8. Water Resources

8.1 Existing Surface Water Resources

8.1.1 Burnett Catchment and Burnett Basin

The Burnett River rises in the Burnett Ranges east of Monto and flows some 400 km to discharge into the sea at Burnett Heads. Other major streams in the catchment include:

- Three Moon Creek;
- Nogo River;
- Auburn River;
- Boyne River;
- Barambah Creek;
- Perry River; and
- Degilbo Creek.

The Burnett River Catchment has an area of 33 380 km2.

Water resource management in the area is based on the Burnett Basin Water Resources Plan, which includes the catchments of:

- Burnett River;
- Kolan River;
- Gregory River;
- Elliott River; and
- Isis River.

The Burnett River Basin has an area of 38 000 km^2.

The Burnett River catchment and major streams are shown in **Figure 3.1.**

Land uses within the catchment include:

- Agriculture (sugar cane, cereals, horticulture, citrus, pasture);
- Stock grazing (mainly cattle);
- State forest;
- National Parks and conservation areas; and
- Urban and town areas.

The predominant landuse in the catchment is grazing which covers an estimated 75% of the catchment area. Agricultural and "other rural use" each comprise approximately 10% of the area. Urban landuse occupies approximately 5% of the catchment area.

8.1.2 Surface Water Hydrology

8.1.2.1 Overview

The major streams of the Burnett Basin, their catchment area and stream length are listed in **Table 8.1** below. The principal flow direction for the river is south in the inland reaches, east in the middle section and finally north-east towards Bundaberg and the coast.

Table 8-1 Major Streams in the Burnett Basin

Major Streams	Stream Length (km)	Catchment Area (km^2)
NORTH BURNETT		
Monal Creek	72	350
Three Moon Creek	156	1 580
CENTRAL BURNETT		
Eastern Creek	66	490
Upper Burnett		1 010
Burnett River at Ceratodus	117	3 910
Nogo River	120	2 485
Ungauged		765
Burnett River at Eidsvold		7 160
Auburn River	251	7 380
Ungauged		1 610
Boyne River		5 735
Burnett River at Jones Weir		21 885
Reids Creek	86	790
Ungauged		815
Burnett River at Gayndah	236	23 311
Barambah Creek	434	5 905
Ungauged		179
Burnett River at Mt Lawless		29 395
SOUTH BURNETT		
Barker Creek		1 670
Upper Barambah Creek	172	3 185
Stuart River	166	1 785
Upper Boyne River		4 200
LOWER BURNETT		
Ungauged		1 895
Degilbo Creek	61	750
Perry River	55	415
Burnett River at Walla	438	32 455
Ungauged		640
Burnett River at Ben Anderson Barrage		33 085
Ungauged		305
Burnett River estuary		33 380
OTHER STEAMS		
Kolan River at Fred Haigh Dam		1 300
Gin Gin Creek		740
Kolan River at Bucca		2 385
Kolan River at Barrage		2 539
Kolan River estuary	187	2 795
Elloitt River	57	365
Gregory River	127	855
Isis River		530

Source: DNRM – Burnett Catchment Appraisal Study, June 2001

Note: Catchment areas shown for the Burnett River gauging stations are the cumulative total area of all sub-catchments above that site.

8.1.2.2 Existing Water Storage Structures

Water storage development in the Burnett Basin has been occurring gradually over the past 35 years mainly for agricultural developments with small industrial demands for mining and power generation. A summary of the existing water storage structures within the Burnett Basin is provided in **Table 8.2**. From **Table 8.2** it can be seen that within the basin the distribution of existing water storages based on storage volume is as follows:

- large storages (> 100 000 ML) 4
- moderate storages (100 000 ML – 10 000 ML) 4
- small storages (10 000 ML – 1 000 ML) 6
- minor storages (< 1 000 ML) 11

These structures provide a total storage capacity of 1 267 142 ML. Approximately 50% of this capacity is in the Burnett River catchment, with 6% of this storage on the main river. From the existing infrastructure in the basin, a total nominal allocation of319 385 ML/a is available with 192 233 ML/a from the Burnett catchment and 127 152 ML/a from the Kolan catchment. These water supplies are fully committed.

Table 8-2 Existing Water Storage Structures in the Burnett Basin

Stream	Storage	Date Completed	AMTD (km)	Catchment Area (km^2)	Storage Capacity at FSL (ML)	Dead Storage (ML)	Inundated Area at FSL (ha)	Nominal Allocation (ML/a)
NORTH BURNETT								
Three Moon Creek	Cania Dam[1]	1982	110.1	285	89 000	1 200	720	15 314
Monal Creek	Mungungo Weir	1951	16.2	250	166	16	9	
Three Moon Creek	Youlambie Weir	1974	70.3	660	143	2	8	
Three Moon Creek	Monto Weir	1972	64.8	700	27	3	3	
Three Moon Creek	Bazley Weir	1988	58.7		75	14	5	
Three Moon Creek	Avis Weir	1988	46.8		275	0	15	
Three Moon Creek	Mulgildie Weir	1952	35.9	1 345	333	40	13	
Sub-total					90 019	1 275	773	15 314
CENTRAL BURNETT								
Nogo River	Wuruma Dam	1969	23.0	2 320	165 000	2 000	1 640	9 450
Burnett River	John Goleby Weir	1986	324.0		1 700	60	59	1 560
Burnett River	Jones Weir	1951	240.1	21 885	3 720	700	167	5 985
Burnett River	Claude Wharton Weir	1987/1992	202.4		12 600	52	363	11 970
Sub-total					183 020	2 812	2 229	28 965
SOUTH BURNETT – Boyne Catchment								
Boyne River	Boondooma Dam	1982	86.7	4 200	212 000	2 840	1 920	42 783
Stuart River	Gordonbrook Dam	1942	83.0	605	2 960	0	-	1 100
Burnett River	Proston Weir	1967	30.3	1 530	123	5	11	430
Sub-total					215 083	2 845	1 933	44 313
SOUTH BURNETT – Barambah Catchment								
Barker Creek	Nanango Weir	1951	85.7	660	154	10	8	
Barker Creek	Bjelke-Petersen Dam	1989	1.3	1 670	125 000	1 000	2 150	32 439
Barambah Creek	Joe Sippel Weir	1983	171.8	645	732	72	28	
Barambah Creek	Silverleaf Weir	1953/1995	120.4	2 915	621	35	24	
Barambah Creek	Murgon Weir	Unknown	148.9	2 470	500	49	-	
Sub-total					127 720	1 166	2 210	32 439
LOWER BURNETT								
Burnett River	Walla Weir	1998	74.5	32 760	29 600	2 247	-	
Burnett River	Ban Anderson Barrage	1983	25.9	32 635	22 300	6 647	631	
Burnett River	Bingera Weir	1933	42.5	32 635	4 800	406	-	
Kolan River	Fred Haigh Dam[2]	1975	76.4	2 565	586 000	3 2525	5 340	198 354[3]
Kolan River	Bucca Weir[2]	1987	38.0	2 385	9 800	3 038	231	
Kolan River	Kolan Barrage[2]	1973	14.5	2 565	3 950	2 240	219	
Sub-total					656 450	47 103	6 421	198 354
TOTAL					**1 267 492**	**55 201**	**13 566**	**319 385**

Source: DNRM – Burnett Catchment Appraisal Study, June 2001

Notes:
1. Cania Dam is primarily for groundwater recharge
2. These storages are on the Kolan River and outside the Burnett Catchment
3. Total allocation for Bundaberg Water Supply Scheme.

The existing water storage structures in the Burnett Basin impound 410 km or about 21% of the length of reaches of the major rivers and creeks within the basin. The construction of the Burnett River dam will impound an additional 45 km of the Burnett River. This will result in approximately a 2.2% increase in the total length of the impounded waterway in the basin.

8.1.2.3 Current Operation of Storages

There are a number of storages in the Burnett catchment, including several weirs in the lower Burnett reaches on which the proposed Burnett River Dam is located. Many of the larger storages in the catchment service the BWSS and other regulated watercourses. They are generally operated in conjunction with each other by means of relatively complex operating rules. Storages outside of these regulated sections are mostly operated independently of each other.

These complex patterns of interaction between the storages in the catchment are incorporated into the IQQM model. At present, the majority of the management rules for storages within the catchment are focussed on maintaining a reliable supply of water to regulated water users. This means that most storages are managed so that the maximum amount of water is available for use during the summer irrigation period. The rules incorporate a certain amount of risk that the storages will be "empty" in some years, however this is offset by the fact that this makes more water available to users on average over several years.

A relatively small amount of the storage in the catchment is managed to provide a highly reliable supply – mainly for town and industrial water users. The general operating philosophy for these storages is more conservative than for irrigation storages, and their management rules are focussed on ensuring that the storage never empties while still satisfying the water needs of its users. As a result these storages will tend to be "fuller" than irrigation storages at any particular point in time.

8.1.2.4 Flows Upstream and Downstream

Streamflow data for selected stations along the Burnett River are provided in **Table 8.3**. This table presents historical and modelled streamflows for pre-development and existing development scenarios as prepared for the draft WAMP using IQQM modelling. Discrepancies between actual historic flow records and modelled existing stream flows may be due to the assumptions of the model. Nevertheless, inclusion of the pre-development model allows comparison with the modelled existing streamflows using the same assumptions.

