies reserves of unallocated water for urban and industrial supplies in the Gladstone area and urban supplies in the Capricorn Coast area. These reserves are associated with proposed new water infrastructure on the Fitzroy River:

- GAWB: up to 30,000 ML of the reserve may be granted to GAWB through a supplemented water allocation for urban and industrial use in the Gladstone area. Granting of the allocation is subject to the provision of additional water infrastructure necessary to supply the water allocation, specifically the Project and the Gladstone-Fitzroy Pipeline Project (Chapter 1 Introduction)
- A local government authority: up to 4,000 ML may be granted for urban water supplies for the Capricorn Coast. A supplemented water allocation for all or part of the unallocated water held as this reserve may be granted to a local government authority
- The remaining reserve volume (up to 42,000 ML) may be granted to a person or entity. The water supply use for this reserve is not specified.

The granting of the water allocations from the strategic water infrastructure reserve must retain consistency with EFOs and WASOs (as stated in the Fitzroy ROP), amongst others.

9.2.6 Water resource infrastructure and operational regimes

The existing Eden Bann Weir (Stage 1) was constructed in 1994 on the Fitzroy River to supply water to Stanwell Power Station. It is a conventional concrete weir that spans a distance of 412 m and has a full supply level of 14.5 m AHD. The existing infrastructure is approximately 8 m high and stores in the order of 35,900 ML at full supply. The weir comprises a fish lock on the northern bank adjacent to the outlet works and a 1.5 m diameter outlet conduit. A diversion channel cut through a rock bar services the outlet works and fish lock. The current inundation surface area is 670 ha with an upstream limit at 192 km AMTD. A control weir and gauging station at Wattlebank, some 3 km downstream maintains the tailwater level. The existing Eden Bann Weir operates within the Lower Fitzroy Water Supply Scheme.

Supplemented water released from Eden Bann Weir is captured in the Fitzroy Barrage, which is then pumped to consumers. In accordance with the Fitzroy ROP releases are made from Eden Bann Weir to maintain the Fitzroy Barrage storage at its nominal operating level of EL 3.38 m AHD (75,000 ML). This enables the Fitzroy Barrage fishway to continue to function, minimises pumping costs for barrage water users and supports continued recreational use. Rules for infrastructure operation and environmental management are detailed in the Fitzroy ROP.

Water stored within the Fitzroy Barrage impoundment is treated at the Glenmore Water Treatment Plant before being distributed via an existing reticulation system (SunWater 2008b). In addition, commercial raw water allocations and water for Stanwell Power Station is sourced from the Fitzroy Barrage impoundment along with irrigation supply. The Fitzroy Barrage is located on the Fitzroy River (59.6 km AMTD) in Rockhampton and forms a barrier between saltwater and freshwater. Completed in 1970, the Fitzroy Barrage holds a maximum of 80,000 ML of water in a 55 km long impoundment confined to the river and some tributary creeks (SunWater 2008b). Supplemented water from the Fitzroy Barrage is supplied through the Fitzroy Barrage Water Supply Scheme. RRC, currently has an allocation of 50,000 ML/a, generating supply reliability of 99.6 per cent. This reliability exposes RRC to a potential supply shortfall under an extreme drought scenario.

The Fitzroy Water Management Area encompasses the Eden Bann Weir and proposed Rookwood Weir site (as well as the Fitzroy Barrage). Operating rules for unsupplemented water allocations (water harvesting and waterholes) are defined in the Fitzroy ROP and include environmental management rules as applicable:

- Releases will cease to be made to the Fitzroy Barrage if the water level in Eden Bann Weir is below its local supply level of EL 9.55 m AHD (11,280 ML)). Releases will however continue to be made to supply water allocations upstream of the Fitzroy Barrage impoundment until such time as it is no longer practicable or restrictions are imposed
- Releases must not be made if water levels are below the minimum operating level of EL 7.25 m AHD (4,800 ML)
- For a waterhole within the extent of the Lower Fitzroy Water Supply Scheme, supplemented water should not be taken from a waterhole that is more than 0.5 metres below its cease to flow level (unless authorised by the Chief Executive)
- The fishlock operates between EL12.7 m AHD and 16.0 m AHD and at other times if releases coincide with volumes for water supply and/or to maintain the Fitzroy Barrage impoundment
- Rights to riparian entitlement water are maintained

- Currently water may be released from Eden Bann Weir at a rate up to the maximum discharge capacity of its outlet works. Any reduction in the rate of a release must occur incrementally, such that the risk of fish stranding and bank slumping is minimised
- There is no first post-winter flow management strategy
- Seasonal base flows are passed through Eden Bann Weir as a consequence of the seasonal base flow management rules for the Fitzroy Barrage Water Supply Scheme and the requirement for releases from Eden Bann Weir to maintain the level in the Fitzroy Barrage
- Critical water supply management actions deal with arrangements for periods of low water availability.

9.3 Potential impacts and mitigation measures

9.3.1 Construction

9.3.1.1 Overview

Construction activities associated with the project are described in detail in Chapter 2 Project description. Activities such as earthworks and excavations within the riverbed and banks, the implementation of in-stream diversion strategies (coffer dams) and abstraction of water for construction purposes have the potential to impact on surface water resources of the Fitzroy River.

Potential impacts arising from construction of the Project may include:

- Disruption to or diversion of downstream flows as a result of weir construction within the bed and banks of the river
- Disruption to or diversion of downstream flows as a result of construction of river crossings (temporary access during construction and permanent infrastructure such as bridges)
- Localised drawdown within natural ponded areas (Rookwood Weir), particularly during low flow conditions as a result of abstraction of water from the river for construction purposes

Potential impacts on water quality of surface water resources and associated mitigation is described in Chapter 11 Water quality. Potential impacts on aquatic ecology and fish passage are discussed in detail in Chapter 7 Aquatic ecology and Appendix X.

9.3.1.2 Disruption and diversion of flows – weir infrastructure

Downstream flows (and operational releases as applicable to the existing Eden Bann Weir) will be maintained throughout the construction period and it is not expected that flows will be adversely impacted as a result of the Project's construction. Furthermore it is not expected that construction of the Project will be adversely impacted by flood flows.

Raising Eden Bann Weir and construction of Rookwood Weir are each scheduled in four stages dictated by alternating wet and dry seasons over an approximate two to two-and-a half--year period. For the most part, construction activities undertaken during the wet season (and by inference a period of high flow) are confined to works outside of the river bed (such as site establishment during the first wet season) or in areas of advanced construction (that is during the second wet season following excavation of abutments and establishment of coffer dams during the first dry season). Further, as appropriate, in-stream diversion strategies (including coffer dams at both sites) will be implemented to temporarily divert flows away from the Project activities but retain them within the river channel. All works will be undertaken in

accordance with the Project EMP (Chapter 23 Environmental management plan) and subsequent site-specific construction EMPs, in consideration of work schedules and seasonal constraints.

Eden Bann Weir is an existing structure that has varying flood immunity for different work areas across its length. Work in the river channel downstream of the existing spillway is limited to the depth of flow of water that can be channelled around areas so that work can continue. Work adjacent to the spillway needs to be protected by low height cofferdams. These offer limited immunity to flooding. Work to be carried out on both abutments can be carried out over a longer periods as the abutments themselves offer a higher level of immunity to flooding. Through analysis of flood levels during the summer months, relative cofferdam levels and flood diversion capacity have been estimated. Table 9-10 provides a summary.

Table 9-10 Eden Bann Weir construction cofferdam levels and associated flood flows

Section of works / river diversion arrangements	Height above existing spillway (m)	Cofferdam height (m AHD)	Flood diversion capacity (m^3/s)
Spillway and riverbed / sand bagging or boarding of spillway in lengths	+ 0.3	14.8	40
Right abutment works/upstream cofferdam	+ 1.0	15.5	300
Right abutment low level works / downstream cofferdam		10.0	300
Right abutment works protected by existing abutment	+ 3.0	17.5	2000
Left abutment works / protected by existing abutment	+ 1.5	16.0	605
Left abutment works/downstream cofferdam; upstream baffle system	+ 1.5	16.0	605

In accordance with Queensland Fisheries requirements to maintain fish movement upstream and downstream during construction at Eden Bann Weir, the following actions will be undertaken:

- The existing fish lock and outlet structure will remain operational throughout construction.
- At weir closure, the existing and new fish movement structures will be fully operational.

Eden Bann Weir operations are not expected to be adversely impacted during construction of the Project. Scheduling of construction activities at Eden Bann Weir will be undertaken in consultation with the asset owner/operator, namely SunWater, to ensure that operational releases (and subsequently EFOs and WASOs) are maintained through the existing infrastructure or new infrastructure components as necessary.

Construction activities associated with Rookwood Weir limit (in-channel) river diversion will be confined to a single dry season. Initially low longitudinal cofferdams will be constructed to protect the works and secure the abutments with the river remaining in its natural course. To allow for dewatering and excavation of the weir abutment foundations, longitudinal cofferdams between 1.5 m and 10 m high above the riverbed (to accommodate flood flows of between 90 m^3/s and 1,500 m^3/s, respectively) will be constructed across the river with the river remaining in its natural course. These coffer dams can be easily replaced and result in little or no increase in river sediment when overtopped. Finally, river flows

will be diverted through the partly completed outlet structure (up to 90 m^3/s) which will be open to fish passage. Larger floods will pass over the partly completed roller compacted concrete embankment. Temporary works, if not designed to withstand flood events, will be removed prior to flooding.

9.3.1.3 Disruption and diversion of flows – associated infrastructure

Existing river crossings (low level causeways) will be removed and replaced with low-level bridge infrastructure at one location upstream of Eden Bann Weir (Glenroy Crossing) and two locations upstream of the proposed Rookwood Weir site (Riverslea Crossing and Foleyvale Crossing). Further, the low-level crossing downstream of the proposed Rookwood Weir site (Hanrahan Crossing) is to be augmented to accommodate operational releases made from Rookwood Weir. Downstream flows will be maintained throughout the construction period and it is not expected that flows will be adversely impacted as a result of the Project's construction.

9.3.1.4 Drawdown

Water for construction purposes will be pumped from the impoundment at Eden Bann Weir and pools in the vicinity of the proposed Rookwood Weir site, subject to the obtaining of the relevant permit/s under the Water Act or application of exemptions as applicable and appropriate. The Fitzroy River is a regulated stream, and it is considered unlikely that the Project construction will be affected by water shortages.

Construction water will be pumped to storage tanks on site and then reticulated to the various sections of the works. Demand for water will come from: aggregate production and evaporative cooling of aggregates; earthworks moisture content control; concrete and grout mixing; concrete curing; foundation and lift joint clean-up; and dust suppression. Where possible, water from dewatering activities and sediment basins will be utilised for construction purposes to reduce the reliability on abstracted sources.

There will be no on-site workers accommodation camps. Potable water for human consumption (ablutions and amenities) will be trucked to the site.

It is not intended that water supply from groundwater sources will be utilised.

9.3.2 Operation

9.3.2.1 Overview

Operational activities associated with the project are described in detail in Chapter 2 Project description. In simple terms, during operations the storages capture and retain river flows during the wet season allowing for slow, regulated releases through the dry season, and allowing for environmental releases as necessary and in accordance with regulations. Releases downstream are made through 'run of river' methods, that is, releases are made directly to the river and not through the use of pipelines, canals or other infrastructure.

Potential impacts requiring consideration in regard to the operation of the Project include:

- Inundation of river and creek bed and banks and infrastructure upstream within the impoundment
- Altered stream flow patterns potentially affecting current flow regimes and availability of water supplies to the environment and water users (supplemented and unsupplemented entitlements)
- Altered flood flows
- Changes to river morphology (fluvial processes)
- Uncontrolled releases of water due to system failure.

9.3.2.2 Inundation and operational strategy

Inundation associated with the existing Eden Bann Weir extends 43 km and has a submerged area of 670 ha. Raising Eden Bann Weir to Stage 2 increases the inundation extent by 21 km to 64 km with a total inundation area of 1,170 ha. Adding gates at Stage 3 increases the inundation extent by a further 6 km (total inundation extent of 70 km of river length) with a total inundation area of 1,690 ha.

The proposed Rookwood Weir site represents a greenfield site with typical run-of-river flows experienced. Rookwood Weir Stage 1 will inundate approximately 61 km of river with a total inundation area of 1,430 ha. Adding gates at Stage 2 increases the inundation extent by 23 km (total inundated extent of 84 km) and a total area of 1,930 ha.

Impoundment associated with a raised Eden Bann Weir and construction of Rookwood Weir will be retained within the river bed and banks. Weirs are in-river structures that are designed to be overtopped. Unlike a dam, the whole of the structure is located within the bed and banks of the watercourse. Subsequently, inundation associated with weirs is designed to bank full, that is the elevation where water will 'break out' of the river banks.

The existing Eden Bann Weir reaches its current storage capacity of 35,900 ML within a period of a week. It is expected that the raised Eden Bann Weir and new Rookwood Weir will be operational within the first wet season post-construction and will fill in a relatively short period (in the order one to two months) as shown in Figure 9-13 and Figure 9-14, respectively.

Operationally it is intended that weir storages remain impounded for approximately eight months of the year with draw down occurring in the drier period. At ultimate development, Rookwood Weir storage would be drawn down and pass to the Fitzroy Barrage for use and abstraction. Once Rookwood Weir reaches its minimum operating level (and the storage is depleted) releases would be made from Eden Bann Weir to the Fitzroy Barrage for use and abstraction. WASOs and EFOs will be maintained in accordance with Fitzroy WRP performance indicators and operating rules provided for in the Fitzroy ROP (amended as necessary) (Section 9.3.2.4 and Section 9.3.2.5, respectively).

