

7.	Surface Water Resources	7-1
7.1.	Introduction	7-1
7.2.	Submissions Received	7-1
7.3.	Flooding	7-2
7.4.	Hydrology Modelling (IQQM) Model Version	7-3
7.5.	Water Resources Assessment – Current Climate Conditions	7-4
7.6.	Water Resources Assessment – Climate Change Conditions	7-12

7. SURFACE WATER RESOURCES

7.1. Introduction

This Surface Water Resources chapter addresses the submissions received on the EIS for the proposed Emu Swamp Dam. The proposal addressed in the SEIS remains unchanged from the Combined Urban and Irrigation Dam outlined in Section 3.1.1.1 of the EIS. The proposed storage characteristics Emu Swamp Dam are presented in Table 7-1.

Table 7-1 Dam Storage Characteristics

	Emu Swamp Dam
Full Storage Volume (ML)	10,500
Full Storage Level (m AHD)	738
Minimum Operating Volume (ML)	330
Minimum Operating Level (m AHD)	726
Inundated Area at Fully Supply Level (ha)	196
Bed Level (m AHD)	721
Catchment Area (km ²)	586
Stream	Severn River
AMTD (km)	264.0
Environmental Release Strategy	Inflow to the dam < 30 ML/d – release from dam = inflow to dam Inflow to the dam > 30 ML/d – release from dam = 30 ML/d

7.2. Submissions Received

A number of submissions were received on the EIS, these submission have been grouped by similar themes. The main themes for the submissions received are outlined below.

7.2.1. Dam Performance under Recent Climate Conditions

A number of submissions requested further information and assessment of the performance of the proposed Emu Swamp Dam under recent climate conditions, particularly from 1996 to 2011.

Further assessment has been undertaken to provide additional information on the impacts of the proposed Emu Swamp Dam in an extended climatic period. The following sections provide further information on issues raised in the submissions on this theme:

- The model used to undertake this assessment is outlined in Section 7.4.1; and
- Information on proposed Emu Swamp Dam performance in terms of predicted dam yield and storage levels is provided in Section 7.5.1 and Section 7.5.2 respectively.

7.2.2. Environmental Flow Release Strategy and Spills

The request for further information on the environmental releases from the proposed Emu Swamp Dam and the spills from the dam was a key theme in a number of submissions. Concerns were raised in the submissions of the ability of the proposed environmental release strategy to replicate natural flow regimes and to trigger ecological function. A number of statistics have been prepared to demonstrate the predicted performance of the

proposed Emu Swamp Dam in terms of environmental releases and spills, this information is provided in Section 7.5.3 and Section 7.5.4.

7.2.3. *Climate Change*

The effect of climate change to the proposed Emu Swamp Dam was raised in several submissions. The submissions covered the potential change in yield on the dam and impacts to the downstream flow regime. Section 7.4.2 provides information on the model used to assess the impact of climate change and Section 7.6 outlines the climate change assessment undertaken for the proposed Emu Swamp Dam.

7.2.4. *Weir Drown Out*

Submissions were received on the issue of weir drown out in relation to fish passage for the wall of the proposed Emu Swamp Dam. Analysis of weir drown out for a waterway barrier is required to demonstrate it is not necessary or desirable to provide for the movement of fish across the barrier. Since the submission of the EIS, the proposed design for the dam wall has been modified to include fish passage. Details of the proposed fish passage are provided in Section 1.4.5 of the SEIS.

7.2.5. *Flood Heights*

The recorded flood height information was requested for the period from when the EIS was published to present, this information is presented in Section 7.3.

7.3. Flooding

The historical flooding information for the Ballandean and Farnbro gauges were presented in Section 7.1.1.4 of the EIS. Since the EIS there has been two notable floods in 2008 and 2011. The gauge heights and peak discharges have been presented in Table 7-2 and Table 7-3 for the Farnbro and Ballandean respectively.

Table 7-2 Historical Flooding at Farnbro (416310a)

Date	Gauge Height (m)	Peak Discharge (m ³ /s)
December 1975	3.47	485
February 1976	6.24	1,600
May 1983	3.08	358
April 1988	3.90	624
January 2008	3.73	547
January 2011	5.43	1,211

Table 7-3 Historical Flooding at Ballandean (416318a)

Date	Gauge Height (m)	Peak Discharge (m ³ /s)
January 2008	3.31	138
January 2011	5.51	945

Based on the recorded flood levels for Farnbro is 2011 was a significant flood event and the flood event of 2008 was comparable to a number of previous events. The Ballandean gauge is only relatively new being installed in 1999. The recent flooding events are consistent with the assessment undertaken for flooding in the EIS.