Table 8.3: Comparison of Historic, No Development and Existing Annual Flow Statistics for Gauging Stations Along the Burnett River

Burnett River Station	Gauging Station	Time Period for Comparison	Historic Flows				No-Development Case				Existing Entitlement Case			
			Mean Annual (ML)	Median Annual (ML)	Cv(1)	Iv(2)	Mean Annual (ML)	Median Annual (ML)	Cv	Iv	Mean Annual (ML)	Median Annual (ML)	Cv	Iv
Ceratodus	136103B	1986-1997	94639	40028	1.07	1.36	110710	50591	1.19	1.13	91682	33144	1.27	1.54
Eidsvold	136106A	1986-1997	133314	61771	1.04	0.94	148917	67426	1.15	0.93	128515	59135	1.07	0.94
Jones Weir Tailwater	136094A	1986-1997	223656	80422	1.18	0.90	314363	123790	1.13	0.63	219005	73917	1.24	0.94
Mount Lawless	136002D	1987-1997	441557	164278	0.94	0.49	611018	248017	0.92	0.58	440748	148322	1.01	0.58
Figtree	136007A	1890-1997	N/A	N/A	N/A	N/A	1381741	841561	1.24	0.58	1198788	672015	1.38	0.63
Walla Weir Tailwater	136008A	1890-1997	N/A	N/A	N/A	N/A	1689299	992449	1.19	0.58	1516330	840468	1.28	0.65
Ben Anderson Barrage TW	136014B	1890-1997	N/A	N/A	N/A	N/A	1706037	982619	1.20	0.57	1408708	695009	1.40	0.72

Source: Condensed from Burnett WAMP – Appendix C (DNR Surface Water Assessment Group, 2000)
(1) Co-efficient of variation
(2) Inter-annual flood variability

The change in flow regimes of the Burnett River since the commencement of development in the catchment was assessed (Brizga, 2000) as part of the WAMP studies leading to the formulation of the WRP. It was concluded that despite the presence of several weirs, the river has not been altered by historic water resources development to as great a degree as tributaries with dams. There are no major dams on the Burnett River itself, and the impacts of dams in tributary catchments are mitigated by flows from unregulated tributaries. High flows in the Burnett River have been reduced, but typically remain at least 70% or more of the undeveloped regime, compared with the much greater reductions reported at tributary sites in the near existing dams. The effects of water resources development on low and medium flows vary along the river, in some places they are elevated and more sustained, and in others reduced and less sustained.

8.1.2.5 Flows at Burnett River Dam Site

The closest gauging station to the Burnett River Dam site is the Figtree Gauge (GS136007A) located at AMTD 119km. This gauge is 12 kilometres downstream of the dam site. The gauge was opened in January 1997. Flow statistics have been calculated at the site as it is a reference node in the WRP (Node 2). These statistics are based on the WRP simulation period of 1 July 1890 to 30 June 1997, 107 years.

These statistics have been calculated for the Existing Entitlements Case (IQQM model Case). This case represents the full utilisation of existing water allocation entitlement in the Burnett River system.

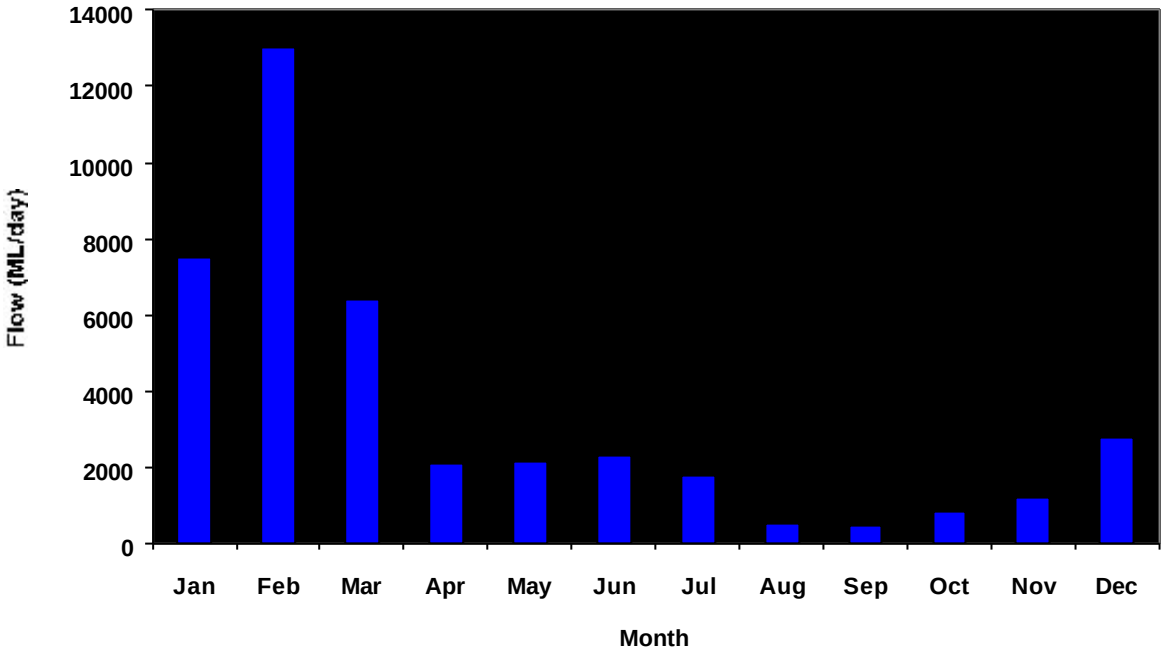
The mean annual flow (MAF) in Burnett River calculated at Figtree is 1 233 484 ML while at the river mouth the MAF was estimated to be 1 547 809 ML.

The seasonal variation in river flows at the dam site are represented by the estimated mean daily flows in each month at Figtree, presented in **Figure 8-1** and **Table 8.4**. These represent unmodified inflows to the proposed dam, and are also representative of existing entitlement flows upstream of the storage.

Table 8-4 Mean Monthly Flow Statistics Burnett River at Figtree, ML/day

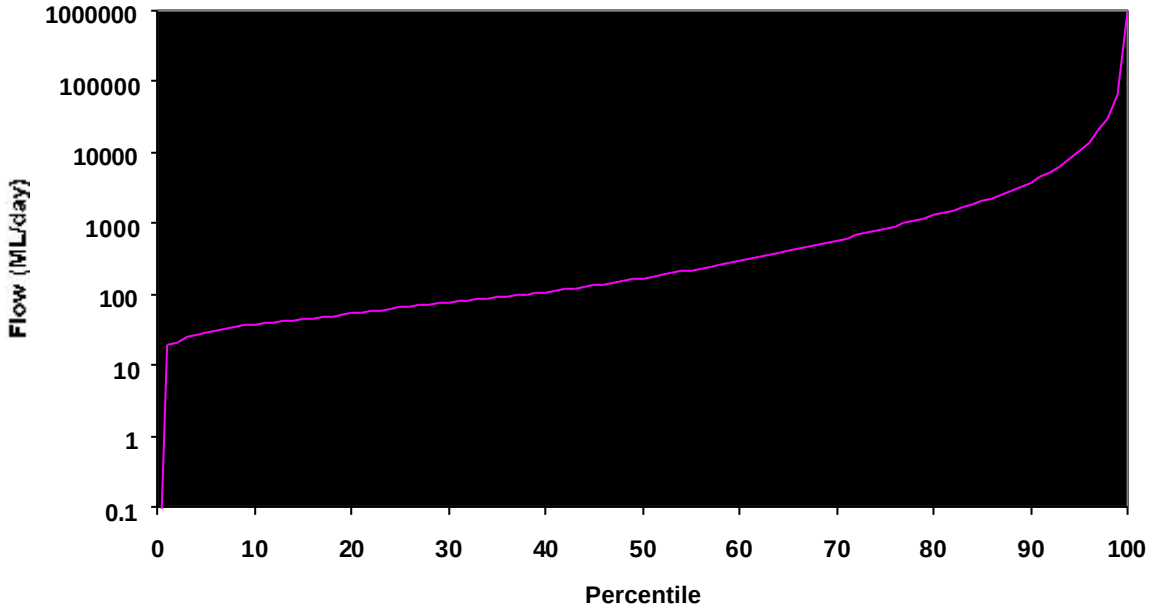
Month	Flow (ML/day)					
	Mean	Max	10% Exceedence	50% Exceedence	90% Exceedence	Min
January	7 486	679 499	11 479	617	61	1
February	13 044	996 849	18 834	788	73	2
March	6 393	408 514	11 301	570	76	3
April	2 089	273 293	3 174	222	45	4
May	2 158	331 262	1 700	109	40	5
June	2 288	462 619	2 793	123	37	6
July	1 758	725 042	1 876	126	22	7
August	542	49 345	733	73	26	0
September	445	59 245	713	96	24	0
October	838	114 136	974	90	29	0
November	1 223	97 176	2 783	112	35	0
December	2 774	377 011	4 598	300	51	12

Figure 8-1 Mean Daily Flow at Figtree



Flow duration characteristics of Burnett River at Figtree are illustrated in **Figure 8-2**

Figure 8-2 Daily Flow Duration Curve at Figtree (Existing Entitlements Case)



In this diagram, the flow is less than or equal to the magnitude shown on the vertical axis for the percentage of time shown on the horizontal axis. For example the flow will be equal to or less than 200 ML/day for about 50% of the time in the Existing Entitlements Case at this site, while the flow will be at or below 2 000 ML/day for about 80% of days.

8.1.4 Water Resources (Burnett Basin) Plan

The Water Resources (Burnett Basin) Plan 2000 was legislated to provide a sustainable framework for allocation and general water management within the Burnett Basin. This legislation follows consideration of submissions regarding the Draft Water Allocation Plan (WAMP) for the Burnett Basin.

The WRP aims to maintain adequate supplies to existing users while giving consideration to the riverine environment. A framework for assessment of future water allocations and development is also provided

The purpose of the WRP is to provide a legislative framework for a 10 year period for the sustainable allocation and management of water in the Burnett River Basin. The WRP sets limits on additional water allocations to varying extents in the basin.

Average annual surface water diversions for current levels of water resources development in the Burnett Basin were estimated in the Draft WAMP at 380,000 ML/annum. This would rise to 430,000 ML/annum as existing water entitlements become fully utilised. This increase will be due to the implementation of existing licences which are currently not being utilised.