The operational regime will be developed further once a Project trigger is initiated and a specific development scenario (and associated infrastructure) is defined. It is acknowledged that the operational regime will be subject to the provisions of the Fitzroy WRP and augmentation of the Fitzroy ROP will be required.

Figure 9-13 Eden Bann Weir (Stage 2) operational storage volumes

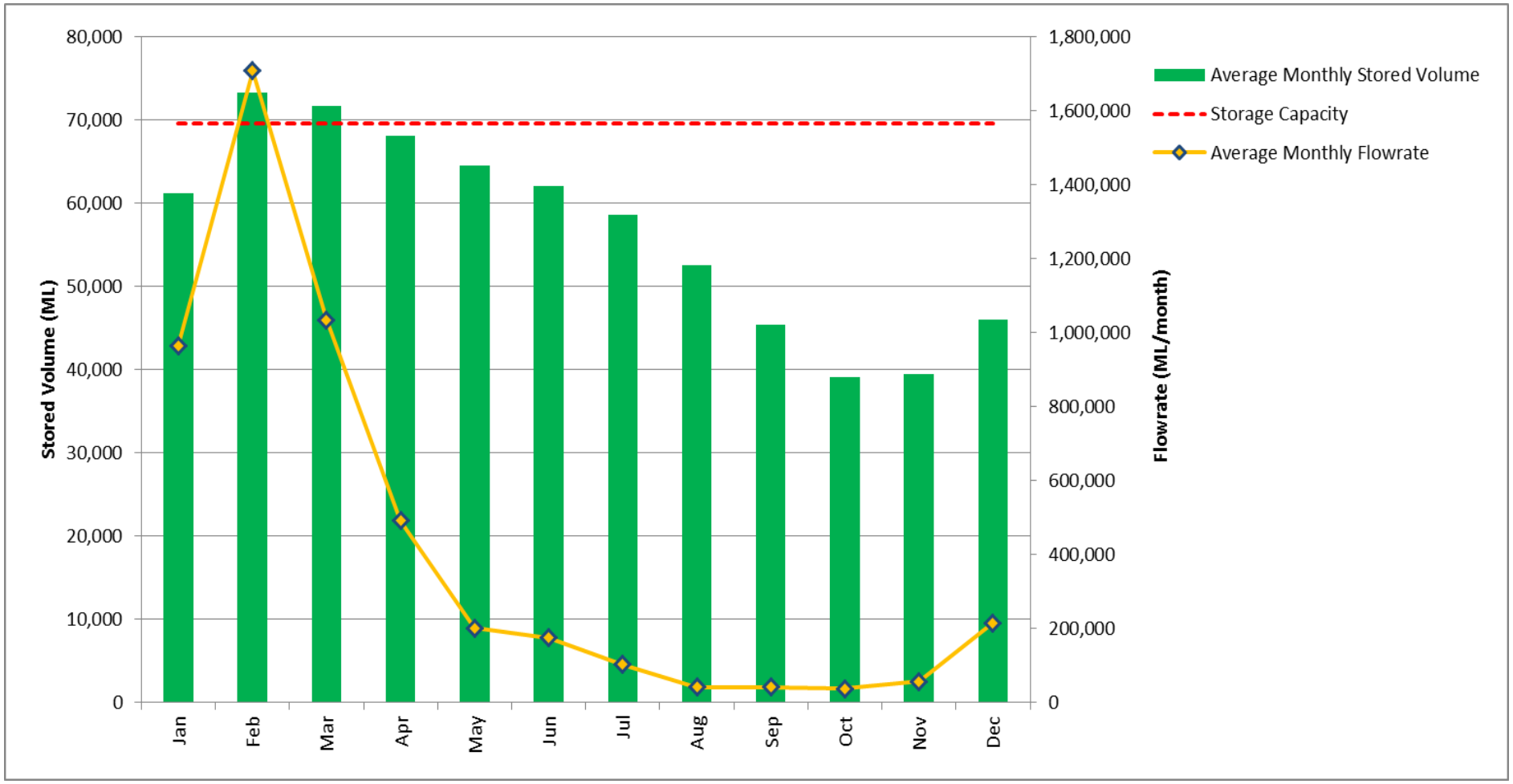
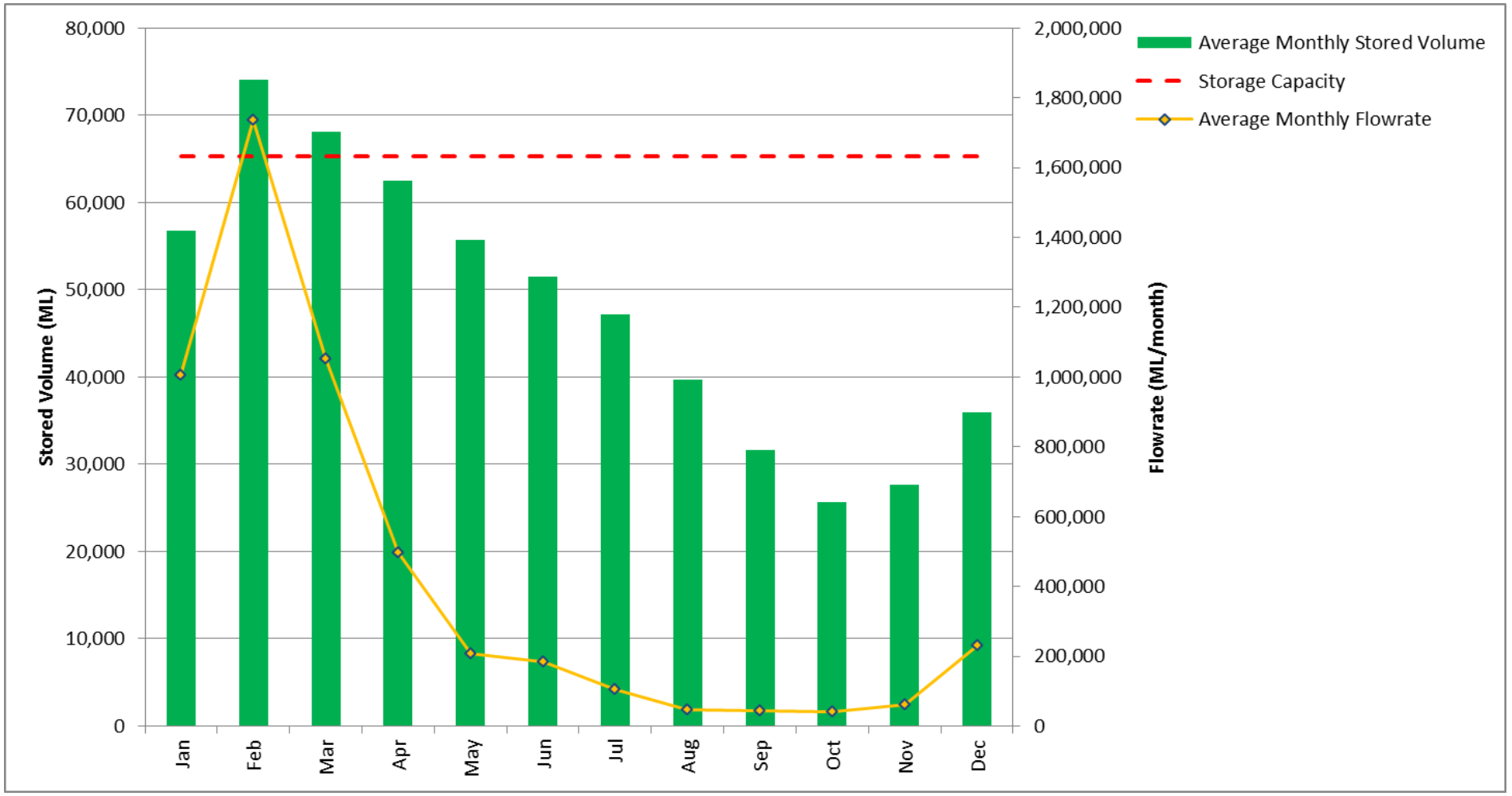


Figure 9-14 Rookwood Weir (Stage 1) operational storage volumes



The alteration of surface flows and increase in inundation areas will potentially impact on public and private infrastructure, such as roads (tracks) and river crossings (low level bridges and causeways) and other installations (stream gauges) that may require upgrades to accommodate raised water levels as follows:

- The Glenroy Crossing (at 193 km AMTD) will be impacted as a result of raising Eden Bann Weir (Stage 2). It is proposed that this crossing will be upgraded to a single lane bridge with improved immunity equivalent to a 1 in 2 AEP event (Chapter 16 Transport)
- Causeway-type river crossings at Riverslea (at 276 km AMTD) and Foleyvale (323.5 km AMTD on the Mackenzie River) and will be impacted as a result of developing Rookwood Weir. It is proposed that Riverslea Crossing be upgraded to single lane bridge and Foleyvale Crossing to a double lane bridge. Both upgrades will provide an improved immunity equivalent to a 1 in 5 AEP event (Chapter 16 Transport)
- Hanrahan Crossing, located downstream of the proposed Rookwood Weir may be impacted as a result of operational releases. The crossing will be upgraded through the installation of a new bank of culverts designed to accommodate flows up to 50 m^3/s. In addition, communication protocols will also be established to disseminate information regarding potential releases (Chapter 16 Transport). No crossings located downstream of Eden Bann Weir will be adversely impacted as a result of releases from Eden Bann Weir
- For all Project areas, some opportunistic crossings used by landowners during the dry season will no longer be available to the same extent as current. Potential impacts to these private access tracks (such as those that cross gullies close to the Fitzroy River and its tributaries) will be addressed through individual compensation negotiations with landholders (Chapter 18 Social impact)
- Stream gauges at Riverslea and The Gap are expected to be impacted as a result of inundation associated with the Project. It is proposed that new stream gauges be established as necessary, or existing stream gauges be reinstalled post-inundation as negotiated with DNRM.

Inundation will impact on landholder access to and use of riparian land. These impacts and proposed mitigation measures are discussed in Chapter 5 Land and Chapter 18 Social impact.

9.3.2.3 Altered stream flow patterns

Analysis of the IQQM flow data at locations upstream, within and downstream of the Project (Table 9-7 and Figure 9-5) revealed that there were no significant differences between current modelled flow regimes and the flow regimes projected with any additional infrastructure associated with the Project in place.

Hydrographs and flow duration curves developed for the base case (existing Eden Bann Weir) and development scenarios at locations within, upstream and downstream of Project areas are presented in Appendix P. A summary is provided:

- Eden Bann Weir

  Analysis of flows pre- and post-development of Eden Bann Weir Stage 2 at data locations downstream and upstream of the weir can be summarised as follows:

  – Releases from Eden Bann Weir Stage 2 do not significantly influence flows at the end of the system (IQQM1, downstream of the Fitzroy Barrage). Statistical analysis shows that for all years, there were no significant differences (across all significance levels) between the base case and the development scenario

  - The annual and monthly flow patterns post-development at IQQM2 (Wattlebank, immediately downstream of the weir) mimic the pre-development situation. Post-development there is a no change in the percentage of days with flows above 1,000 ML/d and a five per cent increase in the percentage of days with flows above 10 ML/d. This is consistent with an increased storage volume and releases required to achieve WASOs and EFOs, in particular base flows. This will result in the downstream reaches remaining marginally wetter for longer durations
  - Flows into the impoundment (IQQM 3, The Gap) remain unchanged pre- and post-development
  - Operational releases from (and impoundment of) Eden Bann Weir Stage 2 will not impact on flow regimes in upstream areas (IQQM4 and IQQM5).
- Rookwood Weir
  - Releases from Rookwood Weir Stage 2 do not significantly influence flows at the end of the system (IQQM1, downstream of the Fitzroy Barrage). Statistical analysis shows that for all years, there were no significant differences (across all significance levels) between the base case and the development scenario
  - Annual flows downstream of Eden Bann Weir (IQQM2, Wattlebank), the Eden Bann Weir impoundment (IQQM3, The Gap) and downstream of Rookwood Weir (IQQM4) mimic pre-development regimes. This is consistent with the operational strategy whereby Eden Bann Weir would be maintained at its FSL while releases are made from Rookwood Weir, until Rookwood Weir is drawn down. The percentage of days with flows above 1,000 ML/d increases from 40 per cent to 60 per cent under the development scenario consistent with an increased storage volume and releases required to satisfy WASOs and EFOs, in particular base flows. This will result in the downstream reaches remaining wetter for longer durations
  - Flows into the proposed Rookwood Weir impoundment (IQQM5, Riverslea) remain unchanged pre- and post-development.
- Rookwood Weir Stage 2 and Eden Bann Weir Stage 3 combined
  - Statistical analysis shows that for all years analysed, releases from the Project at its upper limits of development (RW2+EB3), with the exception of 1969, 1982 and 1994, do not significantly influence flows at the end of the system. This indicates that under the upper limit development scenario (with yield capped at 76,000 ML/a), minimal impacts on flow are expected to occur during years of high flow
  - Annual flow in 1969 was 1,935 ML, an extreme low flow year. This result was due to the release of small volumes of water (between 300 ML and 900 ML) under the development scenario during months that had zero or very little flow under the base case scenario, namely March to August
  - Annual flow in 1982 (367,382 ML) and 1994 (2,297,885 ML) is considered low and moderate, respectively. Analysis of the 1982 data shows significance levels of P = 0.1 (P = 0.073) between the base case and the development scenario. For 1994, the significance levels of P = 0.1 and P = 0.05 (P = 0.022) are recorded (Appendix P). Examination of the base case hydrographs and outflow data for these years identified that the majority of the flows occurred in March (i.e. a large outflow event in an otherwise dry year). The significant differences between the base case and development scenario arises due to an initial reduction in flow during the outflow event (in January and February) followed by the release of small volumes of water under the development scenario during months that had zero or very little flow under the base case scenario (June to October).

