LOWER FITZROY RIVER
INFRASTRUCTURE PROJECT

Appendix P2

Surface water resources supporting material

Part 2 Section 3 Existing environment (stream flow hydrology and flooding)

Part 2 Section 4 Potential impacts on stream flow patterns

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3. Existing environment

3.1 Stream flow hydrology

3.1.1 Approach and methodology

To characterise flows within the Fitzroy, Mackenzie and Dawson rivers (as reflective of flows in the Project area) flow data from four stream gauging stations was assessed as described in Table 3-1 and shown in Figure 3-1.

Stream flow data is not available from the Bureau of Meteorology (BoM) station at Laurel Bank (located approximately 12 km upstream from the Fitzroy Barrage). This station does not record stream flow data but rather acts as a flood warning river height station.

A common historic period of data was selected as the period 1974 to 2009. That is a common period for all the available record from which data from all four sites was available) Flow patterns for a more 'current' period were evaluated by interrogating data for the period 1999/2000 to 2009, covering the drought between 2004 and 2007 and wetter than average years experienced in the region in 2008 and 2009. In terms of flow characterisation it is considered that assessment of the historic data and the selected current period are adequate and capture high, medium and low flow conditions experienced within the system.

For each dataset (that is from each gauging station), and for each period within the dataset (that is historic and current records), the following information was prepared to inform discussion on stream flow characteristics in the Project area:

- Hydrographs
- Flow duration curves
- Average total monthly flow (in megalitres (ML)).

3.1.2 Stream flow characteristics

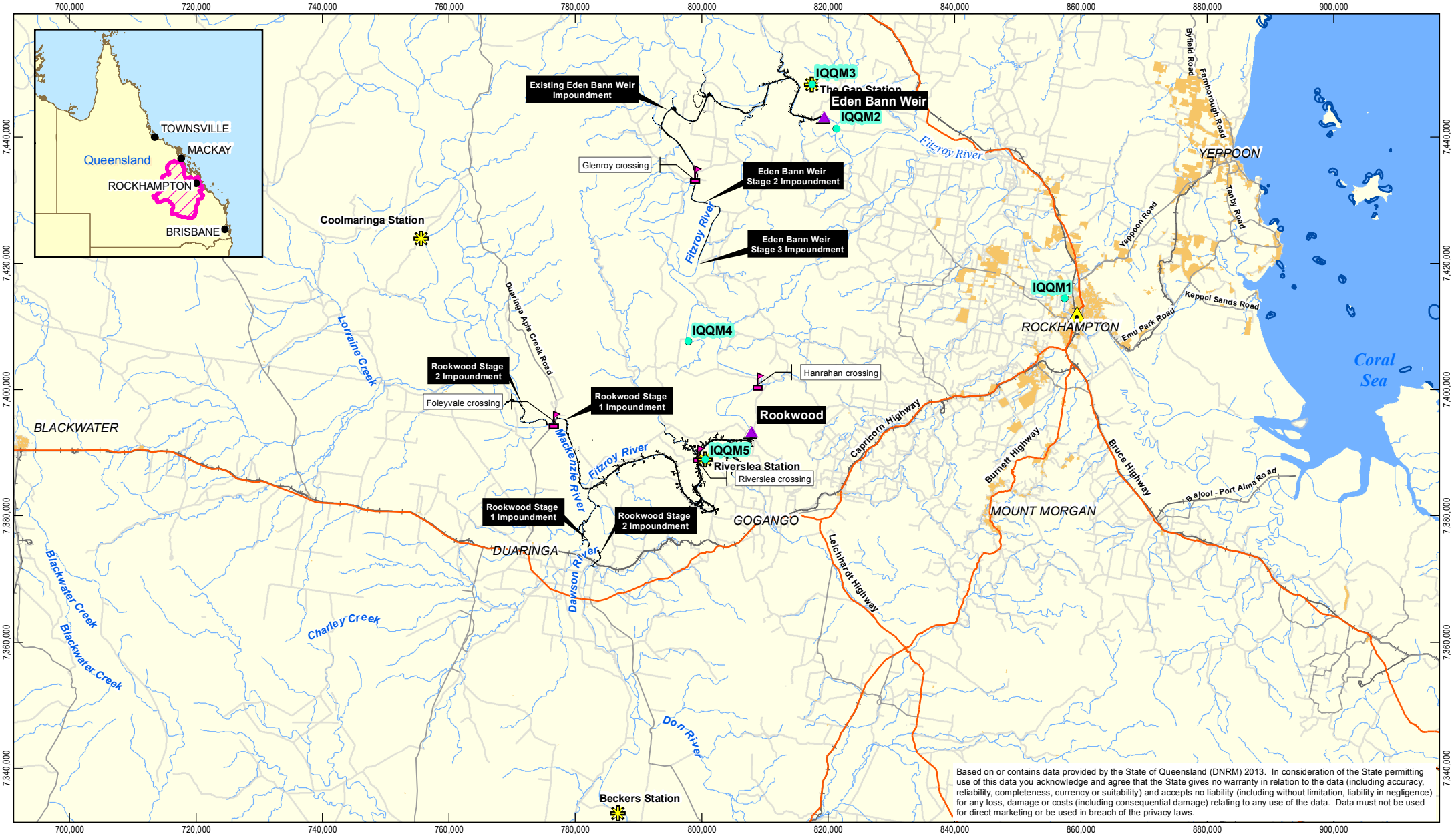
Figure 3-2 and Figure 3-3 show hydrographs that present flow discharges and show the longer term variability in flows (as total annual flow) for the historic and current periods, respectively, at each gauging station defined in Table 3-1.

Flow duration curves summarising the range and distribution of flows are shown in Figure 3-4 for the historic and current periods at all selected gauging stations.

The average total monthly flow (ML) reflecting the seasonal variability in flow as shown in Figure 3-5 for historic and current periods for each gauging station.