The data presented in the previous section has been sourced from simulations undertaken with the IQQM model. This model simulates catchment behaviour in response to climate conditions and recorded or estimated river flows. The model has been used to simulate the historical 107 years period from 1890 to 1997.

In addition to the standard hydrological statistics presented above, the Technical Advisory Panel (TAP) involved in the assessment of environmental flow requirements for the draft WAMP, has assessed a range of additional flow statistics which are intended to be linked to the ecological response of the waterway systems.
These flow statistics have been established as performance indicators in the WRP.

These statistics have been separated into two broad categories:

(a) medium to high flow environmental flow objectives (MHFEFOSs) as documented in Schedule 5 Part 2 of the WRP

(b) low flow environmental flow objectives (LFEFOSs) as documented in Schedule 5 Part 1 of the WRP.

Flow statistics generally relevant to river channel geomorphology and estuarine habitats are included in the MHFEFOSs. These include:

1) **Annual proportional flow deviation (APFD)** means the statistical measure of changes to flow season and volume in the simulation period.

2) **Flow regime class (FRC)** means the measure of flow regime seasonality.

3) **Mean annual flow (MAF)** means the total volume of flow in the simulation period divided by the number of years in the simulation period.

4) **Mean wet season flow (MWSF)** means the total volume of flow during the months of January to March in the simulation period divided by the number of years in the simulation period.

5) **1.5 year average recurrence interval daily flow volume (1.5 year ARI)** means the daily flow volume that has a 67% probability of being reached at least once a year.

6) **5 year average recurrence interval daily flow volume (5 year ARI)** means the daily flow volume that has a 20% probability of being reached at least once a year.

7) **20 year average recurrence interval daily flow volume (20 year ARI)** means the daily flow volume that has a 5% probability of being reached at least once a year.

Flow statistics generally relevant to instream ecosystems and processes are included in the LFEFOSs. These include:

1) <2 ML daily flow

2) **50% daily flow exceedence (50%DFE)** for a month, means the flow, in megalitres, that is equalled or exceeded on 50% of days in the month in the simulation period.

3) **90% daily flow exceedence (90% DFE)** for a month, means the flow, in megalitres, that is equalled or exceeded on 90% of days in the month in the simulation period.

4) **Low flow exceedence duration (10 cm above cease-to-flow) (LFED 10 cm)** means the percentage of the total number of days in the simulation period that the watercourse's daily flow is at least 10 cm above the cease –to-flow level in the watercourse at a given location.

5) **Low flow exceedence duration (30 cm above cease-to-flow) (LFED 30 cm)** means the percentage of the total number of days in the simulation period that the watercourse's daily flow is at least 30 cm above the cease –to-flow level in the watercourse at a given location.

6) Number of periods of no flow of at least 1 month in the simulation period (NF1)

7) Number of periods of no flow of at least 3 months in the simulation period (NF3)

8) Number of periods of no flow of at least 6 months in the simulation period (NF6)

9) Number of periods of no flow of at least 9 months (NF9).

In the WRP these statistics are specified at 2 nodes relevant to the Burnett River Dam. These locations are:

- Node 1 Burnett River Mouth (EOS)
- Node 2 Figtree Gauging Station (AMTD 119 km)

The location of these nodes and other locations used for assessments are shown on **Figure 8.3**.

These statistics are presented for the existing entitlements case and compared with the specified Performance Indicators in the WRP in **Table 8.5** for Node 1 and **Table 8.6** for Node 2.

Table 8-5 Existing Entitlements Flow Statistics at Node 1 Burnett River Mouth

Environmental Flow Objectives	WRP Specification for Performance Indicators	Existing Entitlements Case
Medium to High Flows		
APFD	<2	1.08
FRC	Late Summer	Late Summer
MAF	>75% of PF (1)	83%
MWSF	>80% of PF (1)	88%
1.5 year ARI	>69% of PF (1)	95%
5 year ARI	>71% of PF (1)	89%
20 year ARI	>82% of PF (1)	94%
Low Flows		
<2 ML	Between 2-18% (2)	5%
50% DFE	Between 32% and 68% of days in month ≥ flow of ML (3)	
	Month: Jan — No. of Days: 10-21 — Flow (ML/d): 1310	11 days
	Feb — 9-19 — 1519	11 days
	Mar — 10-21 — 1154	11 days
	Apr — 10-20 — 583	9 days
	May — 10-21 — 315	9 days
	Jun — 10-20 — 280	10 days
	Jul — 10-21 — 255	11 days
	Aug — 10-21 — 154	8 days
	Sept — 10-20 — 137	6 days
	Oct — 10-21 — 212	6 days
	Nov — 10-20 — 370	6 days
	Dec — 10-21 — 789	8 days
90% DFE	Between 72% and 100% of days in month ≥ flow of ML/d (4)	
	Month: Jan — No. of days: 22-31 — Flow (ML/d): 173	16 days
	Feb — 20-28 — 191	16 days
	Mar — 22-31 — 163	16 days
	Apr — 22-30 — 73	15 days
	May — 22-31 — 49	17 days
	Jun — 22-30 — 38	17 days
	Jul — 22-31 — 28	20 days
	Aug — 22-31 — 23	17 days
	Sept — 22-30 — 13	17 days
	Oct — 22-31 — 15	15 days
	Nov — 22-30 — 28	10 days
	Dec — 22-31 — 132	12 days
LFED10	N/A	-
LFED30	N/A	-
NF1	Between 0-2 events	4
NF3	0 events	0
NF6	0 events	0
NF9	0 events	0

(1) Pre-development Flow
(2) Of the total number of days in the simulation period
(3) Flow stated for each month should be equalled or exceeded between 32% and 68% of the total number of days in the month in the simulation period.
(4) Flows stated for each month should be equalled or exceeded between 72% and 100% of the total number of days in the month in the simulation period.

Table 8-6 Existing Entitlements Flow Statistics at Node 2 Figtree

Environmental Flow Objectives	WRP Specification for Performance Indicators	Existing Entitlements Case
Medium to High Flows		
APFD	<2	1.26
FRC	Late Summer	Late Summer
MAF	>75% of PF (1)	86%
MWSF	N/A	-
1.5 year ARI	>69% of PF (1)	96%
5 year ARI	>71% of PF (1)	96%
20 year ARI	>82% of PF (1)	93%
Low Flows		
<2 ML	Between 2-20%	0%
50% DFE	Between 32% and 68% of days in month ≥ flow of ML/d	
	Month: Jan — No. of days: 10-21 — Flow (ML/d): 976	13 days
	Feb — 9-19 — 1108	12 days
	Mar — 10-21 — 828	13 days
	Apr — 10-20 — 403	12 days
	May — 10-21 — 208	12 days
	Jun — 10-20 — 208	11 days
	Jul — 10-21 — 195	12 days
	Aug — 10-21 — 109	11 days
	Sept — 10-20 — 101	14 days
	Oct — 10-21 — 140	11 days
	Nov — 10-20 — 244	11 days
	Dec — 10-21 — 621	11 days
90% DFE	Between 72% and 100% of days in month ≥ flow of ML/d	
	Month: Jan — No. of days: 22-31 — Flow (ML/d): 92	26 days
	Feb — 20-28 — 110	23 days
	Mar — 22-31 — 76	28 days
	Apr — 22-30 — 28	30 days
	May — 22-31 — 19	31 days
	Jun — 22-30 — 17	30 days
	Jul — 22-31 — 16	31 days
	Aug — 22-31 — 12	31 days
	Sept — 22-30 — 9	29 days
	Oct — 22-31 — 11	31 days
	Nov — 22-30 — 15	30 days
	Dec — 22-31 — 71	26 days
LFED10	Between 76% and 98% (5)	100%
LFED30	Between 52% and 88% (6)	60%
NF1	Between 0-5	2
NF3	Between 0-2	0
NF6	0	0
NF9	0	0

(1) Pre-development Flow
(2) Of the total number of days in the simulation period
(3) Flow stated for each month should be equalled or exceeded between 32% and 68% of the total number of days in the month in the simulation period.
(4) Flows stated for each month should be equalled or exceeded between 72% and 100% of the total number of days in the month in the simulation period.
(5) Of the number of days in the simulation period that the rivers daily flow is at least 10 cm above the cease-to-flow level at this node.
(6) Of the number of days in the simulation period that the rivers daily flow is at least 30 cm above the cease-to-flow level at this node.

Examination of the data presented in **Tables 8.5** and **Tables 8.6** provides the following assessment of the performance of the existing entitlements case with respect to the WRP:

- The Existing Entitlements Case complies with all medium to high flow EFOSs objectives at Nodes 1 and 2.
- At the Burnett River Mouth (Node 1) the MAF is 83% of the natural (predevelopment) case. The nominated MAF under the WRP is 75% of the natural case.
- At Node 1 the Existing Entitlements Case has 3 of the 7 low flow EFOSs less than those specified. For the 50% DFE, 7 months have less flow than specified, while for the 90% DFE no months satisfy the WRP criteria. For the NF1 statistic 4 periods were identified when 2 periods were specified.
- At Node 2 the Existing Entitlements case has 2 of the 7 low flow EFOSs less than those specified. For <2 ML statistic no periods were identified when flow was less than 2 ML/d while the WRP specified that the percentage of the total number of days in the simulation period when the daily flow is less than 2 ML should be between 2 and 20%. For the LFED10 statistic, a maximum exceedence of 98% was specified when 100% actually occurs.

From **Tables 8.5** and **Tables 8.6** it can be seen that the Existing Entitlements case generally complies with the WRP. Some of the low flow statistics fall just outside the ranges identified in the WRP.

8.1.4 Flood Characteristics

Flood records in the Burnett River date back to the early 1900's. Records of the largest floods in the vicinity of the dam site were recorded at the Walla gauge (GS136001). A summary of the largest floods is given in **Table 8.7**.

