**PART B – AEIS**

# 14. SURFACE WATER

## 14.1. Water resource modelling (IQQM)

Several submissions raised the concern that the EIS used information from the superseded Water Resource Plan (WRP), with water resource modelling based on models associated with the superseded WRP.

At the time of initial preparation of the EIS the *Water Resource (Fitzroy Basin) Plan 1999* was the gazetted legislation governing water resource planning in the Fitzroy Basin. While the WRP was under review by the Department of Environment and Resource Management (now the Department of Natural Resources and Mines (DNRM)) at the time of preparing the EIS, the EIS was still required to comply with the gazetted WRP. As such, all information presented in the EIS was in accordance with the 1999 WRP. The EIS also noted that the WRP was under review and information presented in the EIS would need to be revised, once the WRP was finalised and released.

As committed to in the EIS, the entirety of the hydrologic modelling presented in the EIS has been revised, based on the *Water Resource (Fitzroy Basin) Plan 2011 and associated* 2011 WRP Integrated Quantity and Quality Models (IQQM) prepared by DNRM. The revised hydrologic modelling is presented in **Section 14.1.4**. This includes a description of the Nathan Dam operational strategy, impacts to the flow regime, compliance with WRP objectives, impacts on existing users, time to fill analysis, climate change sensitivity modelling, level of service analysis and a cumulative impacts assessment.

### *14.1.1. IQQM and climate variability*

There was concern from one submission regarding the suitability of the IQQM modelling to investigate the impacts of climate variability and climate change, on long term water supply.

The IQQM model of the Fitzroy Basin simulates over 100 years of historical climate data. This data covers periods of natural climate variability, including periods of extreme flooding and long term droughts. In addition to modelling the operations of Nathan Dam under historical climate conditions, climate change sensitivity modelling was undertaken, based on the 2050 climate change projection under the highest emissions scenario (A1F1). This emissions scenario assumes a high reliance on fossil fuels and most closely follows current actual emissions levels.

The IQQM modelling is considered suitable to model natural climate variability as well as projected climate change. However, it is acknowledged that climate change projections contain a level of uncertainty. In order to address the uncertainty three scenarios were modelled, representing the most likely future case ($50^{th}$ percentile) and the outlying confidence estimates ($10^{th}$ and $90^{th}$ percentiles).

### *14.1.2. Changes to the WRP*

In December 2011 the regulator, DNRM, released the new Water Resource (Fitzroy Basin) Plan 2011. Prior to its release DNRM had spent 3 years reviewing and updating the WRP (and associated models). Key changes are discussed below and include changes to the performance indicators used to assess water resource development within the Basin, and the simulation period of the hydrologic models associated with the WRP.

These changes have been made by DNRM, and are outside the control of SunWater. However, now that the WRP has been updated, SunWater is required to use the new models to assess proposed development within the Fitzroy Basin.

#### *14.1.2.1. Performance indicators*

The WRP establishes two key sets of objectives for surface water management:

- Environmental Flow Objectives (EFOs); and
- Water Allocation Security Objectives (WASOs).

**Environmental flow objectives (EFOs)**

The EFOs set out a series of mandatory and non-mandatory flow objectives for key locations in the catchment. The EFOs for the Fitzroy Basin cover a range of low, medium and high flow conditions, as well as seasonal flow requirements. The EFOs include seasonal baseflow, mean annual flow, median annual flow, annual proportional flow deviation (APFD), mean wet season flow, 4% and 10% daily exceedance duration, the 2 year daily flow volume, the 5 year daily flow volume, the 20 year daily flow volume and a range of indicators around the first post winter flow objective. Technical definitions for these flow objectives are provided in the WRP.

There are 17 surface water reporting nodes identified in the WRP, however only five are located downstream of Nathan Dam. Of these nodes, only two have Environmental Flow Objectives specified under the WRP, these are node 2 (Dawson River at Beckers) and node 0 (Fitzroy River at Fitzroy Barrage).

Under the 1999 WRP, seasonal baseflow and first post winter flow objectives were specified for all five of the nodes downstream of Nathan Dam, while medium and high flow objectives were specified only at node 2 and node 0.

It is important for readers to appreciate that changes to the WRP, and the IQQM model behind it, have occasionally led to significant changes in compliance with the specified EFOs and WASOs, irrespective of any potential impacts associated with the Project. For this reason some comparisons of results from the former (EIS) assessment and the current (AEIS) assessment are included in this chapter.

**Seasonal baseflow objectives**

The seasonal baseflow objectives for the 1999 and 2011 WRPs for nodes 2 and 0 are presented in **Table 14-1**, where the modelled performance indicators should be between 0.8 and 1.2 times the values presented. Comparison of the values in **Table 14-1** shows the magnitude of changes that have been made to the seasonal baseflow indicator in the WRP.

### Table 14-1 Seasonal baseflow objectives

| | Baseflow (ML/d) | Seasonal baseflow performance indicator values (based on pre-development flow pattern) | | |
|---|---|---|---|---|
| | | January - April | May - August | September - December |
| **Node 2** (Dawson River at Beckers) | | | | |
| 1999 WRP | 86 | 67% | 29% | 35% |
| 2011 WRP | 86 | 64% | 27% | 35% |
| **Node 0** (Fitzroy River at Fitzroy Barrage) | | | | |
| 1999 WRP | 288 | 89% | 65% | 50% |
| 2011 WRP | 288 | 88% | 57% | 47% |

### First post winter flow objectives

The first post winter flow (FPWF) objectives for the 1999 and 2011 WRPs for nodes 2 and 0 are presented in **Table 14-2**. There have been some changes to the compliance values; also, one of the timing objectives has been changed from testing whether events occur within four weeks of the pre-development event (termed 'PDV' in the table below), to five weeks tolerance.

### Table 14-2 First post winter flow objectives

| Indicator | Node 2 (Dawson River at Beckers) | | Node 0 (Fitzroy River at Fitzroy Barrage) | |
|---|---|---|---|---|
| | 1999 WRP | 2011 WRP | 1999 WRP | 2011 WRP |
| No. of FPWF events | 80% | 80% | 80% | 80% |
| No. events within 2 weeks of PDV case | 50% | 70% | 50% | 70% |
| No. events within 4 weeks of PDV case | 70% | | 70% | |
| No. events within 5 weeks of PDV case | | 60% | | 60% |
| Average flow volume | n/a | n/a | 70% | 70% |
| Average peak flow | 70% | 60% | n/a | n/a |
| Flow duration (2x baseflow) | 70% | 60% | 70% | 70% |
| Flow duration (5x baseflow) | 70% | 60% | 70% | 70% |

### Medium to high flow objectives

The medium to high flow objectives for the 1999 and 2011 WRPs for nodes 2 and 0 are presented in **Table 14-3**. Two of these objectives have been renamed (for example, the "Marine and estuarine processes statistic" has been renamed the "Mean wet season statistic") while some are new. The "2yr daily flow volume" is similar to the "Channel morphology statistic" and the "5yr daily flow volume" is similar to the "Floodplain zone statistic".

**Table 14-3 Medium to high flow objectives**

| 1999 WRP | | | | | | 2011 WRP | |
|---|---|---|---|---|---|---|---|
| WRP Indicator | Node 2 (Dawson River at Beckers) | | Node 0 (Fitzroy River at Fitzroy Barrage) | | WRP Indicator | Node 2 (Dawson River at Beckers) | Node 0 (Fitzroy River at Fitzroy Barrage) |
| | Environmental flow limit | Planned development limit | Environmental flow limit | Planned development limit | | | |
| Mean annual flow | 74% | 69% | 74% | 77% | Mean annual flow | 65% | 77% |
| Median annual flow | 50% | 50% | 50% | 50% | Median annual flow | 48% | 58% |
| Marine and estuarine processes statistic | n/a | n/a | n/a | 80% | Mean wet season flow | n/a | 80% |
| Floodplain zone statistic | 70% | 69% | 70% | 70% | | | |
| Upper riparian zone statistic | 85% | 80% | 85% | 80% | | | |
| In-channel riparian zone statistic | 75% | 75% | 75% | 75% | | | |
| Channel morphology statistic | 65% | 60% | 65% | 65% | | | |
| Fish species diversity statistic | 3.0 | 3.0 | 3.0 | 3.0 | APFD | 3.1 | 2.5 |
| | | | | | 10% daily exceedance duration flow | 45% | 55% |
| | | | | | 4% daily exceedance duration flow | 53% | 74% |
| | | | | | 2 yr daily flow volume | 55% | 75% |
| | | | | | 5 yr daily flow volume | 69% | 87% |
| | | | | | 20 yr daily flow volume | 80% | 88% |

#grey highlighting indicates no equivalent statistic exists

**Water allocation security objectives (WASOs)**

The WASOs define a level of security for supplemented and unsupplemented water entitlement holders. Water products are available as high priority (HP) and medium priority (MP) supplemented water, i.e. supplied from a water storage within a water supply scheme, or as unsupplemented water, which is accessed via run of river flows. Within the Dawson catchment high priority water is used for town water supply and for industrial uses, while medium priority water is used for agricultural purposes.

There are three water supply schemes which are relevant to this Project. These are the Dawson Valley Water Supply Scheme, the Lower Fitzroy Water Supply Scheme and the Fitzroy Barrage Water Supply Scheme. WASOs for these schemes are presented below.

*Dawson Valley Water Supply Scheme (DVWSS)*

1. For water allocations in the high priority group:
    a) the annual supplemented water sharing index is to be at least 95%; and
    b) the monthly supplemented water sharing index is to be at least 98%.
2. For water allocations in the medium priority group the monthly supplemented water sharing index is to be at least 82%.
3. For water allocations in the medium A priority group the monthly supplemented water sharing index is to be at least 82%.

*Lower Fitzroy Water Supply Scheme (LFWSS) and Fitzroy Barrage Water Supply Scheme (FBWSS)*

1. For water allocations in the high priority group:
    a) the annual supplemented water sharing index is to be at least 94%; and
    b) the monthly supplemented water sharing index is to be at least 98%.
2. For water allocations in the medium priority group the monthly supplemented water sharing index is to be at least 82%.

For unsupplemented water users an annual volume probability (AVP) is specified, for separate zones in the Fitzroy Basin. The annual volume probability is the percentage of years (in the simulation period) in which the volume of water that may be taken by the group is at least the total of the nominal volumes for the allocations in the group.

**Table 14-4 Unsupplemented water allocation groups (downstream of Nathan Dam)**

| Place | Flow condition | Water allocation group | AVP |
|---|---|---|---|
| Dawson River from its junction with Mimosa Creek at AMTD 133 km to its junction with the Mackenzie River# | 1,296 ML/d | Class 10A | 68% |
| | 2,596 ML/d | Class 10B | 68% |
| Dawson River from the end of the supplemented section at AMTD 18.37 km to its junction with the Mackenzie River# | 0 to 25 ML/d | Class 10C | 66% |
| Dawson River from Orange Creek Weir at AMTD 270.7 km to its junction with Mimosa Creek at AMTD 133 km# | 1,296 ML/d | Class 11A | 63% |
| | 2,596 ML/d | Class 11B | 60% |
| Dawson River from the upstream limit of Glebe Weir at AMTD 356.5 km to Orange Creek Weir at AMTD 270.7 km# | 1,296 ML/d | Class 12A | 63% |
| Fitzroy River from the Dawson River junction to the Fitzroy Barrage | 2,592 ML/d | Class 5A | 61% |
| | 4,320 ML/d | Class 5B | 73% |
| Fitzroy River from the Dawson River junction to the upstream limit of Eden Bann Weir | 9 ML/d | Class 6C | 95% |
| | 260 ML/d | Class 7D | 93% |

# including sections of tributaries where Dawson River flows are accessible.

**Unallocated water and strategic reserves**

The WRP identifies unallocated water which is held in the Fitzroy Basin, for a variety of future uses. Unallocated water relevant to the Dawson catchment includes:

- Strategic reserve – 15,000 ML/a available for a State purpose and 5,000 ML/a available for indigenous purpose (available across the entire Fitzroy Basin);
- General reserve – 11,500 ML/a in the Upper Dawson; and
- Strategic water infrastructure reserve – 90,000 ML/a for water infrastructure on the Dawson River.

The strategic water infrastructure reserve has changed from the previous WRP, which identified a total volume of 190,000 ML for water allocations in the medium priority group (DNRW, 1999). Further details can be found in Schedule 8 of the WRP (DERM, 2011a).

SunWater is proposing that Nathan Dam be operated to supply an additional 66,011 ML/a of high priority water, below the strategic water infrastructure reserve of 90,000 ML/a identified for water infrastructure on the Dawson River.

**Changes to the WRP hydrologic model**

The WRP specifies the use of the Integrated Quantity Quality Model (IQQM) developed by DNRM for the assessment of water resource development within the Fitzroy Basin (where practicable). The model represents streamflow in major watercourses within the Basin and water resource development, including dams, weirs, stock and domestic use, town water supplies, irrigators and waterharvesters. The model also represents water management rules at storages, such as fishway operations, baseflow releases and first post winter flow releases.

The current model was developed for the update to the Fitzroy Basin WRP 2011; it operates on a daily timestep and uses an historic simulation period of 119 years, from 1889 to 2007. However, results are reported for the water years 1900 to 2007, to allow a sufficient 'warm-up' period for the model. This reduces the effect of starting conditions on results (DERM, 2011c).

Currently, the DVWSS is operated as two schemes (Upper Dawson and Lower Dawson), however, once Nathan Dam is operational the DVWSS will be managed as one scheme.

As part of the 2011 WRP revision a large number of changes were made to the IQQM model. The majority of these changes are either very small or irrelevant to the operation of Nathan Dam. However, **Table 14-5** lists the model changes which are of interest to this Project, compared to the original modelling undertaken for the EIS.

## Table 14-5  Key model changes

| Parameter changed | Description | Impact |
|---|---|---|
| Simulation period | Previously 1898-1995, this has been extended to 1889-2007. | Statistical assessment periods have changed; this may change Environmental Flow Objective (EFO) and Water Allocation Security Objective (WASO) performance.<br>(note that DNRM has updated EFO and WASO targets, in some cases) |
| Evaporation | The method for estimating daily evaporation has been improved. | This has led to an increase in the estimated evaporation losses across the Fitzroy Basin |
| Inflows | The rainfall-runoff models which are used to generate subcatchment inflows have been reviewed and extended to the new simulation period. Some of the models have also been recalibrated. | Through the recalibration process the inflows at many locations have changed. There is a general trend of increased peak flow for large flow events.<br>At Nathan Dam the peak flow for extreme events has increased, while more frequent flows have decreased in volume, and there is a greater incidence of zero flow periods. |
| Sub-model configuration | There are now two models which cover the Fitzroy Basin; the Dawson catchment (consisting of the Dawson and Callide subcatchments) and the Fitzroy catchment (consisting of the Isaac-Connors, Nogoa-Mackenzie, Comet and Lower Fitzroy subcatchments), where previously each subcatchment was modelled separately. | This arrangement makes modelling of the whole Basin much simpler. |
| Dawson River inflow | The Fitzroy Catchment existing conditions model uses the inflow from the Dawson Catchment full development scenario; this includes the operation of 'Big' Nathan Dam[#]. | It is understood that this has been adopted to facilitate modelling of Nathan Dam and in order to provide a conservative representation of streamflow in the Lower Fitzroy.<br>However, any modelling of the Dawson Catchment which then assesses impacts on the Lower Fitzroy should create a separate baseline model. |
| Nathan Dam | DNRM have created a 'Full Development' scenario, representing the maximum anticipated development in the catchment. This includes a 'Big' Nathan Dam[#], with the maximum extraction from it. | This scenario has not been used for the SEIS, as it does not represent Nathan Dam, as proposed by SunWater. |
| Orange Creek Weir | Orange Creek Weir is now explicitly modelled (it was not included in the previous model). | The inclusion of Orange Creek Weir makes the model more realistic. |
| Dawson Valley Water Supply Scheme | A number of the parameters detailed for the operation of the Dawson Valley Water Supply Scheme have been changed. These include storage operation levels, high priority reserve volumes and transmission loss specifications. | Reflects current operational strategies. |
| Unallocated Water | Three types of unallocated water have been included in the Dawson catchment model, this amounts to 1,500 ML/a for projects of State significance, 750 ML/a for town water supply and 11,500 ML/a general unallocated water.<br>The volume for general reserve has been located in the Upper Dawson (zone DP), while the other two volumes have been located on the Lower Dawson, above the confluence with the Don River. | Minor change to flows |

| Parameter changed | Description | Impact |
|---|---|---|
| Unsupplemented irrigation | The representation of unsupplemented irrigation demand on the Dawson River, downstream of Glebe Weir, has been changed. This has affected the location and volume of demand. | This information supersedes the EIS modelling of the potential impacts to existing waterharvesting licence holders. |

#This represents the maximum development possible at the Nathan Dam site, in terms of physical infrastructure and allowed volume of extractions. This is larger than the Nathan Dam development proposed by SunWater.

The simulation period and reporting periods for the original model and the new model are presented in **Table 14-6**. The critical period for Nathan Dam was originally identified as occurring in 1969. This has not changed under the new WRP model.

Note that flow statistics are calculated based on a July to June water year, while water use statistics are calculated based on an October to September water year, as specified in the 2011 WRP and the Resource Operations Plan (ROP).

**Table 14-6 Model simulation period and reporting periods**

| | Original WRP model (EIS) | Revised WRP model (SEIS) |
|---|---|---|
| Simulation Period | 01/01/1900 to 31/12/1995 | 01/01/1889 to 31/12/2007 |
| EFO compliance period | 01/07/1900 to 30/06/1995 | 01/07/1900 to 30/06/2007 |
| WASO compliance period | 01/10/1900 to 30/09/1995 | 01/10/1900 to 30/09/2007 |
| Statistics period (FDC, spells, etc.)# | 01/01/1900 to 31/12/1995 | 01/01/1900 to 31/12/2007 |

# This is the period adopted for the purposes of the EIS/SEIS

**Existing water users**

**Table 14-7** presents the approved supplemented water allocations in the DVWSS by water supply zone, as reported in the Fitzroy Basin ROP (DERM, 2011b). The upper Dawson is considered to consist of management zones M to E, while the lower Dawson consists of management zones D to B.

Table 14-7 Supplemented water allocations in the DVWSS (DERM, 2011b)

| Zone | Description | Medium Priority water allocation (ML/a) | Medium A priority water allocation (ML/a) | High priority water allocation (ML/a) |
|---|---|---|---|---|
| M | Glebe Weir to upstream limit of Glebe Weir | 1,160 | 0 | 0 |
| L | Effective upstream limit of Gyranda Weir to Glebe Weir | 0 | 0 | 0 |
| K | Orange Creek Weir to effective upstream limit of Gyranda Weir | 2,500 | 0 | 400 |
| J | Effective upstream limit of Theodore Weir to Orange Creek Weir | 5,850 | 0 | 0 |
| I | Theodore Weir to effective upstream limit of Theodore Weir | 2,074 | 19,456 | 862 |
| H | Effective upstream limit of Moura Weir to Theodore Weir | 6,524 | 0 | 0 |
| G | Moura Weir to effective upstream limit of Moura Weir | 9,131 | 0 | 3,319 |
| F | Mimosa Creek junction to Moura Weir | 0 | 0 | 0 |
| E | Effective upstream limit of Neville Hewitt Weir to Mimosa Creek junction | 2,720 | 0 | 0 |
| D | Neville Hewitt Weir to effective upstream limit of Neville Hewitt Weir | 4,263 | 0 | 648 |
| C | Don River junction to Neville Hewitt Weir | 1,892 | 0 | 0 |
| B | End of supplemented section to Don River junction | 683 | 0 | 350 |
| | | **36,797** | **19,456** | **5,579** |

### *14.1.3. Changes to the ROP*

The ROP is a plan prepared by DNRM under the provisions of the Water Act 2000 to implement a WRP for water resources in all or part of the plan area, i.e. the Fitzroy Basin ROP implements the Fitzroy Basin WRP. While the WRP sets out the strategic goals for water resource management in the plan area, the ROP defines the rules that govern the allocation and management of water in order to achieve the WRP outcomes.

The current ROP is the Fitzroy Basin Resource Operations Plan September 2014 (amended September 2015) and implements the Water Resource (Fitzroy Basin) Plan 2011. The previous version was the Fitzroy Basin Resource Operations Plan January 2004 (amended December 2013 (Revision 4)). As the version in place during the preparation of the EIS was the Fitzroy Basin Resource Operations Plan January 2004 (amended October 2011 (Revision 3)), some reference made in the EIS may now be out of date.

#### *14.1.3.1. Strategic Reserve*

The previous ROP identified 190,000 of unallocated medium priority water from the Dawson River, as provided in the 1999 WRP, specifically associated with Nathan Dam (Chapter 7). However, this volume is superseded by the 2011 WRP, which specifies 90,000 ML of unallocated water, held as a strategic water infrastructure reserve for water infrastructure on the Dawson River (WRP Sections 44 and 45).

#### *14.1.3.2. Central Queensland Regional Water Supply Strategy*

Nathan Dam was identified in the Central Queensland Regional Water Supply Strategy (CQRWSS) as the preferred short to medium term water supply solution to meet future water demands in the Dawson-Callide sub-region.

### *14.1.4. Revised hydrologic modelling*

The following section presents the hydrologic modelling undertaken for the EIS, revised using the most recent 2011 WRP models relevant to the Dawson River. Subsections include:

- Nathan Dam modelled operational strategy;
- Changes to the flow regime;
- Environmental flow objectives;
- Water allocation security objectives;
- Time to fill analysis;
- Climate change;
- Level of service analysis; and
- Cumulative impacts assessment.

#### *14.1.4.1. Nathan Dam modelled operational strategy*

The modelled operational strategy for Nathan Dam includes the provision of new high priority water, environmental flow releases (first post winter flow and low flow releases), operation of a fishway and turtleway, and the resupply of downstream storages. Details are provided in the following section.

**Water supplied from Nathan Dam**

New water supplied from the Nathan Dam is currently intended to be entirely HP. The assumed distribution of new HP demand associated with the Project is summarised in **Table 14-8** and has not changed from the EIS.

## Table 14-8 Nathan Dam: new high priority water products

| Management Zone | Supplied from | Allocation volume (ML/a) |
|---|---|---|
| Zone M | Nathan Dam | 47,700 |
| Zone J | Gyranda Weir | 750 |
| Zone I | Theodore Weir | 400 |
| Zone G | Moura Weir | 7,092 |
| Zone D | Neville Hewitt Weir | 2,269 |
| Zone B | extracted at Duaringa and supplied from Neville Hewitt Weir | 7,800 |
| **Total** | | **66,011** |

### First Post Winter Flow Release

The first post winter flow is a key environmental flow objective defined under the WRP, with release guidelines described in the ROP. The first post winter flow release strategy releases the first high flow event into a water storage, between the period 1 October and 10 April. Inflows to the water storage are then released for 21 days.

A summary of the first post winter flow release rules for storages on the Dawson River is presented in **Table 14-9**. These have not been changed from the DNRM specifications, apart from increasing the maximum release at Nathan Dam from 3,500 ML/d to 3,888 ML/d, in line with the current dam design details.

## Table 14-9 First Post Winter Flow Release Rules

| Storage | Requirements | Inflow to storage (ML/d) | Maximum release (ML/d) | Minimum Storage Volume (ML) |
|---|---|---|---|---|
| Nathan Dam | Flow of 2,000 ML/d for at least 3 days at inflow to Nathan Dam | >35 | 3,888 | 34,502 |
| Gyranda Weir | Flow of 2,000 ML/d for at least 3 days at inflow to Nathan Dam | >30 | 1,000 | 9,000 |
| Moura Weir | Flow of 2,000 ML/d for at least 3 days at inflow to Nathan Dam<br>Start of event at Moura delayed by 6 days | >35 | 860 | 4,900 |
| Neville Hewitt Weir | Flow of 2,000 ML/d for at least 3 days at inflow to weir | >35 | 300 | 4,000 |

### Seasonal Baseflow Release

The WRP model specifies a seasonal baseflow (SBF) release at Nathan Dam, Theodore Weir, Moura Weir and Neville Hewitt Weir, as presented in **Table 14-10**. Generally, the SBF releases inflows to the storage (between a specified range) when the storage is above a given volume. SBF releases are made throughout the year, although releases are not made during the first post winter flow event.

In the modelling the SBF release at Nathan Dam was turned off, as the seasonal baseflow requirement was already met through the low flow release and fishway operations of the dam. The SBF release at Theodore Weir was only required for the January to April period, as low flow releases from the weir were already high during the rest of the year and an additional release was not required to meet the SBF targets. The SBF release at Moura Weir and Neville Hewitt Weir was not adjusted.

### Table 14-10 Seasonal Baseflow Release Conditions

| Storage | Requirements | Inflow release (ML/d) | Trigger Storage Volume (ML) |
|---|---|---|---|
| Nathan Dam | - | - | - |
| Theodore Weir | Releases made January to April only | 60 – 100 | 4,200 |
| Moura Weir | Releases made from non-consumptive releases from upstream and tributary inflows between Theodore and Moura weirs. | 70 – 110 | 4,500 |
| Neville Hewitt Weir | Releases made from non-consumptive releases from upstream and tributary inflows between Moura and Neville Hewitt weirs. | 70 – 110 | 4,000 |

**Low Flow Release and Fishway Operation**

A low flow environmental release was adopted, which mirrored the dam inflows, up to a maximum release of 50 ML/d. For the purpose of this investigation the requirement of the fishway operation has been met by the low flow release strategy, which is not restricted by the dam storage level, until the dam reaches minimum operating volume (MOV).

**Turtleway Operation**

Modelling of the turtleway was based on a release of up to 2 ML/d (mirroring inflows to the dam). Turtleway releases are made in addition to fishway releases and occur during the natural movement periods for turtles of January to February (inclusive) and August to November (inclusive). These can be adjusted based on further advice from turtle experts.