9.3.2.4 Water allocation security objectives

Table 9-11 provides a summary of Project compliance with high and medium priority user group supplemented WASOs in the Lower Fitzroy Water Supply Scheme and the Fitzroy Barrage Water Supply Scheme. Table 9-11 indicates that the WASOs are achieved at the theoretical yield volumes.

For infrastructure scenarios that achieve at least 76,000 ML/a (if the yield is capped at 76,000 ML/a) WASOs are achieved and water sharing indices for high and medium priority user groups are improved.

Table 9-11 Compliance with high and medium priority supplemented water user group WASOs

Infrastructure scenario	Theoretical Project yield (ML/a)	High priority user groups		Medium priority user groups
		Annual supplemented water sharing index (94%)	Monthly supplemented water sharing index (98%)	Monthly supplemented water sharing index (82%)
EB1	0			
EB2	35,000			
EB3	50,000			
RW1 + EB1	54,000			
RW1 + EB2	77,000			
RW1 + EB3	87,000			
RW2 + EB1	86,000			
RW2 + EB2	105,000			
RW2 + EB3	110,000			

Key: All Fitzroy WRP objectives are achieved

Table 9-12 provides a summary of compliance with unsupplemented water user group WASOs in the Fitzroy Water Management Area.

Table 9-12 indicates that unsupplemented WASOs are achieved for flow classes 5B, 6C and 7D for all infrastructure scenarios at the theoretical yields. Unsupplemented WASOs are achieved for flow Class 5A under infrastructure scenario Eden Bann Weir Stage 2. For the remaining infrastructure scenarios, the system average annual volume probabilities fall between one and five per cent below the specified objective. Further modelling will be undertaken once development of a specific infrastructure scenario is triggered to assess Project yields against the performance of supplies delivered by the existing infrastructure. The Project is committed to maintaining existing supply reliability for current water allocation licensees.

For infrastructure scenarios that achieve at least 76,000 ML/a if the yield is capped at 76,000 ML/a WASOs compliance mimics the results presented in Table 9-12.

Table 9-12 Compliance with unsupplemented water user group WASOs

Infrastructure scenario	Theoretical Project yield (ML/a)	Water allocation group (annual volume probability) (%)			
		Class 5A (61%)	Class 5B (73%)	Class 6C (95%)	Class 7D (93%)
EB1	0				
EB2	35,000				
EB3	50,000				
RW1 + EB1	54,000				
RW1 + EB2	77,000				
RW1 + EB3	87,000				
RW2 + EB1	86,000				
RW2 + EB2	105,000				
RW2 + EB3	110,000				

Key: All Fitzroy WRP objectives are achieved
Fitzroy WRP mandatory objectives are not achieved

It is considered that existing water harvesting entitlements (that is water take under high flow conditions) can co-exist with supplemented entitlements arising as a result of the Project, as they currently do elsewhere in the Fitzroy Basin.

Low flow or no flow (waterholes) entitlements have the potential to be impacted as a result of the project, both upstream and downstream of the weirs. It is likely that changes to stream flow regimes will alter the ability of these users to extract water under the existing licence conditions. It is acknowledged that this impact will be addressed in the amended Fitzroy ROP. It is envisaged that individual negotiations will be undertaken between the proponent and entitlement holder once the Project receives a trigger and a development scenario is determined. The negotiations will be based on the voluntary purchase/sale of entitlements and will consider the inclusion of options for the provision of an alternative water supply. Proposed arrangements will be submitted to the State for review and approval.

Once demands for the Project are realised and development of a specific infrastructure scenario is triggered, detailed design and further modelling will be required to ensure compliance with the underlying Fitzroy WRP requirements. Since changes to existing operational rules are also likely to be required, a ROP amendment will be sought, again requiring compliance with WRP objectives. Consideration will be given to parameters such as reduced yield volumes and operating regimes and rules to satisfy flow requirements.

9.3.2.5 Environmental flow objectives

Table 9-13, Table 9-14, and Table 9-15 present compliance with EFOs in relation to seasonal base flows, medium to high flows and FPWF events, respectively.

Table 9-13 indicates that seasonal base flow environmental benchmark objectives are met for all Project theoretical yields (and capped yields as applicable) during the January to April water flow season. During the May to August water flow season and September to December water flow season the existing system (EB1) does not meet the Fitzroy WRP seasonal base flow objectives, reporting 0.7 and 0.6, respectively against the 0.8 – 1.2 benchmark values. Similarly all Project infrastructure scenarios achieve the same or similar values. Discussions with DNRM and DSITIA indicate that while the Project does not achieve the guideline objectives, they are considered appropriate as they do not adversely impact on the existing situation and are consistent with the non-mandatory nature of the specific EFOs.

Table 9-14 shows that all infrastructure scenarios (at their theoretical yields and capped yields, as applicable) comply with medium to high flow EFOs except scenario RW2+EB3 which failed against the 20 year daily flow volume objective (reporting 87.46 per cent against the 88 per cent benchmark). It is noted that the RW2+EB3 yield may be limited by the Fitzroy WRP requirement to achieve the 20 year daily flow volume. Alternatively operating rules may be modified.

Table 9-15 shows that all FPWF event EFOs are achieved for all Project infrastructure scenarios at theoretical and capped yields.

Table 9-13 Compliance with seasonal base flow environmental objectives

Infrastructure scenario	Theoretical Project yield (ML/a)	Water flow season (non-mandatory objective 0.8 – 1.2)		
		January - April	May - August	September - December
EB1	0			
EB2	35,000			
EB3	50,000			
RW1 + EB1	54,000			
RW1 + EB2	77,000			
RW1 + EB3	87,000			
RW2 + EB1	86,000			
RW2 + EB2	105,000			
RW2 + EB3	110,000			

Key:
- All Fitzroy WRP objectives are achieved
- Fitzroy WRP non-mandatory objectives not achieved and Project achieves at least the same results as existing case
- Fitzroy WRP non-mandatory objectives are not achieved and Project achieves results of less than the existing case

Table 9-14 Compliance with medium to high flow environmental objectives

Medium to high flow environmental objective performance indicators (Objective)	Infrastructure scenarios (theoretical Project yield in ML/a)								
	EB1	EB2 (35,000)	EB3 (50,000)	RW1 + EB1 (54,000)	RW1 + EB2 (77,000)	RW1 + EB3 (87,000)	RW2 + EB1 (86,000)	RW2 + EB2 (105,000)	RW2 + EB3 (110,000)
Mean annual flow (77%)									
Median annual flow ratio (58%)									
Annual proportional flow deviation (2.5)									
Mean wet season flow (80%)									
2-year daily flow volume (75%)									
5-year daily flow volume (87%)									
20-year daily flow volume (88%)									
4% daily exceedance duration flow (74%)									
10% daily exceedance duration flow (55%)									

Key: All Fitzroy WRP objectives are achieved

Fitzroy WRP mandatory objectives are not achieved

Table 9-15 Compliance with first post-winter flow event objectives

FPWF event objective performance indicators (Objective)	Infrastructure scenarios (theoretical Project yield in ML/a)								
	EB1	EB2 (35,000)	EB3 (50,000)	RW1 + EB1 (54,000)	RW1 + EB2 (77,000)	RW1 + EB3 (87,000)	RW2 + EB1 (86,000)	RW2 + EB2 (105,000)	RW2 + EB3 (110,000)
Number of FPWFs (80%)									
Number of five-week lag events (60%)									
Number of two-week lag events (70%)									
Average volume ratios (70%)									
Average of the peak flow ratios									
Number of two-times base flow events (70%)									
Number of five-times base flow events (70%)									

Key: All Fitzroy WRP objectives are achieved

For infrastructure scenarios that achieve at least 76,000 ML/a and if the yield is capped at 76,000 ML/a compliance with Fitzroy WRP EFOs is summarised as follows:

- Seasonal base flows: compliance reflects that shown for the theoretical yields in Table 9-13
- Medium to high flows: all benchmark objectives are met, including the 20-year daily flow volume at RW2+EB3
- FPWF events: all benchmark objectives are met.

As for WASO non-compliances, once demands for the Project are realised and development of a specific infrastructure scenario is triggered, the Fitzroy ROP will be required to be amended to incorporate operating rules relative to the infrastructure built. It is expected that refinement of operating rules in development of the Fitzroy ROP will address non-compliance.

Low flows through the outlet works for the Project have a capacity to discharge at a rate of 15 m^3/s or a volume of 1,300 ML/day. The outlet can be operated after the post-winter flow to allow for the required number of days of release to be met. After this, the outlet works will only discharge base flows or flows required to meet downstream demands. The outlet works also serve to provide attraction flows to fish at the downstream end of the fish locks. Releases for the required environmental flow base flow of 15 m^3/s are supplemented through the fish locks (various release volumes and velocities). Preference will be given to releases through the fish lock over releases via the low flow outlet as far as is practicable. Differential overtakes will facilitate mixing to satisfy water temperature and quality requirements.

Environmental flow outlets have the capacity to discharge at a rate of 58 m^3/s or a volume of 5,000 ML/day when the weir is full. It is important to note it is possible for this discharge to be met without the environmental flow outlets if the weirs fill and spill quickly. The existing Eden Bann Weir operates in this way, with 58 m^3/s passing over the spillway upon filling within the required timeframe as opposed to being met through environmental flow outlets.

Refinement to flows will be considered further and IQQM will be undertaken through the detailed design phase of the Project following a trigger for a specified development scenario. EFOs will further be interrogated to inform Fitzroy ROP amendments to meet compliance requirements.

9.3.2.6 Altered flood flow regimes

Overview

As described in Section 9.2.3, the Fitzroy River catchment is capable of producing severe flooding following heavy rainfall events due to its immense size and fan-like shape. The Fitzroy River at Rockhampton has a long and well-documented history of flooding with flood records dating back to 1859. The highest flood occurred in January 1918 and reached 10.11 metres on the Rockhampton gauge.

In order to inform design and for the purposes of the EIS, flood hydrological investigations and hydraulic modelling have been undertaken (Section 9.1.3.4 and Section 9.1.3.5) and the results discussed. Potential impacts on access to and use of riparian land as a result of flooding are discussed in Chapter 5 Land.

With regard to floods and flooding, it is important to note that, weirs are in-river structures and are designed to be overtopped. In floods that result in water breaking the banks of the waterc ourse and flowing over the adjacent flood plain, a weir will be inundated, resulting in drownout of the structure. Subsequently, Eden Bann Weir and Rookwood Weir are not designed for flood mitigation.

Eden Bann Weir

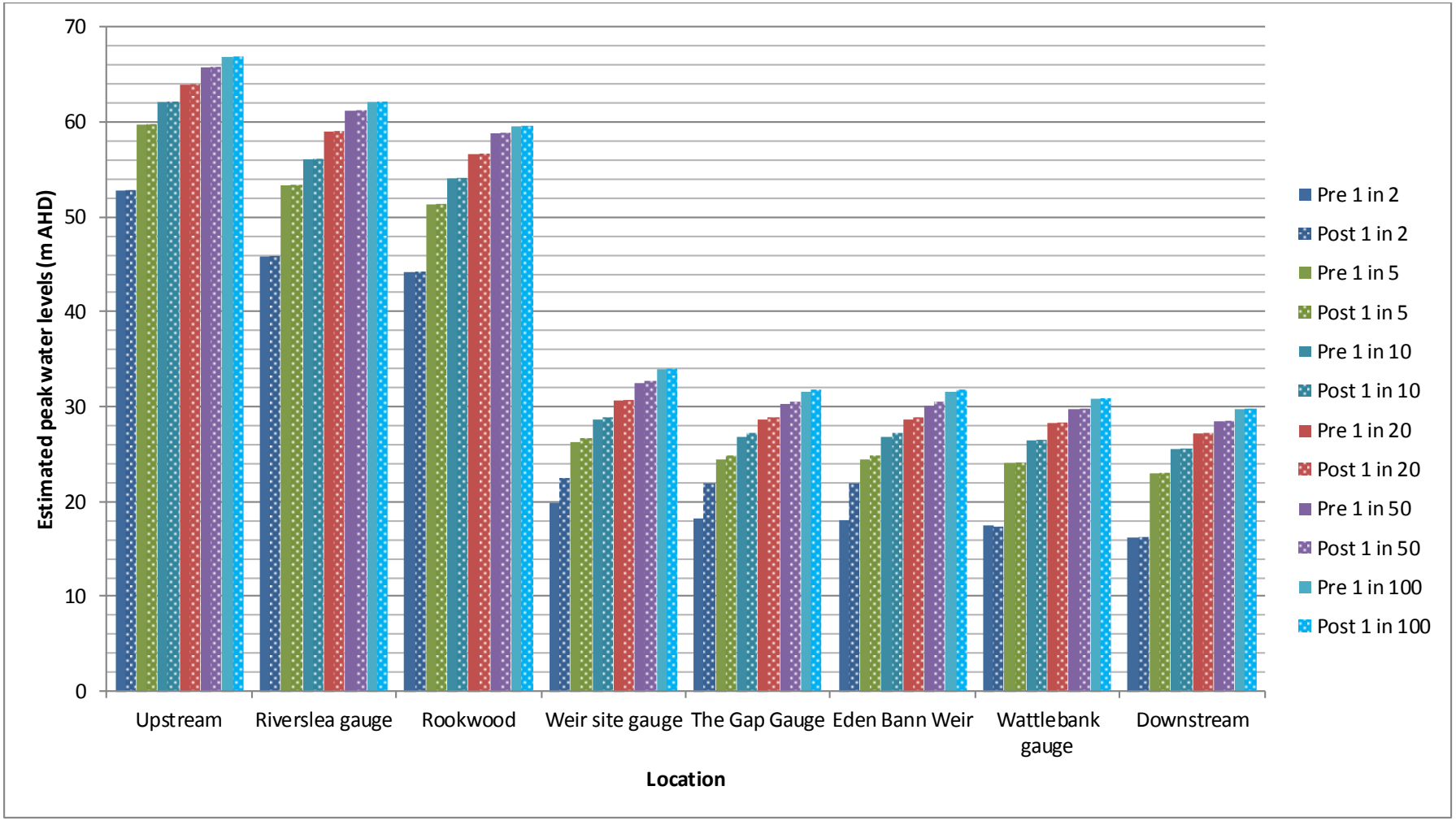
For Eden Bann Weir, pre- and post-development river geometry has been modelled for the 1 in 2, 1 in 5, 1 in 10, 1 in 20, 1 in 50 and 1 in 100 year AEP events.

