QUEENSLAND FLOODS COMMISSION OF INQUIRY

SUBMISSIONS ON BEHALF OF SUNWATER LIMITED (AND BURNETT WATER PTY LTD)

About SunWater and Burnett Water

1. SunWater Limited (**SunWater**) and its wholly owned subsidiary, Burnett Water Pty Ltd (**Burnett Water**) together own and operate 23 referable storages (as defined under the *Water Supply (Safety and Reliability) Act* 2008), which includes 19 major dams, across the State of Queensland (collectively referred to as "**the SunWater Dams**").

2. SunWater also provides flood operations services to Seqwater under a Service Level Agreement in relation to the Wivenhoe, Somerset and North Pine Dams. Under this Agreement, SunWater provides the following services to Seqwater (in summary):

   2.1. SunWater has established and operates a Flood Operations Centre from which flood operations for those dams is conducted by staff from Seqwater, SunWater and the Department of Environmental and Resource Management; and

   2.2. SunWater provides expert engineers and technical assistants for flood operations at those dams; and

   2.3. SunWater engineers assist in the preparation of the flood report that is required by the flood mitigation manuals to be submitted by Seqwater to the Department of Environment and Resource Management (**DERM**) for those dams following a flood event.

Submission to the Commission of Inquiry by way of witness statements

3. In SunWater's application to the Commission of Inquiry seeking leave to appear dated 25 February 2011, SunWater foreshadowed preparing and filing two witness statements by 11 March 2011 prepared on behalf of SunWater, Burnett Water and SunWater's employees:

   3.1. Witness 1 is a SunWater employee and was the Senior Flood Operations Engineer who was providing services to Seqwater during

SUBMISSIONS

On behalf of SunWater Limited (and Burnett Water Pty Ltd)

Holding Redlich
Level 1, 300 Queen Street
BRISBANE QLD 4000
Telephone: (07) 3135 0500
Facsimile: (07) 3135 0599
Reference: TZB: 11800005

the flood event at Wivenhoe, Somerset and North Pine Dams in January 2011.

3.2. Witness 2 is a SunWater employee and holds the position of Manager – Asset Management.

4. The process of the taking of those statements is well advanced, but has been a significant undertaking in the limited timeframe that has been available.

5. Please find ***enclosed*** Witness 2's statement by way of submission to the Commission of Inquiry. Schedule 1 to the statement provides information as to the various water supply schemes relevant to the SunWater Dams. Schedules 2 to 20 set out information in respect of each of the SunWater Dams.

6. In relation to the statement of Witness 1, that statement is not yet ready to be submitted. Witness 1 has been fulfilling his role as the Senior Flood Operations Engineer and has been engaged in continuing flood operations during the current wet season. In addition, Witness 1 has been assisting in preparing the mandatory Flood Report for Wivenhoe and Somerset Dams, and the Flood Report for North Pine Dam. We are working to have Witness 1's statement submitted as soon as possible next week.

7. These statements are provided without any knowledge of other evidence or submissions that have or will be provided to the Commission of Inquiry. Any further information or explanation required by the Commission of Inquiry can be provided on request. These statements may be supplemented with further statements or submissions as issues arise during the Commission of Inquiry.

Overview of the statements

8. Witness 2's statement deals with regional dams owned and / or managed by SunWater. Some of the key points to note from witness 2's statement are:

8.1. Witness 2 has high-level qualifications and extensive experience in his field of expertise. His role at SunWater entails overarching responsibility for the standard of maintenance and coordination and planning of maintenance and asset refurbishment activities and processes, asset data and systems for SunWater. Witness 2 provides information about his qualifications and experience in section 1 of his statement.

8.2. In section 3 of Witness 2's statement, a detailed overview of SunWater's assets (including dams) is provided. Table 3-1 summarises the relevant statistics for the 19 SunWater Dams dealt with in the statement. Further details on those dams and the water supply schemes that impact upon those dams is provided in sections 11 and 12 of the statement.

8.3. In section 4 of the statement, Witness 2 provides a comprehensive explanation of the function of dams. Some dams are designed principally for water supply purposes, and some dams fulfill both a water supply and flood mitigation purpose. Not all dams have the capacity to mitigate floods; however, all dams do have the capacity to attenuate floods to some extent. Witness 2 explains the difference between active and passive flood mitigation and flood attenuation. The SunWater Dams are designed principally for water supply purposes and thus do not have a flood mitigation capacity (with the exception of Peter Faust Dam which has a passive, as opposed to active, flood mitigation capacity).

8.4. Witness 2 provides an analysis of the flood mitigation opportunities for SunWater Dams. The key findings of this analysis are set out in section 4.5 of the statement. The details of the analysis for each dam are included in schedules 2 – 20 of the statement.

8.5. Section 5 of the statement provides a detailed explanation of the water regulation framework in Queensland which is comprised of legislative instruments, subordinate legislation, referenced documents and industry and technical standards.

8.6. SunWater's comprehensive and thorough planning, processes, procedures, inspections, and reviews means that the SunWater Dams are safe and operated in accordance with clearly defined rules and standards designed to ensure that the safety and reliability of the SunWater Dams is maintained. Operational requirements, emergency operations and maintenance procedures are all well documented. SunWater's Dam Safety Management Program ensures that the SunWater Dams adhere to, and in many cases exceed the requirements of the regulatory framework. SunWater's Dam Safety Upgrade Program ensures that SunWater's dams are structurally safe and incorporate appropriate advances in engineering and hydrological expertise. SunWater's compliance with the regulatory framework is addressed in section 6 of Witness 2's statement.

8.7. The Emergency Management Framework within which SunWater operates is dealt with in section 7 of the statement. The role of various agencies in emergency management is outlined and an explanation of SunWater's role in that emergency framework is provided. SunWater enhances the emergency management framework through the operation of the flood operations centre and its liaison with various agencies, the implementation of the emergency action plans, and by thorough preparation for each wet season.

8.8. The SunWater Dams performed very well during the 2010/11 flood event. SunWater's dams are safe and are designed to handle flood events that are far larger than the events experienced over the 2010/11 wet season. The SunWater Dams are maintained to a standard that generally exceeds the minimum standards imposed under the regulatory regime. Witness 2 provides a summary of the key conclusions to be drawn from the statement at section 9.

9. Witness 1's statement will deal with his role as the Senior Flood Operations Engineer for the flood event in January 2011 at Wivenhoe, Somerset and North Pine Dams. Some of the points to note from the statement (once it is provided) are:

9.1. Witness 1 has high-level qualifications and extensive experience in his field of expertise. Witness 1 has over 28 years experience in water engineering projects in Queensland's surface water resources. His areas of expertise includes flood operation of dams with gated spillways (Wivenhoe, Somerset and North Pine Dams all have gated spillways).

9.2. Wivenhoe, Somerset and North Pine Dams are all required to be operated in accordance with approved flood mitigation manuals. Witness 1 provides a detailed account of the purpose and objectives of those manuals and provides an explanation of the strategies that seek to achieve those objectives. Failure of Wivenhoe Dam, Somerset Dam or North Pine Dam could have catastrophic consequences, and so it is imperative that the dams are operated during flood events in accordance with defined procedures to minimise the impact to life and property. The structural safety of the dam is the paramount consideration.

9.3. The flood mitigation manuals provide for certain trigger points at which different strategies (and gate operations) must be implemented. Wivenhoe, Somerset and North Pine Dams were operated in accordance with these strategies and objectives during the January 2011 flood events. Witness 1 will also address the procedural requirements imposed under the flood mitigation manuals. Those procedural requirements were met during the January 2011 flood event.

9.4. In his statement, Witness 1 provides a detailed account of the discharge of his duties in the flood operations centre and his role in setting the strategies under the flood mitigation manuals for the January 2011 Flood Event.

Holding Redlich

On behalf of SunWater Limited (and Burnett Water Pty Ltd)

Dated: 11 March 2011

[redacted]

Table of Contents

Table of Figures

List of Tables

1 Introduction – [redacted]

[redacted] care of SunWater, 179 Turbot Street, Brisbane, am employed by SunWater Limited as Manager, Asset Management.

1.1 Preliminary nature of this statement

This statement has been provided without any knowledge of the content of other evidence that will or may be adduced, or the submissions that have or will be made to the Commission of Inquiry. I will supplement this statement with addendum statements if it is necessary.

I am willing to provide any further information or explanation required by the Commission of Inquiry.

Words that are italicised are defined in the Glossary at section 10.

Documents referenced in this statement can be provided on request.

1.2 CV – qualifications, training,

I hold the following relevant qualifications and memberships:

- Degree in Civil Engineering with first class honours from the University of Technology, Sydney;
- Registered Professional Engineer of Queensland (RPEQ).

1.3 Employment history

I have been employed by SunWater (and its predecessors) since 1989 and have held the position of Manager, Asset Management since July 2007.

My prior roles in SunWater and its predecessor organisations have included:

- Design Engineer for the Burdekin Haughton *Water Supply Scheme*;
- District Engineer for the Biloela district in central Queensland;
- Regional Manager Toowoomba
- Regional Manager Ipswich;
- Technical Services Manager; and
- Project Director for the Asset Management Process Improvement Project

From 1982 to 1989 I was employed by the Water Resources Commission of NSW as a cadet engineer and then civil engineer. My roles included dam design and construction and operations engineer.

1.4 Role at SunWater

My role as Manager, Asset Management, entails overarching responsibility for dam safety, the standard of maintenance and coordination and planning of maintenance and asset refurbishment activities and processes, asset data and systems for SunWater;

I am listed as a point of contact for emergency services in SunWater's Dam Emergency Action Plans.

2 About SunWater

SunWater Limited is a registered 'Large Service Provider for Water Supply and Sewerage Services' under the *Water Supply (Safety & Reliability) Act 2008* and is licensed to provide bulk, irrigation, and retail water services as well as drainage and sewerage services.

SunWater is a company Government Owned Corporation (GOC)[1], operating in a competitive market place on an equal commercial footing with private sector providers. SunWater Limited invests in new infrastructure where it is commercially viable and appropriate.

SunWater has its Corporate Office in Brisbane and has Regional Offices in, Ayr, Mackay, Bundaberg, and Toowoomba. In addition, it has Service Centres in Mareeba, Biloela, Emerald, St George, and Moranbah and Depots at most of its *water supply schemes*. Employees at the Regional Centres are responsible for the overall management of the *water supply schemes* within the centre's designated area, while employees at the depots are responsible for the day-to-day operation and maintenance of the schemes to which they have been assigned.

As from 1 July 2008, SunWater owns and operates 22 *water supply schemes*. All are bulk *water supply schemes* that supply untreated water for irrigation, mining, power generation, groundwater replenishment, and stock watering. Together, the schemes comprise 23 *referable dams* (within the meaning of the *Water Supply (Safety & Reliability) Act 2008)* including 18 major dams (refer Table 3-1), 60 weirs and barrages, 77 major pump stations, 2920km of pipelines and channels, and 690 km of drainage works with an estimated combined replacement value in excess of $6.3 billion (2008)[2]. In addition, SunWater owns and operates 12 small licensed water and sewerage treatment plants to cater for staff and recreational visitors at dam sites and occasionally, for small nearby settlements. SunWater did own a further four *water supply schemes* (Central Lockyer, Lower Lockyer, Logan River and Warrill Valley *water supply schemes*), including five dams (Atkinson Dam, Bill Gunn Dam, Clarendon Dam, Maroon Dam and Moogerah Dam) prior to July 2008. These assets were sold to SEQwater under the provisions of the *South East Queensland Water (Restructuring) Act 2007.*

SunWater provides facility management services to other water infrastructure owners. These services include operations and maintenance, dam safety, flood operations and asset management. Dams managed under these arrangements include Ross River, Scrivener (ACT), and Glenlyon.

SunWater has around 5,000 customers across the mining, power generation, industrial, local government and irrigated agriculture sectors.

SunWater owns a number of subsidiary companies one of which, Burnett Water Pty Ltd, owns Paradise Dam.

---

[1] SunWater Limited ACN 131 034 985

[2] 2008 valuation

SunWater undertakes a wide range of activities from designing and building dams, managing and operating bulk water infrastructure, conducting environmental impact studies to finding new ways to deliver water to remote locations. SunWater engineers are specialists that industry, mining and government turn to for water infrastructure development, management, operations and maintenance. Our complete offering includes but is not limited to:

- Design and design review services;
- Infrastructure development;
- Asset management, planning and review;
- Flood hydrology, hydraulics and flood management;
- Infrastructure operations and management;
- Customer water account management and billing; and ,
- Water management and policy strategy advice.

2.1 Communication with Stakeholders, community relationships

2.1.1 Customers

SunWater has around 5,000 customers across the mining, power generation, industrial, local government and irrigated agriculture sectors. These customers are mostly allocation holders in *water supply schemes*.

SunWater has a water supply contract with most of its customers. The contracts detail the services provided by SunWater and the obligations of both SunWater and the customer. SunWater has also negotiated and published scheme supply arrangements and service targets for each scheme (scheme rules). The scheme rules are annexed to the water supply contracts. The rules are summarised in the Strategic Asset Management Plan (SAMP). Performance against the service targets are reported each year in the annual SAMP report.

Customers can contact SunWater through either an online service or a central call centre. Outside of normal business hours the call centre provides a 24/7 emergency contact service. Customers, media and the general public can contact SunWater through this service for any form of emergency. This includes service interruptions, pipe breaks and flood events. SunWater's role in emergency communications is described further in Section 7.

As discussed in section 2, SunWater has a regional network of Service Centres and depots. Service Managers in regional centres work and live in the same communities as customers. Most *water supply schemes* have a *Local Advisory Committee* (LAC) made up of elected customer representatives. LACs are engaged by Service Managers to provide advice on operational matters such as the timing of maintenance shutdowns.

SunWater provides an online service for customers that provides water storage and water allocation information, access to customer and water accounts and online transactions, and water ordering.

During 2009 SunWater introduced an SMS message service for its customers. Fifty-five per cent of customers have registered their mobile phones with the service. The SMS service has been used for notifications relating to pipe breaks, shutdowns, temporary transfer approvals, announced allocations and other information announcements. One suggestion from the "lessons learnt" (refer Section 3.1.2) exercise following the 2010-11 flood events is to extend the service to the landholders downstream of dams listed in Emergency Action Plans (refer Section 5.1.2.5.2).

2.1.2 Other Stakeholders

Service and Area Operation Managers have regular contact with Local Disaster Management Groups (LDMG). Staff attended meetings with a number of LDMGs before the 2010-11 wet season to ensure they had knowledge of the lines of communication and knowledge of EAPs. The LDMGs that were contacted by SunWater prior to the wet season included:

- Whitsunday;
- Burdekin;
- Mareeba;
- Emerald;
- Warwick; and
- South Burnett.

The St George and Mackay LDMG were already very familiar with SunWater's EAPs due to earlier events in 2010 and regular communications.

During the 2010-11 flood events SunWater staff remained in contact with LDMGs. SunWater worked with the following LDMGs during the events:

- Whitsunday;
- Burdekin;
- Mareeba;
- Emerald;
- Biloela;
- Warwick;

- Inglewood;
- Bundaberg;
- South Burnett;
- St George; and
- Mackay.

3 SunWater's Assets

3.1 Outline of Dams owned and Operated by SunWater

SunWater and its subsidiary company Burnett Water Pty Ltd own 23[3] referable storages consisting 18 *Category 2* (refer to section 5.1.2.3) dams and 5 *Category 1* dams under the *Water Supply (Safety and Reliability) Act 2008* and *Water Act 2000*. Three of the 23 referable storages are pumped storages that are not located on a *watercourse* and generally do not flood. One *referable dam* is a weir which is completely submerged during major floods. These four storages are noted as minor dams in Table 3-1. The balance of this paper will be limited to the remaining 19 dams designated as major dams in Table 3-1.

Four of SunWater's dams have *spillway gates* installed. The gates store water above the *fixed crest* of the *spillway*. All of SunWater's gated dams have the *full supply level* (*FSL*) near the top of the gates with just a small *freeboard*. The gates are operated to maintain the storage level close to FSL during a flood event. The gates are not designed to regulate flood flows other than to match the *spillway discharge* to the rate of inflow to the storage. The four dams with gated *spillways* are Callide, Coolmunda, EJ Beardmore and Leslie dams.

The other 15 major dams have *ungated* or *uncontrolled spillways*. This means that when inflows occur the storage level rises. When the storage level exceeds the FSL the *spillway* will commence to *discharge*. The rate of *discharge* is a function of the height of the storage above the fixed crest, the width of the *spillway* and the flow characteristics of the design (refer Equation 2 below section 4.4).

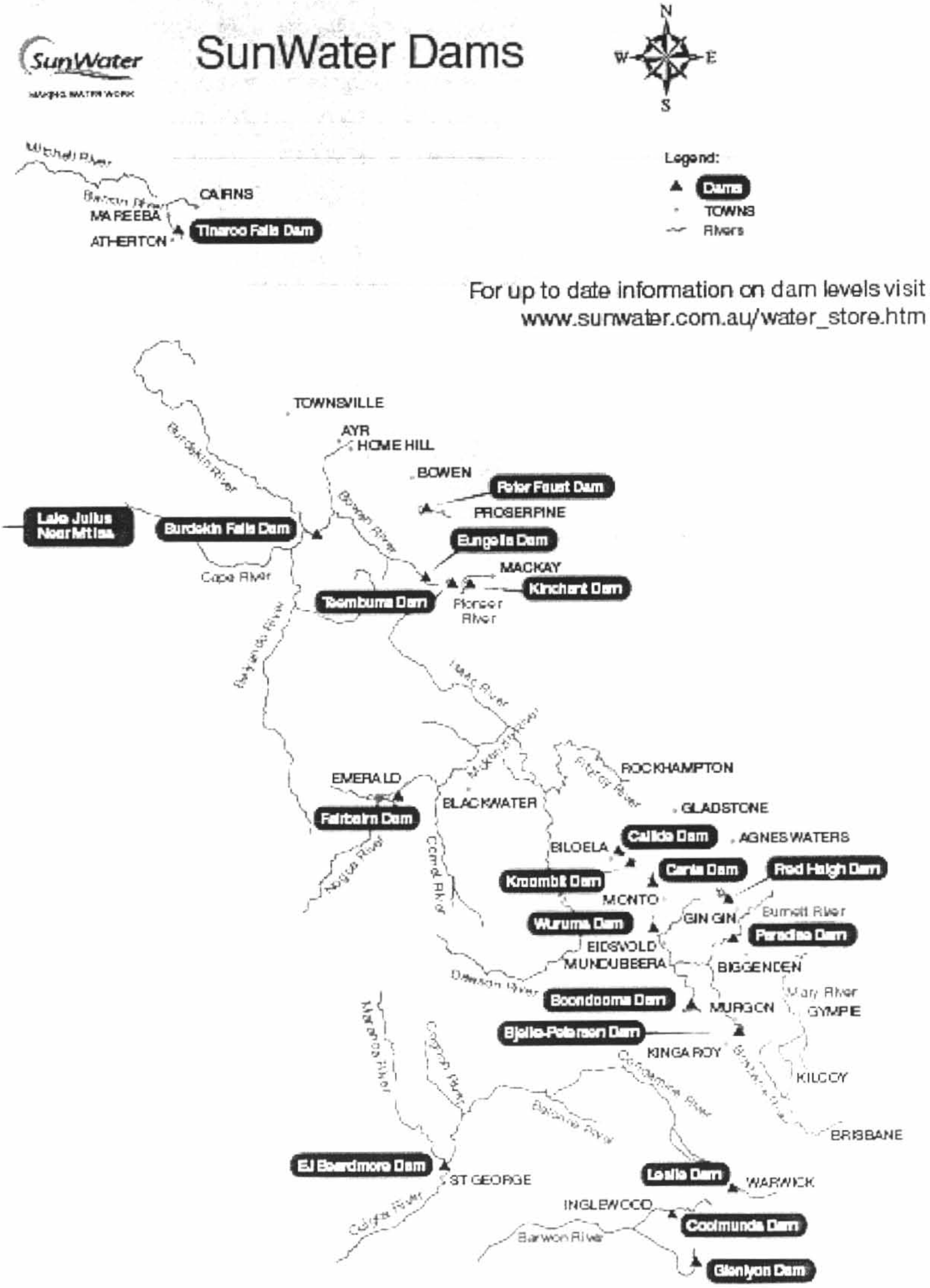
In addition to the dams SunWater owns, the following storages are managed under facility management contracts:

- Glenlyon Dam – (*Category 2* dam) for the Border Rivers Commission;
- Scrivener Dam – (Equivalent to a *category 2* dam) for the National Capital Authority, ACT;
- Ross River Dam – (*Category 2* dam) for the Townsville City Council;

SunWater is the facility manager of Glenlyon and Ross River dams. SunWater operates and maintains these dams in accordance with the approved documentation and SunWater's dam safety management program. SunWater makes recommendations to the dam owner on matters such as major replacements or refurbishments, reviews of documentations or additional investigations that might be considered prudent.

I have not provided any details on the operation of Ross River Dam or Glenlyon Dam in this document. If required by the Commission of Inquiry, a supplementary statement can be provided on these two dams. As Scrivener Dam is not in Queensland no further reference will be made to that dam in this document.

[3] Claude Wharton Weir has an inflatable crest control device that is temporarily out of commission. This reduces the number to 22 by agreement with DERM



3-1 Map of SunWater Dams

Table 3-1 SunWater Dam Statistics

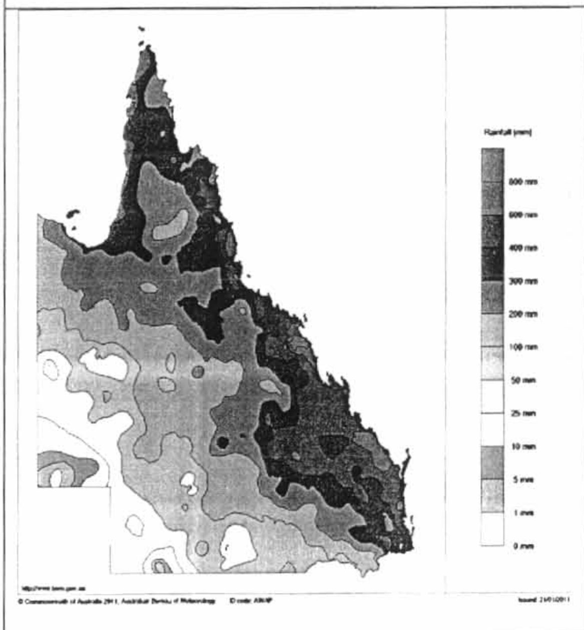
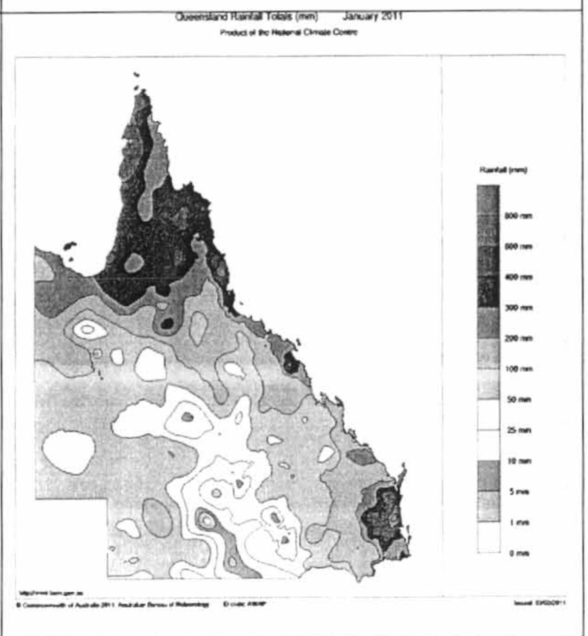
		Dam	Storage Volume (ML)	Failure Impact Rating	Stream	Stream Distance (km)	Type	Height (m)	Surface Area at FSL (Ha)	Date Completed	Purpose	Nearest town	Significant down stream Communities
Major Dams	1	Burdekin Falls	1,860,000	2	Burdekin River	159.3	Mass Concrete with earth and rockfill saddle dams	40	22,000	1987	Water Supply	Ravenswood	Ayr
	2	Fairbairn	1,301,000	2	Nogoa River	685.6	Earthfill	31.7	15,000	1972	Water Supply	Emerald	Emerald
	3	Fred Haigh	562,000	2	Kolan River	76.4	Earth and Rockfill	43	5,345	1975	Water Supply	Gin Gin	
	4	Peter Faust	491,400	2	Proserpine River	57.7	Earth and Rockfill	39.6	4,350	1990	Water Supply & Flood Mitigation	Proserpine	Proserpine
	5	Tinaroo Falls	438,900	2	Barron River	101.4	Post tensioned Mass Concrete	41.8	3,500	1958	Water Supply	Atherton	Mareeba
	6	Paradise	300,000	2	Burnett River	131.4	RCC	31.1	2,951	2005	Water Supply	Biggenden	Bundaberg
	7	Boondooma	204,200	2	Boyne River	86.7	Concrete faced rockfill	64		1982	Water Supply	Proston	Munduberra
	8	Wuruma	165,400	2	Nogo River	23	Mass Concrete	36.6	1,639	1968	Water Supply	Eidsvold	Eidsvold
	9	Teemburra	147,500	2	Teemburra Ck	20.4	Concrete faced rockfill	57	1,085	1996	Water Supply	Mirani	Mackay
	10	Callide	136,300	2	Callide Ck	80.1	Earthfill & mass concrete with Radial gates	34.8	1,240	1965-1988	Water Supply	Biloela	Biloela
	11	Bjelke-Petersen	134,900	2	Barker Ck	1.3	Earth and Rockfill	26.5	2,150	1988	Water Supply	Murgon	Murgon
	12	Eungella	112,400	1	Sandy Ck	8.4	Earth and Rockfill with sloping core	44.5	848	1969	Water Supply	Eungella	
	13	Julius	107,500	1	Leichardt River	390.9	Overshot Multiple Arch Concrete	25.2	1,415	1976	Water Supply	Mt Isa	
	14	Leslie	106,200	2			Mass concrete with Radial gates	28.9	1,288	1965-86	Water Supply	Warwick	Dalby Chinchilla
	15	Cania	88,500	2	Three Moon Ck	110.1	Earth and Rockfill	40.1	760	1982	Water Supply	Monto	Monto
	16	EJ Beardmore	81,700	2	Balonne River	251.4	Earthfill & mass concrete with vertical lift gates	12.1	2,850	1972	Water Supply	St George	St George
	17	Coolmunda	69,000	2	Macintyre Brook	78	Earthfill & mass concrete with Radial gates	16.1	1,645	1968	Water Supply	Inglewood	Inglewood
	18	Kinchant	62,800	2	Sandy Ck	9.4	Earth and Rockfill	18.1	920	1977-86	Water Supply	Eton	Mackay
	19	Kroombit	14,600	2	Kroombit Ck	68.8	Earth and Rockfill with RCC	23	289	1992	Water Supply	Biloela	Biloela
Minor Dams	20	Claude Wharton Weir	12,800	2	Burnett River	202.4	Mass Concrete with inflatable crest	12		1987-93	Water Supply	Gayndah	Gayndah
	21	Isis Balancing Storage	6,160	1	N/A	N/A	Earthfill	14.2		1986	Irrigation Distribution		
	22	Moura Offstream Storage	2,820	1	N/A	N/A	Earth and Rockfill	10.5		1999	Water Supply	Moura	
	23	Woongarra Balancing Storage	4,605	1	N/A	N/A	Earth & Rockfill	9		1977	Irrigation Distribution		

3.1.1 Performance of SunWater Dams during 2010-11 Wet Season

SunWater's dams are designed to safely handle very large rainfall events; events that far exceed the rainfall that was experienced during the 2010-11 wet season. A sample of the *design rainfall* events for SunWater dams is shown in Table 3-3. Whilst some of SunWater's dams will require a future upgrade to pass some extreme events (refer section 6.2), all of SunWater's dams are very safe and can pass very rare events[4]. The rainfall experienced over the 2010-11 wet season in the catchments for SunWater's dams was up to the range of 400mm to 600mm for the major inflow events (refer Table 3-2). Whilst this level of rainfall was significant it was well short of the rainfall events that the dams are design to safely pass (refer Table 3-3).

The SunWater dams performed very safely during the recent events. Whilst there was some erosion damage downstream of some *spillways*, overall there was little damage. Further, details of the damage to each dam is included in the schedules for each dam at the end of this document.

Table 3-2 2010-11 Wet Season recorded rainfall[5]

Queensland Rainfall Totals (mm) Dec 2010 Product of National Climate Centre	Queensland Rainfall Totals (mm) Jan 2011 Product of National Climate Centre
	

[4] The Dam Safety Guiedelines on Acceptable Flood Capacity identify that the Annual Exceedence Probability flood for dams ranges from 1 in 10,000 years to 1:10,000,000 years

[5] www.bom.gov.au/

Table 3-3 Sample of Design rainfall for SunWater dams

Dam	Duration (hr)	Rainfall (mm)
Fairbairn	96	1,070
Peter Faust	120	3,300
Teemburra	36	2,320
Fred Haigh	72	2,160
Boondooma	36	890

3.1.2 Lessons Learnt from the 2010-11 Wet Season.

Following the flood events of the 2010-11 wet season, each SunWater region undertook a review of the events. The purpose of each review was to identify what worked well, what did not work as well and to identify improvement opportunities.

Key learning points included:

- Generally the implementation of the EAPs worked well;
- The dam documentation was found to be a valuable resource for the operators and managers;
- Some refinement of Emergency Action Plans was identified to more clearly define responsibilities and review of trigger levels. This is in progress;
- Some minor updates identified for Operations and Maintenance Manuals. This is in progress;
- Improvements to staff rostering, shift hand over procedures, accommodation and support logistics were identified; and'
- Review some communication systems where issues were experienced such as mobile phone coverage.

Further details of the lessons learnt for each dam are included in the schedules for each dam at the end of this document.

3.2 Water Supply Schemes

A *water supply scheme* is a geographically distinct set of water infrastructure assets. When operated in combination they make it possible to supply water to a group of customers. Each *water supply scheme* has one or more headwork assets in the form of dams and/or weirs. The headwork assets store water and make water available for use when required.

SunWater owns and operates 22 *Water Supply Schemes* plus the Awoonga Callide pipeline. The *water supply scheme* each dam supplies is shown in Table 3-4. An overview of each of SunWater's *water supply schemes* is located in Schedule 1 to this document from page 3.

	Dam	Storage Volume (ML)	Water Supply Scheme
1	Burdekin Falls	1,860,000	Burdekin Haughton
2	Fairbairn	1,301,000	Nogoa Mckenzie
3	Fred Haigh	562,000	Bundaberg
4	Peter Faust	491,400	Proserpine River
5	Tinaroo Falls	438,900	Mareeba Dimbulah
6	Paradise	300,000	Bundaberg
7	Boondooma	204,200	Boyne River and Tarong
8	Wuruma	165,400	Upper Burnett
9	Teemburra	147,500	Pioneer River
10	Callide	136,300	Callide Valley
11	Bjelke-Petersen	134,900	Barker Barambah
12	Eungella	112,400	Bowen Broken Rivers
13	Julius	107,500	Julius Dam
14	Leslie	106,200	Upper Condamine
15	Cania	88,500	Three Moon Creek
16	EJ Beardmore	81,700	St George
17	Coolmunda	69,000	Macintyre Brook
18	Kinchant	62,800	Eton
19	Kroombit	14,600	Callide Valley

Table 3-4 SunWater Dams and Water Supply Schemes

3.3 Communities affected by 2010/11 flooding

Table 3-5 identifies the communities that were significantly affected by flooding during the 2010-11 wet season. The list is limited to those communities in close proximity to SunWater *water supply schemes* or the dams operated by SunWater. It should be noted that a number of communities are not immediately downstream of a dam and therefore not significantly impacted by flows passing through a dam.

Table 3-5 Communities significantly affected by flooding in 2010-11 in SunWater Water Supply Schemes

Communities affected by flooding 2010-11	Dam	SunWater Water Supply Scheme
Emerald Comet	Fairbairn	Nogoa Mackenzie
Bundaberg	Paradise	Bundaberg
Eidsvold	Wuruma	Upper Burnett
Mundubbera Gaydah	Wuruma & Boondooma	Upper Burnett & Boyne River & Tarong
Murgon	Bjelke-Petersen	Barker Barambah
Warwick	Leslie	Upper Condamine
St George Dirranbandi	EJ Beardmore	St George
Inglewood	Coolmunda	Macintyre Brook
Townsville	Ross River	N/A
Goondiwindi	Glenlyon	N/A
Chinchilla	Not immediately below a dam	Chinchilla Weir
Rockhampton		Lower Fitzroy
Maryborough		Lower Mary River
Theodore Moura Baralabah		Dawson Valley

In addition to the communities listed in Table 3-5 SunWater is aware of a number of communities that were not significantly affected but in which there was a heightened concern about the risk of flooding. Communities in this category include Mareeba which is downstream from Tinaroo dam and Proserpine which is downstream from Peter Faust dam. SunWater became aware of these community concerns through media reports and/or direct approaches from members of the community. In these communities SunWater became aware of media and/or community comment which speculated that dams upstream of the communities should be lowered to help mitigate the risk of future floods. I have addressed these concerns in respect to each dam in the schedules at the end of this document.

4 Functions of Dams

Dams can be designed for a number of purposes. These include:

- Water supply;
- Active Flood mitigation;
- Passive flood mitigation;
- Hydroelectric generation;
- Recreation.

All of SunWater dams are designed principally for water supply purposes. Peter Faust Dam has been designed to provide both water supply and *passive flood mitigation* (refer section 4.4). No other SunWater dam has a purpose built flood mitigation role. However all dams will attenuate flood flows to some degree (refer section 4.3)

4.1 Water Supply

A water supply dam is designed to capture water during times of excess flow. The water is then stored and released from the reservoir during times when natural flows are inadequate to meet the needs of water users.[6]

The *yield* of a water supply dam is the volume of water that can be allocated for use each year. The *yield* of a dam is linked to a certain *reliability* of supply and set of operating rules. The *reliability* is a measure of how frequently the full *yield* of a dam will be available for use. Under the regulatory framework the *yield* has been expressed as the water allocations defined in the relevant *Water Resource Plan (WRP)*. The *reliability* of supply has been expressed as *water allocation security objectives* in the *WRP*. Any material deviation from the operating rules established in the relevant *Resource Operations Plan* (refer section 5) could impact on the *reliability* of supply from a dam and have adverse economic effects.

4.2 Dam v weir

Weirs and dams both retain and store water. A dam has a number of components including wall, *spillway* and outlet works. The storage of a dam backs up along the *watercourse* and over land adjacent to the *watercourse*. The *spillway* allows flood flows to safely pass the dam, generally without *overtopping* the main wall. Flows then return to the *watercourse* down stream of the dam.

A weir is in effect a small dam that is constructed wholly within the banks of the water course. Whereas a dam will have a purpose built *spillway* section that is designed to prevent *overtopping* of the main wall, the entire weir structure is designed to be safely overtopped during flood events. During large events weirs are designed to be completely submerged and to have almost no impact on the flood levels within the stream. One design

[6] www.ancold.com.au

criteria that has typically been used for weirs in Queensland is to limit the afflux (increase in upstream level) to no more than 300mm. Typically weirs have no attenuation effect on large flows (refer to section 4.3).

Typically the storage volume of a weir is small relative to the flood flows from the catchment. A weir relies on multiple refills during a year to achieve its water supply *yield*. This contrasts with a dam that typically has a larger storage volume than a weir. A dam's *yield* is often achieved through infrequent fills. A dam may only be expected to fill once every several years so any missed fill opportunities can significantly reduce the *yield* and/or *reliability* of supply.

4.3 Attenuation effect of Dams

Notwithstanding that not all dams are designed as flood mitigation storages, all dams will attenuate flood flows to some extent.

Attenuation is the modifying effect a storage has on the shape of a flood wave or hydrograph[7]. A dam will attenuate a flood in two ways. Firstly the peak *discharge* or *outflow* from a storage will be less than the peak inflow. Secondly the storage will delay the peak so that the peak *outflow* will occur some time after the peak inflow.

The process of determining the *outflow* from a dam during a flood given a particular inflow is known as flood or storage routing. The process for *uncontrolled* or *ungated spillways* is governed by Equation 1.

$$\frac{I_1 + I_2}{2} \cdot dt - \frac{O_1 + O_2}{2} \cdot dt = S_2 - S_1$$ [8]

Where O_2 & S_2 are determined as a function of the storage above the spillway.

Equation 1 - Storage Routing Equation

An uncontrolled or *ungated spillway* on a dam is designed to allow flood flows to pass a dam unhindered in accordance with the above formula. The *full supply level (FSL)* of SunWater's ungated dams is equal to the *spillway* crest[9] (refer Figure 4-3). The dam will behave in such a way that as the inflow increases the storage level will rise and drive the *outflow* in accordance with the *spillway discharge* formula for that particular dam (refer Equation 2). A key characteristic of an ungated *water supply* dam is that the flood level in the storage can be significantly higher than *FSL*.

Spillway gates are sometimes installed on a *water supply* dam to maximise the available storage volume whilst minimising upstream flood levels. Often upstream flood levels will be a constraint on the design of the dam. An example might be where there is some

[7] Water Resource Engineering, RK Linsley & JB Franzini, 3rd edition 1984, p60

[8] Water Resource Engineering, RK Linsley & JB Franzini, 3rd edition 1984, p60 (3-13)

[9] Kinchant Dam is an exception to this rule where the spillway crest is 1m higher than the FSL

development upstream of a proposed dam. If avoidance of flooding of this upstream development is a design criteria then a larger storage could be achieved with a gated structure rather than an ungated structure. In this case the *FSL* would be located near the top of the gates (refer Figure 4-2). The gates are operated in a manner whereby the *outflow* is balanced with the inflow to maintain the storage level within a narrow band close to the FSL (i.e Match O_2 with I_2 in Equation 1 so that $S_2 \sim S_1$). This arrangement is typical of SunWater's gated storages.