Table 3-1 Stream gauging stations

Gauging station	Reference	Description
The Gap	130 005A	Located on the Fitzroy River at 142.1 km AMTD, approximately 1 km upstream from the existing Eden Bann Weir and situated within the current impoundment. The associated catchment covers an area of 135,757 km^2. The gauging station commenced in 1964 at which time the location was unregulated. Since the start of operations of the Eden Bann Weir (in 1994), the gauge has reflected a regulated impoundment. The gauge is currently in operation and records both time series flow and water quality data.
Riverslea	130 003B	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. The associated catchment spans an area of 131,385 km^2. The record at Riverslea commenced in 1974 and is still current. The gauge records time series flow data only.
Coolmaringa	130 105A	Located at 376 km AMTD on the Mackenzie River, downstream of Tartrus Weir and upstream of the confluence with the Dawson River. The associated catchment area is 76,645 km^2. The gauge commenced its record in 1971 and remains current recording both time series flow and water quality data.
Beckers	130 322A	Located at 71 km AMTD on the Dawson River, downstream of the Neville Hewitt Weir (82.6 km AMTD). The associated catchment spans an area of 40,500 km^2. The gauge has been in operation since 1964 and remains current. It records both time series flow and water quality data.



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1:800,000 (at A4)

0 5 10 15 20

Kilometres

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

N

LEGEND

- 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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Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision A
Date 31 Oct 2014

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

Figure 3-1

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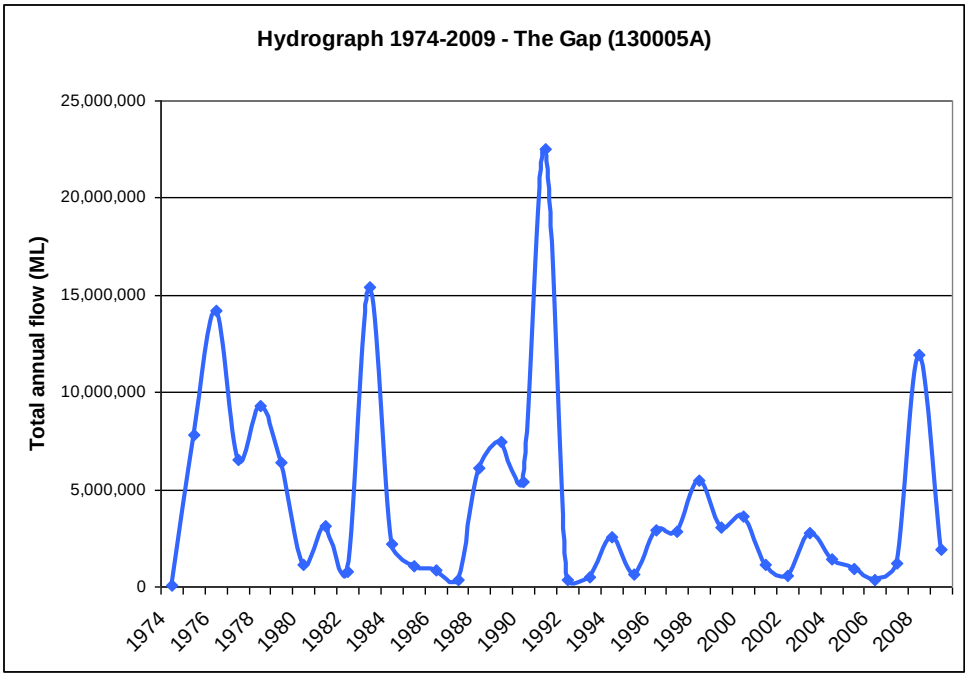
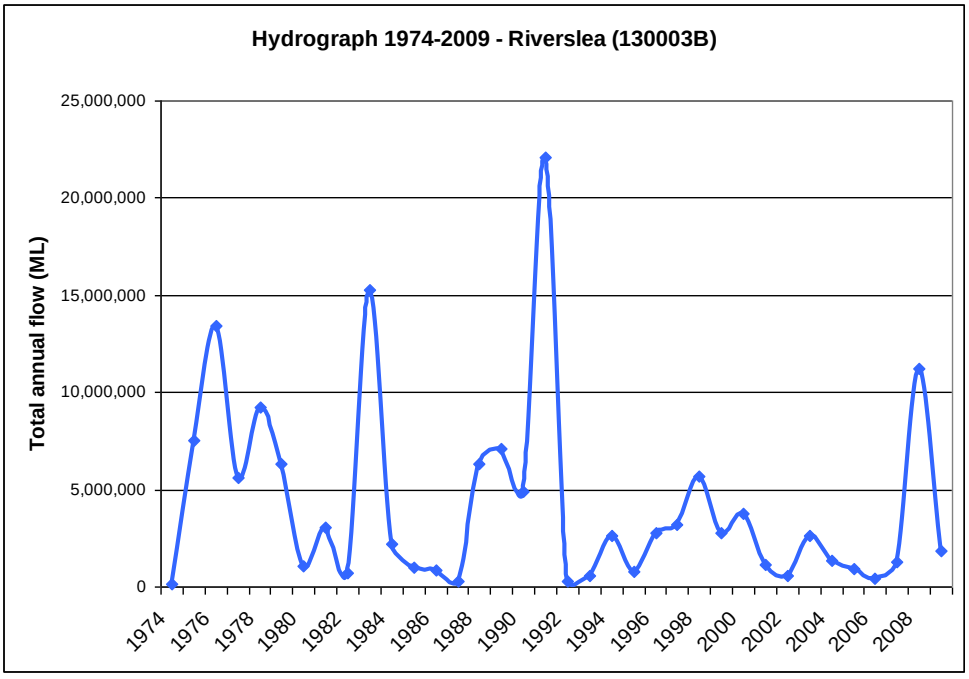
Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Places, Waterways (2007); Sunwater: Waterways, Weir Locations - 2008; DNRM: Railways, Roads, Fitzroy River Delta, Stream Gauges - 2010;
GHD: Impoundment Area, Crossings (2012), Flow assessment locations - 2014. Created by: MS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