7.4. Hydrology Modelling (IQQM) Model Version

For the EIS, the hydrology model (IQQM) for the Granite Belt was supplied by the Department of Natural Resources and Water (DNRW) to SKM, under licence agreement number 2005/50729. This was the Water Resource Plan (WRP) model and was used by SKM to assess the impact of the proposed Emu Swamp Dam on surface water resources in the Granite Belt catchment. This assessment included:

- compliance with environmental flow objectives (EFOs) and water allocation security objectives (WASOs);
- yield of the proposed Emu Swamp Dam;
- spills and releases from the proposed Emu Swamp Dam; and
- changes to the downstream flow regime.

This model was run with the simulation period from 1 January 1890 to 30 September 1996.

The hydrologic models associated with the WRP process are now under the jurisdiction of the Department of Science, IT, Innovation and the Arts (DSITIA). The hydrology models have been further developed by DSITIA since the publication of the EIS as described below.

7.4.1. *Extended and Upgraded IQQM*

DSITIA have undertaken an upgrade of the Granite Belt IQQM model, this upgrade includes:

- extension of the model simulation period to 31 of December 2011;
- recalibration of the model inputs with additional gauge information of rainfall, streamflow and evaporation; and
- improved representation of farm dams in the system.

This model has been supplied by DSITIA to SKM under Licence number CAS2143 with supporting documentation. This extended model version allows for the improved assessment of the proposed Emu Swamp Dam with an improved representation of the system through recalibration of streamflows and representation of the farm dams in the system. This model also allows for the assessment of recent important hydrological periods (eg the dry period in the early to mid 2000s and the wet periods in the late 2000s).

DSITIA have advised that this model is not suitable for assessing compliance with EFOs and WASOs, as a predevelopment model has not been developed for the extended and upgraded IQQM. Therefore, the assessment of compliance with EFOs and WASOs for the proposed Emu Swamp Dam remains unchanged from the assessment presented in the EIS. The extended and upgraded IQQM can be used to assess the performance of the proposed Emu Swamp Dam. The subsequent assessment in this chapter uses this extended and upgraded IQQM for the assessment of performance of the proposed Emu Swamp Dam in order to respond to a number of submissions received on the EIS.

The simulation period for this model is from the 1 January 1889 to the 31 December 2011 and is referred to as the “Extended IQQM” in the remainder of this chapter.

7.4.2. *Climate Change*

A number of submissions received on the EIS requested further information on the performance of the proposed Emu Swamp Dam under climate change conditions. DSITIA have supplied SKM with inputs of rainfall, evaporation and streamflow for climate change scenarios, to allow for the assessment of the performance of the

proposed Emu Swamp Dam under climate change conditions. To be consistent with other recent dam impact assessments, three climate change scenarios were assessed, representing the changes in stream flow of :

- 10th percentile;
- 50th percentile (median); and
- 90th percentile.

Further description of the climate change methodology developed and applied by DSITIA is provided in Appendix D.

7.4.3. *Model Limitations*

While every care is taken to ensure the accuracy of Hydrology Information supplied by DNRW and DSITIA, they make no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaim all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the Hydrology Information being inaccurate or incomplete in any way and for any reason.

Evaporation losses have been included in the assessment of the storages however the seepage losses from the storage have not been included in the assessment.

7.5. Water Resources Assessment – Current Climate Conditions

7.5.1. *Yield Assessment*

As outlined in Section 7.1.3.6 of the EIS, the proposed Emu Swamp will have an annual urban water supply demand of 750 ML and irrigation water supply of 1,740 ML. The urban water allocation volume for the SDRC is 1,500 ML; however, this is proposed to be taken in a staged approach, with the pipeline infrastructure being developed with a capacity of 750 ML/yr. Therefore, the impact assessment for the proposed Emu Swamp Dam is based on the extraction of 750 ML/yr.