The gated *water supply* dam contrasts with the design and operation of a gated *active flood mitigation* dam such as Wivenhoe (refer Figure 4-1). The FSL of a gated *active flood mitigation* dam is typically well below the top of the gates and the objective is not necessarily to minimise upstream flooding but rather manage a flood to maximise the downstream attenuation. In effect S_2 is maximised to minimise O_2 in Equation 1. SunWater does not own any *active flood mitigation* dams.

4.4 Mitigation v Water Supply

Using a dam for flood mitigation is the process of reducing the impact of flooding below a dam. Flood mitigation deliberately enhances the attenuation affect of the dam. Flood mitigation can be either active or passive i.e. if the dam operator can exert some control on the flow it is active flood mitigation. Flood mitigation will not prevent all downstream flooding: The larger an inflow event the less capacity a dam has to mitigate the effect of flooding.

In order for a dam to provide flood mitigation there must be a provision to make air space available to temporarily store flood inflows. This is demonstrated by examining Equation 1. The more the storage volume (S_2) is allowed to increase the lower the *outflow* (O_2) will be.

An *active flood mitigation* storage usually has *spillway gates* where the FSL of the water supply component (if any) is well below the top of the gates (refer Figure 4-1). The air space between FSL and the top of the gates (less some allowance for *freeboard*) is available to the operator to temporarily store inflows. The operator of such a storage is able to make decisions during a flood event about how quickly this storage is filled subject to any operating rules. The objective of *active flood mitigation* is to fill the storage volume during the peak of the inflow to maximise the attenuation of the *outflow*. An *active flood mitigation* dam can reduce and delay the peak of a flood. It cannot completely prevent a flood where the total volume of water in the event is greater than the available storage volume. *Active flood mitigation* requires two key factors. First, the availability of air space to store flood water. Secondly the ability to release significant volumes of water to manage the event and return the storage level to FSL as quickly as possible after an event in case there is a second event shortly after the first event. Water supplies cannot be stored in the flood mitigation partition.

A *passive flood mitigation* storage such as Peter Faust Dam creates the air space for temporary storage through a different mechanism. For example, Peter Faust Dam has a *fixed crest spillway* with no *spillway gates* (refer Figure 4-3) i.e. the *spillway* is *uncontrolled*. Peter Faust Dam has two key aspects. Firstly the width of the *spillway* is relatively narrow. Secondly the crest of the dam is high relative to the *fixed crest* of the *spillway*. Equation 2 defines the *discharge* of water through an *uncontrolled spillway*. It is noted that the *discharge* is a function of the *spillway* width. Peter Faust Dam is designed to provide greater attenuation by virtue of the smaller *spillway* width (38.9m)[10]. The dam has a relatively high crest to reduce the risk of *overtopping* and any dam safety issue. The flood mitigation partition for Peter Faust exists above the *fixed crest* of the *spillway* as a temporary storage. The flood mitigation provided by Peter Faust is passive in that the operator has no discretionary control of the flows.

$$Q=C_w * {}^2/_3 * \sqrt{(2g)} * H^{3/2} * W^{11}$$

Where

Q = *Discharge*
H = height of water in the storage above the fixed crest of the spillway
C_w = the coefficient of *discharge* for the spillway
W= width of the spillway

Equation 2 Spillway *Discharge* Formula

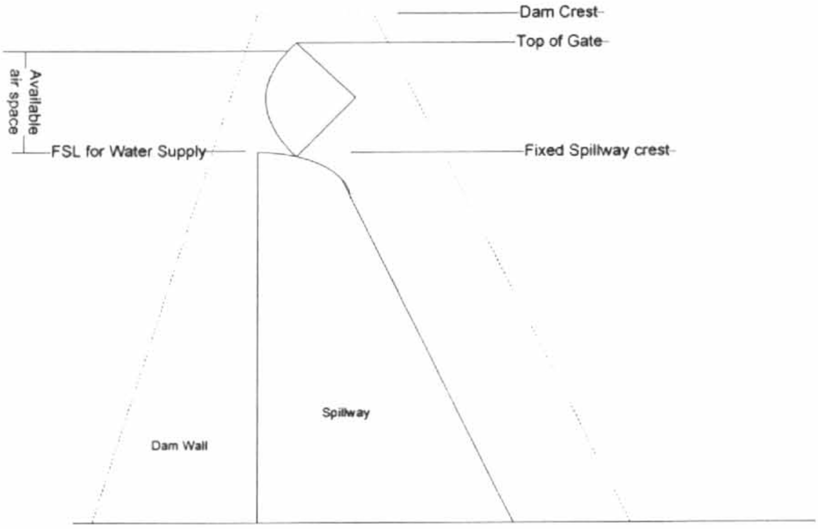


Figure 4-1 Cross Section of Gated Dam with active flood mitigation

[10] Contrast with other spillway widths – Burdekin 504m, Fairbairn 158.5m, Tinaroo 76.3m

[11] Elementary Fluid Mechanics, Vennard & Street, 6ed, eq 11.20, p540

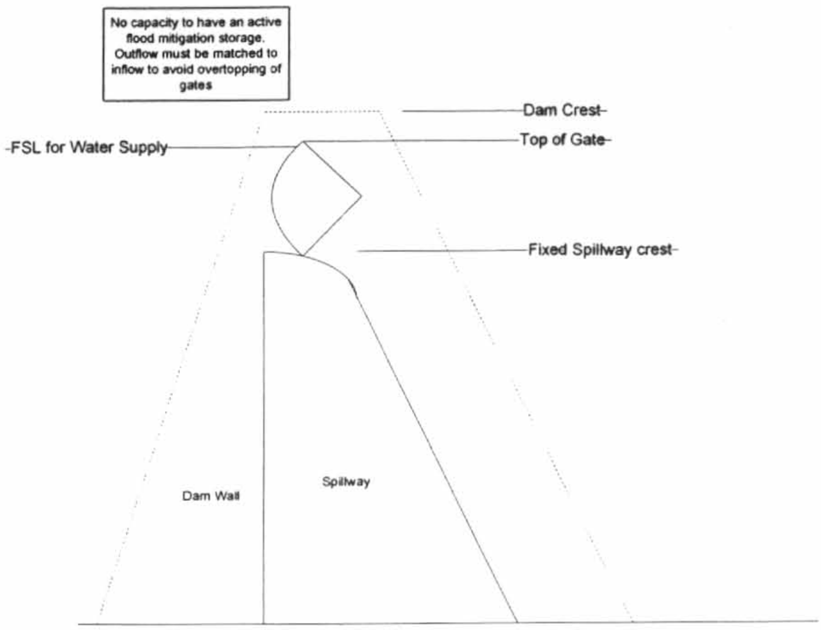


Figure 4-2 Cross Section of Gated Water Supply Dam – no flood mitigation

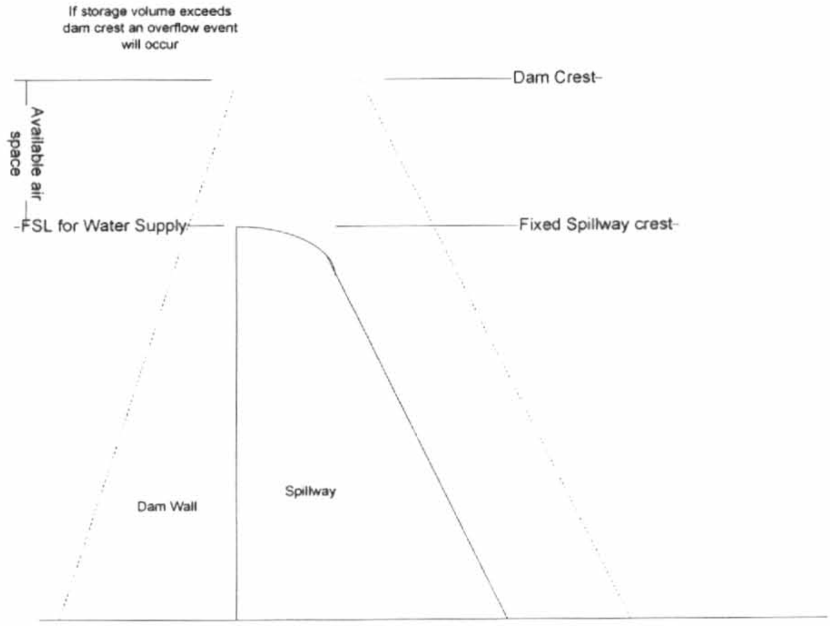


Figure 4-3 Cross Section of Water Supply Dam with ungated or uncontrolled spillway – May have passive flood mitigation

4.5 Mitigation Opportunities for SunWater Dams

SunWater has recently undertaken a review of the operations of a number of the dams that experienced significant flood events during the 2010-11 wet season. The purpose of the review was to assess whether the existing dam infrastructure could be operated in such a way that further attenuation to *spillway discharge* could be achieved. The details of the assessment for each dam are included in Schedules 2 to 20.

The key findings of the assessment are as follows:

- Flood mitigation could only be provided from the existing configuration by lowering the water supply *FSL* to create air space (refer section 4.4), however for reasons set out in point 3 below this would have been ineffective.

- The flood volumes over the 2010-11 wet season were generally many times greater than the storage volume of the dams. For example the full storage volume of Paradise dam is 300,000ML. The total flow into the dam over a 20 day period was 22 times the full storage volume.

- If the *FSL* had been drawn down significantly prior to 1 December 2010 the peak *discharge* from the dam and hence flood levels would have been unchanged in most cases. The dam in which lowering the water level would have had the greatest reduction to the peak *discharge* is Fairbairn dam. For example, if the dam had been at 50% on 1 December 2010 then the peak storage level would have been 5.32m over the *spillway*. This is just 260mm lower than the actual level. The flood levels downstream of Fairbairn dam would still have exceeded the 2008 flood levels. In 2008 large parts of Emerald were still inundated.

- Even if the benefits of lowering the *FSL* were not insignificant or non-existent, it is not practical to lower the *FSL* as:

  1. The capacity of the outlet works is very small relative to the storage volume. It would take several months to lower the storage level to any significant extent for most SunWater dams and weather forecasting is not accurate enough to predict flooding several months beforehand. In the case of Fairbairn Dam it would take 12 months to lower the dam to 50%, even if there was no inflow in that time.

  2. Lowering of the *FSL* would be a breach of the *ROP* because the *ROP* does not allow for pre-flood releases.

- The cost of infrastructure modifications would be very substantial and in addition would change the purpose of the dams from being water supply dams. It would appear that the flooding risk below SunWater dams is already at a level that would be considered *as low as reasonably practical* (ALARP).

- Even if the extreme measure of emptying dams were possible prior to the wet season (in most cases this is not feasible in practice for the reasons discussed above) there would have been no change to the peak *discharge* for some dams such as Burdekin Falls Dam.

5 Water Regulation

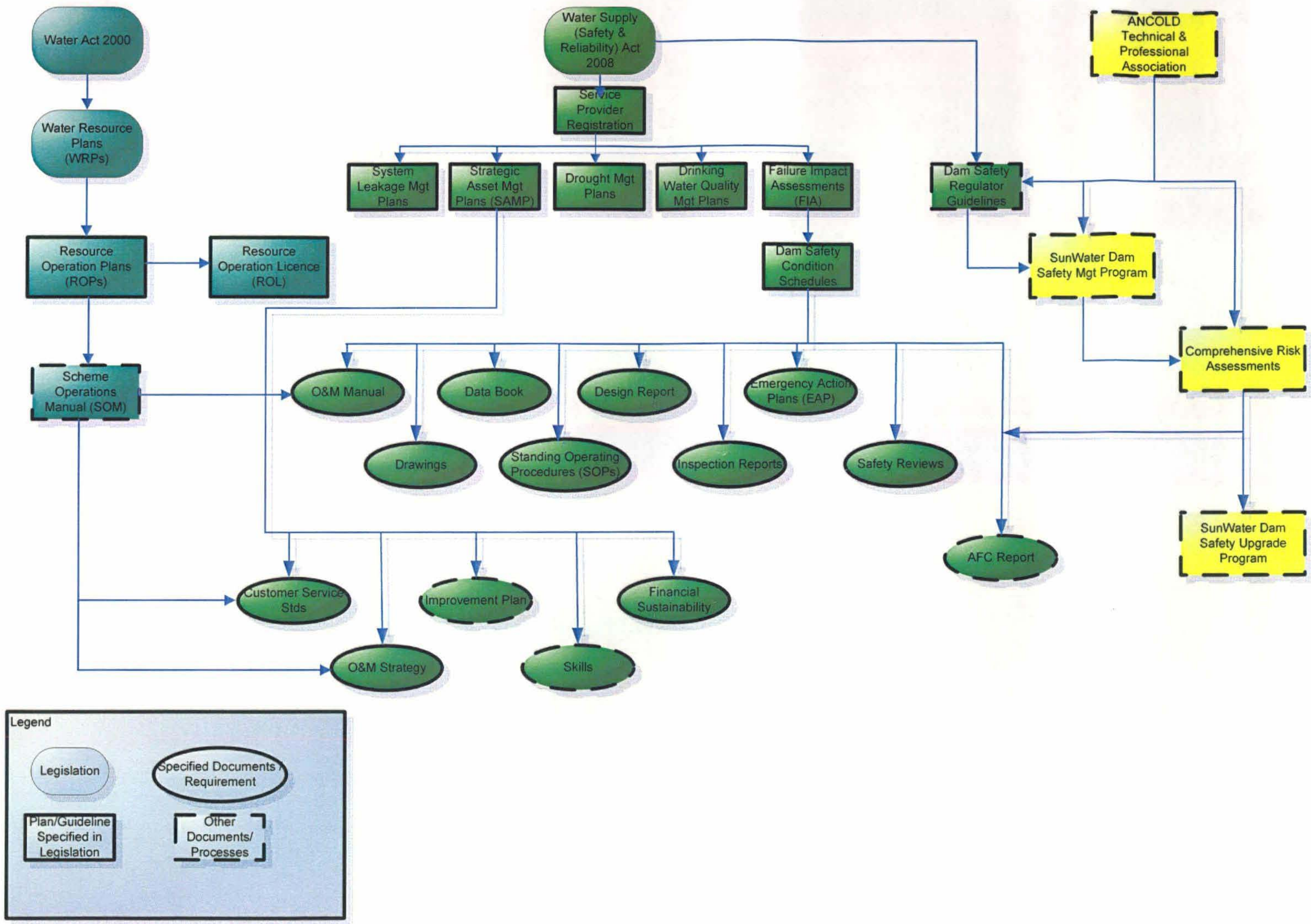
5.1 General regulatory framework

The water industry in Queensland is regulated by a number of legislative instruments impacting on matters concerning operations, dam safety and emergency management. In terms of the operation of bulk *water supply schemes* and dams there are two key pieces of legislation, the *Water Act 2000* and the *Water Supply (Safety and Reliability) Act 2008*. There is also an array of subordinate legislation and referenced documents that combine to form the general regulatory framework. In addition to legislation are industry standards that provide a technical basis for behaviour and decision-making. In the case of dams the major source of these technical standards is the Australian National Committee on Large Dams (ANCOLD) and the Queensland dam safety regulator.

Figure 5-1 provides an overview of the regulatory framework that applies to SunWater dams.

SunWater has systems in place to ensure that full compliance with the framework is achieved. In some cases SunWater aims to exceed the minimum standards specified in the framework.

By way of background as to SunWater's systems in respect to dam safety and emergency management, set out below is a description (taken largely, and in some cases directly, from the DERM website) of the relevant legislation, regulations and standards that govern water and dam management.



5-1 Regulatory Framework

5.1.1 Water Act 2000

The Act sets out the Minister for Environment and Resource Management's responsibility to plan for the State's future needs by securing supplies for social and economic needs—like towns, industry, irrigation and mines—while setting out strategies to support river health. To achieve this, the Act allows for *WRPs* to be developed for any part of the state to ensure that water is equitably managed for each area's unique balance of water uses for the ensuing 10 years[12].

5.1.1.1 Water Resource Plans

The water resource planning process is governed by the *Water Act 2000*. *WRPs* strive to achieve a sustainable balance between meeting human needs and those of the environment. *WRPs* are strategic in nature and establish an overall framework for the management of water resources in a catchment.

The water resource planning process aims to ensure that the health of Queensland rivers and groundwater reserves is maintained so that the needs of future generations are provided for in a fast-changing world. They are a framework for striking the correct balance. Each plan has an expected life of 10-years. Plans are developed to complement parallel state and national initiatives such as regional water supply strategies, the Reef Water Quality Protection Plan and the Caring for Our Country program. They are also consistent with the principles and goals of the National Water Initiative, agreed to in 2004 to replace the 1994 National Water Reform Agenda.[13]

5.1.1.2 Resource Operations Plans

Resource Operations Plans (ROPs) are concerned with the day-to-day management of water resources, in a way that meets the *WRP* goals. A *ROP* outlines how a *Water Resource Plan* (*WRP*) will be implemented in specified areas. The *ROP* puts into effect strategies which support the objectives of the *WRP*. The *ROP's* provisions ensure that water in the plan area is managed for consistency with the *WRP's* overall goals for water entitlement security and ecological health.

A *ROP* sets out:[14]

- The process under which water allocations can be traded and the areas where trading can occur. Rules will ensure that *water allocation security objectives* and environmental flow objectives specified in the *WRP* are protected from the effects of trading;
- The process for making available any unallocated water identified in the *WRP*;

[12] www.derm.qld.gov.au

[13] www.derm.qld.gov.au

[14] www.derm.qld.gov.au

- Rules for accessing water in areas where entitlements do not convert to water allocations in a way that recognises local flow variability patterns. In some plans, rules may be set out for limited trading of water taken under licences;
- Detailed operating rules for infrastructure operators to ensure the management of dams and weirs complies with the *WRP*; and
- Monitoring and reporting requirements as specified in the *WRP*. Monitoring and regular reporting ensure that emerging issues can be identified and addressed and will also contribute to the plan's renewal at the end of its 10-year life.

The main implication of *ROPs* for SunWater in the context of this paper is specification of operating rules for infrastructure and water sharing rules.

5.1.1.3 Resource Operations Licence

A *resource operations licence* is issued under the *Water Act 2000* and authorises the holder of the licensee to interfere with the flow of water to the extent necessary to operate the water infrastructure to which the licence applies.

5.1.2 Water Supply (Safety & Reliability) Act 2008

The purpose of *Water (Safety & Reliability) Act 2008* is to provide for the safety and *reliability* of *water supply*. The purpose is achieved primarily by providing for a regulatory framework for water and sewerage services, the regulation of *referable dams*, flood mitigation responsibilities, and protecting the interests of customers of service providers.[15]

5.1.2.1 Water Service Provider Registration

The *Water Supply (Safety and Reliability) Act 2008* requires certain owners of infrastructure that supply water or sewerage services to be registered as service providers. Registered organisations include local governments, water authorities and other entities, that intend to charge for supplying water or sewerage services.[16] SunWater is a registered water service provider under the Act (service provider ID: 204). SunWater is registered to provide bulk, irrigation, and retail water services as well as drainage and sewerage services.

5.1.2.2 Strategic Asset Management Plan (SAMP)

The *Water Supply (Safety and Reliability) Act 2008* requires service providers to prepare a strategic asset management plan (SAMP). A SAMP focuses on continuity and sustainability of supply of each of the service provider's registered services. A SAMP must be certified by a registered professional engineer (RPEQ) (see *Professional Engineers Act 2002* (Qld)).[17]

A SAMP must have regard to best practice industry standards and include[18]

---

[15] *Water Supply (Safety & Reliability) Act 2008 s3*

[16] www.derm.qld.gov.au/factsheets/pdf/water/w95.pdf

[17] www.derm.qld.gov.au/factsheets/pdf/water/w99.pdf

[18] www.derm.qld.gov.au/factsheets/pdf/water/w99.pdf

- Details of the services provided:
- The infrastructure for supplying those services:
- Standards for appropriate levels of service, including customer service and performance indicators for the service:
- A strategy that demonstrates how each standard will be achieved. This strategy must consider the issues of operation, maintenance and renewal of relevant infrastructure: and
- The provider's proposed arrangements for financing the implementation of the SAMP.

SunWater has had a number of versions of its SAMP submitted to and approved by DERM. SunWater's current approved SAMP is version 3A and is dated June 2009.

5.1.2.3 Failure Impact Assessments (FIA)

A failure impact assessment evaluates the population at risk if failure of a water dam was to occur. A dam is considered to have failed, if there is a physical collapse of all or part of the dam or an uncontrolled release of any of its contents. The assessment is required to be certified under the *Water Supply (Safety and Reliability) Act 2008*[19] and may give the assessed dam a failure impact rating, based on the population at risk:

- Less than two people—no failure impact rating.
- Two to 100 people—*category 1* rating.
- More than 100 people—*category 2* rating

Water dams given a *category 1* or a *category 2* failure impact rating are, where the regulator has accepted the assessment, classified as "*referable dams*" under the *Water Supply (Safety & Reliability) Act 2008*. SunWater's *referable dams* and their failure impact category ratings are listed at Table 3-1. It should be noted that downstream development can alter the failure impact rating of a dam as the population at risk increases.

5.1.2.4 Dam Safety Conditions Schedules

Construction of or modification to a *referable dam* is 'assessable development' under the *Sustainable Planning Act 2009* (SPA). A development permit is required for these works under the SPA. SunWater's dams that were in existence at the time the *Water Act 2000* was proclaimed were deemed by the *Water Regulation 2002* to have a prescribed failure impact rating. The *Water Supply (Safety and Reliability) Act 2008* deems a dam that does not otherwise have a development permit to have a development permit once the dam safety regulator has applied safety conditions to that dam[20].

---

[19] S. 342

[20] S. 353 (3) *Water Supply (Safety and Reliability) Act 2008*.

The dam safety regulator (who is currently Peter Allen of DERM) issues safety conditions for *referable dams*. Safety conditions are taken to be conditions attached to the permit.

The dam safety regulator has issued safety conditions to SunWater for each of its *referable dams.*

5.1.2.5 Standing Operating Procedures

Dams are normally designed to operate within a range of operating criteria. A good dam safety management program will ensure that[21]:

- These operating criteria are known;
- The dam is operated within these criteria; and
- The dam is maintained so that it can perform within the established criteria.

This is done through Standing Operating Procedures (SOPs). These procedures should[22]:

- Define responsibilities for actions critical to the safety of the dam;
- Identify procedures for particular daily activities, which ensure that these activities are done safely, in the same way each time and in accordance with development permit conditions; and
- Ensure appropriate people are notified when unforseen or unusual events occur.

SunWater has in place a full set of SOPs for each of its dams in hardcopy form as a controlled document (meaning that it cannot be amended, except by a set procedure involving detailed review).

The SOP for each dam is located in the office occupied by the dam operator at the dam and also in SunWater's Brisbane office. Some of the hardcopy SOP documents have been superseded by electronic maintenance schedules and work instructions in SunWater's electronic work maintenance system or as procedures in the corporate quality system. Where there are electronic procedures the hard copy is noted as superseded and the new procedure is referenced. Operators have access to the electronic documents.

5.1.2.5.1 Operations and Maintenance Manuals

Detailed Operations and Maintenance Manuals address how to operate, maintain and overhaul individual pieces of equipment for a dam and its associated structures (eg the operation, maintenance and replacement of valves and motors for the gates). The dam owner should operate and maintain the dam in accordance with the O&M manuals[23].

[21] www.derm.qld.gov.au/water/regulation/pdf/guidelines/dam_safety/chapter_05.pdf

[22] www.derm.qld.gov.au/water/regulation/pdf/guidelines/dam_safety/chapter_05.pdf

[23] www.derm.qld.gov.au/water/regulation/pdf/guidelines/dam_safety/chapter_05.pdf

The manuals contain the following[24]:

- Work Instructions, which detail the way in which equipment should be operated and outline the steps involved in performing a task. For example, a work instruction may be developed for the use of the gantry crane for placement of bulkheads gates;
- Maintenance Schedules, which detail the asset, description of task and the frequency of maintenance;
- Special requirements for servicing and maintaining the equipment. For example, a maintenance schedule should be developed for maintaining and servicing all mechanical and electrical equipment; and
- Equipment data sheets or Manufacturer's Manuals which comprise technical information needed for maintenance, repair and overhaul of equipment. For example, an equipment data sheet or manufacturer's manual should exist for the operation, maintenance, repair and overhaul for the emergency generating set.

SunWater has in place a full set of O&M manuals for each of its dams in hardcopy form as a controlled document. These documents are located in the office occupied by the dam operator and in the Brisbane office. The O&M manuals are also located on the SunWater intranet system for easy access by operators and maintainers.

5.1.2.5.2 Emergency Action Plans

An Emergency Action Plan (EAP) is a formal plan that[25]:

- Identifies emergency conditions which could endanger the integrity of the dam and which require immediate action;
- Prescribes procedures which are followed by the dam owner and operating personnel in the event of an emergency; and
- Provides timely warning to appropriate emergency management agencies for their implementation of protection measures for downstream communities.

SunWater has in place a full set of EAPs for each of its dams in hardcopy form as a controlled document. These documents are located in the office occupied by the dam operator and in the Brisbane office. A controlled copy is also issued to each staff member in the management structure of SunWater who has direct responsibilities under the EAP. Controlled copies are also issued to local and district disaster coordinators and Emergency Management Queensland.

[24] www.derm.qld.gov.au/water/regulation/pdf/guidelines/dam_safety/chapter_05.pdf

[25] www.derm.qld.gov.au/water/regulation/pdf/guidelines/dam_safety/chapter_09.pdf

SunWater's EAPs have evolved over time under a continuous improvement process. Most dam EAPs have had a number of issues (i.e., versions) of the documents. The notification and emergency communication list is reviewed annually and reissued when changes occur.

5.1.2.5.3 Inspections

Dam safety inspections are conducted to determine the status of the dam and its features relative to its structural and operational safety. Different types of dam safety inspections should be undertaken for different purposes[26]. These include:

- Routine inspections/surveillance - to identify physical deficiencies of the dam;
- Periodic inspections - generally carried out by a dams engineer with the purpose of identifying physical deficiencies of the dam by visual examination and review of surveillance data against prevailing knowledge. Generally undertaken on an annual basis;
- Special inspections – the examination of a particular physical feature of operational aspect of a dam for some special reason, for example, where a dam has been identified as having a possible deficiency or has been subject to abnormal loading conditions; and
- Comprehensive inspections - a periodic inspection of the dam and a review of the owner's whole dam safety management program. Generally with a frequency of five years.

The minimum frequency of periodic and comprehensive inspections is specified in the dam safety conditions schedule for each dam. Periodic inspections are not required for some lower hazard dams, however under SunWater's dam safety management systems, periodic inspections are undertaken annually for all dams.

Any recommendations arising from periodic and comprehensive inspections are included in the SunWater SAP maintenance system to ensure the assignment and follow-up of actions required as a result of the recommendations.

5.1.2.5.4 Design Report

A Design Report is compiled once the design and construction stages are completed. Design reports are an important reference for the operation of the dam because they provide an overview of the design assumptions and dam safety features. The designer should document the design and construction of the dam including:[27]

- Designer's Operating Criteria (DOC), e.g. gate operating rules and cone valve operation protocols
- Design parameters adopted and assumptions made (and their bases)

---

[26] www.derm.qld.gov.au/water/regulation/pdf/guidelines/dam_safety/chapter_06.pdf

[27] www.derm.qld.gov.au/water/regulation/pdf/guidelines/dam_safety/chapter_04.pdf

- Methods of analyses
- Results of analyses and investigations (numerical and physical)
- Hydraulic model testing of final *spillway* arrangements
- Complete set of drawings and specifications
- Summary of As-Constructed documentation and other construction information
- The Design Report must contain sufficient information so that in the event of any safety problems relating to the dam, information can be quickly and easily obtained to resolve the problem.

SunWater also produces a design report for any major upgrades or modification of a dam.

5.1.2.5.5 Data Book

Dam owners should compile and maintain a Data Book[28]. A Data Book is a convenient source of information summarising all pertinent records and history. It should include documentation in respect to investigation, design, construction, operation, maintenance, surveillance, remedial action as well as monitoring measurements. A Data Book may be large and consist of several documents e.g. drawings, electronic data files and printed reports or smaller depending on the type and complexity of the dam.

SunWater has an up to date data book for each of its dams. Volume 1 of the SunWater data books is effectively a catalogue of the documents for the dam. The data book lists all reports, studies and other relevant documents for each dam.

5.1.2.5.6 Safety Reviews

A safety review is a procedure for systematically assessing the safety of a dam after its original construction. It is a fresh engineering assessment of the integrity of all elements of a dam. It usually incorporates a[29]:

- Current failure impact assessment;
- Detailed review of structural, hydraulic, hydrologic and geotechnical design aspects;
- Review of historical operational performance;
- Review of surveillance reports;
- Comprehensive inspection of the dam; and
- Comparison of the standards used for building and upgrading the dam against current design standards.

[28] www.derm.qld.gov.au/water/regulation/pdf/guidelines/dam_safety/chapter_04.pdf

[29] www.derm.qld.gov.au/water/regulation/pdf/guidelines/dam_safety/chapter_07.pdf

The frequency (generally 20 years) of safety reviews is specified in the safety conditions schedule for each dam.

SunWater undertook a program of safety reviews from about 1998 to 2002. The next round of safety reviews will commence from about 2018 (refer Table 6-4).

5.1.2.6 Flood mitigation

Under the provision of Chapter 4, Part 2 of the *Water Supply (Safety and Reliability) Act 2008*[30], the dams safety regulator may nominate the owner of a dam as an owner who must prepare a flood mitigation manual (the nomination is set out in a regulation). A flood mitigation manual ensures that such dams make controlled releases of water for flood mitigation purposes in accordance with pre-agreed conditions[31]. No regulation has yet been made under this section of the Act, however manuals for three dams were approved under the *Water Act 2000.* These dams were Wivenhoe, Somerset and North Pine. These dams are owned by Seqwater. There are no flood mitigation manuals for any of SunWater's dams.

5.1.2.7 Dam Safety Regulator Guidelines

The Queensland dam safety regulator (DERM) may issue guidelines on various dam safety topics. The guidelines are issued to assist dam owners understand and exercise their responsibilities for the safety of dams. The regulator has issued the following guidelines:

- The Queensland Dam Safety Management Guidelines (February 2002)
- Guidelines for Failure Impact Assessment of Water Dams (April 2002)[32]
- Acceptable Flood Capacity (AFC) for Dams (February 2007)
- Flood mitigation manual for dams (October 2010)

SunWater has incorporated the first three of these guidelines into its dam safety system (refer section 6.1). The guideline for flood mitigation manual for dams applies to the implementation of Chapter 4, Part 2 of the *Water Supply (Safety and Reliability) Act 2008* (the Act)[33]. As previously discussed, this guideline does not currently apply to SunWater dams.

5.2 Allocation and ownership of water

An important consideration in the management of dams and other water infrastructure is the issue of ownership of the water supplies from that infrastructure. As stated in section 5.1.1 the *Water Act 2000* sets responsibility to plan for the state's future needs by securing supplies for social and economic needs. A key concept here is water security. The water

[30] www.derm.qld.gov.au/about/policy/documents/3991/wir_2009_3991.pdf

[31] Explanatory Note to the Water Supply (Safety and Reliability) Bill p122

[32] www.derm.qld.gov.au/water/regulation/guidelines_refer_dams.html

[33] www.derm.qld.gov.au/about/policy/documents/3991/wir_2009_3991.pdf

resource planning process is designed to plan for the allocation and sustainable management of water to meet Queensland's future water requirements[34]. The process provides for water entitlements to be converted to tradeable allocations. In SunWater's *water supply schemes*, these tradeable allocations are generally owned by individual customers. The security of these allocations is dependant, in part, on the water infrastructure being operated in accordance with the rules established in ROPs.

The implications of this framework for SunWater can be summarised as follows:

- SunWater does not generally own the water allocations. The allocations are primarily owned by SunWater's customers;
- SunWater has a duty to operate its water infrastructure in accordance with the arrangements and supply requirements detailed in the *ROP*.

5.3 ANCOLD

The Australian National Committee on Large Dams Inc. (ANCOLD) is an Australian based non-government, non-profit and voluntary association of organisations and individual professionals with a common technical interest in dams. ANCOLD currently has 53 member companies covering all aspects of the dams industry, and 153 individual associate members.

Individual associate members are typically specialist professional civil, mechanical, electrical and environmental engineers working in the dam industry. Corporate members comprise a range of public and private sector dam owners, consultants, contractors, government agencies and other organisations with a professional interest in dams. SunWater is a corporate member of ANCOLD.

ANCOLD members may participate in the work of a variety of ANCOLD technical working groups. Technical working groups prepare reports and papers for publication by ANCOLD. SunWater actively participates in working groups.

5.4 Additional risk/safety management

SunWater has established systems (refer section 6.1) aimed at ensuring full compliance with the regulatory framework.

Compliance with regulations and standards is a minimum position. SunWater, as a prudent dam owner, has carefully considered its position on risk in the context of being a leading corporate citizen. As a government owned company, the community may hold SunWater to a higher standard than say a small private dam owner. In a number of areas SunWater has adopted a standard that is higher than the minimum standard imposed by regulation. Areas in which SunWater has adopted a higher standard include the following:

- SunWater undertakes annual periodic inspection of its *category 1* dams. Generally condition schedules for *category 1* dams do not require annual periodic inspections;

[34] www.derm.qld.gov.au/water/strategy/index.html

- SunWater instigated a program of comprehensive risk assessments for each of its dams a number of years in advance of the regulator issuing guidelines on acceptable flood capacity;

- The regulators guideline on *acceptable flood capacity* (AFC) allows dam owners to adopt risk based assessments to determine AFC of a dam. A risk based assessment will usually result in a lower standard than a standards based assessment. It is SunWater's policy to adopt a standards based assessment except where the cost of the standards based approach is grossly disproportionate to the benefits gained (refer Figure 6-3);

- An important consideration for dam safety upgrade decisions is the determination of whether or not an *As Low as Reasonably Practicable* (ALARP) position for AFC has been reached. When considering the risk based acceptable flood capacity, the dam safety regulator's guideline considers that ALARP is satisfied once a cost to benefit ratio of 1 is reached. SunWater considers this to be too low a hurdle. SunWater does not consider that ALARP has been satisfied until a higher ratio of 3 is obtained; and

- Dam deformation surveys to monitor movement are conducted annually by SunWater for most dams regardless of the hazard category of the dam. ANCOLD recommends a minimum frequency of annual surveys for extreme hazard category dams only and 2 yearly survey for high hazard category dams.

6 Dam Safety

All of SunWater dams are designed principally for *water supply* purposes. Peter Faust dam has been designed to provide both *water supply* and *passive flood mitigation.* One of SunWater's principle objectives is to operate its dams and other infrastructure to provide reliable *water supply* to the water allocation holders. SunWater achieves this objective by:

- Operating the dams and other infrastructure to the established rules defined in the ROPs;
- Ensuring that the dams are at *FSL* at the end of each spill event. This is achieved by closing *spillway gates* where they exist and/or only releasing water through the outlet works in accordance with the *ROP*;
- Releasing water from the dams on a "just-in-time" basis to meet demands whilst minimising any *discharge* from the end of the *water supply schemes.*

An objective of equal importance is to minimise the risk of harm. That is to make sure that each dam remains safe. This also appears to be the underlying objective of chapter 4, part 1 of the *Water Supply (Safety & Reliability) Act* 2008. If a medium to large dam were to fail[35] there could be a large population down stream whose safety would be at risk. A failure could result in the loss of life.

Whilst SunWater has a number of processes and programs in place to manage infrastructure (including dams) to ensure reliable water supplies, there are two specific programs related to ongoing dam safety that should be specifically addressed:

- The dam safety management program; and
- The dam safety upgrade program.

The dam safety management program seeks to ensure that all dams owned or managed by SunWater (refer 6.1 below):

- perform safely to their current design standard;
- are operated safely;
- have their condition evaluated on a regular basis;
- are maintained to an appropriate standard;
- are prepared for an emergency situation;
- comply with the regulatory framework; and
- have the risk of failure minimised.

[35] Dam Failure is the uncontrolled release of water due to physical collapse or component failure

The dam safety upgrade program is a program whereby the risks of dams owned by SunWater have been fully evaluated against current engineering standards. Where deficiencies exist the dams are upgraded as soon as practicable on a priority basis. The dam safety upgrade decision criteria is outlined in section 6.2.2. Although a number of dams either have been upgraded or are programmed to be upgraded, SunWater's dam safety management program ensures that all of SunWater's dams are safe under normal conditions. The upgrades are required to satisfy extreme, low probability events.

6.1 Dam Safety Management Program

The safety management of each of SunWater's storages is guided by a Dam Safety Condition Schedule issued by the office of the Dam Safety Regulator which sits within the Department of Environment and Resource Management (DERM) (refer section 5.1.2.4). These schedules outline SunWater's minimum compliance requirements in terms of inspections (annual and 5 yearly), design, incident management and documentation, and have been incorporated into SunWater's dam safety management program which is based on industry best practice.

The dam safety management program is incorporated into the SunWater SAP PM[36] maintenance schedules and maintenance items. This means that work orders for inspections and document revisions are automatically generated by the system on a monthly basis which then creates a controlled document trail that requires actioning and closing out. The recommended work is also programmed in SAP in advance and the work order number is included in the inspection report.