**High Priority Reserve**

Under the new WRP models, changes have been made to the way that the high priority reserve within the water supply scheme is represented. This parameter is used in the announced allocation formula contained within the ROP. The HP reserve is essentially water which is held back to protect the supply of HP allocations in dryer conditions, typically up to a maximum of 2 years. The reserve is now commonly defined in the models as a part of reach transmission and operation losses. The reserve for Nathan Dam is specified in reach 7, as listed in

**Table 14-11**.

**Table 14-11 Nathan Dam high priority reserve in ML (reach 7)**

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 87596 | 93142 | 99071 | 104809 | 110738 | 116475 | 122404 | 128333 | 134071 | 70000 | 75738 | 81667 |

# the water year for users begins in October

**Dawson Valley Water Supply Scheme**

Although in principle the DVWSS is one scheme, covering the Dawson River from the upstream limit of Glebe Weir to the downstream limit of the Boolburra waterhole, in practise it is currently operated as two schemes; Upper Dawson and Lower Dawson (as detailed in the ROP). The upper scheme is supplied from the storages from Glebe Weir to Moura Weir, while Neville Hewitt Weir supplies the lower scheme. While the storages within the upper scheme are resupplied from the next upstream storage, Neville Hewitt Weir operates independently and is not resupplied from Moura Weir. Because of this, the two schemes have independent calculations of Announced Allocation (AA).

However, once Nathan Dam is operational the DVWSS will be managed as one scheme. All of the storages will ultimately be resupplied from Nathan Dam, including Neville Hewitt Weir, and one AA will be calculated for the entire scheme.

The inter storage release rules and top up conditions adopted for the 'With Dam' scenario are described below.

**Inter Storage Release Rules**

Within the model, the majority of the storages on the Dawson River are resupplied from the next upstream storage when they fall below a specified storage volume. The exceptions are Glebe Weir (Full Entitlement scenario) and Nathan Dam ('With Dam' scenario), which have no upstream storage, the Moura Off Stream Storage (MOSS), and Neville Hewitt Weir, which operates independently under the Full Entitlement scenario.

The storages and their trigger supply volumes adopted for the 'With Dam' scenario are specified in **Table 14-12**. At Gyranda Weir, Moura Weir and Neville Hewitt Weir the supply trigger varies seasonally, in order to facilitate the WRP first post winter flow objectives. The supply triggers at these three storages have been adjusted in order to balance passing the first post winter flow, maintaining downstream storage levels and minimising additional flushing flows in the reach between Orange Creek Weir and Theodore Weir. This reach is a known nesting area for the Fitzroy River Turtle and is vulnerable to increased occurrence of flows which are large enough to drown out nesting sites, during the nesting season of September to December.

### Table 14-12 Inter-storage release trigger volumes

| Storage | Full Supply Volume (ML) | Minimum Operating Volume (ML) | Resupply Trigger Volume (ML) | | |
|---|---|---|---|---|---|
| | | | All Months | Jan-Sep | Oct - Dec |
| Nathan Dam | 888,312 | 34,502 | - | - | - |
| Gyranda Weir | 16,500 | 2,120 | - | 6,000 | 11,000 |
| Orange Creek Weir | 6,140 | 2,320 | 6,140 | - | - |
| Theodore Weir | 4,760 | 750 | 3,930 | - | - |
| Moura Off Stream Storage | 2,820 | 140 | - | - | - |
| Moura Weir | 7,700 | 600 | - | 5,000 | 6,500 |
| Neville Hewitt Weir | 11,300 | 2,120 | - | 4,200 | 5,000 |

The conditions for top up, or re-ordering, from upstream storages under the ‘With Dam’ scenario are as follows:

- Top-up from Nathan Dam to Gyranda Weir when Gyranda Weir is below 11,000 ML and Nathan Dam is above 50,000 ML;
- Top-up from Gyranda Weir to Theodore Weir when Gyranda Weir is above 3,700 ML;
- Top-up from MOSS to Moura Weir when Moura Weir is below 4,500 ML;
- Top-up from Theodore Weir to Moura Weir when Theodore Weir is above 3,930 ML and Moura Weir is below 6,500 ML; and
- Top-up from Moura Weir to Neville Hewitt Weir when Moura Weir is above 3,630 ML and Neville Hewitt Weir is below 5,000 ML.

**Modelling assumptions**

Other modelling assumptions adopted for this investigation include:

Medium priority water is currently supplied from Glebe Weir (1,160 ML/a) and it is assumed that this entitlement will be transferred to Nathan Dam, once the dam becomes operational. For the purpose of the ‘With Dam’ scenario this entitlement has been modelled at Nathan Dam.

There are also several unsupplemented irrigators, located upstream of Glebe Weir, who may be affected by the upstream extent of the Nathan Dam impounded area. A final decision has not been made regarding the management of these entitlements once the dam is operational. For example, will the entitlement remain in place, be sold or move to another location? For the purpose of this investigation these entitlements have therefore not been moved and have been modelled as per their current configuration. This is intended to provide a conservative case, as the current configuration provides the maximum impact on flow; however, the impact of this is relatively small, and is not likely to be a critical factor in decision making.

Under the DNRM IQQM Full Development scenario the Medium A advantage in zone I was removed. This change was made under the assumption that with Nathan Dam in place the Medium A advantage would no longer be required. However, SunWater has retained the Medium A priority group reporting in the AEIS since the Fitzroy Water Resource Plan still makes reference to this priority group.

All other entitlements remain in their existing location, with no changes to their operational rules.

No other changes have been made to the Dawson Valley Water Supply Scheme operations, as configured for operation by DNRM. In all other aspects operations are as per the original IQQM models supplied by DNRM and are generally consistent with the Fitzroy ROP.

#### *14.1.4.2. Environmental flow objectives*

The following section presents the compliance of the modelled scenarios with the EFOs specified in the Fitzroy Basin WRP (DERM, 2011a), for reporting nodes 2 (Dawson River at Beckers) and node 0 (Fitzroy River at Barrage). For interest, environmental flow statistics have also been presented at the WRP nodes 5, 4 and 1, although environmental flow objectives are not currently specified at these locations.

In summary:

- All medium to high flow objectives (mandatory) are met under both the Full Entitlement and 'With Dam' scenarios;
- All first post winter flow objectives (mandatory) are met under both the Full Entitlement and 'With Dam' scenarios;
- the seasonal baseflow objectives (non-mandatory) at node 2 are not met under the Full Entitlement scenario, however; under the 'With Dam' scenario compliance is reached for two out of the three seasons; and
- the seasonal baseflow objectives (non-mandatory) at node 0 are not met for two seasons under both the Full Entitlement and 'With Dam' scenarios.

**Table 14-13** presents the colour code used to indicate compliance or non-compliance with the WRP performance indicators.

**Table 14-13 Colour codes for WRP objectives**

| Description | Colour Code |
|---|---|
| WRP objectives achieved (mandatory and non-mandatory) | |
| WRP non-mandatory objectives not achieved | |
| Mandatory WRP objectives failed | |
| WRP objectives are not specified at this location | |

**Medium to high flow objectives (mandatory)**

Compliance with the medium to high flow objectives is presented in **Table 14-14** to **Table 14-15**. These objectives are all met, at both nodes 2 and 0, for the Full Entitlement and 'With Dam' scenarios. While substantial changes are seen on the Dawson River, these changes are much reduced on the Fitzroy River.

**Table 14-14 Medium to high flow objectives for the Dawson River**

| Performance Indicator | Mandatory Objective | Nathan Gorge (EFO node 5) | | D/S Theodore (EFO node 4) | | Beckers (EFO node 2) | |
|---|---|---|---|---|---|---|---|
| | | Full Entitlement | 'With Dam' scenario | Full Entitlement | 'With Dam' scenario | Full Entitlement | 'With Dam' scenario |
| Mean Annual Flow | ≥ 65% | 95% | 67% | 90% | 68% | 88% | 71% |
| Median Annual Flow Ratio | ≥ 48% | 92% | 64% | 82% | 61% | 74% | 53% |
| APFD | ≤ 3.1 | 0.8 | 5.1 | 0.9 | 3.5 | 1.1 | 2.8 |
| 10% daily exceedance duration flow | ≥ 45% | 73% | 122% | 73% | 59% | 59% | 50% |
| 4% daily exceedance duration flow | ≥ 53% | 88% | 60% | 87% | 58% | 82% | 59% |
| 2 yr daily flow volume | ≥ 55% | 94% | 14% | 92% | 43% | 90% | 56% |
| 5 yr daily flow volume | ≥ 69% | 98% | 36% | 99% | 70% | 94% | 70% |
| 20 yr daily flow volume | ≥ 80% | 99% | 64% | 99% | 72% | 95% | 85% |

**Table 14-15 Medium to high flow objectives Fitzroy River**

| Performance Indicator | Mandatory Objective | D/S of Eden Bann Weir (EFO node 1) | | Fitzroy Barrage outflow (EFO node 0) | |
|---|---|---|---|---|---|
| | | Full Entitlement | 'With Dam' scenario | Full Entitlement | 'With Dam' scenario |
| Mean Annual Flow | ≥ 77% | 87% | 84% | 85% | 82% |
| Median Annual Flow Ratio | ≥ 58% | 75% | 71% | 71% | 67% |
| APFD | ≤ 2.5 | 1.4 | 1.7 | 1.5 | 1.9 |
| Mean Wet Season Flow | ≥ 80% | 88% | 86% | 87% | 85% |
| 10% daily exceedance duration flow | ≥ 55% | 75% | 69% | 72% | 68% |
| 4% daily exceedance duration flow | ≥ 74% | 85% | 80% | 86% | 81% |
| 2 yr daily flow volume | ≥ 75% | 88% | 87% | 84% | 83% |
| 5 yr daily flow volume | ≥ 87% | 94% | 94% | 92% | 92% |
| 20 yr daily flow volume | ≥ 88% | 95% | 93% | 91% | 91% |

### First post winter flow event objectives (mandatory)

Compliance with the FPWFE objectives is presented in **Table 14-16** and **Table 14-17**. At both nodes 2 and 0, the first post winter flow objectives are all achieved, under both the Full Entitlement and 'With Dam' scenarios. Changes to these objectives are generally much less than changes to the medium to high flow objectives.

### Table 14-16 First post winter flow event objectives for the Dawson River

| Performance Indicator | Mandatory Objective | Nathan Gorge (EFO node 5) | | D/S Theodore (EFO node 4) | | Beckers (EFO node 2) | |
|---|---|---|---|---|---|---|---|
| | | Full Entitlement | 'With Dam' scenario | Full Entitlement | 'With Dam' scenario | Full Entitlement | 'With Dam' scenario |
| No. of FPWFE | ≥ 80% | 90% | 91% | 84% | 76% | 88% | 82% |
| No. Flows within 2 Weeks of PD Case | ≥ 70% | 88% | 93% | 80% | 94% | 90% | 89% |
| No. Flows within 5 Weeks of PD Case | ≥ 60% | 67% | 74% | 57% | 60% | 66% | 60% |
| Average Peak Flow | ≥ 60% | 83% | 76% | 78% | 65% | 82% | 76% |
| Flow Duration (2-times base flow) | ≥ 60% | 89% | 45% | 81% | 75% | 81% | 71% |
| Flow Duration (5-times base flow) | ≥ 60% | 85% | 43% | 80% | 73% | 72% | 60% |

### Table 14-17 First post winter flow event objectives Fitzroy River

| Performance Indicator | Mandatory Objective | D/S of Eden Bann Weir (EFO node 1) | | Fitzroy Barrage outflow (EFO node 0) | |
|---|---|---|---|---|---|
| | | Full Entitlement | 'With Dam' scenario | Full Entitlement | 'With Dam' scenario |
| No. of FPWFE | ≥ 80% | 95% | 96% | 93% | 91% |
| No. Flow within 5 Weeks of PD Case | ≥ 60% | 83% | 85% | 77% | 75% |
| No. Flow within 2 Weeks of PD Case | ≥ 70% | 89% | 90% | 81% | 77% |
| Average Flow Volume | ≥ 70% | 68% | 64% | 88% | 85% |
| Flow Duration (2-times base flow) | ≥ 70% | 95% | 95% | 93% | 91% |
| Flow Duration (5-times base flow) | ≥ 70% | 80% | 78% | 92% | 89% |

**Seasonal baseflow objectives (non-mandatory)**

Compliance with the seasonal baseflow objective is presented in **Table 14-18** and **Table 14-19**. At node 0 the objective is only achieved from January to April and compliance is not affected by the dam operations. At node 2, this objective is not achieved under the Full Entitlement scenario, for any of the seasons, while under the 'With Dam' scenario this objective is achieved for two of the three seasons. This is primarily due to the release of water to supply the new high priority users downstream of Beckers, which elevates the low flows in this region.

**Table 14-18 Seasonal baseflow objectives for the Dawson River**

| Season | Non-mandatory objective | Nathan Gorge (EFO node 5) | | D/S Theodore (EFO node 4) | | Beckers (EFO node 2) | |
|---|---|---|---|---|---|---|---|
| | | Full Entitlement | 'With Dam' scenario | Full Entitlement | 'With Dam' scenario | Full Entitlement | 'With Dam' scenario |
| Jan - Apr | 0.8 – 1.2 | 0.9 | 1.0 | 0.8 | 0.9 | 0.7 | 0.8 |
| May - Aug | 0.8 – 1.2 | 1.1 | 1.3 | 1.1 | 1.5 | 0.7 | 0.7 |
| Sep - Dec | 0.8 – 1.2 | 1.3 | 1.4 | 1.0 | 1.5 | 0.6 | 0.8 |

**Table 14-19 Seasonal baseflow objectives for the Fitzroy River**

| Season | Non-mandatory objective | D/S of Eden Bann Weir (EFO node 1) | | Fitzroy Barrage outflow (EFO node 0) | |
|---|---|---|---|---|---|
| | | Full Entitlement | 'With Dam' scenario | Full Entitlement | 'With Dam' scenario |
| Jan - Apr | 0.8 – 1.2 | 1.0 | 1.0 | 0.8 | 0.8 |
| May - Aug | 0.8 – 1.2 | 1.0 | 1.0 | 0.7 | 0.7 |
| Sep - Dec | 0.8 – 1.2 | 1.0 | 1.0 | 0.6 | 0.6 |

#### *14.1.4.3. Impacts to the flow regime*

The following section presents statistics describing the flow regime of the Pre-development, Full Entitlement (current development) and 'With Dam' scenarios.

Key findings can be summarised as follows:

- There will be a range of impacts on the flow regime along the Dawson River due to the operation of Nathan Dam and the integration of the DVWSS into one operational scheme.
- Changes to the flow regime generally decrease with distance downstream from the dam, as flow from additional tributaries enters the river. Downstream of the Boolburra waterhole (approximately 297 km downstream of the dam) the flow regime has returned to close to what it was under the Full Entitlement scenario.
- Impacts to the flow regime directly downstream of the dam (at Nathan Gorge) can be categorised as follows:
    - Low flows – the low flow range (0 to 50 ML/d) will return to near pre-development levels due to the low flow release strategy adopted for the fishway and turtleway operations. This is expected to improve instream connectivity and water quality, as well as increasing the opportunities for fish movement;
    - Low to Medium flows – flows in this range (50 to 300 ML/d) are reduced for approximately 25% of the time;
    - Medium flows - the medium flow range (300 to 2,000 ML/d) is slightly elevated;

   - Medium to High flows – flows in this range (2,000 to 30,000 ML/d) will be moderately reduced;
   - High flows - the high flow range (flows over 30,000 ML/d) will not change significantly;
- Overall flow volume – the overall flow volume (on an annual basis) will decrease; and
- The Project will have minimal impacts on flow regimes in the Fitzroy River, downstream of the Dawson River.

Flow statistics are reported at the locations listed in **Table 14-20**.

### Table 14-20 Reporting locations

| River | Location | AMTD (km) |
|---|---|---|
| Dawson River | Nathan Gorge (EFO node 5) | 307.2 |
| | D/S Theodore (EFO node 4) | 228.5 |
| | Beckers (EFO node 2) | 71.0 |
| | End of Dawson River | 0 |
| Fitzroy River | Eden Bann Weir (inflow) | 143.0 |
| | Fitzroy River immediately D/S of Eden Bann Weir (EFO node 1) | 141.2 |
| | Fitzroy Barrage (inflow) | 115.0 |
| | Fitzroy Barrage outflow (EFO node 0) | 59.6 |

One submission questioned the location of EFO node 4, as referred to in the EIS.

While the 2011 Fitzroy WRP specifies EFO node 4 at AMTD 228.5 km the reporting location used within the model is actually the downstream Woodleigh gauge (AMTD 193.6 km). This gauge represents the Theodore weir tailwater flow (i.e. water released or spilled from the weir) and is considered to provide the best representation of flows in the Dawson River immediately downstream of Theodore Weir (C. Musgrove, DSITIA, personal communication 19/11/2012). As the 1999 Fitzroy WRP did not identify an AMTD for the majority of nodes, these were inferred from the gauge locations used to calculate the EFO statistics, as defined in the IQQM. This does not affect the accuracy of the results presented in the EIS.

**Annual flow statistics**

**Table 14-21** and **Table 14-22** present the mean and median annual flows at the reporting locations. The impacts to the mean annual flow reflect the change to the overall flow volumes, while the median annual flow, which is the flow equalled or exceeded in 50% of years, reflects the change to high and low flow distribution. That is, an increase in median annual flow reflects an increased number of high flow years, while a decrease in median annual flow reflects an increase in the number of low flow years.

With Nathan Dam in place the mean annual flow on the Dawson River is expected to decrease in the range of 29% to 13%, with the level of impact decreasing with distance from the dam, as tributaries contribute to the main stream. On the Fitzroy River the mean annual flow will decrease by 3%. The much lower level of impact on the Fitzroy River reflects the significant contribution of flow made by the Nogoa Mackenzie catchment, relative to the volumetric impact made by Nathan Dam.

Median annual flow is expected to decrease in the range of 57% to 16% on the Dawson River, reflecting the increased occurrence of years of lower flow volumes. Again, the level of impact decreases with distance from the dam. However, on the Fitzroy River the change to median annual flow increases with distance downstream. This is primarily caused by changes to the behaviour of Eden Bann Weir and Fitzroy Barrage, regulating the flow regime downstream of Eden Bann Weir, and increasing the number of years of lower flow compared to the Full Entitlement scenario.

**Table 14-21 Fitzroy catchment modelled mean annual flow (GL/a)**

| Location | Pre-development | Full Entitlement | 'With Dam' scenario | | |
|---|---|---|---|---|---|
| | | | (GL/a) | % change from Pre-development | % change from Full Entitlement |
| Nathan Gorge (EFO node 5) | 597 | 568 | 403 | -33% | -29% |
| D/S Theodore (EFO node 4) | 715 | 646 | 486 | -32% | -25% |
| Beckers (EFO node 2) | 1,028 | 899 | 729 | -29% | -19% |
| End of Dawson River | 1,569 | 1,392 | 1,212 | -23% | -13% |
| Eden Bann Weir (inflow) | 5,737 | 4,984 | 4,817 | -16% | -3% |
| Fitzroy Barrage (inflow) | 5,977 | 5,173 | 5,006 | -16% | -3% |
| Estuary (Fitzroy Barrage outflow – EFO node 0)* | 5,977 | 5,066 | 4,900 | -18% | -3% |

*Flows at the Estuary represent freshwater inflows only

**Table 14-22 Fitzroy catchment modelled median annual flow statistics (GL/a)**

| Location | Pre-development | Full Entitlement | 'With Dam' scenario | | |
|---|---|---|---|---|---|
| | | | (GL/a) | % change from Pre-development | % change from Full Entitlement |
| Nathan Gorge (EFO node 5) | 310 | 284 | 122 | -61% | -57% |
| D/S Theodore (EFO node 4) | 399 | 318 | 170 | -57% | -47% |
| Beckers (EFO node 2) | 588 | 420 | 296 | -50% | -29% |
| End of Dawson River | 874 | 695 | 584 | -33% | -16% |
| Eden Bann Weir (inflow) | 2,886 | 2,080 | 2,016 | -30% | -3% |
| Fitzroy Barrage (inflow) | 2,974 | 2,235 | 2,030 | -32% | -9% |
| Estuary (Fitzroy Barrage outflow – EFO node 0)* | 2,974 | 2,129 | 1,924 | -35% | -10% |

*Flows at the Estuary represent freshwater inflows only

### Daily flow duration curves

The following figures (**Figure 14-1** to **Figure 14-7**) present the daily flow duration curves at the reporting locations. These curves show the percentage of days that flow rates may be expected to be equalled or exceeded, at each location. Impacts are discussed in terms of changes to parts of the flow regime, i.e. low, medium or high flows, where each flow range has ecological or water supply significance. The ecological significance of changes to the flow regime was discussed in Chapter 13 of the EIS.

These figures show that while there are some definite changes to the flow regime at the reporting locations on the Dawson River, the flow regime at the reporting locations on the Fitzroy River remains largely unchanged.

Due to the operation of the Nathan Dam fishway and turtleway, as well as water supply releases, flows less than 100 ML/d along the Dawson River are generally elevated, compared to the Full Entitlement scenario. The low flow range is also slightly elevated above Pre-development conditions, however; it should be noted that the log scale used on the following figures tends to exaggerate the impact at the lower end of the scale. For example, at Nathan Gorge the 80$^{th}$ percentile flow under Pre-development conditions is 3 ML/d, increasing to 6 ML/d with the dam in place. This equates to a change of approximately 1-2 cm depth of flow within the channel.

The change to the low flow range is expected to improve instream connectivity and water quality, as well as increasing the opportunities for fish movement between pools.

At Beckers (**Figure 14-3**) the daily flow duration curve shows elevated low flows (29 to 44 ML/d) for approximately 62% of the simulation period. This is primarily due to the supply of new HP water at Duaringa, downstream of Beckers. This water is extracted before the end of the Dawson River, with the flow duration curve moving towards pre-development conditions at this location (**Figure 14-4**).

Flows in the low to medium flow range (50 to 300 ML/d), are moderately impacted under the 'With Dam' scenario at Nathan Gorge (**Figure 14-1**), affecting the flow regime for approximately 25% of the time. Flows below this range are maintained through the low flow release and fishway operation. Flows above this range are altered through flow captured by the dam, generally reducing the peak flow level or the duration of the event.

However, downstream of Nathan Gorge flows in this range are not as consistently impacted. This flow range is increased downstream of Theodore (**Figure 14-2**), primarily due to the seasonal baseflow release, releases to Moura Weir from Theodore Weir, and tributary inflows.

The 'steps' observed in the daily flow duration curves at Nathan Gorge, Theodore and Beckers indicate that the system will experience increased regulation. This is particularly evident at Beckers, where the releases from Neville Hewitt weir sustain low flows at Beckers, providing the high reliability water supply downstream of this location.

Medium to high flows, in the 2,000 to 30,000 ML/d range, are moderately impacted in the 'With Dam' scenario. This range generally covers flushing flows through to half bankfull flows in this reach. This is particularly evident at Nathan Gorge as these flows are generally captured by the dam; however, these impacts decrease at downstream locations. Flows above 30,000 ML/d usually occur as part of a large flood event, when the dam receives enough inflow to fill. The larger flows therefore pass through the storage with minimal loss of volume.

By the end of the Dawson River (**Figure 14-4**) the flow regime has moved closer to pre-development conditions, compared to the upstream reporting site at Beckers. Low flows are slightly elevated, below 60 ML/d, and higher flows are slightly reduced, compared to the Full Entitlement scenario. This is primarily due to inflows from the Don River catchment. The impacts of the dam on flows in the Lower Fitzroy River (**Figure 14-5** to **Figure 14-7**) are minor, and are strongly influenced by inflows from the larger Nogoa-Mackenzie catchment.