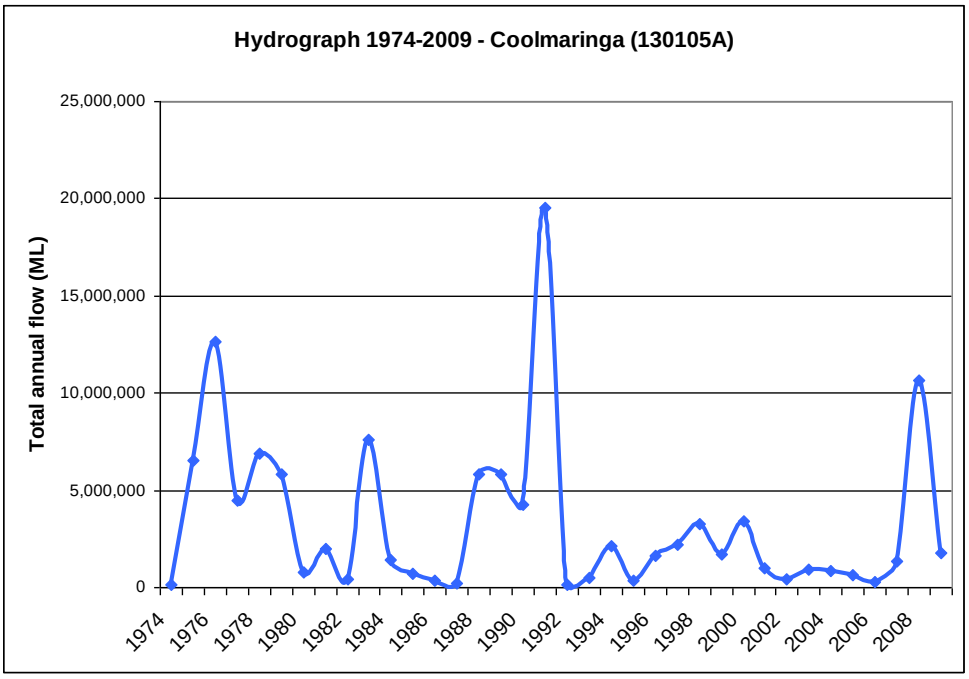
Figure 3-2 Hydrographs for the historic (1974 – 2009) period



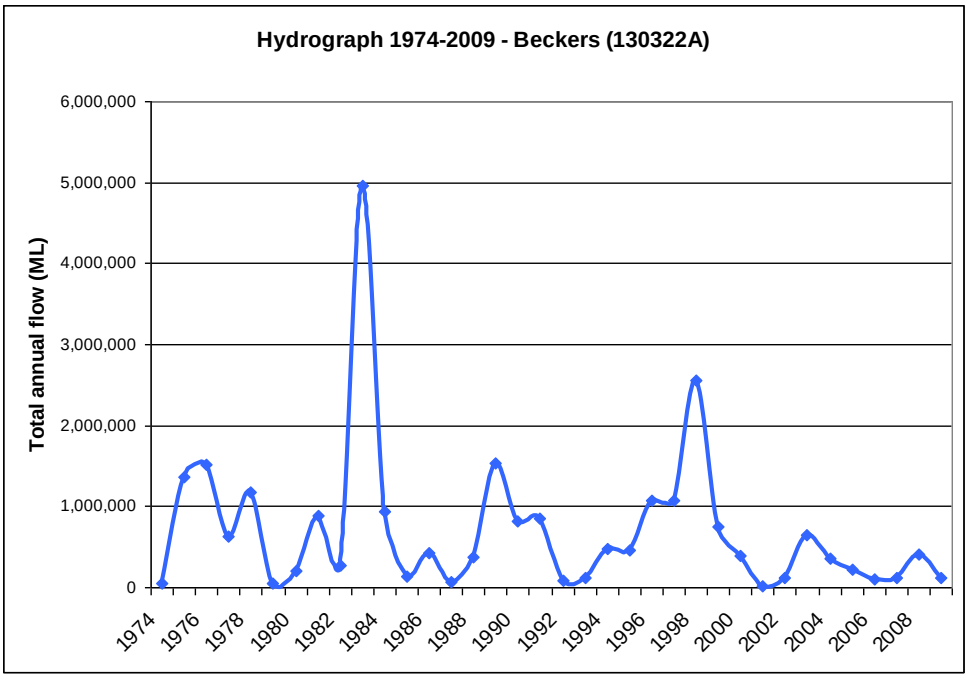
(a) The Gap gauging station (130 005A) (Fitzroy River)



(b) Riverslea gauging station (130 003B) (Fitzroy River)