The dam safety management program procedures have been documented in a quality system[37]. The system has 15 procedures (DS Procedures) which are notated "DS01" through to "DS 15". These procedures are:

- DS01 – Dam Safety Management Program Overview;
- DS02 – Dam Safety Management Structure and Responsibilities;
- DS03 – Operations and Maintenance Manuals for Referable Dams;
- DS04 – Standing Operating Procedure for Referable Dams;
- DS05 – Emergency Action Plans for Referable Dams;
- DS06 – Data Books for Referable Dams;
- DS07 – Safety Reviews;

[36] SAP PM – SAP Plant Maintenance module that is SunWater's corporate maintenance system that is fully integrated into the enterprise wide business system

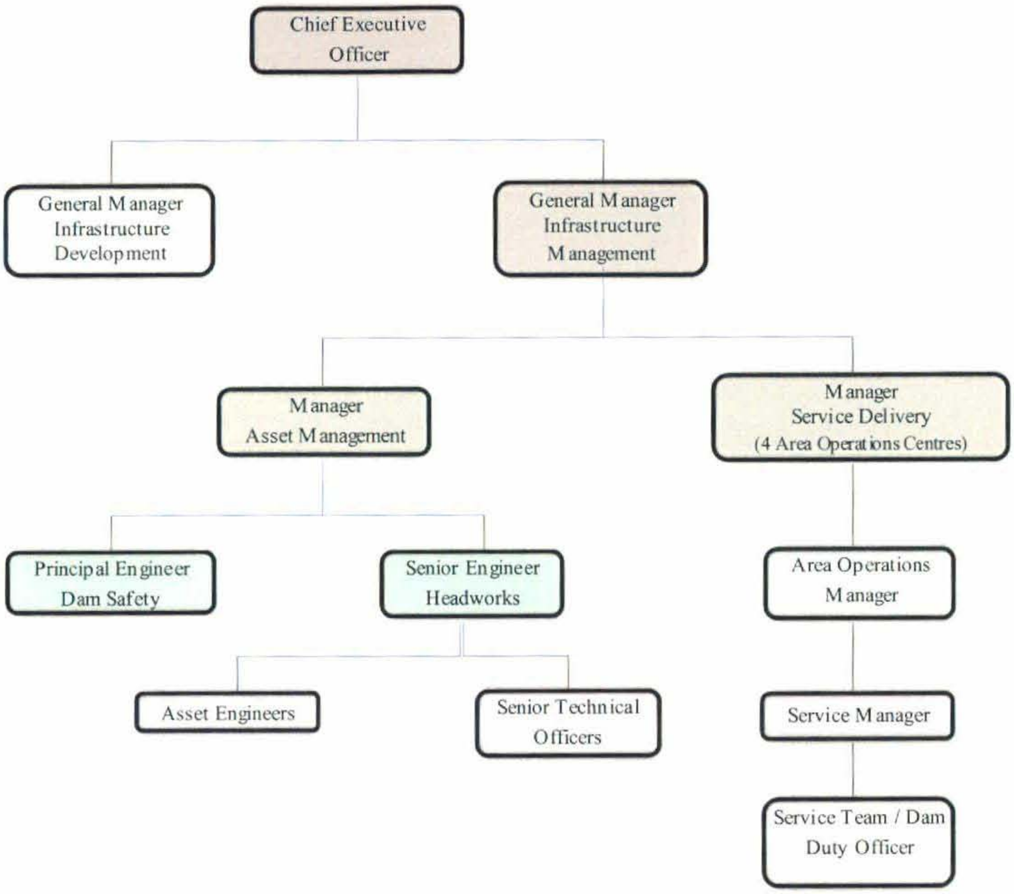
[37] The dam safety system is based on international quality business system standards, however the certification process for the system is not yet complete.

- DS08 – Impact Failure Assessments;
- DS09 – Acceptable Flood Capacity and Risk Assessments;
- DS10 – Annual Inspections;
- DS11 – 5 Yearly Comprehensive Inspections;
- DS12 – Dam Safety Training Program;
- DS13 – Dam Inspection Techniques;
- DS14 – Documentation Control and Review; and
- DS15 – Instrumentation Monitoring Program.

SunWater also has in place a dam safety upgrade program which has evolved over the last seven years as each study or review has added to the information base and broader understanding of the structures and their behaviour. The dam safety upgrade program is explained in section 6.2 below

6.1.1 Roles and Responsibilities:

DS02 clearly defines and assigns responsibility for dam safety within SunWater (refer Table 6-1). The SunWater Infrastructure Management Division is responsible for the portfolio of dams. SunWater manages its portfolio of referable structures through four (4) Area Operations Centres, each responsible for the dam safety management program for the operation and maintenance infrastructure under its management control. SunWater has a centralised asset management function. The Asset Management group is responsible for asset planning, inspection, maintenance governance and the dam safety management program.



6-1 SunWater Staff Structure

Set out in Table 6-1 below is a summary of the various functions and responsibilities under Sunwater's dam safety management program, together with the position title of the person responsible for the matters.

Table 6-1 SunWater Dam Safety Functions & Responsibilities

Role and Responsibilities	Current Position Title
Owner	
• Approve the suite of Dam Safety Management Standards after review and recommendation by the Owner's Head Office Representative • Approve funding for the Area Operations Centres' 'Dam Safety Management Programmes'	1 General Manager Infrastructure Management 2 Chief Executive Officer

Role and Responsibilities	Current Position Title
Owner's Head Office Representative – Assets	
• Authorise the issuing of EAPs, SOPs and O&M Manuals and amendments • Review the suite of Dam Safety Management Standards to ensure that they reflect the current SunWater Management structure and business practices before recommending for approval by the Owner.	1 Manager Asset Management 2 Principal Engineer Dam Safety
Owner's Head Office Representative – Service Delivery	
• Ensures that necessary resources are made available to the Area Operations Centres so that the Owner's Area Representatives and Service Teams can execute the required Dam Safety responsibilities as outlined in the individual Condition Schedules and the respective Area Operations Centre's Dam Safety Management Programme • Liaise with the Owner's Representative – Headworks who manages the Dam Safety management Program and advises on priorities	1 Manager Service Delivery
Owner's Representative - Headworks	
• Manage the Dam Safety Program • Day-to-day control and updating content of Dam Safety documentation including the Emergency Action Plans (EAPs), Standing Operating Procedures (SOPs) and Operations and Maintenance Manuals (O&M Manuals) • Ensure requirements of the Dam Condition Schedule are met • Undertake 5 Yearly Comprehensive Inspections with suitably qualified personnel in conjunction with the Principal Engineer Dam Safety within the timeframes specified in the Condition Schedule • Prepare the 5 yearly Comprehensive Inspection Reports within the time specified in the Condition Schedule • Undertake Annual Inspections and prepare reports within the time frames specified in the 'Condition Schedule'. • Prepare notifications to the Regulator (DERM), for proposed inspection dates; and when inspections are completed – as per the Condition Schedule • Maintain a Dam Safety Instrumentation Database for all dams being managed and evaluate data to verify the structural integrity of the dams on a regular basis and maintain a log book for this verification for audit and quality control • Ensure the work instructions are correct and the Log Books, SOPs, Data Books, and EAPs are reviewed annually as per the Condition Schedule • Facilitate 20 Year Safety Reviews • Prepare Condition Assessments using trained personnel as per the Asset Management Guidelines	1. Senior Engineer Headworks 2. Asset Engineer Headworks

Role and Responsibilities	Current Position Title
Owner's Area Representative • Ensure that the Service Team Leader has adequate resources to carry out responsibilities • liaise with the Service Team Leader and arrange responsibilities and duties of the Emergency Event Co-ordinator's (EEC) role for the Area, and train the nominated officers for this role • Prepare an EEC roster (as outlined in DS05) and arrange a dedicated mobile phone for the EEC position • Attend LDMG meeting and provide regular updates on dam status during emergency events. • Ensure visual inspections and instrumentation monitoring frequencies conform to ANCOLD Guidelines (any variations to be formally approved by **Owner's Head Office Representative – Assets**) • Ensure competent, trained and accredited personnel operate the storages • Prepare Event Reports as specified in the Condition Schedule • Overall responsibility for water supply in the Area Operations Centre Area Operations Centre • Deliver the Dam Safety Program in the Area Operations Centre • Ensure these Standards are applied in the Area Operations Centre and the work conform to the requirements in Dam Safety Condition Schedule for all the dams managed by the Area Operations Centre	1 Area Operations Manager 2 Service Manager
Owner's Area Service Delivery Team Leader • Annually update the EAP notification list (Section 3 of the EAP) and issue to PEDS and other controlled copy holders • Update and issue of work instructions • Activate EAPs and ensure instructions specified in EAPs are followed during an event. • Following an emergency event or major deficiency, debrief the Owner's Area Representative, Owner's Representative – Headworks and the Dam Duty Officer (DDO), regarding any issue with the SOP, EAP and O&M manual. If the documents need improvement, suggestions for improvements should be recorded and ensure their implementation • Make staff aware of the purpose and the contents of the Dam Safety Documentation, and ensure that all changes to these are implemented immediately • Ensure competent, trained and accredited personnel operate the storages • Participate in the Dam Safety training programmes, 5 Yearly Comprehensive Inspections, and Annual Dam Safety Inspections • Advise the Owner's Representative – Headworks of changes to SOPs, EAPs, and O&M Manuals due to update and replacement of equipment, change in work processes or safety issues • Ensure any amendments are inserted into Controlled copies of documents held at the dam sites and/or at the Area Operations Centres and Area Depots.	1 Service Manager 2 Dam Duty Officer

Role and Responsibilities	Current Position Title
Dam Safety Technical Manager • Develop and maintain the suite of Standards that outline SunWater's Dam Safety Management Program • Ensure that all the Standards conform to the requirements of the Queensland Dam Safety Management Guidelines, Feb. 2002 and reflect the current SunWater Management structure and business practices • Coordinate and audit the Dam Safety Management Program to ensure it is consistent throughout the State for each dam • Internal auditing to ensure Dam Safety documentation, Dam Safety library, monitoring database and annual and 5 yearly inspection reports are up-to-date • Attend and certify 5 Yearly Comprehensive Inspections to ensure that each Area Operations Centre is up-to-date and operating within the requirements of the Queensland Dam Safety Management Guidelines (2002) • Portfolio Dam Safety Management – Liaise with Regulator (DERM) • Facilitate Dam Safety Training Courses for Area Operations Manager, Service Manager and Dam Operators	1 Principal Engineer Dam Safety
Dam Safety Technical Advisor • Provide expert technical advice in relation to Dam Safety • Respond to any incident or emergency and provide guidance and advice to **Owner's Area Service Delivery Team Leader and EEC** • Provide technical advise when necessary to the Crisis Manager	1 Principal Engineer Dam Safety 2 Manager Asset Management 3 Chief Civil Engineer 4 Senior Engineer Headworks
Flood Operations Centre • Undertake predictive flood modelling for selected dams • Provide flood modelling reports to the EEC and dam duty officer on a timely basis • Respond to adhoc requests for information from EEC • Liaise with BOM on flood model predictions and data	1 Senior Engineer Headworks 2 Asset Engineer Headworks

6.1.2 Emergency Action and Event Reporting

Emergency Action Plans (EAPs) have been developed for all of SunWater's dams. The EAPs have a clear set of actions, responsibilities and communications that are to be undertaken in a range of emergency scenarios.

The emergency scenarios expressly considered in the EAPs include:

- Flood Operation
- Rapid Drawdown
- Sunny Day Failure (Earthquake or Piping)
- Chemical /Toxic Spill
- Terrorist Activity

The response framework includes a range of incidents from local incidents, through to emergencies and crisis. The framework also assigns lead accountability (refer Table 6-2).

Table 6-2 SunWater Emergency Response Framework

Category	Lead Accountability
Localised Incident/Near Miss (EAP ACTION 1) These are managed by routine procedures and existing resources available on site, and are locally contained with a short-term impact. Generally, these will not escalate to an emergency	**Duty Operator** (Storage Supervisor, Supervisor or Operator)
Emergency (EAP ACTION 2) These require a coordinated regional response together with overview, advice and action from an expert on subject matter who is usually located in the Brisbane Office. Emergency Action Plans, which typically apply during Flood Events, require the Dam Duty Operator to phone the Emergency Event Coordinator (EEC) who will then initiate the relevant ACTION 2 emergency procedure. An emergency may or may not result in the activation of the Crisis Management Plan	**Emergency Event Coordinator** (EEC) (Area Operation Manager, Service Manager, Manager or Project Manager)
Crisis (EAP ACTION 3) A crisis relates to a situation that imminently threatens or has actually resulted in critical or catastrophic consequences (based on SunWater's standard risk definitions) or is considered to be a critical infrastructure security event	**Crisis Manager** (General Manager or Senior Manager)

The EAPs also provide a framework whereby those individuals with lead accountability are provided with technical advice from senior and experienced engineering staff. The latest EAP version also outlines predictive flood modelling from the Flood Operations Centre (FOC) for certain high hazard dams. The SunWater dams currently serviced by the FOC include:

- Tinaroo Falls;
- Burdekin Falls;
- Fairbairn;
- Paradise;
- Fred Haigh;
- Coolmunda; and
- EJ Beardmore

The SunWater EAPs are not static documents. A number of versions (noted as Issue 1, 2 etc) have been released over a period of time. The EAPs have been subject to continuous improvement from reviews[38], exercises and lessons learnt (refer section 3.1.2) from events. Most dams operated under Issue 2 of the EAP over the 2010-11 wet season. Tinaroo Falls dam had Issue 3 prior to the 2010-11 wet season. Issue 3 includes a number of improvements such as clearer roles and responsibilities following a recent restructure of SunWater, inclusion of the FOC role and an emergency response framework consistent with the most recent Crisis Handbook for the organisation.

The dams operating under Issue 2 were issued with a supplementary notice prior to the 2010-11 wet season to clarify roles and responsibility in light of the developments described above.

All EAPs set out communications that are required during an emergency. This includes communication with the Local Disaster Management Group and landholders immediately downstream of the dam. The EAP notification and communication lists are reviewed and updated annually. All EAP notification lists were reviewed and updated in November 2010, prior to the 2010-11 wet season.

EAPs are issued as controlled documents (meaning they can only be altered through a defined process) to a number of stakeholders who have a role in emergency management. By way of example the distribution list for Tinaroo Falls Dam is shown in Table 6-3.

[38] Including an externally facilitated exercise for Leslie Dam and Coolmunda Dam and subsequent review.

Table 6-3 Sample EAP Controlled Document Distribution (Tinaroo Falls)

Copy Number	Position	Location
1	Storage Supervisor, Tinaroo Falls Dam	SunWater – Tinaroo Falls Dam
2	Service Manager/ EEC	SunWater – Mareeba Depot
3	Area Operations Manager	SunWater - Area Operations Centre – Far North (Clare)
4	Manager, Asset Management	SunWater, Brisbane
5	Director, Dam Safety (Water Supply), Office of the Water Supply Regulator	DERM (Dept of Environment and Resource Management), Brisbane
6	Senior Advisor – Disaster Management Local Disaster Management Group - Tablelands	Tablelands Regional Council
7	Coordinator – Disaster Management Local Disaster Management Group - Cairns	Cairns Regional Council
8	District Disaster Coordinator (Mareeba)	Police, Mareeba
9	District Disaster Coordinator (Cairns)	Police, Cairns
10	Director Disaster Management Services, Emergency Management Queensland	State Disaster Coordination Centre - Department of Community Safety, Brisbane
11	Regional Director Emergency Management Queensland	Department of Community Safety, Cairns

Training exercises on specific dam EAPs are typically conducted as part of the 5 yearly comprehensive inspections. Regional management also conduct pre-wet season training/review exercises as part of wet season preparations. Awareness training in 2010 was extended to the Executive Management and the Chairman of the SunWater Board.

EAPs were activated for all the dams during 2010-11 wet season. Brief event reports will be forwarded to the Regulator in due course when the events are completed.

6.1.2.1 Flood Operations Centre (FOC) for SunWater Dams

SunWater has maintained a flood operations centre for a number of years. Prior to the 2010-11 wet season the FOC generally provided services for externally owned dams. Services were provided for Wivenhoe, Somerset, North Pine, Ross River and Scrivener dams. These are all gated dams with significant populations at risk. The FOC is located in a secure room in SunWater's head office. The room has independent and redundant power supplies, communication and computer networks. The FOC has gathered rainfall and runoff data prior to and during events to run rainfall/runoff flood routing models. The models are used to monitor automatic systems (where they exist), inform decisions regarding gate operations and provide information to disaster management groups.

Prior to 2010 SunWater did not generally utilise a real time flood modelling service for its portfolio of dams. The reason was that as SunWater did not provide an active flood operation service, its gated dams mostly operated in an automatic mode[39] and SunWater had engineering staff located in each region. One of the lessons learnt following the February 2008 Fairbairn dam flood[40] was that there was a community and LDMG expectation that SunWater had more information available for its dams and could work more closely with the Bureau of Meteorology (BOM) on flood predictions.

In 2010 SunWater developed runoff routing models for a number of its dams. The modelling of the dams was prioritised by reference to criteria such as hazard rating, population at risk, frequency of flooding and type of structure. Technical staff use the models with flow data from the BOM published data to provide a prediction of the height and time of the peak *discharge* from the dam. This is aimed at assisting the dam duty officer (DDO) on dam operations and the emergency event coordinator (EEC) in discussions with LDMG. SunWater is moving towards a virtual FOC model rather than a dedicated flood room. A virtual FOC means one whereby the models are installed on a laptop that can download data over the web from almost any location.

The FOC operated successfully over the 2010-11 wet season for the following SunWater operated dams:

- Burdekin Falls
- Fairbairn
- Tinaroo Falls
- Paradise
- EJ Beardmore
- Coolmunda
- Ross River

6.1.3 Comprehensive (5 yearly) Dam Safety Inspections

Comprehensive inspections incorporate detailed inspections to identify any physical deficiencies of a dam along with a review of the whole of the dam's safety management program. Inspections are conducted by a multidisciplinary engineering team. The team is lead by a registered professional engineer of Queensland (RPEQ). Detailed reports of each inspection are compiled and submitted to the regulator. SunWater's inspections are taking place according to schedule. Recommendations from the inspections are incorporated into

[39] EJ Beardmore dam gates are a manual system

[40] February 2008 was the flood of record for Fairbairn. This has since been exceeded in December 2010

formal work programs. Progress on the implementation of recommendations is reviewed at each periodic (annual) inspection.

6.1.4 Periodic (Annual) Inspections

Periodic inspections are visual inspections carried out to identify any deficiencies and to monitor the existing condition of a dam. Engineering staff undertake the inspections. A report is produced following each inspection. The reports address the behaviour of the structure and contain detailed recommendations for modified maintenance strategies and general opportunities for improvement. These recommendations are included in the SAP maintenance system to ensure assignment and follow-up of action. The report also tracks progress of recommendations from previous comprehensive and annual inspections and from DERM audits. Where the recommendations of these reports change the procedures in the O&M Manual, EAPs, SOPs or data books, it will be programmed to amend the documents.

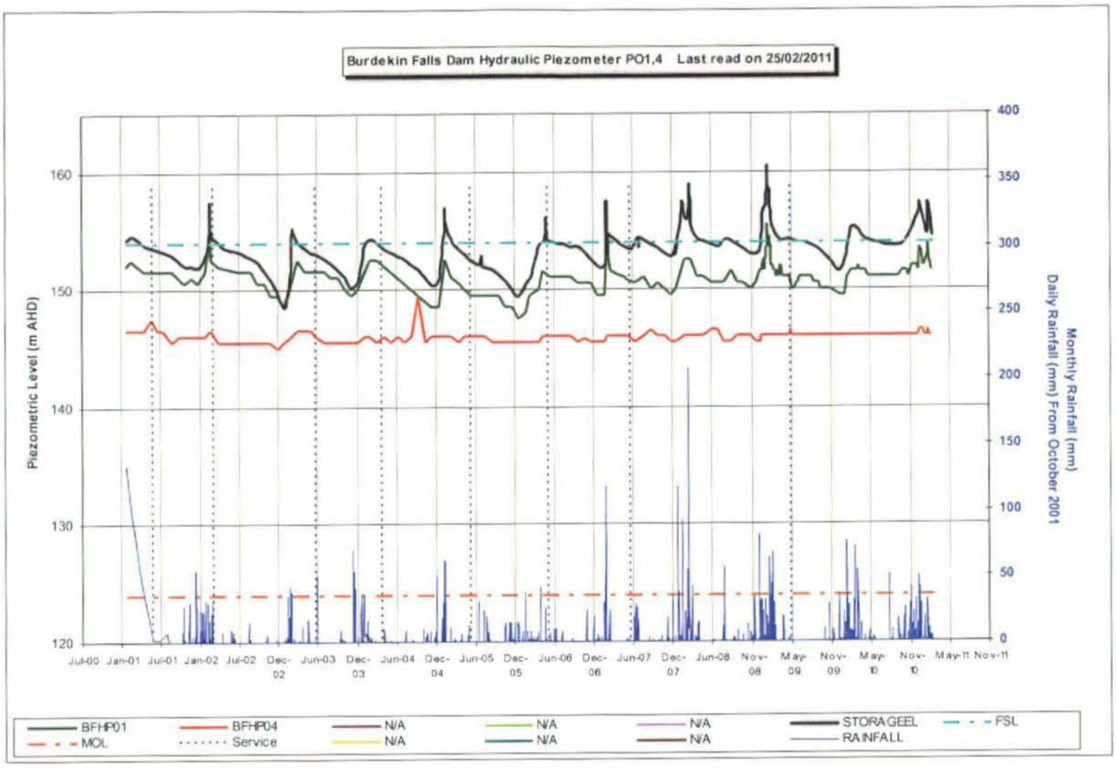
All of SunWater's dams are in a satisfactory condition. This opinion is based on inspections, instrumentation and other aspects of SunWater's dam safety management program.

6.1.5 Dam Safety Instrumentation Database and Plots

SunWater maintains an instrumentation database and plots. The database is available online to all SunWater staff. The database presents data as either data or plots. A sample of a plot is displayed in figure 6-2. The database captures reports and displays information on:

- Piezometers
- Seepage
- Settlement
- Rainfall
- Storage level

The plots are available to staff as part of routine surveillance. The data is formally reviewed by engineering staff as part of the inspections program. The data provides value by assisting a quick response to any emerging issues. Data can provide early indications of a worsening dam safety situation. The data can be assessed for any abnormal behaviour. Such abnormalities can be a trigger for remedial action.



6-2 Sample Instrumentation Plot - Burdekin Falls Dam

6.1.6 Operator Training and Accreditation

SunWater runs a comprehensive training course for dam operators and other staff working on dam infrastructure. The course is highly regarded by industry and many other dam owners enrol their staff in the SunWater course. The course is very similar to one run in NSW by some members of the NSW Dam Safety Committee.

SunWater aims to have every dam operator successfully complete the training task every 5 years. During each comprehensive inspection the operators or the particular dam are assessed on their knowledge of that dam. If found to be competent they are provided with an internal accreditation for that dam.

The dam safety training course is held regularly. The next training course is planned in June 2011 in Proserpine.

6.1.7 Continuing Professional Development of Engineering staff

SunWater is a corporate member of ANCOLD. A significant number of staff attend the annual conference each year to present papers and undertake professional development. SunWater encourages its engineering staff to maintain their competence through recognised continuing professional development programs.

6.1.8 20 Year Dam Safety Reviews

A Safety review is a procedure for assessing the safety of a dam against current standards, and comprises a detailed study of structural, hydraulic, hydrologic and geotechnical design aspects and review of the records and reports from surveillance activities.

The initial safety reviews for SunWater dams were carried out in 1998 and the next review will be in the year 2018 (refer Table 6-4).

6.1.9 Failure Impact Assessments (FIAs)

FIAs are required to be completed for all the *Category 1* structures and for structures with flow control devices on their crest. They have to de done initially and then at 5 yearly intervals. This is to ensure that there are no developments since the previous FIA, increasing the population at risk (PAR). SunWater has completed FIAs for its dams. The outputs are used in the EAPs (refer section 6.1.2) and CRAs (refer section 6.1.10)

6.1.10 Comprehensive Risk Assessments (CRAs) and the Portfolio Risk Assessment (PRA)

A Comprehensive Risk Assessment is a risk assessment study conducted for a particular dam in accordance with the ANCOLD risk assessment Guidelines. It is a study intended to enable SunWater to evaluate the deficiencies and available risk reduction options.

The initial CRA program is now complete. The information in the CRAs has now been compiled into a Portfolio Risk Assessment document (PRA) and forms the basis for SunWater's Dam Safety Upgrade Program (refer section 6.2 below).

6.1.11 Documentation

SunWater maintains a full suite of documentation for each dam as defined in figure 5-1. The documents are reviewed on a regular basis, usually as part of the periodic (annual) inspection. When material deficiencies are identified a new issue or revision is issued through the controlled document process. Table 6-4 details the last Issue or revision release date for each document for each dam.

Documentation is held in a secure dam safety library in Brisbane with a duplicate for the relevant dam stored in the office that the dam operator works from. Uncontrolled copies of documents are also available electronically to staff.

SunWater has two significant projects underway to review and update its documentation. Firstly the EAPs are being updated to Issue 3. Issue 3 includes a number of improvements such as:

- clearer roles and responsibilities;
- inclusion of the role of the FOC;
- lessons learnt from 2010-11 wet season; and
- an emergency response framework consistent with the most recent Crisis Handbook for the organisation.

The second project is a review and update as necessary of the O&M Manuals.

Table 6-4 Last Issue/revision date of Dam Safety Documentation

	Dam	Storage Volume (ML)	Data Book	EAP	O&M Manual	SOP	Annual Inspection	Comprehensive (5yr) inspection	Safety Review	Comprehensive Risk Assessment
1	Burdekin Falls	1,860,000	Dec-10	Nov-10	Jun-05	Jun-05	Jun-10	Jun-07	Apr-01	Jun-06
2	Fairbairn	1,301,000	Dec-10	Nov-10	Nov-06	Jun-09	Jul-10	Aug-07	Sep-99	Nov-09
3	Fred Haigh	562,000	Dec-10	Nov-10	Jun-09	Jun-06	Aug-10	Jul-06	Apr-99	Jun-05
4	Peter Faust	491,400	Dec-10	Nov-10	Jun-05	Jun-05	May-10	Jun-08	May-01	Oct-08
5	Tinaroo Falls	438,900	Dec-10	Nov-10	Jun-02	Dec-06	Aug-10	Nov-08	Dec-98	Dec-08
6	Paradise	300,000	Dec-10	Nov-10	Dec-05	May-09	Mar-09	Nov-10	N/A	Oct-09
7	Boondooma	204,200	Dec-10	Nov-10	Jun-09	Jun-09	Apr-10	Apr-09	Dec-00	Jun-06
8	Wuruma	165,400	Dec-10	Nov-10	Oct-09	Oct-09	Oct-10	Nov-06	Apr-00	Mar-08
9	Teemburra	147,500	Dec-10	Nov-10	Jun-05	Jun-05	Sep-09	Aug-10	Feb-02	Aug-09
10	Callide	136,300	Dec-10	Nov-10	Dec-05	Dec-05	May-09	Apr-10	Mar-99	Jun-06
11	Bjelke-Petersen	134,900	Dec-10	Nov-10	Jun-09	Jun-09	Apr-10	Apr-08	Mar-01	Oct-09
12	Eungella	112,400	Dec-10	Nov-10	Jun-05	Jun-05	Oct-10	Sep-09	Jun-00	Apr-07
13	Julius	107,500	Dec-10	Nov-10	Jun-05	Jul-09	Sep-10	Aug-09	Jun-00	Jan 10
14	Leslie	106,200	Dec-10	Nov-10	Dec-06	Jun-05	Apr-10	May-09	Jun-99	Nov-08
15	Cania	88,500	Dec-10	Nov-10	Mar-06	Mar-10	Mar-10	Jun-09	May-01	Feb-05
16	EJ Beardmore	81,700	Dec-10	Nov-10	Jun-05	Jun-05	Aug-10	Oct-07	May-00	Jun-09
17	Coolmunda	69,000	Dec-10	Nov-10	Dec-06	Jun-05	Oct-10	Nov-10	Jun-00	Nov-09
18	Kinchant	62,800	Dec-10	Nov-10	May-04	Jun-05	Oct-10	Oct-07	Mar-99	Nov-09
19	Kroombit	14,600	Dec-10	Nov-10	Mar-06	Sep-00	May-09	Apr-10	Dec-01	Nov-09

6.2 Dam Safety Upgrade Program

6.2.1 Dam Safety Upgrade Policy

Over the last fifty years there has been significant development of the methodologies used to estimate extreme rainfall events. These have resulted in substantial increases in probable maximum flood (PMF) estimates for most of SunWater's dams. SunWater's dams are already designed to safely handle very large rainfall events. Whilst some of SunWater's dams will require a future upgrade to pass some of the most recent extreme rainfall estimates, all of SunWater's dams are very safe and can pass very rare events[41].

For a number of years, SunWater has been implementing a process of assessment and upgrades to its portfolio of dams because of the changes mentioned above. This process has included peer review of assessments and consultation with shareholding Ministers and the Queensland Dams Regulator (the Regulator) on upgrade programs. The intent has been to lead to a comprehensive and thorough portfolio approach to dam safety.

In 2007, the Regulator produced Guidelines on Acceptable Flood Capacity for Dams issued pursuant to the *Water Supply (Safety and Reliability) Act 2008* (Qld) and *Water Act 2000* (Qld). The Regulator has established a timetable for *referable dams* to meet the minimum requirement based on the proportion of the Acceptable Flood Capacity (AFC) that a dam can safely pass.

SunWater is also very mindful of the dam safety standards and guidelines issued by the ANCOLD. This is an authoritative and well-established source of dam safety guidance. ANCOLD recommends what is termed a traditional Standards Based Approach (SBA) while acknowledging that a generally lesser standard Risk Based Approach (RBA) is a valid approach in support of the SBA.

[41] The Dam Safety Guiedelines on Acceptable Flood Capacity identify that the Annual Exceedence Probability of the design flood for dams ranges from 1 in 10,000 years to 1:10,000,000 years

SunWater has considered its approach to dam safety upgrades with due regard to these two sources of guidance.

In September 2008, the Board of SunWater (the Board) resolved to adopt the following policy:

"That SunWater's referable dams shall be upgraded to 100% of Acceptable Flood Capacity as determined by the traditional standards based approach, except where it can be demonstrated that the cost of an individual dam upgrade is grossly disproportionate to the benefit gained.

SunWater will consider each dam on a case by case basis. Where it can be demonstrated that the cost of an individual dam upgrade is grossly disproportionate to the benefit gained, SunWater will determine the extent of the required upgrade, which will at least achieve 100% of Acceptable Flood Capacity as determined by the risk assessment approach, in consultation with shareholding Ministers. The upgrade of SunWater's dam portfolio will be prioritised based on overall risk."

The development and adoption of this policy was the culmination of a number of studies and consideration of a wide range of information and publications.

6.2.2 Dam Safety Upgrade Decision Criteria

In order to meet the dam safety upgrade policy (refer section 6.2.1), the Board requested that management develop a process which facilitates the review, assessment and prioritisation of dam safety upgrades. A higher standard than that required by the Regulator has been proposed to be adopted to reflect the Board's reliance upon the Standards Based Approach which is described in the ANCOLD *Guidelines on Risk Assessment, October 2003.*

The decision to upgrade a dam will, following Board approval, follow a stepped approach as described below and illustrated in Figure 6-3.

Step 1: Determine Acceptable Flood Capacity – Standards Based Approach

SunWater will initially determine both:

(a) the *Acceptable Flood Capacity* (AFC) of a dam using the *Standards Based Approach* (SBA) – the "AFC_{SBA}"; and

(b) the existing Safe Discharge Capacity (SDC) of a dam.

This will provide a baseline with which to progress the assessment and allow a "first cut" filter to be applied.

A comprehensive risk assessment study will then be conducted for each *referable dam* and include other contributory risk factors such as adequacy of filters, stability etc.

An upgrade to dam safety to meet 100% of *Acceptable Flood Capacity* using the *Standards Based Approach* is referred to as a standards based upgrade.

If the current SDC of a dam is greater than the AFC_{SBA}, no upgrade is required unless the risk assessment shows intolerable risks. In the case of the latter, the dam will be upgraded to reduce risks to a tolerable level (step 3), if physically possible, under the guidelines. This is referred to as a risk based upgrade and the AFC referred to as $\mathrm{AFC}_{\mathrm{RBA}}$. In this case, the $\mathrm{AFC}_{\mathrm{RBA}}$ will be greater than the AFC_{SBA}.

If the AFC_{SBA} is greater than the SDC, the decision process progresses to Step 2.

Step 2: Determine the cost of a standards based upgrade and assess whether the cost is grossly disproportionate to benefits gained;

This step occurs if the SDC is less than the AFC_{SBA}.

The work required to upgrade the dam to a 100% of *Acceptable Flood Capacity* (SBA) and rectify any deficiencies will be defined and costed.

Once the costs have been established, the estimated cost of the upgrade works will be assessed against the benefits gained to determine whether or not the costs are grossly disproportionate to the benefits. Risks must be reduced *as low as reasonably practical* (ALARP), and measures to reduce risk can be ruled out only if the sacrifice involved would be grossly disproportionate to the benefits gained.

The test for gross disproportionality will include benefit assessments of life safety (societal) risks and business risks. SunWater will apply the following criteria to determine if the costs are grossly disproportionate to the benefit:

(a) Where an upgrade is being considered to address a scenario where there are **Life safety risks,** upgrade costs will be considered grossly disproportionate to the benefits (societal and business) gained if:

(i) The *Cost to Save a Statistical Life* (CSSL) **exceeds $100 million**; or

(ii) The *Cost to Benefit Ratio* (C/B Ratio) **exceeds 3**.

(b) Where an upgrade is being considered to address a scenario where there are no life safety risks but there is **Business Risk**, upgrade costs will be considered grossly disproportionate if the *Cost to Benefit Ratio* (C/B Ratio) is greater than 1. Benefits, in this case, are defined as the net present value of business risk costs saved over the life of the dam by the upgrade.

If the cost is ***not*** grossly disproportionate on ***any one*** of the above criteria, an upgrade will be recommended to the traditional AFC_{SBA}; or the $\mathrm{AFC}_{\mathrm{RBA}}$ if the risks assessed for the AFC_{SBA} are determined to be intolerable. If the cost is grossly disproportionate on all three criteria, the decision process progresses to Step 3.

Step 3: Determine if life safety risks meet the minimum standard expected by society (Limits of Tolerability)

For those dams where the upgrade costs are assessed as being grossly disproportionate to the benefit, but still retain life safety risks, the decision process will then assess life safety risks against *Limits of Tolerability* established by the Regulator and ANCOLD. If the existing life safety risks are on or above the *Limits of Tolerability,* an upgrade is recommended if physically possible. The upgrade will be to the risks based standard to AFC_{RBA}. If there is no risk based option to achieve tolerability other than SBA, the AFC_{SBA} will be adopted.

If in Step 3 the life safety risks satisfy the *Limits of Tolerability*, the decision process progresses to Step 4.

Step 4: Determine if the cost of a proposed upgrade is relatively small;

If the costs of an upgrade are assessed as grossly disproportionate and life safety risks are tolerable, an upgrade will still be recommended if the cost of that upgrade is considered small relative to the annual refurbishment and maintenance budget. The cost limit for "relatively small" determination is $1 million. For those dams progressing to Step 4, if the cost is between $1 million and $5 million, SunWater will consider and decide on a case by case basis if the upgrade will be implemented.

For dams where an upgrade is not recommended from Step 4, the decision process progresses to Step 5.

Step 5: Determine Acceptable Flood Capacity – Risk Based Approach;

If, as a result of an assessment against the above criteria outlined in steps 1 through 4, an upgrade to a standards based Acceptable Flood Capacity (AFC_{SBA}) is not justified, then the risk based Acceptable Flood Capacity of the dam will be determined by the Risk Based Approach (RBA). This calculation determines the AFC_{RBA}.

If the existing ***Safe Discharge Capacity*** of the dam is less than the risk based ***Acceptable Flood Capacity (***AFC_{RBA}***)***, the work required to upgrade the dam to 100% of the risk based ***Acceptable Flood Capacity*** will be defined and scheduled.

