LOWER FITZROY RIVER
INFRASTRUCTURE PROJECT

# Appendix P4

## Surface water resources supporting material

Part 4 Section 7 Hydraulic modelling

Part 4 Section 8 References

SunWater
MAKING WATER WORK

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# Appendix P4 Surface water resources supporting material

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# 7 Hydraulic modelling

## 7.1 Introduction

Hydraulic modelling was undertaken to estimate the peak water levels for the existing river and as a result of raising Eden Bann Weir to a crest level of RL 18.2 m AHD and constructing a new weir at Rookwood with a fixed crest of RL 45.5 m AHD. The work builds on the previous hydraulic modelling undertaken by SunWater (2008).

New hydraulic models were developed for the Project with a one-dimensional (1D) model covering the Fitzroy River downstream from the Mackenzie and Dawson Rivers junction to approximately 15 km downstream of the existing Eden Bann Weir. The lower reaches of the Mackenzie and Dawson Rivers were assessed using a two-dimensional 2D) model.

## 7.2 Scope of works

The scope of works for the hydraulic modelling component included:

- Development of a MIKE 11 1D hydraulic model for the Fitzroy River and contributing tributaries from downstream of the Mackenzie and Dawson River confluence to downstream of Eden Bann Weir;
- Calibration of the MIKE 11 model using historical flood events;
- Development of a MIKE 21 2D hydraulic model for the lower Mackenzie and Dawson Rivers areas and confluence;
- Assessment of the peak flood water levels for the 1 in 2 year, 1 in 5 year, 1 in 10 year, 1 in 20 year, 1 in 50 year and 1 in 100 year AEP design rainfall events for existing river conditions and with the construction of the new weir.

A variety of information was utilised for the Project. In relation to development of hydraulic models this included:

- Data from previous studies, namely:
  - Rookwood Weir Concept Design Report (SunWater, 2008a)
  - Rookwood and Eden Bann Weirs Design Flood Hydrology Report (SunWater, 2008b)
  - Rookwood Weir Hydraulic Model Study Report (SunWater, 2008c)
  - Eden Bann Weir Hydraulic Model Study Report (SunWater, 2008d)
  - URBS hydrology modelling files (calibration events and design events (SunWater,2008b)
  - Airborne Laser Survey (ALS) data, and pre-Eden Bann Weir river cross sections.
- Historical flood events as documented by The Commonwealth Bureau of Meteorology (BOM) in its web-based documentation entitled ‘Flood Warning System for the Fitzroy River’ (BOM, 2011).
- Streamflow gauging data as described in Table 6.1.

## 7.3 1D hydraulic modelling

### 7.3.1 Model description

#### 7.3.1.1 Overview

The 1D MIKE 11 (Version 2010) model is a hydrodynamic model that uses an implicit, finite-difference computation scheme for unsteady flows in rivers and estuaries. The results of a hydrodynamic simulation consist of a time series of water levels and discharges.

Data requirements for the MIKE 11 model include:

- Definition of the watercourse network schematic;
- Cross-sectional information at various locations along the reach of the watercourse;
- Surface roughness values;
- Definition of upstream and downstream boundary conditions; and,
- Inflow hydrographs at various locations along the reach of the watercourse.