Table 7-4 presents the update performance of the proposed Emu Swamp Dam, while the performance of Storm King Dam is presented for comparison.

Table 7-4 Dam Performance

	Proposed Emu Swamp Dam		Storm King Dam
	Urban Water Supply	Irrigation Water Supply	Urban Water Supply
Allocation Volume (ML/year)	1,500	1,740	700
Annual Extraction Volume (ML/year)	750	1,740	700
Mean Annual Diversion (ML)	742	1,676	691
Monthly Reliability (%)	99.9	96.6	97.6
Annual Reliability (%)	99.2	93.5	95.1

These results show that the proposed Emu Swamp Dam will have high reliability, greater than 99% monthly and annual reliability, for the urban water supply. For urban water supply it is preferred if the reliability is more than 99%. The irrigation supply reliability is also significantly above other comparable water supply schemes. The only time in the simulation period (1889 to 2011) that the proposed Emu Swamp Dam was predicted to fail to meet the water supply requirements is at the end of 2007, following an extended dry period.

7.5.2. Dam Storage Behaviour

Figure 7-1 presents the modelled storage exceedance curve for the proposed Emu Swamp Dam with annual allocations of 750 ML and 1,740 ML, for urban and irrigation water supplies respectively.

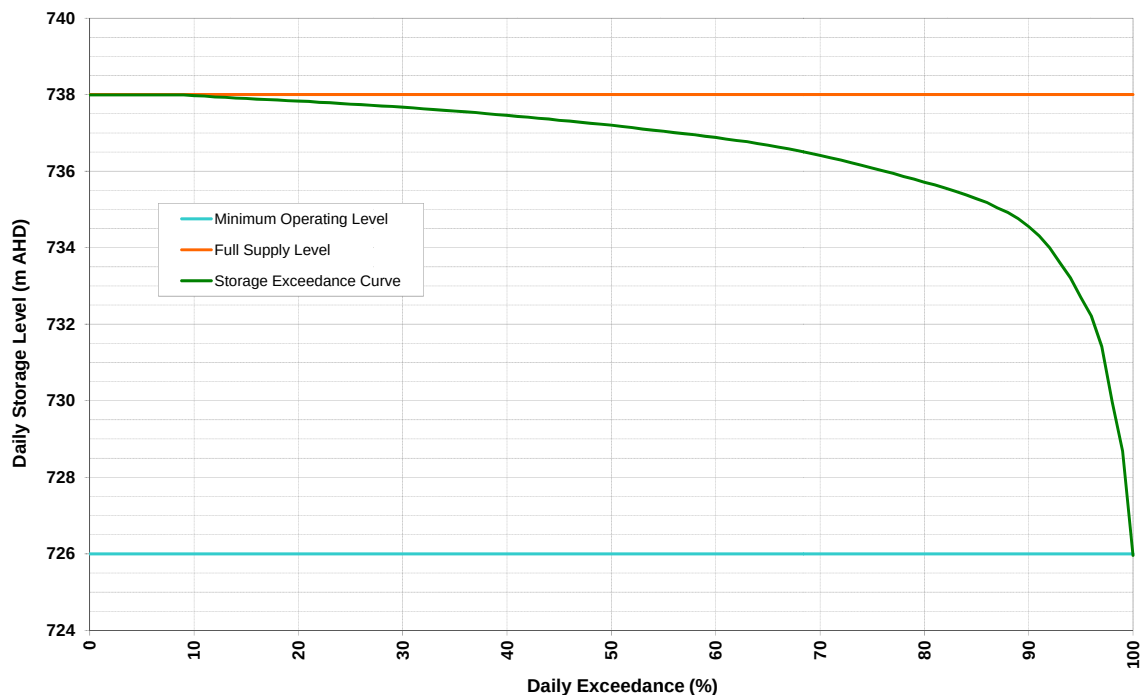


Figure 7-1 Dam Storage Behaviour

The exceedance curve presented in Figure 7-1 shows the percentage of days during the simulation when the storage equals or exceeds a particular storage level. It can be seen that during the modelled simulation period the proposed Emu Swamp Dam is above, at, or near full capacity (i.e. less than 1 m below the FSL) for 55% of the time. The dam fails (i.e. falls below the minimum operating level of 726 m AHD) for less than 1% of the time.