Step 6: Determine the relative priority and timing of an upgrade;

Following the five step process for every dam, the prioritisation process to establish an upgrade program will be as follows:

1. Assign the greatest priority to upgrades that address life safety risks over and above projects that only reduce business risks;

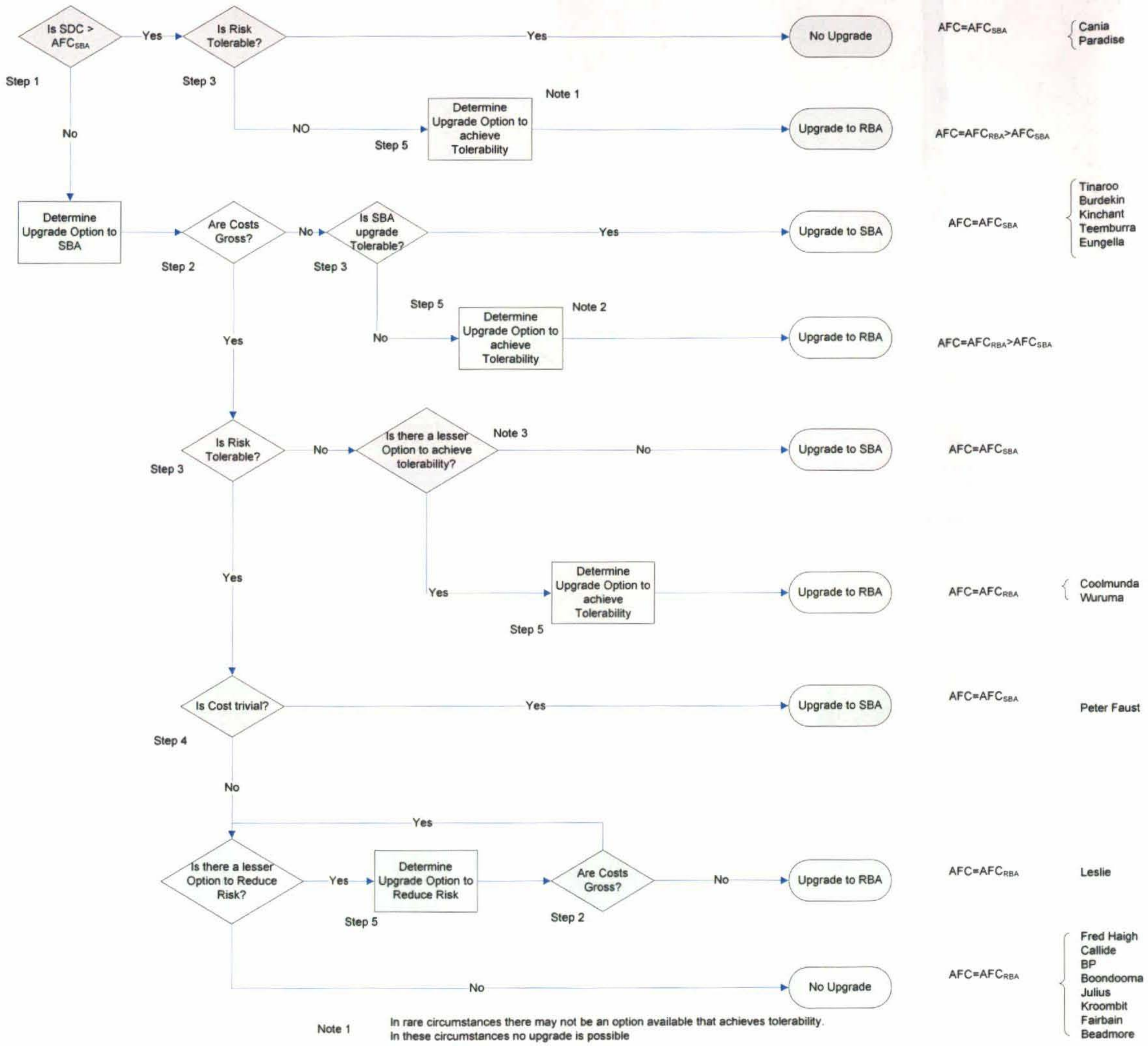
2. Of those dams that have been assessed as having a life safety risk and warrant an upgrade, the highest priority will be assigned to those dams that have a life safety risk higher than the Limit of Tolerability (social or individual) as defined by the Regulator;

3. For dams with intolerable life safety risks, prioritise the dam upgrades on the basis of overall life safety risk in descending order;

4. Following on from the completion of upgrades on all dams with intolerable life safety risks, those remaining dams that have been assessed as requiring an upgrade will be prioritised in descending order of overall life safety risk;

5. The scheduling (timing) of upgrades will occur in priority order and be based on resource constraints assuming one each of design and construction teams which results in an overlapping sequential program. Scheduling may also be constrained by the availability of funding;

6. The scheduling (timing) of upgrades will need to consider the target dates specified in the Queensland Government's guideline on Acceptable Flood Capacity for *Referable Dams.* This constraint may result in lower priority upgrades being bought forward in the program in order to satisfy regulatory requirements.



Note 1 In rare circumstances there may not be an option available that achieves tolerability. In these circumstances no upgrade is possible

Note 2 In rare circumstances there may not be an option available that achieves tolerability. In these circumstances the dam will be upgraded to the maximum extent practical under current engineering standards

Note 3 In rare circumstances there may not be an option available that achieves tolerability. In these circumstances the dam will be upgraded to the Standards Based Approach

SDC = Safe Discharge Capacity
AFC = Acceptable Flood Capacity
AFC$_{SBA}$ = Standard based AFC
AFC$_{RBA}$ = Risk Based AFC

Figure 6-3 Dam Safety Upgrade Decision Criteria Process Flow

6.2.3 Dam Safety Upgrade Program

SunWater commenced an upgrade program in 2005. To date the following upgrade projects have been completed

- Fred Haigh Stage 1
- Bjelke Petersen
- Tinaroo Falls

The upgrade of Fred Haigh Dam involved the installation of a 2.02m high reinforced concrete wave wall along the downstream edge of the embankment crest and a similar increase of the upstream *spillway* training walls. A 2m deep cutoff wall connects the wave wall to the central clay core. A further upgrade to the saddle dam will be required to satisfy full AFC requirements.

The upgrade of Bjelke Petersen involved the installation of a 1.8 to 2.4m high reinforced concrete wave wall along the downstream edge of the embankment crest. A 0.5m to 0.7m deep cutoff wall connects the wave wall to the central clay core.

The upgrade of Tinaroo involved:

- Installation of post tension anchors in the concrete monoliths of the main wall and *spillway*;
- Erosion protection slabs to the toe of the main wall;
- Passive anchors in the *spillway* apron slabs;
- A crest wave wall; and
- Raising of the saddle dam

The upgrade of Kinchant Dam is in progress. This upgrade will be completed in 2013.

A number of other dams will be progressively upgraded, however a final decision on these projects has not yet been made.

6.2.4 The development of SunWater's approach to changing standards and circumstances

SunWater's approach to dam safety upgrades and acceptable flood capacities developed over a period of time as discussed below.

6.2.4.1 Changes in Flood Hydrology and PMP Estimation[42]

The major dams that SunWater owns were constructed over a fifty-year period commencing from the mid-1950's. Whilst there may be an expectation in the community that the majority of these assets would conform to contemporary design standards this is not necessarily so. Hydrometeorological assessment techniques during this same time frame have evolved considerably in line with technological and computing capability.

For the design of SunWater's first dam during the 1950's, (Tinaroo Falls Dam), the Myer empirical relationship was used as the basis to derive the original design *spillway* capacity. This particular technique did not necessarily use storms relevant to the particular catchment of the dam.

Many of the SunWater dams designed and constructed during the 1960's utilised the US Weather Bureau 'Insitu-maximisation' method of Probable Maximum Precipitation (PMP) extreme *design rainfall* estimation, which was based only upon the maximisation of storms located within the catchment of the dam. Adjustment was made to the rainfall depth recorded in the largest observed storms, by the ratio of the highest observed atmospheric moisture content in the area of the catchment to that observed in the storm event. This approach led to somewhat inconsistent assessments of catchments located within relatively close proximity due to the differences in the available records.

To overcome this problem, during the late 1960's and early 1970's, the concept of 'maximisation and transposition' was gradually introduced. It improved the consistency of PMP estimates within regions and also led to a general increase in PMP depth estimates. However, this method did have its drawbacks. The choice of storms for transposition introduced a significant level of subjectivity to the method and the temporal and spatial distribution patterns adopted for the design assessment was still relatively arbitrary.

The US Weather Bureau and the World Meteorological Organization developed 'Generalised Methods' during the late 1970's and early 1980's. These methods incorporate storm events recorded over large regions to enable the transposition of storms over large areas.

The Australian Bureau of Meteorology (BoM) developed the earliest generalised method for Australia in the early 1980's. Interestingly, four of the seven extreme storms used in the derivation of this technique were events that were observed in Queensland. This technique is referred to as the Generalised Tropical Storm Method, (GTSM). This method defines spatial and temporal patterns for use in design that are largely independent of individual storm event characteristics. Other generalised methods that have subsequently been developed by the BoM including the Generalised Short Duration (or Thunderstorm) Method (GSDM).

Around half of SunWater's dams were designed using the GTSM or GSDM of PMP estimation. It was noted that when these methods were introduced, comparisons with estimates based on the earlier techniques such as 'insitu-maximisation' and 'maximisation-

[42] Rob Ayre, Headworks Design Manager, SunWater

transposition' showed significant increases. Increases in the order of 150 to 250 % were not uncommon.

The Bureau of Meteorology maintains a database of extreme storm events that provides a basis for PMP estimates. Extreme events such as the Rainbow Beach 2007 event are added to the database and have the potential to increase future estimates of PMP. The Flood hydrology group in SunWater is informed of any changes through regular events such as the Hydrology and Water Resources Symposium. Although increased assessments of PMP are possible, such revisions are not expected to be issued in the next few years.

The Bureau of Meteorology last revised PMP estimates in 2003. In response to this revision SunWater has revised the flood estimates for all dams. These revised estimates are a key input to the dam safety upgrade program.

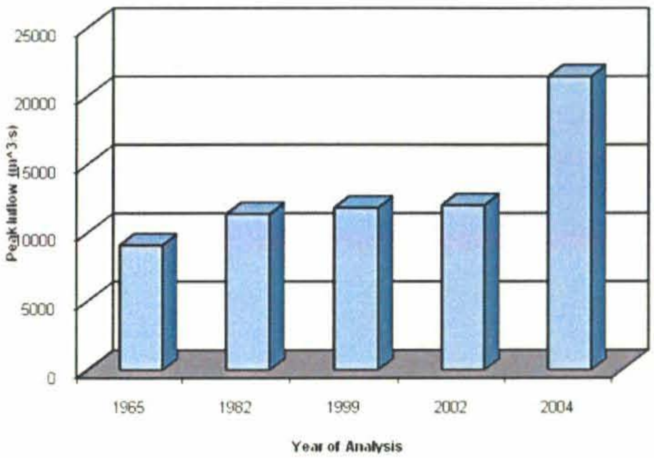


Figure 6-4 Comparison in the estimation of PMP Design Flood inflow estimates for Fred Haigh Dam over time

6.2.4.2 Chronology of the development of SunWater's Approach

The following table provides a chronology of SunWater's development of its approach to dam safety upgrades.

Table 6-5 Chronology of the development of SunWater's Approach

Date	Action
2002	20 year dam safety reviews completed
2003-2005	Design flood hydrology review based on Revised PMP estimates (GTSMR 2003)
Oct 2003	ANCOLD Risk Assessment Guidelines Published
2003 - 2005	Dam break analysis based on flood hydrology – 2003.
2004-2005	Spillway adequacy assessment

Date	Action
June 2004	Board considers consequences of reviewed PMFs. Actions => Stage 1 program to meet 50% AFC(fall-back) and limit of tolerability on societal risk. Stage 2 program for all CRAs, final design and upgrade to full AFC all dams
Oct 2004	Stage 1 Spillway Upgrades program for SunWater Dams. Included Fred Haigh, Bjelke Petersen, & Tinaroo
Dec 2004	Report on Spillway Upgrades to AFC for SunWater Dams (SBA)
2005 to 2010	Program to undertake comprehensive risk assessments of individual dams
2005 to 2006	Fred Haigh Stage 1 Upgrade
June 2006	CSO agreement includes 3 stage 1 upgrades
2006 to 2007	Bjelke Petersen Upgrade
June 2007	Report on Portfolio Risk Assessments of SunWater Dams (mainly flood based)
Sep 2007	NRW requests both updated fall back program and Risk based program
Nov 2007	Independent review of Wuruma CRA highlighted imminent changes to the design criteria for uplift pressures as a result of the new ANCOLD Guidelines on Concrete Gravity Dams which increases cost of concrete gravity structures such as Wuruma, Tinaroo and Burdekin.
2007	Failure Impact Assessments were undertaken on the dams deemed as Category 1 in 2002 in accordance with the NRW Guidelines for Failure Impact Assessment of Dams – April 2002.
Feb 2008	Estimated cost of Tinaroo Falls Dam upgrade increases from due mainly to changes in the design criteria for uplift pressures in light of the new ANCOLD Guidelines on Concrete Gravity Dams.
April 2008	Independent review of Portfolio Risk Assessments of SunWater Dams
May 2008	Report *SunWater Dam Safety Upgrades – Based on Risk Assessments*
September 2008	Adoption of Dam Safety Upgrade Policy
Feb 2009 – Feb 2011	Development, review and adoption of Dam Safety Upgrade Criteria
Ongoing	Dam safety upgrades

7 Emergency Management Frameworks

7.1 Roles and Functions of Various Agencies in Emergency Management

Queensland has a tiered disaster management arrangement. It is based on local, district and state levels. The structure enables a progressive escalation of support and assistance through each tier as required. The Australian government is also included in the arrangements as a fourth level, recognising that Queensland may need to seek federal support in times of disaster.[43]

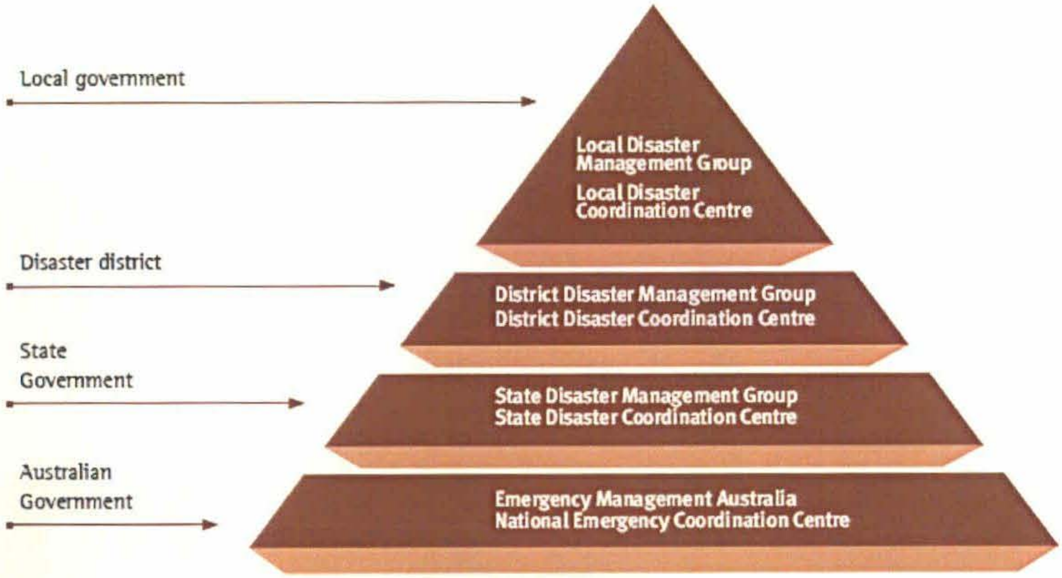
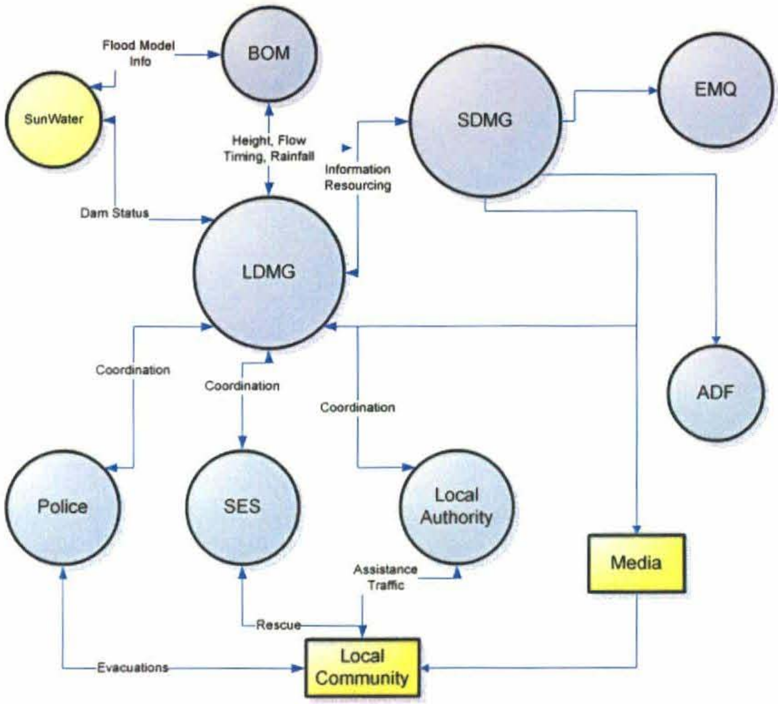


Figure 7-1 Queensland Disaster Management Arrangements

7.1.1 Players in emergency management

Figure 7-1 below is a graphic representation of the lines of communication for emergency management organisations in respect to flood emergencies. SunWater's role in those communications is described in section 7.1.2 below.

[43] www.disaster.qld.gov.au/publications/pdf/State%20Disaster%20Man%20Plan%20A050908.pdf



District disaster level omitted for clarity

Figure 7-2 Relationship of Emergency Management Organisations

7.1.1.1 Local Disaster Management Group (LDMG)

The Local Disaster Management Group (LDMG) is a group established for each Local government area in the State to carry out a number of functions relating to disaster management, the primary ones of which are:[44]

- To ensure that disaster management and disaster operations in the district are consistent with the State group's strategic policy framework for disaster management for the State;
- To develop effective disaster management, and regularly review and assess disaster management arrangements; and
- To help the Local government for its area to prepare a local disaster management plan.

7.1.1.2 District Disaster Management Group (DDMG)

The *District Disaster Management Group* (DDMG) is a group established for each Disaster district in the State to carry out a number of functions relating to disaster management, the primary ones of which are[45]:

[44] www.disaster.qld.gov.au/publications/pdf/State%20Disaster%20Man%20Plan%20A050908.pdf

[45] www.disaster.qld.gov.au/publications/pdf/State%20Disaster%20Man%20Plan%20A050908.pdf

- To ensure that disaster management and disaster operations in the district are consistent with the State Group's strategic policy framework for disaster management for the State; and
- To develop effective disaster management for the district, including a district disaster management plan, and regularly review and assess disaster management arrangements.

DDMGs are established to provide a whole-of-government planning and coordination capability to support local governments in disaster management. The DDMG is responsible to the SDMG for all aspects of the State government's capabilities in disaster management for their district.[46]

7.1.1.3 State Disaster Management Group (SDMG)

The State group is the peak policy and planning group for disaster management in Queensland. It is established under the *Disaster Management Act 2003* (section 17) as the principal organisation for the purposes of disaster management throughout the State. In particular, the State group is responsible for disaster mitigation and disaster planning and preparation at a State level and for coordinating whole-of-government response and recovery operations prior to, during and after an event. This includes accessing interstate and/or Australian government assistance when local and State resources are exhausted or not available.[47]

7.1.1.4 Emergency Management Queensland (EMQ)

The functions of EMQ as described in the *Disaster Management Act 2003*, include;[48]

- Provision of advice and assistance to all agencies within Queensland's disaster management arrangements;
- Provision of advice to disaster managers at all levels of the state's disaster management arrangements;
- Ensuring that disaster management activities within the State are consistent with the strategic policy framework;
- Facilitation of the development and maintenance of the State's Disaster Management Plan;
- Operation and maintenance of the SDMG;
- The maintenance of arrangements between the State and Australian government about matters relating to effective disaster management; and the coordination of

---

[46] www.disaster.qld.gov.au/publications/pdf/District%20Disaster%20Management%20Guidelines.pdf

[47] www.disaster.qld.gov.au/publications/pdf/State%20Disaster%20Man%20Plan%20A050908.pdf, p19

[48] www.disaster.qld.gov.au/publications/pdf/State%20Disaster%20Man%20Plan%20A050908.pdf p31

State and Australian government assistance for disaster management and disaster operations;

- Training of disaster management stakeholders; and
- Review of District and Local Plans.

7.1.1.5 Police

The role of the police during a disaster include:[49]

- Preservation of peace and good order;
- Prevention of crime;
- Maintenance of any site as a possible crime scene;
- Coronial investigation procedures;
- Traffic control, including assistance with road closures and maintenance of road blocks;
- Crowd control;
- Coordination of evacuation operations;
- Coordination of rescue operations;
- Security of evacuated areas;
- Security of damaged premises;
- Registration of evacuated persons;
- Tracing or coordination of search for missing members of the community;
- Traffic, rail and air accidents; and
- Guidance on Counter-Terrorism Issues.

7.1.1.6 State Emergency Service (SES)

The functions of the SES are:[50]

- To perform rescue or similar operations in an emergency situation;
- To perform search operations in an emergency or similar situation;

[49] www.disaster.qld.gov.au/publications/pdf/State%20Disaster%20Man%20Plan%20A050908.pdf p31

[50] www.emergency.qld.gov.au/ses/aboutses/

- To perform other operations in an emergency situation to -
  1. Help injured persons; or
  2. Protect persons or property from danger or potential danger associated with the emergency;
- To perform other activities to help communities prepare for, respond to and recover from an event or a disaster.

7.1.1.7 Local Authority

The role of the local authority during a disaster include:[51]

- Maintenance of Local government functions (via Local government business continuity and recovery Planning);
- Maintenance of normal Local government services to the community and critical infrastructure protection;
- Development and maintenance of disaster management plans for the shire;
- Development and maintenance of a public education/awareness program;
- Establishment, maintenance and operation of a LDMG including the training of sufficient personnel to operate the centre;
- Coordination of support to emergency response agencies;
- Maintenance of warning and telemetry systems;
- Collection and interpretation of information from telemetry systems;
- Reconnaissance and post impact assessments for the shire;
- Debris clearance of roads and bridges;
- Issuance of public information prior to, during and post disaster impact events;
- Recommendations with regard to areas to be considered for authorised evacuation;
- Public advice with regard to voluntary evacuation;
- Provision of locally based community recovery services in conjunction with other recovery agencies; and
- Evacuation centre management.

[51] www.disaster.qld.gov.au/publications/pdf/State%20Disaster%20Man%20Plan%20A050908.pdf p34

7.1.1.8 Bureau of Meteorology (BOM)

The Bureau's flood forecasting and warning service uses rainfall and streamflow observations, numerical weather predictions and hydrologic models to forecast and warn for possible flood events across Australia. [52]

This information provides the basis for flood response by emergency services and other flood managers and is vital for water resource managers responding to large inflows of water into their dams and rivers.

The role of the BOM during a disaster includes:[53]

- Forecasting of weather and the state of the atmosphere;
- Issue of warnings for gales, storms and other weather conditions likely to endanger life or property, including weather conditions likely to give rise to floods;
- Supply of meteorological information;
- Publication of meteorological reports and bulletins; and
- Provision of advice on meteorological matters.

7.1.1.9 Australian Defence Force (ADF)

The SDMG may request the Federal Government to make the ADF available to assist with disaster cleanup and recovery activities. The ADF may also be called upon to provide additional resources for search and recovery activities.

7.1.2 SunWater's role

During flood events SunWater undertakes the following activities:

- Monitor water inflows into the dam and notify stakeholders as per the EAP;
- Provide regular inflow updates to LDMG;
- Pass water inflows through the dam's *spillway* or outlet works in accordance with established operational guidelines and manage and maintain water levels in gated dams: and
- Undertake predictive flood modelling for selected dams and liaise with BOM to share information and ensure the veracity of the modelling. The SunWater modelling is not catchment wide and is limited to dam inflows and *outflows*. SunWater uses the information for operational purposes. The BOM modelling is catchment wide and has the responsibility to provide the modelling predictions to the emergency management groups.

---

[52] www.bom.gov.au/water/floods/index.shtml

[53] www.disaster.qld.gov.au/publications/pdf/State%20Disaster%20Man%20Plan%20A050908.pdf p32

Those functions are described further below.

7.1.2.1 Dam EAPs

SunWater dams are safe and designed for extreme flood events that are far larger than the events experienced over the 2010-11 wet season. However, Emergency Action Plans (EAPs) have been developed for all of SunWater's dams. The EAPs have a clear set of actions, responsibilities and communications that are to be undertaken under a range of emergency scenarios.

The emergency scenarios explicitly considered in the EAPs include:

- Flood Operation
- Rapid Drawdown (rapid drop in water level within the storage)
- Sunny Day Failure (Earthquake or Piping)
- Chemical /Toxic Spill
- Terrorist Activity

The EAPs also provide a framework whereby those with lead accountability are provided with technical advice from senior and experienced engineering staff. The latest EAP version also outlines predictive flood modelling from the Flood Operations Centre (FOC) for certain high hazard dams. The SunWater dams currently serviced by the FOC include:

- Tinaroo Falls;
- Burdekin Falls;
- Fairbairn;
- Paradise;
- Fred Haigh;
- Coolmunda; and
- EJ Beardmore

The EAPs are provided to the LDMG and SunWater discusses the plans with local coordinators prior to the wet season. The controlled documents are reviewed and updated regularly. Notification and communication lists are updated annually and distributed those listed organisations in the EAPs including the LDMG.

7.1.2.2 Flood Operations Centre

In 2010 SunWater developed runoff routing models for a number of its dams. The dams were prioritised on criteria such as hazard rating, population at risk, frequency of flooding and type of structure. Technical staff use the models with flow data from the BOM to provide a prediction of the height and time of the peak *discharge* from the dam. This is aimed at assisting the dam duty officer (DDO) on dam operations and the emergency event coordinator (EEC) in discussions with the LDMG. SunWater liaises with the BOM to share information and ensure the veracity of the modelling. The BOM modelling is catchment wide and BOM has the responsibility to provide the modelling predictions to the emergency management groups.

The FOC operated successfully over the 2010-11 wet season for the following SunWater operated dams:

- Tinaroo Falls;
- Burdekin Falls;
- Fairbairn;
- Paradise;
- Coolmunda; and
- EJ Beardmore

7.1.2.3 Wet season preparation

A significant amount of SunWater's infrastructure is located in areas prone to frequent and/or large flood events. SunWater routinely undertakes preparations in advance of the wet season. Preparations prior to the 2010-11 wet season included:

- Development and release of Issue 3 of the Tinaroo Falls dam EAP. Issue 3 includes a number of improvements such as clearer roles and responsibilities following a recent restructure of SunWater, inclusion of the FOC role and an emergency response framework consistent with the most recent Crisis Handbook for the organisation;
- The dams operating under Issue 2 of the EAPs were issued with a supplementary notice prior to the wet season to clarify roles and responsibility;
- All EAP notification and Communication Lists were updated and issued;
- Briefings were conducted with a number of LDMGs (refer section 2.1.2);
- A number of staff training and awareness exercises were conducted;
- Rosters for the EAP roles of Emergency Event Coordinators (EEC), and Dam Duty Officers (DDO) and other roles were developed and issued;
- The Executive, senior management, and the Chairman were put through an EAP awareness training exercise;
- Routine preparatory maintenance of critical equipment which included:

1. Servicing & Testing of generators;

2. Full stock of fuel supplies;

3. Testing of Gates and SCADA (supervisory control and data acquisition) systems;

- Placement of an additional emergency backup generator for *spillway* gates at EJ Beardmore Dam; and

- Development and issue of a revised *Crisis Handbook* was developed and issued (refer section 7.1.2.4).

Not all of the above preparations were undertaken for all dams. Schedules 2 onward detail the specific preparations at each dam.

7.1.2.4 Crisis Management

The EAPs for SunWater's dams are designed to deal with incidents, emergencies and crisis at a specific dam. Since 2007 SunWater has also had in place a formal incident, emergency, crisis and disaster management framework. During 2010 SunWater undertook a review of that framework. The review considered learnings from previous events.

In December 2010 SunWater published the 2011 edition of the Crisis Handbook. The handbook provides a structure for a crisis management team (refer to Figure 7-3) and roles for each member of that team.

Figure 7-3 SunWater's Crisis Management Structure

The Crisis Handbook includes:

- A listing of emergency contact numbers;

- Definition of SunWater's emergency response framework;

- Key SunWater contacts including senior managers and subject matter experts;

- A tool kit of forms for use by crisis team members during an event;
- Duty cards for each member of the crisis team.

The handbook was provided to all staff along with necessary instruction prior to the 2010 Christmas holiday period.

8 Overview of SunWater Dams during the 2010-11 wet season

Set out in the schedules at the rear of this document is information in respect to each of SunWater's major *referable dams* and, in particular, information in respect to any flood event at each dam during the 2010-11 wet season.

At the time of submission of this statement schedules for a number of the dams in SunWater's portfolio were not complete. I will supplement this statement with addendum statements as those schedules are completed.

9 Conclusions

SunWater, together with its subsidiary Burnett Water, owns 19 major dams across the State. All of these 19 dams are principally for the purpose of providing water supplies. Peter Faust has been designed for a dual role of *water supply* and *passive flood mitigation.*

SunWater and its subsidiaries do not own any dams that provide *active flood mitigation.*

Notwithstanding that SunWater's dams are generally not designed to provide a flood mitigation service, SunWater's dams do attenuate the peak flood *discharge.*

The rainfall across the catchment areas of SunWater's dam during the 2010-11 wet season, although significant, was much less than the extreme rainfall events that SunWater's dams are designed to safely pass.

SunWater has in place a rigorous dam safety management system. Emergency and operations & maintenance procedures are well documented. The processes are well understood by staff. SunWater took the steps required by the relevant procedures to prepare for the 2010-11 wet season at each of its dams. That preparation, compliance with operating procedures during flood events and SunWater's systems ensured that SunWater's dams performed safely during the 2010-11 wet season. SunWater's approach to dam management meets or exceeds the minimum standards set down by the regulatory framework.

SunWater plays a limited role in the Queensland disaster management framework. SunWater works closely with local disaster management groups in accordance with emergency management procedures and ensures that those groups are kept informed of the status of SunWater's dams.

SunWater has reviewed the operation of its dams in the context of whether SunWater dams could provide a flood mitigation benefit from the existing asset configuration. The review concluded that there are no opportunities to provide flood mitigation services from SunWater's existing dams for the following reasons:

- The regulatory framework within Queensland prevents SunWater from pre releasing water from dams for flood mitigation purposes;
- On a practical level, significant reductions in dam levels prior to a wet season would be very difficult to achieve. It would take several months in most cases to release significant volumes of water from the outlet works of SunWater dams. The outlet works are designed to only release sufficient water to satisfy downstream demands;
- A significant reduction in dam levels prior to a wet season could compromise the very purpose for which Sunwater Dams are designed, namely *water supply*;
- The flood volumes in moderate to major floods are typically very large relative to the storage capacity of SunWater dams. For example, the volume that passed Paradise Dam in a 20 day period was 22 times the full storage volume of the dam.

- Even if the dam levels could have been lowered significantly before the commencement of the 2010-11 wet season (by say 25% to 50%) (which is not viable for the reasons outlined above) there would have been insignificant mitigation of any major flood.

10 Glossary of Terms

As Low as Reasonably Practicable (ALARP)

The principle which states that risk to life, lower than the *limit of tolerability* (- a risk within a range that society can live with so as to secure certain net benefits), are tolerable only if risk reduction is impractical or if its cost is grossly disproportionate to the improvement gained[54].

Design rainfall

Design rainfall information is generally expressed in terms of point rainfall intensity, which is the rainfall depth (mm) at a location per hour. However, for flood estimates of large catchments, an estimate of the average areal rainfall intensity across the catchment is required. This is the mean rainfall depth per hour over the entire catchment[55].

Discharge

The flow of water out of water supply infrastructure, such as a dam, weir or pipeline.

District Disaster Management Group

District Groups comprise representatives from regionally based Queensland government agencies which can provide and coordinate whole-of-government support and resource gap assistance to disaster-stricken communities. The District Groups perform a 'middle management' function within the disaster management arrangements by coordinating the provision of functional agency resources when requested by Local Groups on behalf of local governments[56].

Flood Classification

A description by the Bureau of Meteorology of the severity of flooding - minor, moderate or major - according to the effects caused in the local area or in nearby downstream areas[57].

Flood mitigation - Active

Design function of a dam built for the purpose of reducing the impact of flooding downstream of a dam where the dam operator can exert some control on the discharge from the dam, usually by the operation of spillway gates included in the

---

[54] www.derm.qld.gov.au/water/regulation/pdf/guidelines/dam_safety/flood_capacity/accept_flood_capacity.pdf

[55] www.gmat.unsw.edu.au/currentstudents/ug/projects/howell/howell.htm

[56] www.disaster.qld.gov.au/about/

[57] www.bom.gov.au/hydro/flood/qld/brochures/georgina/georgina.shtml#FloodClassifications

	dam design, e.g., Wivenhoe Dam.
Flood mitigation – Passive	Design function of a dam built for the purpose of reducing the impact of flooding downstream of a dam where the operator cannot control the discharge from the dam, e.g., Peter Faust Dam.
Freeboard	The distance between normal water level in a structure and the top of the structure, such as a dam, that impounds or restrains water.
FSL (Full Supply Level)	For a dam, means the level of the water surface when the water storage is at maximum operating level when not affected by flood[58].
iROL (interim Resource Operations Licence)	Authorises the holder of the licence to interfere with the flow of water to the extent necessary to operate the water infrastructure to which the licence applies[59] where a ROP is not in place for the infrastructure.
Local Advisory Committee	Also know as Irrigator Advisory Committees - a group of SunWater's customers within a water supply scheme who have been elected by other customers to represent the interests of the broader customer base in relation to scheme operations and water supply issues and improvements with SunWater. There is a local irrigator advisory committee in most of SunWater's water supply schemes.
Local Disaster Management Group	Local Groups established to support local government disaster management activities. The Local Group is supported by the relevant District Disaster Management Group if and when disaster management activities exceed the capacity of a Local Group[60].
Overtopping	The flow of water over a dam wall or embankment
Outflow	The flow of water out of a dam or water storage.
Referable dam - Category 1	In Queensland, a water storage with a failure impact rating accepted by the dam safety regulator as having a population at risk in the

[58] Sch. 3, *Water Supply (Safety and Reliability) Act* 2008

[59] S. 167A *Water Act 2000*

[60] www.disaster.qld.gov.au/about/

	event of failure of the dam of 2 or more persons and not more than 100 persons[61].
Referable dam - Category 2	In Queensland, a water storage with a failure impact rating accepted by the dam safety regulator as having a population at risk in the event of failure of the dam of more than 100 persons[62].
Reliability	A measure of how frequently the full yield of a dam will be available for use.
ROL (Resource Operations Licence)	Authorises the holder of the licence to interfere with the flow of water to the extent necessary to operate the water infrastructure to which the licence applies[63] where a *ROP* is in place for the infrastructure.
ROP (Resource Operations Plan)	A plan, approved by the regulator under the *Water Act 2000*, concerned with the day-to-day management of water resources in a way that meets the WRP goals, outlining how a WRP will be implemented in specified areas.
Spillway	A channel or other structure used to provide for the controlled release of flows from a dam or water storage into a downstream area, typically being the watercourse that has been dammed.
Spillway – fixed crest	The height of the spillway without any operable gates or other mechanisms to allow for human control of the flow of flood water over the spillway.
Spillway gates	Mechanisms to allow for operator control the rate of flow of flood water over the spillway of a dam.
Spillway – Uncontrolled	A spillway with no operable gates or other mechanisms for controlling the flow of water over the spillway – the rate of discharge is controlled only by the depth of water within the water storage.
Spillway – Ungated	See ***Spillway - Uncontrolled***.

---

[61] S. 346 *Water Supply (Safety and Reliability) Act* 2008

[62] S.346 *Water Supply (Safety and Reliability) Act* 2008

[63] S. 170A *Water Act 2000*

Watercourse	A river, creek or other stream, including a stream in which water flows permanently or intermittently, regardless of the frequency of flow events and includes artificial channels that have changed the course of the stream. For further details see section 5 of the *Water Act 2000*
Water allocation security objective	An objective that may be expressed as a performance indicator and is stated in a water resource plan for the projection of the probability of being able to obtain water in accordance with a water allocation[64].
Water Supply	In Queensland, the capture, storage and distribution of water for use in accordance with the *Water Act 2000*.
Water Supply Scheme	Water infrastructure or other works for the supply of water or the storage, distribution or treatment of water[65].
WRP (Water Resource Plan)	Subordinate legislation prepared by the Minister responsible for the administration of the *Water Act 2000* to advance the sustainable management of water.
Yield	The volume of water in a dam or water storage that can be allocated for use each year.

[64] Sch. 4 *Water Act 2000*

[65] Sch.4 *Water Act 2000*

SIGNED BY:

[redacted]

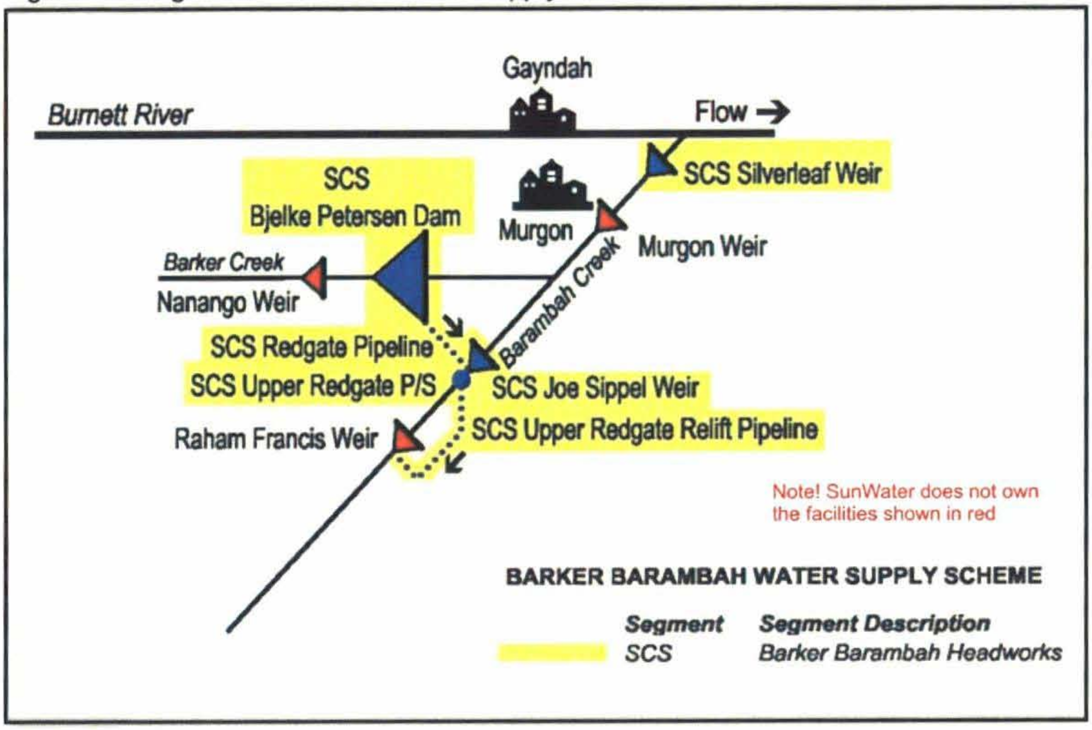
11-3-2011

Date

Schedule 1: Overview of SunWater's Water Supply Schemes

1.1 Barker Barambah Water Supply Scheme

Figure 1-1 Diagram of Barambah Water Supply Scheme



The Barker Barambah *Water Supply Scheme* is located west of Gympie near Murgon. Its main source of supply is Bjelke Petersen Dam located on Barker Creek. The scheme includes several weirs, but SunWater only owns the Joe Sippel and Silverleaf Weirs.