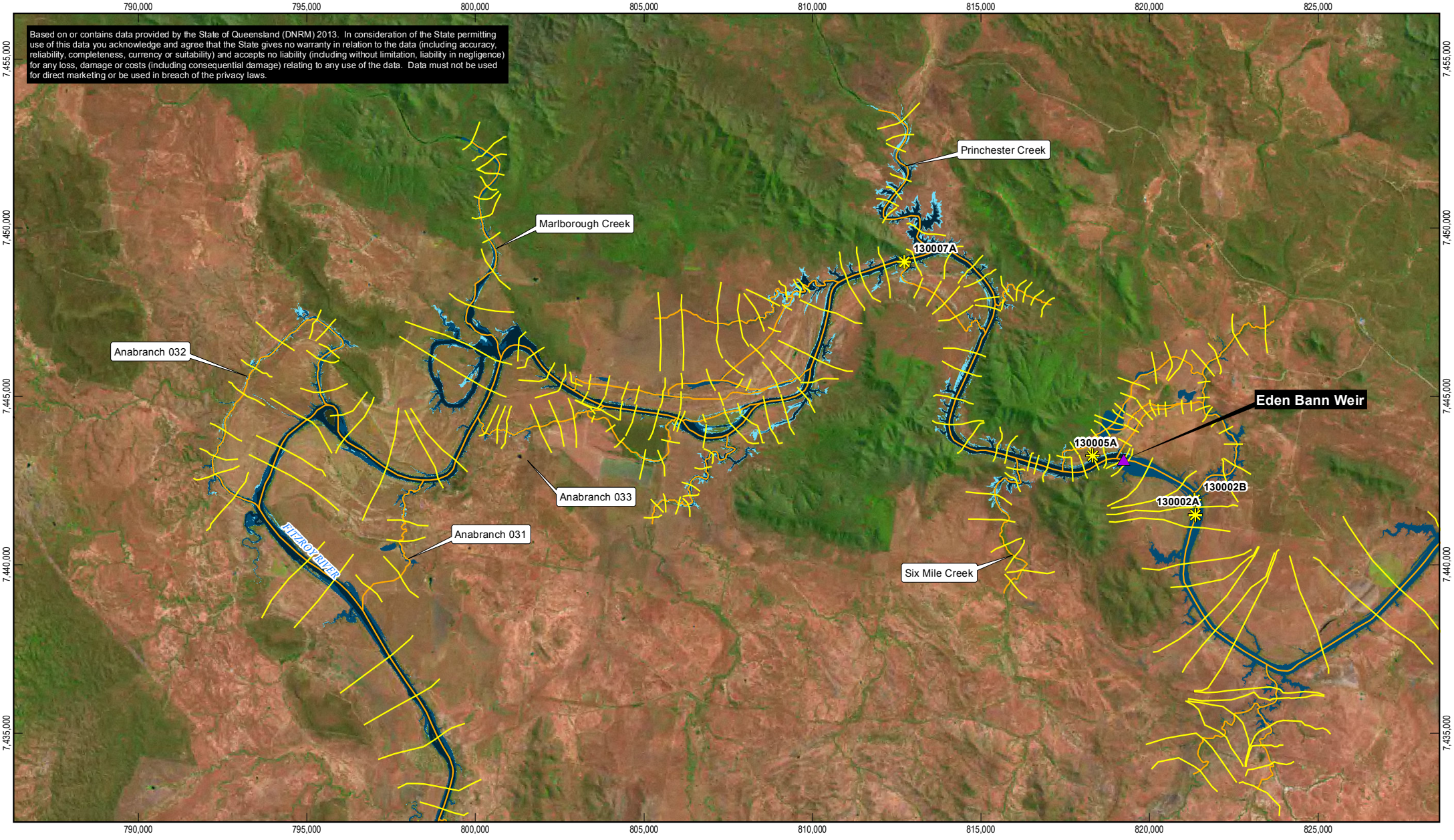
The afflux for the 1 in 5 to 1 in 100 AEP events was less than 0.5 m at the raised Eden Bann Weir, while for the 1 in 2 AEP event the estimated afflux was 3.6 m. The afflux reduced to 2.6 m approximately 13 km upstream of the weir, and to 0.3 m approximately 54 km upstream of the weir for the 1 in 2 AEP event.

For Eden Bann Weir, the difference in peak water levels between the existing Eden Bann Weir and Eden Bann Weir Stage 2 are shown on Figure 9-15. Figure 9-15 indicates a negligible increase in peak water levels with the raised weir compared to the existing weir for the 1 in 50 and 1 in 100 AEP events as both weir arrangements are drowned by the flood flows for those design events. By a distance of 23 km upstream of the existing weir, the peak water level difference with the raised weir reduces to around 300 mm for the 1 in 10 AEP event. For the 1 in 2 and 1 in 5 AEP events, the peak water level difference reduces to around 300 mm at approximately 50 km upstream.

An overview of pre- and post-development flood extents for the 1 in 2 AEP, 1 in 5 AEP, and 1 in 10 AEP events are shown in Figure 9-16, Figure 9-17 and Figure 9-18, respectively. These figures compare the estimated extent of flooding for the existing river and with the proposed raised weir. The impact on flood extents for the 1 in 2 AEP event is evident in many of the tributaries upstream of the proposed weir. As the flood magnitude increases, the increases in flood extent tends to diminish as the weir becomes drowned.

Figure 9-15 Estimated peak water levels for modelled AEPs pre- and post-development at Eden Bann Weir





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0 1 2 3 4 5

Kilometres

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

N

LEGEND

- Stream Gauges
- Weir Location
- Roads
- Model Cross Sections
- Flow Paths
- 2 Year ARI Flood Extent (Existing)
- 2 Year ARI Flood Extents (Proposed Weir)
- Impoundment Area

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Overview of the 1 in 2 year AEP event pre- and post-development flood extents associated with Eden Bann Weir

Figure 9-16

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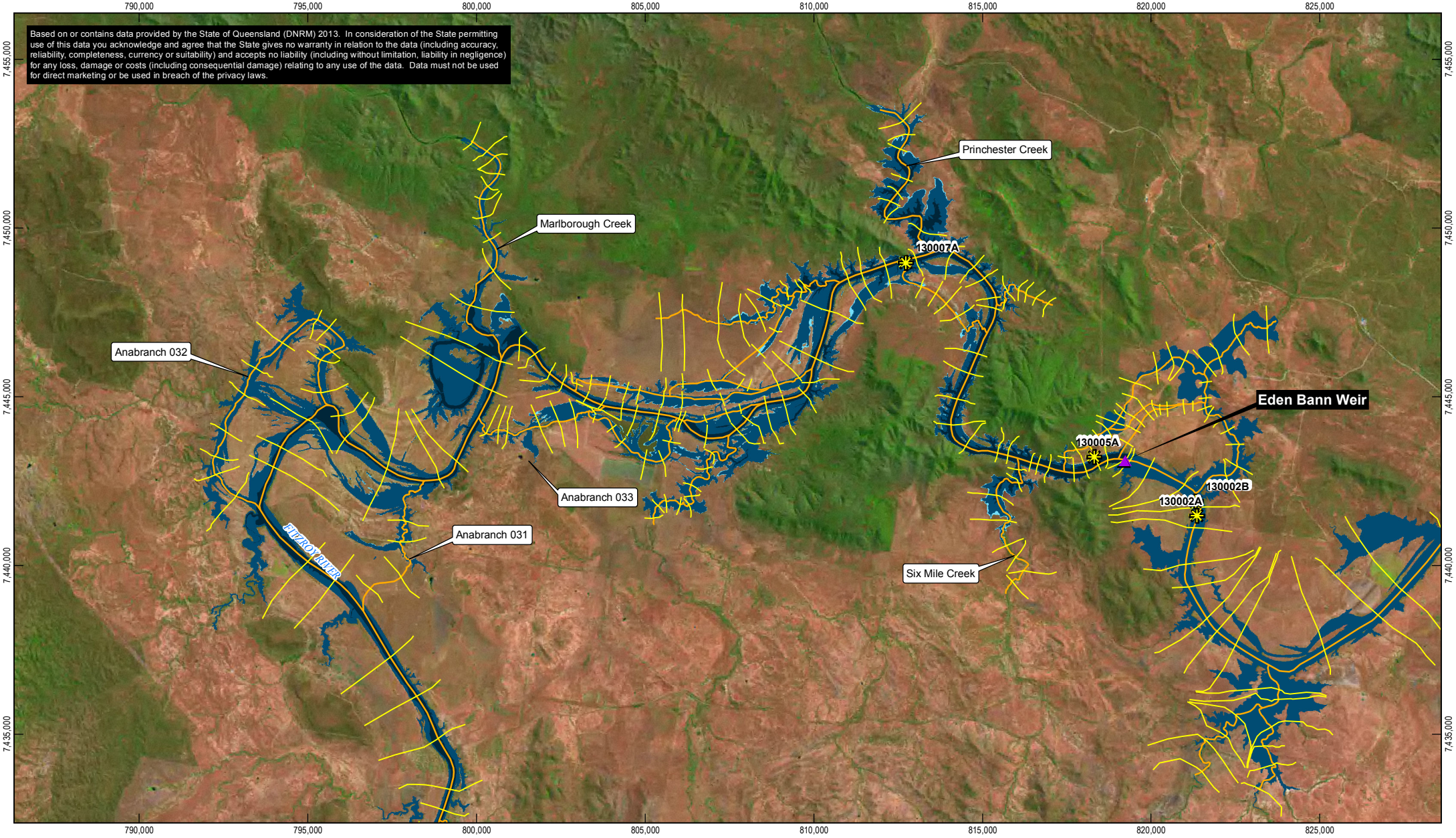

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Kilometres

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

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LEGEND

- Stream Gauges
- Weir Location
- Roads
- Model Cross Sections
- Flow Paths
- 5 Year ARI Flood Extent (Existing)
- 5 Year ARI Flood Extents (Proposed Weir)
- Inundation Area (GHD)

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Overview of the 1 in 5 year AEP event pre- and post-development flood extents associated with Eden Bann Weir