7.5.3. Spills and Environmental Releases

This section describes the spills and environmental releases from Emu Swamp Dam, which will create the streamflow directly downstream of the dam.

An environmental release strategy has been developed with the aim of maintaining the low flow regime for the Severn River, downstream of the proposed Emu Swamp Dam. The environmental release will pass flows through the dam of up to 30 ML/d when a flow is received into the dam. For example, if a flow of 8 ML/day is received into the proposed Emu Swamp Dam, 8 ML/d will be released from the dam to continue on downstream. When flows in excess of 30 ML/d are received by the dam, 30 ML/d will be released to continue on downstream.

This strategy is aimed at maintaining the natural flow regime for low flows and the ephemeral nature of the Severn River, particularly in the reach downstream of the proposed Emu Swamp Dam to the confluence with Accommodation Creek. The discussion of the flow statistics with the proposed Emu Swamp Dam and the associated environmental release strategy is presented in Section 7.5.4.

Figure 7-2 presents a daily time series of spills and environmental releases from the proposed Emu Swamp Dam.



Figure 7-2 Dam Release and Spills

Table 7-5 presents the key spill statistics for the proposed Emu Swamp Dam. The proposed Emu Swamp Dam was predicted to spill in 88 years of the 123 year of the simulation period. This assessment shows that the dam spills on average 46 days per year and that the average period between spills is 0.4 years. The average duration of a spill from the dam is 14 days. Figure 7-3 shows the annual number of spill days in the simulation period.

Table 7-5 Dam Spill Statistics

Spill Statistics		
Total number of days of spill in the simulation period (123 years)	(days)	4,015
Total number of years in the simulation period with spills	(years)	88
Average duration of spills	(days)	14
Average number of days of spill per year	(days)	46
Average period between spills	(years)	0.4
Longest period between spills	(years)	6.8

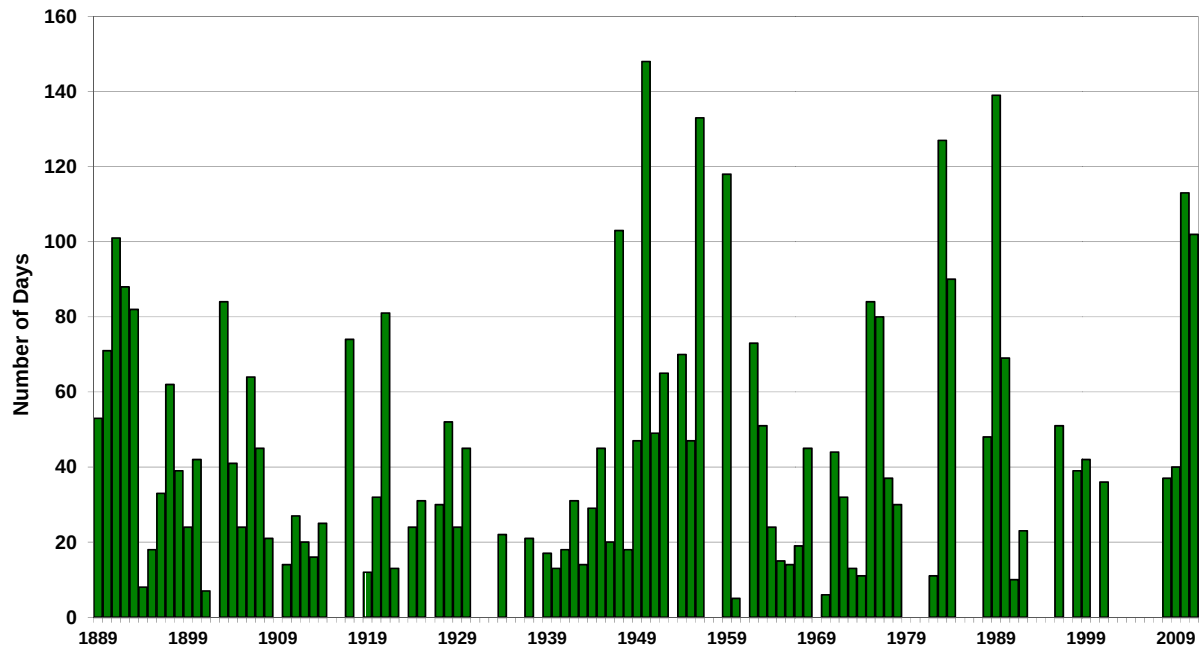


Figure 7-3 Dam Annual Number of Spill Days

7.5.4. Flow Statistics

As outlined in Section 7.1.3 of the EIS, changes in streamflow were assessed at a number of locations:

- Severn River downstream of the proposed the dam site at Ballandean Gauge – this shows the change to streamflow in the reach downstream of the dam to Accommodation Creek (Figure 7-4);
- Severn River immediately downstream of the confluence with Accommodation Creek – this shows the changes to streamflow for the Severn River downstream of the Accommodation Creek confluence (Figure 7-6);
- Dumaresq River at Farnbro – this is shows the changes in streamflow in the Sundown National Park (Figure 7-7).

The proposed Emu Swamp Dam will not impact of the flow regime upstream of the proposed dam location.

The flow statistics show that the change to the flow regime at the Ballandean Gauge predominantly occurs between the 2% and 20% daily exceedance, as shown in Figure 7-5. It is important to compare the depth of flow in the river through this range, in order to understand the potential impact to the aquatic and terrestrial environment. Figure 7-5 shows the cross section at this location in the river, which shows a defined channel with a channel depth of approximately 2 m.

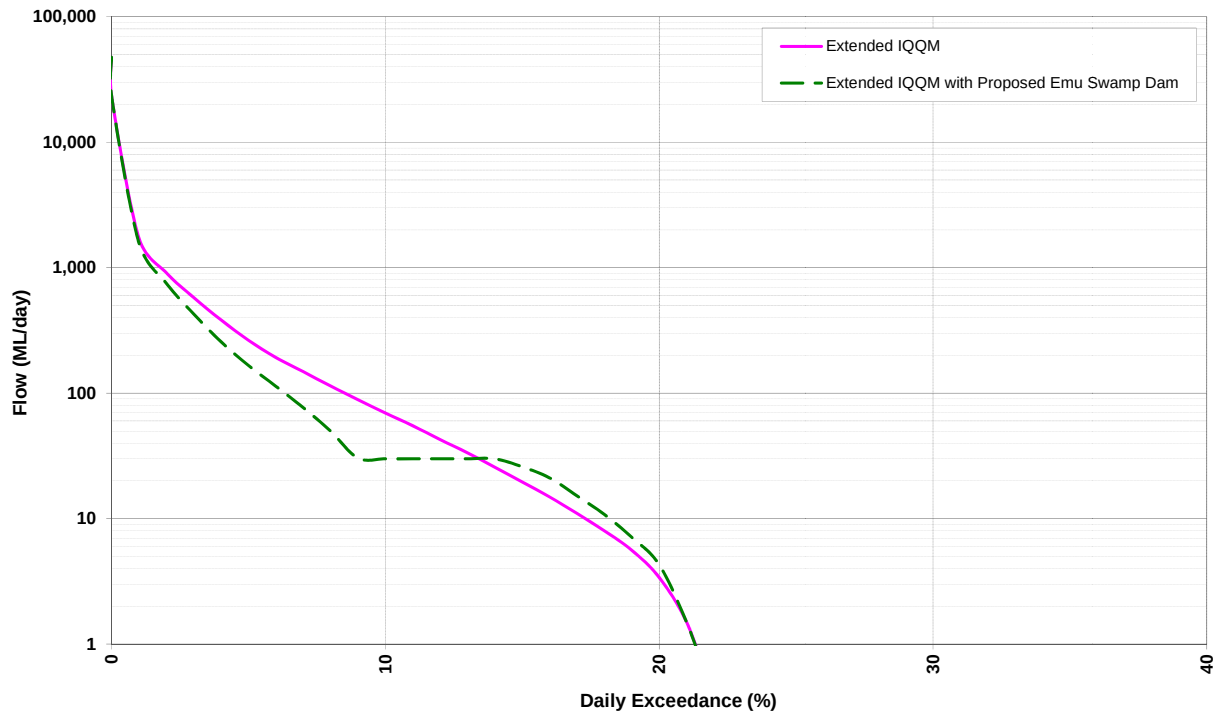


Figure 7-4 Flow Duration Curve – Downstream of the Dam Site (Ballandean Gauge)