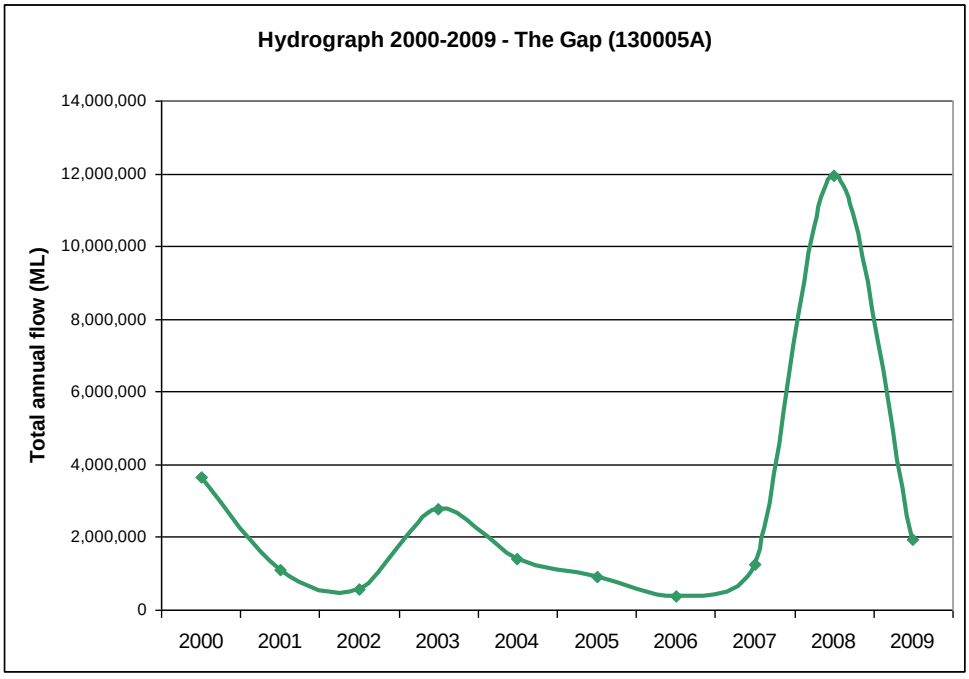


(c) Coolmaringa (130 105A) gauging station (Mackenzie River)

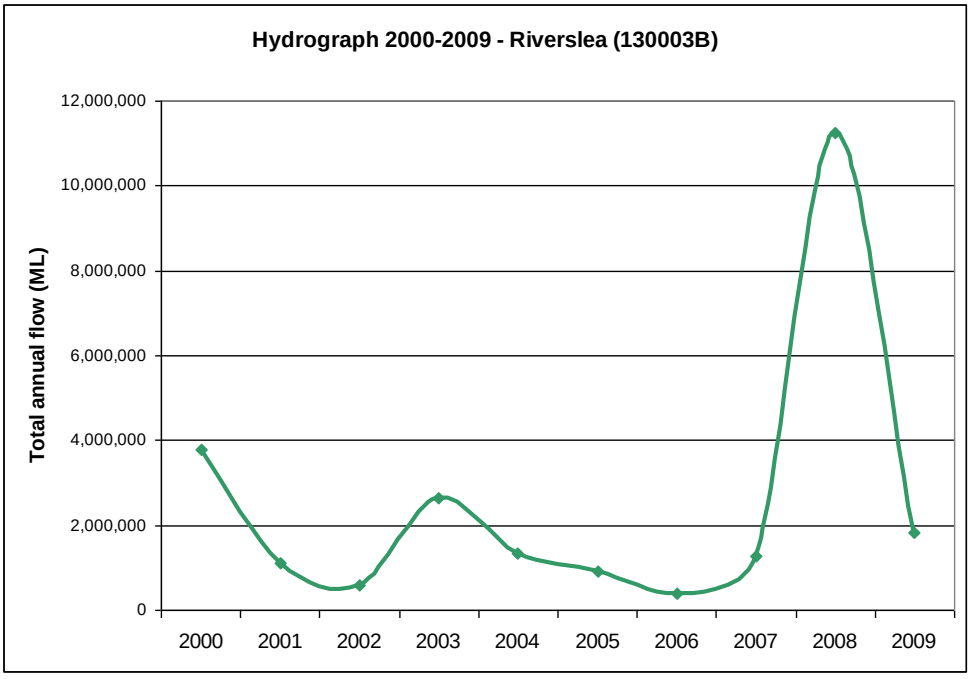


(d) Beckers gauging station (130 322A) (Dawson River)

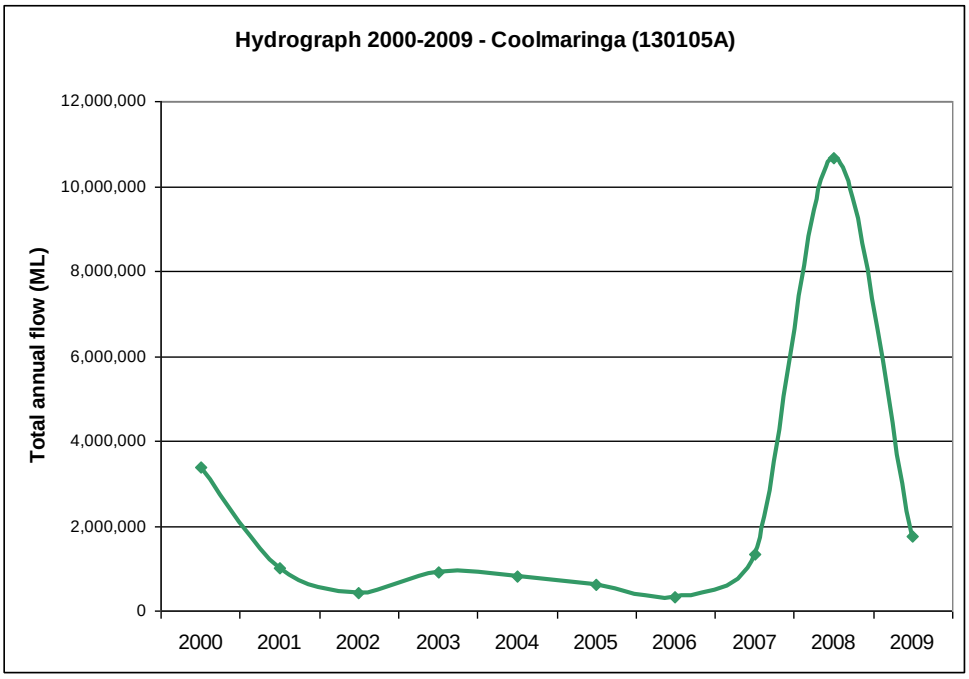
Figure 3-3 Hydrographs for the current (1999 – 2009) period