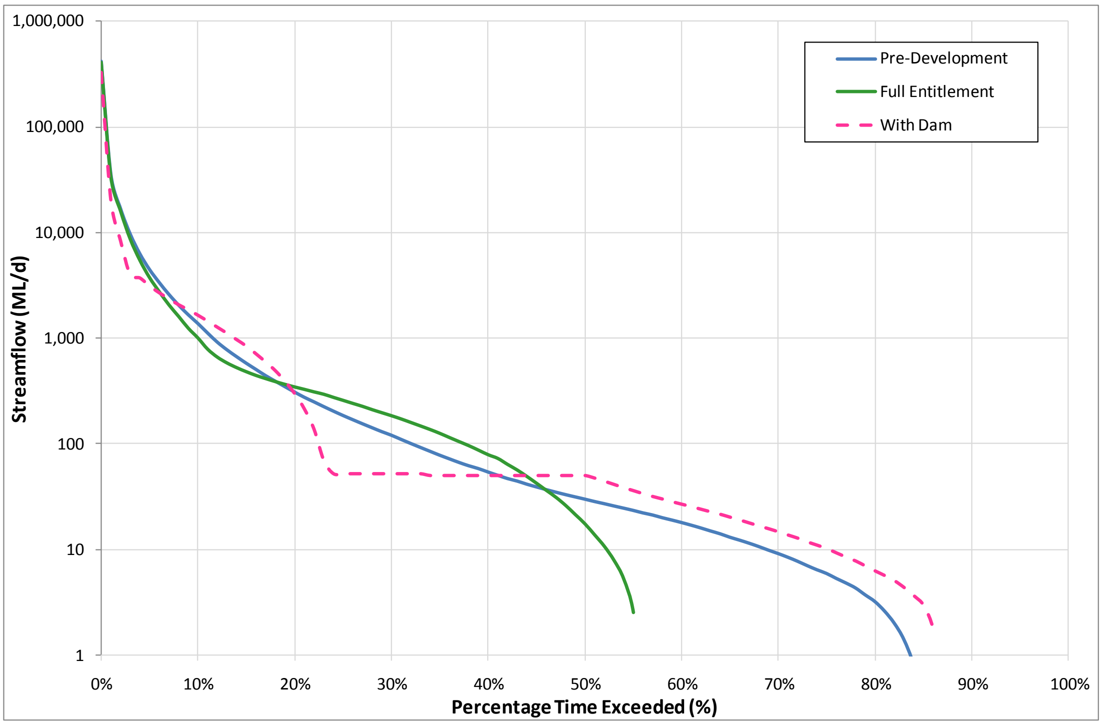



**Figure 14-1 Dawson River at Nathan Gorge daily flow duration curve**

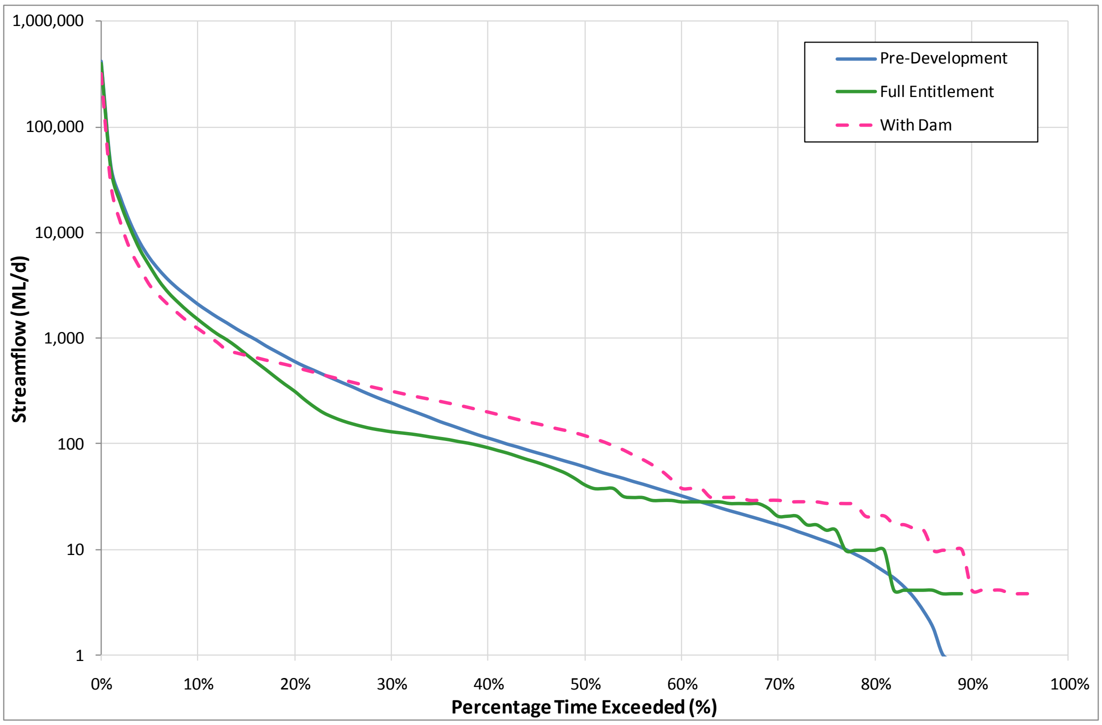



**Figure 14-2 Dawson River D/S Theodore daily flow duration curve**

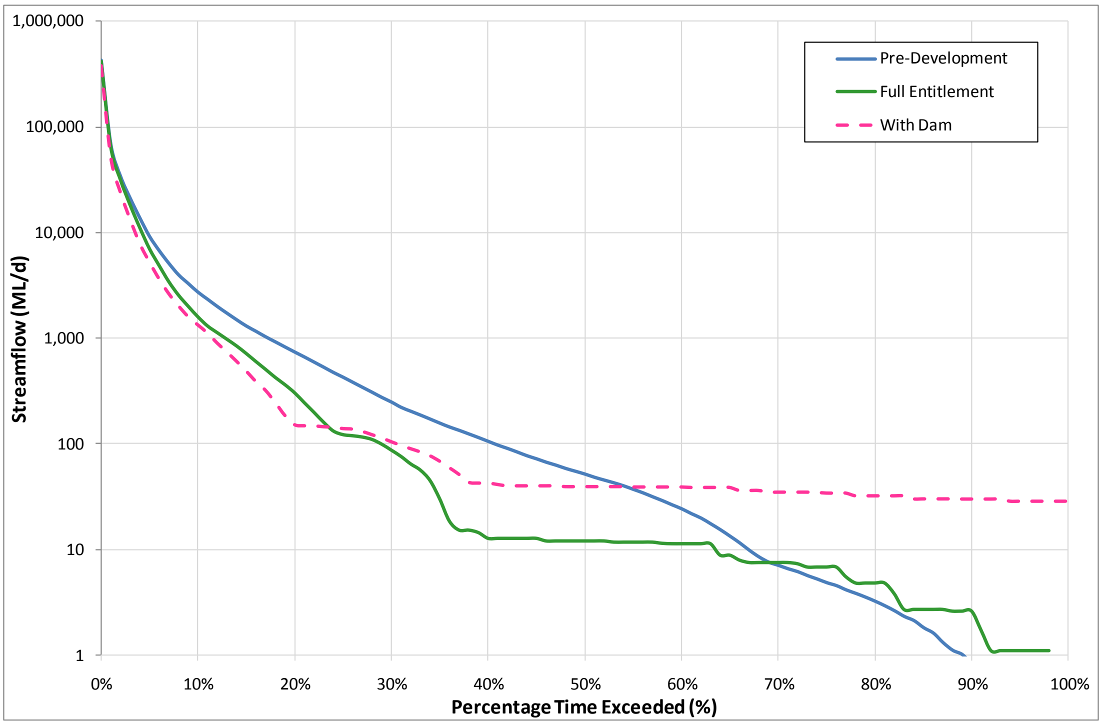



**Figure 14-3 Dawson River at Beckers daily flow duration curve**

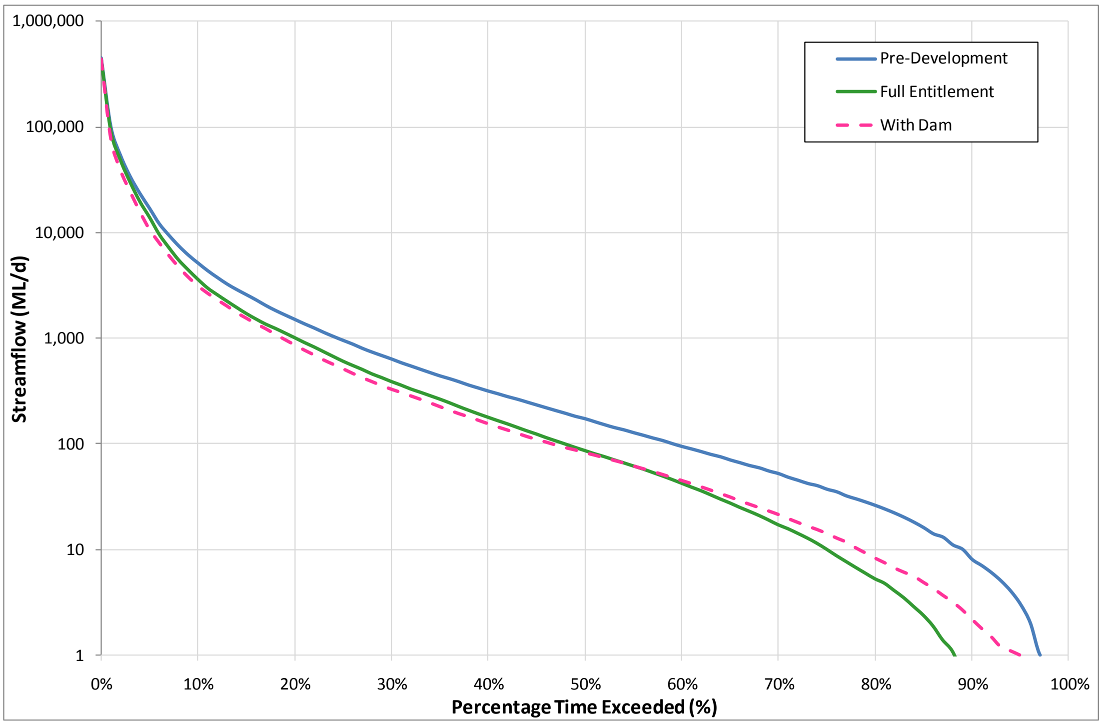



**Figure 14-4 End of Dawson River daily flow duration curve**

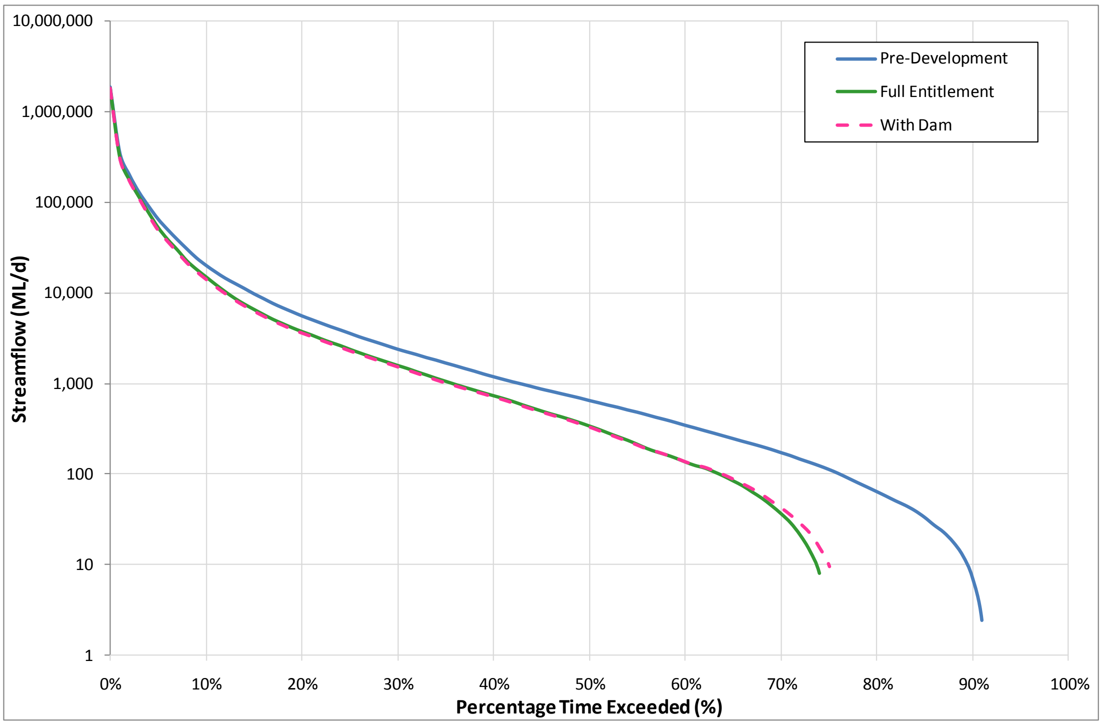



**Figure 14-5 Fitzroy River inflow to Eden Bann Weir daily flow duration curve**

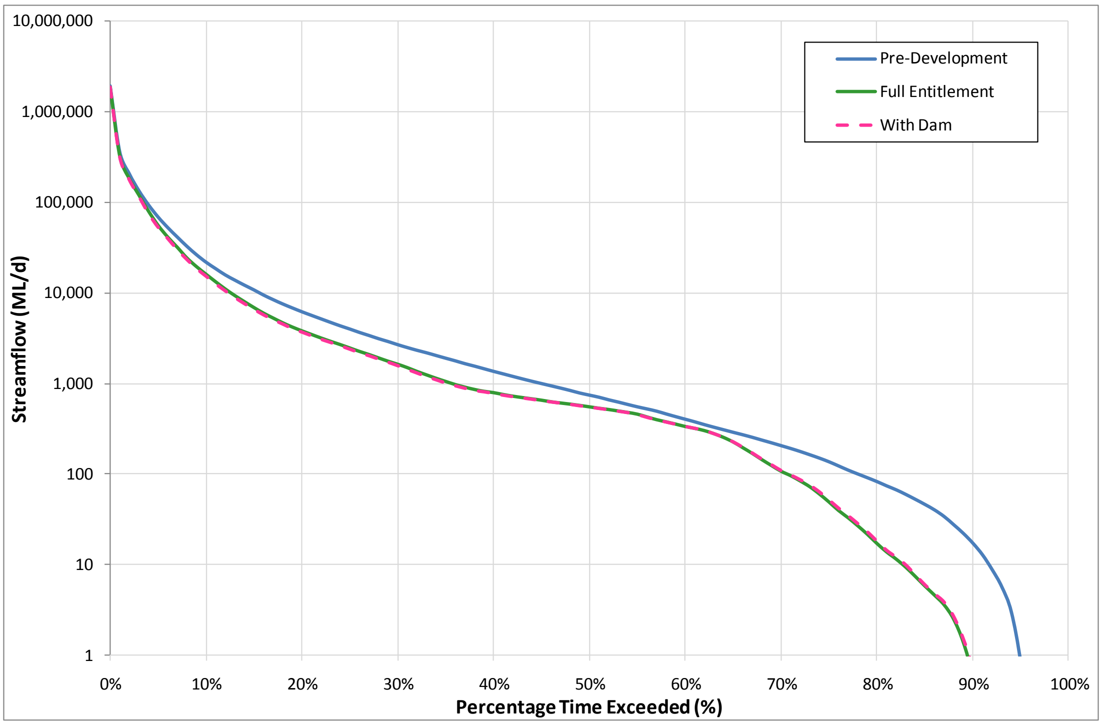



**Figure 14-6 Fitzroy River inflow to Barrage daily flow duration curve**

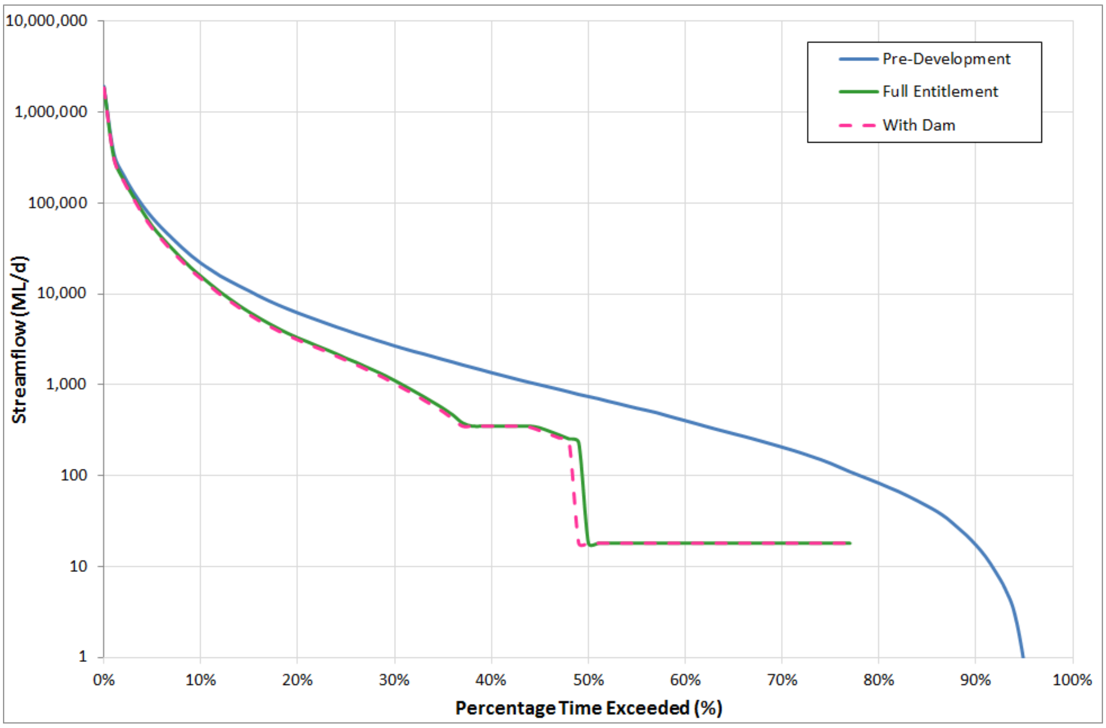



**Figure 14-7 Fitzroy River at end of system daily flow duration curve**

**Nathan Dam storage behaviour**

**Figure 14-8** presents the modelled storage trace for Nathan Dam. The critical period for the dam operation occurs in 1969, where the dam volume approaches its minimum operating volume (MOV) for approximately 6 months. This is the same critical period identified using the previous WRP model. While more recent data has been included in the new WRP model (01/01/1996 to 31/12/2007) and flows during this period are low, the severity of the drought was not worse than the 1969 critical period, in terms of dam operations and long term yield. The storage is also quite low for an extended period during 1903, although it does not reach the MOV during this drought period, or at all during the simulation period.

Gauged streamflow data at Taroom and Glebe Weir indicates that a moderate wet season occurred in 2007/8, followed by a low wet season in 2008/9. Total inflows for these periods were approximately twice that of the 2005/6 and 2006/7 wet seasons, respectively. High flows after the drought period did not occur until the 2009/10 wet season. This indicates that, were the Nathan Dam modelling extended past 2007, the dam storage trace would show a similar pattern of behaviour as during 2005-2007 for two years (although at a higher level), followed by a significant jump in storage volume from the start of 2010. The dam is likely to have spilled in February or March 2010, when the combined flow at Taroom over these months was approximately one and a half times the capacity of the dam.

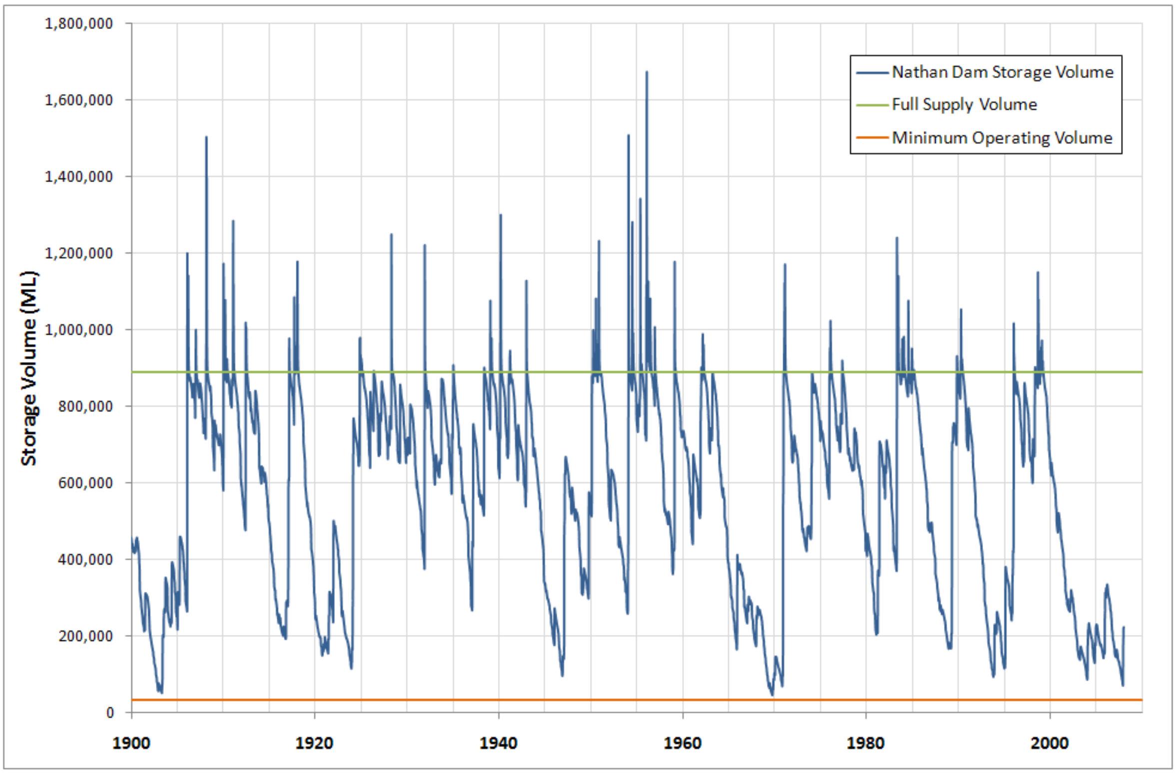



**Figure 14-8 Nathan Dam modelled storage trace**

**Figure 14-9** presents the Nathan Dam modelled daily storage volume exceedance curve, while **Figure 14-10** presents the Nathan Dam modelled daily storage elevation exceedance curve. These figures present the percentage of time that the storage is expected to equal or exceed a given volume/elevation.

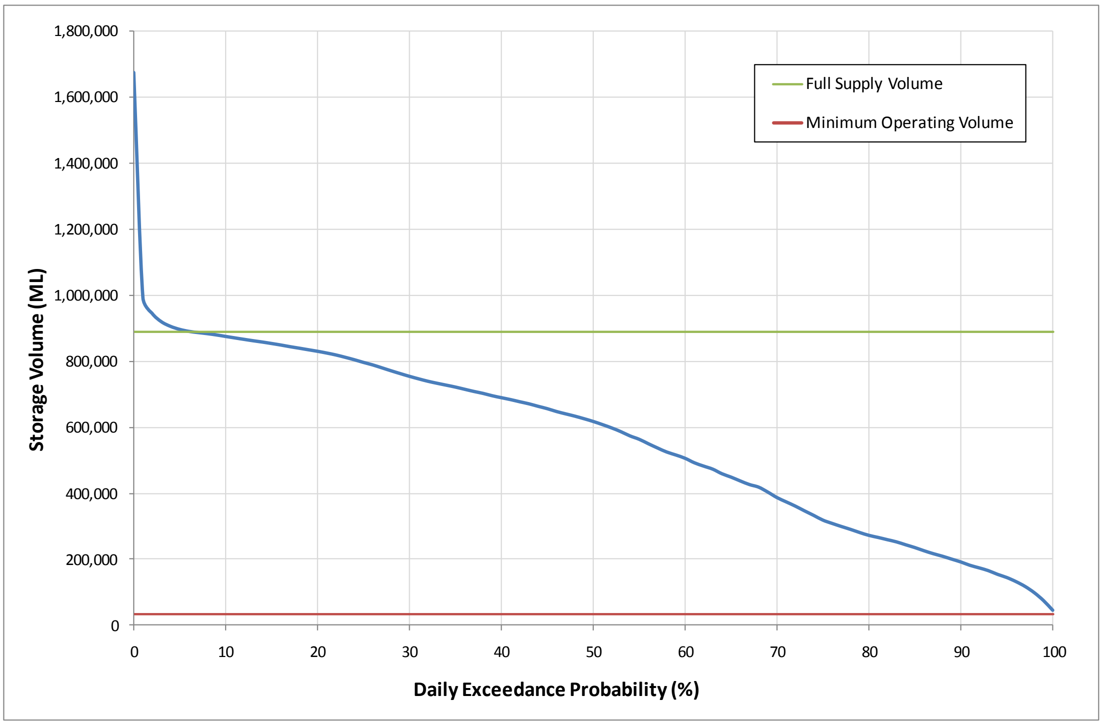



**Figure 14-9 Nathan Dam modelled storage exceedance curve (storage volume)**

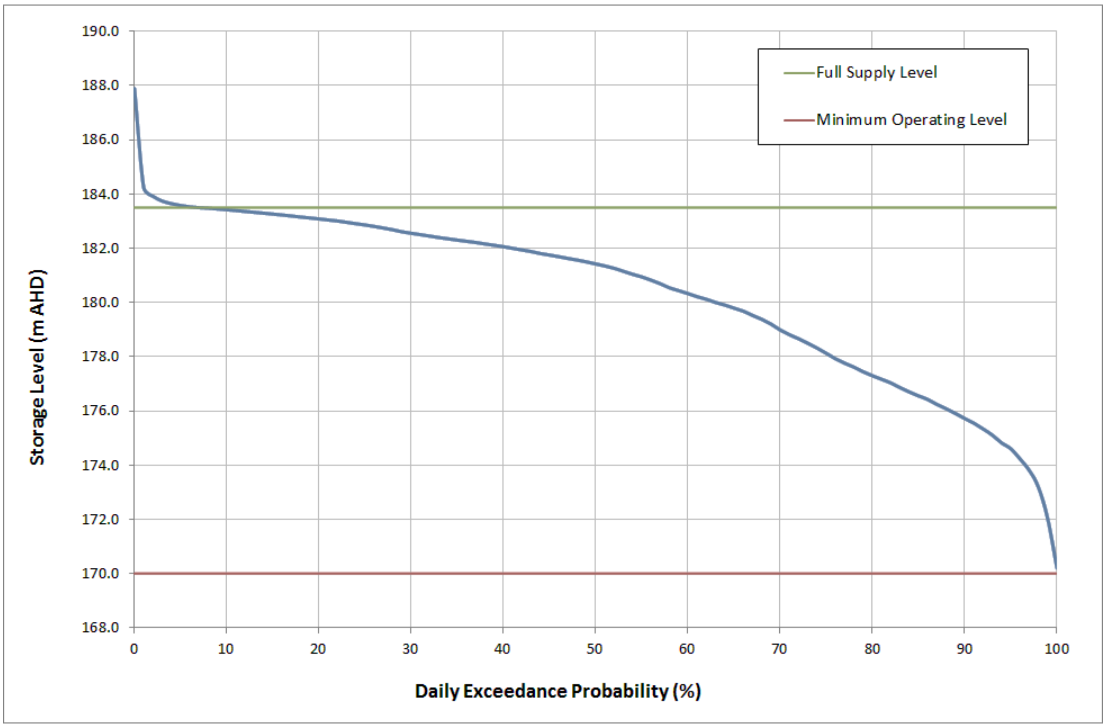



**Figure 14-10 Nathan Dam modelled storage exceedance curve (storage elevation)**

#### *14.1.4.4. Water allocation security objectives*

The WRP specifies water allocation security objectives (WASOs) for high priority, medium priority and unsupplemented allocation groups on the Dawson and Fitzroy Rivers, where compliance is measured at a group level. This section presents group WASO compliance, while the subsequent **Section** (**14.1.4.5**) presents the impacts to individual users.