The Barker Barambah *Water Supply Scheme* (Figure 1-1) supplies water to irrigators along sections of Barker and Barambah Creeks, Murgon and Wondai Shire Councils, the Merlwood Water Board, and the Cherbourg Community Council.

Water levels in Silverleaf Weir are maintained through releases from the Bjelke Petersen Dam's river outlet, and the Joe Sippel Weir through the Redgate Diversion Pipeline. The scheme includes the Upper Redgate Relift Pipeline, which diverts water from the Joe Sippel Weir to the Francis Weir. SunWater owns the relift pipeline, but not the Francis Weir.

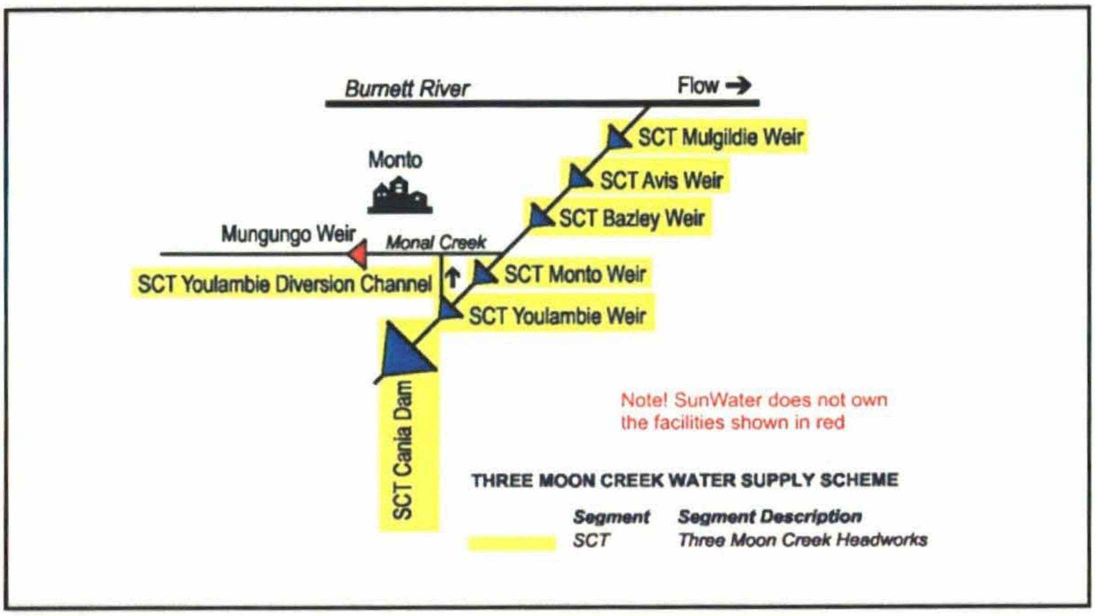
Table 1-1 Main Facilities of Barker Barambah Water Supply Scheme

Facility	Function	Capacity
Bjelke Petersen Dam	Head works for Barker Barambah Scheme. Supplies Joe Sippel and Silverleaf Weirs	134,900 ML
Joe Sippel Weir	Ponds water for irrigators along Barambah Creek and Upper Redgate Pump Station	710 ML
Silverleaf Weir	Ponds water for irrigators along Barambah Creek	620 ML

Facility	Function	Capacity
Upper Redgate PS	Pumps water from Joe Sipple Weir into Francis Weir.	20 ML/d

1.2 Three Moon Creek Water Supply Scheme

Figure 1-2 Diagram of Three Moon Creek Water Supply Scheme



Three Moon Creek *Water Supply Scheme* supplies riparian users along Three Moon Creek and the town of Monto, recharges groundwater supplies, and replenishes in-stream storages. The scheme centres on Cania Dam on Three Moon Creek 125 km west of Bundaberg and 36 km northwest of Monto.

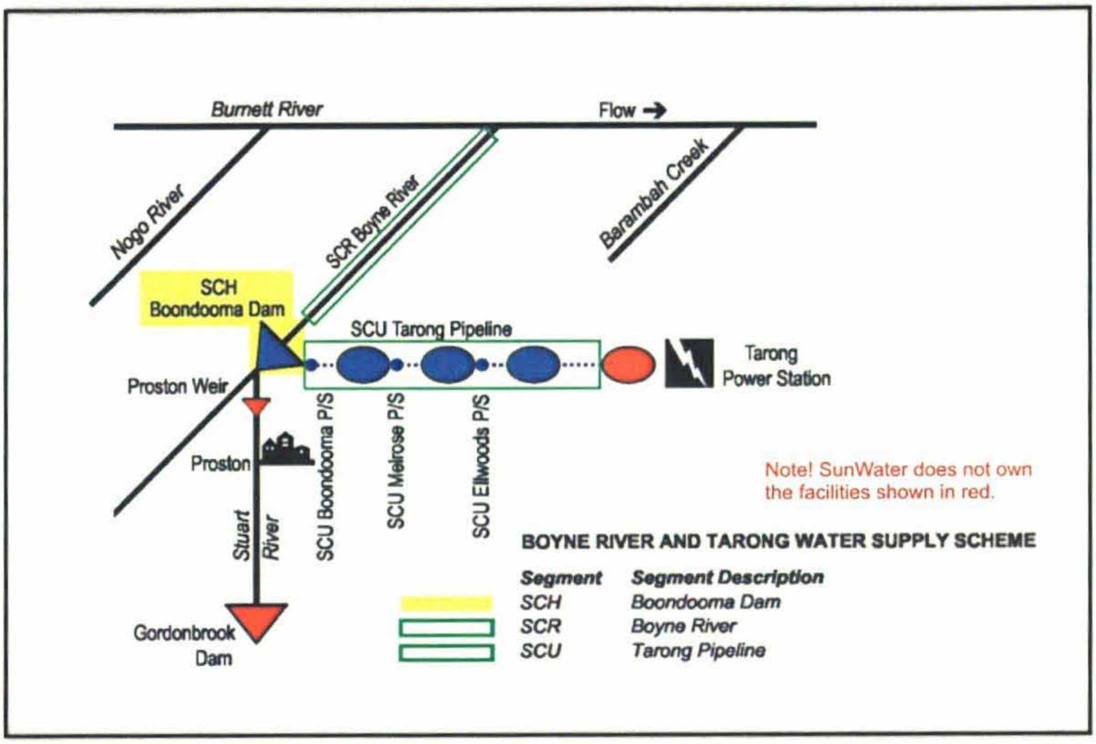
Water released from Cania Dam successively fills the ponded areas formed by the Three Moon Creek weirs.

Table 1-2 Main Facilities of Three Moon Creek Water Supply Scheme

Facility	Function	Capacity
Cania Dam	Headworks for Three Moon Creek Water Supply Scheme	88,500 ML
Youlambie Weir	Ponds water for irrigators and GW recharge	143 ML
Monto Weir	Ponds water for irrigators and GW recharge	27 ML
Bazley Weir	Ponds water for irrigators and GW recharge	75 ML
Avis Weir	Ponds water for irrigators and GW recharge	270 ML
Mulgildie Weir	Ponds water for irrigators and GW recharge	330 ML

1.3 Boyne River and Tarong Water Supply Scheme

Figure 1-3 Diagram of Boyne River and Tarong Water Supply Scheme



The Boyne River and Tarong *Water Supply Scheme* (Figure 1-3) is centred on Boondooma Dam on the Boyne River northwest of Kingaroy. It is designed to supply water to the Tarong Power Station and to downstream landholders along the Boyne River.

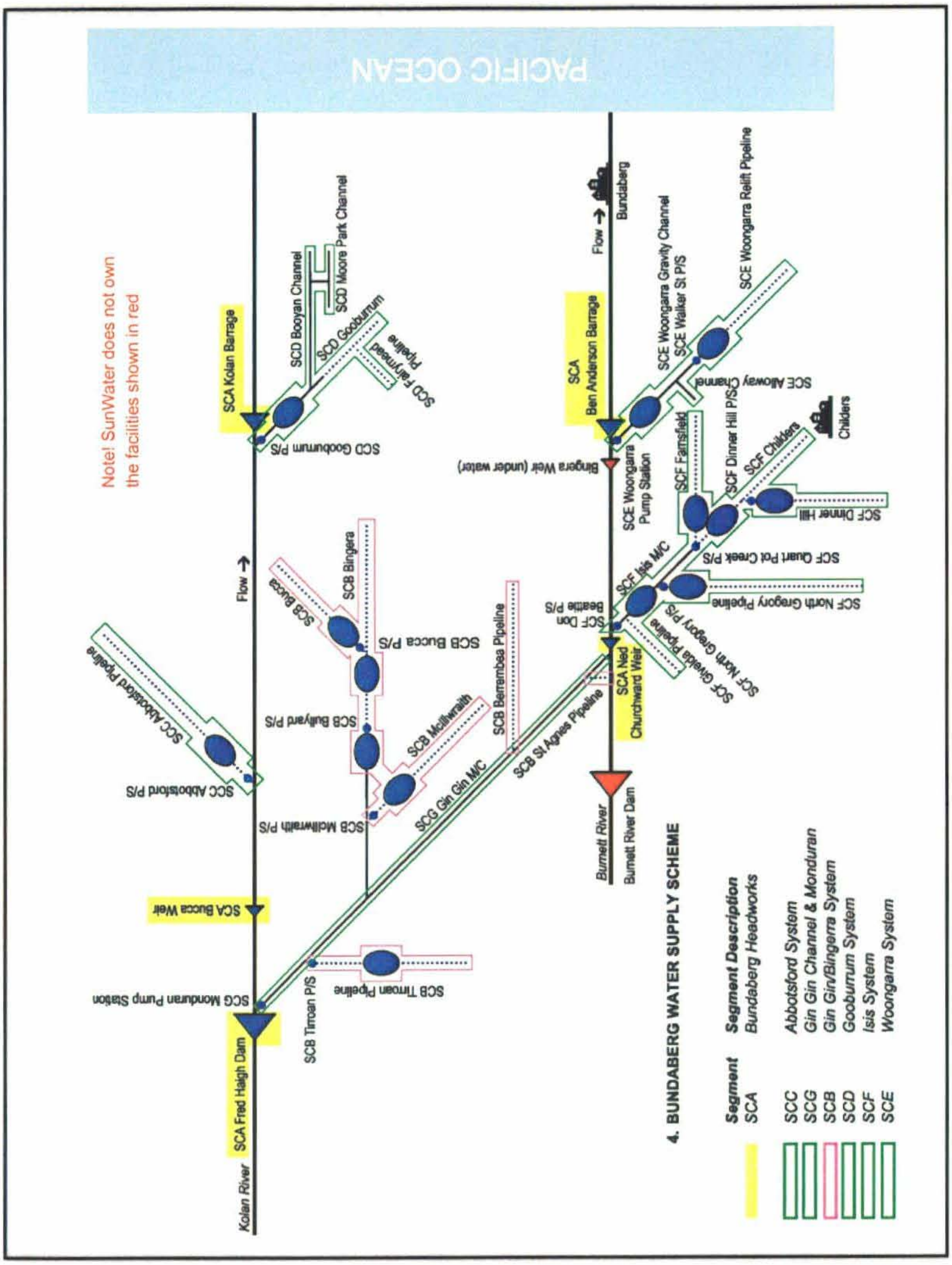
The Tarong Pipeline – that supplies the Tarong Power Station – is the scheme's other main feature. It is 94 km long and incorporates 3 pump stations and 3 balancing storages.

Table 1-3 Main Facilities of Boyne River and Tarong Water Supply Scheme

Facility	Function	Capacity
Boondooma Dam	Supplies Boyne River and Tarong Water Supply Scheme	204,200 ML
Boondooma PS	Tarong Pipeline	136 ML/d
Melrose PS	Tarong Pipeline	136 ML/d
Ellwoods PS	Tarong Pipeline	136 ML/d

1.4 Bundaberg Water Supply Scheme

Figure 1-4 Diagram of Bundaberg Water Supply Scheme



The Bundaberg *Water Supply Scheme* (Figure 1-4) is located near Bundaberg. It supplies irrigation, industry, and urban communities through two linked river systems: One system is served from the Kolan River (Fred Haigh Dam, Bucca Weir and Kolan Barrage) and the other system is served from the Burnett River (Paradise Dam, Ned Churchward Weir and Ben Anderson Barrage). Each system consists of a series of sub-systems supplied through a network of pump stations, balancing storages, channels, and pipelines which delivers water to customers.

Table 1-4 Main Facilities of Bundaberg Water Supply Scheme

Facility	Function	Capacity
Fred Haigh Dam	Supplies Kolan Barrage and Gin Gin Main Channel	562,000 ML
Paradise Dam	Supplies Burnett River, Ned Churchward Weir	300,000 ML
Bucca Weir	Regulates flow and supplies riparian landholders	11,600 ML
Kolan Barrage	Supplies Abbotsford and Gooburrum systems	3,810 ML
Ned Churchward Weir	Stores water for release into Ben Anderson Barrage and riparian landholders	29,500 ML
Ben Anderson Barrage	Supplies Woongarra and Isis systems	30,300 ML
Abbotsford PS	Supplies Abbotsford System	24 ML/d
Bucca PS	Supplies Bucca Pipeline	60 ML/d
Bullyard PS	Supplies Bingera Pipeline	415 ML/d
Dinner Hill PS	Supplies Dinner Hill Pipeline	160 ML/d
Don Beattie PS	Supplies Isis System	648 ML/d
Gooburrum PS	Supplies Gooburrum System	300 ML/d
McIllwraith PS	Supplies McIllwraith Pipeline	60 ML/d
Monduran PS	Supplies Gin Gin Main Channel	1100 ML/d
North Gregory PS	Supplies North Gregory Pipeline	63 ML/d
Quart Pot PS	Supplies Childers and Farnfield Pipelines	250 / 275 ML/d
Tiroan PS	Supplies Tirroan Pipeline	72 ML/d
Walker St PS	Supplies Woongarra Relift Pipeline	226 ML/d
Woongarra PS	Supplies Woongarra System	400 ML/d

1.5 Burdekin Haughton Water Supply Scheme

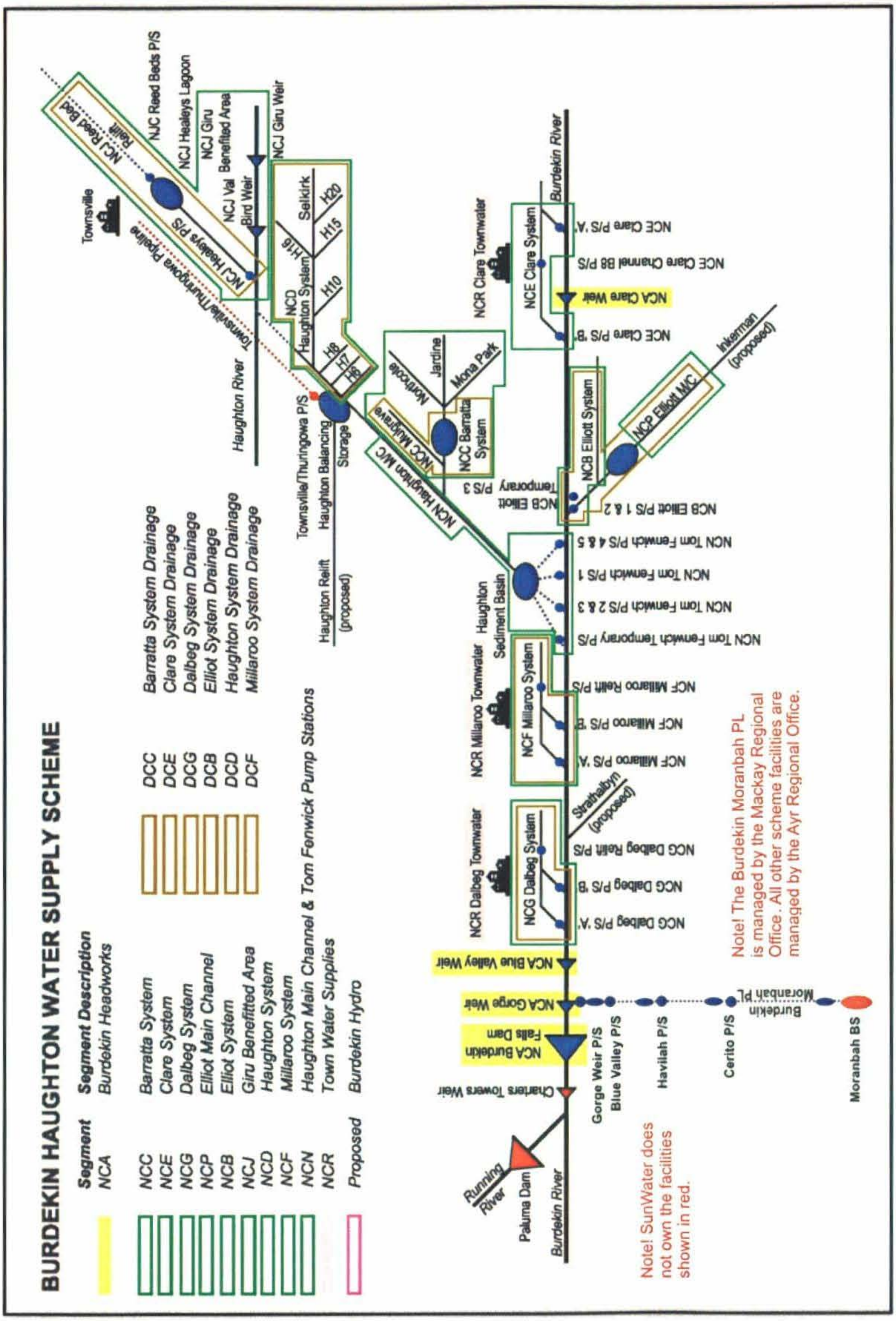
The Burdekin Haughton *Water Supply Scheme* (Figure 1-5) is located west of Ayr. It supplies raw water for irrigation, towns and industry, stock watering, and aquifer recharge.

The scheme extends north from the Burdekin Falls Dam on the Burdekin River to the Giru Weir on the Haughton River and supplies water to farms spread over 9 sub-systems. Six of these 9 sub-schemes incorporate drains designed to intercept irrigation runoff.

The Burdekin Falls Dam is the main water storage facility of the scheme. Other controlling facilities are the Gorge, Blue Valley, Clare, and Val Bird Weirs. Water from the storages created by the weirs is distributed through networks consisting of pump stations, pipelines, balancing storages, channels, creeks, and metered outlets.

A recent addition (2007) is the Burdekin Moranbah Pipeline, which draws from the Gorge Weir. The Burdekin Moranbah pipeline joins with the Eungela Pipeline to supply the Balancing Storage at Moranbah which in turn supplies the expanding coalfields of Queensland's Bowen Basin

Figure 1-5 Diagram of Burdekin Haughton Water Supply Scheme



B:1282436_3 NJX

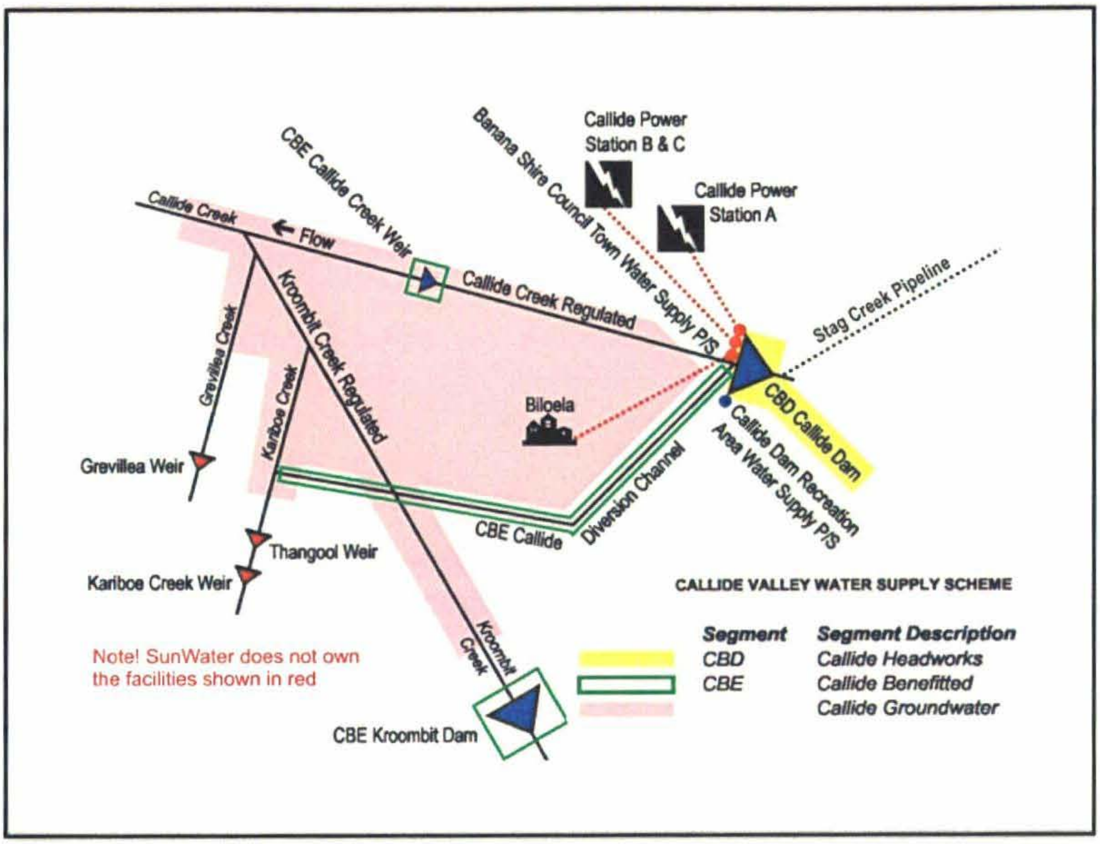
11/03/2011 3:45 PM

Table 1-5 Main Facilities of Burdekin Haughton Water Supply Scheme

Facility	Function	Capacity
Burdekin Falls Dam	Supplies the Burdekin River based part of the water supply scheme including Gorge, Blue Valley, and Clare Weirs	1,860,000 ML
Gorge Weir	Pond water downstream of Burdekin falls dam	9.095 ML
Blue Valley Weir	Pond water downstream of Gorge Weir	3,820 ML
Clare Weir	Ponds water for Dalbeg, Millaroo, Haughton, Barratta, Elliott and Clare Systems	15,900 ML
Val Bird Weir	Supplies the Giru System	2, 055 ML
Giru Weir	Supplies the Giru System	1, 025 ML
Clare Channel B8 PS	Supplies Clare System	21 ML/d
Clare PS 'A'	Supplies Clare System	166 ML/d
Clare PS 'B'	Supplies Clare System	122 ML/d
Dalbeg PS 'A'	Supplies Dalbeg System	74 ML/d
Dalbeg PS 'B'	Supplies Dalbeg System	74 ML/d
Dalbeg Relift PS'	Supplies Dalbeg System	18 ML/d
Elliot PS 1/2	Supplies Elliot System	180 ML/d
Healeys PS	Supplies Giru Benefited Area System	98 ML/d
Millaroo PS 'A'	Supplies the Millaroo System	180 ML/d
Millaroo PS 'B'	Supplies the Millaroo System	111 ML/d
Millaroo Relift PS	Supplies the Millaroo System	34 ML/d
Reed Beds PS	Supplies Giru Benefited Area System	45 ML/d
Tom Fenwick PS 1	Supplies the Haughton and Barratta Systems	605 ML/d
Tom Fenwick PS 2/3	Supplies the Haughton and Barratta Systems	1209 ML/d
Tom Fenwick PS 4/5	Supplies the Haughton and Barratta Systems	1209 ML/d
Tom Fenwick Temp PS	Supplies the Haughton and Barratta Systems	180 ML/d
Gorge Weir PS	Supplies the Burdekin Moranbah Pipeline from Gorge Weir	47 ML/d
Blue Valley PS	Booster Pump Station on Burdekin Moranbah Pipeline	47 ML/d
Havilah PS	Booster Pump Station on Burdekin Moranbah Pipeline	47 ML/d
Cerito PS	Booster Pump Station on Burdekin Moranbah Pipeline	47 ML/d

1.6 Callide Valley Water Supply Scheme

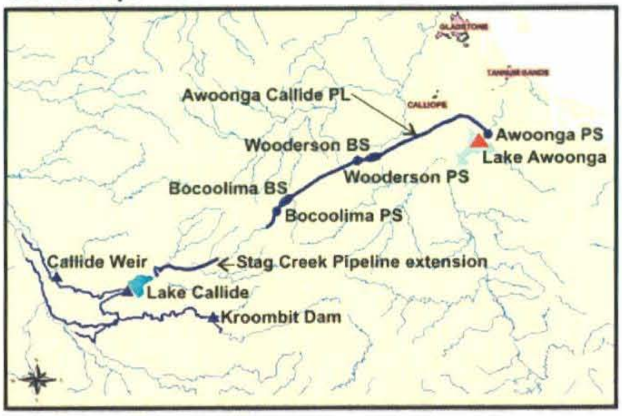
Figure 1-6 Diagram of the Callide Valley Water Supply Scheme



The Callide Valley *Water Supply Scheme* (Figure 1-6) supplies bulk water for the Town of Biloela and the Callide Power Station and recharges the area's aquifer for the benefit of local irrigators and industry. The scheme comprises the Kroombit and Callide Dams, Callide Creek Weir, and the Callide Diversion Channel.

In addition to holding water for the Callide Valley *Water Supply Scheme*, Callide Dam also acts as a temporary storage for water owned by the Callide Power Station supplied via the Awoonga Callide and Stag Creek Pipelines from the Awoonga Dam near Gladstone (Figure 1-7). Although the Awoonga-Callide and Stag Creek Pipeline are not formally included in any *IROLS ROP* issued by DERM, they are included here because they are an integral part of the operation of the Callide Dam.

Figure 1-7 Diagram of Stag Creek and Awoonga-Callide Pipelines



The Awoonga-Callide Pipeline is 54 km long and has three pump stations, Awoonga, Wooderson, and Bocoolima. The Awoonga Pump Station pumps directly from Awoonga Dam (owned by GAWB). The Wooderson and Bocoolima Pump Stations pump from balancing storages.

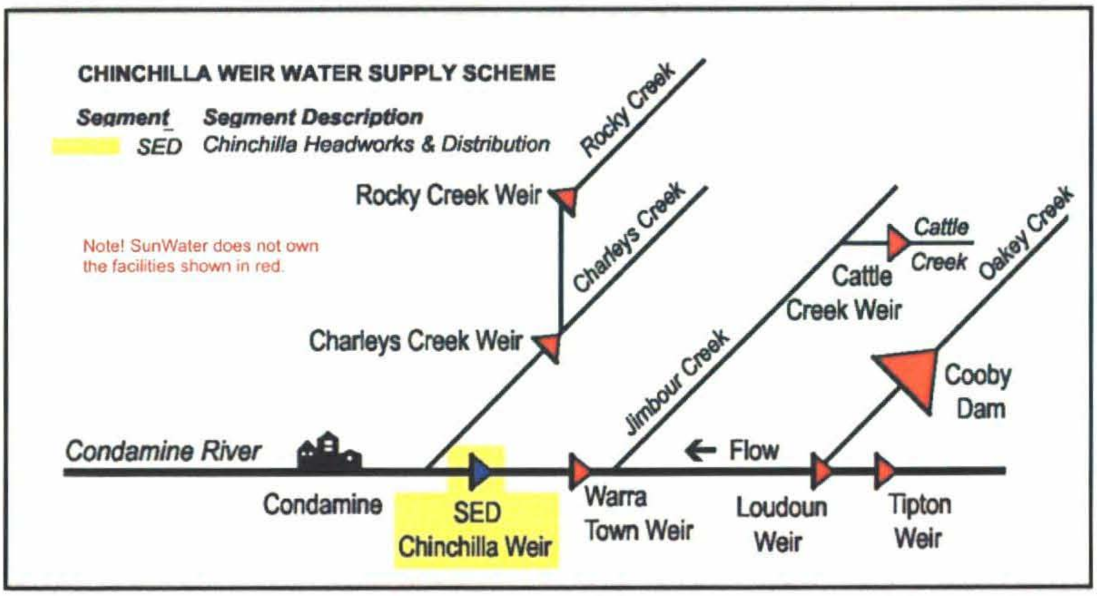
The Awoonga Callide Pipeline *discharges* into Stag Creek Gorge from where it flows into the Stag Creek weir andPipeline that ends just upstream of Callide Dam.

Table 1-6 Main Facilities Callide Valley Water Supply Scheme and Awoonga Callide Pipeline

Facility	Function	Capacity
Callide Valley WSS		
Callide Dam	Supplies Callide Valley Water Supply Scheme and pump pool for Callide Power Stations and Banana Shire Council Town water Supply	136,370 ML
Kroombit Dam	Supplies Callide Valley Water Supply Scheme for irrigators and GW recharge	14,600 ML
Callide Weir	Ponds water for irrigators and GW recharge	506 ML
Awoonga-Callide PL	(54 km long rising main)	90 ML/d
Awoonga PS	Awoonga Callide Pipeline	90 ML/d
Wooderson PS	Awoonga Callide Pipeline (Relift)	90 ML/d
Bocoolima PS	Awoonga Callide Pipeline (Relift)	90 ML/d
Stag Creek PL	(15 km long gravity main)	90 ML/d

1.7 Chinchilla Weir Water Supply Scheme

Figure 1-8 Diagram of Chinchilla Weir Water Supply Scheme



The Chinchilla Weir *Water Supply Scheme* (Figure 1-8) consists of Chinchilla Weir on the Condamine River south of the Town of Chinchilla. The weir supplies local irrigators upstream and downstream of the weir as well as the Town of Chinchilla. Under the arrangement, upstream irrigators pump directly from the pond created by the weir and downstream irrigators from the flows regulated by releases from the weir.

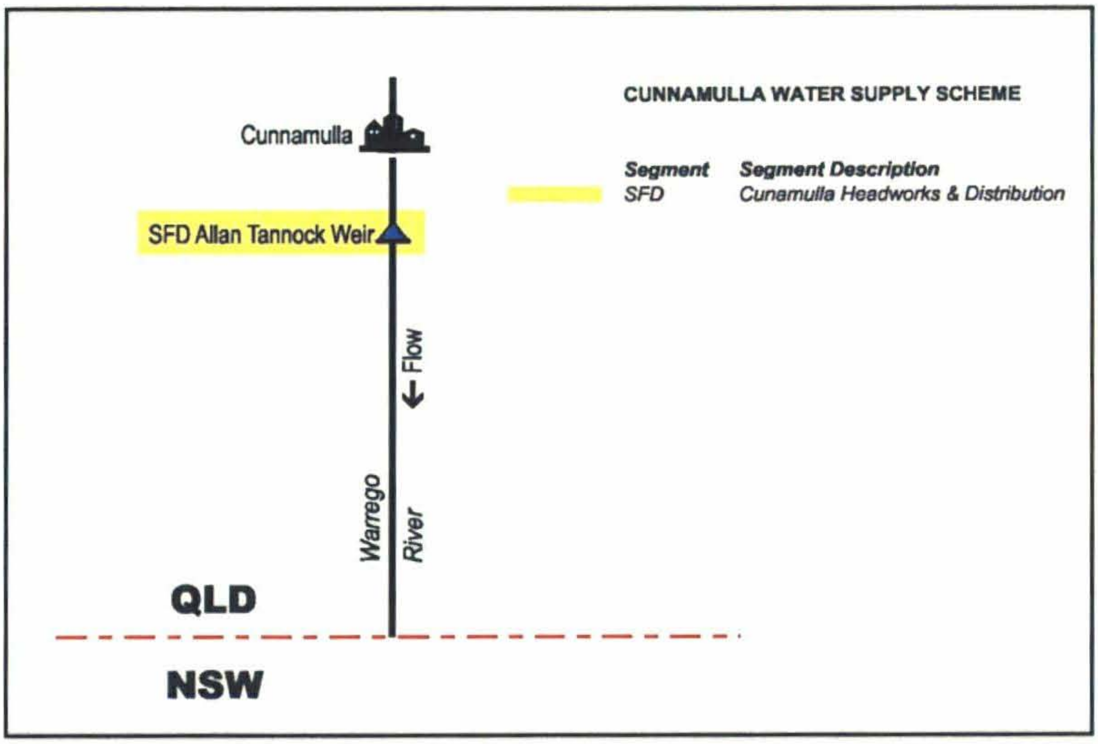
Table 1-7 Main Facilities of Chinchilla Water Supply Scheme

Facility	Function	Capacity
Chinchilla Weir	Headworks for the Chinchilla Weir Water Supply Scheme	9780 ML

There is no dam in this scheme

1.8 Cunnamulla Weir Water Supply Scheme

Figure 1-9 Diagram of Cunnamulla Weir Water Supply Scheme



The Cunnamulla Weir *Water Supply Scheme* (Figure 1-9) comprises Allan Tannock Weir on the Warrego River just south of the Town of Cunnamulla. It supplies water to landholders along its ponded area and downstream of the weir, as well as bulk water for Cunnamulla to supplement the town's bore *water supply scheme.*

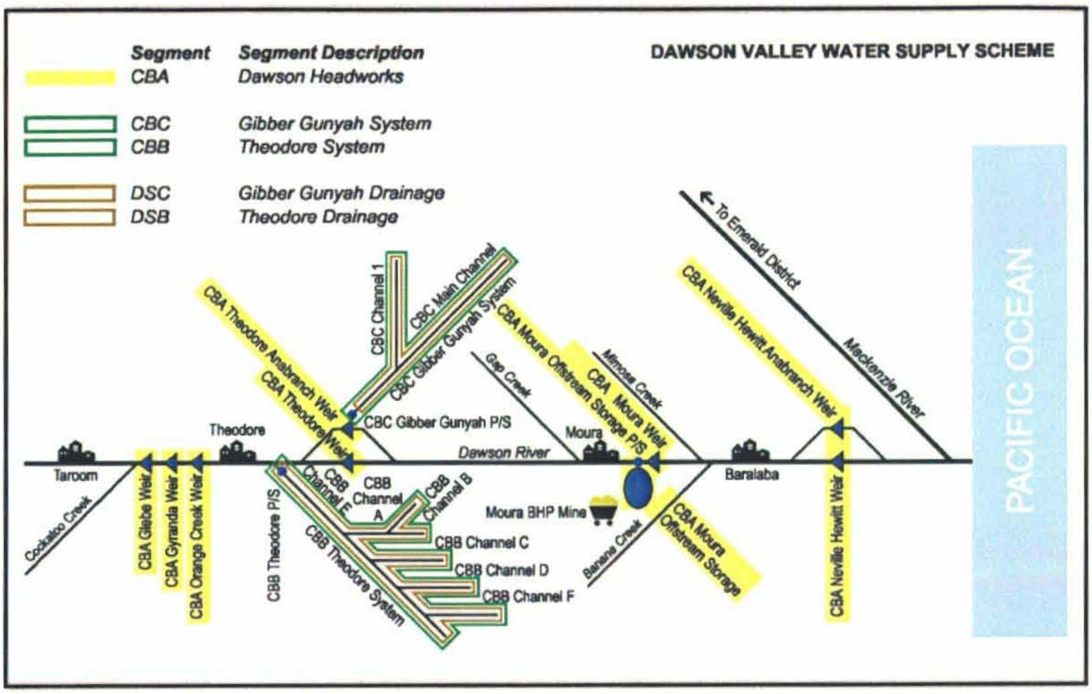
Table 1-8 Main Facilities of Cunnamulla Weir Water Supply Scheme

Facility	Function	Capacity
Allan Tannock Weir	Headworks for the Cunnamulla Weir Water Supply Scheme	4772 ML

There is no dam in this scheme.

1.9 Dawson Valley Water Supply Scheme

Figure 1-10 Diagram of Dawson valley Water Supply Scheme



The Dawson Valley *Water Supply Scheme* (Figure 1-10) is centred on Town of Theodore, and covers regulated sections of the Dawson River controlled by Glebe Weir, Gyranda Weir, Orange Creek Weir, Theodore Weir, Moura Weir, Neville Hewitt Weir and the Moura Offstream Storage. The scheme supplies untreated water for irrigators, mines, other industries, and urban authorities.

The scheme also incorporates the Theodore and Gibber Gunyah irrigation distribution systems that consist of a combination of open channels and pipelines. Both systems draw from Theodore Weir through Pump Stations named after the sections they serve.