Table 8.7: Major Recorded Floods

Burnett River at Walla Weir (GS136001)			
Date	**Peak Discharge**	**Gauge Height**	**Flood Level**
	(ML/day)	(m)	(m AHD)
Jan. 1890	1 413 681	23.10	39.53
Feb. 1893	1 384 199	22.85	39.28
Feb. 1942	1 350 729	22.55	38.98
Jul. 1954	1 016 349	19.40	-
Feb. 1971	888 664	18.07	-
Mar. 1947	733 863	16.33	-
Jan. 1929	632 094	15.09	-

Source: Adapted from DNR (In SKM, 1998)

The maximum instantaneous flow recorded in the Burnett River was 1 413 681 ML/day at Walla Gauging Station in January 1890, however the peak flood levels upstream were highest during the 1942 flood.

Floods in the Burnett River have the potential to rise very rapidly. Flash floods have been recorded, with river flood surge waves up to 1.2 m and channel velocities of 6.4 m/s being reported. A further characteristic of the Burnett River was experienced in the 1890 flood, when significant flood rise occurred at Bundaberg without any register of local rainfall. Much of the initial rise was due to heavy rainfall in the Central Burnett catchment.

Flooding also occurs within individual tributaries with significant rises in local levels as a result of localised storms. Large tributary floods often do not coincide with general flooding in the catchment as a whole. This is also the case for the maximum flood events. For example, although the largest known flood in the Lower Burnett occurred in 1890, the flood peak in Munholme Creek was actually higher in the 1942 flood than in the 1890 event.

Twenty one major floods appear to have occurred in the Bundaberg region since 1847. Twelve of these occurred in the 58 years between 1847 and 1905, and nine in the 93 years to 1997.

Generally, major mainstream floods in the Burnett River occur in the period mid January to mid March, although significant floods have occurred in winter (eg: July 1954 with a flow of 1 016 300 ML/day). Many of these events have occurred as a result of widespread cyclonic or depressional rainfall that has also affected adjacent coastal river systems.

A flood frequency analysis of historical stream flow data provides an estimate of the magnitude of floods for a range of Average Recurrence Intervals (ARI). This analysis used peak instantaneous recorded flows.

The results of the instantaneous flood frequency analysis is presented in **Table 8.8**.

Table 8-8 Instantaneous Peak Flows at Walla

Average Recurrence Interval	Peak Flow FFA (1) ML/day
1 year (Q1)	4 750
5 year (Q5)	85 768
10 year (Q10)	250 000
50 year (Q50)	1 184 000
100 year (Q100)	1 684 000

(1) Flood Frequency analysis based on Instantaneous Peak Flows HYDSYS database from DNR (from SKM, 1998)

The data in **Table 8.7** and **Table 8.8** indicate that the largest recorded flood at Walla has an average recurrence interval of between 50 and 100 years.

8.2 Impacts on Surface Water Resources

8.2.1 Surface Water Hydrology

Flow statistics applicable to the Burnett River Dam site are summarised in **Table 8.9**. This data shows that a dam at this site will result in a decrease in mean annual flow of approximately 3 percent immediately downstream. However, the maximum and minimum annual flows and the maximum monthly flows are expected to increase.

The 82 000 ML increase in flow in the minimum year (from 15 000 ML to 97 000 ML) is due to the dam being able to store water during wet years for release during dry years. This "regulation" of the river flow improves the reliability of supply to water users.

Regulation of the river flow is also largely responsible for the 100 000 ML increase in the flow during the maximum year. Most of the flow during the maximum year is flood flow, however the actual flood only occurs for a relatively short period of time each year, so for the remainder of the year the flows are essentially "normal". The fact that the increase in flow caused by the dam in the minimum and maximum years is much the same indicates that the change in regulated flow is responsible for the increase in flow in the maximum year. It also indicates that the dam has only a marginal impact on the magnitude of large flood flows over the long term.

Table 8-9 Comparison of Flow Statistics at Figtree

Parameter	Daily (ML/d)	Monthly (ML/month)	Annual (ML/a)
Existing Entitlement Case			
Mean	3 377	102 784	1 233 484
Minimum	0	0	15 152
Maximum	996 848	9 579 390	12 507 653
90 percentile	3 718	193 072	2 637 721
50 percentile	167	9 891	607 504
10 percentile	37.3	1 380	151 140
With Burnett River Dam			
Mean	3 285	99 993	1 199 999
Minimum	0	0	96 834
Maximum	982 651	9 622 601	12 607 200
90 percentile	3 150	143 442	2 762 505
50 percentile	397	29 598	593 526
10 percentile	3.2	352	186 078

The data in **Table 8-9** also highlights the extreme variability of flows in the Burnett River. In the 107 years of simulated data, the annual flow varied between about 15 000ML and 12 507 000 ML in the existing entitlements case - a difference of 833%. This variability is just as evident on a monthly and a daily basis with flows ranging from zero to 9 579 000 ML/month and 996 000ML/day respectively.

Similar statistics calculated at the mouth of the Burnett River are presented in **Table 8-10**.

Table 8-10 Comparison of Flow Statistics at River Mouth

Parameter	Daily (ML/d)	Monthly (ML/month)	Annual (ML/a)
Existing Entitlement Case			
Mean	4 238	128 976	1 547 809
Minimum	0	4	6 044
Maximum	1 121 689	11 181 426	14 663 018
90 percentile	4 686	270 222	3 448 471
50 percentile	36	5 804	822 063
10 percentile	4.9	277	144 115
With Burnett River Dam			
Mean	3 550	108 051	1 296 688
Minimum	0	13	5 501
Maximum	1 080 879	11 173 821	14 533 980
90 percentile	2 884	166 441	3 237 966
50 percentile	21	2 407	460 434
10 percentile	0.7	109	39 803

Flow-Duration curves for the Figtree gauging site just downstream of the proposed dam are presented in Figure 8-4. This data highlights the effects of increasing the regulation of the river downstream of the dam, that is:

- Low flows (<100 ML/day) decrease in frequency;
- Moderate flows (100 – 3 000 ML/day) increase in frequency;
- Large flows (3 000 – 300 000 ML/day) decrease in frequency;
- Very large flows (>300 000 ML/day) occur with unchanged frequency.

These changes are different to those predicted at the River Mouth as presented in At this location, all flows of up to about 1 100 000 ML/day occur with reduced frequency. The difference between these flow duration curves at these two sites is due to the flood mitigating effect of the dam for flows between 3 000 and 300 000 ML/day and due to the regulated releases of water from the dam for flows of less than 3 000 ML/day

Figure 8-4 Daily Flow-Duration Curves at Figtree

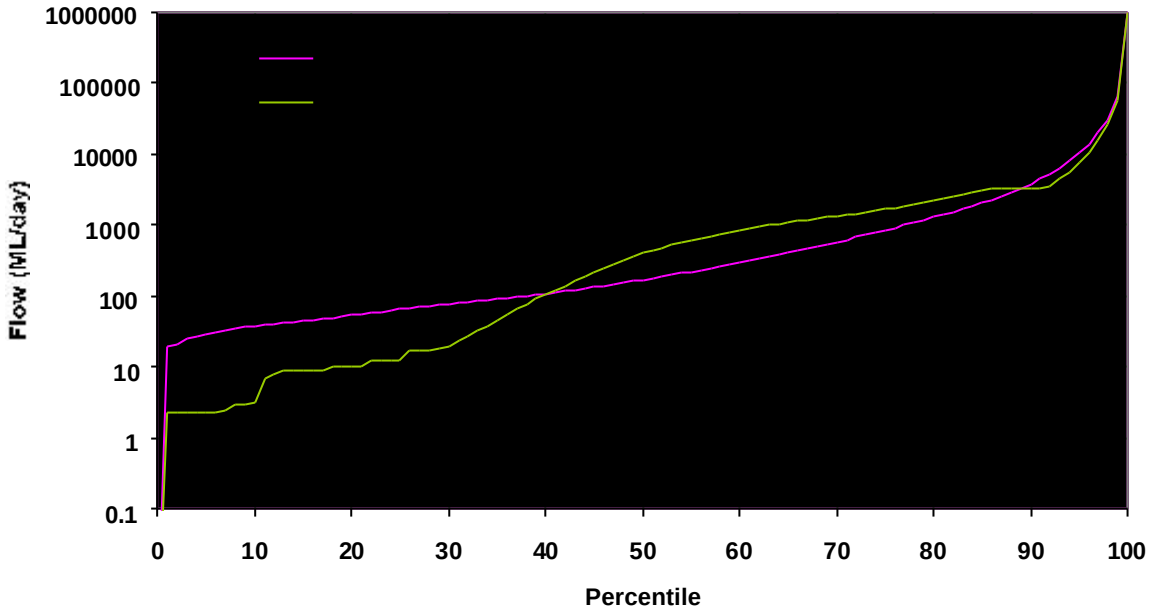
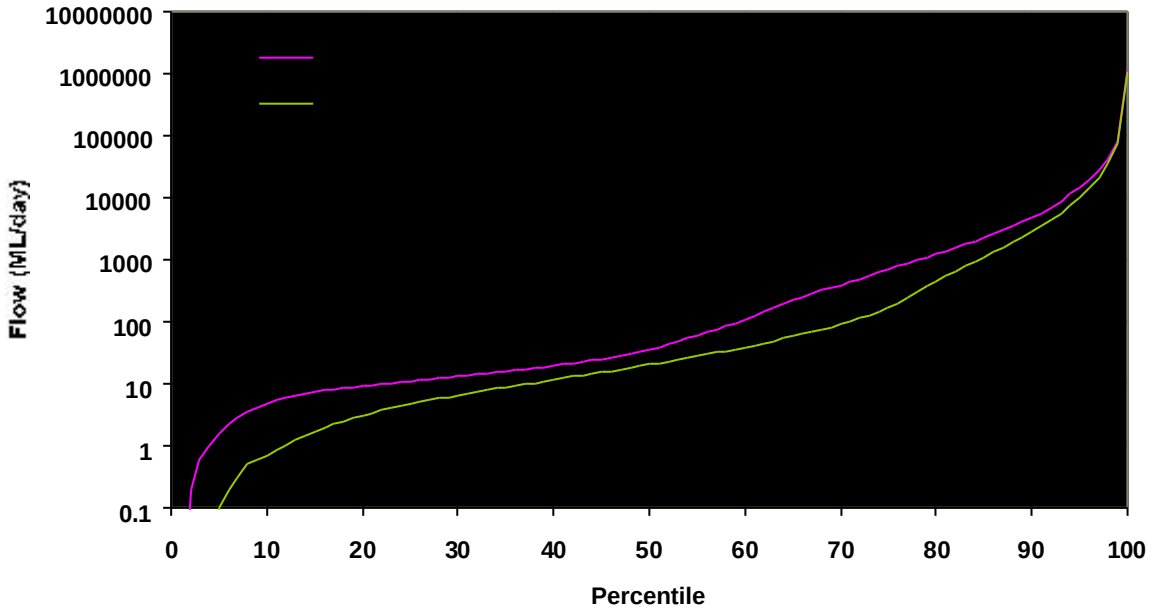