**Table 14-23** presents the WASO compliance for the supplemented user groups on the Dawson and Fitzroy Rivers. All of the supplemented user groups achieve their compliance objectives, under both the Full Entitlement and 'With Dam' scenarios. Overall, user groups in the DVWSS are advantaged under the 'With Dam' scenario, while the compliance of the user groups on the Fitzroy River is not affected.

**Table 14-23 High priority and medium priority WASO compliance – monthly/annual reliability of supply**

| | Mandatory Objectives | | Full Entitlement | | 'With Dam' Scenario | |
|---|---|---|---|---|---|---|
| | Monthly Reliability (%) | Annual Reliability (%) | Monthly Reliability (%) | Annual Reliability (%) | Monthly Reliability (%) | Annual Reliability (%) |
| **High Priority** | | | | | | |
| Dawson Valley WSS | ≥98 | ≥95 | 100 | 98 | 100 | 100 |
| Lower Fitzroy WSS & Fitzroy Barrage WSS | ≥98 | ≥94 | 99 | 94 | 99 | 94 |
| **Medium Priority** | | | | | | |
| Dawson Valley WSS | ≥82 | | 83 | | 89 | |
| Lower Fitzroy WSS & Fitzroy Barrage WSS | ≥82 | | 93 | | 93 | |

**Table 14-24** presents the annual volume probability (AVP) for the unsupplemented irrigator groups downstream of Nathan Dam. The annual volume probability is the percentage of years that the diversion is at least the nominal volume (calculated on an annual basis). For the unsupplemented AVP the calculation adopts the mean annual diversion as the nominal volume.

For the user groups on the Dawson River the AVP is met for all groups under the Full Entitlement scenario. However, under the 'With Dam' scenario only two of the groups are compliant. The largest reduction, in terms of percentage impact to mean annual diversions, occurs in Class 12A, the users located between the upstream limit of Glebe Weir and Orange Creek Weir. On the Fitzroy River, the level of compliance is not affected, although the AVP does drop slightly for two of the groups (Class 5A and Class 5B).

**Table 14-24 Unsupplemented irrigation (Dawson and Fitzroy Rivers) – annual volume probability (AVP)**

| River | Water Allocation Group | Mandatory objective | Full Entitlement | | 'With Dam' Scenario | |
|---|---|---|---|---|---|---|
| | | | Mean Annual Diversion (ML/a) | AVP (%) | Mean Annual Diversion (ML/a) | AVP (%) |
| Dawson River | Class 12A | ≥ 63% | 1,209 | 68 | 795 | 44 |
| | Class 11A | ≥ 63% | 20,008 | 66 | 17,466 | 59 |
| | Class 11B | ≥ 60% | 4,090 | 64 | 3,187 | 51 |
| | Class 10A | ≥ 68% | 10,762 | 72 | 9,998 | 68 |
| | Class 10B | ≥ 68% | 9,894 | 72 | 8,477 | 59 |
| | Class 10C | ≥ 66% | 97 | 99 | 97 | 100 |
| Fitzroy River | Class 5A | ≥ 61% | 36,323 | 66 | 35,677 | 64 |
| | Class 5B | ≥ 73% | 8,258 | 82 | 8,131 | 78 |
| | Class 6C | ≥ 95% | 8,049 | 100 | 8,049 | 100 |
| | Class 7D | ≥ 93% | 4,277 | 99 | 4,274 | 99 |

**Reliability of new water products**

**Table 14-25** presents the mean annual diversions, and monthly and annual reliability of supply of the new Nathan Dam high priority water products. These products have a combined allocation volume of 66,011 ML/a and an expected mean annual diversion of 65,852 ML/a[1]. Each of the new users achieves 100% monthly and annual reliability of supply.

[1] IQQM calculates daily demand based on a 366 day water year, which means that in three out of every four years one day of demand will be missing. The reported MAD will therefore be lower than the licence volume, even when reliability is reported as 100%. The exception to this occurs when the demand is close to 1 ML/d; in this case the model may demonstrate a small rounding error, related to resolving the calculation of small volumes of water.

**Table 14-25 New high priority water (Dawson River) – reliability of supply and mean annual diversions**

| | Allocation volume (ML/a) | 'With Dam' Scenario | | |
|---|---|---|---|---|
| | | Mean Annual Diversion (ML/a) | Monthly Reliability (%) | Annual Reliability (%) |
| Zone M – Urban/industrial | 47,700 | 47,591 | 100.0 | 100.0 |
| Zone J – Urban/industrial | 750 | 731 | 100.0 | 100.0 |
| Zone I – Urban/industrial | 400 | 402 | 100.0 | 100.0 |
| Zone G – Urban/industrial | 7,092 | 7,086 | 100.0 | 100.0 |
| Zone D – Urban/industrial | 2,269 | 2,265 | 100.0 | 100.0 |
| Zone B – Urban/industrial | 7,800 | 7,779 | 100.0 | 100.0 |
| **Total** | **66,011** | **65,852** | | |

#### *14.1.4.5. Impacts to existing users*

The following section presents a summary of the predicted impacts on existing water users on the Dawson River. Impacts have been assessed in terms of changes to mean annual diversions, reliability and seasonality of supply.

**High Priority**

**Table 14-26** presents the reliability of supply and mean annual diversions for existing high priority users (town water supplies and industrial users) on the Dawson River. Under the 'With Dam' scenario the monthly and annual reliability increases to 100% for all users. While this represents a significant jump in terms of reliability of supply it actually only represents an additional 24 ML/a of mean annual diversions. Under the original modelling for the EIS high priority users were also supplied at 100% monthly reliability.

SunWater acknowledges that supplying water to urban communities on the basis of Historical No Fail Yield (HNFY) does not guarantee supply under any future drought conditions. A contingency plan approach will be considered in discussion with DEWS, DNRM and relevant local authorities to ensure that urban communities retain sufficient water supply to meet essential human needs in line with the level of service parameters adopted by the communities in question.

**Table 14-26 High priority water (Dawson River) – reliability of supply and mean annual diversions (existing users)**

| | Allocation volume (ML/a) | Full Entitlement | | | 'With Dam' Scenario | | |
|---|---|---|---|---|---|---|---|
| | | Mean Annual Diversion (ML/a) | Monthly Reliability (%) | Annual Reliability (%) | Mean Annual Diversion (ML/a) | Monthly Reliability (%) | Annual Reliability (%) |
| Zone K - Urban | 400 | 402 | 100.0 | 100.0 | 402 | 100.0 | 100.0 |
| Zone I - Urban | 262 | 253 | 98.4 | 94.4 | 256 | 100.0 | 100.0 |
| Zone I - Distribution losses | 600 | 587 | 98.4 | 94.4 | 594 | 100.0 | 100.0 |
| Zone G - Urban | 3,319 | 3,315 | 99.6 | 98.1 | 3,324 | 100.0 | 100.0 |
| Zone D - Urban | 648 | 655 | 99.5 | 97.2 | 657 | 100.0 | 100.0 |
| Zone B - Urban | 350 | 362 | 99.3 | 96.3 | 365 | 100.0 | 100.0 |
| **Total** | **5,579** | **5,574** | | | **5,598** | | |

**Medium Priority**

**Table 14-27** presents the impact to mean annual diversions for medium priority irrigator groups on the Dawson River. Monthly reliability varies considerably under the Full Entitlement scenario (83.3% to 90.3%), but is much more consistent under the 'With Dam' scenario (88.4% to 89.3%). This consistency of supply between the different users represents an increase in equity within the system, and is one of the advantages of the dam and the operation of the DVWSS as a single scheme.

Under the original modelling for the EIS medium priority irrigators were estimated to achieve a total mean annual diversion of 46,250 ML/a under Full Entitlement conditions, increasing to 47, 513 under the 'With Dam' scenario. This represents an overall increase of 3%.

Using the new WRP model (**Table 14-27**) medium priority irrigators are estimated to achieve a total mean annual diversion of 50,147 ML/a under Full Entitlement conditions, an increase of approximately 3,900 ML/a compared to the previous WRP model. Under the 'With Dam' scenario the total mean annual diversion is not significantly altered, at 50,144 ML/a, and is still in excess of the total mean annual diversion under both the Full Entitlement and 'With Dam' scenarios calculated using the original WRP model.

**Table 14-27 Medium priority irrigation (Dawson River) – monthly reliability and mean annual diversions**

| Sub-scheme | Management Zones | Allocation volume | Full Entitlement | | 'With Dam' Scenario | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean Annual Diversion | Monthly Reliability | Mean Annual Diversion | Monthly Reliability | Change to Mean Annual Diversion | |
| | | (ML/a) | (ML/a) | (%) | (ML/a) | (%) | (ML/a) | (%) |
| Upper Dawson | Dawson M | 1,160 | 1,008 | 83.8 | 1,030 | 88.8 | 22 | 2.2% |
| | Dawson K | 2,500 | 2,172 | 83.9 | 2,220 | 88.8 | 48 | 2.2% |
| | Dawson J | 5,850 | 5,082 | 83.3 | 5,190 | 88.8 | 109 | 2.1% |
| | Dawson I – Med A | 3,405 | 3,135 | 90.3 | 3,048 | 89.3 | -87 | -2.8% |
| | | 15,904 | 14,620 | 90.3 | 14,218 | 89.3 | -402 | -2.7% |
| | Dawson I | 1,974 | 1,716 | 83.6 | 1,754 | 88.8 | 38 | 2.2% |
| | Dawson H | 6,384 | 5,550 | 83.3 | 5,655 | 88.8 | 105 | 1.9% |
| | Dawson G | 8,536 | 7,419 | 83.3 | 7,583 | 88.8 | 164 | 2.2% |
| | Dawson E | 3,357 | 2,920 | 83.5 | 2,973 | 88.8 | 53 | 1.8% |
| Lower Dawson | Dawson D | 4,661 | 4,176 | 88.5 | 4,140 | 88.8 | -36 | -0.9% |
| | Dawson C | 1,942 | 1,740 | 88.3 | 1,728 | 88.8 | -13 | -0.7% |
| | Dawson B | 685 | 609 | 88.1 | 605 | 88.4 | -4 | -0.7% |
| | **Total** | **56,358** | **50,147** | | **50,144** | | **-2.2** | **0.0%** |

**Unsupplemented Users**

**Table 14-28** presents the impact to mean annual diversions for waterharvester groups on the Dawson River. These users have high pumping thresholds (1,296 ML/d or 2,592 ML/d), and are affected by the changing peak or duration of high flow events.

Under the original modelling for the EIS unsupplemented users achieved a total mean annual diversion of 66,939 ML/a under Full Entitlement conditions, reducing to 60,067 under the 'With Dam' scenario, an overall decrease of 10%. The highest impacts were seen in zones K, I, H, G and F (-20% to -26%), while other zones experienced a reduction of mean annual diversions of 0% to 10%.

Under the new WRP model the total mean annual diversions for unsupplemented users drops by 20,879 ML/a (or one third), under Full Entitlement conditions, compared to the previous WRP model. The differences between the two models reflect the changes made by DNRM to the model calibration and configuration, as well as the redistribution of entitlements, intended to more accurately represent existing licence locations and conditions.

Overall, mean annual diversions by unsupplemented irrigators are expected to reduce by approximately 6,040 ML/a, or 13%, with the dam in place. The highest impact is seen in zone M, the next highest impacts are seen in zones K, G, and F which experience a reduction of 21% to 27%. Other zones experience a reduction of mean annual diversions of 0% to 15%.

Although there is a substantial change in the total mean annual diversions between the two WRP models, the relative impact of the dam operations on waterharvesters diversions does not change significantly.

### Table 14-28 Unsupplemented irrigation (Dawson River) – mean annual diversions

| Sub-scheme | Management Zones | Full Entitlement | 'With Dam' Scenario | | |
|---|---|---|---|---|---|
| | | Mean Annual Diversion | Mean Annual Diversion | Change to Mean Annual Diversion | |
| | | (ML/a) | (ML/a) | (ML/a) | (%) |
| Upper Dawson | Dawson M | 304 | 133 | -171 | -56% |
| | Dawson K | 905 | 662 | -243 | -27% |
| | Dawson J | 7,504 | 6,697 | -807 | -11% |
| | Dawson I | 2,058 | 1,813 | -245 | -12% |
| | Dawson H | 8,151 | 7,150 | -1,001 | -12% |
| | Dawson G | 5,303 | 4,179 | -1,124 | -21% |
| | Dawson F | 1,082 | 813 | -269 | -25% |
| | Dawson E | 3,180 | 3,103 | -77 | -2% |
| Lower Dawson | Dawson D | 6,856 | 6,235 | -621 | -9% |
| | Dawson C | 1,735 | 1,620 | -115 | -7% |
| | Dawson B +A | 8,885 | 7,518 | -1,368 | -15% |
| | Dawson A | 97 | 97 | 0 | 0% |
| | **Total** | **46,060** | **40,021** | **-6,040** | **-13%** |

**Impact to seasonality of diversions**

*Medium Priority*

The following section presents a number of figures in order to illustrate the impacts to the seasonality of medium priority irrigation diversions. The results of the Full Entitlement and 'With Dam' scenarios are compared for the change in volume that is diverted in the median number of months, and in wet and dry periods. The figures show the following series[2]:

- Median – the volume diverted in 50% of months;
- 20th percentile – the volume diverted in the 20th percentile of months (dry months); and
- 80th percentile – the volume diverted in the 80th percentile of months (wet months).

The medium priority irrigators all have the same general pattern of demand; with two peaks and two troughs during the year. There is a peak in demand during July to September, for early irrigation, and again in December and January, during the main irrigation period.

[2] Note that in the figures below, where no column is present this indicates that no diversions occur during that month

On a monthly basis, impacts to medium priority irrigation are generally minor for the 'With Dam' scenario, under median and wet conditions, and across all zones.

However, under dry conditions (20th percentile), moderate to high impacts can be seen with the pattern of impact differing between the Upper and Lower Dawson zones. In the Upper Dawson (zones M to E) there is generally an increase in diversions from October to January. (Although the Medium A irrigators in zone I only receive an increase during October, and in zones H and E there is also a small decrease during June and July.) However, in the Lower Dawson (zones D, C and B) there is a decrease in diversions during November and December, and an increase in diversions in January.

The changes seen in the 20th percentile results reflect the influence of the dam in providing increased water supply security during dry conditions, particularly for high priority water, as well as the changing operations of the Dawson Valley Water Supply Scheme.

a) b)

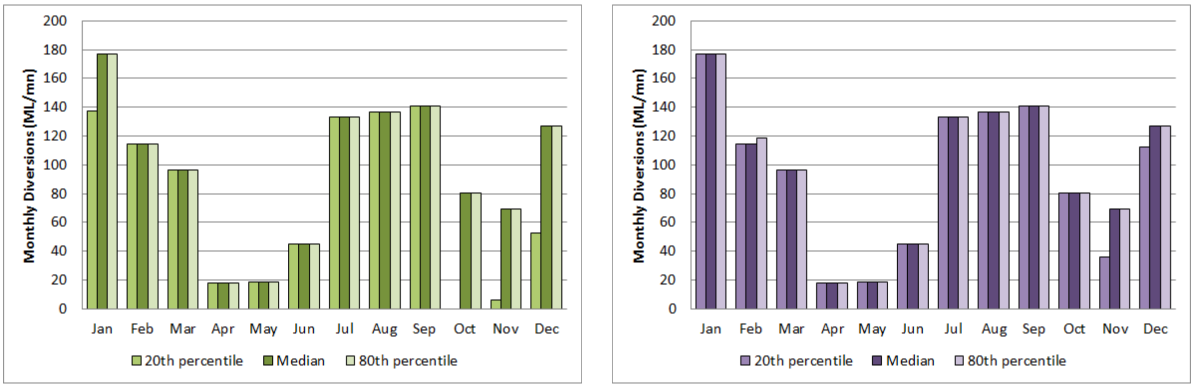



**Figure 14-11 Zone M: seasonal impacts to medium priority irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

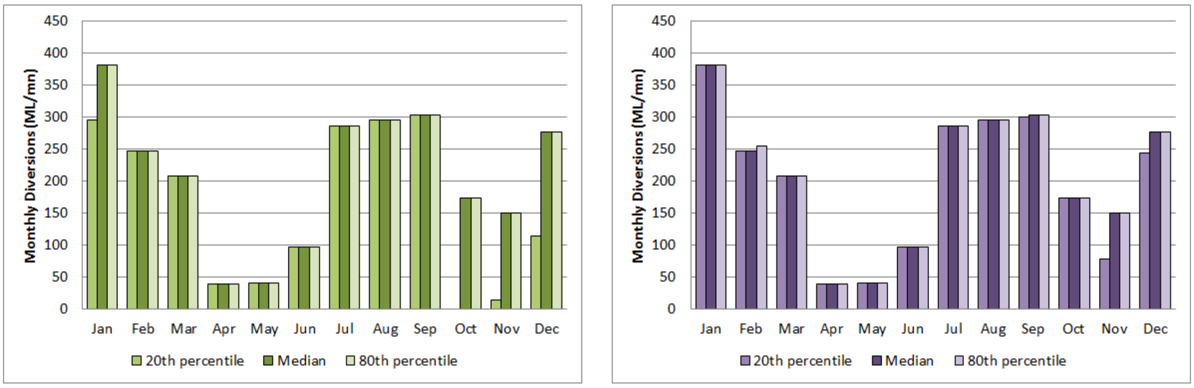



**Figure 14-12 Zone K: seasonal impacts to medium priority irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

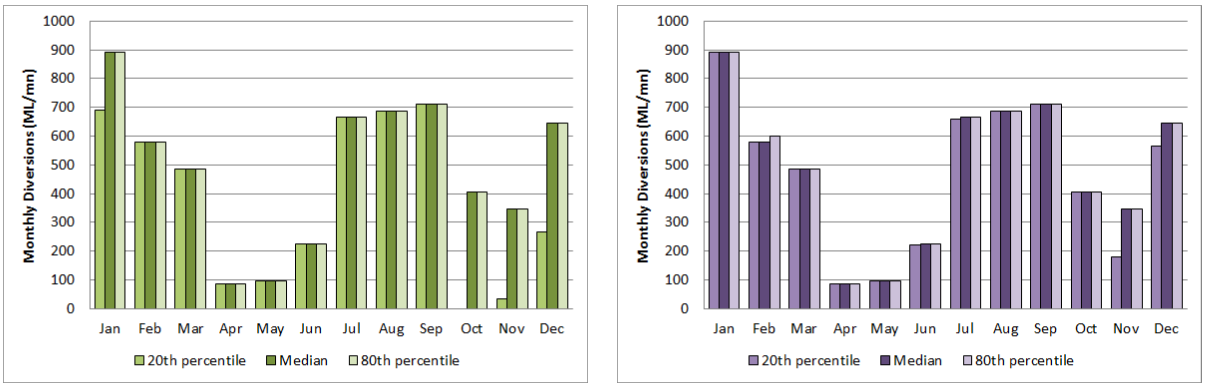



**Figure 14-13 Zone J: seasonal impacts to medium priority irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

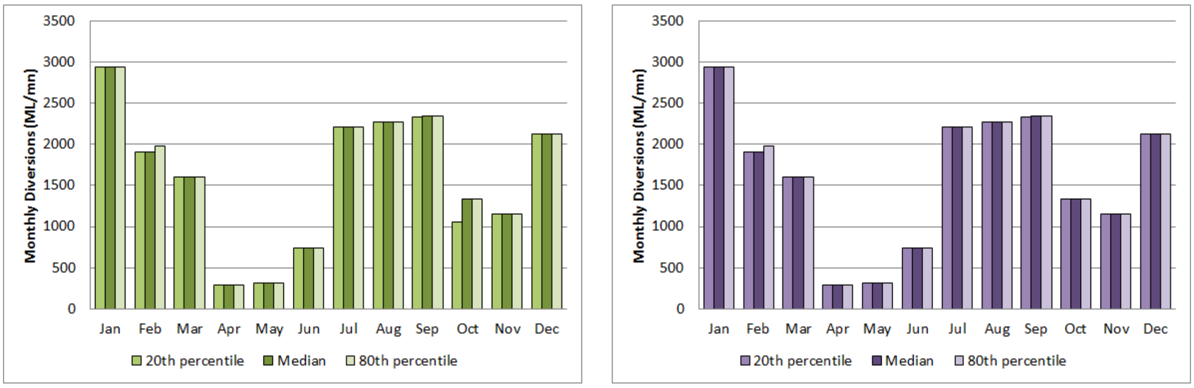



**Figure 14-14 Zone I (Medium A): seasonal impacts to medium priority irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

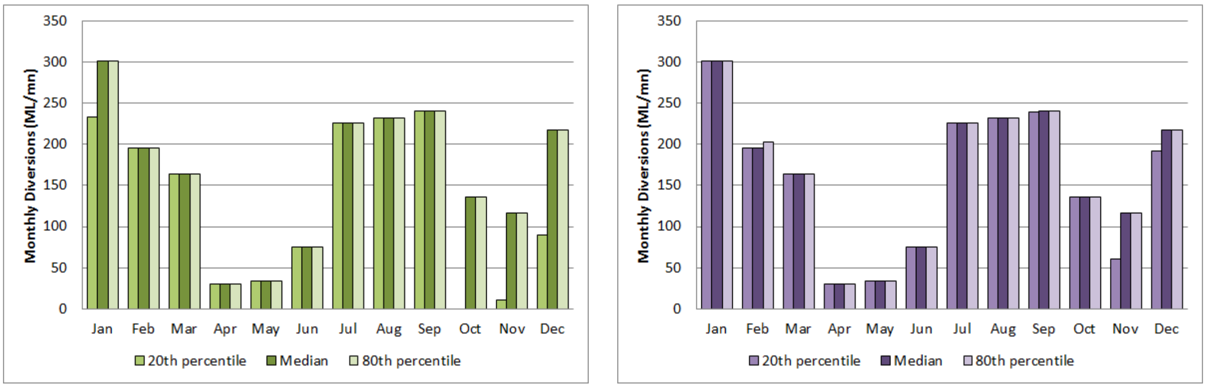



**Figure 14-15 Zone I: seasonal impacts to medium priority irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

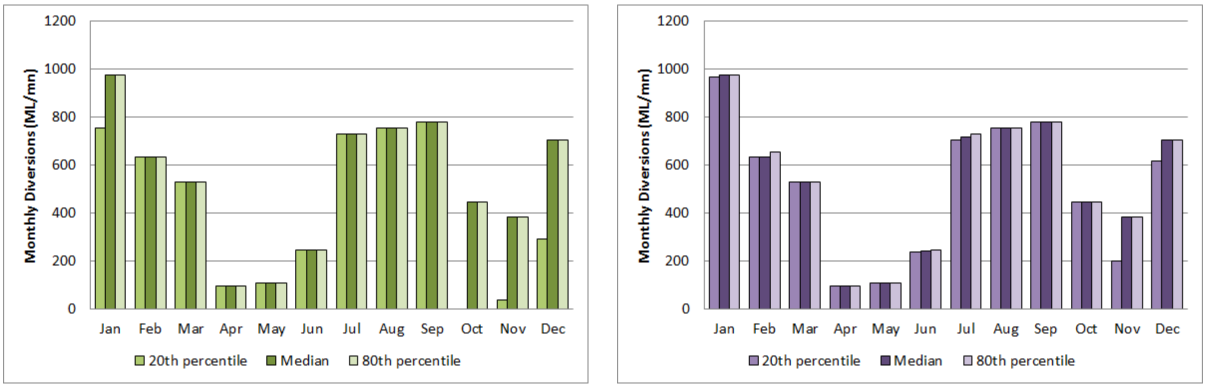



Figure 14-16 Zone H: seasonal impacts to medium priority irrigation diversions, a) Full Entitlement and b) 'With Dam'

a) b)

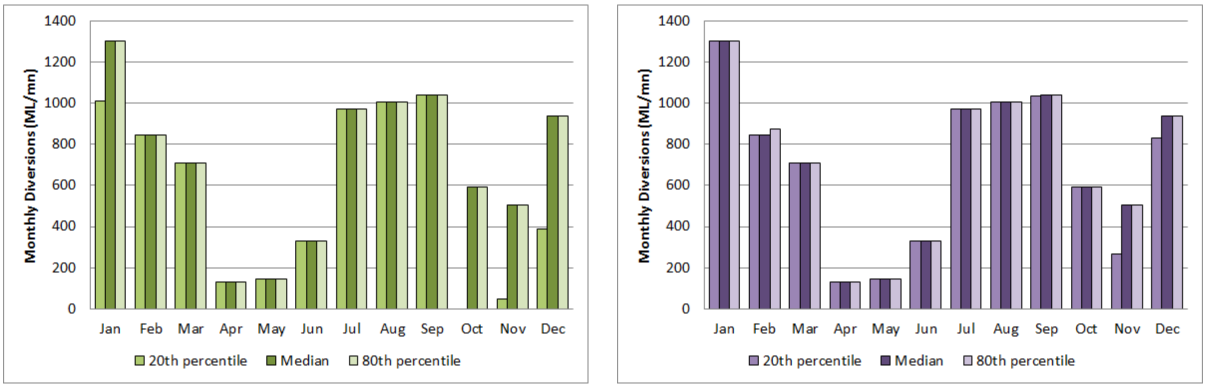



Figure 14-17 Zone G: seasonal impacts to medium priority irrigation diversions, a) Full Entitlement and b) 'With Dam'

a) b)