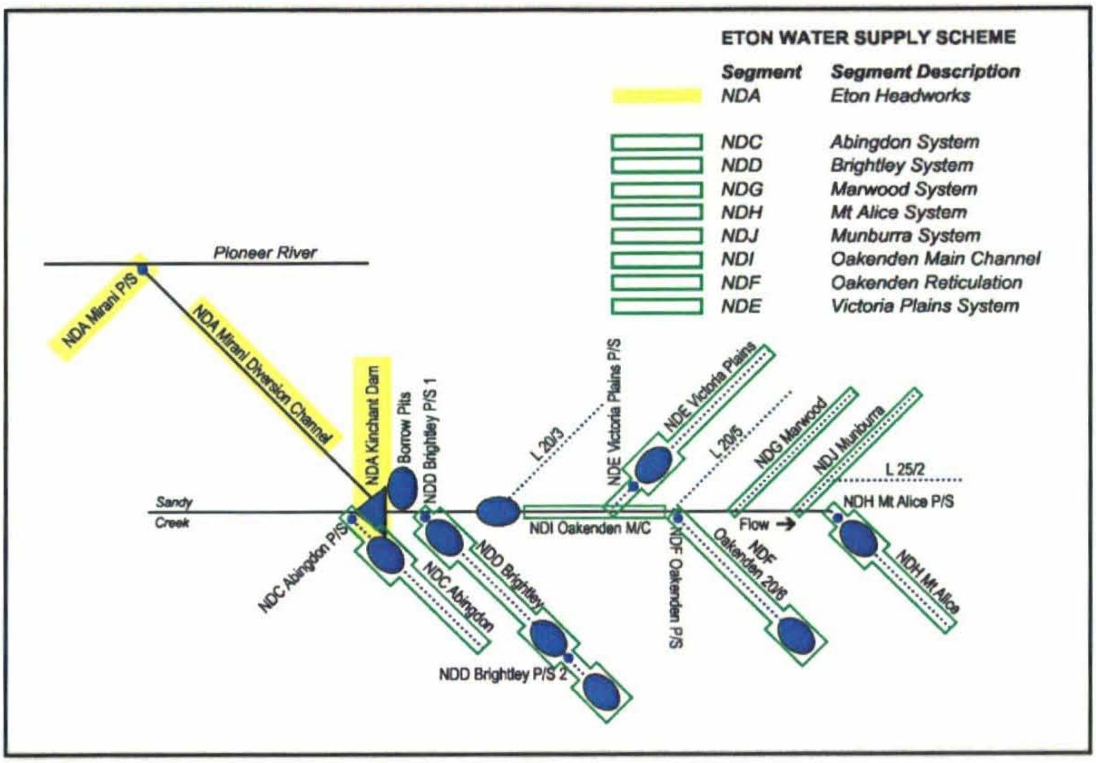
Table 1-9 Main Facilities of Dawson Valley Water Supply Scheme

Facility	Function	Capacity
Glebe Weir	Supplies Dawson River riparian landholders + Taroom	17,700 ML
Gyranda Weir	Supplies Dawson River riparian landholders	16,400 ML
Orange Creek Weir	Supplies Dawson River riparian landholders	6,780 ML
Theodore Weirs	As above + pump pool for Theodore and Gibber Gunyah PS	4760 ML
Moura Weir	Supplies Dawson River riparian landholders + Moura +industry	7,700 ML
Neville Hewitt Weirs	Supplies Dawson River riparian landholders + Barabala	11,300 ML
Moura OS Storage	Provides additional storage capacity adjacent to Moura Weir	2,820 ML
Theodore PS	Supplies Theodore System	102 ML/day
Gibber Gunyah PS	Supplies Gibber Gunyah System	121 ML/day
Moura OS PS	Fills Moura OS Storage	173 ML/day

There is no dam in this scheme.

1.10 Eton Water Supply Scheme

Figure 1-11 Diagram of Eton Water Supply Scheme



The Eton *Water Supply Scheme* (Figure 1-11) is located near Mackay. It supplies water to irrigators, stock and domestic water users, and the Haypoint Coal Loading Facilities near Sarina. Kinchant Dam on Sandy Creek is the main storage.

During periods of high flow in the Pioneer River, the Mirani Pump Stations pump water from the river into Kinchant Dam via the Mirani Diversion Channel. From there, water is progressively released into Oakenden Main Channel for distribution through a network of sub-systems, pipelines, small pump stations, and balancing storages.

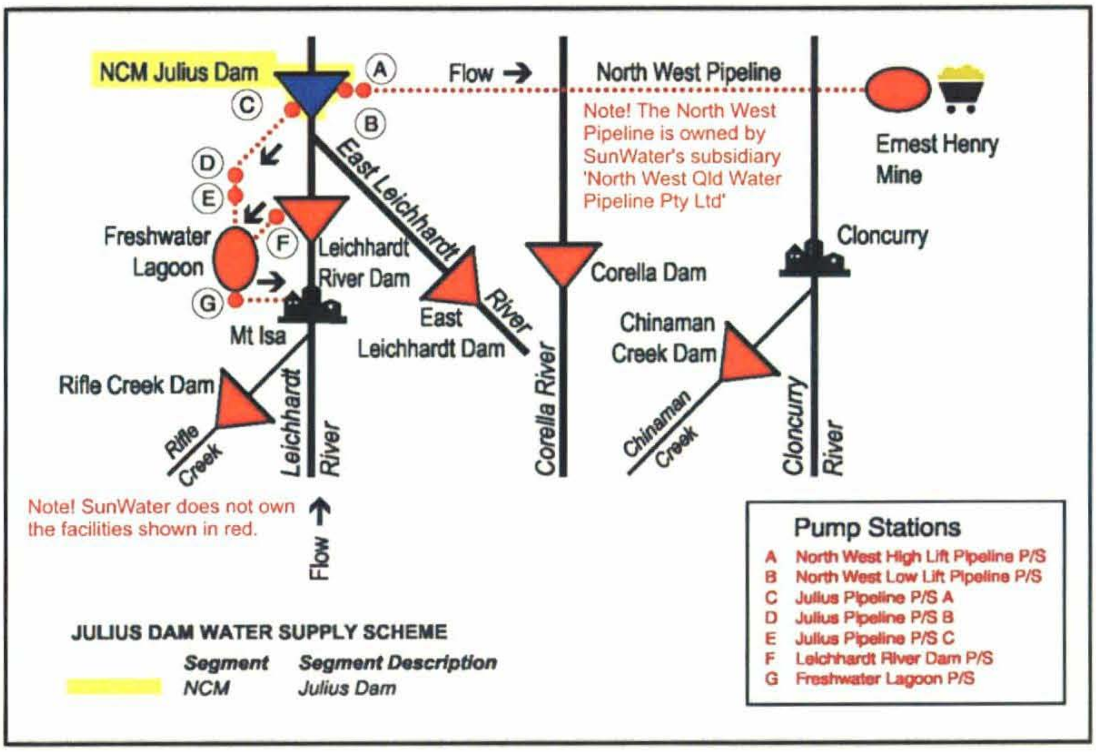
Table 1-10 Main Facilities of Eton Water Supply Scheme

Facility	Function	Capacity
Mirani PS	Supplies Kinchant Dam	860 ML/d
Kinchant Dam	Supplies Eton Water Supply Scheme	62,800 ML
Abingdon PS	Supplies Abingdon System	32 ML/d
Brightley PS '1'	Supplies Brightley System	62 ML/d
Brightley PS '2'	Supplies Brightley System (Relift)	19 ML/d
Mt Alice PS	Supplies Mt Alice System	121 ML/d
Oakenden PS	Supplies Oakendon System	31 ML/d
Victoria Plains PS	Supplies Victoria Plains System	82 ML/d

1.11 Julius Dam Water Supply Scheme

The Julius Dam *Water Supply Scheme* (Figure 1-12) is located on the Leichhardt River 60 km north of Mount Isa.

Figure 1-12 Diagram of Julius Dam Water Supply Scheme



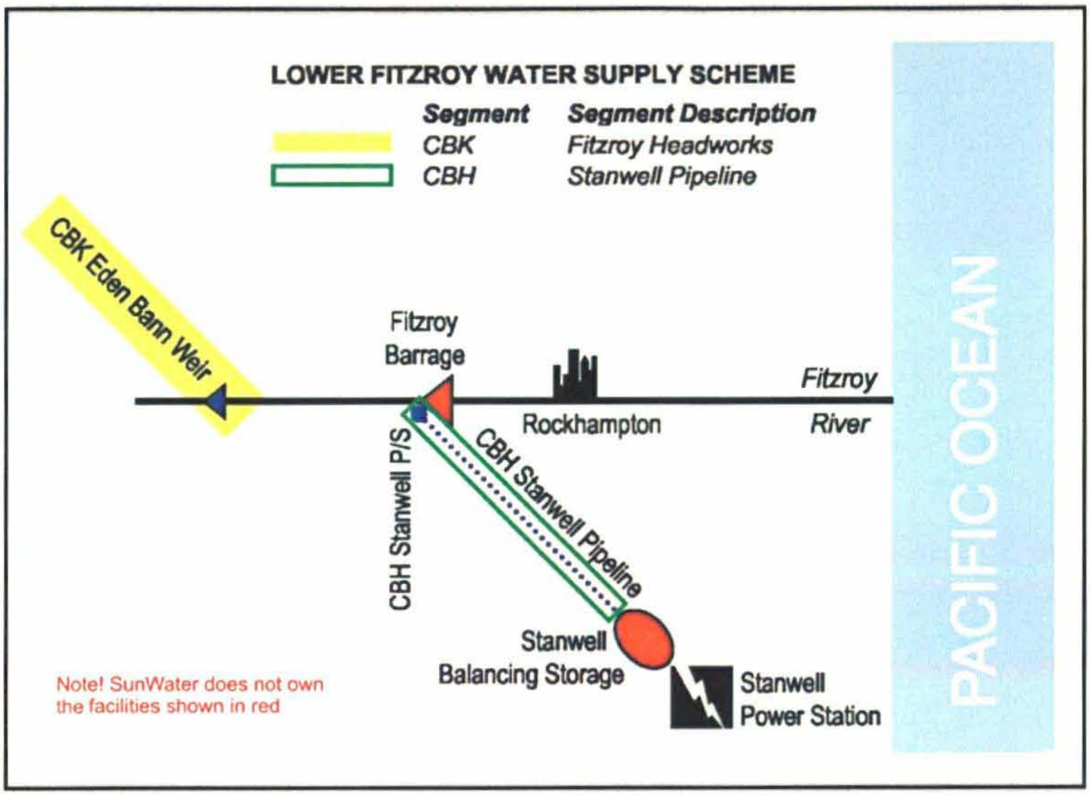
Julius Dam is the water source for the North West Pipeline owned by the North West Queensland Water Pipeline Company Pty Ltd and is used by the Mount Isa Water Board as a backup for Lake Moondarra near the City of Mount Isa.

Table 1-11 Main Facilities of Julius Dam Water Supply Scheme

Facility	Function	Capacity
Julius Dam	Supplies water for Mt Isa Water Board and North West Qld Water Supply Pipeline Company P/L	107,500 ML

1.12 Lower Fitzroy Water Supply Scheme

Figure 1-13 Diagram of the Lower Fitzroy Water Supply Scheme



The Lower Fitzroy *Water Supply Scheme* (Figure 1-13) comprises Eden Bann Weir on the Fitzroy River and Stanwell Pipeline. The scheme supplies the Stanwell Power Station, riparian landholders on the Fitzroy River downstream of the weir, and landholders along the Stanwell pipeline. The scheme is operated in conjunction with the Fitzroy Barrage, which is owned and operated by Rockhampton Regional Council.

Flows in the Fitzroy River are stored by Eden Bann Weir from where it is progressively released to maintain water levels in the Fitzroy Barrage from which the Stanwell Pipeline draws its supply.

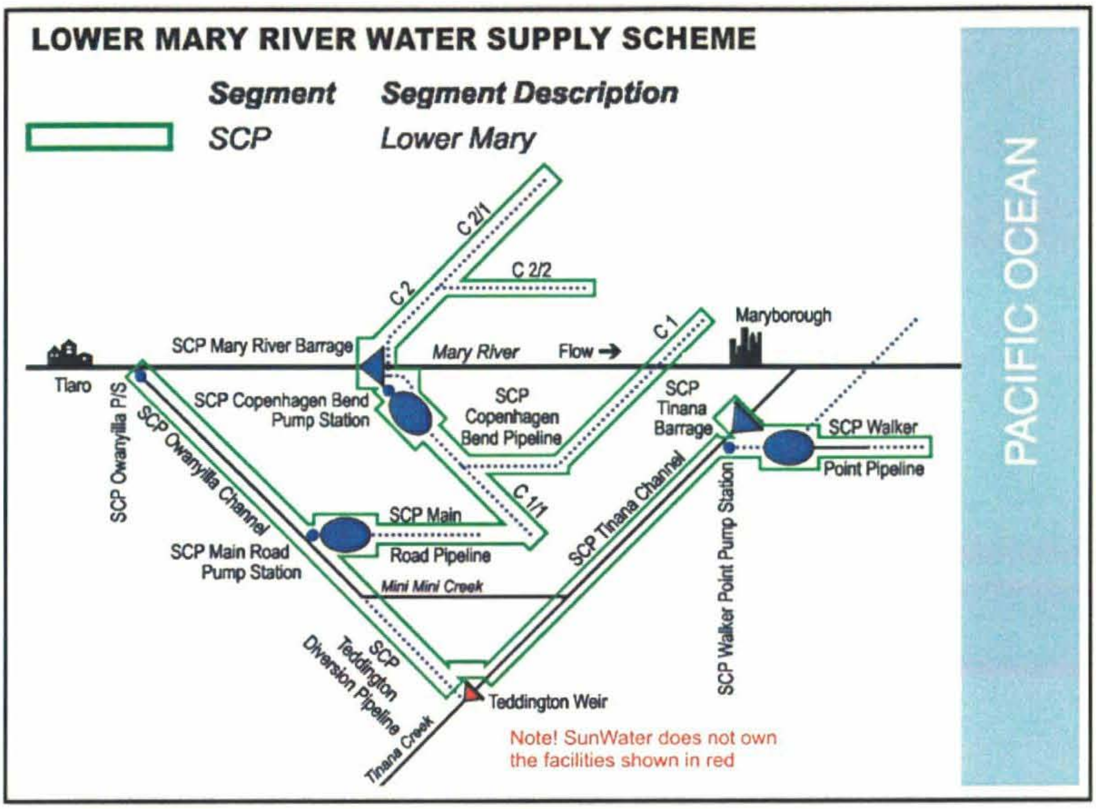
Table 1-12 Main Facilities of Lower Fitzroy Water Supply Scheme

Facility	Function	Capacity
Eden Bann Weir	Headworks for Lower Fitzroy WSS and Fitzroy Barrage	35,900 ML
Stanwell PS	Supplies Stanwell Power Station through Stanwell Pipeline	79 ML/day

There is no dam in this scheme.

1.13 Lower Mary River Water Supply Scheme

Figure 1-14 Diagram of Mary River Water Supply Scheme



The Lower Mary *Water Supply Scheme* (Figure 1-14) supplies water for irrigation, urban and industrial use around Maryborough and for irrigators. It is divided into Owanyilla, Copenhagen Bend, and Walker Point distribution systems; utilising regulated streams, pump stations, channels, and pipelines. Owanyilla and Copenhagen Bend draw from the Mary River Barrage. Walker Point draws from the Tinana Creek Barrage.

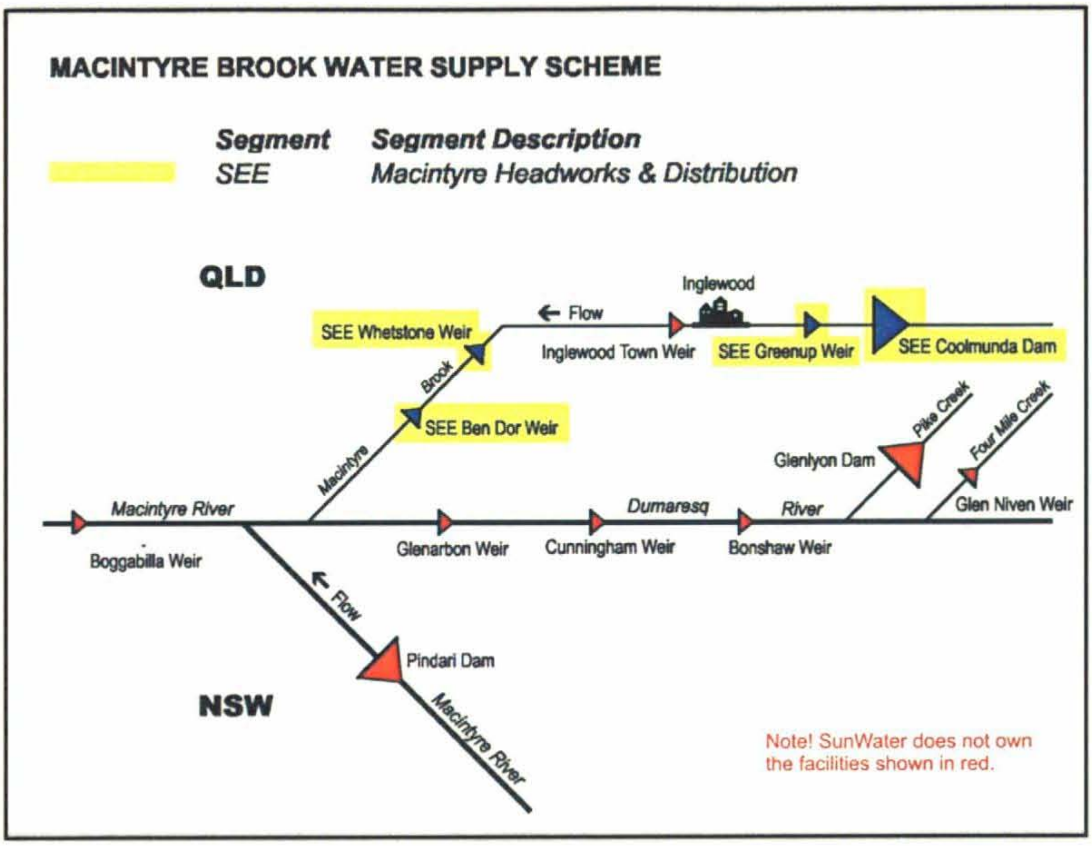
Table 1-13 Main Facilities of Mary River Water Supply Scheme

Facility	Function	Capacity
Mary Barrage	Ponds water for Mary River riparian users and Owanyilla and Copenhagen Bend PS	12,000 ML
Tinana Barrage	Storage and pumping pool for Walker Point PS	4,700 ML
Owanyilla PS	Pumps from Mary River Barrage into Owanyilla Channel	230 ML/day
Main Road PS	Supplies Main Roads Pipeline in Lower Mary System	70 ML/day
Copenhagen Bend PS	Pumps from Mary River barrage into Copenhagen Bend Balancing Storage	65 ML/day
Walker Point PS	Pumps into Walker Point Balancing Storage	81 ML/day

There is no dam in this scheme.

1.14 Macintyre Brook Water Supply Scheme

Figure 1-15 Diagram of Macintyre Brook Water Supply Scheme



Macintyre Brook *Water Supply Scheme* (Figure 1-15) is centred on Coolmunda Dam east of Inglewood. The dam provides raw water for irrigators along the lower reaches of Macintyre Brook and for the Inglewood Town and bulk water for the Dumaresq River Irrigation Project.

Water is progressively released from Coolmunda Dam to Greenup Weir, Whetstone, Inglewood Town, and Ben Dor Weirs to the junction with the Dumaresq River near the Town of Yelarbon. Customers pump directly from the regulated sections of Macintyre Brook. SunWater does not own the Inglewood Town Weir

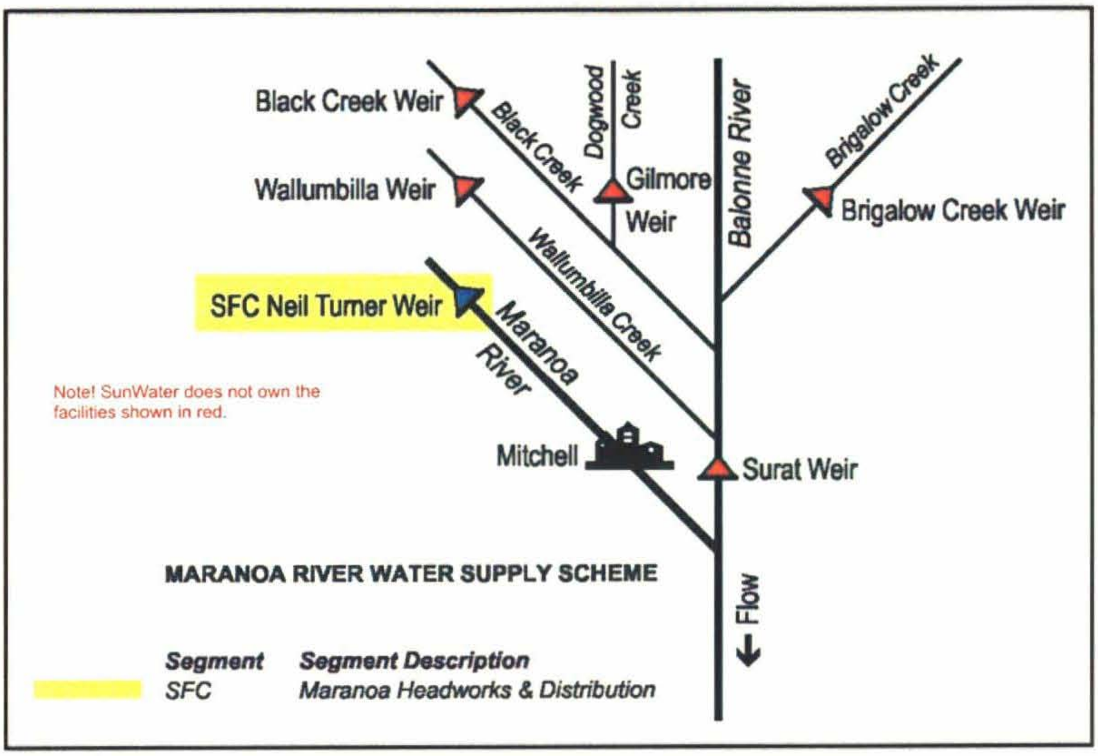
Table 1-14 Main Facilities of Macintyre Brook Water Supply Scheme

Facility	Function	Capacity
Coolmunda Dam	Headworks for Macintyre Brook Water Supply Scheme	69,000 ML
Greenup Weir[66]	Ponds water in MacIntyre River for riparian users	370 ML
Whetstone Weir	Ponds water in MacIntyre River for riparian users	506 ML
Ben Dor Weir	Ponds water in MacIntyre River for riparian users	734 ML

[66] Greenup Weir is an old timber piled structure that is not essential for the effective operation of the scheme. It will not be refurbished or replaced

1.15 Maranoa River Water Supply Scheme

Figure 1-16 Diagram of Maranoa River Water Supply Scheme



The Maranoa River *Water Supply Scheme* (Figure 1-16) centres on Neil Turner Weir near Mitchell in South Western Queensland. It was designed to provide water for the Town of Mitchell and for irrigators.

Table 1-15 Main Facilities of Maranoa River Water Supply Scheme

Facility	Function	Capacity
Neil Turner Weir[67]	Headworks for Maranoa River Water Supply Scheme	1,110 ML

There is no dam in this scheme.

1.16 Mareeba Dimbulah Water Supply Scheme

The Mareeba Dimbulah *Water Supply Scheme* (Figure 1-17) comprises Tinaroo Falls Dam, a number of regulating weirs on the Barron and Walsh river systems and a network of channels and pipelines delivering water for irrigation, urban and industrial use. The dam's outlet is channelled through a SunWater owned and operated hydro power station, which helps to offset the scheme's electricity use and reduce SunWater's carbon foot print.

The scheme is predominately a gravity supply scheme, but also includes five small pump stations. Five balancing storages – Nardello's Lagoon, East Barron, Arriga, Biboohra, and Jabiru Lagoon – regulate the daily variances between supply and demand along the channel system.

[67] Neil Turner Weir used to hold 1960 ML, but is slowly sanding up

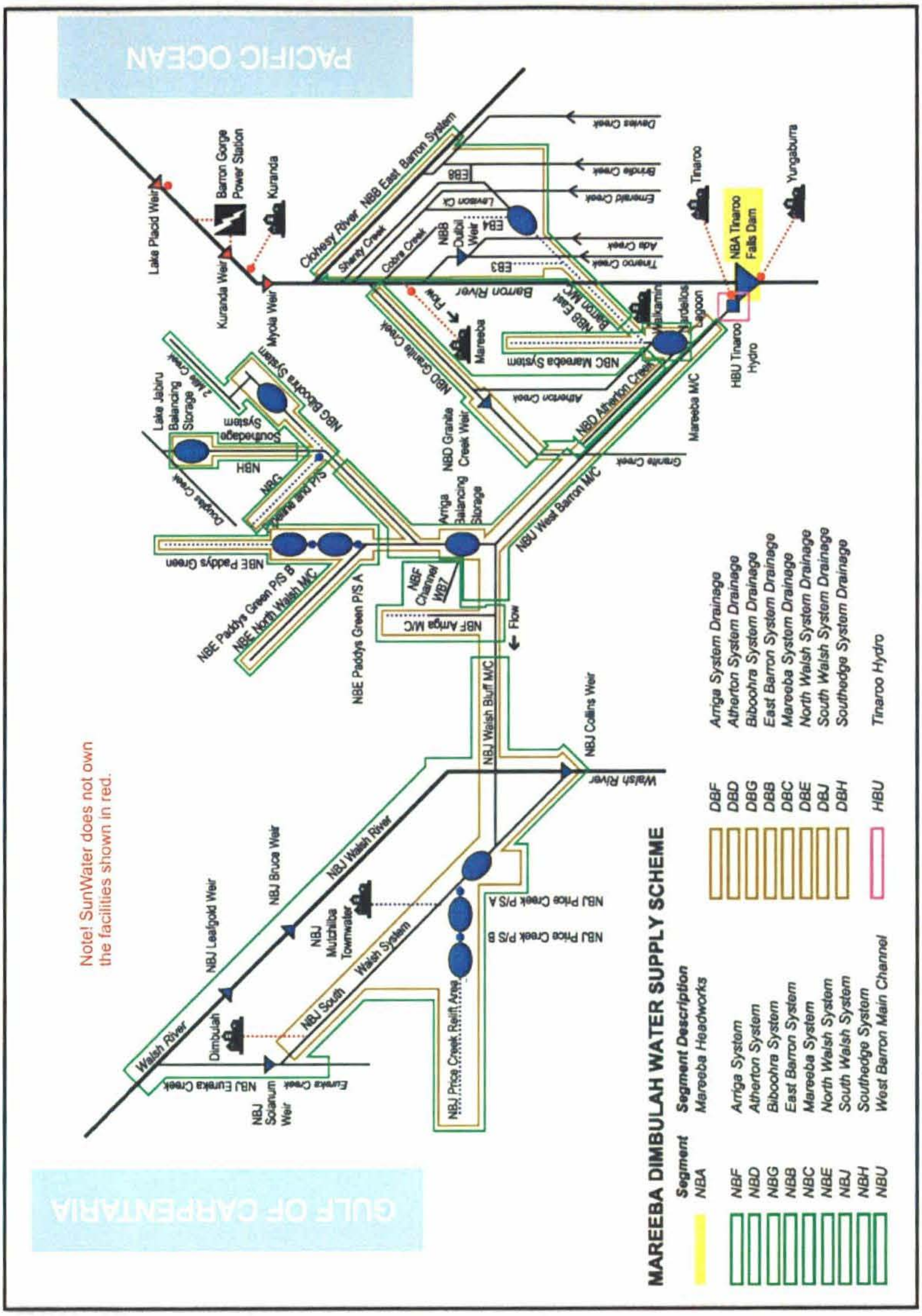
Tinaroo Falls Dam regulates flow along the Barron River downstream to Kuranda to supply water for irrigation, urban and hydro power generation. The channel system also supplements *watercourses* throughout the area to provide irrigation supplies to riparian landholders.

The scheme includes drains to capture run-off from irrigated land, but does not include the Kuranda, Dulbil, and Granite Creek Weirs.

Table 1-16 Main Facilities of Mareeba Dimbulah Water Supply Scheme

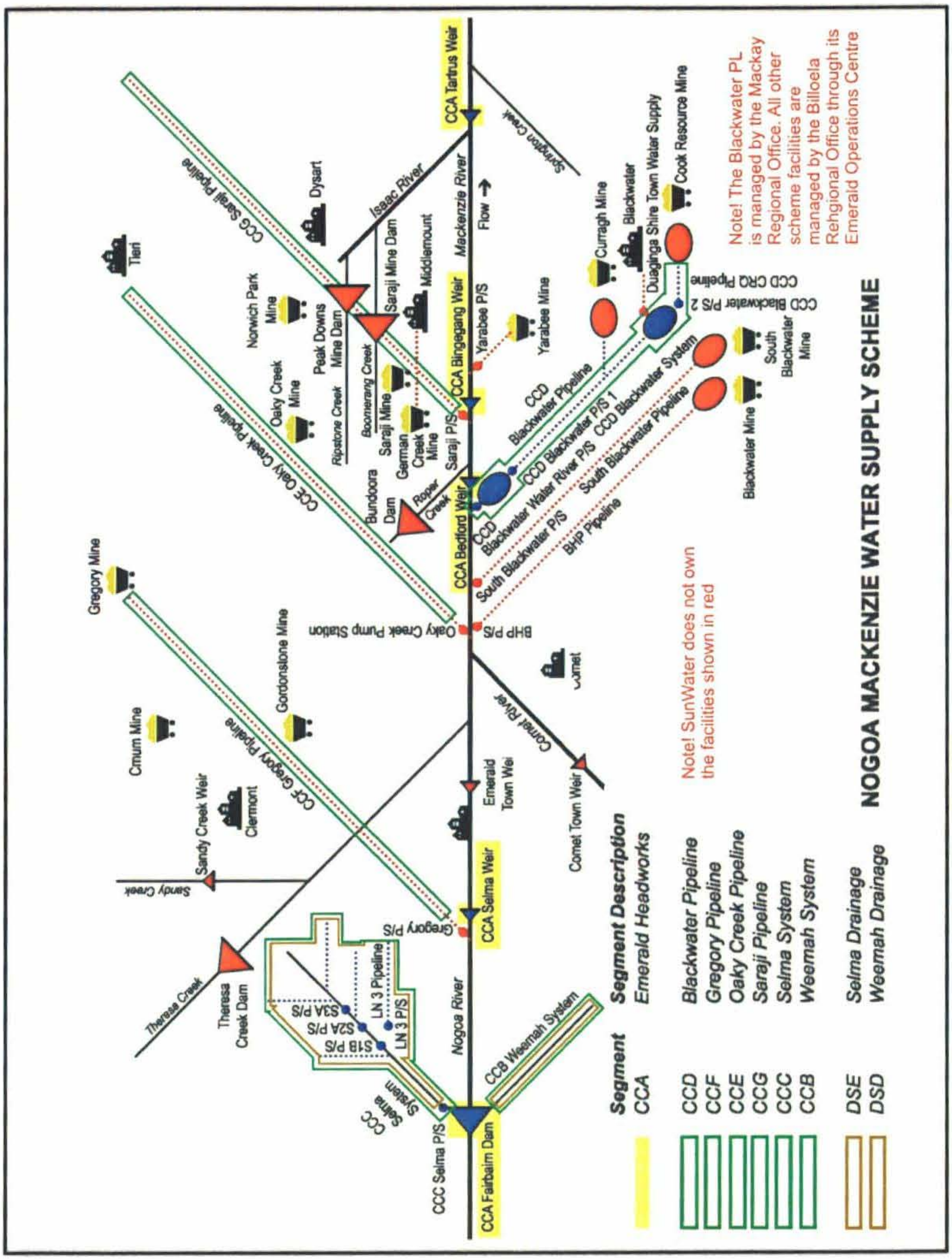
Facility	Function	Capacity
Tinaroo Falls Dam	Headworks for Mareeba Dimbullah Water Supply Scheme	438,920 ML
Collins Weir	Supplies South Walsh System from Walsh River	600 ML
Bruce Weir	Supplies South Walsh System from Walsh River	970 ML
Leafgold Weir	Supplies South Walsh System from Walsh River	260 ML
Solanum Weir	Supplies South Walsh System from Eureka Creek	68 ML
Granite Creek Weir	Ponds water in Granite Creek	244 ML
Dulbil Weir	Ponds water in Tinaroo and Ada Creek	270 ML
Price Creek PS A	Supplies Price Creek Relift in South Walsh System	34 ML/day
Price Creek PS B	Supplies Price Creek Relift in South Walsh System	24 ML/day
Paddys Green PS A	Supplies Paddys Green Relift in North Walsh System	58 ML/day
Paddys Green PS B	Supplies Paddys Green Relift in North Walsh System	44 ML/day
Biboohra PS	Supplies Biboohra System	5 ML/day

Figure 1-17 Diagram of the Mareeba Dimbulah Water Supply System



1.17 Nogoa Mackenzie Water Supply Scheme

Figure 1-18 Diagram of Nogoa Mackenzie Water Supply Scheme



Fairbairn Dam – located approximately 18 km south of Emerald – is the main source of supply for the Nogoa Mackenzie *Water Supply Scheme*. The dam is operated in conjunction with Selma, Bedford, Bingegang and Tartrus Weirs to regulate supplies along the Mackenzie

River and downstream to the Springton Creek junction. The dam also releases into the Selma and Weemah channel systems to supply irrigators.

The scheme is also the source of supply for six industrial water supply pipelines serving the Central Queensland coalfields area. Only one of these, the Blackwater Pipeline is owned by SunWater.

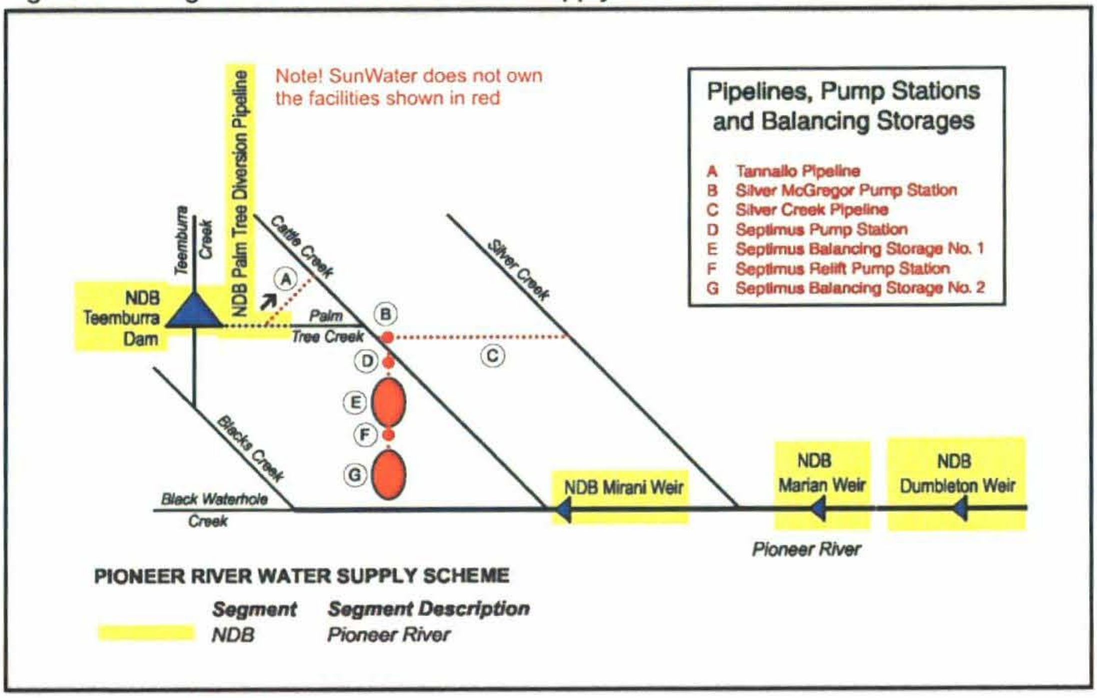
A system of drains in the Selma and Weemah distribution systems intercept overland runoff.

Table 1-17 Main Facilities of Nogoa Mackenzie Water Supply Scheme

Facility	Function	Capacity
Fairbairn Dam	Headworks for Nogoa Mackenzie Water Supply Scheme	1,301,130 ML
Selma Weir	Nogoa River riparian users + pump pool for Gregory Pipeline	1,180 ML
Bedford Weir	Mackenzie River riparian users + pump pool for Oakey Creek, BHP, South Blackwater and Blackwater Pipelines	22,980 ML
Bingegang Weir	Mackenzie River riparian users + pump pool for Seraji Pipeline	8,060 ML
Tartrus Weir	Mackenzie River riparian users + pump pool for Yarabee Pipeline	12,000 ML
Selma PS	Pumps from Fairbairn Dam when dam level is low	770 ML/day
Blackwater River PS	Pumps from Mackenzie River into Blackwater BS storage	56 ML/day
Blackwater PS 1	Relift for Blackwater pipeline	32 ML/day
Blackwater PS 2	Pumps water to mine sites	14 ML/day

1.18 Pioneer River Water Supply Scheme

Figure 1-19 Diagram of Pioneer River Water Supply Scheme



The Pioneer *Water Supply Scheme* (Figure 1-19) supplies water for urban and industrial use around Mackay and irrigation water for rural users. Mirani, Marian, and Dumbleton Weirs regulate flows along the Pioneer River, supplemented by releases from Teemburra Dam. The dam also supplies the Pioneer Valley Water Board via Palm Tree Creek Pipeline.