Figure 8-5 Daily Flow-Duration Curves at River Mouth

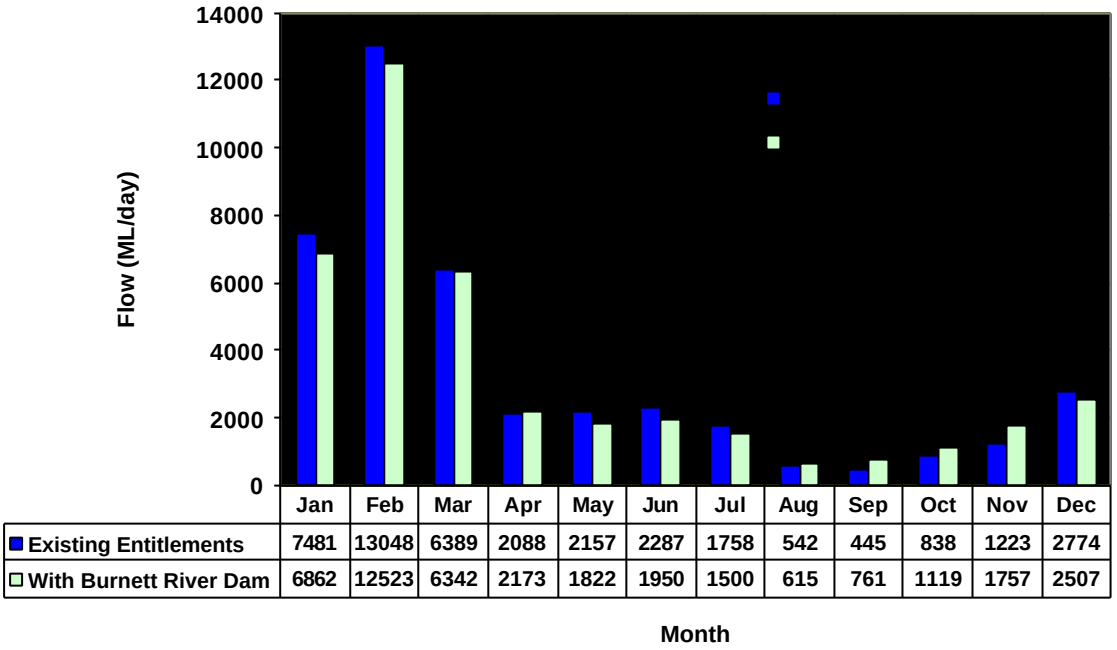


Average daily flows in the Burnett River at Figtree and the River Mouth are summarised by month in **Figure 8-6** and **Figure 8-7** both for the Existing Entitlements and post-Burnett River Dam cases.

This data shows that daily flows will increase at Figtree for five months of the year mainly in the drier post-winter months of August to November. For the remaining months, the average daily flow is reduced by up to 16%.

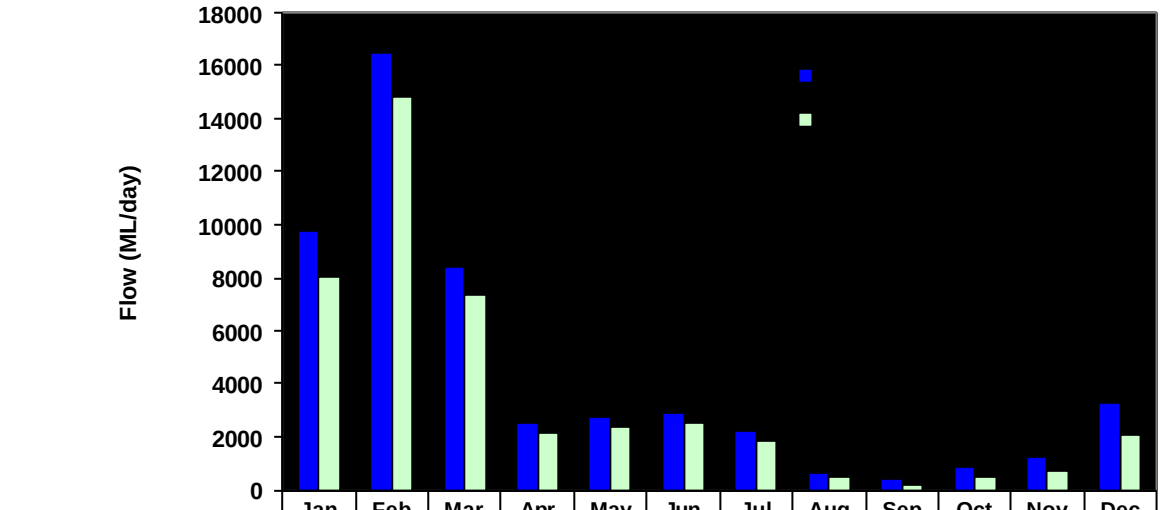
Average daily flows are expected to be reduced at the River Mouth in all months of the year. Generally, this reduction will be in the order of about 10%.

Figure 8-6 Average Daily Flow at Figtree



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing Entitlements	7481	13048	6389	2088	2157	2287	1758	542	445	838	1223	2774
With Burnett River Dam	6862	12523	6342	2173	1822	1950	1500	615	761	1119	1757	2507

Figure 8-7 Average Daily Flow at River Mouth



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing Entitlements	9775	16467	8391	2536	2741	2933	2208	620	384	885	1261	3270
With Burnett River Dam	8054	14845	7395	2133	2369	2555	1872	479	189	495	741	2062

It is important to interpret this information in the context of the relative volume of flow occurring at different times of the year. **Table 8.11** summarises the flow statistics for the wet season (November – April) and dry season (May – October), and shows that:

- the volume of flow during the wet season is about four times that during the dry season
- the mean flow is reduced by approximately the same percentages for the wet and dry seasons (approx 3% at Figtree and 16% at the River Mouth).

Table 8-11 Average Seasonal Flow Statistics

Parameter	Units	Wet Season (November - April)		Dry Season (May – October)		Full Year	
		Figtree	River Mouth	Figtree	River Mouth	Figtree	River Mouth
Existing Entitlements	ML	987 291	1 248 024	246 193	299 785	1 233 484	1 547 809
With Burnett River Dam	ML	961 912	1 052 452	238 087	244 236	1 199 999	1 296 688
Volume Change	ML	-25 379	- 195 572	-8 106	- 55 549	- 33 485	- 251 122
Percent Change	%	-2.6 %	-15.7 %	-3.3 %	-18.5 %	-2.7 %	-16.2 %

8.2.2 Environmental Flows

The environmental flow objectives for the Burnett Basin are stated in the Burnett WRP Schedule 5. A range of performance indicators for low flow and medium to high flow environmental flow objectives are also stated for each output node nominated in Schedule 4 of the WRP. Nodes 1 and 2 at the Burnett River mouth and the Figtree Creek Gauge respectively are located downstream of the proposed Burnett River Dam.

To meet the nine and seven respective flow objectives for the low flow and medium to high flow conditions, an extremely complex and time-specific flow release pattern from the dam would be required. Many factors contribute to the variability of this required release pattern including;

- varying storage volume in the Burnett River Dam;
- gate outlet capacity for environmental releases from the dam which are in excess of the releases to meet the demands of other users;
- daily flows at Figtree Creek Gauge (Node 2) and at the Burnett River mouth (Node 1);
- daily water demands by high and medium priority users;
- flow thresholds for extraction of water from the river by unregulated users;
- antecedent conditions in the river (for up to a 20 year timeframe); and
- climatic variability which will naturally impact upon runs in the river and demands from the river.

To determine a pattern of release consistent with the WRP flow objectives, a tool is required to simulate the "triggering" of environmental flow releases from the dam on the Burnett River. The IQQM model which has been set up for use in the WAMP and WRP process, is the obvious choice of a tool to undertake this assessment. This model however does not readily permit the inclusion of a relevant node to simulate the complex decision making process required to trigger the environmental flow releases from the dam. In other catchments, for example the Fitzroy in Queensland, DNRM have had IQQM code specifically written to assist with the determination of an environmental release pattern which is specific to the requirements of the WRP in that catchment. In the case of the Burnett River catchment a similar process would need to occur if the IQQM model is to be used for this purpose. The model would need to be developed to allow the development of a detailed environmental release strategy for this EIS.

Another aspect of the current Burnett IQQM model also restricts the use of the model in its current form as a tool to develop a meaningful resource operation plan.

The Burnett IQQM model is based on an "entitlement modelling" approach. Regulated irrigation demands are modelled such that the annual demand of a group of irrigators is equal to their total nominal allocation and this does not change from one year to another. Annual demand is then distributed using fixed monthly patterns based on the historical pattern of metered water usage. A "pseudo crop model" has been used to describe these demands which are constant every year of the simulation period. This process overrides all regulated irrigation demand decision-making processes in the model and consequently climatic variability is not taken into account in determining irrigation diversions from the river.