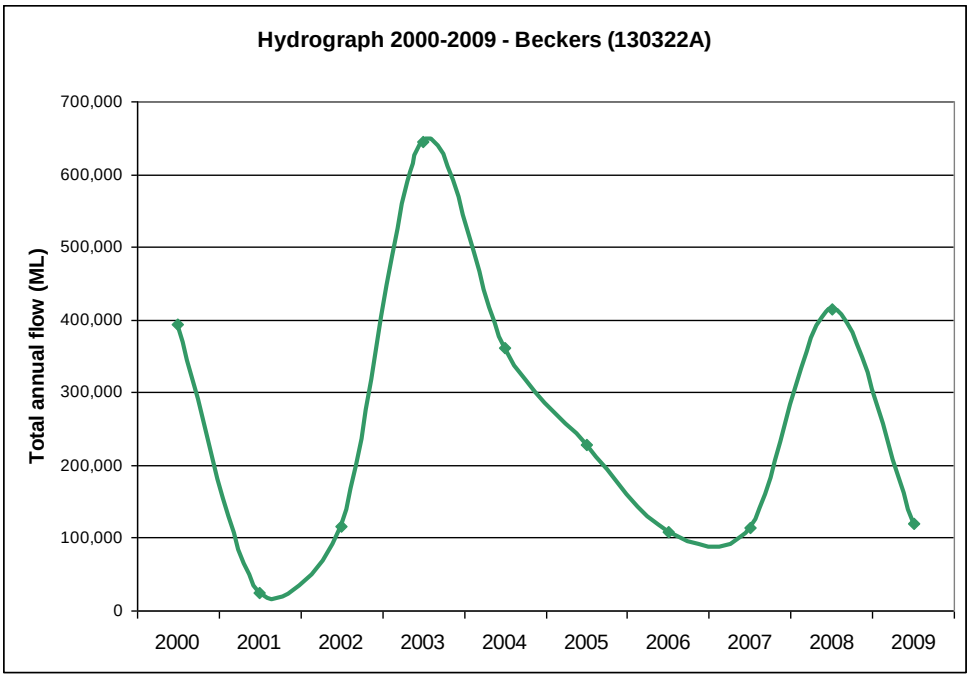
(a) The Gap gauging station(130 005A) (Fitzroy River)



(b) Riverslea gauging station (130 003B) (Fitzroy River)



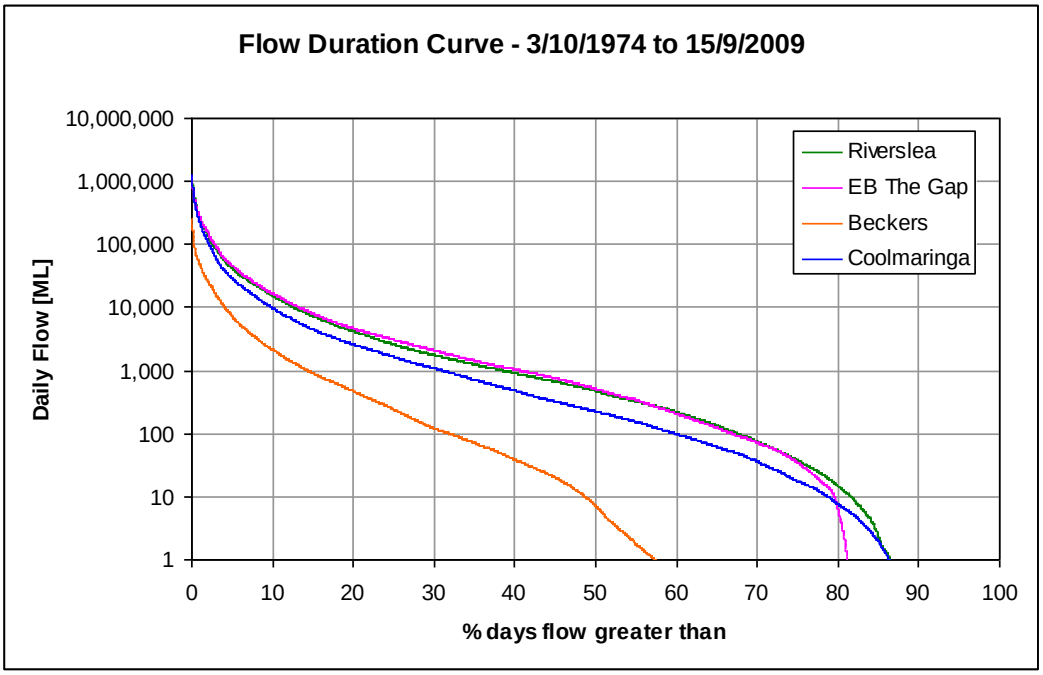
(c) Coolmaringa (130 105A) gauging station (Mackenzie River)



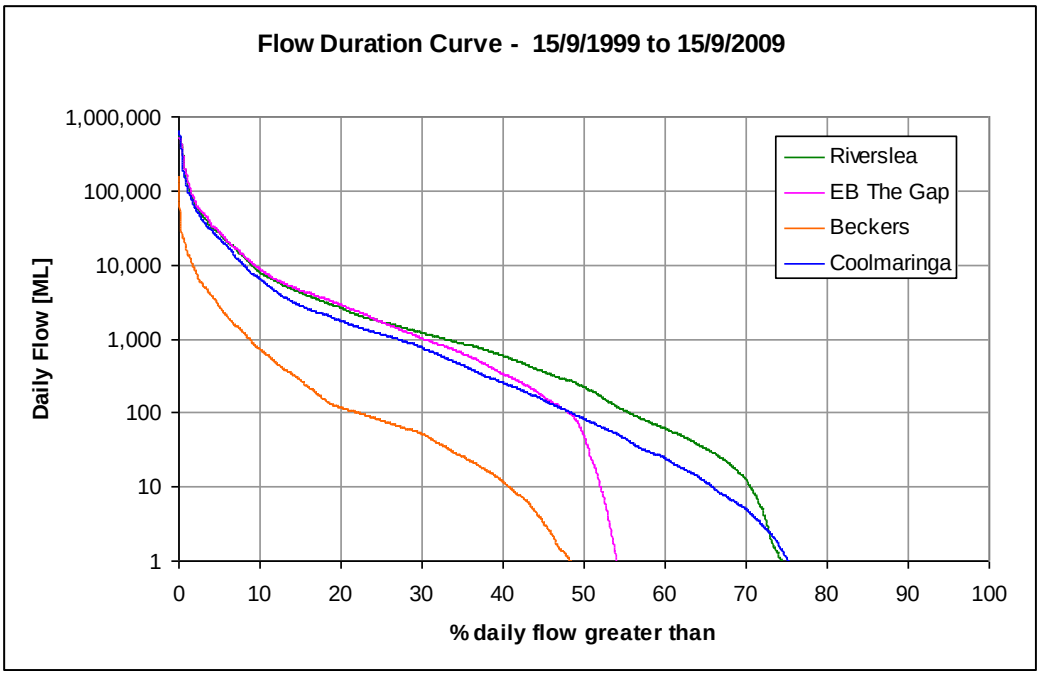
(d) Beckers gauging station (130 322A) (Dawson River)