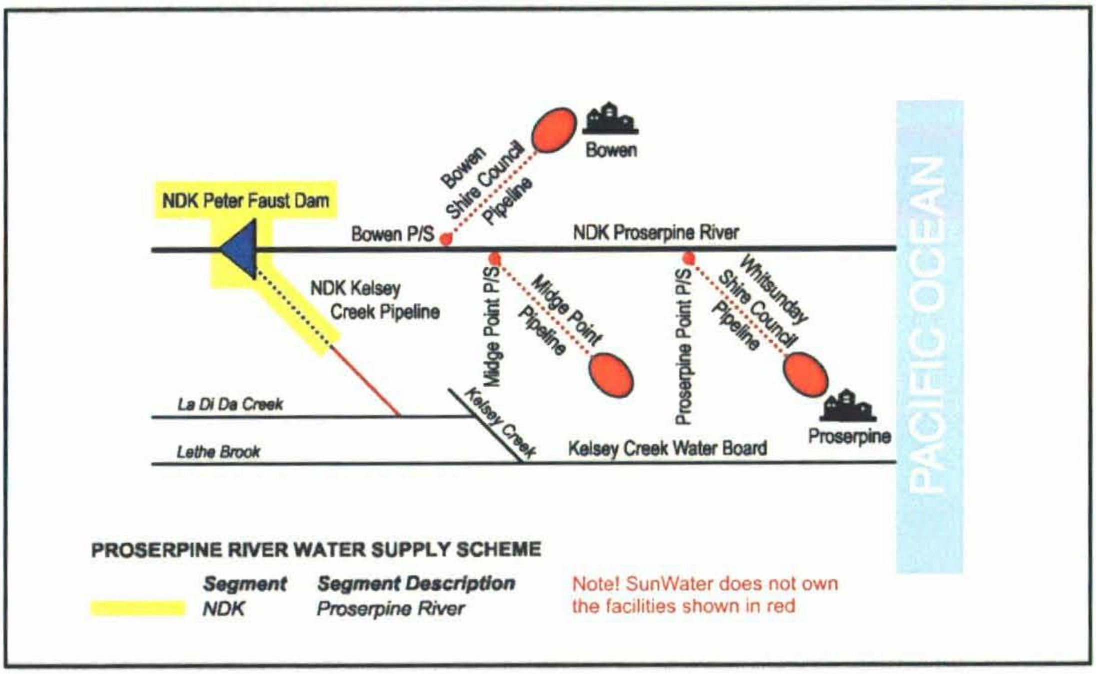
The Eton *Water Supply Scheme* is supplied from Mirani Weir.

Table 1-18 Main Facilities of Pioneer River Water Supply Scheme

Facility	Function	Capacity
Teemburra Dam	Headworks for Pioneer River Water Supply Scheme	147,500 ML
Mirani Weir	Ponds water for riparian landholders, urban and industrial	4,600 ML
Marian Weir	Ponds water for riparian landholders, urban and industrial	3,900 ML
Dumbleton Weir	Ponds water for riparian landholders, urban and industrial	8,700 ML

1.19 Proserpine River Water Supply Scheme

Figure 1-20 Diagram of Proserpine Water Supply Scheme



The Proserpine *Water Supply Scheme* comprises Peter Faust Dam which regulates flows along the Proserpine River for urban and irrigation use. The dam also provides passive flood mitigation benefits for the Town of Proserpine.

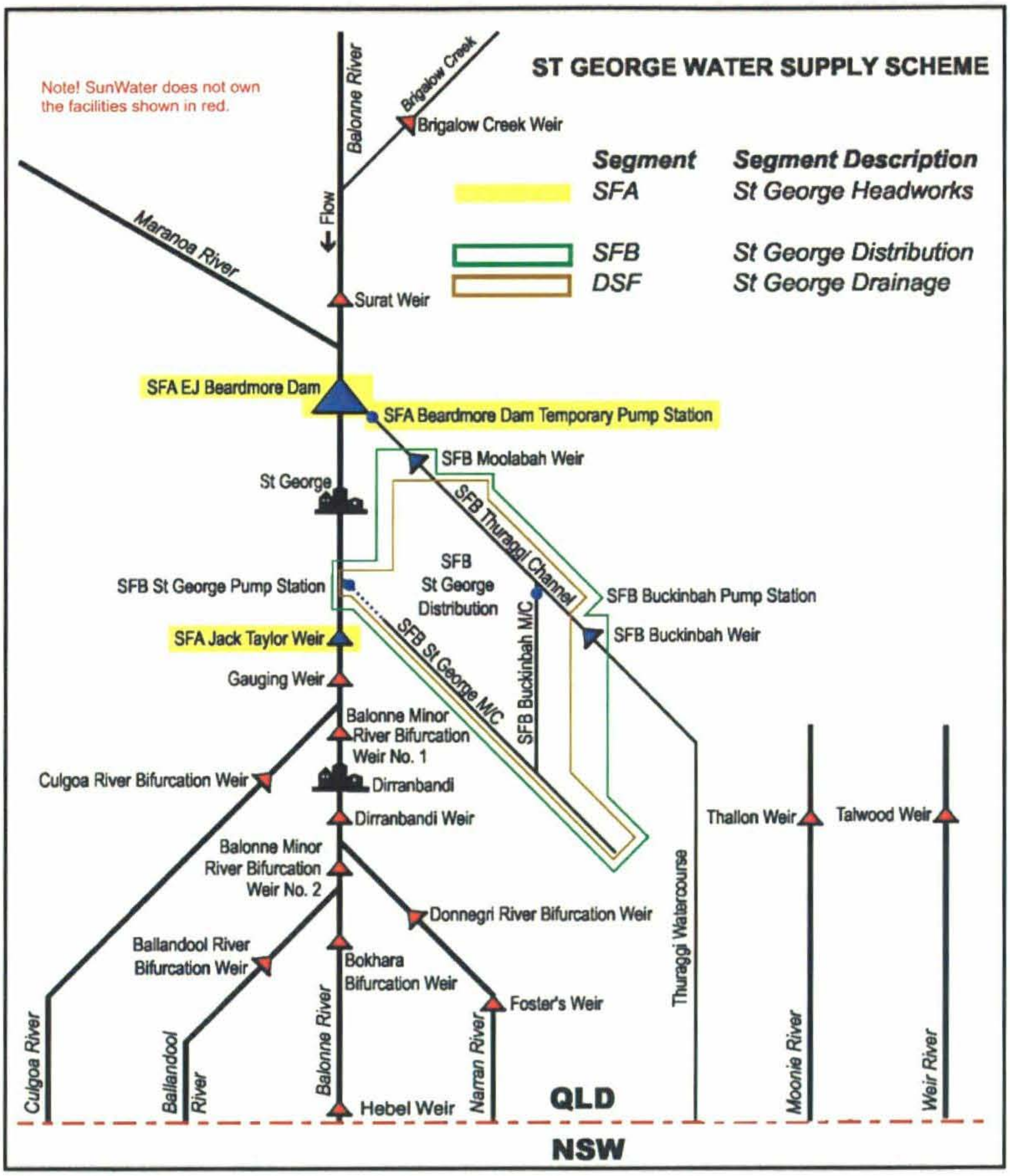
The Peter Faust Dam has two outlets; one for Proserpine River, the other for Kelsey Creek Pipeline which serves the Kelsey Creek Water Board.

Table 1-19 Main Facilities of Proserpine River Water Supply Scheme

Facility	Function	Capacity
Peter Faust Dam	Headworks for Proserpine River Water Supply Scheme	491,400 ML

1.20 St George Water Supply Scheme

Figure 1-21 Diagram of St George Water Supply Scheme



Beardmore Dam north of St George and the Jack Taylor Weir at St George are the main sources of supply for the St George *Water Supply Scheme* (Figure 1-21).

The Buckinbah section of the scheme is supplied from Beardmore Dam via the Thuraggi Channel, Moolabah and Buckinbah Weirs, while the St George section of the scheme is supplied through St George Pump Station just upstream of the Jack Taylor Weir.

The scheme also regulates water along the Balonne River for 175 kilometres.

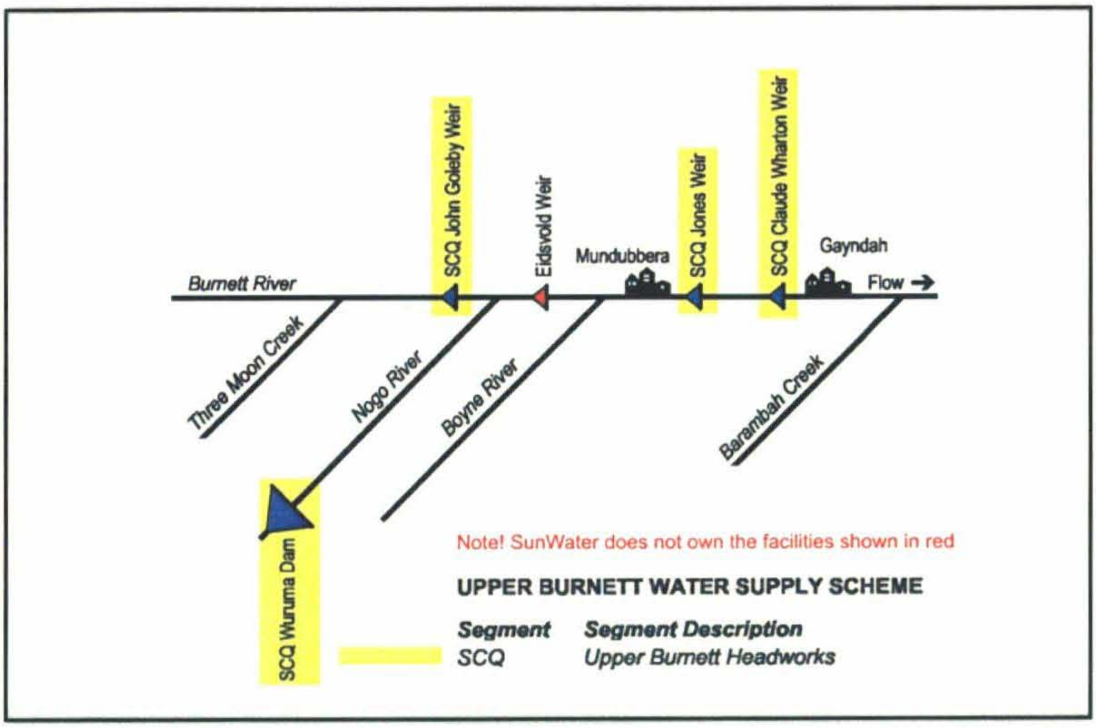
A system of drains provides drainage services for irrigators in the *Water Supply Scheme*.

Table 1-20 Main Facilities of St George Water Supply Water Supply Scheme

Facility	Function	Capacity
Beardmore Dam	Headworks for St George Water Supply Scheme	81700 ML
Jack Taylor Weir	Ponds water for irrigators and St George PS	10,100 ML
Moolabah Weir	Ponds water for irrigators and St George irrigators	2,580 ML
Buckinbah Weir	Ponds water for irrigators and St George Irrigators	5,120 ML
St George PS	Pumps from Balonne River into St George main Channel	110 ML/d
Buckinbah PS	Pumps from Thuraggi Channel into Buckinbah MC when levels are low	490 ML/d
Beardmore Dam Low Level PS	Pumps from Beardmore Dam into Thuraggi Channel when dam levels are low	440 ML/d

1.21 Upper Burnett Water Supply Scheme

Figure 1-22 Diagram of Upper Burnett Water Supply Scheme



The Upper Burnett *Water Supply Scheme* (Figure 1-22) supplies irrigators and raw water for the town water supplies of Mundubbera, Eidsvold, and Gayndah. The main source of supply is Wuruma Dam on the Nogo River, which regulates supplies along the Nogo and Burnett Rivers, in conjunction with John Goleby, Kirar, Jones and Claude Wharton Weirs. Kirar Weir is owned by Burnett Water.

Table 1-21 Main Facilities of Upper Burnett Water Supply Scheme

Facility	Function	Capacity
Wuruma Dam	Headworks for Upper Burnett Water Supply Scheme	165,400 ML

Kirar Weir	Pump pool for irrigators along Burnett River	9,540 ML
John Goleby Weir	Pump pool for irrigators along Burnett River	1,600 ML
Jones Weir	Pump pool for irrigators along Burnett River and Mundubbera	3,700 ML
Claude Wharton Weir	Pump pool for irrigators along Burnett River and for Gayndah	12,800 ML

1.22 Upper Condamine Water Supply Scheme

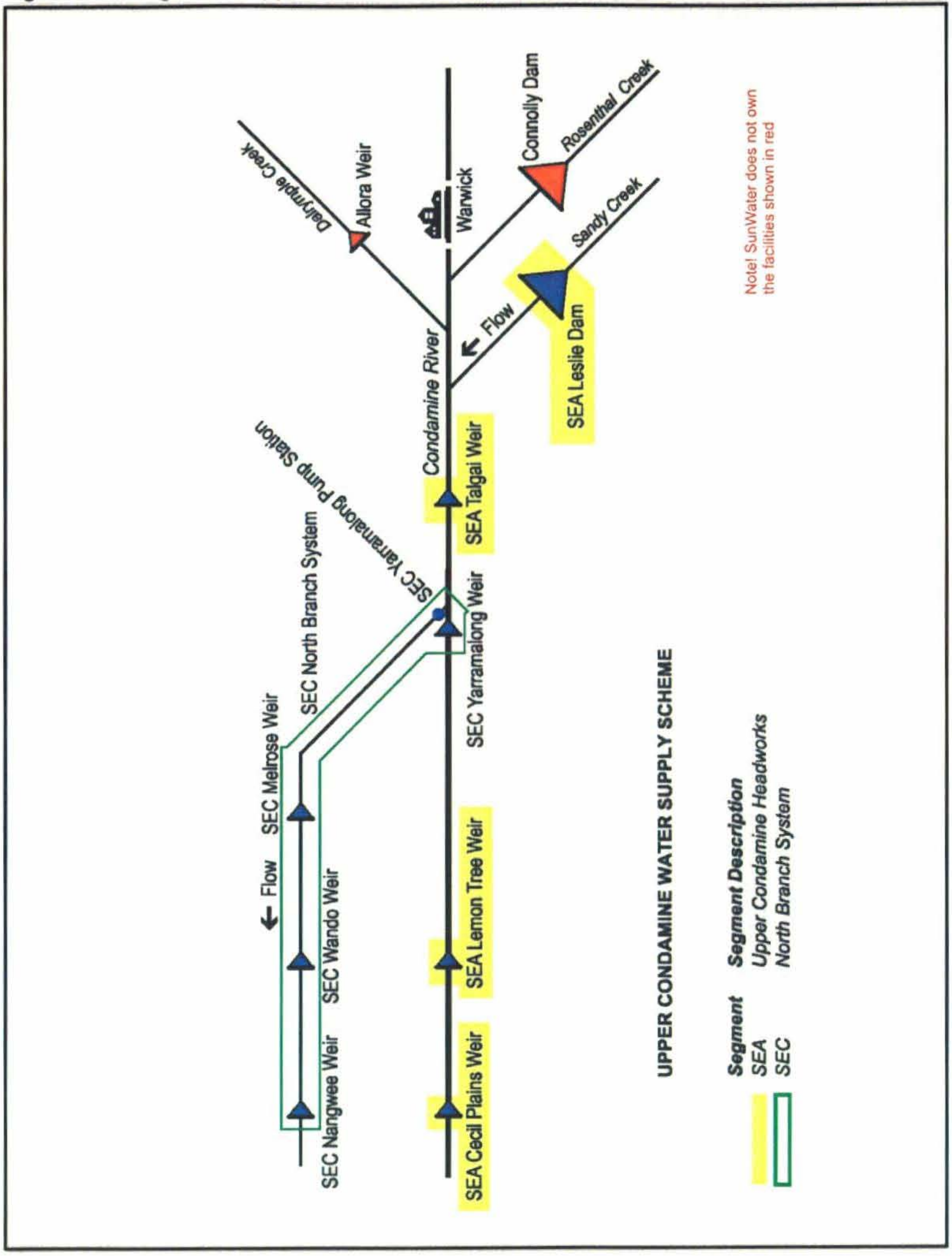
The Upper Condamine *Water Supply Scheme* (Table 1-22) centres on Leslie Dam and a regulated section of the Condamine River near the Town of Pittsworth approximately 80 km southwest of Toowoomba. It supplies water for irrigation, and supplements the town water supplies of Warwick and Cecil Plains.

Water released from Leslie dam flows down from Sandy Creek into the Condamine River to Talgai, Yarramalong, and Lemon Tree Weirs down to Cecil Plains Weir. The ponded area at Yarramalong Weir is used as a pump pool for diverting water to the North Branch controlled by the Melrose, Wando, and Nangwee Weirs.

Table 1-22 Main Facilities of Upper Condamine Water Supply Scheme

Facility	Function	Capacity
Leslie Dam	Headworks for Upper Condamine Water Supply Scheme	106,200 ML
Talgai Weir	Supplies Condamine River riparian landholders	640 ML
Yarramalong Weir	As above + pump pool for Yarramalong Pump Station	390 ML
Lemon Tree Weir	Supplies Condamine River riparian landholders and irrigators	300 ML
Cecil Plans Weir	Supplies Condamine River riparian landholders and irrigators	700 ML
Melrose Weir	Supplies irrigators in North Branch System	160 ML
Wando Weir	Supplies irrigators in North Branch System	310 ML
Nangwee Weir	Supplies irrigators in North Branch System	80 ML
Yarramalong PS	Pumps from Yarramalong Weir into North Branch System	346 ML/d

Figure 1-23 Diagram of Upper Condamine Water Supply Scheme



Schedule 2: Burdekin Falls Dam

2.1 Burdekin Falls

Burdekin Falls dam has been spilling continuously since the beginning of the 2010-11 wet season. However the flows have remained at minor68 or below minor level throughout.

2.1.1 Overview

The Burdekin River is one of the largest rivers in Queensland with a length of 731.4 km and a catchment area of approximately 13 million hectares, equating to nearly 7% of the entire area of the state (Refer figure 2-1)69.

Burdekin Falls Dam is a major asset in the Burdekin Haughton Water Supply Scheme's delivery infrastructure. The dam, combining with a series of weirs down the Burdekin River, supplies the scheme with the water needed for the water supply scheme.

Burdekin Falls Dam is situated at Adopted Middle Thread Distance (AMTD) 159.3 km on the Burdekin River, approximately 210 km by road SSW of Townsville. The dam has a catchment of 114,200 km2. The 22,400 ha lake formed by the dam is called Lake Dalrymple. The lake covers 22,400 ha starting 50 km upstream of the dam wall

The dam's design allows for the storage to be in increased to 8,500,000 ML by raising the wall to increase the FSL to 168.60 m AHD.

The CRA for Burdekin Falls Dam concludes that upgrade to the Standard-based approach ANCOLD Fallback AFC be undertaken. The proposed dam safety upgrade would involve:

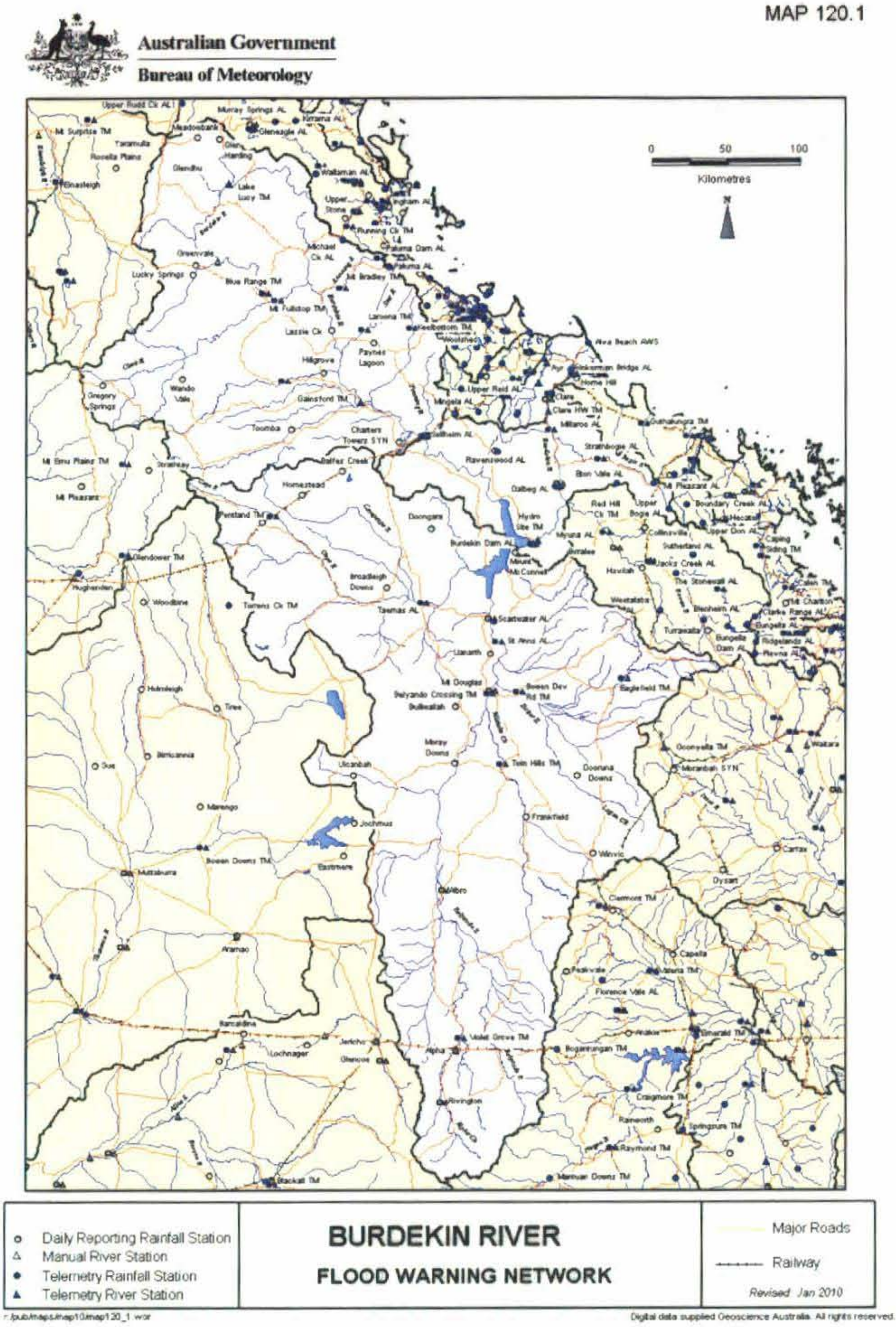
- Raising of the Left Bank and Mt Graham North and South saddle dams by 1.5m;
- Strengthening of the main dam spillway and non-overflow monoliths by installing post tensioned anchors; and
- Raising of the North Abutment Saddle Dam to maintain access during extreme flood events.

The upgrade is expected to be undertaken in two stages.

Dam	Storage Volume (ML)	Stream	Stream Distance (km)	Type	Height (m)	Surface Area at FSL (Ha)	Date Completed	Purpose	Nearest town	Significant down stream Communities
Burdekin Falls	1,860,000	Burdekin River	159.3	Mass Concrete with earth and rockfill saddle dams	40	22,000	1987	Water Supply	Ravenswood	Ayr

[68] Flood Classification levels by BOM as Minor, Moderate or Major

[69] www.bom.gov.au



2-1 Burdekin River Catchment

The management of the dam is documented in a number of regulatory dam safety documents including:

- The Burdekin Falls Dam Operations and Maintenance Manual
- Burdekin Falls Dam: Standing Operating Procedures

- Emergency Action Plan: Burdekin Falls Dam
- Burdekin Falls Dam: Data Book Part 1 – Text
- Burdekin Falls Dam: Data Book Part 2 – Drawings
- Burdekin Falls Dam: Dam Safety Review (April 2001)

In an emergency situation the procedures in the Emergency Action Plan take precedence.

Type

The dam itself is constructed of mass concrete and is nearly 876m long. The dam has central spillway that is 504m long with a crest height of EL 154.0 m AHD, providing a maximum storage volume of 1.86 million ML. Construction of the dam commenced in 1982 and was completed in 1987.

The Burdekin Falls Dam system includes three earth and rockfill saddle dams: Mt Graham South, Mt Graham North, and Left Bank.

Main Dam[70]

- Type Mass concrete
- *Full Supply Level (FSL)* 154.00 m AHD
- Storage capacity at FSL 1,860,000 ML
- Storage area at FSL 22,000 ha
- Dead storage 7,860 ML (at 124.00m AHD)
- Dam Crest Level (DCL) 169.2 m AHD
- Maximum height of the dam 57.0 m
- Crest length along axis (main embankment) 876.0 m
- Crest Width 7.0 m
- Total Quantities 650,000 m^3 concrete

Spillway

- Spillway type Central Ogee Crest ending at a flip bucket
- Spillway crest level 154.00 m AHD

[70] Burdekin Fall Dam O&M Manual

- Crest length 504 m
- Spillway design capacity 64,600 m3/s
- Spillway capacity for DCF 69,800 m3/s

Outlet Works

- Description Three Outlet Chutes with radial gates
- Radial Gate Dimensions 3.0 m x 2.0 m
- Outlet Chute Design Velocity 30.0 m/s

At FSL each of the three outlets can release 12000 ML/day (140 m3/s), but the combined release is not allowed to exceed 8640 ML/day (100 m3/s) to prevent downstream flooding and erosion.

Saddle Dams

Mt Graham North Saddle Dam

- Earth and rock fill with central clay core. Length 1,200 m. Max height 11.0 m. Crest width 10.0 m

Mt Graham South Saddle Dam

- Earth and rock fill with central clay core. Length 2,100 m. Max height 11.0 m. Crest width 10.0 m

Left Bank Saddle Dam

- Earth and rock fill with central clay core. Length 1,200m. Max Height 36.0 m. Crest width 10.0 m (Typical), 23.2 m at Headrace Channel

Purpose

The foreword of the Burdekin Basin *Resource Operations Plan* (*ROP*) notes that:

> *The provisions in this plan incorporate a number of powerful drivers that will foster new standards of innovation and efficiency to help the community maximise the benefits it derives from these vital resources. Foremost of these is the conversion of more than 800 entitlements to tradeable water allocations.*
>
> *In addition, the plan sets out rules that will guide supplemented water management in the two water supply schemes, flow access rules and volumetric limits for unsupplemented water, and how water allocations can be traded and changed in other ways.*

The plan also implements strategies to support a range of ecological outcomes and the water and ecosystem monitoring requirements that will be used to assess the effectiveness of the implemented water resource plan.

The purpose of the Burdekin Falls Dam is to supply water for irrigation and for rural, urban, and industrial water supplies. In 2009-10, 543,000ML was supplied to agricultural users, Water Boards, and towns.

The operational objectives [71]of the Burdekin Falls Dam are as follows:

- The Burdekin Falls Dam and all its associated structures, facilities, and spaces shall be operated and monitored in accordance with
    - a) Burdekin Falls Dam Operations and Maintenance Manual;
    - b) SunWater policies and approved practices;
    - c) Burdekin Basin *Resource Operations Plan*; and
    - d) Sound engineering and water management standards and practices.
- Water releases from Burdekin Falls Dam must be scheduled to comply with
    - a) Schedule 2 of the Burdekin Haughton *Water Supply Scheme Interim Resource Operations Licence* (November 2000);
    - b) SunWater's Customer Charter; and
    - c) All applicable supply agreements and licences.

The Burdekin Falls Dam Operations and Maintenance Manual notes that the dam also provides a level of flood attenuation to the Burdekin River flood plains. The presence of the dam reduces the severity and incidence of low-level flooding.

2.1.2 Implementation of System Operations Plans for 2010-11 Wet Season

2.1.1.1 Pre-wet season EAP reviews/training

The EAP was reviewed as part of annual inspection June 2010

The notification and emergency communication list (EAP section 3) was revised and reissued in November 2010.

A supplementary notice for Issue 2 of the EAP was issued in October 2010 by the Principal Engineer Dam Safety.

[71] Burdekin Falls Dam O&M Manual

2.1.1.2 Emergency Preparedness/Actions/Redundancy/ back up systems

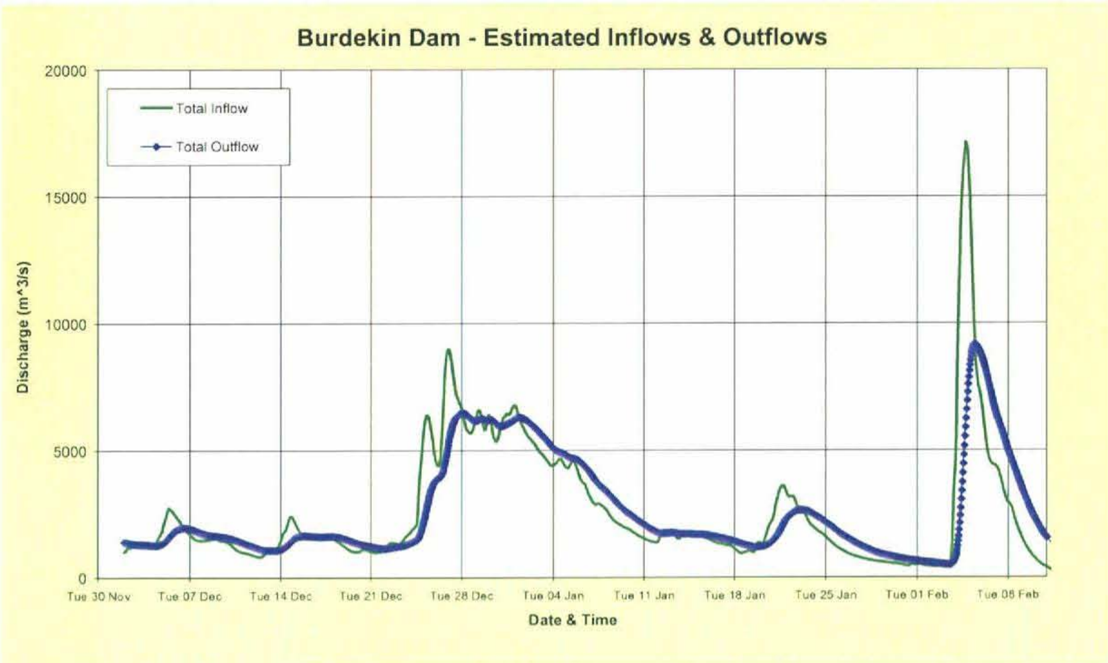
The EAP was first activated on 6th October 2010 and remains active to after the end of February 2011. The landholders identified in the EAP were also notified on 6th October 2010.

The dam is equipped with a 325kVA standby diesel alternator to enable the operations at the dam to continue in the event of failure of mains power. The alternator is tested on a monthly basis

2.1.3 Outline of flood event 2010/2011

The Burdekin Falls dam has been over 100% of capacity for several months. Figure 2-2 outlines the recorded inflows and *outflows* from the dam for the period 1 December 2010 to 7 February 2011 inclusive. The highest peak occurred in early February following cyclone Yasi. The plot in figure 2-2 demonstrates how a dam behaves during different events. The February event was a short duration event. The dam significantly attenuated this event. This is in contrast with the December-January event which was a longer duration. The amount of attenuation of this event was smaller.

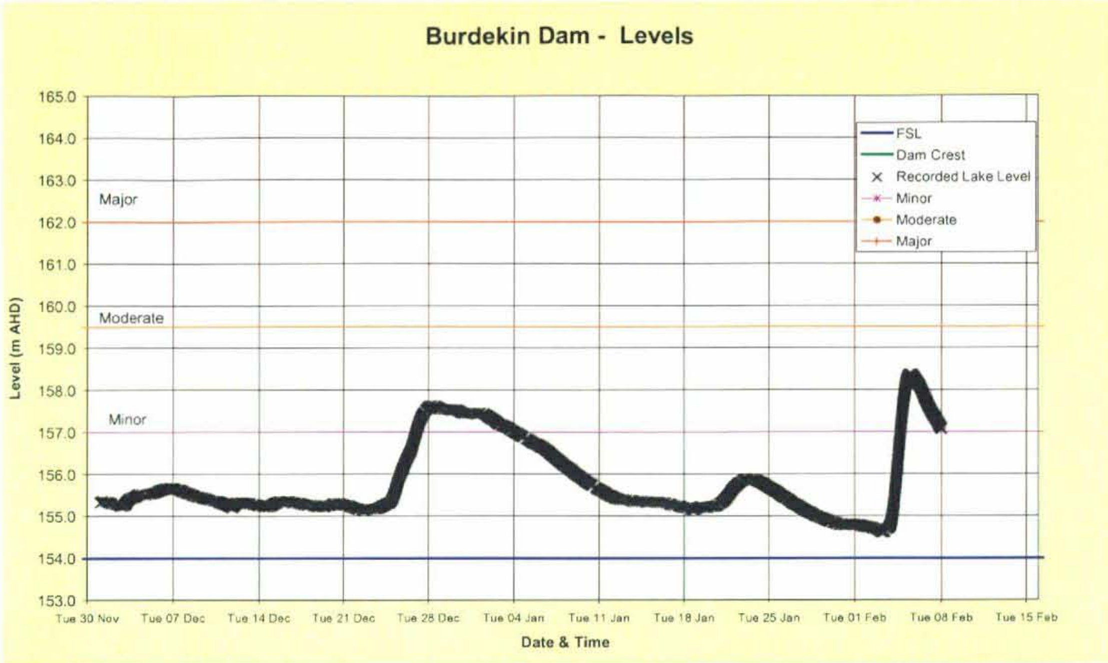
The total inflow into the dam over the period 1 December 2010 to 7 February 2011 was 15,682,000ML or 8.4 times the full storage volume of the dam.



2-2 Burdekin Falls Dam Inflow and Outflow (Dec 2010 - Feb 2011)

Figure 2-3 plots the recorded storage level of the dam for the period 1 December 2010 to 7 February 2011 inclusive. The plot also shows the *flood classification* levels[72]. Both the December-January and February events were reported as minor[73] floods.

[72] www.bom.gov.au



2-3 Burdekin Falls Dam recorded flood levels

2.1.4 Communities that were affected

No downstream communities were significantly affected by flooding.

2.1.5 Damage and response to damage

There has been no reported damage to Burdekin Falls dam following the flood events.

2.1.6 Gauging stations – effect on data collection

Figure 2-1 shows the location of gauging stations. The key stations remained available through the BOM web page throughout the event. This data was used for predictive flood modelling.

2.1.7 Community inquiries

Although SunWater did receive a small number of inquiries from the public concerning Burdekin Falls dam, those inquiries did not relate to the safety of the dam or downstream flooding impacts. The inquiries received related to recreation facilities and conditions or road conditions.

2.1.8 Media Coverage

An article was published in The Advocate, "Dam policy questioned" on 7 January 2011. The article reported that the management of the dam's water resources had been questioned as the Burdekin Falls Dam was at 100% capacity. SunWater had responded that earlier releases would not have eased water levels and that the dam had operated in accordance with the Resource Operation Plan. SunWater further stated that the dam had been spilling

[73] www.bom.gov.au

since October and even if it had been emptied at the beginning, it would have refilled within 3 days.

2.1.9 Previous flood events

The February event is ranked as the fifth largest flood through the dam since it was constructed.

Table 2-1 Burdekin Falls Dam Historic Floods

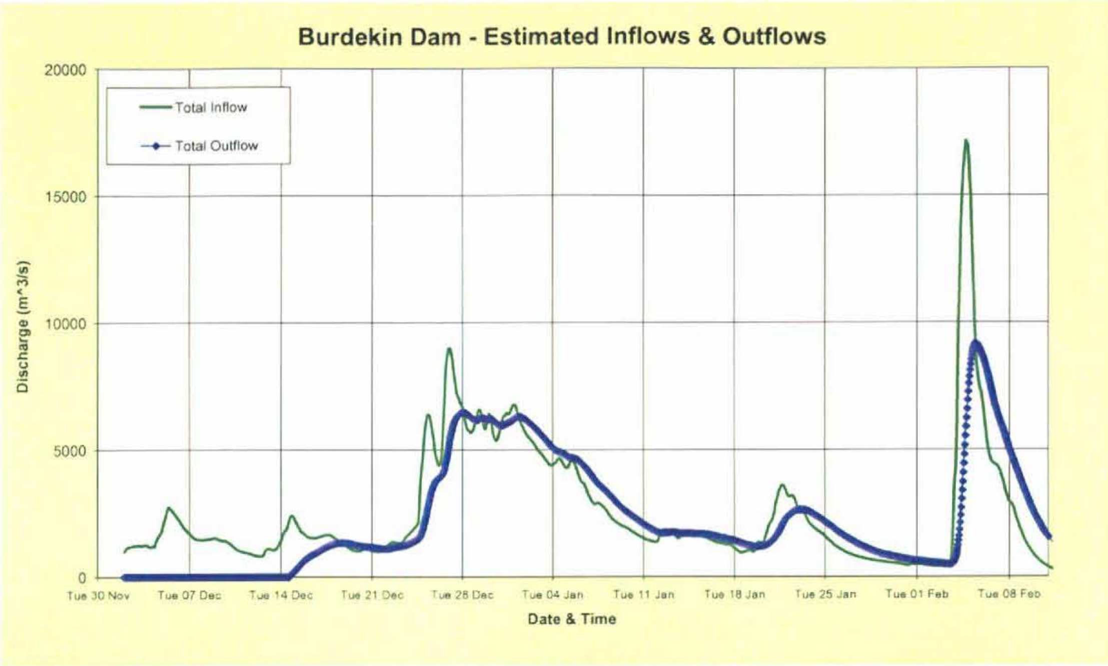
		FSL	154 m
Flood Rank	Date	Peak Height EL	Above Crest
1	Feb-91	160.85	6.85
2	Feb-09	160.73	6.73
3	Feb-08	159.05	5.05
4	Jan-98	158.867	4.87
5	Feb-11	158.37	4.37
6	Feb-07	157.73	3.73
7	Feb-02	157.64	3.64
8	Mar-97	157.59	3.59
9	Feb-00	157.563	3.56
10	Jan-01	157.32	3.32
2010-11 Flood			
5	Feb-11	158.37	4.37

2.1.10 Flood mitigation opportunities/ upgrade or communities potentially affected

The maximum release rate from the dam is limited to $100m^3/s$[74]. At this rate it would take several months to significantly lower the storage notwithstanding any regulatory restrictions on such a release.