As the crop water demands are fixed in the model, it is likely that in dry periods, the crop demands will not be sufficient such that "successes" may be recorded where in fact the average irrigation demand would not have been sufficient to sustain the crops. Conversely it may eventuate that during these dry periods, the demands may be too high leading to a recorded "failure" which would probably not have occurred in practice due to the lesser risk taking behaviour of the farmer.

It is also likely that during wet periods, the fixed average irrigation demands may actually be too high, with respect to allocations resulting in a "failure" to supply where in fact rainfall may have been more than sufficient to satisfy the crop requirements. Conversely it may also eventuate that in wet times, the fixed average irrigation demands may be too low, prompting a "success" to supply where in fact additional irrigation was required and would have been extracted from the river.

These examples provide evidence in layman's terms as to how the pseudo crop model may either result in an overestimate or indeed an underestimate of the demands on water resources of the river. It is not possible to relate the applicability of the pseudo crop model to a real life situation or to determine the accuracy of the river flows or storage volumes reported by IQQM. In this regard, the model in its current form is not considered appropriate for use as an operational model and therefore its lack of relevance for use in determining an environmental flow release pattern is accentuated. Section 15(2) of the WRP allows for the consideration of the use of an alternative method to calculate the performance indicators. In this case the alternative method would be a refined IQQM model as discussed previously.

The flow statistics linked with environmental flows in the WRP have been calculated for the case of development of a Burnett River Dam as described in this EIS.

These statistics are presented along with those associated with the Existing Entitlements case in **Tables 8.12** and **8.13**. These tables provide details of the change in various flow statistics associated with development of the dam and associated additional water allocations. The dam case presented does not include an environmental release strategy.

Table 8-12 Burnett River Dam Case Flow Statistics at Node 1 Burnett River Mouth

Environmental Flow Objectives	WRP Specification for Performance Indicators	Existing Entitlements Case	Burnett River Dam Case	Change from Existing Entitlements Case	Comparison with WRP
Medium to High Flows					
APFD	<2	1.08	2.43	+ 1.35	+ 0.43
FRC	Late Summer	Late Summer	Late Summer	No change	No change
MAF	>75% of PF (1)	83%	69%	- 14%	- 6%
MWSF	>80% of PF (1)	88%	76%	- 12%	- 4%
1.5 year ARI	>69% of PF (1)	95%	61%	- 34%	- 8%
5 year ARI	>71% of PF (1)	89%	80%	- 9%	As specified
20 year ARI	>82% of PF (1)	94%	85%	- 9%	As specified
Low Flows					
<2 ML	Between 2-18% (2)	5%	15%	+ 13%	As specified
50% DFE	Between 32% and 68% of days in month ≥ flow of ML/d (3)				
	Month / No. of Days / Flow (ML/d)				
	Jan 10-21 1310	11 days	7 days	-4 days	-3 days
	Feb 9-19 1519	11 days	8 days	-3 days	-1 days
	Mar 10-21 1154	11 days	8 days	-3 days	-2 days
	Apr 10-20 583	9 days	7 days	-2 days	-3 days
	May 10-21 315	9 days	7 days	-2 days	-3 days
	Jun 10-20 280	10 days	8 days	-2 days	-2 days
	Jul 10-21 255	11 days	7 days	-4 days	-3 days
	Aug 10-21 154	8 days	4 days	-4 days	-6 days
	Sept 10-20 137	6 days	3 days	-3 days	-7 days
	Oct 10-21 212	6 days	3 days	-3 days	-7 days
	Nov 10-20 370	6 days	4 days	-2 days	-6 days
	Dec 10-21 789	8 days	5 days	-3 days	-5 days
90% DFE	Between 72% and 100% of days in month ≥ flow of ML/d (4)				
	Month / No. of days / Flow (ML/d)				
	Jan 22-31 173	16 days	11 days	-5 days	-11 days
	Feb 20-28 191	16 days	12 days	-4 days	-8 days
	Mar 22-31 163	16 days	13 days	-3 days	-9 days
	Apr 22-30 73	15 days	13 days	-2 days	-8 days
	May 22-31 49	17 days	15 days	-2 days	-7 days
	Jun 22-30 38	17 days	15 days	-2 days	-7 days
	Jul 22-31 28	20 days	17 days	-3 days	-5 days
	Aug 22-31 23	17 days	14 days	-3 days	-8 days
	Sept 22-30 13	17 days	13 days	-3 days	-9 days
	Oct 22-31 15	15 days	9 days	-6 days	-13 days
	Nov 22-30 28	10 days	6 days	-4 days	-16 days
	Dec 22-31 132	12 days	7 days	-5 days	-15 days
LFED10	N/A	-	-		
LFED30	N/A	-	-		
NF1	Between 0-2 events	4	13	+9 periods	+11 periods
NF3	0 events	0	0	0	As specified
NF6	0 events	0	0	0	As specified
NF9	0 events	0	0	0	As specified

1. Pre-development Flow
2. Of the total number of days in the simulation period
3. Flow stated for each month should be equalled or exceeded between 32% and 68% of the total number of days in the month in the simulation period.
4. Flows stated for each month should be equalled or exceeded between 72% and 100% of the total number of days in the month in the simulation period.

Table 8-13 Burnett River Dam Case Flow Statistics at Node 2 Figtree

Environmental Flow Objectives	WRP Specification for Performance Indicators	Existing Entitlements Case	Burnett River Dam Case	Change from Existing Entitlements Case	Comparison with WRP
Medium to High Flows					
APFD	<2	1.26	2.72	+1.46	+0.72
FRC	Late Summer	Late Summer	Late Summer	No change	As specified
MAF	>75% of PDF (1)	86%	84%	-2%	As specified
MWSF	N/A	-	-	-	-
1.5 year ARI	>69% of PF (1)	96%	63%	-33%	-6%
5 year ARI	>71% of PF (1)	96%	81%	-15%	As specified
20 year ARI	>82% of PF (1)	93%	79%	-14%	-3%
Low Flows					
<2 ML	Between 2-20%	0%	1%	1%	-1%
50% DFE	Between 32% and 68% of days in month ≥ flow of ML/d				
	Month: No. of days / Flow (ML/d)				
	Jan 10-21 976	13 days	19 days	+6 days	ok
	Feb 9-19 1108	12 days	17 days	+5 days	ok
	Mar 10-21 828	13 days	18 days	+5 days	ok
	Apr 10-20 403	12 days	17 days	+5 days	ok
	May 10-21 208	12 days	8 days	-4 days	-2 days
	Jun 10-20 208	11 days	8 days	-3 days	-2 days
	Jul 10-21 195	12 days	11 days	-1 days	ok
	Aug 10-21 109	11 days	13 days	+2 days	ok
	Sept 10-20 101	14 days	17 days	+3 days	ok
	Oct 10-21 140	11 days	21 days	+10 days	ok
	Nov 10-20 244	11 days	22 days	+11 days	+2 days
	Dec 10-21 621	11 days	18 days	+7 days	ok
90% DFE	Between 72% and 100% of days in month ≥ flow of ML/d				
	Month: No. of days / Flow (ML/d)				
	Jan 22-31 92	26 days	23 days	-3 days	ok
	Feb 20-28 110	23	22	-1	ok
	Mar 22-31 76	28	25	-3	ok
	Apr 22-30 28	30	23	-7	ok
	May 22-31 19	31	13	-18	-9 days
	Jun 22-30 17	30	14	-16	-8
	Jul 22-31 16	31	18	-13	-4
	Aug 22-31 12	31	17	-14	-5
	Sept 22-30 9	29	21	-8	-1
	Oct 22-31 11	31	25	-6	ok
	Nov 22-30 15	30	25	-5	ok
	Dec 22-31 71	26	23	-3	ok
LFED10	Between 76% and 98% (5)	100%	95%	-5%	As specified
LFED30	Between 52% and 88% (6)	60%	60%	No change	As specified
NF1	Between 0-5	2	2	No change	As specified
NF3	Between 0-2	0	1	+1 period	As specified
NF6	0	0	0	No change	As specified
NF9	0	0	0	No change	As specified

1. Pre-development Flow
2. Of the total number of days in the simulation period
3. Flow stated for each month should be equalled or exceeded between 32% and 68% of the total number of days in the month in the simulation period.
4. Flows stated for each month should be equalled or exceeded between 72% and 100% of the total number of days in the month in the simulation period.
5. Of the number of days in the simulation period that the rivers daily flow is at least 10 cm above the cease-to-flow level at this node.
6. Of the number of days in the simulation period that the rivers daily flow is at least 30 cm above the cease-to-flow level at this node.

Examination of the data presented in **Tables 8.12** and **8.13** provides an indication of the impact of the proposed dam on the Existing Entitlements case flow regime as well as illustrating the level of compliance with the WRP objectives.

Based on this information the following can be identified:

8.2.1.1 Medium to High Flows

The regulation of the river reach downstream of the dam is the reason for the change in APFD. At the mouth of the Burnett River (Node 1), the MAF EFO for the dam case is 6% less than for the WRP specified value of 75%. Immediately downstream of the dam at Figtree Gauge (Node 2), the MAF EFO is 9% greater than the WRP minimum specified value. For the Mean Wet Season Flow (MWSF) EFO the dam case is 4% less than the WRP specified value at Node 1.

For the 1.5 year ARI, 5 year ARI and 20 year ARI EFOs at Node 1, the 1.5 year ARI EFO is 8% less than the WRP minimum specified value while the 5 year ARI and 20 year ARI EFOs are greater than the WRP specified value. In terms of flow, the 1.5 year ARI EFO is 9 245 ML less than the targeted value of 83 930 ML/day. This will result in a reduction in the depth of flow in the river of less than 0.2 m. The reduction in this flow indicates that the frequency of flood flows has been altered. In this case the 1.5 year ARI daily flow volume as specified by the WRP has shifted from having a probability of being reached at least once a year of 67% to 63%.