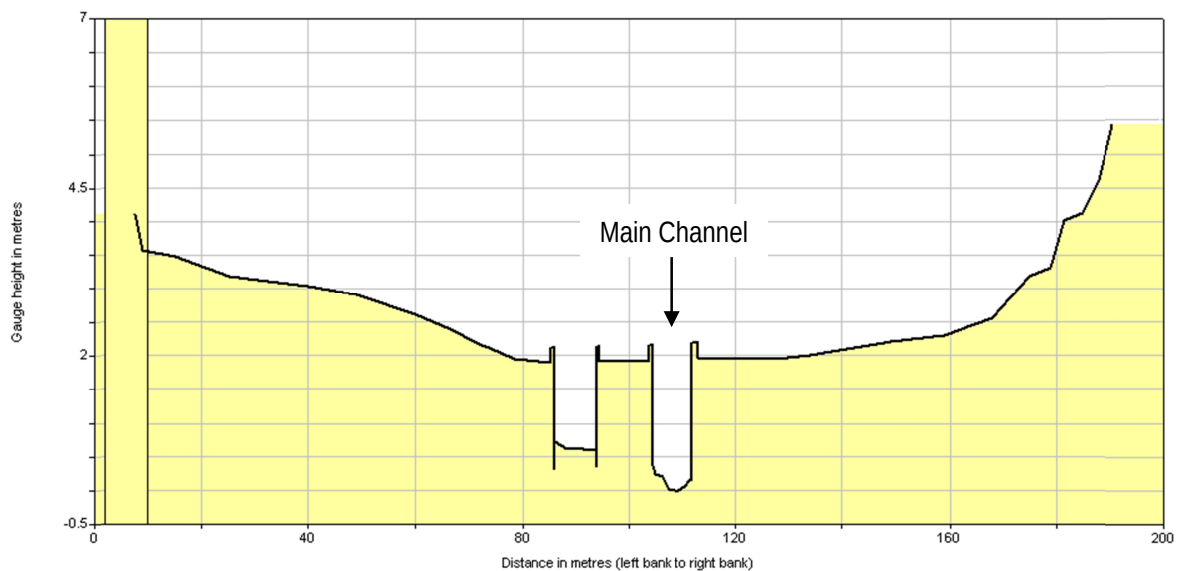


Figure 7-5 Cross Section at Ballandean Gauge (adapted from DNRW Website)

Table 7-6 presents the predicted flow and gauge depth at Ballandean gauge for the 5%, 10% and 15% daily exceedance. This table shows that the predicted change in flow depth is in the order of 100 mm. This is considered to be a negligible change, which is likely to have minimal impact on water quality and instream ecological requirements.

Table 7-6 Flow Statistics – Ballandean Gauge

Daily Exceedance (%)	Scenario	Flow (ML/d)	Gauge Depth (m)	Change in Flow Depth (m)
15%	Extended IQQM	20	0.84	+ 0.1 (100 mm)
	Extended IQQM with Proposed Emu Swamp Dam	26	0.94	
10%	Extended IQQM	70	0.64	- 0.1 (100 mm)
	Extended IQQM with Proposed Emu Swamp Dam	30	0.54	
5%	Extended IQQM	264	0.50	- 0.04 (40 mm)
	Extended IQQM with Proposed Emu Swamp Dam	167	0.64	

Figure 7-6 presents the change in the flow regime downstream of the Accommodation Creek confluence. This figure shows that the change in the flow regime occurs between the 2% and 15% daily exceedance. There is no rating curve available for this location to determine the change in the flow depth; however, this change is considered to be less than the change at the Ballandean Gauge, as outlined above.