#### 7.3.1.2 Model development

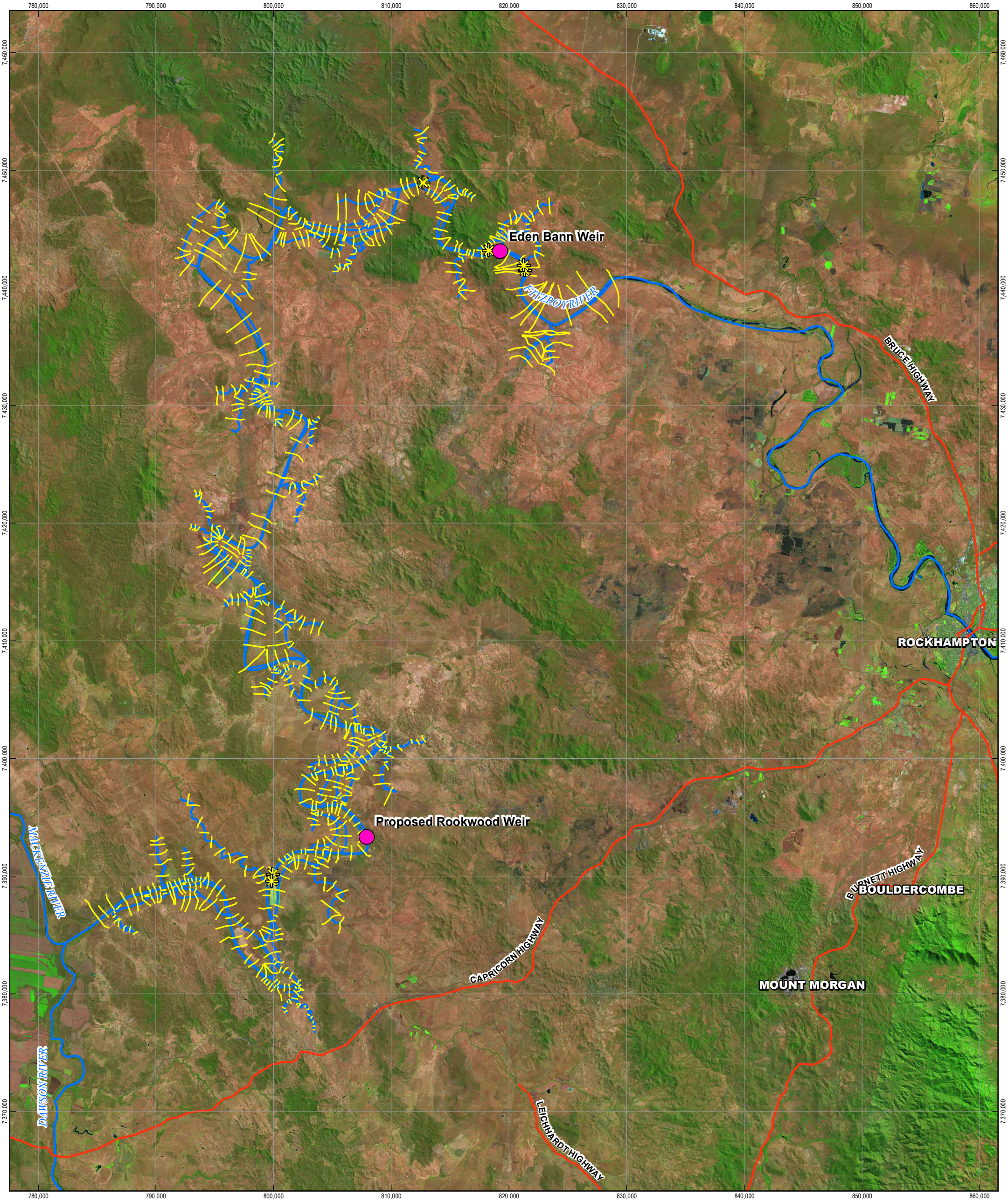
To ease the complexity of model building a large, complex river network, the 12D Rivers interface was used to develop the basic structure of the model. 12D is a civil and surveying software package that has a number of modules, one of which creates the cross sections and network schematics for a MIKE 11 hydraulic model. The Bigfoot version of the 12D software was utilised and has a data point limitation of 250 million.

The ALS data was thinned using the Terrascan software to generate a more manageable dataset while maintaining the key characteristics of the ground surface. GIS software was used to produce the required input data to the 12D Rivers interface, being river strings to define the centreline and river banks of the watercourses, and the location of the cross sections.

#### 7.3.1.3 Network schematic, cross-sectional information and structures

The location and chainage of cross sections used in the model are shown in Figure 7-1. The main river network of the Fitzroy River extends from downstream of the Mackenzie and Dawson River confluence to 15 km beyond Eden Bann weir, a total distance of approximately 180 km. A total of 79 major creeks, tributaries and anabranches have been included as part of the river network represented by 694 cross sections.

Cross sections locations were chosen to best represent the river system and account for the volume of the system. The ALS data was thinned and gridded to produce a Digital Elevation Model (DEM) from which the cross section profiles were extracted. The cross sections between chainages 121112 and 165692 were modified as the ALS data represents the water surface upstream of Eden Bann Weir. These cross sections were reshaped in the lower portion to have a trapezoidal section with an invert interpolated from cross sections unaffected by the weir and associated water surface. The inverts of these sections were then adjusted using inverts from cross sections obtained during a survey conducted in 1957.




LEGEND

- Weir Sites
- Stream Gauges
- Model Cross Sections
- Roads
- Watercourses

Paper Size A3

0 2.5 5 7.5 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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GHD CLIENTS | PEOPLE | PERFORMANCE

Gladstone Area Water Board

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Lower Fitzroy River Infrastructure Project

| | |
|---|---|
| Job Number | 41-20736 |
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# 1D Hydraulic Model Layout

Figure 7-1

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Data source: GA - Imagery, Place Names, Major Roads (2007). Sunwater - Model Subcatchments (2011). GHD - Weir Sites, Model Cross Sections, River Strings, Stream Guages (2011). Created by: CM

For Eden Bann Weir, modelling considered the following:

- The only structure (road, bridge or weir) inserted in the model for the existing scenario is the current Eden Bann Weir (RL 14.8 m) at a model chainage of 164,894 m (AMTD 141.2 km)
- The proposed raised Eden Bann Weir has a crest level of 18.2 m AHD
- The weir is assumed to be at full supply level at the start of the modelling.