At Node 2, the 1.5 year ARI EFO is 6% less than the WRP minimum specified value of 69%. In terms of flow volume, this EFO is 12 365 ML less than the targeted value of 83 627 ML/day. This will result in a reduction in the depth of flow in the river of less than 0.5 m in a 6.0 m flow depth. The change in the frequency of a flood of this magnitude due to the dam would be from a probability of being reached at least once a year of 67% to 56%.

At Node 2, the value of the 5 year ARI EFO is greater than that specified by the WRP.

The 20 year ARI EFO at Node 2 is 3% less than the minimum specified value in the WRP. In terms of flow volume this EFO is 21 690 ML less than the targeted value of 584 349 ML/day. This will have minor impacts on river levels at this site as a flood of this magnitude would be over the low banks of the river and breaking out onto the floodplain. The change in the frequency of a flood of this magnitude due to the dam would be from a probability of being reached at least once a year of 5% to 4.3%.

8.2.1.2 Low Flows

For the low flow statistic of <2 ML the Burnett River Dam Case complies with the requirements of the WRP at Node 1 and is 1% less than the WRP requirement specified at Node 2.

For the 50% daily flow exceedance EFO, at Node 1, the dam case will result in a lesser number of days stipulated flows than specified in the WRP. As shown in Table 8.12, the number of days the flow is not achieved in any month is not more than 7 days and generally 3 days or less. At Node 2, the dam case complies with 9 of the 12 month values specified in the WRP. The remaining 3 months are all 2 days less than the specified number of days.

The shortfall in this EFO could be satisfied with an appropriately sequenced environmental release strategy. It is estimated that on average, an annual release of about 8 500 ML/a or less than 1% of the MAF would be required.

For the 90% daily flow exceedance EFO, at Node 1, the dam case will result in a lesser number of days the specified flows than documented in the WRP. This is also true for the Existing Entitlements Case. In general, the dam case will only provide about half the minimum number of days specified in the WRP while the Existing Entitlements Case can only provide about 70% of the minimum number of days specified.

At Node 2, the dam case complies with 7 of the 12 month values specified in the WRP. As for the 50% DFE EFO, this shortfall could be satisfied by an environmental release strategy. It is estimated that an average annual release of about 6 100 ML/a or less than 0.5% of the MAF in addition to the releases for the 50% DFE EFO would be required.

The total average annual release to satisfy these low flow EFO's would be about 14 600 ML. Almost 30% of this flow volume could be supplied from the flows required to operate the fishway in the dam and Walla Weir. Supply of the remaining flow would only have minor affects on the yield of the dam and the associated Water Sharing Index.

8.2.3 Environmental Flow Release Strategy

An appropriately sequenced environmental flows release strategy is likely to improve the flow statistics associated with the dam, moving the flow regime closer to that specified in the WRP.

8.2.1.3 Low Flows

As previously discussed, without environmental releases, the river downstream of the dam did not meet the "zero" flow (<2 ML/day), 50% exceedance or 90% exceedance flow criteria. This could be corrected by releasing a small amount of water from the dam on a regular basis. It is estimated that on average about 8 500 ML/year would be required to meet the 50% exceedance criteria and an additional 6 100 ML/year to meet the 90% exceedance criteria. Providing these releases is likely to correct the <2 ML/day criterion.

8.2.1.4 Medium to High Flows

Without environmental releases, flows at Figtree do not achieve the 1.5 year ARI and 20 year ARI flow criteria, while flows at the River Mouth do not achieve the 1.5 year ARI criterion.

A release strategy which would correct these shortfalls on average would utilise in the order of 30 000 ML per year. In some years, the volume of water released for environmental purposes would be much more than this, while in other years they would be significantly less. These releases would be much larger in magnitude than those required to satisfy the low flow objectives. It is likely that they would occur when the dam is spilling.

Such releases would not lift the MAF to a level that complies with the WRP, however the deviation from the WRP would be minimised.

8.2.4 Release Mechanisms

Environmental releases required to meet the low-flow criteria would be relatively small in volume, and would be need to able to be carried out even if the water level in the dam is well below full supply level. It is estimated that these releases would be up to about 1 000ML/.day.

Medium to high flow environmental releases would need to be up to about 35 000 ML/day to satisfy the 1 in 20 year criterion at Figtree. Releases of this magnitude would be quite infrequent. The modelling indicates that medium to high flow environmental releases will occur while the dam is spilling. On this basis, the releases could be achieved using gates operated so that the flood storage of the dam could be accessed.

8.2.5 Total Environmental Releases

On the basis of the strategies described above, it is estimated that about 50 000 ML/year of environmental flow releases would be required to meet the WRP criteria (with the exception of the mean annual flow criterion). This flow is 17% of the dam storage volume and 4% of the mean annual flow at the dam site. It is expected that the Water Sharing Index associated with the yield from the dam will be retained within the limits of the WRP when an environmental flow release strategy is included in the dam operations.

8.2.6 Impacts on Flooding

8.2.1.5 Upstream of Dam

Introduction

In 1998, an initial engineering appraisal study was carried out for the Burnett River Dam site on the Lower Burnett River by Engineering Services, State Water Projects. As a part of this study, hydrological and hydraulic studies were undertaken. These involved the derivation of design flood estimates and an investigation of dam storage development levels. The objective of the current analysis was to re-examine the backwater effect at Gayndah caused by a dam being built at the proposed Burnett River Dam site (131.2 km), using a more accurate hydrodynamic assessment, based on recently surveyed information.

Topographic and Cross-Sectional Information

The topographical data that was used for this study was based upon 1:25,000 aerial photography. This level of photogrammetric modelling provides an accuracy of +/- 0.7 m in both the vertical and horizontal. This survey data was used to formulate a Digital Terrain Model (DTM). Cross-sections were then extracted from this DTM at approximately 1.5 km spacings.

Model Construction and Calibration

A hydrodynamic modelling package, Mike-11 (DHI, 2000) was used to construct the model of the lower Burnett River. The model extended from AMTD 131.2 km (Burnett River Dam site) to 203.0 km (upstream of Gayndah). The major tributary, Barambah Creek, was included from AMTD 0.0 km to 14.9 km. It joins the Burnett River at approximately AMTD 187 km. In addition, four other major tributaries upstream of the dam site were included. Mike-11 was able to take into account storage effects of the flood plain and junction areas of the Burnett River and its associated tributary streams. The boundary conditions, including the design flood hydrographs and rating curves, were obtained from the previous study.

The model was calibrated, for the natural river case, to the 1942 flood event. Calibration involved adjusting the Mannings 'n' factor for the river bed until the water levels and peak discharges closely resembled the recorded values. A 'n' value of 0.043 was adopted for the reach upstream of Mingo Crossing, whilst a value of 0.0675 was adopted from Mingo Crossing to Burnett River Dam site. The calibration results are provided in **Table 8.14**.

Table 8.14 – Model Calibration Results

Location	AMTD (km)	Model Distance (km)	Recorded	Current Study	Difference
			Peak Water Level (m AHD)		
GS 136003B Gayndah	203.0	0.0	105.91	105.97	0.06
GS 136002C Mt Lawless	183.9	19.1	92.86	92.98	0.12
GS 136012A Mingo Crossing	154.5	48.5	69.42	69.54	0.12
			Peak Discharge (m^3/s)		
GS 136003B Gayndah	203.0	0.0	15225	15,242	17
GS 136002C Mt Lawless	183.9	19.1	17055	16,911	-144
GS 136012A Mingo Crossing	154.5	48.5	16380	16,856	476

Cases Considered

The 100 year ARI design flood event was routed through the river section for two scenarios:

1. the natural river;
2. Burnett River Dam at AMTD 131.2 km with a storage capacity of 300 000 ML
   (Fixed crest level at 67.58 m AHD; Spillway Width = 285 m).

Results

Table 8.15 summarises the peak water levels at points of interest along the river for both scenarios.

Table 8.15 - Results From 100 year ARI Analysis

Location	AMTD (km)	Model Distance (km)	Current Study	Afflux
			Natural River Condition – Peak Water Level (m AHD)	
Upstream Gayndah	201.2	1.8	105.09	
Gayndah Bridge	200.6	2.4	104.72	
Mt Lawless	185.2	17.8	95.27	
	169.0	34.0	83.57	
Mingo Crossing	154.5	48.5	72.33	
Damsite	131.2	71.8	58.44	
			With Burnett River Dam – Peak Water Level (m AHD)	
Upstream Gayndah	201.2	1.8	105.10	+0.01
Gayndah Bridge	200.6	2.4	104.74	+0.02
Mt Lawless	185.2	17.8	95.40	+0.13
	169.0	34.0	85.20	+1.63
Mingo Crossing	154.5	48.5	80.56	+8.23
Damsite	131.2	71.8	79.06	+20.62

Alternative Flood Events

The 50 year ARI design flood event, as well as the PMF, were also analysed. The results are shown in **Table 8.16**.

Table 8.16 – Peak Flood Level (m AHD) Results

			50 y ARI			100 y ARI			PMF		
Location	AMTD (km)	Model Distance (km)	No Dam	Dam	Afflux	No Dam	Dam	Afflux	No Dam	Dam	Afflux
Upstream Gayndah	201.2	1.8	103.73	103.74	0.01	105.09	105.10	0.01	112.31	112.32	0.01
Gayndah Bridge	200.6	2.4	103.29	103.31	0.02	104.72	104.74	0.02	112.12	112.12	0.00
Mt Lawless	185.2	17.8	93.88	94.02	0.14	95.27	95.40	0.13	103.26	103.52	0.26
	169.0	34.0	81.94	83.63	1.69	83.57	85.20	1.63	94.64	96.54	1.90
Mingo Crossing	154.5	48.5	70.32	79.22	8.90	72.33	80.56	8.23	84.54	91.53	6.99
Damsite	131.2	71.8	56.60	77.91	21.31	58.44	79.06	20.62	71.69	89.09	17.40

Conclusions

The current analysis indicates that peak flood levels at Gayndah Bridge would reach 104.74 m AHD, 20 mm higher than the natural river condition for the 300,000 ML storage with a full supply level of 67.58 m. This afflux is also 20 mm for the 50 year ARI design flood event but the dam causes no additional flooding at the bridge for the PMF event.