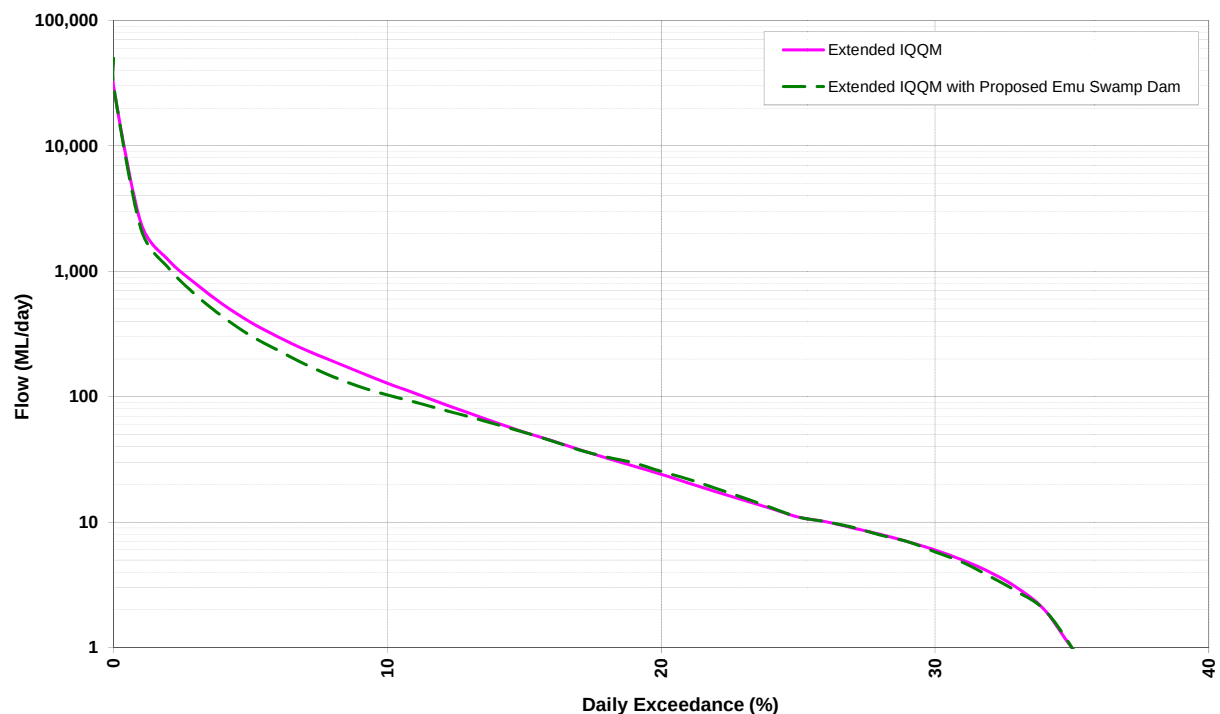


Figure 7-6 Flow Duration Curve – Downstream of the Accommodation Creek Confluence

The flow statistics show that the change to the flow at Farnbro occurs between the 1% and 18% daily exceedance, as shown in Figure 7-7 and Figure 7-8. It is important to compare the depth of flow in the river through this range, in order to understand the potential impact to the aquatic and terrestrial environment. Figure 7-9 shows the cross section at this location in the river, which shows a wide channel.