Figure 9-17

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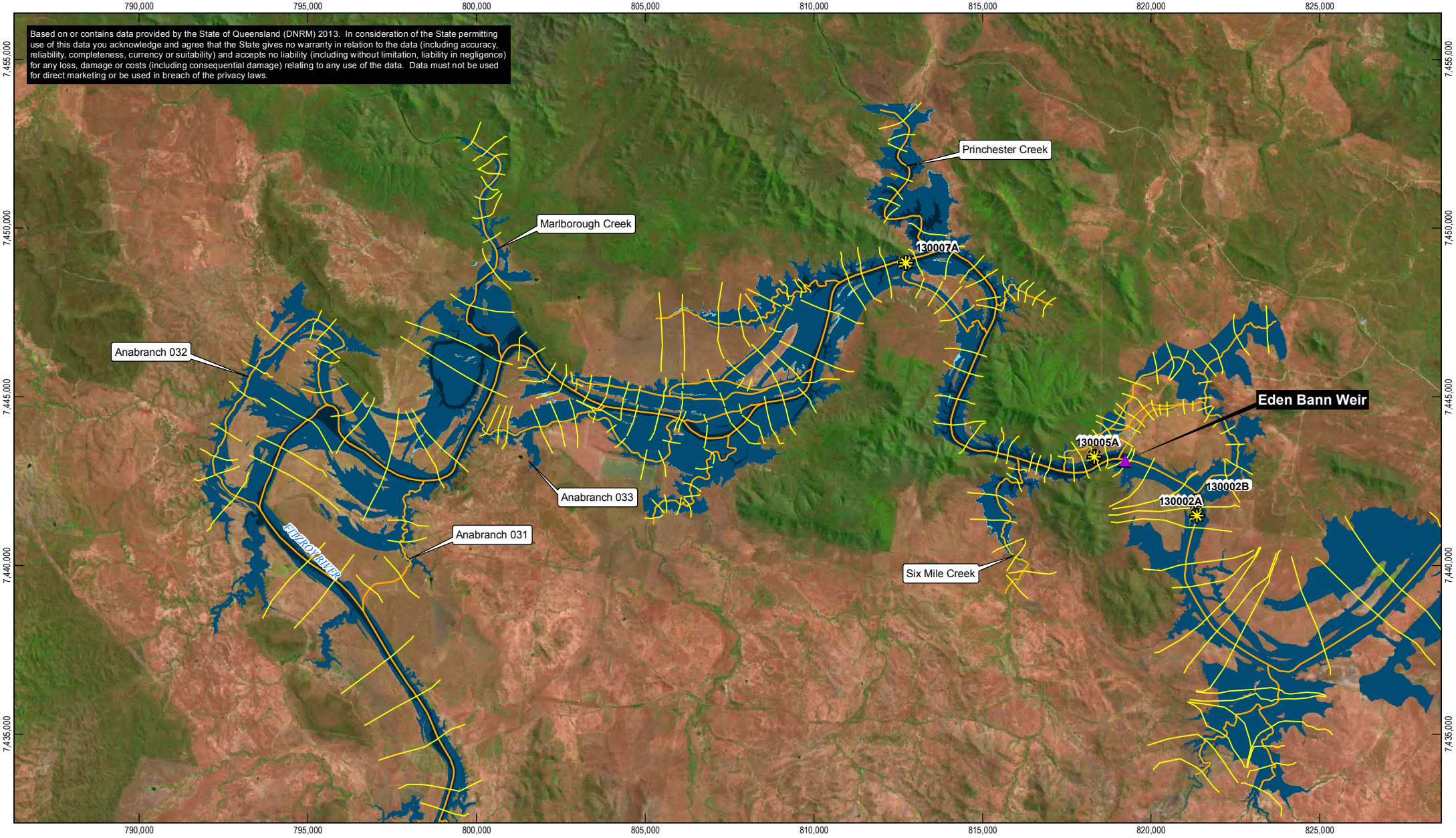

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Kilometres

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

N

LEGEND

- Stream Gauges
- Weir Location
- Roads
- Model Cross Sections
- Flow Paths
- 10 Year ARI Flood Extent (Existing)
- 10 Year ARI Flood Extents (Proposed Weir)
- Inundation Area (GHD)

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Overview of the 1 in 10 year AEP event pre- and post-development flood extents associated with Eden Bann Weir

Figure 9-18

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Rookwood Weir

For Rookwood Weir, the pre- and post-development river geometry has been modelled for the 1 in 2, 1 in 5, 1 in 10, 1 in 20, 1 in 50 and 1 in 100 year AEP events. The estimated peak water levels for the modelled AEPs pre- and post-development for each event are compared and presented in Figure 9-19 for locations along the Fitzroy River. Appendix P provides tabulated data.

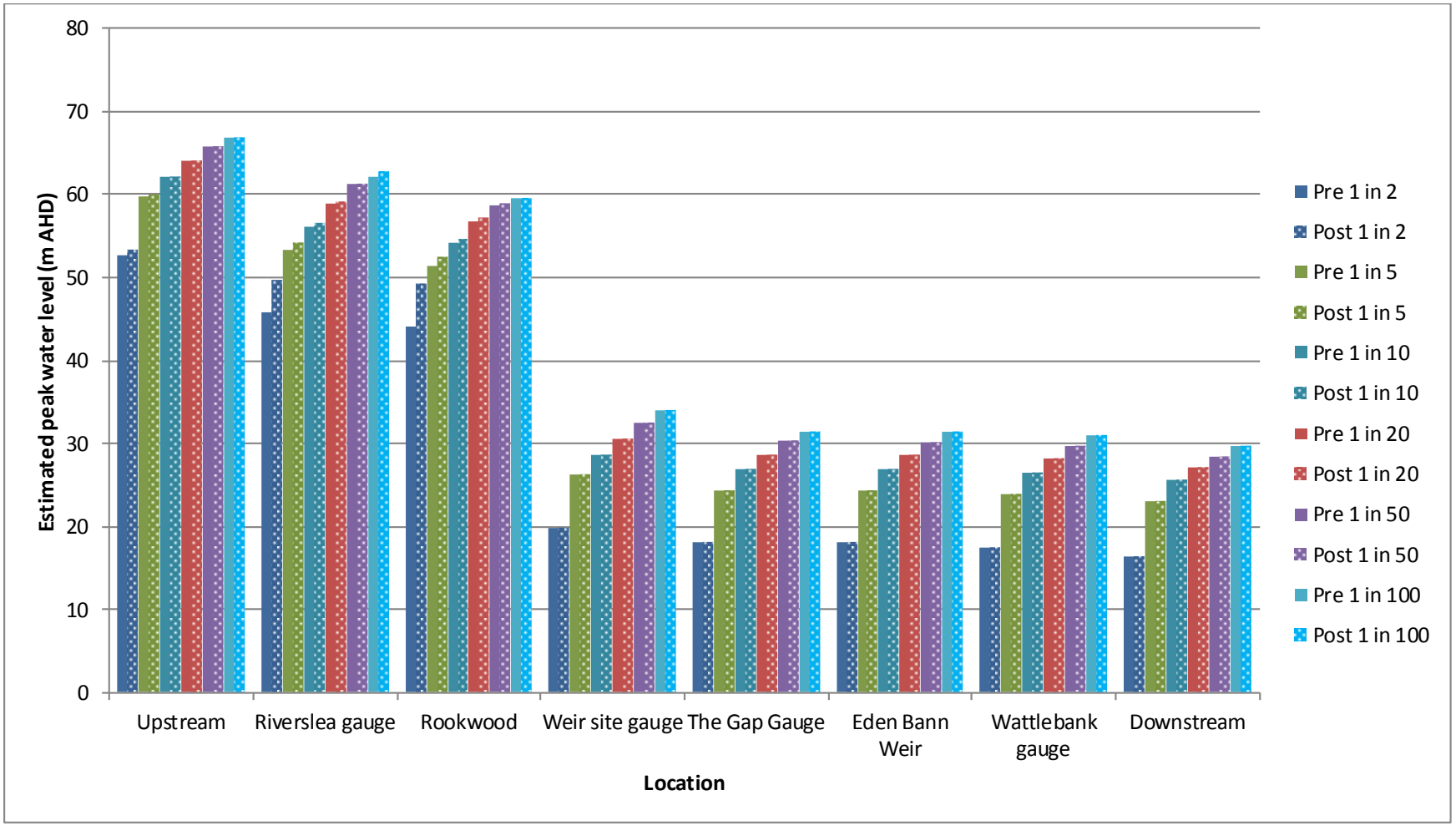
Rookwood Weir influences water levels upstream of the site during smaller magnitude floods (e.g. 1 in 2 and 1 in 5 AEP events). The estimated afflux for the 1 in 2 AEP event is 5.0 m which reduces to approximately 0.6 m about 40 km upstream of the weir. The 1 in 5 AEP event has an estimated afflux of 1.2 m at the weir which reduced to 0.2 m about 40 km upstream. The impact of the weir during larger magnitude events such as the 1 in 10 to the 1 in 100 AEP events is less than or equal to 0.6 m at the proposed weir site. It appears that the weir is significantly drowned during a 1 in 20 AEP event, such that the estimated afflux at the weir is around 0.3 m and is less than 0.1 m at the upstream end of the Fitzroy River at the junction of the Mackenzie and Dawson Rivers.

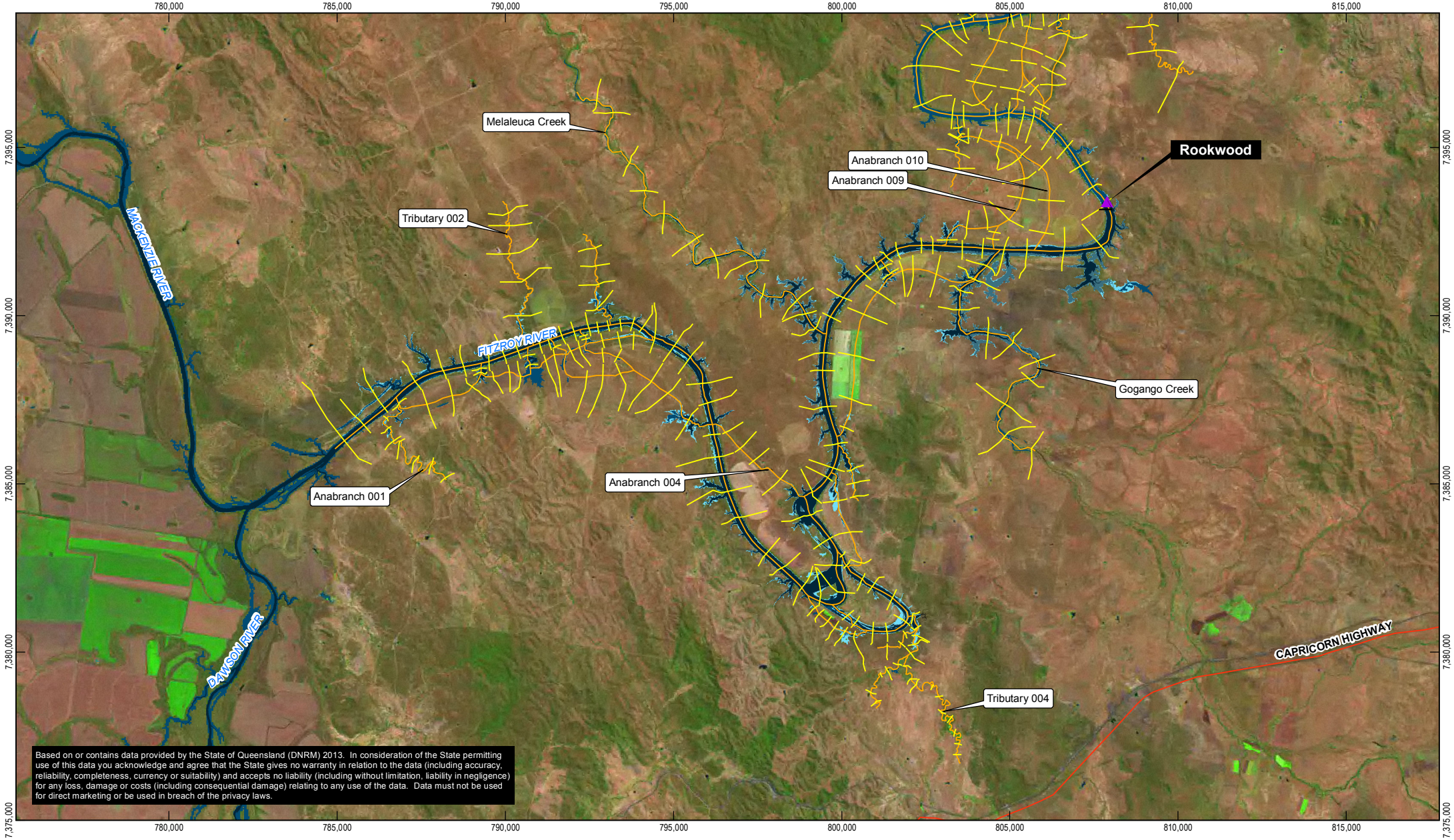
The afflux as a result of Rookwood Weir at the confluence of the Fitzroy River with the Dawson and Mackenzie rivers is in the order of 200 mm for the 1 in 2 year AEP event and 100 mm for the 1 in 5 year AEP event. Thereafter pre- and post-development peak water levels and afflux do not differ and Rookwood Weir ceases to influence flood flows.

An overview of pre- and post-development flood extents for the 1 in 2, 1 in 5 and 1 in 10 year AEP events are shown in Figure 9-20, Figure 9-21 and Figure 9-22, respectively. These figures compare the estimated extent of flooding for the existing river and with the proposed Rookwood Weir. The impact on flood extents for the 1 in 2 AEP event is evident in many of the tributaries upstream of the proposed weir. As the flood magnitude increases, the increases in flood extents tends to diminish as the weir becomes drowned.

Peak water levels were assessed for all AEP events (namely 1 in 1, 1 in 5, 1 in 10, 1 in 20, 1 in 50 and 1 in 100 years) pre-development at the Capricorn Highway (on the Dawson River) and Foleyvale Crossing (on the Mackenzie River) (and tabulated in Appendix P). The only event modelled for the proposed Rookwood Weir scenario is the 1 in 2 AEP event. This methodology was adopted as the 1D model (of the Fitzroy River) showed an increase of less than 0.2 m at the upstream end of that model (which is the downstream boundary condition for the 2D model (covering the Dawson and Mackenzie Rivers)) for the 1 in 5 AEP event and smaller probability events. The influence of Rookwood Weir is therefore considered potentially greatest during small events. Events larger in flood magnitude than the 1 in 2 AEP will have even less of an impact, if any, on water levels further upstream. This is supported by 1 in 2 year AEP event modelled outputs showing that the afflux at the Capricorn Highway post-development is estimated at 0.09 m. Afflux at the Foleyvale Crossing post-development is estimated at 0.22 m for the 1 in 2 year AEP event.