Figure 8-10 demonstrates the flooding effects at Gayndah. The two lines indicate the flooding caused from the 100 year ARI design flood event for the 'no dam' case and the 'with dam' case. It can be seen that there is no significant additional impact caused by the dam for this flood event in Gayndah.

8.2.1.6 Downstream of Dam

The impact of the dam on floods of various magnitudes was investigated by undertaking a flood frequency analysis using daily flows from the Integrated Quantity/Quality Model. The results are illustrated in **Figure 8-8** for the River Mouth and **Figure 8-9** for Figtree.

Figure 8-8 Flood Frequency Curves at the site

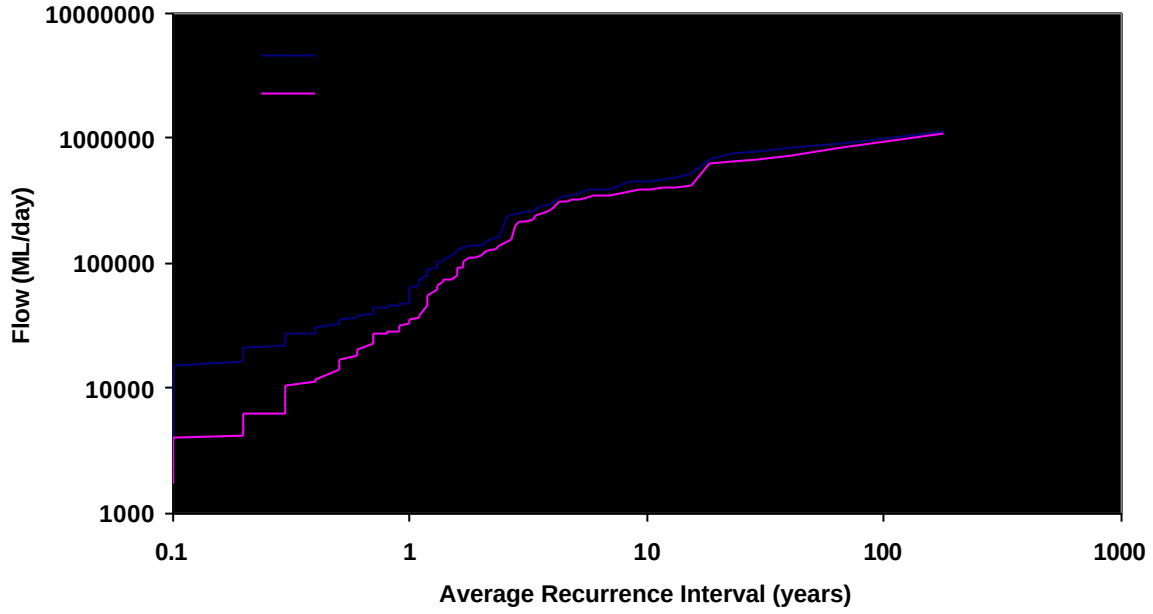
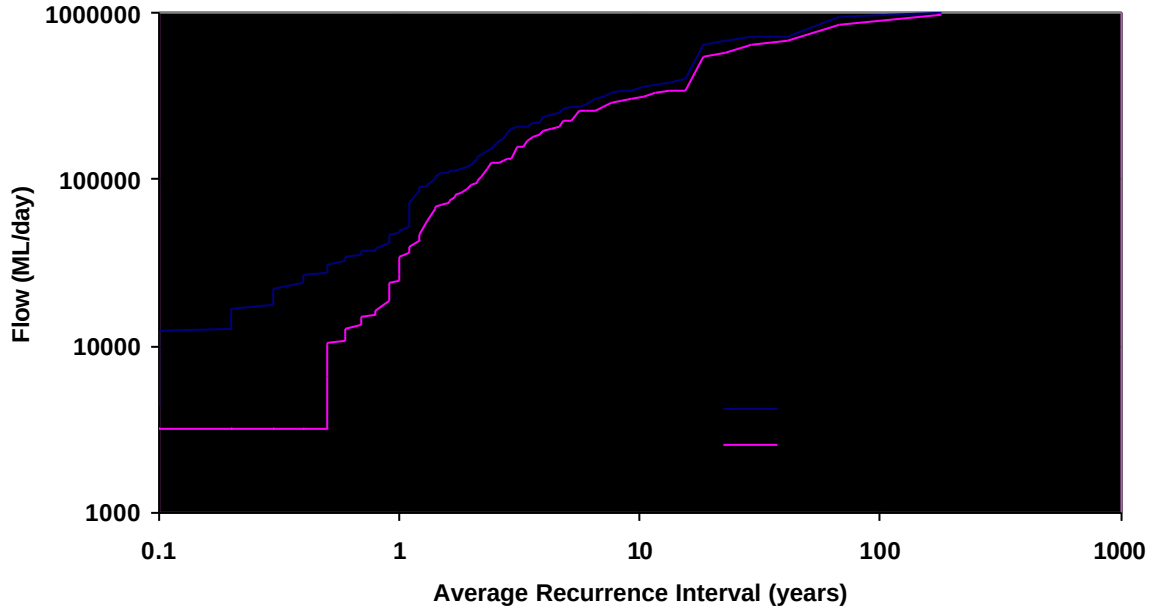


Figure 8-9 Flood Frequency Curves at Figtree



The changes in flowrate for floods of various average recurrence intervals are summarised in **Table 8.17**.

Table 8-17 Change in Flood Flow Magnitude

Average Recurrence Interval of Flood	Flow Magnitude (m^3/s)				Change in Flow (%)	
	Figtree		River Mouth			
	Existing Entitlements	With Burnett River Dam	Existing Entitlements	With Burnett River Dam	Figtree	River Mouth
1 in 1 year	572	351	700	399	-39 %	- 43%
1 in 5 year	3 106	2 602	4 089	3 700	-16 %	-10 %
1 in 10 year	4 120	3 605	5 304	4 557	-12 %	-14 %
1 in 50 year	9 334	8 542	10 164	8 974	-8 %	-12 %
1 in 100 year	11 215	10 307	11 262	10 516	-8 %	- 7 %

This data shows that small floods are reduced in magnitude with the dam in place by up to about 40% at both Figtree and the River Mouth. The impact of the dam on large floods is much less – flowrates are reduced by only about 8% for a 1 in 100 year ARI event.

8.3 Cumulative Impacts

The cumulative impacts case considers the development of all projects proposed by Burnett Water Pty Ltd, including all weirs upstream of Burnett River Dam, the Burnett River Dam and the raising of Walla Weir. An IQQM model set up by DNRM was provided to Sinclair Knight Merz for use in assessment of this scenario in terms of the WRP.

The outcomes of this assessment allow a comparison to be made between the impacts of the cumulative project without Walla Weir raising, and the impacts of the cumulative scenario including the Walla Weir raising. The outcomes are summarised as follows;

- Node 1
  - Medium to high flows: A similar level of compliance with the WRP has been achieved for the cumulative project. The MAF indicator has been decreased marginally from 69% to 68% and the APFD indicator has increased from 2.43 to 2.49 however all other performance indicators remain constant.
  - Low flows: The level of compliance with the WRP has not changed due to the inclusion of the Walla Weir Stage 2 project.

- Node 2
  - Medium to high flows: A similar level of compliance with the WRP has been achieved for the cumulative project. The APFD indicator has increased from 2.72 to 2.83 and the 1.5 yr ARI indicator has reduced from 63% to 62% however all other performance indicators remain constant.
  - Low flows: A similar level of compliance has been achieved for all low flow performance indicators. The Water sharing indices for yield from the Burnett River Dam will remain within the ranges specified in the WRP in the event that all nominated water resources infrastructure is constructed.

8.4 Conclusions and Recommendations

Based on this assessment it is concluded that:

- Construction of the Burnett River Dam will impact upon the flow regime of river downstream of the dam.
- Immediately downstream of the dam the frequency of river flows will be altered as follows:
  - Low flows (<100 ML/day) will decrease in frequency
  - Moderate flows (100 – 3 000 ML/day) will increase in frequency
  - Large flows (3 000 – 300 000 ML/day) will decrease in frequency
  - Very large flows (>300 000 ML/day) will occur with unchanged frequency.

- At the river mouth all flows will occur with reduced frequency. The impact of the dam diminishes as the flow rate increases.
- The Burnett River Dam will result in a flow regime that in general has a similar level of compliance to the Burnett Basin WRP as the Existing Entitlements Case. The level of compliance varies for the following indicators:
  - MAF
  - APFD
  - 1.5 yr ARI
  - 20 yr ARI
  - MWSF.
- Variance from the specified levels for the medium to high flow EFO's is a maximum of 10% of the predevelopment flow and generally of the order of 5%.
- The introduction of an appropriately sequenced environmental flows release strategy will minimise the impact of the dam on the flow regime downstream of the dam, improving the developments performed against the WRP EFO's.
- During low flows, it is expected that operation of the fishway will contribute about 30% of the volume required to meet environmental low flow objectives.
- Flooding upstream of the dam in the Gayndah area will not be significantly impacted upon by construction of the dam.
- The cumulative impacts of the ultimate level of water resources development proposed by the Burnett Water Pty Ltd will not significantly alter the flow regime or water sharing indexes when compared to those attributable to the Burnett River Dam alone.
- The current IQQM model should be modified to allow the development of an environmental flows release strategy and Resource Operations Plan for the Burnett River below the proposed dam.