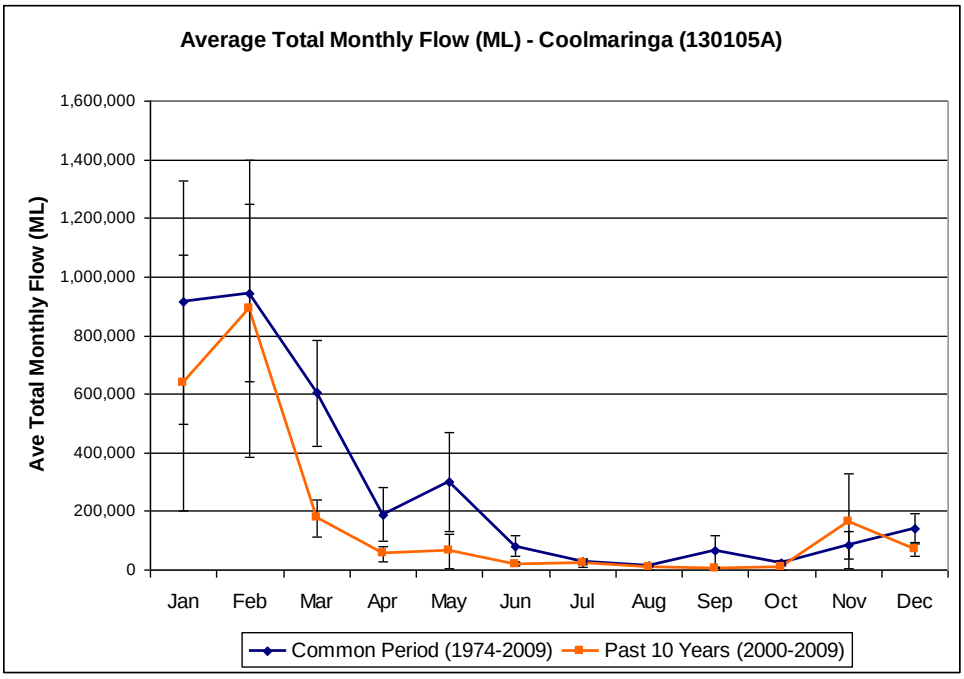
Figure 3-4 Flow duration curves for the historic and current periods

(a) Historic period (1974 – 2009)

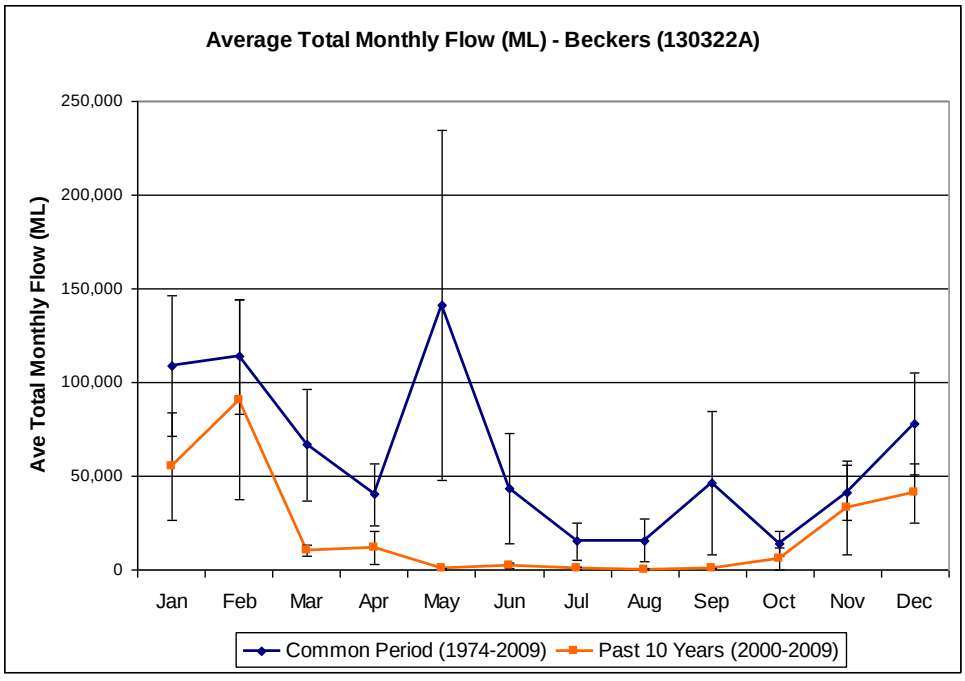


(b) Current period (1999 – 2009)