Figure 9-19 Estimated peak water levels for modelled AEPs pre- and post-development at Rookwood Weir





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0 1 2 3 4 5

Kilometres

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

N

LEGEND

- Stream Gauges
- Weir Location
- Roads
- Model Cross Sections
- Flow Paths
- 2 Year ARI Flood Extent (Existing)
- 2 Year ARI Flood Extents (Proposed Weir)
- Inundation Area (GHD)

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Overview of the 1 in 2 year AEP event pre- and post-development flood extents associated with Rookwood Weir

Figure 9-20

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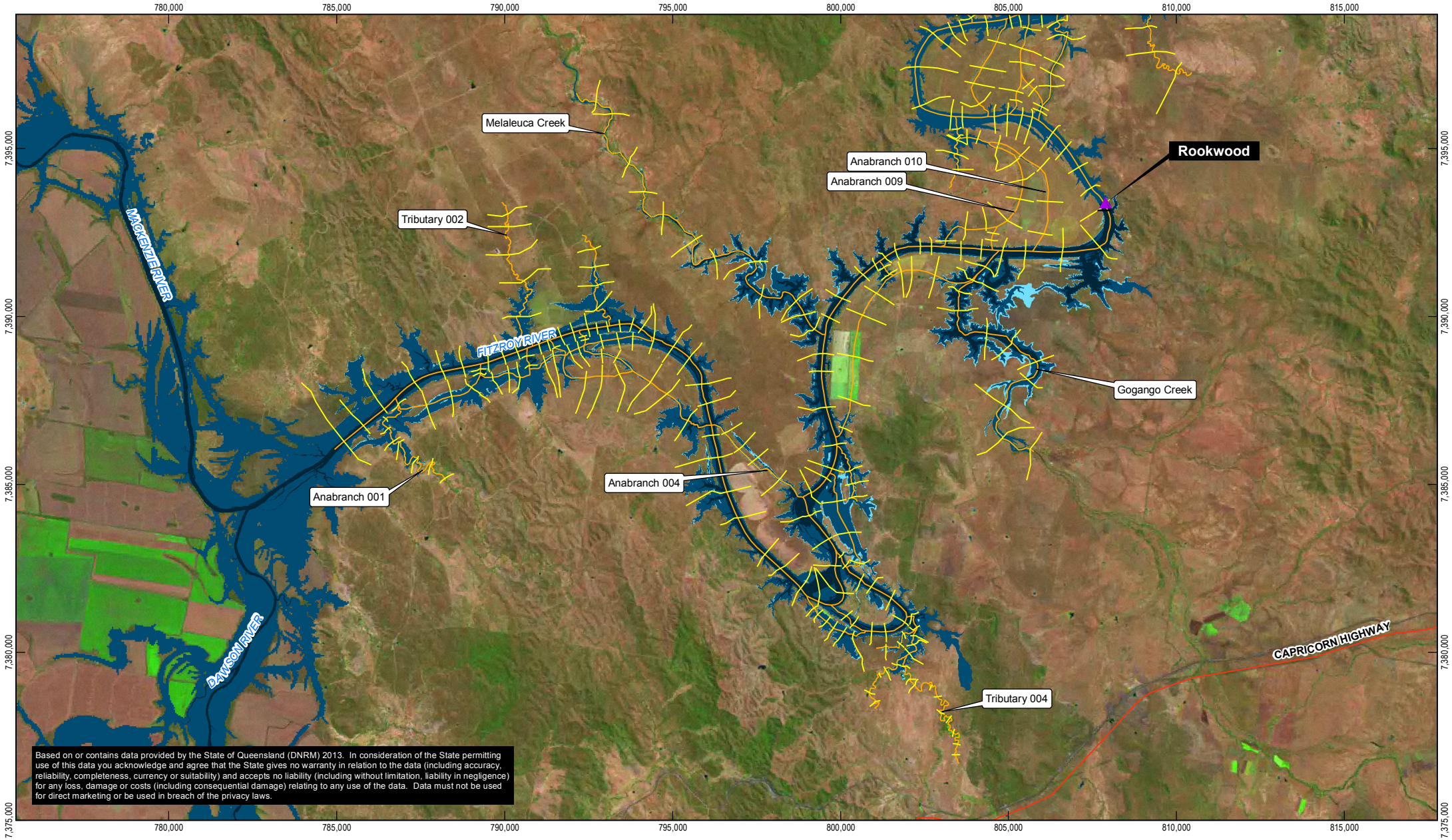

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Kilometres

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

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LEGEND

- Stream Gauges
- Weir Location
- Roads
- Model Cross Sections
- Flow Paths
- 5 Year ARI Flood Extent (Existing)
- 5 Year ARI Flood Extents (Proposed Weir)
- Inundation Area (GHD)

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Overview of the 1 in 5 year AEP event pre- and post-development flood extents associated with Rookwood Weir

Figure 9-21

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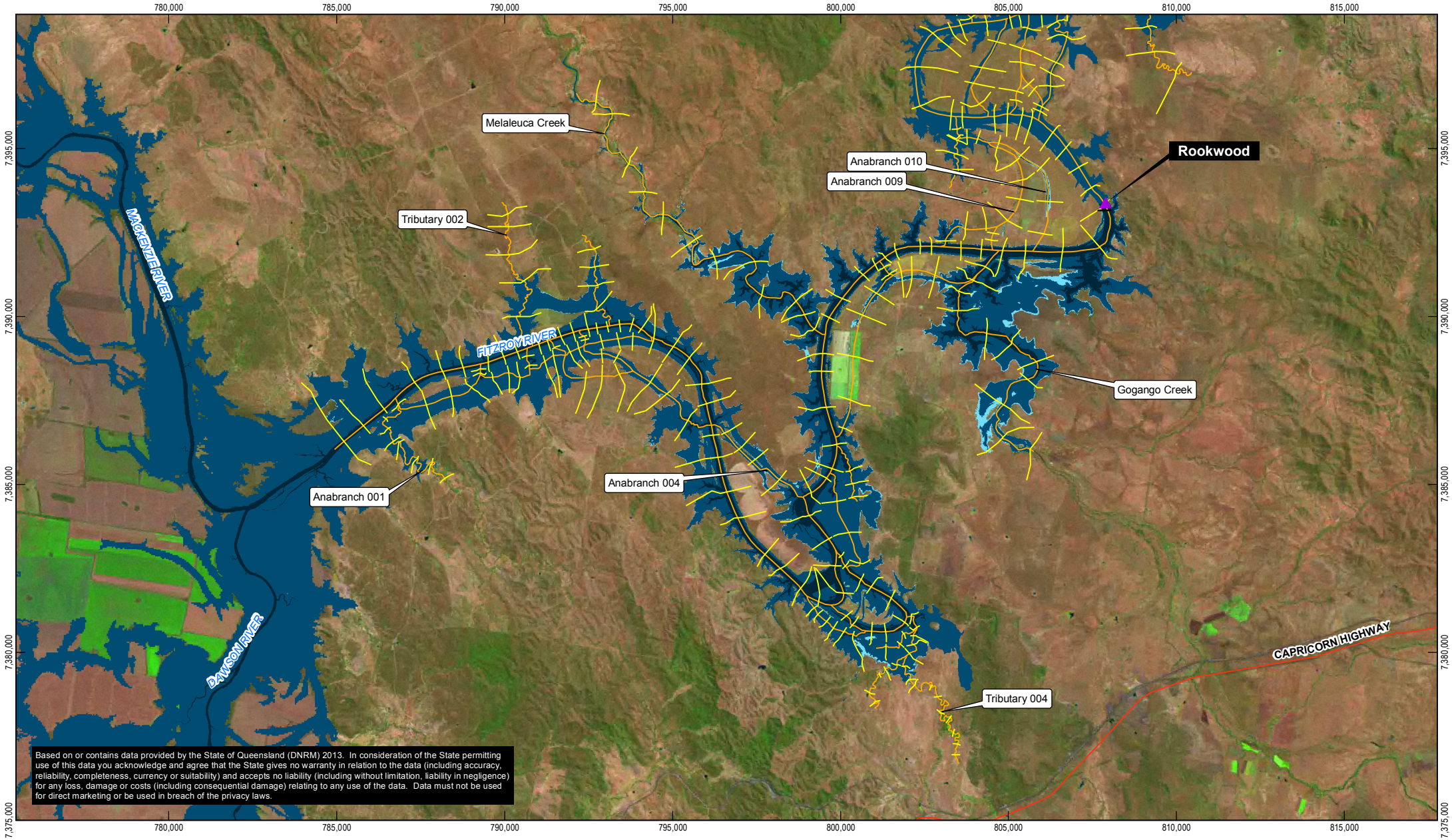

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0 1 2 3 4 5

Kilometres

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

N

LEGEND

- Stream Gauges
- Weir Location
- Roads
- Model Cross Sections
- Flow Paths
- 10 Year ARI Flood Extent (Existing)
- 10 Year ARI Flood Extents (Proposed Weir)
- Inundation Area (GHD)

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Overview of the 1 in 10 year AEP event pre- and post-development flood extents associated with Rookwood Weir

Figure 9-22

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Flooding appears to be generally contained within the river banks during the 1 in 2 AEP event, though some breakouts occur upstream of Foleyvale Crossing on the Mackenzie River and just downstream of Bone Creek on the Dawson River. As the magnitude of the flood events increase, the interaction of the braided watercourses becomes more apparent. The influence of the large natural storage area at the junction of the Mackenzie and Dawson rivers (GHD, 2012) is evident for the 1 in 20, 1 in 50, and 1 in 100 AEP simulations.

Detailed estimated flood extents for the proposed Rookwood Weir site pre- and post-development are provided in Appendix P

Potential flood impacts on the road network associated with development at Eden Bann Weir considered the following:

- River crossing at Glenroy Road (as discussed previously).
- Increased time of inundation during low AEP events at Glenroy – Marlborough/ Coorumburra Road. Hydraulic immunity was tested at Coorumburra Road between 10 Mile Creek and Green Creek. Access at this location was decreased by approximately a day and a half in a 1 in 5 year AEP event from the present 10-12 days. Additionally, a 1 in 10 year event reduces access by less than (0.2) a day. No augmentation is proposed given the minor nature of the impact and the availability of alternate routes.
- Increased time of inundation at Commanche Road (south of Glenroy Crossing). Hydrological modelling at Commanche Road indicates a limited effect on this road due to the raising of Eden Bann Weir. The modelling suggests that the road would be inundated by an additional half a day over the present conditions for a 1 in 5 year AEP flood event. Due to the low traffic volumes and existing flood conditions along this road, no further work is deemed necessary.

In relation to development at the proposed Rookwood Weir site, hydrology modelling indicates potential impacts to existing road networks as follows:

- Thirsty Creek Road will form part of the construction and operational maintenance access to Rookwood Weir. Thirsty Creek Road may be impacted as a result of prolonged flooding, in the order of an additional five days for a 1 in 5 AEP event. Flood immunity was not greatly impacted by higher flood frequency events for example; a 1 in 10 AEP event was modelled to add two days to what is currently a seven day flood event. It is proposed that Thirsty Creek will be augmented at selected areas to be operable for access for construction and operations vehicles especially low loaders. The changes of vertical geometry proposed at waterway crossings including at Gogango Creek will help maintain existing flood immunity.
- Peak water levels at the Foleyvale Crossing[2] on the Mackenzie River and the Capricorn Highway (at Boolburra) on the Dawson River were estimated. The potential impact of Rookwood Weir in relation to flooding at these locations is minimal, with an increase of 220 mm and 90 mm at the Foleyvale and Capricorn Highway crossings, respectively, during a 1 in 2 AEP event. Simulations indicated that the afflux generated by rarer events will have no significant impact at these locations.
- The Riverslea Crossing will be inundated by Rookwood Weir (Stage 1). A new bridge structure is proposed for this location, developed to a 1 in 5 AEP event providing significantly improved flood immunity. Hydrological modelling indicates that with no mitigation, a 1 in 5 year AEP event would increase the flood duration by 4.5 days. Flood immunity was not greatly impacted by higher flood

[2] Where Rookwood Weir is developed to a Stage 1 level only. At a Stage 2 development level, no increased flood impacts are predicted as the crossing will be augmented with a 1 in 5 AEP event bridge design.

events with a 1 in 10 year event only adding 1.5 days to what is currently a 7 day event. The proposed bridge will dramatically increase flood immunity at this location and improve the overall road network connectivity.

- Hydraulic immunity was tested at Smith Road (a local road that runs parallel to the Fitzroy River on the left bank between 298 km and 309 km AMTD, just downstream of the confluence of the Dawson and Mackenzie rivers). Access at this location was decreased by two days in a 1 in 5 AEP event from the present approximate seven days. A 1 in 10 year AEP event reduces access by about half a day. This potential increase in flooding was deemed small for the low volumes of vehicles using the road as there are alternate routes. No upgrade is proposed.

9.3.2.7 Changes to river morphology (fluvial processes)

The Fitzroy River carries a substantial sediment load during periods of flood. Anecdotal evidence from local landowners report sand banks of in excess of 5 m high being deposited in one flood event, and removed in the next event. As such, sediment management is an important part of the design of the weirs on the Fitzroy River.

Sediment movement is determined by the particle size of the sediment, and the velocities of the water transporting the sediment. Figure 9-23 (Ritter 2006) shows the relationships between velocity and particle size required for deposition, transport and erosion.