For Rookwood, modelling considered the following:

- The only structure (road, bridge or weir) inserted in the model for the existing scenario is the current Eden Bann Weir (RL 14.8 m) at a model chainage of 164,894 m (AMTD 141.2 km)
- The proposed Rookwood Weir is located at a model chainage of 40881 m (AMTD 265.3 km) and has a crest level of RL 45.5 m AHD
- The weirs (Rookwood and the existing Eden Bann Weir) are assumed to be at their respective full supply levels.

#### 7.3.1.4 Surface roughness values

Surface roughness is represented in the model by Manning's 'n'. Estimates of 'n' values were based on aerial imagery flown over the extent of the model area. Regions of similar surface cover were manually identified and digitised in a GIS program to produce a layer representing surface roughness. Table 7-1 lists the typical 'n' values used for the modelling. These values are based on values recommended by Chow (1959) for various cross sectional geometries and vegetation.

**Table 7-1 Typical surface roughness values**

| Position | Description | Mannings 'n' value |
|---|---|---|
| Channel | Grass lined | 0.030 |
| | Saplings or shrubs | 0.045 |
| | Trees on embankment | 0.080 to 0.100 |
| Floodplain | Pasture/open space | 0.045 |
| | Tall grass/buildings | 0.055 |
| | Scattered trees | 0.080 |
| | Dense cluster of tress | 0.120 |
| | High density houses | 0.160 |

#### 7.3.1.5 Downstream boundary conditions

The downstream boundary condition for the model is a rating curve derived from a HEC-RAS (steady state, one dimensional backwater model) based on the last eight cross sections (~10 km river) of the MIKE 11 model, with the last cross sections duplicated downstream three times at an interval of 2 km. Elevations of these duplicated sections were adjusted according to the average bed slope of the eight sections from the MIKE 11 model.

#### 7.3.1.6 Inflow hydrographs

Inflow hydrographs were extracted from the calibrated URBS model (GHD, 2012) at locations as close as possible to the centroid of the particular sub-catchment and inserted into the hydraulic model. In some instances the hydraulic model did not extend into a particular sub-catchment and for these cases

the hydrology model performed some routing of the hydrograph from the centroid to the nearest branch of the hydraulic model.

### 7.3.2 Model calibration

The model was calibrated using gauged water levels from the following gauging stations (Figure 6-1):

- Riverslea (130003B)
- Weir Site (130007A) (Eden Bann Weir)
- The Gap (130005A), and
- Wattlebank (130002A).

Of the four gauges, the Riverslea site has the longest record and from the hydrological analysis performed, it is deemed to be the most reliable gauge (GHD, 2012).

The following historical events were considered for calibration:

- February 1954
- April 1983
- March 1988
- December 1990
- February 1991, and
- December 2010/January 2011.

Calibration was performed by adjusting the global surface roughness factor within the model parameters. The best fit between the recorded water level at the gauges and the computed water level was obtained with an increase in surface roughness of 25 per cent. Table 7-2 contains the peak water levels from the river gauges and the calibrated hydraulic model. In general, the model is calibrated best to large events (1954, 1990, and 2010/11), and tends to overestimate water levels in smaller events (1983, 1988, and 1991).

As the model over-estimates smaller floods, yet provides a good representation of larger floods, it was not considered prudent to pursue refinement of the model calibration for the purposes of the Project's business case or EIS. Consideration to refinement will be given to the model during detailed design.

**Table 7-2 Model calibration results – peak water levels**

| Event | Gauging location – peak water levels (m) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Riverslea 130003B | | Weir Site 130007A | | The Gap 130005A | | Wattlebank 130002A | |
| | Recorded | Calculated | Recorded | Calculated | Recorded | Calculated | Recorded | Calculated |
| 1954 | 61.5 | 62.0 | - | 33.6 | - | 31.2 | 29.6 | 30.7 |
| 1983 | 56.3 | 57.7 | 27.2 | 29.8 | 23.4 | 28.0 | - | 27.6 |
| 1988 | 58.6 | 59.6 | 28.9 | 30.7 | 25.1 | 28.7 | - | 28.3 |
| 1990 | 61.4 | 61.4 | 33.3 | 32.6 | 30.3 | 30.4 | - | 29.9 |
| 1991 | 54.8 | 56.7 | 25.3 | 28.7 | 22.8 | 26.9 | - | 26.5 |
| 2010/2011 | 60.7 | 60.5 | - | 31.7 | 29.7 | 29.6 | - | 29.2 |

### 7.3.3 Design rainfall events and estimated peak water levels

Peak water levels from a range of AEPs and storm durations were investigated using the hydraulic model. The assessed AEP events were 1 in 2 year, 1 in 5 year, 1 in 10 year, 1 in 20 year, 1 in 50 year and 1 in 100 year, with durations of 24, 36, 48 and 72 hours. The critical duration was found to be 72 hours in the Fitzroy River.