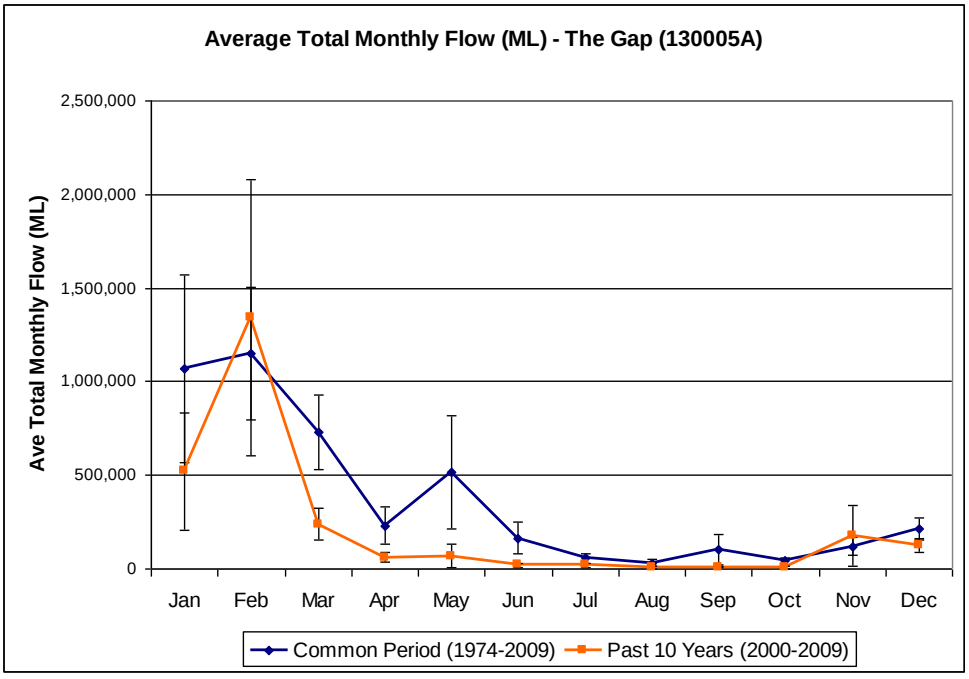
(c) Coolmaringa gauging station (130 105A) (Mackenzie River)



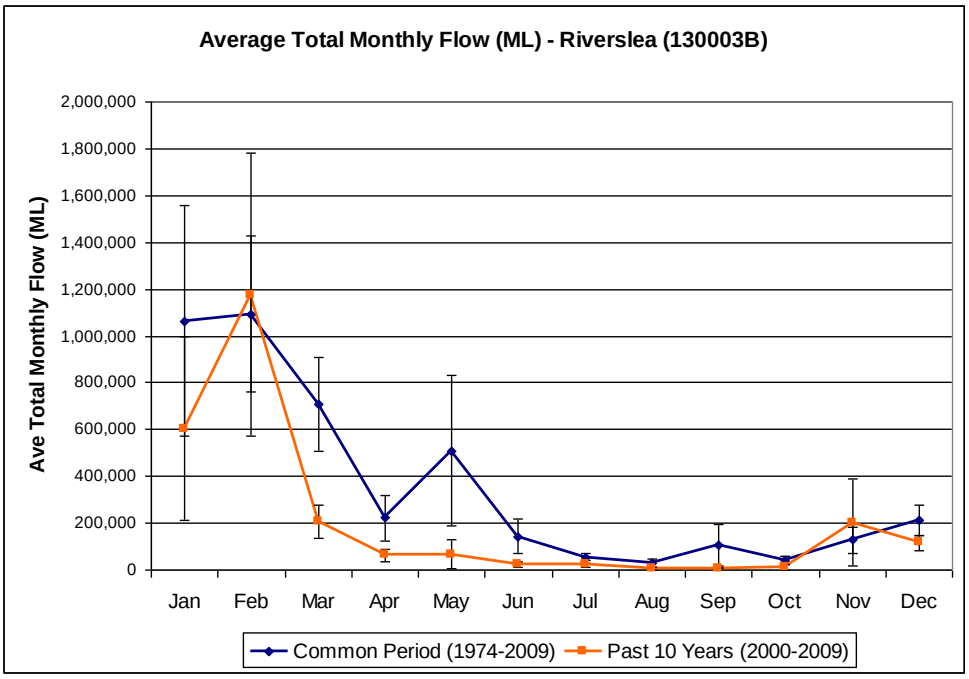
(d) Beckers gauging station (130 322A) (Dawson River)

Note: standard error represented by vertical bars.

Figure 3-5 Total average monthly flows for the historic and current periods



(a) The Gap gauging station (130 005A) (Fitzroy River)



(b) Riverslea gauging station (130 003B) (Fitzroy River)

3.2 Flooding

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 January 1918 and reached 10.11 m on the Rockhampton gauge.

A summary of significant flood events, the respective peak gauge heights along the Fitzroy River (at Riverslea, Yaamba and Rockhampton), Mackenzie River (at Tartrus) and Dawson River (at Moura) (in the vicinity of the Project areas) and flood classification are detailed in Table 3-2.

Table 3-2 Significant flood events and peak gauge heights

River system	Fitzroy			Mackenzie	Dawson
Gauge description	Riverslea	Yaamba	Rockhampton	Tartrus	Moura
Flood event	Peak gauge height (m)*				
January 1918	31.48	17.32	10.11	-	-
February 1954	28.60	16.59	9.40	17.48	-
January 1978	23.15	14.75	8.15	16.60	10.46
April/May 1983	22.89	14.97	8.25	14.90	12.09
December 1990/January 1991	27.97	16.65	9.30	18.10	6.60
January 2008	21.93	14.25	7.50	16.20	8.00
December 2010/January 2011	27.38	16.55	9.20	16.34	12.66
January/February 2013	25.11	15.70	8.60	15.87	9.30