Figure 9-23 Critical velocity (cm/s) for erosion, transportation and deposition of sediment

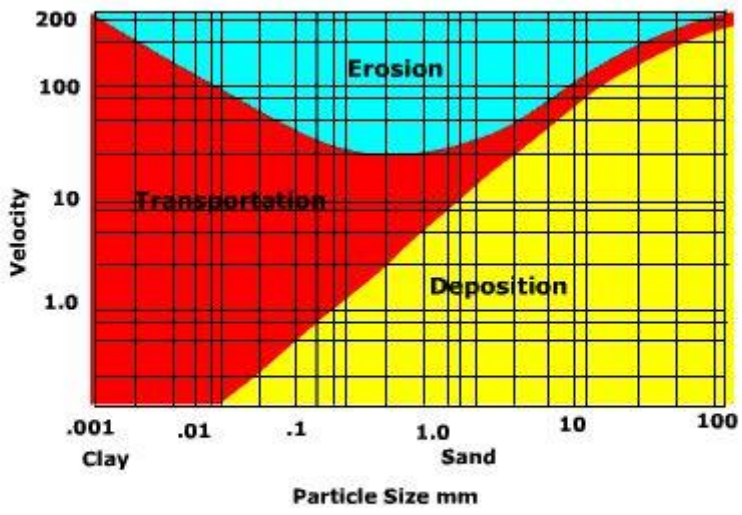

Figure 18.28 Critical velocity (cm/sec) for erosion, transportation and deposition

Source Ritter, 2006 The Physical Environment – An introduction to physical geography.

Sediment management on the Fitzroy River is achieved by transmission of the sediment under or through the weirs. The Fitzroy Barrage is fitted with vertical lift gates that are lifted out of the stream flow during a flood event. This allows unimpeded transfer of sediment. The existing Eden Bann weir is of low height and allows transmission of sediment over the weir because the velocities in the channel are high. Some sand however has deposited in a narrow zone directly upstream of the weir as shown in Figure 9-24. All other sand is washed over the weir and downstream.

Figure 9-24 Sand deposition at Eden Bann Weir

Both the raised Eden Bann Weir and the proposed Rookwood Weir will allow sediment to be swept over the weir as the velocities determined in hydraulic modelling are in excess of 5 m/s (and fall within the erosion range). Aside from local areas of lower velocity around weir structures where local deposition at the upstream face can be expected and low level outlets are provided to assist in flushing this sediment downstream, the weirs are expected to provide unimpeded transfer of sediment down the river.

The presence of fish screens prohibits sediment management through the outlet works as the key objective of the screens is to reduce the velocities to below 0.3 m/s so the fish can swim away from them. This would allow sediment larger than sand size to deposit in front of the screens. A sweeping velocity in front of the screens is required to flush both sediment and fish toward the spillway during spill flows. Because of the interaction of these velocities with successful fishway operation, these velocities will be checked by through computational fluid dynamics and physical modelling during detailed design. It is possible that a low level unscreened outlet would be required to promote sediment flushing during floods.

Flow velocities in excess of 5 m/s (but as low as 2 m/s) have the potential to scour banks downstream of the weir infrastructure.

At the proposed Rookwood Weir site, the silty sands are highly erodible as can be seen in the erosion gullies, 200 m upstream and 600 m downstream of the proposed weir axis on the western embankment. The soil slopes surrounding the proposed weir structure on the left bank will require protection by means of rip-rap and rock mattresses to provide stability and erosion protection.

At the proposed Rookwood Weir site, the alluvial nature of the western embankment required assessment of the potential effect of erosion. When flow starts spilling over the top of the abutment, the tail water level is sufficiently high such that no hydraulic jump occurs on the downstream embankment profile. This flow will be a falling jet, plunging into the tailwater below. The total fall is less than 1 m at this critical level. Notwithstanding this, there will be recirculating velocities and other complex flow conditions at this abutment. These conditions are difficult to assess with simple weir hydraulics formulae. For the purposes of the EIS, an allowance of 40 m of roller compacted concrete and 24 m of rock mattresses for

erosion protection to the embankment has been provided. Detailed hydraulic modelling in the detailed design stage will refine the protection requirements.

The existing Eden Bann Weir has very good founding conditions on relatively massive fresh granodiorite.

Bank slump within the weir impoundment has the potential to occur as a result of the bank soil becoming saturated through inflows followed by rapid drawdown and releases. Bank slump in downstream river reaches has the potential to occur in areas of scouring as a result of releases from the weir.

Retention of riparian vegetation on banks and slopes is proposed for the project, inclusive of the future impounded areas. Retention of vegetation will help to protect the river banks from scouring when water levels rise. Vegetation on the banks and in riparian zones acts to bind and reinforce the bank. It is reported that the trunk or stem of trees and shrubs can act to physically buttress river banks and prevent slumping (Lovett et al. 2003).

Scouring at the weir sites is not expected to be adversely impacted.

Direction of flows through outlet works is expected to create a channel.

Outlet works at the proposed Rookwood Weir are located generally within the main channel area so will not adversely impact on the riverbed and banks form. However approach and departure channels will be excavated into the slope of the eastern flank in variably weathered basalts. These weathered basalts are only likely to be easily excavated to an average of about 1.5 m depth with a maximum of about 2 m and rippable to approximately 4 m. Below approximately 4 m, blasting will be required in generally moderately weathered to fresh basalt. The left bank outlet works at the existing Eden Bann Weir are cut into bedrock. New outlet works associated with a raised Eden Bann Weir will be located within the main channel.

Project commitments during detailed design once a development site is triggered will include:

- Undertaking detailed geomorphic site assessment and will include:
  - A geomorphic condition assessment at selected sites upstream of the future impoundment area, within the future impoundment area and downstream of the weir
  - Stability assessments to describe pre-development characteristics of the river bed and banks, channel stability, the potential for failure and erodibility, amongst others. provide baseline conditions
- Further to geomorphic assessment, identify key indicators for long-term monitoring of geomorphic and fluvial characteristics within the project development area as part of an adaptive management programme.
- In the event that scouring, erosion and slumping do occur, undertake rehabilitation and restoration of impacted areas in accordance with protocols and guidelines as defined in the management plan.

9.3.2.8 Uncontrolled releases of water due to system failure

In the event a weir wall is breached, this may result in an uncontrolled release of water downstream. In addition to health and safety considerations, loss of storage will result.

A failure impact assessment (FIA) has been undertaken for the Project and assessed in Chapter 20 Hazard and risk. The results of the assessment show that estimated incremental population at risk (PAR) due to a breach of the raised Eden Bann Weir is more than 100 for all scenarios considered. Therefore, the raised Eden Bann Weir has a category 2 failure impact rating and is therefore a referable dam in terms of the Water Act.

The FIA for the proposed Rookwood Weir determined that there are no properties that will experience an incremental impact of flooding greater than 300 mm due to a breach of the proposed Rookwood Weir. As the estimate of incremental PAR is less than 2, the proposed Rookwood Weir does not have a failure impact rating. As such, the proposed weir is not referable.

Weir design is in accordance with dam safety provisions of the Water Act, Queensland Dam Safety Management Guidelines and Australian National Committee on Large Dams (ANCOLD) Guidelines. Emergency response plans and policies will be developed in accordance with the *Water Supply (Safety and Reliability) Act 2008* (Qld).

9.4 Summary

9.4.1 Regulatory framework

Unallocated water within the Fitzroy WRP plan area is divided into a strategic reserve, strategic water infrastructure reserve and general reserve. For the Project, unallocated water held as the strategic water infrastructure reserve may be granted for strategic water infrastructure on the Fitzroy River (nominally 76,000 ML). However, the Fitzroy WRP requires that decisions made about the allocation and management of water in the plan area must be consistent with WASOs and EFOs.

In the Fitzroy WRP, the WASO performance indicators for supplemented water in the Lower Fitzroy Water Supply Scheme and Fitzroy Barrage Water Supply Scheme for water allocation in the high priority group are:

- The annual supplemented water sharing index is to be at least 94 per cent
- The monthly supplemented water sharing index is to be at least 98 per cent.

For water allocations in the medium priority group the performance indicator is based on the monthly supplemented water sharing index that must be at least 82 per cent. WASOs are also defined for unsupplemented water allocations per water allocation group in the Fitzroy Water Management Area.

The performance indicators for the EFOs specified in the Fitzroy WRP are:

- For assessing periods of low flow (the seasonal base flow)
- For assessing periods of medium to high flow
- For assessing the FPWF.

The Fitzroy ROP implements the Fitzroy WRP and defines the rules for allocation and management of water in order to achieve WASOs and EFOs.

9.4.2 Approach and methodology

A number of different methodologies and approaches have been used to determine the potential impacts associated with the Project (detailed in Appendix P). The following general assessment approach was adopted with regard to the Project and surface water resources:

- Undertake surface water modelling to quantify the theoretically available yield using the IQQM
- Describe the existing environment with regard to surface water resources, including at the catchment scale, and locally within the Fitzroy, lower Dawson and lower Mackenzie rivers (as applicable)
- Assess the potential impacts of the Project on the surface water resources, surface drainage patterns, flows, flooding and existing users

- Identify appropriate management and mitigation measures to avoid, minimise and/or mitigate the potential impacts.

9.4.3 Existing environment

Strongly seasonal climatic factors heavily influence flows within the Fitzroy Basin, 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 from approximately May to October. Mean annual rainfall is generally higher in the eastern parts of the Fitzroy Basin (800 – 1000 mm), and slightly lower inland to the west (600 mm) (Johnston et al., 2008). Severe flooding occurs within the Fitzroy Basin 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 climate that the Fitzroy Basin is exposed to.

The Fitzroy River at Rockhampton has a long and well-documented history of flooding with flood records dating back to 1859. The highest recorded flood occurred in February 1918 and reached 10.11 m on the Rockhampton gauge.

In general the flood extents for the current 1 in 2 year AEP event are largely contained within the river banks. Anabranch flows develop during the 1 in 5 year AEP event. Flooding starts becoming quite extensive across the river floodplains and anabranches start to run full during a 1 in 20 year AEP event, and become flooded during a 1 in 50 year AEP event.

Flood flows in the Fitzroy River contain a high level of suspended sediment. When flow is captured in a storage or areas where flow velocity reduces, the sediment drops out as silt and sand. As a consequence of the high velocity flows in the Fitzroy River during flood events, deposited silt is remobilised in subsequent floods (Keane 2004).

Joo et al. (2005) estimates the mean annual sediment load in the Fitzroy River (as recorded at The Gap and thus exported past Rockhampton into the Fitzroy River estuary) at 3.1 Mt/a, with most of this sediment coming from the Nogoa and Comet subcatchments.

The Fitzroy Basin is a highly regulated system with a number of existing water storages. In the Project area supplemented water is supplied from Eden Bann Weir (owned and operated by SunWater) through the Lower Fitzroy Water Supply Scheme (25,520 ML/a) and the Fitzroy Barrage (owned and operated by RRC) through the Fitzroy Barrage Water Supply Scheme 50,000 ML/a).

Unsupplemented water in the Project area is managed within the Fitzroy Water Management Area.

The Fitzroy ROP specifies reserves of unallocated water for urban and industrial supplies in the Gladstone area and urban supplies in the Capricorn Coast area:

- GAWB: up to 30,000 ML of the reserve for urban and industrial water supplies
- Local government authority: up to 4,000 ML of the reserve for urban water supplies for the Capricorn Coast.

The Fitzroy ROP does not specify the intended use of the remaining 42,000 ML and nominates that any person or entity may make a submission in this regard

These reserves are associated with proposed new water infrastructure on the Fitzroy River and must retain consistency with EFOs and WASOs, amongst others.

9.4.4 Potential impacts and mitigation measures

9.4.4.1 Construction

Activities such as earthworks and excavations within the riverbed and banks, the implementation of in-stream diversion strategies (coffer dams) and abstraction of water for construction purposes have the potential to impact on surface water resources of the Fitzroy River.

Potential impacts arising from construction of the Project may include:

- Disruption to or diversion of downstream flows as a result of weir construction within the bed and banks of the river
- Disruption to or diversion of downstream flows as a result of construction of river crossings (temporary access during construction and permanent infrastructure such as bridges)
- Localised drawdown within natural ponded areas (Rookwood Weir), particularly during low flow conditions as a result of abstraction of water from the river for construction purposes

Potential impacts on water quality of surface water resources and associated mitigation is described in Chapter 11 Water quality. Potential impacts on aquatic ecology and fish passage are discussed in detail in Chapter 7 Aquatic ecology.

Downstream flows (and operational releases as applicable to the existing Eden Bann Weir) will be maintained throughout the construction period and it is not expected that flows will be adversely impacted as a result of the Project's construction. Further it is not expected that construction of the Project will be adversely impacted by flood flows.

Raising Eden Bann Weir and construction of Rookwood Weir are each scheduled in four phases dictated by alternating wet and dry seasons over an approximate two to two-and-a half--year period. In-stream diversion strategies (including coffer dams at both sites) will be implemented to temporarily divert flows away from the Project activities but retain them within the river channel. All works will be undertaken in accordance with the Project EMP (Chapter 23 Environmental management plan) and subsequent site-specific construction EMPs, in consideration of work schedules and seasonal constraints.

Scheduling of construction activities at Eden Bann Weir will be undertaken in consultation with the asset owner/operator, namely SunWater, to facilitate that operational releases (and subsequently EFOs and WASOs) are maintained through the existing infrastructure or new infrastructure components as necessary.

9.4.4.2 Operations

In simple terms, during operations the storages capture and retain river flows during the wet season allowing for slow, regulated releases through the dry season, and allowing for environmental releases as necessary and in accordance with regulations. Releases downstream are made through 'run of river' methods, that is, releases are made directly to the river and not through the use of pipelines, canals or other infrastructure.