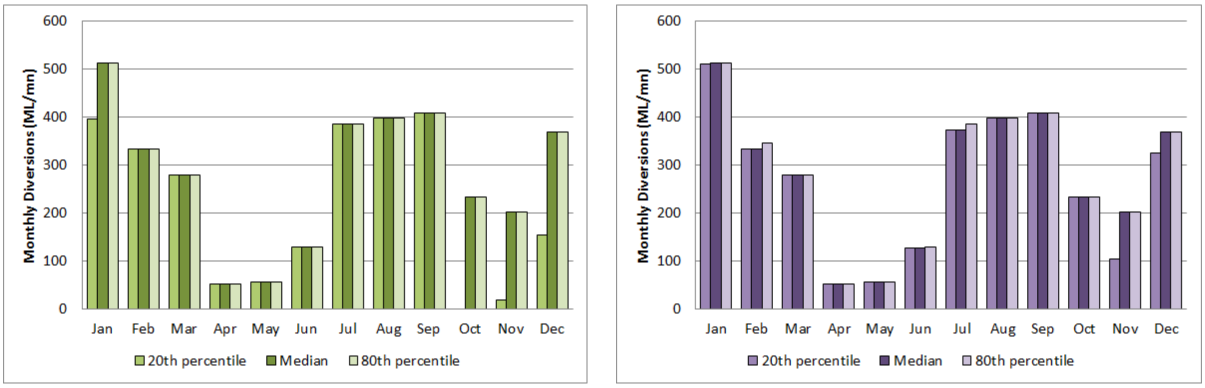



Figure 14-18 Zone E: seasonal impacts to medium priority irrigation diversions, a) Full Entitlement and b) 'With Dam'

a) b)

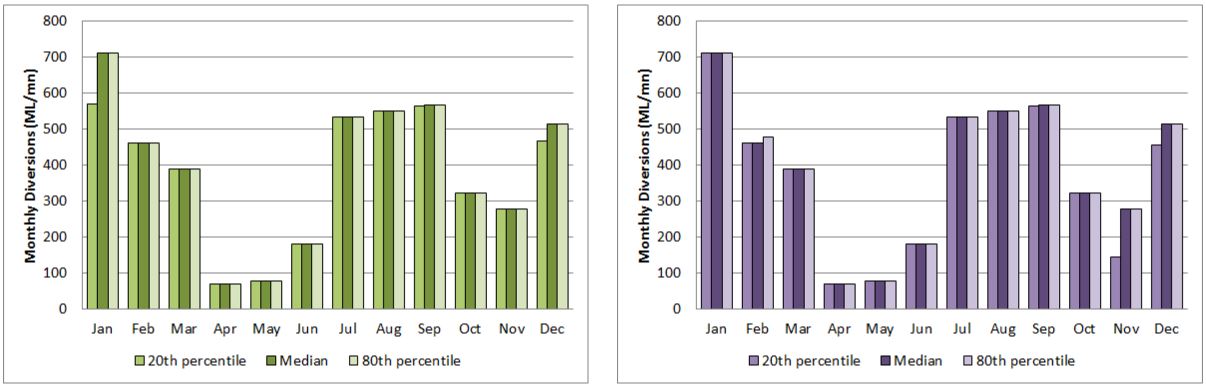



**Figure 14-19 Zone D: seasonal impacts to medium priority irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

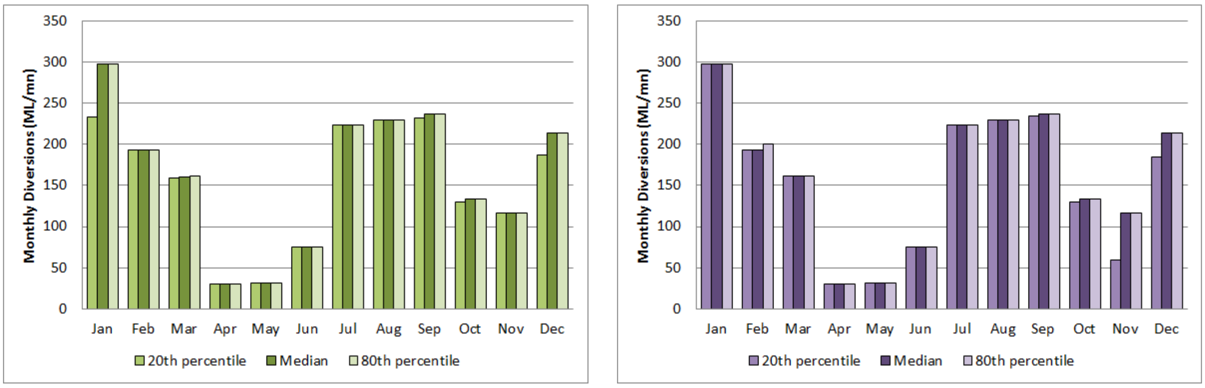



**Figure 14-20 Zone C: seasonal impacts to medium priority irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

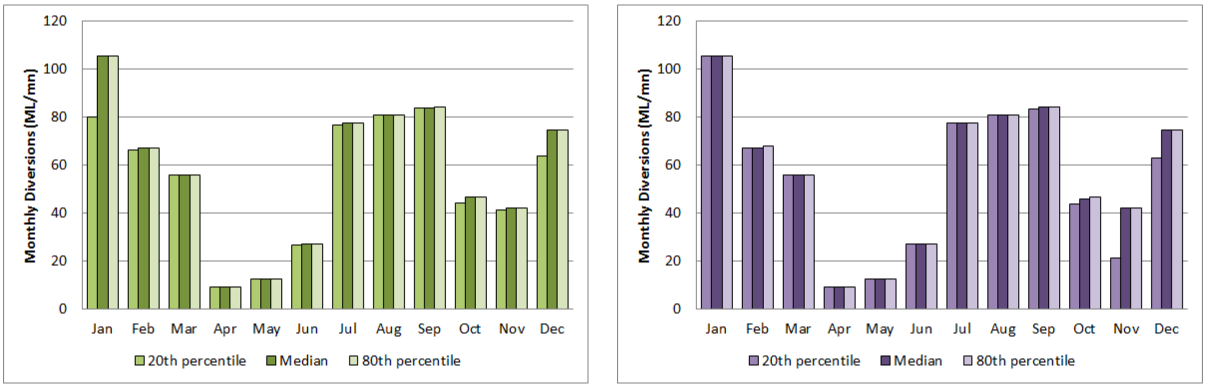



**Figure 14-21 Zone B: seasonal impacts to medium priority irrigation diversions, a) Full Entitlement and b) 'With Dam'**

*Unsupplemented users*

The following section presents a number of figures in order to illustrate the impacts on the seasonality of unsupplemented irrigation diversions. The results of the Full Entitlement and 'With Dam' scenarios are compared for the change in volume that is diverted in the median number of months, and in wet and very wet periods. As these irrigators do not divert in dry months these periods are not considered.

The figures show the following series[3]:

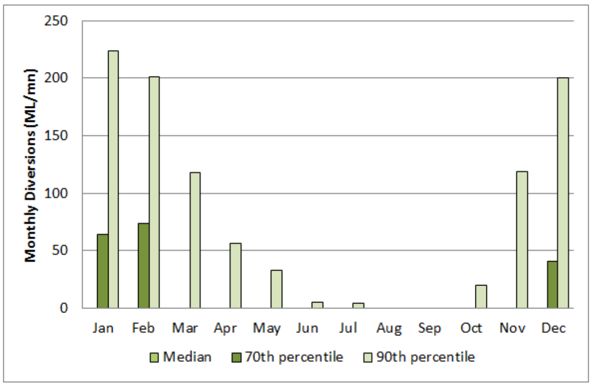
- Median – the volume diverted in 50% of months;
- 70th percentile – the volume diverted in the 70th percentile of months (wet months); and
- 90th percentile – the volume diverted in the 90th percentile of months (very wet months).

The unsupplemented irrigators have been modelled for the WRP as displaying a consistent pattern of demand; with peak diversions over November to February, the period of highest flows, tapering off during the middle of the year.

For the single waterharvester in zone M the unsupplemented diversions are reduced substantially under the 'With Dam' scenario (as shown in **Table 14-28** and **Figure 14-22**). (This is the waterharvester which is located within the Nathan Dam impounded area. This licence is likely to be modified or moved once the dam is constructed).

Waterharvesters in other zones show some impact, with generally reduced diversions through wetter months (November to April) and increased diversion at the start and end of the wetter months (October and May), although the level of impact is usually moderate to low, and varies depending on the location.

a)




b)

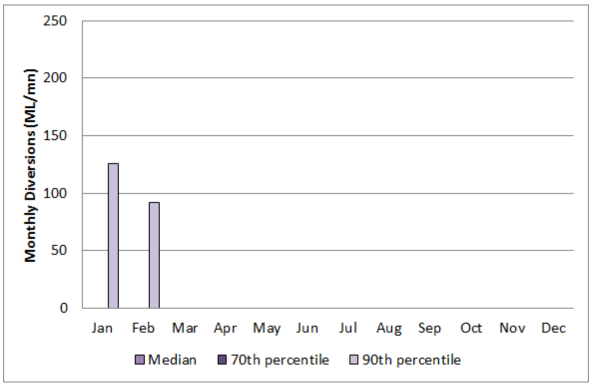



**Figure 14-22 Zone M: seasonal impacts to unsupplemented irrigation diversions, a) Full Entitlement and b) 'With Dam'**

[3] Note that in the figures below, where no column is present this indicates that no diversions occur during that month

a) b)

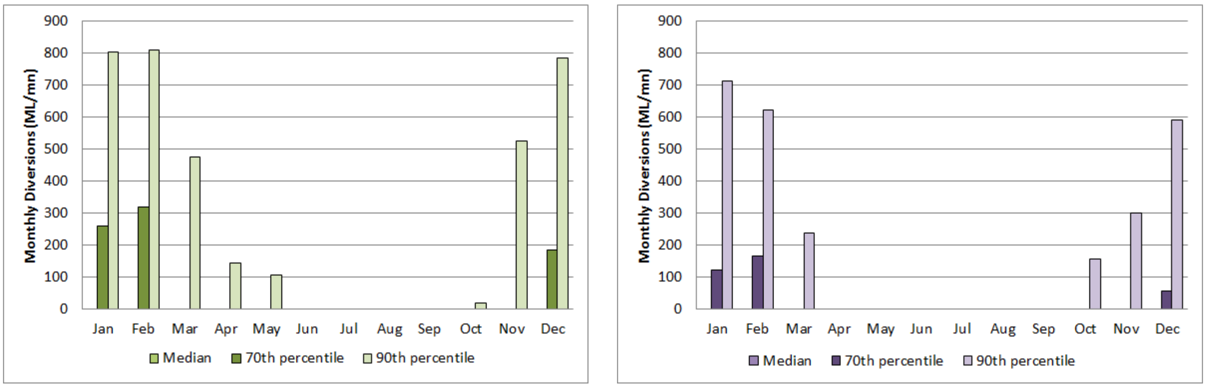



**Figure 14-23 Zone K: seasonal impacts to unsupplemented irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

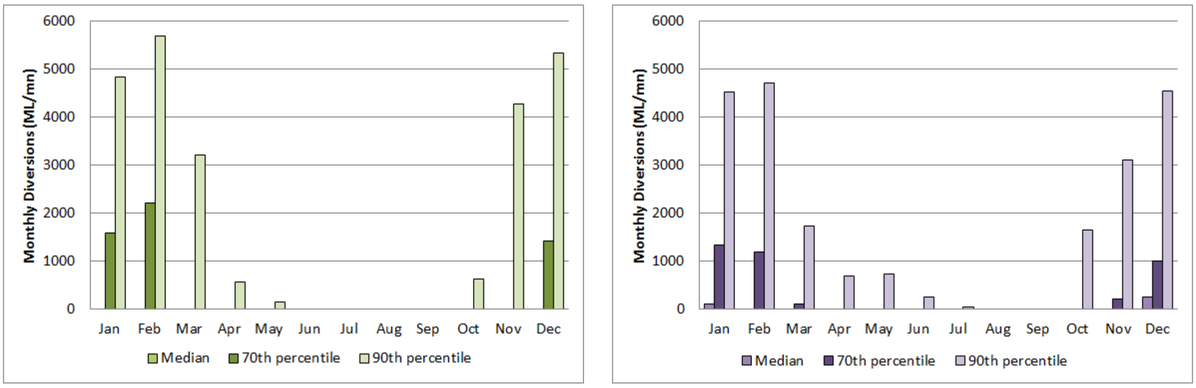



**Figure 14-24 Zone J: seasonal impacts to unsupplemented irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

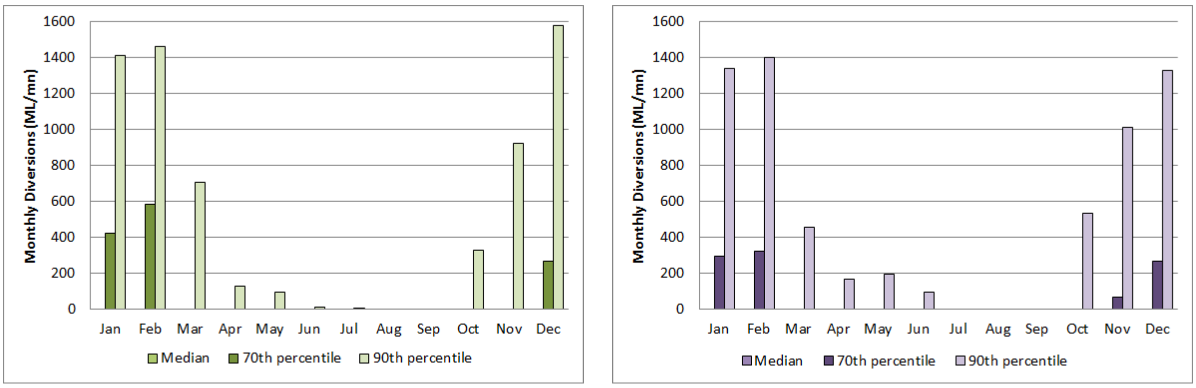



**Figure 14-25 Zone I: seasonal impacts to unsupplemented irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

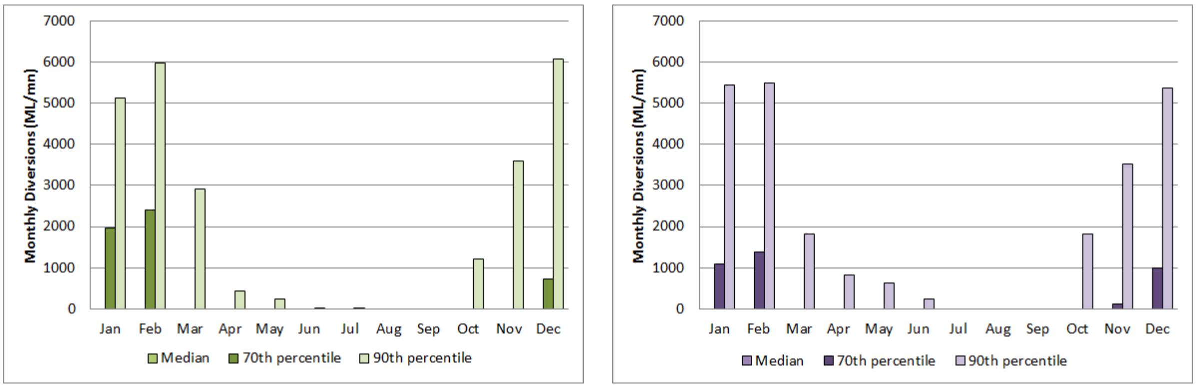



**Figure 14-26 Zone H: seasonal impacts to unsupplemented irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

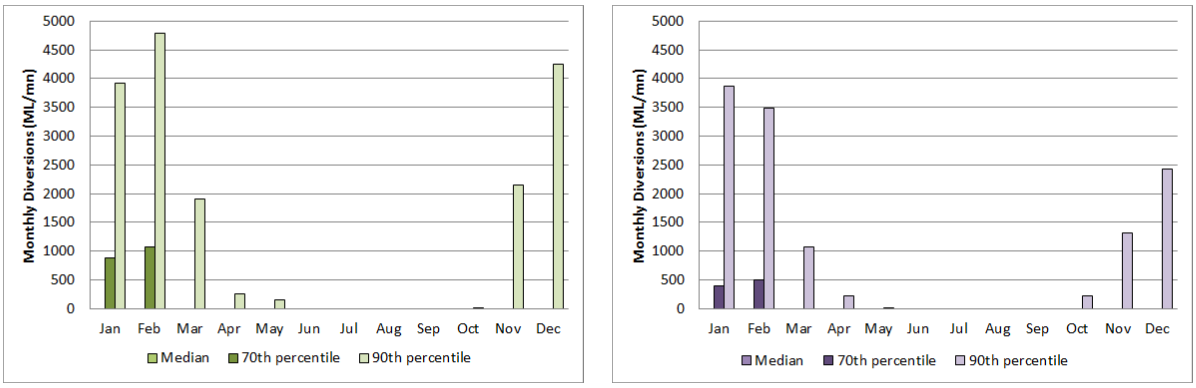



**Figure 14-27 Zone G: seasonal impacts to unsupplemented irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

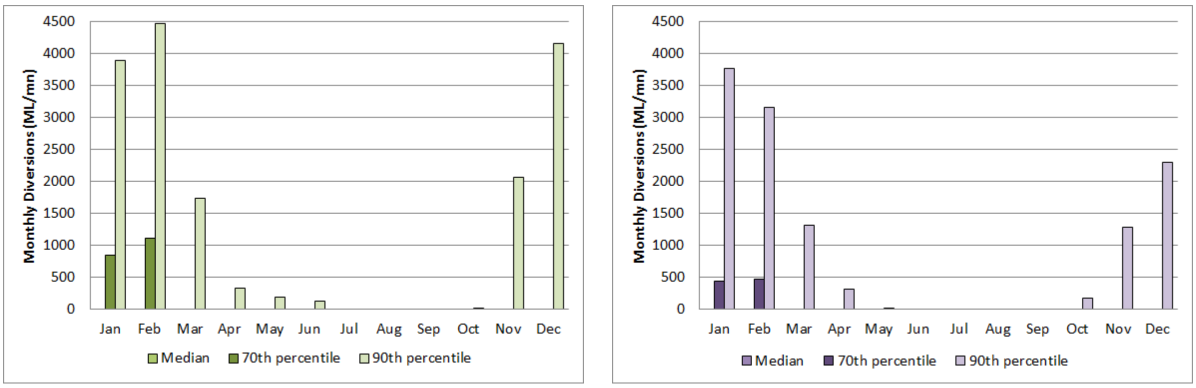



**Figure 14-28 Zone F: seasonal impacts to unsupplemented irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

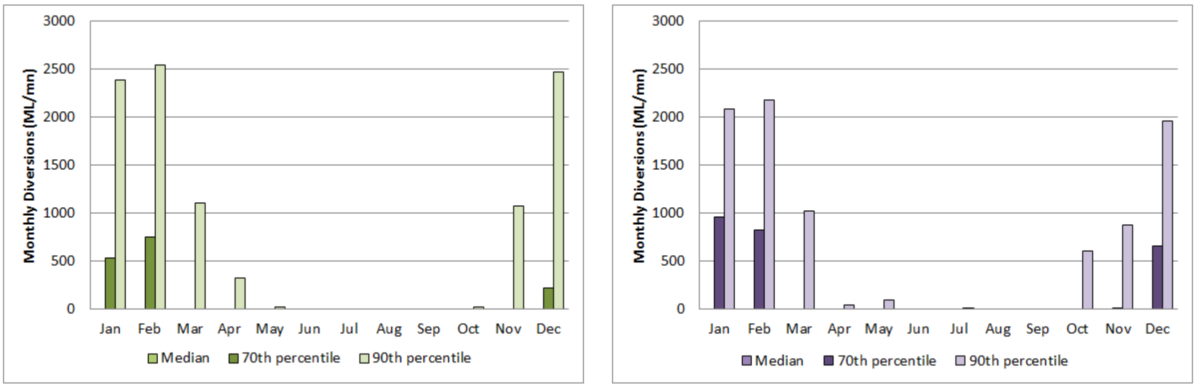



**Figure 14-29 Zone E: seasonal impacts to unsupplemented irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

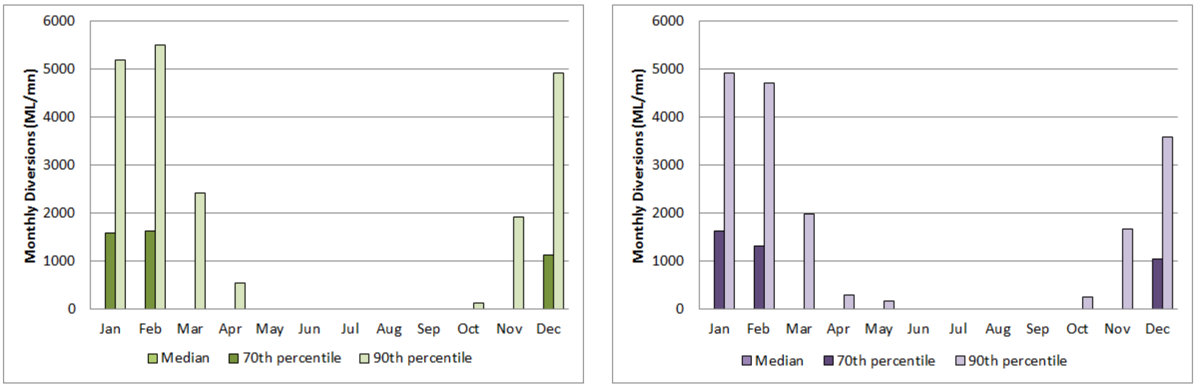



**Figure 14-30 Zone D: seasonal impacts to unsupplemented irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

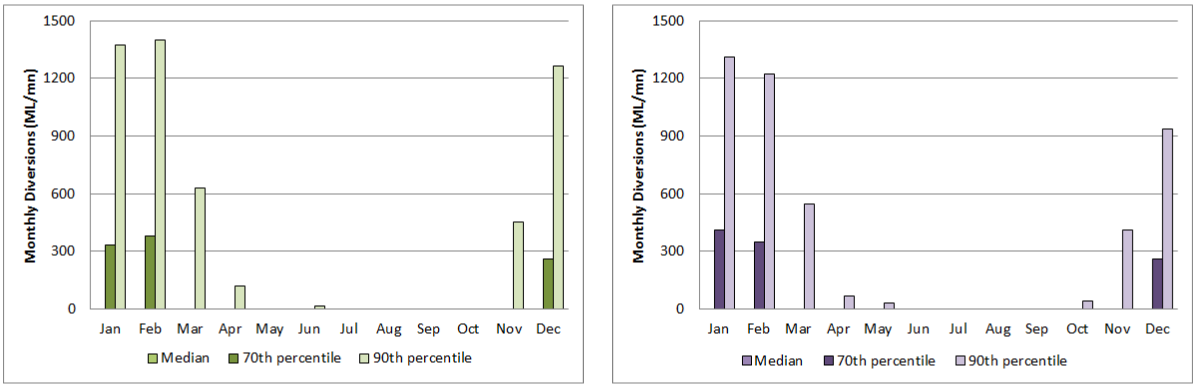



**Figure 14-31 Zone C: seasonal impacts to unsupplemented irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

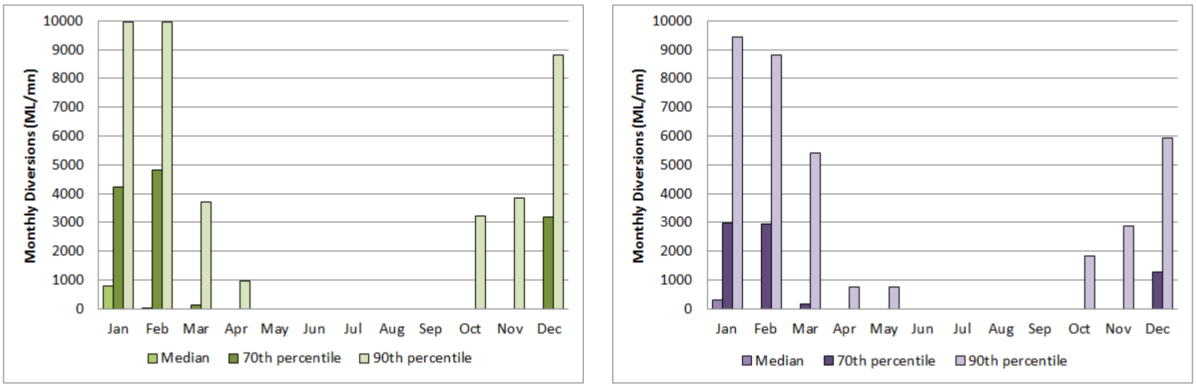



**Figure 14-32 Zone B + A: seasonal impacts to unsupplemented irrigation diversions, a) Full Entitlement and b) 'With Dam'**

a) b)

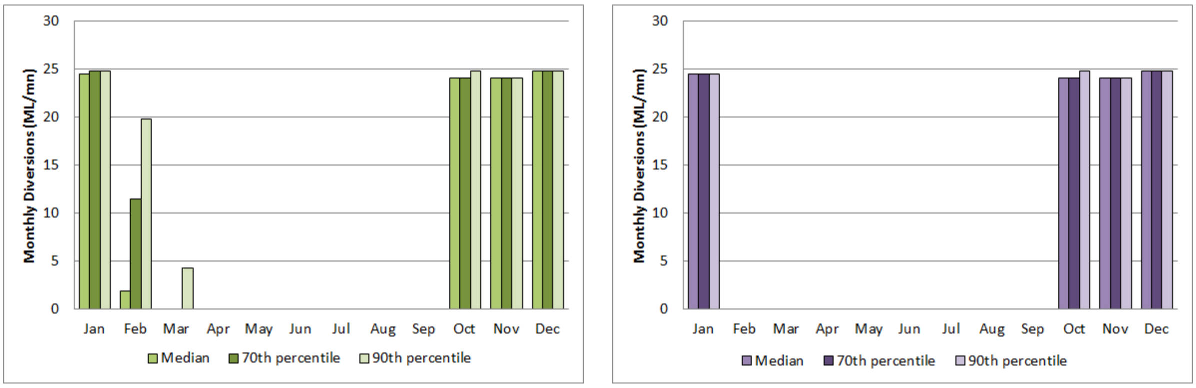


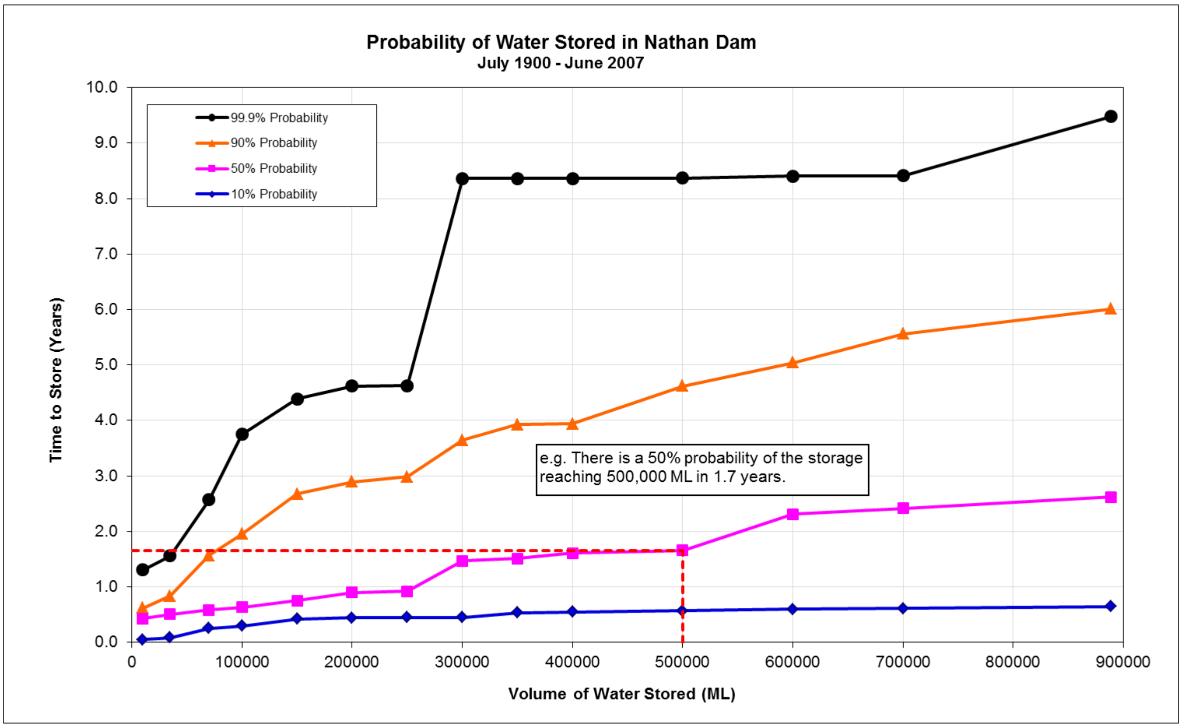

**Figure 14-33 Zone A: seasonal impacts to unsupplemented irrigation diversions, a) Full Entitlement and b) 'With Dam'**

### *14.1.4.6. Time to fill analysis*

An analysis was performed on the probability of the proposed storage reaching key storage volumes. This assessment was carried out using daily IQQM modelling of 98 ten year periods with a rolling start year (1900, 1901….1997), starting in July for each year. The initial storage volume for Nathan Dam was set to zero for each of the ten year periods. This is intended to estimate the time the storage would take to fill, were it to become operational at the start of the water year.