*Flood classification key (BOM 2011)	Major - inundation of large areas, isolating towns and cities, with major disruptions occurring to road and rail links. Also, evacuation of many houses and business premises may be required, and in rural areas widespread flooding of farmland is likely. At Rockhampton a major flood occurs when the river height exceeds 8.5 m At Yaamba a major flood occurs when the river height there reaches 15.0 m At Riverslea a major flood is defined as occurring when the river height is 24.0 m At Tartrus, a river height of 15.0 m denotes a major flood At Moura a river height of 12.0 m denotes a major flood
	Moderate - inundation of low lying areas requiring the removal of stock and/or the evacuation of some houses and main traffic bridges may be closed by floodwaters
	Minor - causes inconvenience such as closing of minor roads and the submergence of low level bridges and makes the removal of pumps located adjacent to the river necessary

The January 1918 flood is considered to be the largest of the recorded events and constituted a major flood in the lower Fitzroy River. During this period the average rainfall across the catchment was approximately 673 mm with the heaviest rainfall occurring in the eastern part of the Isaac River catchment, and through most of the lower Fitzroy River basin. The rainfall event was estimated to last for 42 days. The rainfall due to this event was associated with an intense cyclone that crossed the coast near Mackay. After crossing the coast, this cyclone produced heavy rain over most of the State (BoM, 2010a).

The February 1954 flood event was also associated with a cyclonic event and from rain that fell in the south-east corner of the State (BoM, 2010b), with the heaviest rainfall having occurred in the Mackenzie River basin. The average rainfall across the catchment was approximately 500 mm with the event lasting an estimated 28 days. The 1954 event was classified as a major flood in both the Fitzroy and Mackenzie rivers.

The average catchment rainfall during the April/May 1983 event was 405 mm, and appears to have been fairly evenly distributed across the entire Fitzroy River catchment. The flood event was classified as major on the Dawson River and moderate on the Mackenzie and Fitzroy rivers (albeit at the upper extremes of the classification).

The December 1990/January 1991 flood event was associated with rainfall from tropical cyclone Joy which made landfall in the Ayr region and moved in a south-westerly direction. This led to very heavy rainfall in the Isaac River basin during late December as the cyclone degenerated into a rain depression (BoM, 2010d). Significant rainfall occurred in the lower Fitzroy River basin while the rainfalls across the Mackenzie River and Dawson River catchments were lower still. The average catchment rainfall for the event is estimated at 360 mm with a duration of 28 days.

Several rainfall events occurred in December 2010 that resulted in extensive rainfall across the Fitzroy River catchment. Between 28 November and 4 December 2010, a trough remained over eastern Australia in a humid northerly airstream and the rainfall band in central Queensland extended from Mackay southwards to the Emerald area. Two other trough systems formed in December (between the 7th and 13th, and 19th and 20th) that generated modest rainfall totals (between 50 mm and 100 mm) before further moisture was brought to the region by tropical cyclone Tasha which made landfall south of Cairns on the morning of 25 December (BoM 2011). The largest rainfall totals were recorded in the headwaters of the Isaac River catchment, and in the southern region of the Mackenzie River catchment. It is considered that the 2010 event closely resembled the 1918 event in terms of rainfall with the average rainfall across the entire catchment being approximately 642 mm. The event duration is estimated at 42 days.

Table 3-3 presents the annual series flood frequency analysis for four locations on the Fitzroy River at Yaamba (130 001), Wattlebank (130 002), Riverslea (130 003), and The Gap (130 005) (Figure 3-1). The existing flood extents for Eden Bann Weir (Stage 1) and the Rookwood site (no development) are shown in Appendix E and Appendix F, respectively.

Table 3-3 Annual series flood frequency analysis

Annual exceedance probability (AEP) event	Peak flow rate (m^3/s)			
	Yaamba	Wattlebank	Riverslea	The Gap
	Catchment area (km^2)			
	136,400	135,900	131,400	135,800
1 in 2 year	2,310	2,070	2,300	2,000
1 in 5 year	6,100	4,710	5,500	4,900
1 in 10 year	9,140	7,340	8,230	7,350
1 in 20 year	12,200	10,700	11,200	9,960
1 in 50 year	16,000	16,400	15,400	13,600
1 in 100 year	18,800	22,000	18,800	16,500

4. Potential impacts on stream flow patterns

4.1 Overview

The IQQM-Project was used to predict potential changes to flow regimes at five locations within and downstream of the Project areas as a result of implementing selected development scenarios. This was achieved by using the IQQM-Project to simulate the movement of surface water flows throughout the system on a daily basis over the simulation period which for the Fitzroy WRP is the period from 1 January 1900 to 31 December 2007.

Figure 3-1 shows the assessment locations summarised in Table 4-1. Table 2-3 provides a description of the development scenarios assessed.

Table 4-1 Flow analysis data locations

Reference	Assessment location	Description
IQQM1	End of system	A location 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 at 142.1 km AMTD, approximately 1 km upstream from the existing Eden Bann Weir and situated within the current impoundment since 1994.
IQQM4	-	An area downstream of Rookwood 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.

Hydrographs were developed to illustrate pre- and post-development flows (Section 4.2).

Flow duration curves were generated for each location comparing development scenarios to the existing case (EB1) over the entire time series (Section 4.3). To further differentiate what is occurring at each location for the various scenarios, a sensitivity analysis was conducted. This sensitivity check was done by determining flow duration curves at each location for the 10th (dry) and 90th (wet) percentiles years. Each development scenario was plotted against the existing case (EB1) to gauge the variance of the larger flow events across the varying climatic conditions. These plots demonstrate how each scenario responds to variance in climate, and the associated variance in rainfall. This information can be used to determine which scenarios are impacted most or less by changing rainfall and climate and, for example, it may show that an option which presents a more desirable median value in fact has greater uncertainty when it comes to more extreme climatic conditions.

In addition, statistical analysis was undertaken for 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 as described in Section 5.

4.2 Stream flow hydrographs

Stream flow hydrographs representing pre-development (EB1, base case) versus development scenarios are presented in Appendix C.

4.3 Stream flow duration curves

Stream flow duration curves representing pre-development (EB1, base case) versus development scenarios are presented in Appendix D.