SunWater's predictive flood model for Burdekin Falls Dam has been used to evaluate how the dam, in the current configuration, might operate to mitigate flood events. There is no flood mitigation storage in Burdekin Falls dam. The only air space would be if the dam was below the *full supply level* prior to an event. The maximum benefit would be if the dam was empty at the beginning of the wet season. Figure 2-4 shows the hypothetical scenario of the actual inflows from 1 December 2010 into an empty dam as at 1 December. If compared with figure 2-2 it is noted that there is no difference from about 20 December onwards. There would be no flood mitigation benefit in modifying the outlet works and/or amending the operating rules.

[74] Burdekin Falls Dam O&M Manual



2-4 BFD Simulated Behaviour if empty on 1 December

Schedule 3: Fred Haigh Dam

3.1 Fred Haigh

3.1.1 Overview

Fred Haigh Dam is situated on the Kolan River at AMTD 76.4 km, approximately 30kms north of Gin Gin. The purpose of the dam is to supply irrigation water for agricultural purposes in the Bundaberg Water Supply Scheme as well as water for urban and industrial development in the region. Construction of the dam was completed in 1974. Fred Haigh Dam is owned and operated by SunWater. The dam has a storage of 562,045ML and a catchment area of 1,308 km^2.

The 2005 Comprehensive Risk Assessment Report of Fred Haigh Dam recommended immediate Stage 1 upgrade of the dam spillway capacity to 50% of PMPDF[75] in order to satisfy the ANCOLD Limit of Tolerability for Societal and Individual Risk. The Stage 1 upgrade construction was completed in 2006 with the addition of a 2.02m high reinforced concrete wave wall along the downstream edge of the embankment crest and a similar increase of the upstream spillway training walls. A further upgrade will be required to satisfy AFC requirements. The final upgrade will entail the installation of filters on the saddle dam. This final upgrade has not yet been scheduled but is likely to occur around 2018-2019.

	Dam	Storage Volume (ML)	Failure Impact Rating	Stream	Stream Distance (km)	Type	Surface Area at FSL (Ha)	Date Completed	Purpose	Nearest town	Significant down stream Communities
3	Fred Haigh	562,000	2	Kolan River	76.4	Earth and Rockfill	5,345	1975	Water Supply	Gin Gin	

[75] PMPDF – Probable Maximum Precipitation Design Flood.

Figure 3-1 Kolan River Catchment

The management of the dam is documented in a number of regulatory dam safety documents including:

- The Fred Haigh Dam Operations and Maintenance Manual
- Fred Haigh Dam: Standing Operating Procedures
- Fred Haigh Dam: Operation & Maintenance Manual
- Emergency Action Plan: Fred Haigh Dam

- Fred Haigh Dam: Data Book Part 1 - Text
- Fred Haigh Dam: Data Book Part 2 – Drawings
- Fred Haigh Dam: Dam Safety Review (June 2001)

In an emergency situation the procedures in the Emergency Action Plan take precedence.

3.1.1.1 Type

Fred Haigh Dam is an earth and rock fill embankment dam with an 11m high Earth fill saddle dam and a 47m wide spillway. The spillway is an uncontrolled ogee crest tapering into a concrete chute and flip bucket dissipater. The dam is 592m long and has a storage capacity of 562,000 ML. The dam was designed and constructed by the Queensland Water Resources Commission and construction was completed in 1974.

Table 3-1 Overview of Fred Haigh Dam Details

Overview[76]

Dam Name	Fred Haigh Dam
Nearest Town	Gin Gin
Stream and AMTD	Kolan River 76.4m
Catchment Area	1,308 km^2
Construction Period	1971-1974

Main Dam

Type	Central core earth and rock fill
Full Supply Level (FSL)	75.56 m AHD
Storage capacity at (FSL)	562,045 ML
Reservoir surface area at FSL.	5,345 ha
Dam Crest Level (DCL)	84.09 m AHD
Maximum height of the dam	52 m from lowest level
Crest length	445.8 m
Submerged surface area at FSL	9,292 ha

Spillway

Spillway type	Uncontrolled Ogee Crest with flip bucket
Spillway crest level	75.56 m AHD
Crest length	47.2 m
Spillway capacity for DCF	2,464 m^3/s

[76] FredHaigh Dam O&M Manual Table 1-1

Saddle Dam

Type	Zoned Earth and Rock fill
Crest Elevation	84.09 m AHD
Total Length	144 m
Total Crest Width	11 m

Outlet Works

Description of main outlet	2 x 1200 mm guard valves 2 x 762 mm cone valves 1 x 300 Cone valve
River outlet works capacity	4.5 m^3/s

3.1.1.2 Purpose

The foreword of the Burnett Basin Resource Operations Plan (ROP) notes that:

> *The WRP and the ROP are complementary parts of a water planning process that will ensure that the basin's rivers are sustainably managed. The WRP strives to strike a balance between human needs and those of the environment. The resource operations plan is concerned with the practical business of sharing and managing the basin's water resources from day to day in a way that meets the water resource plan objectives.*[77]

The purpose of the Fred Haigh Dam is to supply water for irrigation and for rural, urban, and industrial water supplies. In 2009-10 the Bundaberg water supply scheme supplied 111,000ML to agricultural users, Industry and towns

The operational objectives [78]of the Fred Haigh Dam are as follows:

1. Fred Haigh Dam and all its associated structures, facilities, and spaces shall be operated and monitored in accordance with:
   - Fred Haigh Dam Operations and Maintenance Manual;
   - SunWater policies and approved practices;
   - The Burnett Basin ROP; and
   - Good engineering and water management standards and practices.
2. Water releases from Fred Haigh Dam must be scheduled to comply with:
   - The Burnett Basin ROP
   - SunWater's Customer Charter.
   - All applicable supply agreements and licences.

[77] Burnett Basin Resource Operations Plan, Forward

[78] Fred Haigh Dam O&M Manual

3.1.2 Implementation of System Operations Plans for 2010-11 Wet Season

3.1.2.1 Pre-wet season EAP reviews/training

The EAP was reviewed as part of an annual inspection in August 2010.

The notification and emergency communication list (EAP section 3) was revised and reissued in November 2010.

A supplementary notice for Issue 2 of the EAP was issued in October 2010 by the Principal Engineer, Dam Safety.

Refresher training on EAP roles and responsibilities was provided to operators and dam duty officers prior to the wet season.

3.1.2.2 Emergency Preparedness/Actions/Redundancy/ back up systems

The EAP was first activated on 15th December 2010 and remained active until after the end of February 2011. The Fred Haigh dam EAP does not identify downstream landholders required to be notified of an event.

3.1.2.3 Outline of flood event 2010/2011

Figure 3-2 outlines the recorded inflows and outflows from the dam for the period 1 December 2010 to 7 February 2011 inclusive. The peak discharge occurred in late December.

The total inflow into the dam over the period 1 December 2010 to 7 February 2011 was 690,900ML or 1.2 times the full storage volume of the dam.

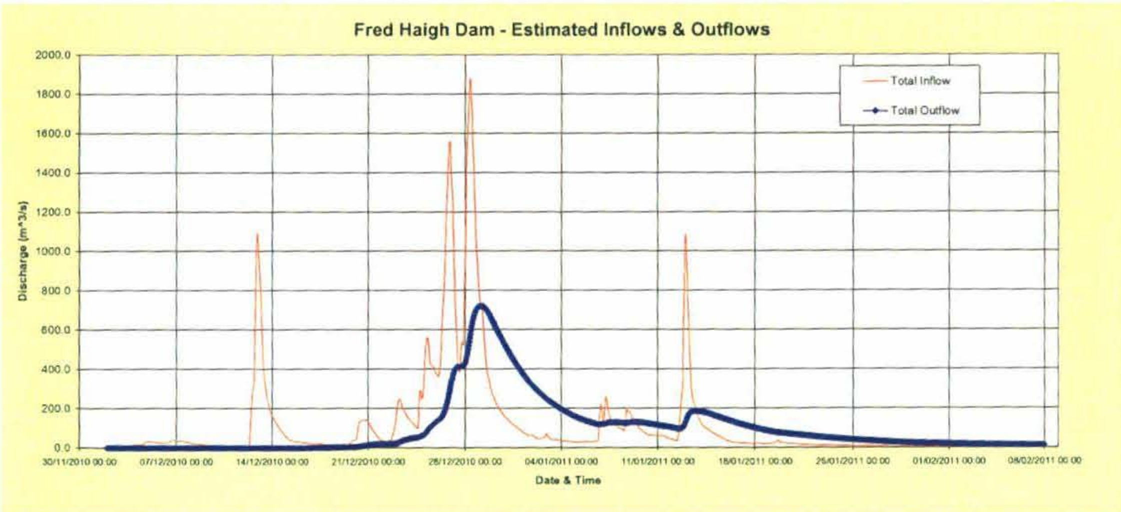


Figure 3-2 Fred Haigh Dam Inflow and Outflow (Dec 2010 - Feb 2011)

Figure 3-3 plots the recorded storage level of the dam for the period 1 December 2010 to 7 February 2011 inclusive. The plot also shows the flood classification levels[79]. The event was reported as a major flood.

[79] www.bom.gov.au

Figure 3-3 Fred Haigh Dam recorded flood levels

3.1.2.4 Communities that were affected

No downstream communities were significantly affected by flooding; however access was disrupted to the Bucca township.

3.1.2.5 Damage and response to damage

There was no significant damage to Fred Haigh Dam. Some minor slumping and erosion of the river bank downstream of the dam was noted. This has been inspected and will be repaired in due course.

3.1.2.6 Gauging stations – effect on data collection

Figure 3-1 shows the location of gauging stations in the catchment. The key stations remained available through the BoM web page throughout the event.

3.1.2.7 Community inquiries

SunWater received a small number inquiries from the general public seeking information on water levels and flows at Fred Haigh Dam.

SunWater staff worked closely with the LDMG and attended briefings as required.

3.1.2.8 Media Coverage

There are no specific references to Fred Haigh Dam in the media reports.

3.1.2.9 Post Event Review

SunWater undertook a review of the event across the Central Region. The review found that:

- The EAP was generally adequate, however some updating is required;
- Some difficulties were experienced with continuity of communication networks. NextG communications in addition to land lines at some dams is being investigated;
- Site facilities for staff were found to be inadequate where staff were on duty and isolated for prolonged periods; and,
- The EEC role across the Bundaberg service centre was found to be too demanding for one person. The role will be split into different sub areas for future events.

3.1.2.10 Previous flood events

The February event is ranked as the largest flood through the dam since it was constructed.

Table 3-2 Fred Haigh Dam - Ranking of historic events

FSL 73.36 m

Flood Rank	Date	Peak Height	
		EL	Above Crest
1	Dec-10	79.41	6.05
2	Mar-77	77.34	3.98
3	Mar-92	77.24	3.87
4	May-83	76.70	3.34
5	Apr-89	76.67	3.31
6	Feb-91	76.26	2.90
7	Mar-82	76.14	2.78
8	Apr-10	73.49	0.13
9			
10			
2010-11 Flood			
1	Dec-10	79.41	6.05

3.1.3 Flood mitigation opportunities/ upgrade or communities potentially affected

The maximum release rate from the dam is limited to $5.3m^3/s$[80]. At this rate it would take several months to significantly lower the storage notwithstanding any regulatory restrictions on such a release.

SunWater's predictive flood model for Fred Haigh Dam has been used to evaluate how the dam might operate to mitigate flood events. There is no flood mitigation storage in Fred Haigh dam. The only air space would be if the dam was below the full supply level prior to an event. The maximum benefit would be if the dam, hypothetically was empty at the beginning of the wet season. Figure 3-4 shows the scenario of the actual inflows from 1 December 2010 if the dam had been empty as at 1 December, however this would not be practical for the reasons set out above. If compared with Figure 3-2 it is noted that the peak outflow would have reduced to 130 m^3/s. This would have been a height over the spillway of

[80] Velocity limited to prevent damage to conduit

1.3m which is minor flood level. Figure 3-5 simulates the behaviour of the dam had it been at 50% on 1 December. Under this scenario major flood levels would still have been reached. It is unlikely that any flood mitigation benefit could be derived from the current configuration of Fred Haigh Dam without a significant loss of water supply to the local community. It is noted that any form of flood mitigation is likely to be of only marginal benefit to the community given the limited towns impacted downstream of Fred Haigh Dam.

Figure 3-4 Fred Haigh Dam Simulated Behaviuor if empty on 1 December

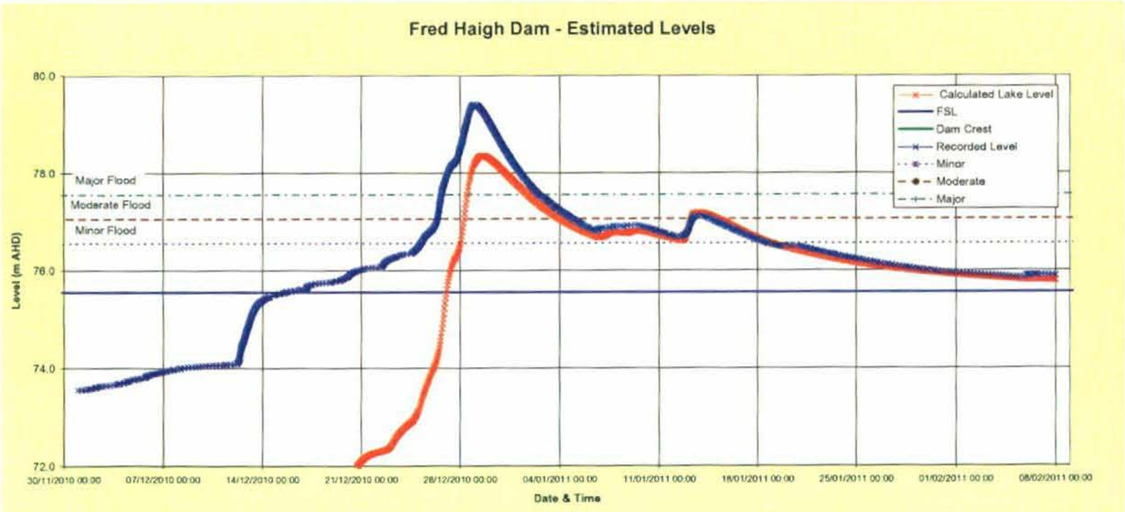


Figure 3-5 Fred Haigh Dam Simulation if at 50% on 1 December

Schedule 4: Fairbairn Dam

4.1 Fairbairn

4.1.1 Overview

The Nogoa catchment is part of the larger Fitzroy basin. The catchment area of the basin at Rockhampton is over 140,000km^2. The catchment area of the Nogoa River at Fairbairn dam is 16,320 km^2

Fairbairn is the main source of supply for the Nogoa Mackenzie Water Supply Scheme. The dam is operated in conjunction with Selma, Bedford, Bingegang and Tartrus Weirs to regulate supplies along the Mackenzie River and downstream to the Springton Creek junction. The dam also releases into the Selma and Weemah channel systems to supply irrigators. The scheme is also the source of supply for six industrial water supply pipelines serving the Central Queensland coalfields area.

Fairbairn Dam – formerly known as Maraboon Dam – is located on the Nogoa River, approximately 17 km southwest of Emerald. It was built in 1972.

Fairbairn dam is capable of safely passing AFC as defined by the dam safety regulator. No upgrade of Fairbairn dam is programmed.

	Dam	Storage Volume (ML)	Failure Impact Rating	Stream	Stream Distance (km)	Type	Surface Area at FSL (Ha)	Date Completed	Purpose	Nearest town	Significant down stream Communities
2	Fairbairn	1,301,000	2	Nogoa River	685.6	Earthfill	15,000	1972	Water Supply	Emerald	Emerald

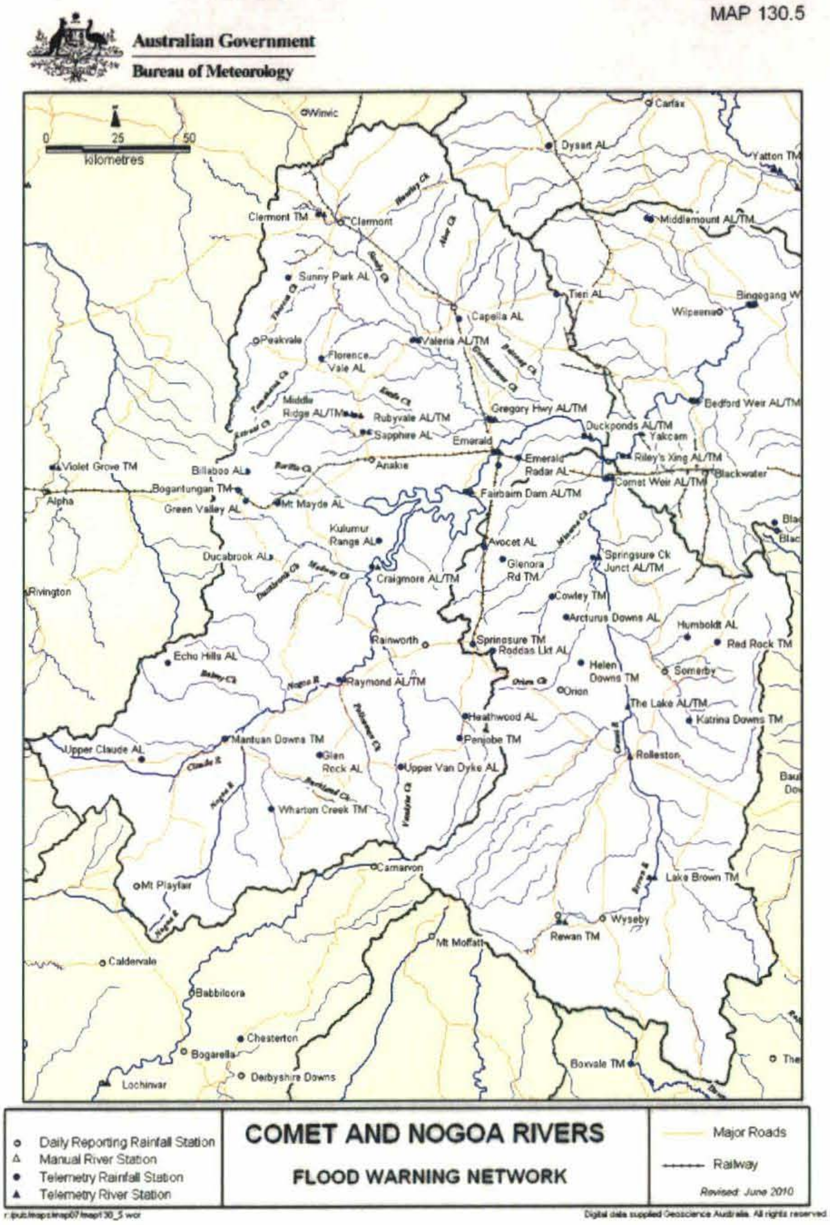


Figure 3-1 Nogoa River Catchment

The management of the dam is documented in a number of regulatory dam safety documents including:

- Fairbairn Dam: Standing Operating Procedures
- Fairbairn Dam: Operation & Maintenance Manual
- Emergency Action Plan: Fairbairn Dam
- Fairbairn Dam: Data Book Part 1 - Text
- Fairbairn Dam: Data Book Part 2 - (Volumes 1, 2, and 3) Drawings
- Fairbairn Dam: Dam Safety Review (September 1999)

In an emergency situation the procedures in the Emergency Action Plan take precedence.

4.1.1.1 Type

The dam itself is constructed of zoned earth and rockfill embankment with a concrete chute spillway with uncontrolled ogee-type crest. The main wall is 823m long with a maximum height above foundations of 46.3m. The spillway is 163m wide.

The dam has 6 earthfill saddle dams with a combined length of 8.4 km.

Table 3-1 Fairbairn Dam Details

Type of dam	Zoned earth and rockfill embankment
Length across crest	823 m
Height above foundation	46.33 m
Embankment crest level	218.86 m AHD
Spillway crest level	204.23 m AHD
Full Supply Level FSL	204.23 m AHD
Spillway type	Chute with uncontrolled ogee-type crest
Full Spillway width	163.07 m
Effective Spillway width	158.50 m
Spillway discharge at DCF	21,400 m^3/sec
Storage capacity/area at FSL	1 301 133 ML / 15,000 ha
Commandable storage	1 288 890 ML
Catchment area	16 320 km^2
Saddle Dams	6 earthfill dams with a combined length of 8.4 km
Right Bank Outlet	Intake tower with outlets into the Nogoa River and the Weemah Channel
Left Bank Outlet	Dual inlet (Channel inlet and Selma Pump Station) with a combined outlet into Selma Channel
Left bank Outlet capacity	770 ML/day
Mean annual rainfall	635 mm

4.1.1.2 Purpose

The Fitzroy Basin Resource Operations Plan (ROP)[81] notes that:

> *"The strategies specified in the WRP are designed to meet environmental flow objectives and water allocation security objectives ..... The Resource Operations Plan (ROP) has been developed to ensure that these objectives are satisfied. The management arrangements in the ROP for supplemented water supply schemes and associated infrastructure, and those for unsupplemented water are dealt with in Chapter 4 and Chapter 5 respectively.*
>
> *The assessment program will check for compliance with the management arrangements in the ROP and, over the long term, will assist in determining how effectively the strategies in the WRP are achieving the WRP outcomes."*

The purpose of the Fairbairn Dam is to supply water to the Emerald Irrigation Area, and to local industrial and urban users. In 2009-10 the scheme supplied 197,000ML to agricultural users, Industry, and towns

The operation of the Fairbairn Dam must meet the following criteria[82]:

- The Fairbairn Dam and all associated structures, facilities, and spaces are operated, monitored, and maintained in accordance with generally accepted engineering and water management practices, SunWater policies, and all applicable legislated requirements
- Water releases from Fairbairn Dam must be scheduled to comply with the Resource Operating License and Resource Operations Plan for the Fitzroy basin and SunWater's customer charter, and supply agreements

4.1.2 Implementation of System Operations Plans for 2010-11 Wet Season

4.1.2.1 Pre-wet season EAP reviews/training

The EAP was reviewed as part of an annual inspection in July 2010.

The notification and emergency communication list (EAP section 3) was revised and reissued in November 2010.

A supplementary notice for Issue 2 of the EAP was issued in October 2010 by the Principal Engineer, Dam Safety.

4.1.2.2 Emergency Preparedness/Actions/Redundancy/ back up systems

The EAP was first activated on 10th September 2010 and remained active until after the end of February 2011. The landholders identified in the EAP were also notified on 10th September 2010.

[81] Fitzroy Basin Resource Operations Plan, Ch 3

[82] Fairbairn Dam O&M Manual

4.1.3 Outline of flood event 2010/2011

Figure 3-2 outlines the recorded inflows and outflows from the dam for the period 1 December 2010 to 7 February 2011 inclusive. The peak discharge occurred on 31 December.

The total inflow into the dam over the period 1 December 2010 to 7 February 2011 was 2,800,000ML or 2.2 times the full storage volume of the dam.

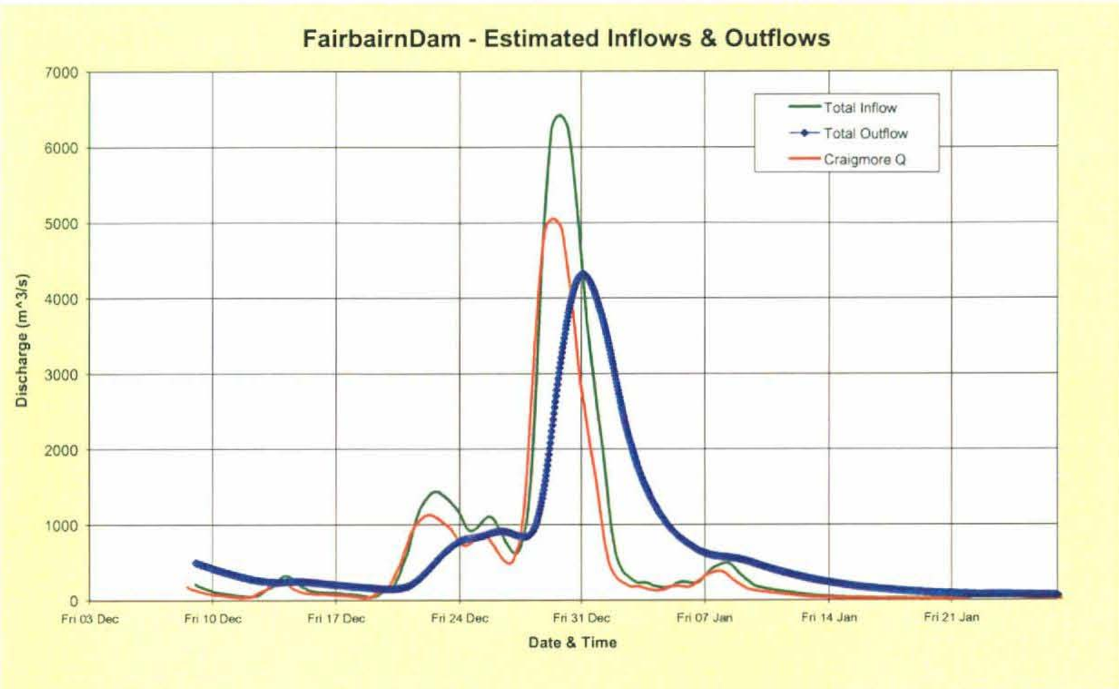


Figure 3-2 Fairbairn Dam Inflow and Outflow (Dec 2010 - Feb 2011)

Figure 3-3 plots the recorded storage level of the dam for the period 1 December 2010 to 7 February 2011 inclusive. The plot also shows the flood classification levels[83]. The December event was reported as a major flood. Emerald was significantly impacted by flooding. It is noted from Figure 3-2 that Fairbairn dam attenuated a peak inflow of 6,422m^3/s to a peak outflow of 4,324m^3/s. An attenuation factor of 33%.

[83] www.bom.gov.au

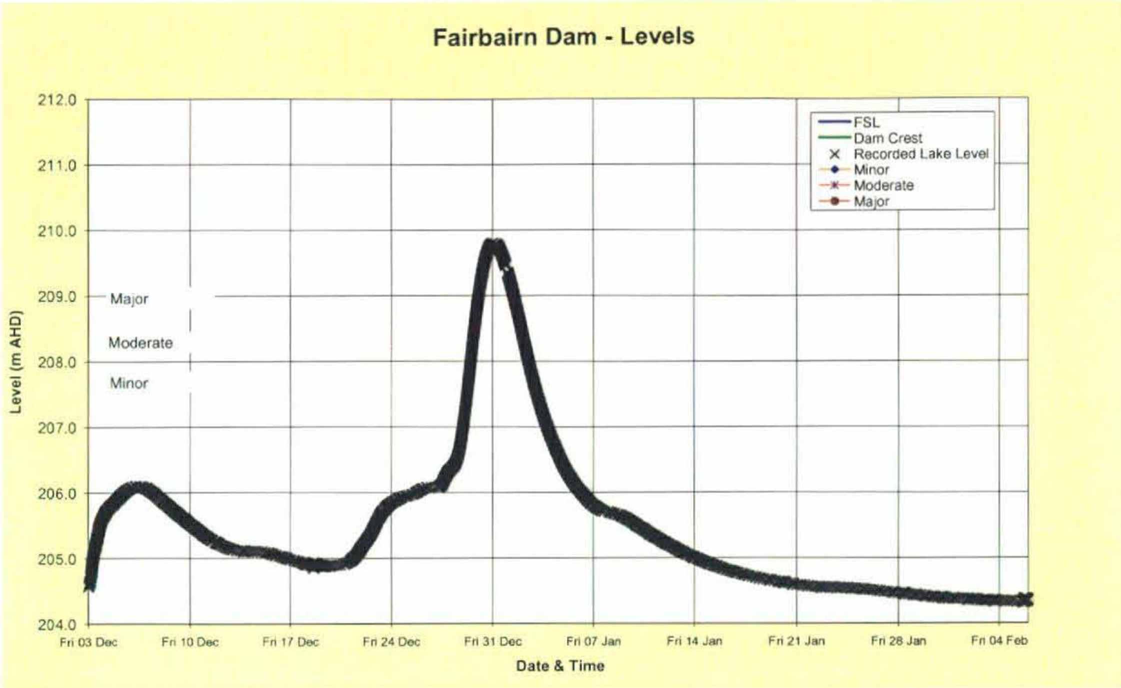


Figure 3-3 Fairbairn Dam recorded flood levels

4.1.3.1 Communities that were affected

The town of Emerald experienced significant flooding. Both residential and commercial areas were inundated.

4.1.3.2 Damage and response to damage

A detailed inspection of all areas of the dam has not yet been possible due to continued spillway flows. However the areas that have been inspected have performed well with no major damage. There was some damage when the lower instrumentation hut was inundated and there is some minor repair required to some concrete slabs in the spillway chute.

4.1.3.3 Gauging stations – effect on data collection

Figure 3-1 shows the location of gauging stations in the catchment. The key stations remained available through the BoM web page throughout the event. This data was used for predictive flood modelling. The only issue of note was that the recorded height at Craigmore, the key inflow gauge for the dam, exceeded the extent of the rating table. The table was extended during the event using model calibrations and engineering judgement.

4.1.3.4 Media Coverage

An article on 8 January 2011 in the Financial Review "The $10bn question – what's with the weather?" by Matthew Dunkley reports that Fairbairn did not spare Emerald from severe flooding however the president of a local lobby group said that it would have been worse if not for the dams.

4.1.3.5 Community inquiries

SunWater received a small number inquiries from the general public seeking information on water levels and flows at Fairbairn Dam.

Throughout the event SunWater staff worked closely with the LDMG and attended daily briefings. The LDMG did approach SunWater just after the peak of the event seeking a forecast of when the flows might drop to a level where the main highway bridge into town might be able to be reopened. SunWater provided them a verbal response giving an indicative 24 hour window of when the water level at the dam would be at a level that might correspond to a water level below the bridge.

4.1.3.6 Post Event Review

SunWater undertook a review of the event. The review found that:

- The EAP and O&M Manual were adequate and provided an excellent guide during the event. Only minor amendments are required to reflect current reporting arrangements;
- A good working relationship was established and maintained with the LDMG;
- SunWater had adequate staff resources to respond to the event; and'
- Access to all of the saddle dams was difficult with staff resorting to horses to access some areas

4.1.3.7 Previous flood events

The February event is ranked as the largest flood through the dam since it was constructed.

Table 3-2 Fairbairn Dam - Ranking of historic flood events

		FSL	204.228
Flood Rank	Date	Peak Height	
		EL	Above Crest
1	Dec-10	209.80	5.57
2	Feb-08	208.67	4.44
3	Feb-78	207.02	2.79
4	May-83	206.67	2.44
5	Apr-90	206,641	2.41
6	Dec-75	206.17	1.94
7	May-77	205.92	1.69
8	Mar-10	205.66	1.43
9	Feb-74	205.49	1.26
10	Sep-10	205.46	1.23
2010-11 Flood			
1	Dec-10	209.80	5.57

4.1.4 Flood mitigation opportunities/ upgrade or communities potentially affected

The maximum release rate from the dam is approximately 2,000ML/d. At this rate it would take several months to significantly lower the storage notwithstanding any regulatory restrictions on such a release. For example, it would take over twelve months to lower the dam to 50%.

SunWater's predictive flood model for Fairbairn Dam has been used to evaluate how the dam might operate to mitigate flood events. There is no flood mitigation storage in Fairbairn dam. The only air space would be if the dam was below the full supply level prior to an event. The maximum benefit would be if hypothetically the dam was empty at the beginning of the wet season. Figure 3-4 shows the scenario of the actual inflows from 1 December 2010 if the dam had been empty as at 1 December, however this would not have been practical for the reasons set out above. If compared with Figure 3-2 it is noted that the peak outflow would have reduced to 2,766 m^3/s. This would have been a height over the spillway of 4.24m which is a moderate flood level. Figure 3-5 simulates the behaviour of the dam had it been at 50% on 1 December. Under this scenario major flood levels would still have been reached. It is unlikely that any flood mitigation benefit could be derived from the current configuration of Fairbairn Dam without a significant loss of water supply to the local community.

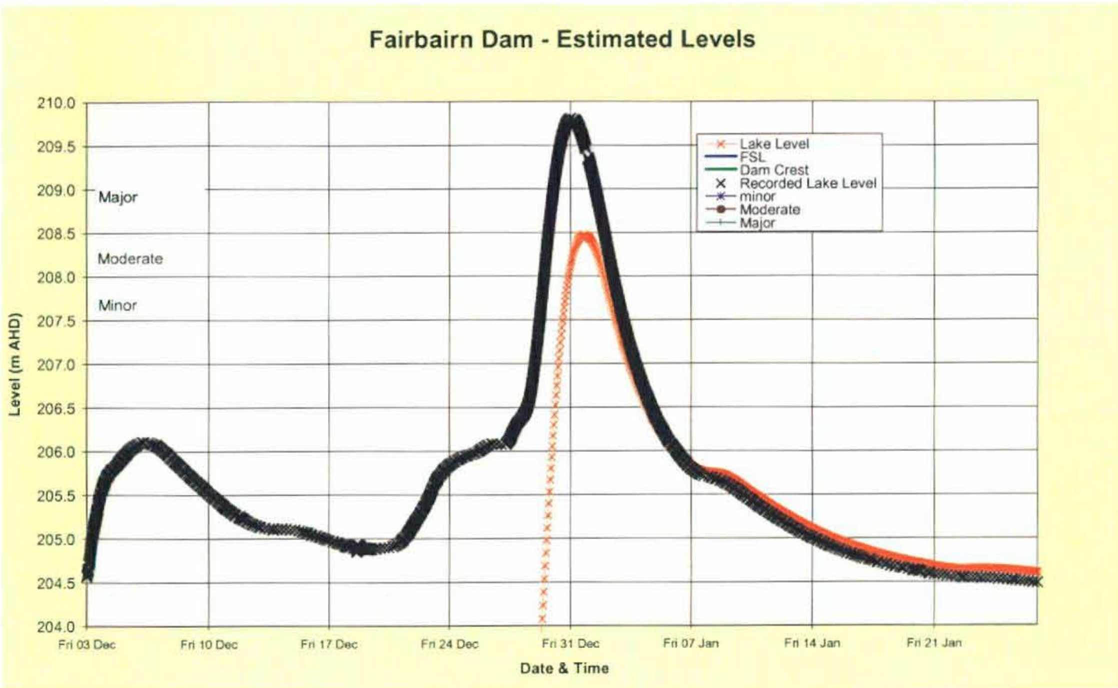


Figure 3-4 Fairbairn Dam Simulated Behaviour if empty on 1 December

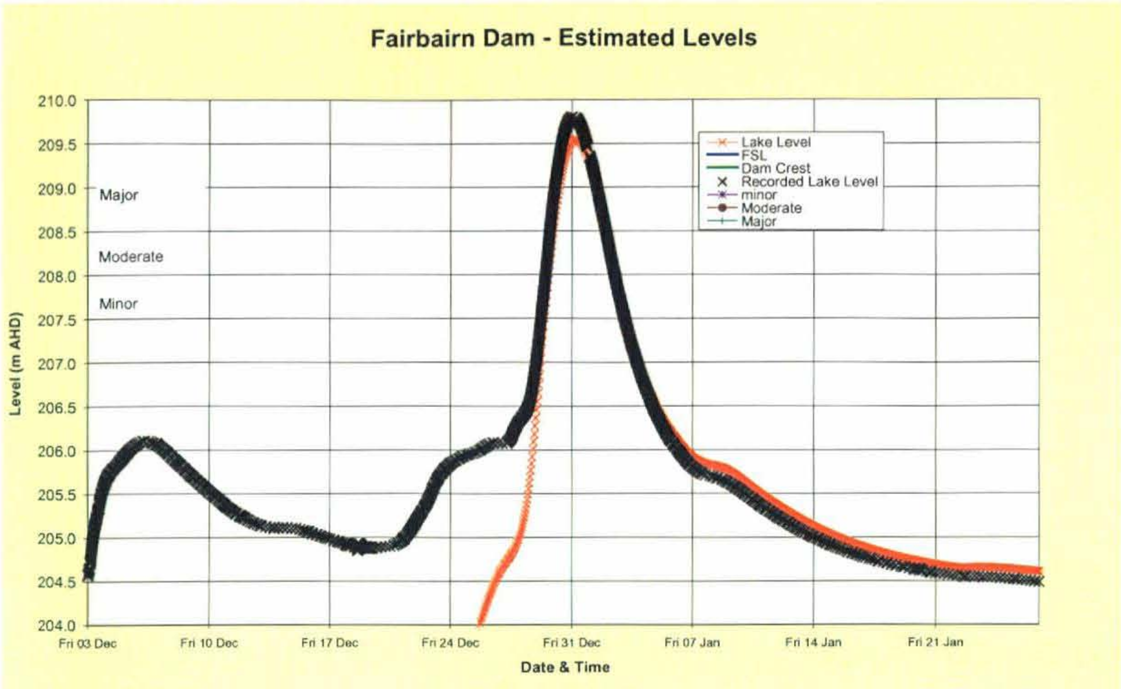


Figure 3-5 Fairbairn Dam Simulated Behaviour if at 50% on 1 December