An assessment was then made of the length of time it took for the storage to reach certain volumes, for each ten year period. Key volumes for the assessment were the minimum operating volume (34,502 ML) and the full storage volume (888,312 ML).

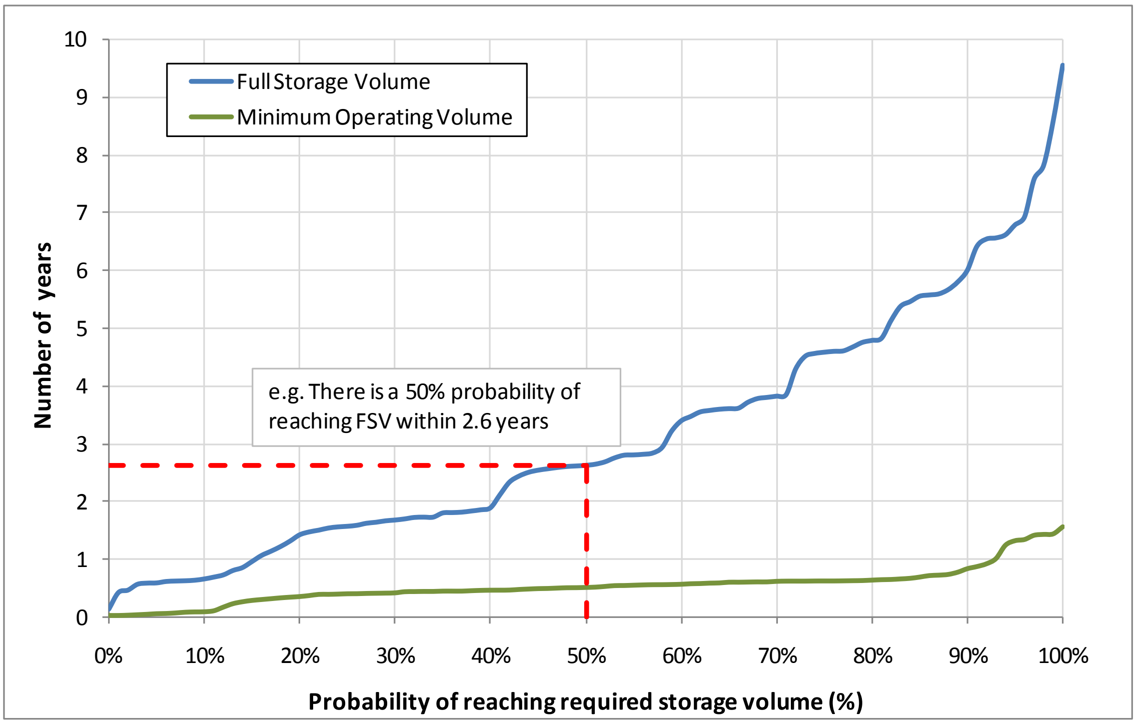
Results of this assessment are presented in **Figure 14-34**, **Figure 14-35** and **Table 14-29**. **Figure 14-34** presents the 10th, 50th, 99th and 99.9th percentile probability of filling within a ten year period. The 50th percentile results show the median outcome, while the 10th, 99th and 99.9th percentile results provide an envelope of probability.




## Figure 14-34 Nathan Dam: probability of water storage

The 99.9th percentile results show a distinct jump in the time taken for the storage to fill from MOV (1.6 years) to the Full Supply Volume of 888,312 ML (9.5 years). This simulates the likelihood of the dam becoming operational during a dry period, with very low inflows to the dam. Alternatively, the 10th percentile results simulate the probability that the dam will become operational during a wet period, where the dam would likely fill within approximately 8 months.

This information can also be presented as the probability of reaching FSV or MOV within a given timeframe, as shown in **Figure 14-35**. This figure shows that there is a 50% probability of reaching FSV within 2.6 years, and MOV within 6 months.




### Figure 14-35 Nathan Dam: probability of reaching FSV and MOV

Results for the key storage volumes are summarised in **Table 14-29**. These results show that there is a 90% probability of exceeding the minimum operating volume within 0.8 years and full storage volume within 6.0 years.

### Table 14-29 Nathan Dam - probability of reaching key storage volumes

| Key Storage Volumes | Volume (ML) | Time to Store (Years) | | | |
|---|---|---|---|---|---|
| | | 10% Probability | 50% Probability | 90% Probability | 99.9% Probability |
| Minimum Operating Volume | 34,502 | 0.1 | 0.5 | 0.8 | 1.6 |
| Full Storage Volume | 888,312 | 0.6 | 2.6 | 6.0 | 9.5 |

Modelling for the time to fill analysis was based on the operational strategy discussed in **Section 14.1.4.1**. This means it has been assumed that the additional demands from Nathan Dam were available from day one, or at least, once the storage fills above the MOV. As such, the information presented for this analysis represents a worst case scenario in terms of maximum extractions during the filling phase and the time taken to reach key storage volumes.

The release of new allocations to meet additional demands is expected to be a staged process consistent with market demands, with a detailed management strategy developed for the filling phase of the dam. This strategy will target specific environmental releases as well as maintaining the water rights of existing downstream users, during the filling phase. The detailed filling strategy for Nathan Dam will be developed in later stages of the Project.

#### *14.1.4.7. Climate change*

The following scenarios were modelled, in order to demonstrate the potential range of sensitivity of the Dawson River catchment under climate change conditions:

- 90th percentile – dry scenario;
- 50th percentile – median scenario; and
- 10th percentile – wet scenario.

The input data for these scenarios was developed from estimates from the 2050 projections under the highest emissions scenario (A1FI). Data for this modelling was developed by the Department of Science, Information Technology and Innovation (DSITI), based on outputs from the General Circulation Models developed by the Queensland Climate Change Centre of Excellence and the method documented in DERM (2009).

**Hydrologic impacts**

**Table 14-30** presents a comparison of mean annual flow at key locations in the Dawson River catchment for the "With Dam" scenario. Under the median climate change scenario, mean annual flow is reduced by 15% to 22% across the catchment. The 90th and 10th percentile climate change scenarios have a high impact on mean annual flow within the Dawson River, ranging from -53% to +53%.

**Table 14-30 Mean annual flow in the Dawson River catchment - under projected 2050 climate change impacts (With Dam scenario) (GL/a)**

| Dawson River | Current Climate (GL/a) | Median Climate Change (GL/a) | % Change | |
|---|---|---|---|---|
| | | | Median Climate Change | 10th and 90th Percentile range |
| Nathan Gorge | 403 | 316 | -22% | -53% to +51% |
| Theodore | 486 | 383 | -21% | -53% to +51% |
| Beckers | 729 | 592 | -19% | -51% to +53% |
| End of Dawson River | 1,213 | 1,031 | -15% | -46% to +46% |

**Table 14-31** presents a comparison of median annual flow at key locations in the Dawson River catchment for the "With Dam" scenario. Under the median climate change scenario, median annual flow is reduced by 6% to 34% across the catchment. Again, the 90th and 10th percentile climate change scenarios have a high impact on flow within the Dawson River, ranging from -70% to +59%.

**Table 14-31 Median annual flow in the Dawson River catchment - under projected 2050 climate change impacts (With Dam scenario)**

| Dawson River | Current Climate (GL/a) | Median Climate Change (GL/a) | % Change | |
|---|---|---|---|---|
| | | | Median Climate Change | 10th and 90th Percentile range |
| Nathan Gorge | 122 | 114 | -6% | -18% to +9% |
| Theodore | 170 | 142 | -17% | -41% to +59% |
| Beckers | 296 | 196 | -34% | -70% to +57% |
| End of Dawson River | 584 | 444 | -24% | -60% to +28% |

**Figure 14-36** to **Figure 14-39** present the daily flow exceedance curves for Dawson River at Nathan Gorge, Theodore, Beckers and the end of Dawson River. These graphs show the impact of the dam operations and regulation of water supply on the overall flow regime, under current climate conditions as well as the three climate change scenarios.

The climate change scenarios presented a range of possible future climates, from 'wet' to 'dry'. The current climate was generally found to fall between the 50th percentile and the 10th percentile climate change scenarios, i.e. at the wetter end of the scale.

Under the climate change scenarios, impacts are expected to be more pronounced in the lower flow ranges at Nathan Gorge, Theodore and the end of the Dawson River, while the flow at Beckers is highly regulated and it is difficult to distinguish any significant differences between the scenarios (in the low flow range).

At Beckers, the flow duration curve shows elevated low flow (below 45 ML/d) for approximately 62% of the simulation period. This is due to the supply of new HP water at Duaringa, downstream of Beckers. This water is extracted before the end of the Dawson River, with the downstream flow duration curve moving back towards pre-development conditions (**Figure 14-39**), although flows at the end of the system are highly influenced by inflows from the Don River.

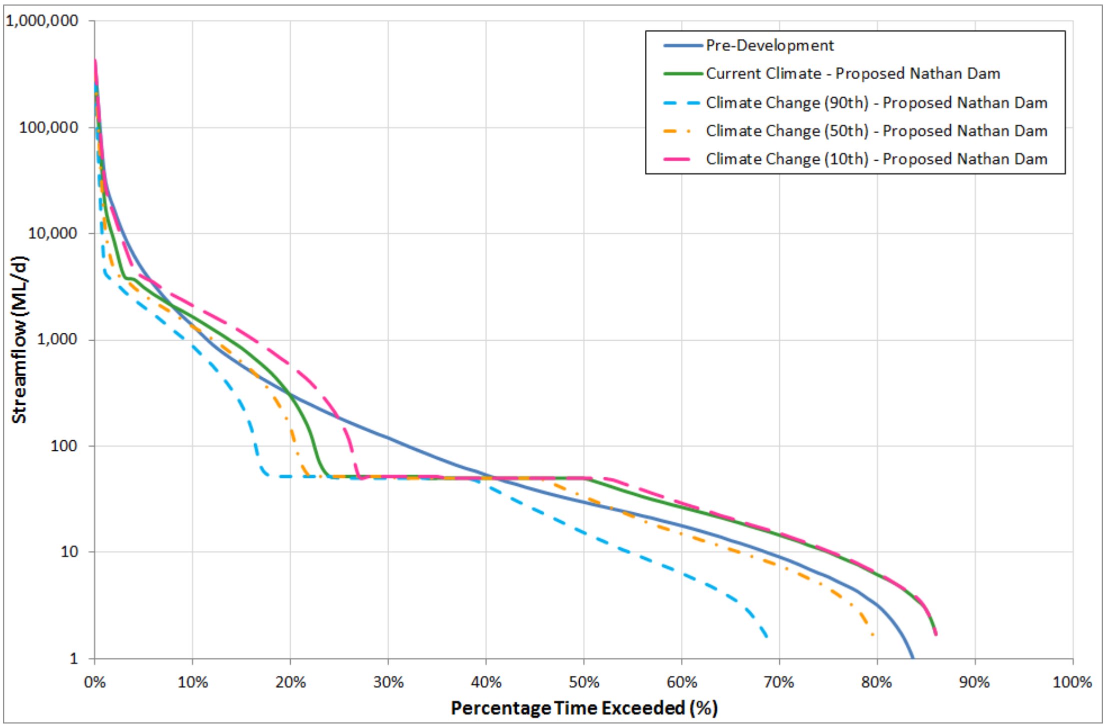



**Figure 14-36 Daily flow exceedance curve - Dawson River at Nathan Gorge**

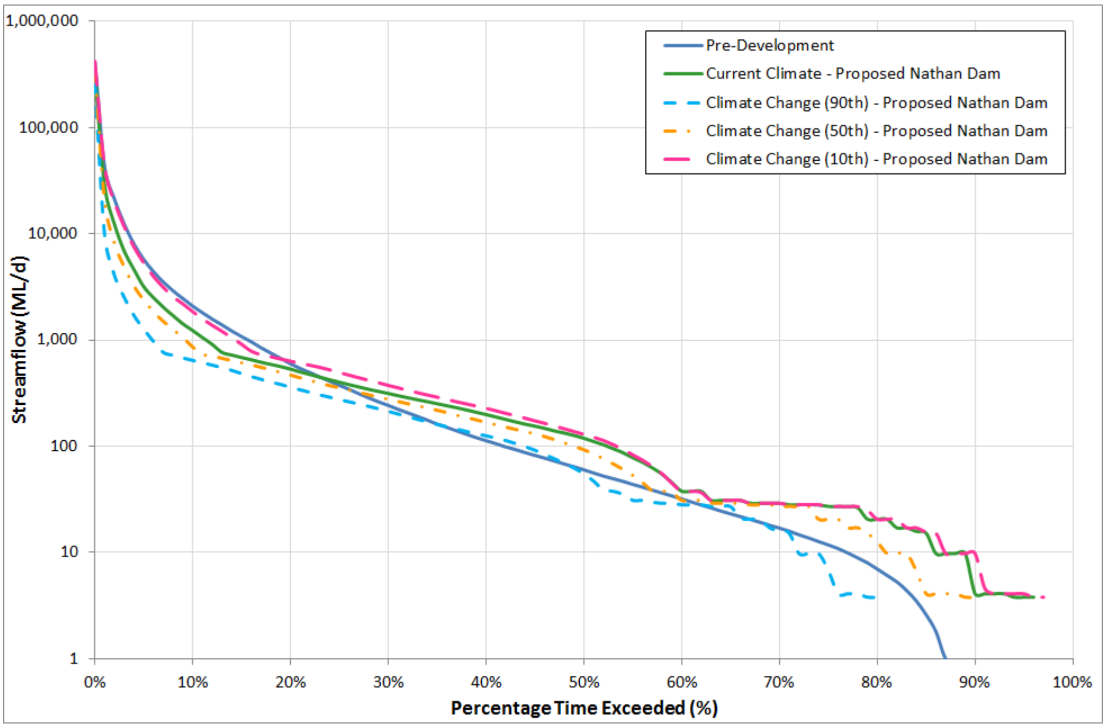



**Figure 14-37 Daily flow exceedance curve - Dawson River at Theodore**

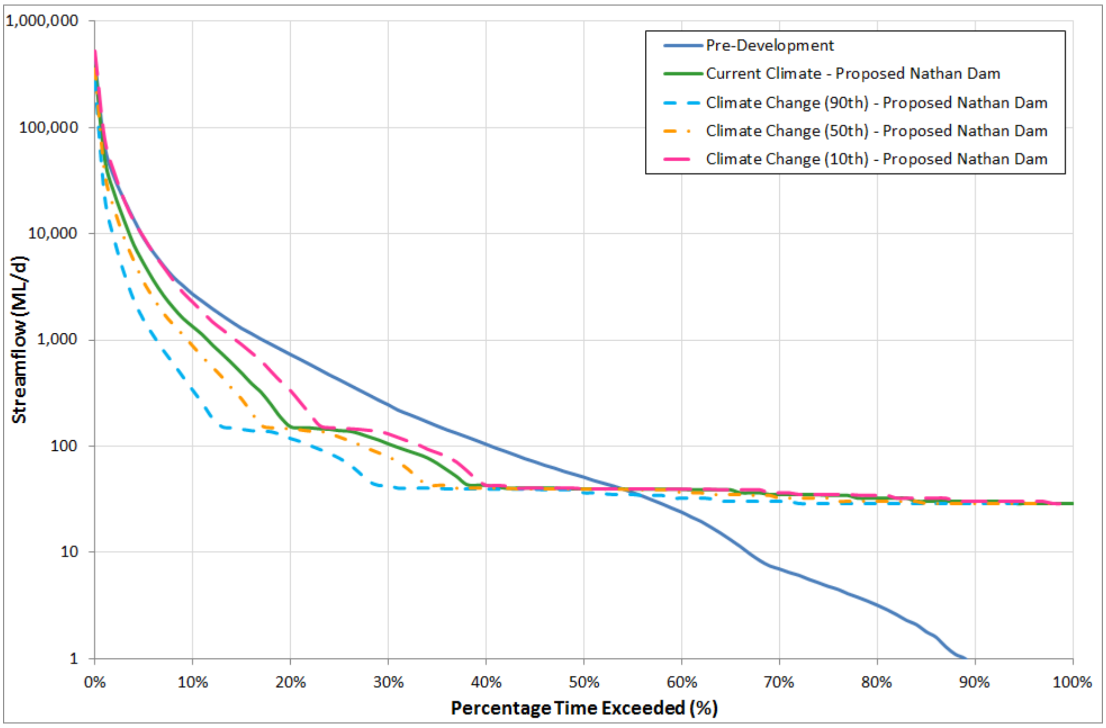



**Figure 14-38 Daily flow exceedance curve - Dawson River at Beckers**

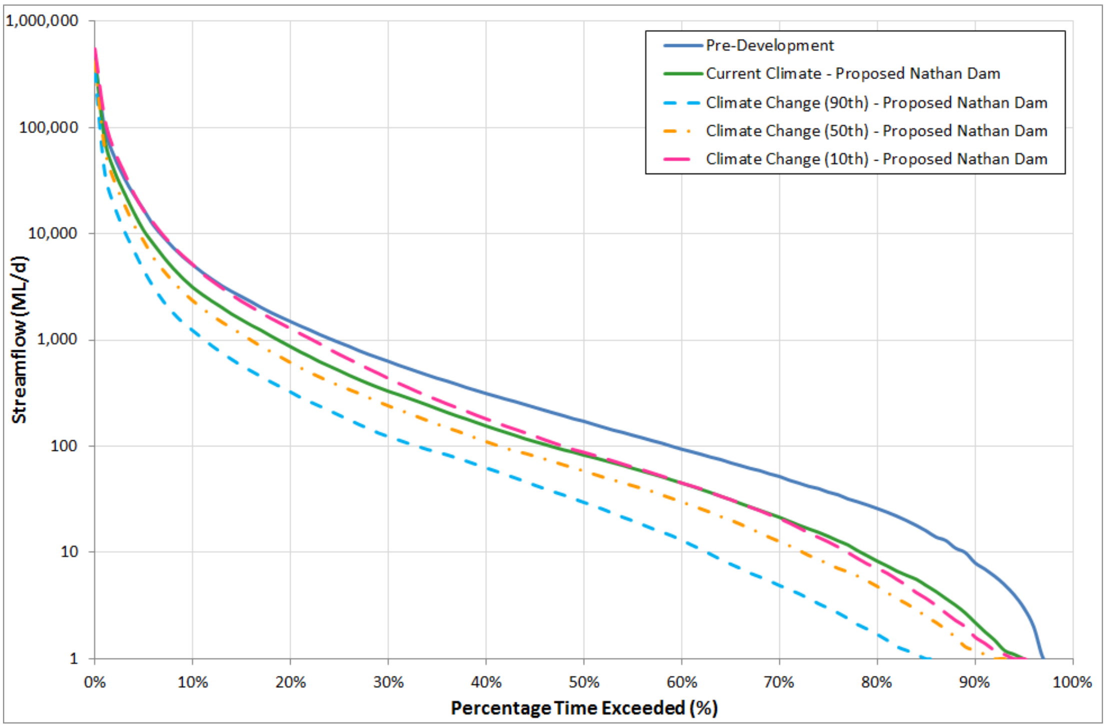



**Figure 14-39 Daily flow exceedance curve - End of Dawson River**

**Low flow analysis**

A low flow analysis was undertaken, in order to characterise the flows into and out of Nathan Dam, under the current climate and projected climate change conditions.

**Table 14-32** presents a summary of no flow statistics for the dam inflow, where no flow is defined as flows below 1 ML/d. This shows that under the median climate change scenario, compared to the current climate, more no flow periods will occur, and these periods will be of a slightly longer duration. The percentage of time no flows occur is likely to increase from 19% to 27% of days, with 90th percentile and 10th percentile scenario estimates of 37% and 21%, respectively. While the total number of no flow days will increase, there is little variation in the length of the longest spell.

### Table 14-32 Nathan Dam inflows - no flow spells analysis, under projected 2050 climate change impacts (With Dam scenario)

| Scenario | Number of events | Total no. of days | % of sim period | Mean spell duration (days) | Longest spell duration (days) |
|---|---|---|---|---|---|
| Pre-development | 245 | 6,461 | 16% | 26 | 276 |
| Current Climate | 296 | 7,602 | 19% | 26 | 276 |
| Climate Change – 50th percentile | 372 | 10,582 | 27% | 28 | 276 |
| Climate Change – 90th percentile | 455 | 14,674 | 37% | 32 | 280 |
| Climate Change – 10th percentile | 284 | 8,112 | 21% | 29 | 273 |

**Table 14-33** presents a summary of no flow statistics at Nathan Gorge, downstream of the dam. This table shows that under the current climate the overall percentage of time that no flows occur is comparable to pre-development conditions, although the no flow periods are longer and more numerous. Compared to the current climate, under the median climate change scenario, the percentage of time that no flows occur will increase from 13% to 20%. The 90th percentile and 10th percentile scenario estimates are 31% and 13%, respectively. Unlike the dam inflows, the longest dry spell downstream of the dam will vary significantly, according to climatic conditions.

The difference between the changes to no flow periods upstream and downstream of the dam reflects the impact of the dam management strategy, and releases made to supply downstream users, through the maintenance of other water supply storages.

**Table 14-33 Nathan Gorge - no flow spells analysis, under projected 2050 climate change impacts (With Dam scenario)**

| Scenario | Number of events | Total no. of days | % of sim period | Mean spell duration (days) | Longest spell duration (days) |
|---|---|---|---|---|---|
| Pre-development | 245 | 6,461 | 16% | 26 | 276 |
| Current Climate | 1,560 | 5,294 | 13% | 3 | 73 |
| Climate Change – 50th percentile | 1,941 | 7,760 | 20% | 4 | 136 |
| Climate Change – 90th percentile | 2,309 | 12,051 | 31% | 5 | 426 |
| Climate Change – 10th percentile | 1,829 | 5,324 | 13% | 3 | 77 |

#### *14.1.4.8. Level of service analysis*

A level of service (LOS) objective is the desirable maximum frequency, duration and severity of water restrictions, deemed suitable for a community (SKM, 2005). This objective will have a significant impact on the yield of a water supply system.

A LOS analysis is intended to evaluate the frequency, duration and severity of water restrictions which would be experienced by a community under defined water restriction rules. This analysis is undertaken for urban water supplies, not for irrigation supply, as restrictions on irrigation supply is managed through the Announced Allocation system.

The LOS approach is outlined in the following papers:

- Framework for Analysing Surface Water Availability in South East Queensland: Technical Report (QWC, 2005);
- Guidelines for Analysing Rural Water Supply System Performance (SunWater & DNRMW, 2006); and
- Framework for Urban Water Resource Planning (SKM, 2005).