This range of AEP events was selected on the basis of the flood hydrology studies undertaken for the Project (GHD, 2012). The design hydrographs were extracted from the URBS runoff-routing model that was recalibrated for the Project (GHD, 2012).

The following scenarios were modelled:

- Eden Bann Weir:
  - Existing Eden Bann Weir (crest level = 14.8 m)
  - A raised Eden Bann Weir (crest level = 18.2 m)
  - Increased rainfall as a result of climate change.
- Rookwood:
  - Existing system (includes the existing Eden Bann Weir but no new development)
  - Proposed Rookwood Weir (crest level 45.5 m)
  - Increased rainfall as a result of climate change.

## 7.4 2D hydraulic modelling

### 7.4.1 Model description

2D hydraulic modelling was undertaken for the proposed weir at Rookwood with a fixed crest level of RL 45.5 m AHD. The 2D modelling component covers the Mackenzie and Dawson River confluence upstream of the 1D model. For the Project, the hydrodynamic module of MIKE 21 has been used to simulate design flooding events at the Mackenzie and Dawson rivers confluence, and the effects of the proposed Rookwood Weir on the Capricorn Highway at the Dawson River and the Foleyvale Crossing at the Mackenzie River.

MIKE 21 is a modelling system for 2D free-surface flows. MIKE 21 is applicable to the simulation of hydraulic and environmental phenomena in lakes, estuaries, bays, coastal areas and seas. It may be applied wherever stratification can be neglected.

### 7.4.2 Model data

Data requirements for the model include:

- Topographic information in the form of a DEM.
- Boundary conditions – the two upstream boundary conditions are inflow hydrographs extracted from the hydrology model. The outflow from Sub-Areas 3, 4 and 5 were used for the Mackenzie River boundary and the outflow from Sub-Area 2, 10, 11, 18 and 19 were used for the Dawson River boundary. The downstream boundary condition is located on the Fitzroy River and is represented by a dynamic water level calculated by the MIKE 11 model.
- Surface roughness values based on the same aerial imagery interpretation for the 1D model (Table 7-1).

No hydraulic structures were included in the modelling.

### 7.4.3 Model calibration

Calibration of the 2D model was not possible as no river gauges exist within the modelling domain.

### 7.4.4 Design rainfall events and estimated peak water levels

Peak water levels from a range of AEPs and storm durations were investigated using that the hydraulic model. The assessed AEP events were 1 in 2 year, 1 in 5 year, 1 in 10 year, 1 in 20 year, 1 in 50 year and 1 in 100 year, and the assessed duration was 72 hours. The design hydrographs were extracted from the calibrated URBS runoff-routing (GHD, 2012).

The following scenarios were assessed:

- Existing system (includes the existing Eden Bann Weir but no new development)
- Proposed Rookwood Weir (crest level 45.5 m)
- The peak water levels for all AEP events were assessed at the Capricorn Highway and Foleyvale Crossing.

The only event modelled for the proposed Rookwood Weir scenario is the 1 in 2 year AEP event as the 1D model 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) for the 1 in 5 year AEP event and smaller probability events. The impact of the Rookwood Weir is greatest during small events and events larger in flood magnitude than the 1 in 2 year AEP will have even less of an impact, if any, on water levels further upstream.

The peak water levels were estimated considering the 2030 (five per cent increase in rainfall) and 2070 (15 per cent increase in rainfall) climate change horizons.

The data used for the assessment was taken from Node 0, which is situated downstream of the Fitzroy Barrage, below all user extraction points, including those for RRC, industrial and irrigation uses. The flow analysis utilised 95 years of IQQM data for the Fitzroy River.

IQQM data was analysed to identify if there were any significant difference in environmental flows under two different scenarios. Both scenarios included the regulated environmental flows currently in place and anticipated to remain if the development proceeds as follows:

- Scenario 1 comprised the base case (pre-development) and considered the Fitzroy River under the current flow regime with the present-day water infrastructure in operation that is the pre-development scenario.
- Scenario 5 considered the post-development flow regime with all proposed development levels constructed and in operation that is Eden Bann Weir raised to Stage 3 and Rookwood constructed to Stage 2.

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