Potential impacts requiring consideration in regard to the operation of the Project include:

- Inundation of river and creek bed and banks and infrastructure upstream within the impoundment
- Altered stream flow patterns potentially affecting current flow regimes and availability of water supplies to the environment and water users (unsupplemented entitlements)
- Altered flood flows

- Changes to river morphology (fluvial processes)
- Uncontrolled releases of water due to system failure.

Inundation associated with a raised Eden Bann Weir and construction of Rookwood Weir is retained within the river bed and banks. Weirs are in-river structures that are designed to be overtopped. Unlike a dam, the whole of the structure is located within the bed and banks of the watercourse. Subsequently inundation associated with weirs is designed to bank full, that is the elevation where water will 'break out' of the river banks.

It is expected that the raised Eden Bann Weir and new Rookwood Weir will be operational within the first wet season post-construction and will fill in a relatively short period (in the order one to two months). Operationally it is intended that weir storages remain impounded for approximately eight months of the year with draw down occurring in the drier period. At ultimate development, Rookwood Weir storage would be drawn down and pass to the Fitzroy Barrage for use and abstraction. Once Rookwood Weir reaches its minimum operating level (and the storage is depleted), releases would be made from Eden Bann Weir to the Fitzroy Barrage for use and abstraction.

The operational regime will be developed further once a Project trigger is initiated and a specific development scenario (and associated infrastructure) is defined. It is acknowledged that the operational regime will be subject to the provisions of the Fitzroy WRP and amendments to the Fitzroy ROP will be required. The links between the Fitzroy ROP and the Fitzroy WRP are outlined in Table 9-16 and a cross-reference to the relevant Project EIS chapter provided.

Table 9-16 Links between the Water Resource (Fitzroy Basin) Plan 2011 and Fitzroy Basin Resource Operations Plan 2014 and the Project

Fitzroy WRP outcomes for the Project	Fitzroy ROP rules	Relevant EIS chapter
Section 12 General outcomes for water in the plan area		
s12(a) to provide for the use of water entitlements and other authorisations in the plan area.	Granting and amending authorisations Operating and environmental management rules Water sharing rules	Chapter 1 Introduction
s12(b) to provide for the continued use of existing overland flow works	Granting and amending water licences to take overland flow water	Chapter 9 Surface water resources
s12(c) to provide for the continued use of existing groundwater works	Granting of authorisations	Chapter 10 Groundwater resources
s12(d) to protect the probability of being able to take water under a water allocation.	Dealing with unallocated water Operating and environmental management rules Water allocation change rules Water sharing rules	Chapter 1 Introduction

Fitzroy WRP outcomes for the Project	Fitzroy ROP rules	Relevant EIS chapter
s12(e) to support water-related cultural values, including the values of the traditional owners in the plan area.	Dealing with unallocated water Operating and environmental management rules Monitoring and reporting (chief executive)	Chapter 17 Cultural heritage
s12(f) to provide mechanisms that support water being made available for the following— (i) population growth in the towns and communities dependent on water resources in the plan area; and (ii) growth in industries dependent on water resources in the plan area; and (iii) stock or domestic purposes in the plan area; and (iv) indigenous communities dependent on water resources in the plan area to achieve their economic and social aspirations	Dealing with unallocated water Granting and amending authorisations Water allocation change rules Seasonal assignment rules Dealing with water licence applications	Chapter 1 Introduction
s12(g) to support flexible and diverse water supply arrangements for consumptive water users.	Water sharing rules, including providing for the use of treated coal seam gas water in the Upper Dawson sub- scheme Water allocation change rules Operating and environmental management rules	Chapter 1 Introduction
s12(h) to maintain flows that support water-related aesthetic, economic and recreational values in the plan area, including, for example, tourism.	Operating and environmental management rules Monitoring and reporting (chief executive) ROL holder monitoring and reporting	Chapter 5 Land Chapter 19 Economics Chapter 18 Social impact
s12(i) to encourage continual improvement in the efficient use of water.	ROL holder monitoring and reporting	Chapter 2 Project description
s12(j) to provide a flow regime that support the quality of water for human and ecological use.	Operating and environmental management rules Monitoring and reporting (chief executive) ROL holder monitoring and reporting	Chapter 6 Flora Chapter 7 Aquatic ecology Chapter 8 Terrestrial fauna Chapter 11 Water quality
Section 13 Specific surface water and groundwater* outcomes		

Fitzroy WRP outcomes for the Project	Fitzroy ROP rules	Relevant EIS chapter
s13(1)(c) to make water available in the Fitzroy subcatchment to support urban, industrial and other uses	Granting and amending authorisations Dealing with unallocated water Water sharing rules Water allocation change rules ROL	Chapter 1 Introduction
Section 14 General ecological outcomes		
s14(a) to minimise changes to the natural variability of flows that support aquatic ecosystems.	Dealing with unallocated water Operating and environmental management rules Management of overland flow water	Chapter 7 Aquatic ecology
s14(b) to provide for the continued capability of 1 part of the river system to be connected to another, including maintaining flows that— (i) allow for the movement of native aquatic fauna between riverine, wetland, estuarine and marine environments; and (ii) support water-related ecosystems; and (iii) support river-forming processes.	Dealing with unallocated water Operating and environmental management rules Management of overland flow water Dealing with water licence applications	Chapter 7 Aquatic ecology Chapter 9, Surface water resources
s14(c) to provide a flow regime that— (i) maintains the delivery of fresh water to the estuaries of watercourses and the Great Barrier Reef Lagoon; (ii) supports productivity in the receiving waters of the Great Barrier Reef and inshore reefs.	Dealing with unallocated water Operating and environmental management rules Monitoring and reporting (chief executive)	Chapter 7 Aquatic ecology Chapter 9, Surface water resources
s14(d) to improve understanding of the matters affecting the flow-related health of ecosystems in the plan area	Monitoring and reporting (chief executive) ROL holder monitoring and reporting	Chapter 9, Surface water resources
s14(f) to protect and maintain refugia associated with waterholes, lakes and wetlands.	Operating and environmental management rules Dealing with water licence applications Monitoring and reporting (chief executive) Resource operations licence holder monitoring and reporting	Chapter 9, Surface water resources

Fitzroy WRP outcomes for the Project	Fitzroy ROP rules	Relevant EIS chapter
s14(h) to support ecosystems dependent on groundwater including, for example, riparian vegetation and wetlands	Operating and environmental management rules ROL holder monitoring and reporting Monitoring and reporting (chief executive)	Chapter 10 Groundwater resources
Section 15 Specific ecological outcomes		
s15(a) to protect flows and water quality for flow-spawning fish and endemic species, including, for example, the Fitzroy golden perch (*Macquaria ambigua oriens*)	Dealing with unallocated water Operating and environmental management rules Monitoring and reporting (chief executive)	Chapter 2, Aquatic ecology
s15(b) to provide for flows necessary for estuarine ecosystem functions, including flows for: (i) barramundi (*Lates calcarifer*) and king threadfin salmon (*Polydactylus macrochir*) recruitment; and (ii) banana prawn (*Penaeus merguiensis*) growth.	Dealing with unallocated water Operating and environmental management rules Monitoring and reporting (chief executive)	Chapter 9, Surface water resources

* Groundwater outcomes are not specified for the Project area.

The alteration of surface flows and an increase in inundation areas will potentially impact on public and private infrastructure, such as roads (tracks) and river crossings (low level bridges and causeways) and other installations (stream gauges) that may require upgrades to accommodate raised water levels, including at: Glenroy Crossing; Riverslea Crossing, Foleyvale Crossing and Hanrahan Crossing.

Inundation will impact on landholder access to and use of riparian land. These impacts and proposed mitigation measures are discussed in Chapter 5 Land and Chapter 18 Social impact.

Analysis of flows pre- and post-development indicate marginal to no significant changes to flow regimes upstream, within and downstream Eden Bann Weir and the proposed Rookwood Weir. Statistical analysis shows that for all years analysed, releases from the Project at its upper limits of development (RW2+EB3), with the exception of 1969, 1982 and 1994, do not significantly influence flows at the end of the system. This indicates that under the upper limit development scenario (with yield capped at 76,000 ML/a), minimal impacts on flow are expected to occur during years of high flow.

At Project theoretical yield volumes, the Project complies with high and medium priority user group supplemented WASOs in the Lower Fitzroy Water Supply Scheme and the Fitzroy Barrage Water Supply Scheme. For infrastructure scenarios that achieve at least 76,000 ML/a if the yield is capped at 76,000 ML/a, WASOs are achieved and water sharing indices for high and medium priority user groups are improved.

Unsupplemented WASOs are achieved for flow classes 5B, 6C and 7D for all infrastructure scenarios at theoretical yields. Unsupplemented WASOs are achieved for flow Class 5A under infrastructure scenario Eden Bann Weir Stage 2. For the remaining infrastructure scenarios, the system average annual volume probabilities fall between one and five per cent below the specified objective.

It is considered that water harvesting entitlements (that is water take under high flow conditions) can co-exist with supplemented entitlements arising as a result of the Project, as they currently do elsewhere in the Fitzroy Basin.

Low flow or no flow (waterholes) entitlements have the potential to be impacted as a result of the project, both upstream and downstream of the weirs. It is likely that changes to stream flow regimes will alter the ability of these users to extract water under the existing licence conditions. It is acknowledged that this impact will be addressed in the amended Fitzroy ROP. It is envisaged that individual negotiations will be undertaken between the proponent and entitlement holder once the Project receives a trigger and a development scenario is determined. The negotiations will be based on the voluntary purchase/sale of entitlements and will consider the inclusion of options for the provision of an alternative water supply. Proposed arrangements will be submitted to the State for review and approval.

Once demands for the Project are realised and development of a specific infrastructure scenario is triggered, detailed design and further modelling will be required to ensure compliance with the underlying Fitzroy WRP requirements. Since changes to existing operational rules are also likely to be required, a ROP amendment will be sought, again requiring compliance with WRP objectives. Consideration will be given to parameters such as reduced yield volumes and operating regimes and rules to satisfy flow requirements.

Seasonal base flow EFOs are met for all theoretical and capped (as applicable) Project yields during the January to April water flow season. During the May to August water flow season and September to December water flow season the existing system (EB1) does not meet the Fitzroy WRP seasonal base flow objectives, reporting 0.7 and 0.6, respectively against the 0.8-1.2 benchmark values. Similarly all Project infrastructure scenarios achieve the same or similar values. All infrastructure scenarios comply with medium to high flow EFOs except scenario RW2+EB3 which failed against the 20 year daily flow volume objective, reporting 87.46 per cent against the 88 per cent benchmark. It is noted that RW2+EB3 yield may be limited by the Fitzroy WRP requirement to achieve the 20 year daily flow volume. Alternatively operating rules may be modified. FPWF event EFOs are achieved for all Project infrastructure scenarios.

There is a negligible increase in peak water levels with EB2 compared to the existing weir for the 1 in 50 and 1 in 100 AEP events as both weir arrangements are drowned by the flood flows for those design events. By a distance of 23 km upstream of the existing weir, the peak water level difference with the raised weir reduces to around 300 mm for the 1 in 10 AEP event. For the 1 in 2 and 1 in 5 AEP events, the peak water level difference reduces to around 300 mm at approximately 50 km upstream.

Rookwood Weir influences water levels upstream of the site during smaller magnitude floods (1 in 2 and 1 in 5 AEP events). The estimated afflux for the 1 in 2 AEP event is 5.0 m which reduces to approximately 0.6 m about 40 km upstream of the weir. The 1 in 5 AEP event has an estimated afflux of 1.2 m at the weir which reduced to 0.2 m about 40 km upstream. The impact of the weir during larger magnitude events such as the 1 in 10 to the 1 in 100 AEP events is less than or equal to 0.6 m at the proposed weir site. The weir is significantly drowned during a 1 in 20 AEP event, such that the estimated afflux at the weir is around 0.3 m and is less than 0.1 m at the upstream end of the Fitzroy River at the junction of the Mackenzie and Dawson Rivers.

Potential flood impacts on the road network have been considered.

Sediment management on the Fitzroy River is achieved by transmission of the sediment under or through the weirs. Both the raised Eden Bann Weir and the proposed Rookwood Weir will allow sediment to be swept over the weir. Aside from local areas of lower velocity around weir structures where local

deposition at the upstream face can be expected and low level outlets are provided to assist in flushing this sediment downstream, the weirs are expected to provide unimpeded transfer of sediment down the river.

In relation to erosion and bank slumping, Project commitments during detailed design once a development site is triggered will include:

- Undertaking detailed geomorphic site assessment and will include:
  - A geomorphic condition assessment at selected sites upstream of the future impoundment area, within the future impoundment area and downstream of the weir
  - Stability assessments to describe pre-development characteristics of the river bed and banks, channel stability, the potential for failure and erodibility, amongst others. provide baseline conditions
- Further to geomorphic assessment, identify key indicators for long-term monitoring of geomorphic and fluvial characteristics within the project development area as part of an adaptive management programme.
- In the event that scouring, erosion and slumping do occur, undertake rehabilitation and restoration of impacted areas in accordance with protocols and guidelines as defined in the management plan.

A FIA has been undertaken for the Project. The raised Eden Bann Weir has a category 2 failure impact rating and is a referable dam. The proposed Rookwood Weir does not have a failure impact rating and is not referable.