New water supplied from Nathan Dam is intended to be HP only, with no restrictions placed on the HP supply, apart from the dam's minimum operating volume. The LOS analysis was carried out for the new HP supply, as a whole, for the current climate and potential climate change scenarios, in order to assess the risk to high priority water supply security, under climate change conditions. The HP supply was assessed against the following criteria:

- Average Annual % of demand supplied - the mean annual diversions over the simulation period as a % of the HP demand.
- Median Annual Reliability - the median % of years in which the HP demand is fully supplied.
- Median Monthly Reliability - the median % of months in which the HP demand is fully supplied.
- Annual supplemented WSI - the percentage of years in the simulation period in which allocations are fully supplied
- Monthly supplemented WSI - the percentage of months in the simulation period in which allocations are fully supplied
- Minimum Storage Volume - the minimum volume in the storage during the simulation period.

- % of Simulation Period < MOV - the % of the simulation period (in days) where the dam is less than the Minimum Operating Volume (MOV) of 34,502 ML.

The results presented in **Table 14-34** show that the storage provides a high reliability of supply, achieving 100% median monthly and median annual reliability for all scenarios. The average annual percentage of demand supplied is also 100% under the current climate, 10th percentile and 50th percentile climate change scenarios. However, this is reduced to 96% in the 90th percentile climate change scenario.

The annual and monthly supplemented WSI results also show that the HP supply has a high level of security of supply, with relatively minor impacts under the climate change scenarios.

### Table 14-34 LOS Assessment Results

| | Current Climate | Climate Change Scenarios | | |
|---|---|---|---|---|
| | **"With Dam" Scenario** | **50th Percentile** | **90th Percentile** | **10th Percentile** |
| Average Annual % of demand supplied | 100% | 100% | 96% | 100% |
| Median Annual Reliability | 100% | 100% | 100% | 100% |
| Median Monthly Reliability | 100% | 100% | 100% | 100% |
| Annual Supplemented WSI | 100% | 97% | 82% | 100% |
| Monthly Supplemented WSI | 100% | 98% | 92% | 99% |
| Minimum Storage Volume (ML) | 36,505 | 31,336 | 23,727 | 45,068 |
| % of Simulation Period < MOV | 0.0% | 0.5% | 4.9% | 0.0% |

**Figure 14-40** displays the Nathan Dam storage trace for the current climate and the three modelled climate change scenarios. The figure shows that the dam is drawn down more frequently and more severely under the 90th percentile (dry) scenario.

The results presented above show that the dam level does not drop below the MOV (34,502 ML) under current climate conditions, nor under the 10th percentile climate change scenario. However, for the 50th and 90th percentile climate change scenarios the dam volume drops below the MOV for 0.5% and 4.9% of the time, respectively.

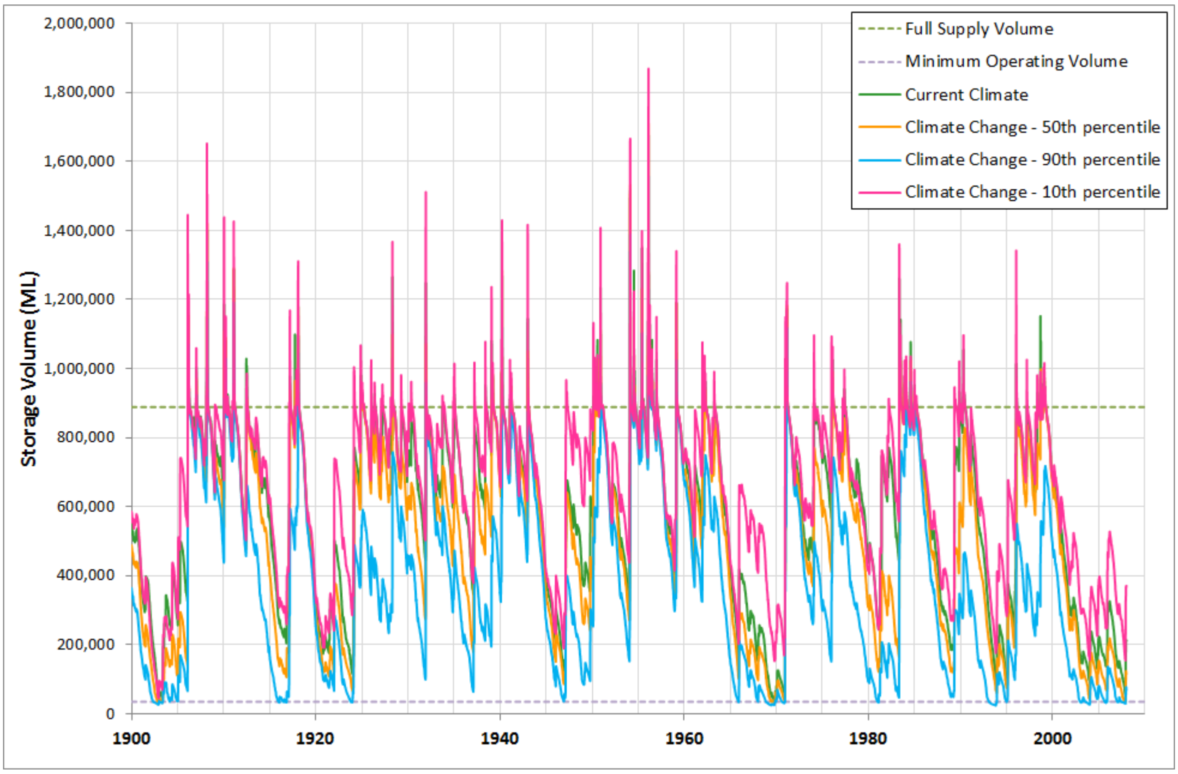



**Figure 14-40  Nathan Dam modelled storage trace – current climate and potential climate change scenarios**

Overall, the statistics presented above show that the storage provides a high level of reliability, and a very low risk of storage levels falling below the MOV.

SunWater acknowledges that supplying water to urban communities on the basis of 100% reliability (Historical No Fail Yield) does not guarantee supply under any future drought conditions.  A contingency plan approach will be considered in discussion with DEWS, DNRM and relevant local authorities to ensure that urban communities retain sufficient water supply to meet essential human needs in line with the level of service parameters adopted by the communities in question.

One submission raised the question of a LOS Analysis for medium priority users.

A LOS Analysis is intended to assess the potential risk that urban or town water supplies will need to go into water restrictions, under defined water restriction rules. This type of assessment is not undertaken for supplemented irrigation water supplies, as restrictions to irrigation supplies are managed under Announced Allocation Rules.

Instead, a probability exceedance plot was produced (**Figure 14-41**), which presents the modelled daily probability that MP users will be at or above a given Announced Allocation (AA). This figure shows that with Nathan Dam in place, and with the Upper and Lower Dawson system operating as one water supply scheme, the AA will generally be much higher than under the Full Entitlement scenario. Under the Full Entitlement scenario the AA for both the Upper and Lower Dawson is below 100% for approximately 50% of the time. By contrast, the AA under the 'With Dam' scenario is below 100% for approximately 7% of the time.

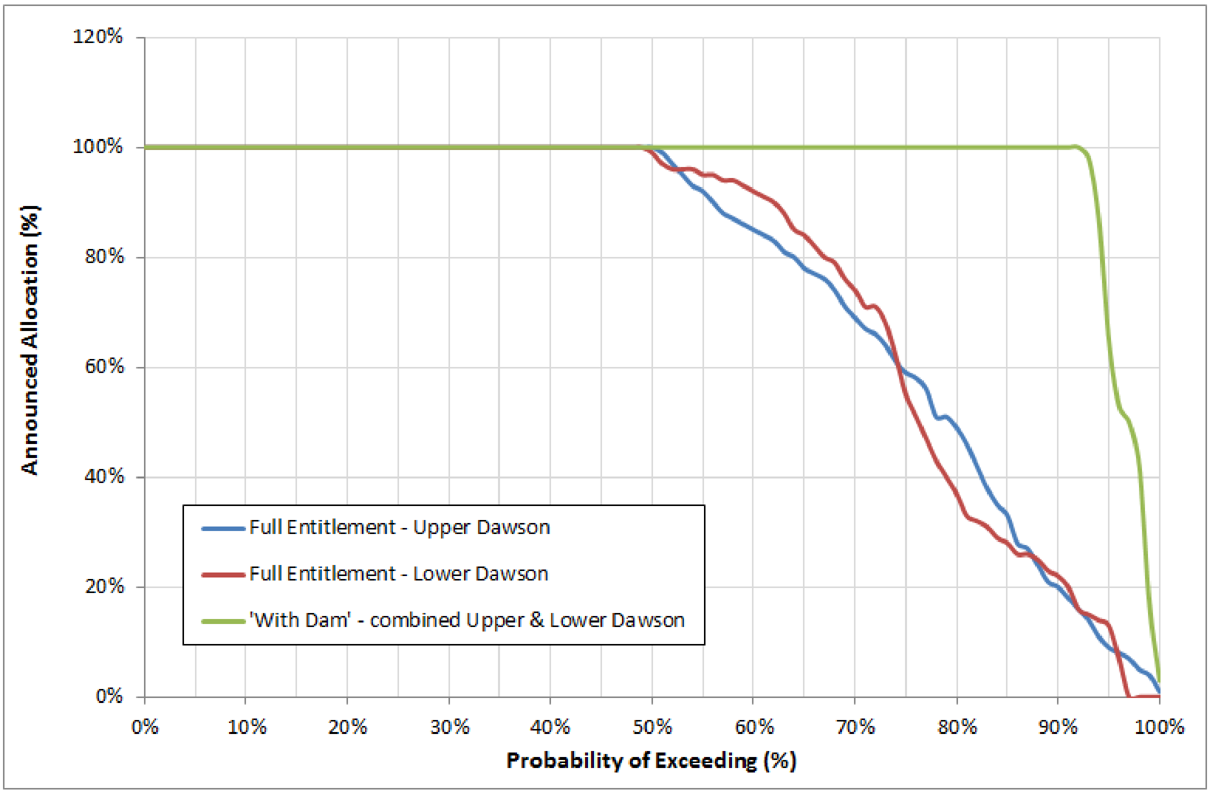



**Figure 14-41 Medium Priority Announced Allocation: daily probability of exceeding**

#### *14.1.4.9. Cumulative impacts*

This case represents the ultimate development scenario in the Fitzroy Basin. Modelling included infrastructure which is approved for development, or currently under consideration: the Connors River Dam, Nathan Dam, Eden Bann Weir Stage 3 and Rookwood Weir Stage 2. The Connors River Dam project has been approved; however, the project is currently on hold.

Modelling results for the Dawson catchment is the same as the results for the "With Dam" scenario, and the results for this catchment have therefore not been reproduced below.

Proposed development in the Lower Fitzroy is based on Eden Bann Weir Stage 3 and Rookwood Weir Stage 2 (with 2.0 m gates). This scenario is modelled to supply an additional 76,000 ML/a of high priority water in the Lower Fitzroy. The modelling of these storages incorporates preliminary operational strategies only. These are expected to be developed as these separate projects progress. As such, there is future scope to address WRP compliance issues.

The overall impact to the Lower Fitzroy for the cumulative impacts scenario is relatively minor considering the level of proposed development within the Basin.

**Environmental Flow Objectives**

The following section presents the compliance of the Cumulative Impacts scenario with the EFOs specified in the Fitzroy Basin WRP (DERM, 2011a), for reporting node 0 (Fitzroy River at Barrage). For interest, environmental flow statistics have also been presented at WRP node 1, although environmental flow objectives are not currently specified at this location.

In summary:

- All medium to high flow objectives (mandatory) are met;
- All first post winter flow objectives (mandatory) are met, with the exception of one indicator; and
- the seasonal baseflow objective (non-mandatory) at node 0 is reduced slightly during May to August, although overall compliance is not affected.

**Table 14-35** presents the medium to high flow event objectives. These objectives are met for all scenarios.

**Table 14-36** presents the first post winter flow event performance indicators. These indicators were achieved for the Full Entitlement and 'With Dam' scenarios, while one indicator fails under the Cumulative Impacts scenario. The number of flows within five weeks of the predevelopment event statistic does not pass the mandatory objective at EFO node 0. However, it is anticipated that this effect can be adequately addressed by the future development of appropriate release strategies.

**Table 14-37** presents the seasonal baseflow results. These results show that compliance with the seasonal baseflow objectives is not changed, although flows are slightly reduced during May to August. However, the modelling of these projects is preliminary and does not include releases such as compensation strategies for unsupplemented irrigators or low flow environmental release strategies. It is possible that this impact could be adequately addressed by the future development of appropriate strategies.

Overall, the impacts of the Cumulative Impacts scenario are minor and expected to be managed through a combination of environmental flow releases and management rules. These will need to be developed if and when the proposed infrastructure is approved and finalised.

### Table 14-35 Cumulative Impacts Scenario: Medium to high flow objectives Fitzroy River

| Performance Indicator | Mandatory Objective | D/S of Eden Bann Weir (EFO node 1) | | | Fitzroy Barrage outflow (EFO node 0) | | |
|---|---|---|---|---|---|---|---|
| | | Full Entitlement | 'With Dam' scenario | Cumulative Impacts | Full Entitlement | 'With Dam' scenario | Cumulative Impacts |
| Mean Annual Flow | ≥ 77% | 87% | 84% | 83% | 85% | 82% | 80% |
| Median Annual Flow Ratio | ≥ 58% | 75% | 71% | 72% | 71% | 67% | 62% |
| APFD | ≤ 2.5 | 1.4 | 1.7 | 2.1 | 1.5 | 1.9 | 2.1 |
| Mean Wet Season Flow | ≥ 80% | 88% | 86% | 85% | 87% | 85% | 83% |
| 10% daily exceedance duration flow | ≥ 55% | 75% | 69% | 62% | 72% | 68% | 60% |
| 4% daily exceedance duration flow | ≥ 74% | 85% | 80% | 79% | 86% | 81% | 80% |
| 2 yr daily flow volume | ≥ 75% | 88% | 87% | 84% | 84% | 83% | 83% |
| 5 yr daily flow volume | ≥ 87% | 94% | 94% | 93% | 92% | 92% | 89% |
| 20 yr daily flow volume | ≥ 88% | 95% | 93% | 92% | 91% | 91% | 89% |

### Table 14-36 Cumulative Impacts Scenario: First post winter flow event objectives Fitzroy River

| Performance Indicator | Mandatory Objective | D/S of Eden Bann Weir (EFO node 1) | | | Fitzroy Barrage outflow (EFO node 0) | | |
|---|---|---|---|---|---|---|---|
| | | Full Entitlement | 'With Dam' scenario | Cumulative Impacts | Full Entitlement | 'With Dam' scenario | Cumulative Impacts |
| No. of FPWFE | ≥ 80% | 95% | 96% | 91% | 93% | 91% | 83% |
| No. Flow within 5 Weeks of PD Case | ≥ 60% | 83% | 85% | 64% | 77% | 75% | 59% |
| No. Flow within 2 Weeks of PD Case | ≥ 70% | 89% | 90% | 61% | 81% | 77% | 75% |
| Average Flow Volume | ≥ 70% | 68% | 64% | 83% | 88% | 85% | 81% |
| Flow Duration (2-times base flow) | ≥ 70% | 95% | 95% | 82% | 93% | 91% | 82% |
| Flow Duration (5-times base flow) | ≥ 70% | 80% | 78% | 76% | 92% | 89% | 82% |

**Table 14-37 Cumulative Impacts Scenario: Seasonal baseflow objective for the Fitzroy River**

| Season | Non-mandatory objective | D/S of Eden Bann Weir (EFO node 1) | | | Fitzroy Barrage outflow (EFO node 0) | | |
|---|---|---|---|---|---|---|---|
| | | Full Entitlement | 'With Dam' scenario | Cumulative Impacts | Full Entitlement | 'With Dam' scenario | Cumulative Impacts |
| Jan - Apr | 0.8 – 1.2 | 1.0 | 1.0 | 1.1 | 0.8 | 0.8 | 0.8 |
| May - Aug | 0.8 – 1.2 | 1.0 | 1.0 | 1.6 | 0.7 | 0.7 | 0.6 |
| Sep - Dec | 0.8 – 1.2 | 1.0 | 1.0 | 1.8 | 0.6 | 0.6 | 0.6 |

**Water Allocation Security Objectives**

This section presents group WASO compliance for high priority, medium priority and unsupplemented allocation groups on the Fitzroy River, where compliance is measured at a group level.

**Table 14-38** presents the WASO compliance for the supplemented user groups on the Fitzroy River. All of the supplemented user groups achieve their compliance objectives, under both the Full Entitlement and 'With Dam' scenarios. Under the Cumulative Impacts scenario the annual reliability of the high priority water falls below its compliance level while the medium priority reliability is increased. These impacts could be balanced through refining the operational rules of Eden Bann Weir and Rookwood Weir.

**Table 14-38 Cumulative Impacts Scenario: High priority and medium priority WASO compliance – monthly/annual reliability of supply**

| | Mandatory Objectives | | Full Entitlement | | 'With Dam' Scenario | | Cumulative Impacts Scenario | |
|---|---|---|---|---|---|---|---|---|
| | Monthly Reliability (%) | Annual Reliability (%) | Monthly Reliability (%) | Annual Reliability (%) | Monthly Reliability (%) | Annual Reliability (%) | Monthly Reliability (%) | Annual Reliability (%) |
| **High Priority** | | | | | | | | |
| Lower Fitzroy WSS & Fitzroy Barrage WSS | ≥98 | ≥94 | 99 | 94 | 99 | 94 | 98 | 93 |
| **Medium Priority** | | | | | | | | |
| Lower Fitzroy WSS & Fitzroy Barrage WSS | ≥82 | | 93 | | 93 | | 96 | |

**Table 14-39** presents the annual volume probability (AVP) for the unsupplemented irrigator groups on the Fitzroy River. The annual volume probability is the percentage of years that the diversion is at least the nominal volume (calculated on an annual basis). For the unsupplemented AVP the calculation adopts the mean annual diversion as the nominal volume. AVP compliance is only affected for Class 5A, who experience a significant reduction in mean annual diversions.

**Table 14-39 Cumulative Impacts Scenario: Unsupplemented irrigation (Fitzroy River) – annual volume probability (AVP)**

| Water Allocation Group | Mandatory objective | Full Entitlement | | 'With Dam' Scenario | | Cumulative Impacts Scenario | |
|---|---|---|---|---|---|---|---|
| | | Mean Annual Diversion (ML/a) | AVP (%) | Mean Annual Diversion (ML/a) | AVP (%) | Mean Annual Diversion (ML/a) | AVP (%) |
| Class 5A | ≥ 61% | 36,323 | 66 | 35,677 | 64 | 30,815 | 49 |
| Class 5B | ≥ 73% | 8,258 | 82 | 8,131 | 78 | 8,035 | 78 |
| Class 6C | ≥ 95% | 8,049 | 100 | 8,049 | 100 | 8,049 | 100 |
| Class 7D | ≥ 93% | 4,277 | 99 | 4,274 | 99 | 4,274 | 99 |

### *14.1.5. Other issues*

One submission requested mapping showing the extent of inundation caused by the dam, at a range of probabilities.

**Table 14-40** and **Figure 14-42** present the modelled probability that the dam will exceed a given elevation, on a daily basis. This information is also mapped in **Figure 14-43**. **Table 14-40** shows that the water level within the dam is expected to be between the MOL and the FSL for 93% of the time. For 7% of the time the dam is expected to exceed the FSL, driven by the occurrence of high flow events.

**Table 14-40 Nathan Dam: modelled elevation probability**

| Water Level (m AHD) | Probability of exceeding (%) | Description |
|---|---|---|
| 170.0 | 100% | Minimum Operating Level (MOL) |
| 172.0 | 100% | |
| 174.0 | 97% | |
| 176.0 | 89% | |
| 178.0 | 76% | |
| 180.0 | 64% | |
| 182.0 | 41% | |
| 183.5 | 7% | Full Supply Level (FSL) |

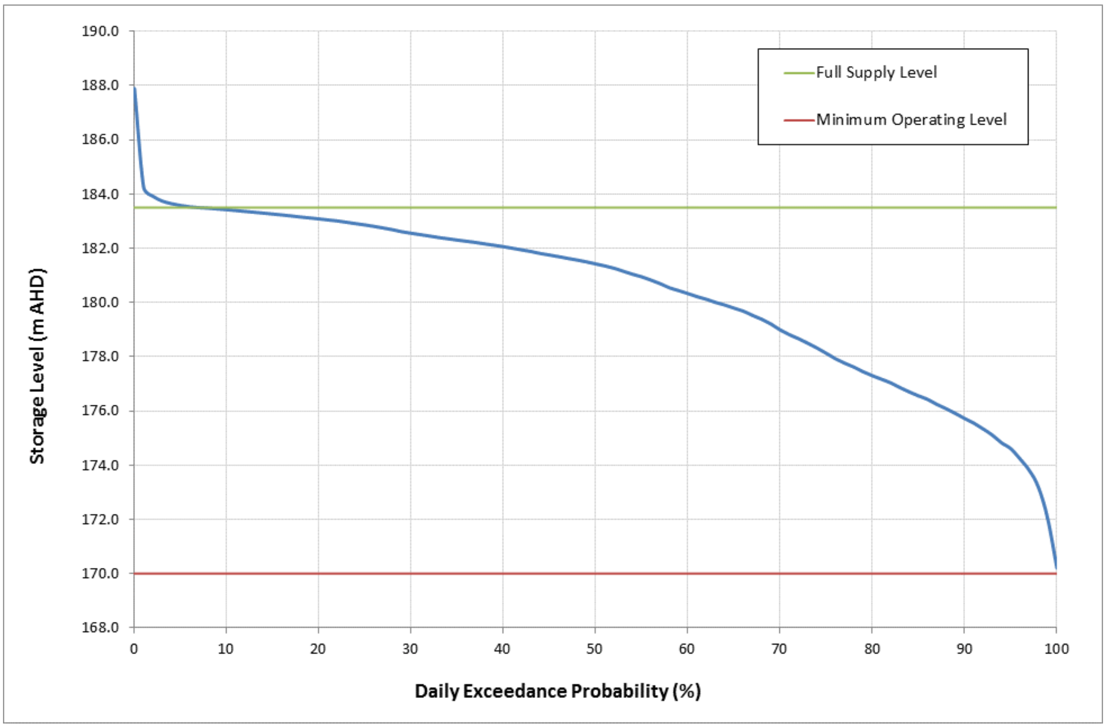
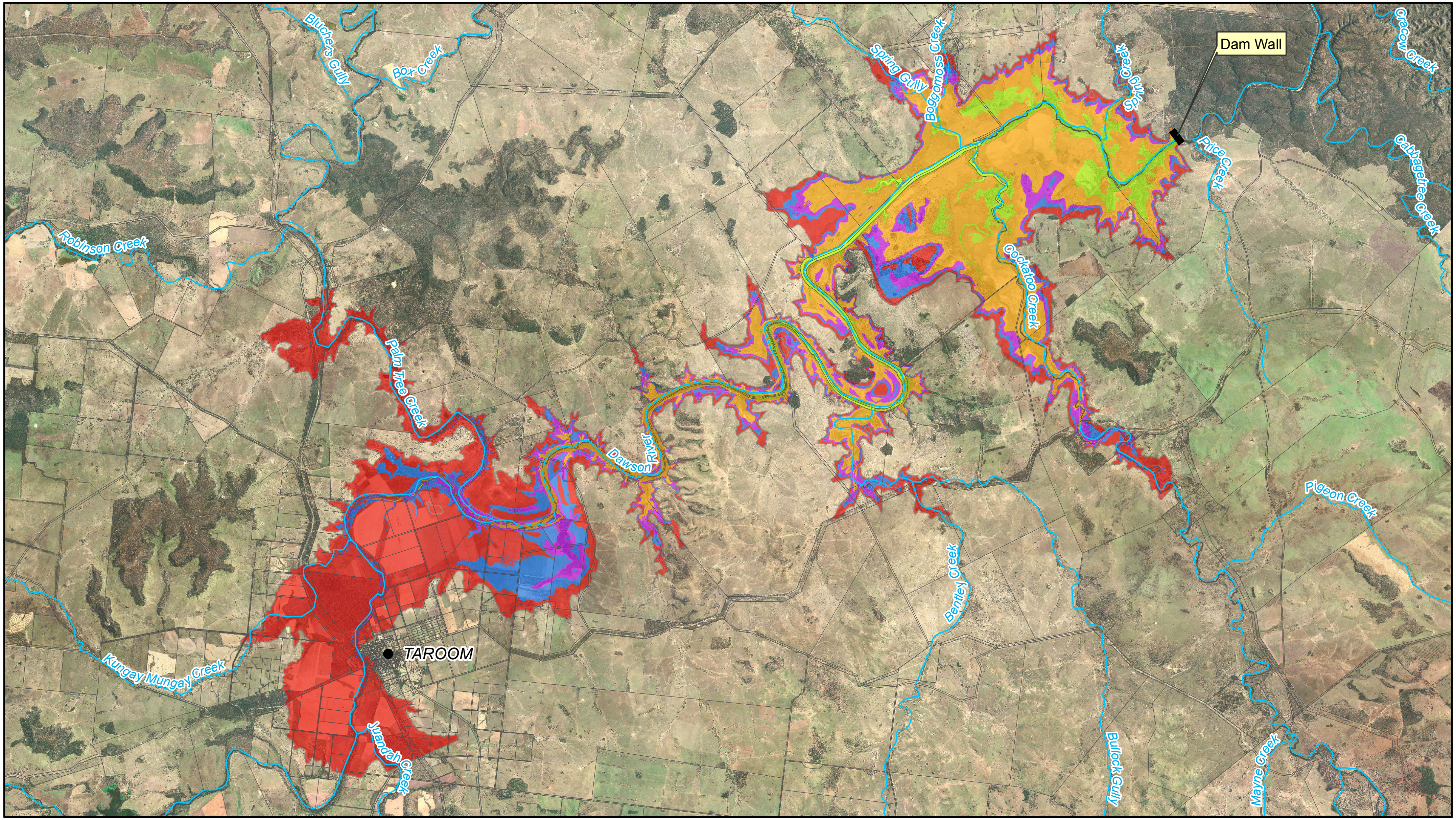



**Figure 14-42 Nathan Dam elevation: modelled daily exceedance probability**




**LEGEND**

- Town
- Dam Wall
- Watercourses
- Cadastre

**Inundation Extent Probabilities**

- 172.0m AHD - exceeded 100% of the time
- 180.0m AHD - exceeded 64% of the time
- 182.0m AHD - exceeded 41% of the time
- 183.4m AHD (Full Supply Volume) - exceeded 7% of the time
- 1 in 100 AEP peak flood level

Projection: GDA94 Zone 56

**Figure 14-43**

0 1.25 2.5 5
Kilometres
N
Scale 1:200,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM EIS SUPPLEMENTARY REPORT

**Nathan Dam inundation extent at a range of probabilities**

Path: I:\QENV2\Projects\QE06601\QE06601.280 Spatial\ArcGIS\Figures\Draft\14_SurfaceWater\130430_InundationExtents_Range_of_Probabilities.mxd Produced: 1/05/2013

One submission raised a concern regarding the effect of Nathan Dam on low flows into Glebe Weir.

The Nathan Dam site is located downstream of Glebe Weir, once operational, the dam will inundate Glebe Weir. The operational strategy of the dam is intended to maintain low flows downstream of the dam, and into Gyranda Weir, as described in **Section 14.1.4.1.**

One submission questioned whether the Wandoan Coal Mine project was included in the future demand analysis.

Yes, the future demand analysis included an assessment of the Wandoan Coal Mine Project, as well as a wide range of other current and proposed projects.

One submission raised a concern that the maps included in the EIS showing the Fitzroy Basin did not show the same area as in the Fitzroy Basin Water Resource Plan 1999 and Fitzroy Basin Water Resource Plan 2011.

Figure 14-1 and Figure 14-20 in the EIS depict the recognised catchment area of Fitzroy Basin. These figures were not intended to represent the Fitzroy Basin Water Resource Plan 1999 area or the Fitzroy Basin Water Resource Plan 2011 area and are not referred to as such in the EIS.

## 14.2. Flooding

### *14.2.1. Downstream flooding*

One submission expressed concern that the dam will not provide significant flood protection for downstream areas.

The flood retention effect of the dam will significantly reduce flood peaks downstream, particularly for smaller flood events. This was shown in Section 14.2.3.2 of the EIS. Although the dam will not have a significant flood protection role for downstream areas, the 1 in 100 AEP peak flood level will reduce as a result of the dam construction. For example, at Theodore the 1 in 100 AEP peak flood level will reduce by 0.5 m, while it will take slightly longer to reach the peak and flows will recede over a longer period.

In addition, the dam is designed to have sufficient discharge capacity to safely pass the probable maximum flood (PMF), as such if an event of this magnitude occurs, the downstream community will not be subject to additional risk due to the dam being in place.

A submission was concerned that reduced discharge from springs upstream from the dam as a result of the process which extracts coal seam gas, in addition to retention of flood waters by the dam, could affect the ecology of areas downstream from the dam. The assumption regarding impacts of coal seam gas extraction are incorrect. The Santos Fairfield gas field is upstream of Taroom and extracts coal seam water but also treats and returns it to the river. SunWater also currently discharges coal seam water from QGC fields to Glebe Weir. Chapter 15 of the EIS also noted that there was a likelihood of increased discharge from springs in the dam area after the dam filled, rather than a decrease. Finally, the dam will be operated in order to comply with the environmental objectives of the Water Resource Plan.

### *14.2.2. Upstream flooding*

Several submissions were concerned about flood levels in Taroom and whether plans had been developed to protect Taroom from additional flood risks.

Flood management in the Taroom area has focused on relatively frequent flood events, up to the 1 in 100 AEP. This event has a 1% chance of occurring in any given year. If the dam were in place, and full, when this event occurred the resulting peak flood level would be 189.7 m AHD, which is 0.6 m higher than if the dam were not present (measured at the Leichhardt Highway Bridge). The peak level would still be below the town's minimum development level of EL 190.1 m AHD, below which new residences may not be constructed.

There are two buildings in Taroom that are predicted to be located between the FSL extent and the 1 in 100 AEP flood extent with the dam in place. The floor levels of these buildings are unknown. The potential impact on properties will be further investigated during the detailed design of the dam. If habitable floor levels are found to be below the 1 in 100 AEP flood level mitigation strategies will be developed in consultation with the property owners. An example of the strategies that may be considered include, building modifications to increase flood resilience, house raising, relocation of the house on the block or voluntary purchase of the property.

Where a residence is above the 1 in 100 AEP flood level but the property, in general, is affected by the influence of the dam SunWater will negotiate easements for these properties so that further development or construction will not expose the residents to additional flood risk. This was discussed in Section 14.2.3.1 of the EIS.

For flood events more frequent than the 1 in 100 AEP the difference in flood peaks, pre and post dam, is less than 0.6 m. For example, there will be no change to peak flood levels for events up to the 1 in 10 AEP (equivalent to the BoM minor to major flood classification at Taroom); while the difference in flood peaks for the 1 in 20 AEP and the 1 in 50 AEP is +0.1 m and +0.3 m, respectively.

A levee to protect Taroom from flooding is not proposed. Plans to manage the higher flood levels involve SunWater negotiating easements with property owners of land and residences, so that further development or construction will not expose the residents to flood risk. A flood management plan will also be developed for Nathan Dam. This will primarily focus on managing dam safety risks under extreme events; however, scope exists to consider how the dam outlets could be used to release additional water, in order to manage upstream flooding.

One submission expressed concern that the elevation reported for Stoney Crossing was inconsistent with the zero elevation reported for the Dawson River at Taroom gauge.

The elevation of the ford across the Dawson River at Stoney Crossing (at the south west end of North Street, Taroom) is reported as approximately 181.5 m AHD, in Section 14.2.3.1 of the EIS. The Bureau of Meteorology reports that the Taroom flood gauge zero elevation is 180.82 m AHD. Although close, these levels are reporting two different locations; one is the road level and one is the gauge zero, within the river channel, and they will therefore be different. It would be expected that the road level would be above/greater than the gauge zero level, which would be expected to be close to the invert of the river.

Several submissions expressed concern about the level of the dam at the beginning of a modelled flood event.

All flood modelling for Nathan Dam was undertaken assuming that the dam level was at FSL (183.5 m AHD) at the beginning of a flood event, as discussed in section 14.1.2.3 of the EIS. This assumption is a standard industry practice, and is intended to provide a conservative basis for flood modelling.

Several submissions expressed concern about the 2010-11 flood event at Taroom.

At the time of preparing the EIS specific data was not available for the 2010-11 flood event, and it was not included in the analysis of historical flooding. Subsequently, the BoM has released a range of data and reports, and DSITIA have also undertaken a flood frequency analysis of the event; this information is discussed below.

At Taroom the 2010-11 flood event peaked on the 29/12/2010, at 10.43m on the flood gauge, equivalent to an elevation of 191.25 m AHD. **Figure 14-44** presents the annual flood peaks at Taroom, dating back to the 1860s. This figure shows that while there are two events on record which were larger than the December 2010 flood event, these occurred prior to 1900.

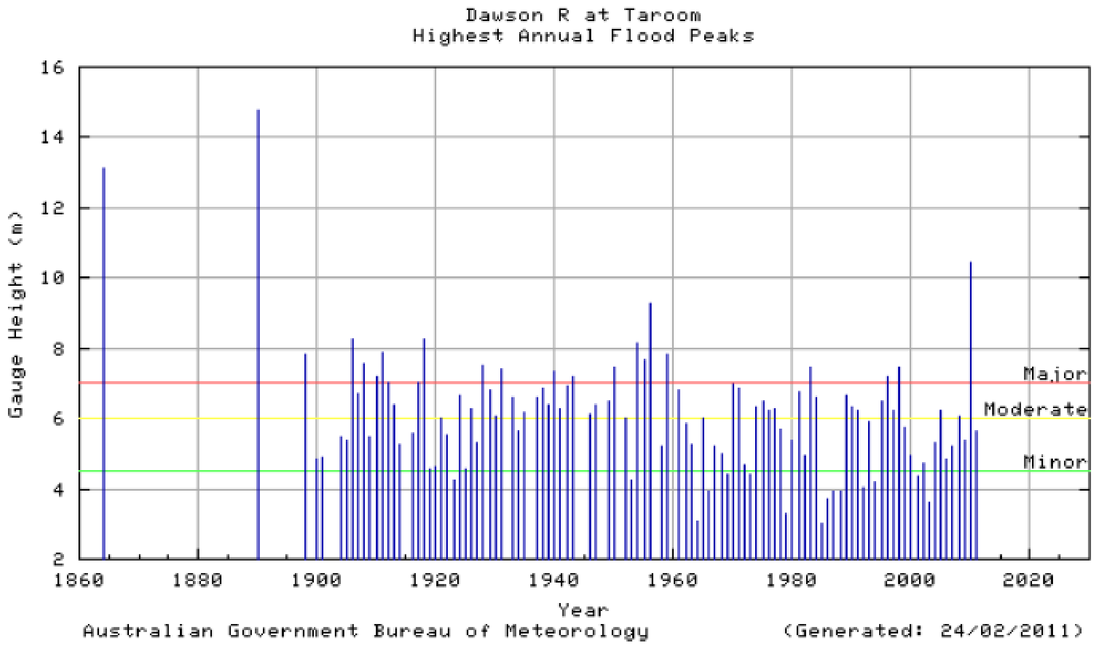



**Figure 14-44 Highest annual flood peaks for the Dawson River at Taroom (BoM, 2011)**

BoM descriptions of flood severity, presented in **Table 14-41**, are expressed in terms of the impact that the flood will have on the surrounding community, and are intended to convey the likely risk to property and people. These terms do not express the frequency, or probability, of the flood event occurring and they may not translate well between locations, depending on factors such as topography and comparative development. For example, a "moderate" flood at one location may close main traffic bridges, but at a downstream location with higher bridge levels this flood may be classified as "minor". The levels associated with each flood classification may also have changed over the years, as the region has developed.

In terms of the BoM classifications, the December 2010 flood at Taroom was considered "major", as is any flood above 7 m at Taroom. The 7m classification is roughly equivalent to a 1 in 10 AEP, i.e. it has a 10% probability of occurring in any given year. Above 7.6 m houses in Taroom begin to be affected by floodwaters (BoM, 2011); which has approximately a 1 in 20 AEP, or 5% probability of occurring in any given year.

The December 2010 flood at Taroom is considered to be approximately equivalent to a 1 in 440 AEP and is considered to be a very rare event, with a low probability of occurrence (of the order of 0.2% in any given year) (DSITIA, 2012). However, there is considerable uncertainty around the probability of the event, and the 90% confidence limits on the estimate range from 1 in 100 AEP to 1 in 4,500 AEP (DSITIA, 2012).

### Table 14-41 BoM flood classification at Taroom (GS 130302A) (BoM, 2011b)

| BoM flood classification | Description | Height (m) | Elevation (m AHD) | Equivalent AEP# 1 in x (%) |
|---|---|---|---|---|
| Minor | Causes inconvenience, such as closing of minor roads, submergence of low level bridges and makes the removal of pumps located adjacent to the river necessary. | 4.5 | 185.32 | 1.2 (57%) |
| Moderate | Causes the inundation of low lying areas requiring the removal of stock and/or the evacuation of some houses. Main traffic bridges may be closed by floodwaters. | 6.0 | 186.82 | 2.3 (35%) |
| Major | Causes inundation of large areas, isolating towns and cities. Major disruptions occur to road and rail links. Evacuation of many houses and business premises may be required. In rural areas widespread flooding of farmland is likely. | 7.0 | 187.82 | 10 (10%) |
| Maximum Flood Level 2010-11 flood (peak occurred 29/12/2010) | Extensive flooding of Taroom, above the “major” flood level for 6 days, many houses flooded and extensive damage caused | 10.43 | 191.25 | 440 (0.2%) |

# based on a flood frequency analysis conducted by DSITIA (annual flood peaks: 1912-2011)

In terms of rainfall probability, the December 2010 flood was not caused by a single extreme rainfall event, but rather by heavy, sustained rainfall over a large area, for the whole of the month. During December 2010 over 600 mm of rainfall was recorded in the upper Dawson catchment and over 400 mm in the middle Dawson catchment (BoM, 2011). In the two days leading up to the flood peak at Taroom (29/12/2010) rainfall intensity in the upper Dawson catchment was in the order of the 2-10 year ARI, depending on location and rainfall duration considered (BoM, 2011). This burst of rainfall built on the existing flood conditions to create the spike in water level, from the 29th December to the 1st January, shown in **Figure 14-45**.

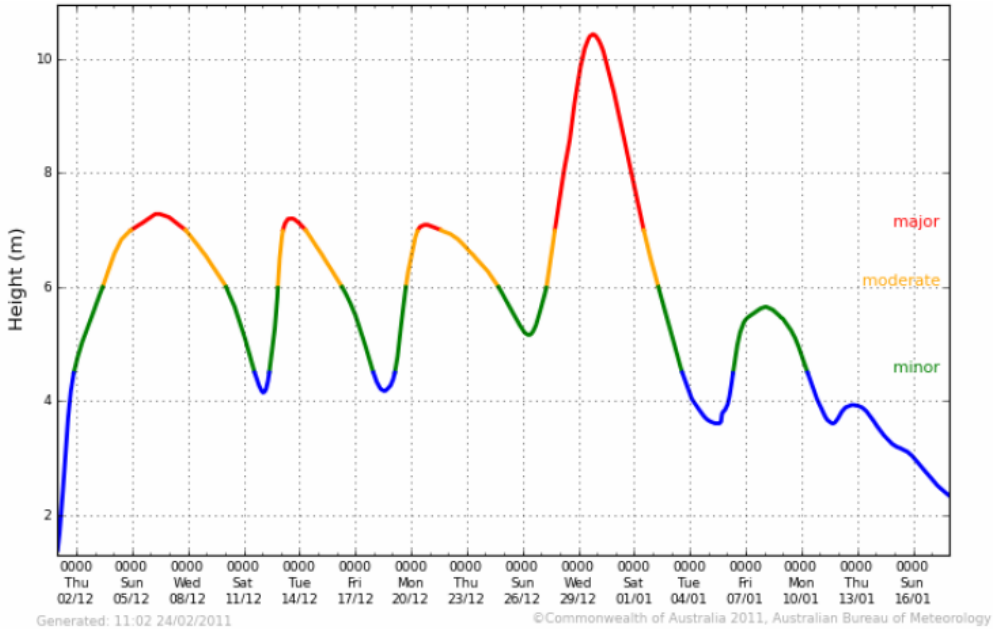



**Figure 14-45 Flood heights at Taroom gauge for December 2010 - January 2011 (BoM, 2011)**

In summary, Taroom regularly experiences floods in the minor to moderate category. Major floods also occur fairly frequently, with a 10% probability of occurring in any given year. The December 2010 flood was an extremely rare event with a very low probability of occurrence; approximately 0.2% in any given year (DSITIA, 2012). While this flood event was very large, it is not the largest flood on record at this location, which occurred in 1890.

Two suggestions were made in submissions that the dam design should be revised to include flood gates.

Flood gates are typically included in a dam spillway in order to control the volume of water being released downstream during a large flood. This is used to manage downstream flood levels, so that impacts to downstream communities can be reduced. However, this may cause an increase in floodwaters backing up behind the dam wall, which could then impact on any upstream communities. The current design configuration (with no gates) is considered to provide the best outcome, in terms of minimising flood impacts both upstream and downstream of the proposed dam.

The reservoir spillway is designed to safely pass the PMF, as outlined in section 14.1.2.3 of the EIS. If additional drawdown of the dam volume is required during a flood event the two outlets can be used for supplementary releases, the combined capacity of these outlets is 23,760 ML/d. Details of the outlets were provided in Section 2.3.1.6 of the EIS.

One submission questioned the on ground accuracy of the predicted 1 in 100 AEP flood event and the way that different areas respond to flooding.

The flood modelling results presented in the EIS are intended to be compared between pre and post dam scenarios, in order to assess the relative impact of the dam. The difference between the two scenarios can be estimated with greater precision than absolute flood levels, as the results from both scenarios are based on the same input data, with any incumbent errors.

However, the absolute flood level predicted by either individual scenario, and therefore how it is depicted on a map, is affected by all the errors and inaccuracies of the input data, along with the accuracy of the local topographic data (in this case +/- 0.7 m or +/- 0.15 m, depending on the area). Given the accuracy of the topographic data, the prediction of the absolute level of a modelled 1 in 100 AEP flood event is likely to have an accuracy of +/- 0.25 m. This is considered acceptable, for the purpose of the EIS.

The modelled post dam 1 in 100 AEP flood event is predicted to have a peak flow level of EL 189.7 m AHD at Taroom, which is 0.4 m below Taroom's minimum development level of EL 190.1 m AHD. This difference is consistent with the freeboard commonly applied to defined flood events.

The peak flood levels presented for the 1 in 100 AEP flood event represent a composite of the modelled results, for storm durations from 24 hours to 120 hours. At each model cross section the peak level across the storm durations is selected and used to prepare a regional peak flood layer, for mapping. This provides an overview of the impact of the1 in 100 AEP at a regional scale, given that different areas of the catchment will respond slightly differently.

One submission questioned the upstream extent of the flood modelling and the potential impact of the dam on the Yeovil Road Crossing on Juandah Creek.

The Nathan Dam hydraulic model extends along the Dawson River from AMTD 403.0 km (18 km upstream of Taroom) to AMTD 307.2 km (Nathan Gorge), although this was truncated for the post dam scenarios. The model includes eleven tributaries, which have a combined model length of over 112 km. Juandah Creek was represented within the model for 11.3 km, upstream of its confluence with the Dawson River, as well as 4 km of its tributary Back Creek.

Figure 14-39 of the EIS presented the inundation extent upstream of the dam, at FSL and for the 1 in 100 AEP event. This figure presented the peak flood level for areas where the level differed between the pre and post dam scenarios. Areas, such as the majority of Juandah Creek, where the peak flood level does not change due to the presence of the dam are therefore not marked on this figure.

At the Juandah Creek confluence with the Dawson River (AMTD 388.1 km) the peak flood level for the 1 in 100AEP event increases by 0.5 m, post dam. At the Back Creek confluence with Juandah Creek (approximately 7 km upstream of the Dawson River) no differences were observed between the pre and post dam modelling results (peak level or duration) for the 1 in 100 AEP event.

The Yeovil Road Crossing on Juandah Creek is a significant distance upstream of where differences between pre and post dam flood levels are observed to cease. As such, the construction of Nathan Dam is not expected to impact on the access to areas upstream of the Yeovil Road Crossing, and the crossing does not need to be raised.

One submission requested predictions of flood probabilities more extreme than the 1 in 100 AEP, given the range of climate variability predicted.

Considerations of climate variability are inherently included in any design flood hydrology analysis which is based on long term flow data. Climate variability is therefore already incorporated in the predictions of flood magnitude and frequency.

Estimates of flood events more extreme than the 1 in 100 AEP are presented in Section 14.2.3 of the EIS. This section presents predictions of the 1 in 1000 AEP event at the dam site and at Taroom, as well as estimates of the Probable Maximum Flood (PMF) flow rates at the dam site.

One submission questioned how changes in water demands over time could influence flood risk.

Changes in water demands are not expected to cause a change to the flood risk, or the releases required to mitigate floods. As the flood modelling includes the assumption that the dam is full when a flood event occurs, this provides a conservative basis for the flood assessment, which precludes the need for considering the impact of reduced demand.

## 14.3. Compensation strategies

One submission requested information on potential compensation strategies which may be offered to waterharvesters who are adversely affected by Nathan Dam.

At the time of preparing the EIS it was felt to be too early to discuss compensation strategies, due to a number of variables associated with the Project. Compensation strategies were planned to be developed at the detailed design phase of the Project, and in consultation with affected landholders. As stated in the EIS, SunWater intends to negotiate compensation agreements with affected individuals, on a one to one basis. This is because individual circumstances and business requirements are expected to vary across the catchment and a single compensation strategy may not suit the needs of individual businesses.

While the option of financial compensation is expected to play a key part in compensation, several alternative water supply strategies were investigated, as part of the AEIS. These included a translucent release strategy and a medium priority conversion, with several different options. Key details of these strategies are presented in **Table 14-42**.

The concept behind the translucent release strategy was to make an additional release from Nathan Dam once a year, or triggered by certain conditions, which downstream users could access under their existing licence conditions, and with no changes to downstream infrastructure or storage operations. The release would be of a naturally occurring flow event, in the same manner as the first post winter flow release. Unfortunately, this release was found to be inefficient, requiring a flow release in the order of 35,000 ML/a to provide 3,500 ML/a of waterharvesting take. Other users in the system would also be affected by the release, experiencing a reduction in water supply and reliability. For these reasons, this strategy was not considered worth pursuing.

The second strategy was based on the supply of a medium priority product to the affected waterharvesters. This could either replace their entire entitlement, or just that volume of water that has been lost, due to the operation of Nathan Dam. This strategy was found to be very effective, however; it will need to be tailored to meet individual needs, given that the usefulness of a MP water product will differ depending on individual farming practises. The effect on other existing users was minimal.

## Table 14-42 Water supply compensation strategies investigated

| Strategy | Description | Effectiveness | Recommendation |
|---|---|---|---|
| Translucent release strategy - annual | Once a year a large flow event is passed through Nathan Dam, in order to provide an additional flow event for impacted users to access. | Not effective | This strategy should not be investigated further, as it requires the release of very large volumes of water from Nathan Dam in return for limited benefit. |
| Translucent release strategy – dry periods | During dry periods a large flow event is passed through Nathan Dam, in order to provide an additional flow event for impacted users to access. | Not effective | This strategy should not be investigated further, as it requires the release of very large volumes of water from Nathan Dam in return for limited benefit. |
| Medium Priority conversion – partial | A portion of mean annual volume of waterharvesting (unsupplemented) entitlement lost with the dam in place is supplied to the affected individual as a new medium priority product. | Very effective | This strategy should be investigated further.<br>The strategy may have a small impact on existing MP users and EFOs. This should be balanced through the consideration of a conversion ratio, i.e. the determination of a compensatory volume of supplemented MP water for the lower reliability waterharvesting entitlement. |
| Medium Priority conversion – total | The unsupplemented water entitlement of existing users is surrendered and SunWater makes available a new medium priority product.<br>(this would require a volume conversion, as outlined in the preceding case) | Very effective | This strategy should be discussed with affected individuals before being investigated further. This strategy is unlikely to be suitable for the majority of users, due to existing on farm water storages and irrigation/farming practises, but may suit some users. |

Compensation options have been discussed with irrigators and this is reported in **Appendix B14**. These discussions were preliminary in nature, as final agreements would only be required in the event of Nathan Dam proceeding. One of the options identified was to use supplemented water (e.g. medium priority water allocations under commercial terms to be agreed) as part of compensation arrangements. SunWater will engage with DNRM as part of this process. In the event of such compensation agreements being agreed between SunWater and individual waterharvesters, SunWater understands that the regulator, DNRM, may need to amend aspects of the Fitzroy WRP and the corresponding ROP in order to give effect to such arrangements.

## 14.4. Monitoring and management

One submission requested further information on the monitoring and management of environmental flow releases.

As part of the management of environmental flow releases a streamflow monitoring gauge will be installed downstream of the dam, between the dam wall and the Gyranda Weir upstream inundation extent. Inflows to the dam will also be monitored, possibly from the relocated Taroom gauge.

While the gauge downstream of the dam will monitor dam releases it is likely that the flow in this reach will also be affected by groundwater inflows, due to the influence of Boggomoss Springs in the reach. This is an issue that has only recently been identified and is currently undergoing fieldwork and research, in order to quantify the level of groundwater connectivity in the region. Initial information indicates that the presence of the dam will increase the level of groundwater inflow to the river. While this may reduce the amount of water that is required to be released from the dam in order to maintain baseflow conditions, the fishway and turtleway will still require the release of some water as part of their operations. The environmental flow release strategy is therefore an area which will need to be studied and monitored carefully, and adjusted in order to improve ecological outcomes.

The effectiveness of the environmental flow releases, fishway and turtleway will also be assessed through ongoing ecological monitoring and surveys. The reach between Orange Creek Weir and Theodore Weir is of particular interest for the management of flows which may affect Fitzroy River Turtle nesting areas and Boggomoss snail habitats. Streamflow in this reach will be monitored through the existing streamflow gauge at Isla-Delusion.

The monitoring will include geomorphic assessments as described in **Appendix B29** Section 10.2.

## 14.5. Risk assessment

One submission requested further information regarding the risk assessment tables presented.

The risk assessment methodology and an explanation of the structure of the tables was provided in Section 1.9 of the EIS (incorrectly cross referenced in Section 14.3.2 to Section 1.8). Separate table sections were presented for the major items of the Project (Dam and surrounds, Pipeline and Associated Infrastructure) and independently for the construction and operation phases.

One hazard identified for the Dam and surrounds item was "Reduced flow levels and volumes downstream of the dam" and this was applicable to both construction and operation phases. In the construction phase the factor which might cause this hazard to occur was construction of the dam, and the associated project control was to construct the diversion channel around the works. This resulted in a low risk ranking being achieved.

In the operations phase this same hazard was repeated a number of times because it could be caused by different factors (being during the first filling phase – termed in the EIS table the "impoundment phase", and during the actual operations phase). It could impact on two clearly different values during the operations phase (being the water users access to water and the EFO's). The "land use restrictions" included as one project control was referring only to the restrictions that may apply in the dam flood buffer area.