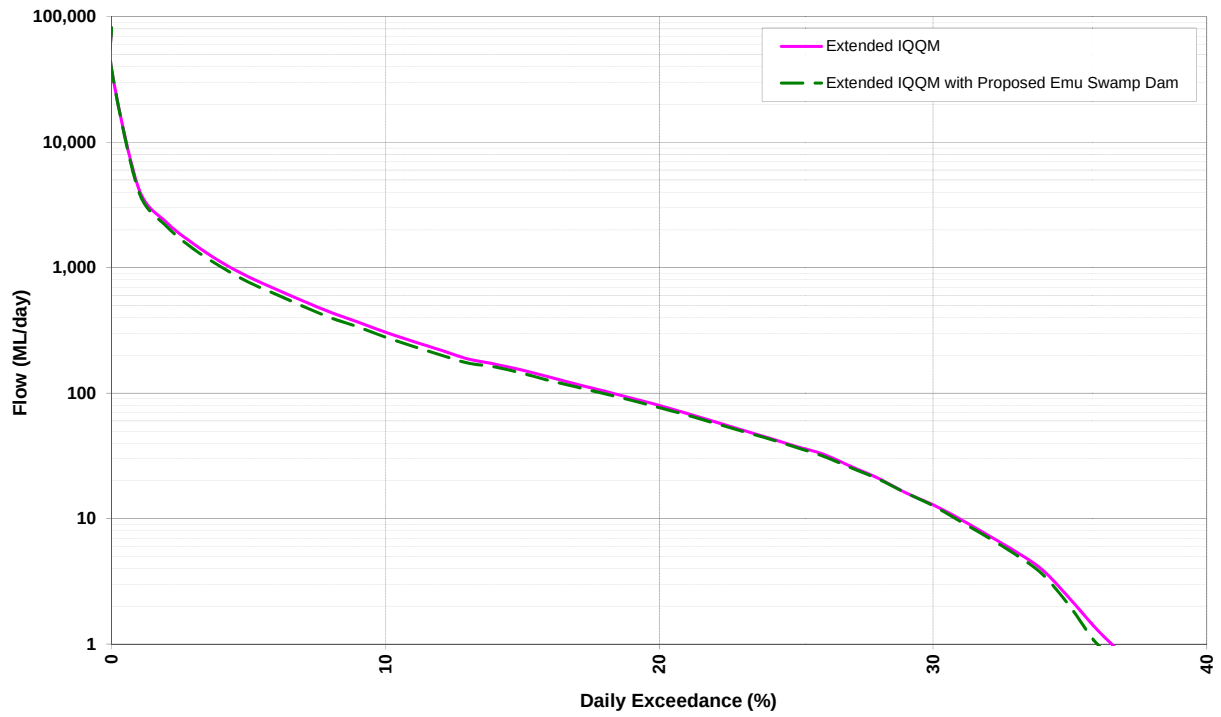


Figure 7-7 Flow Duration Curve – Farnbro

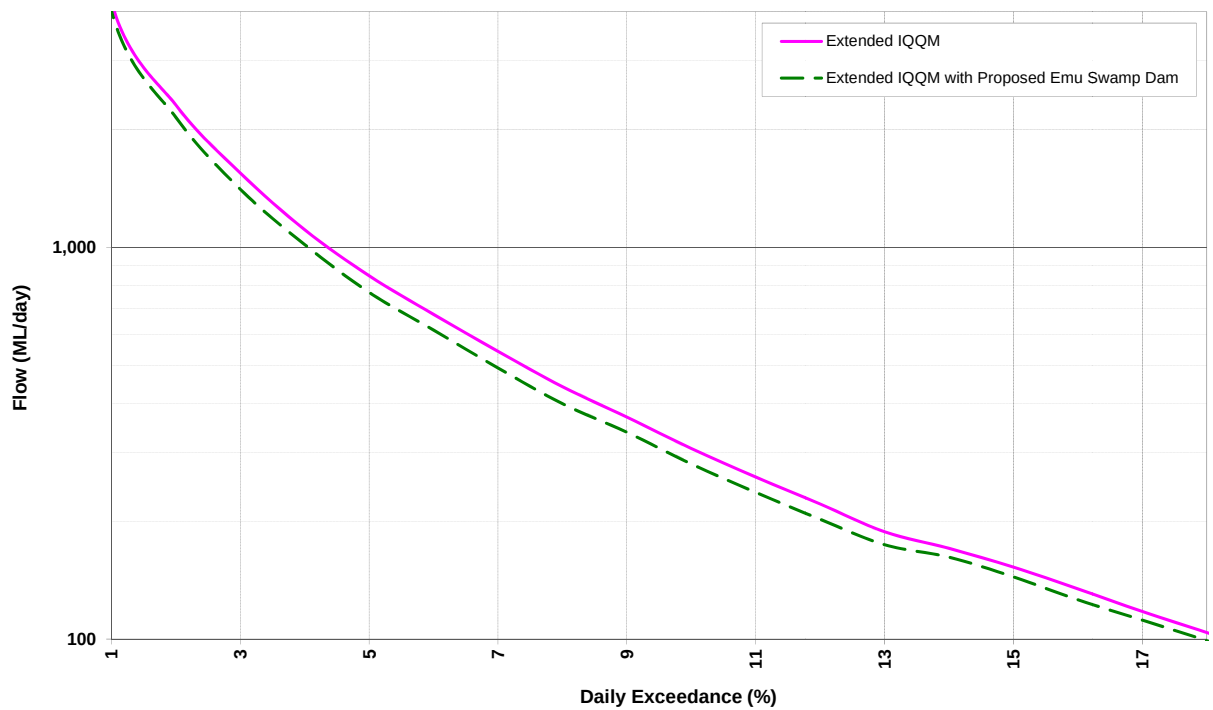


Figure 7-8 Flow Duration Curve – Farnbro – Zoom

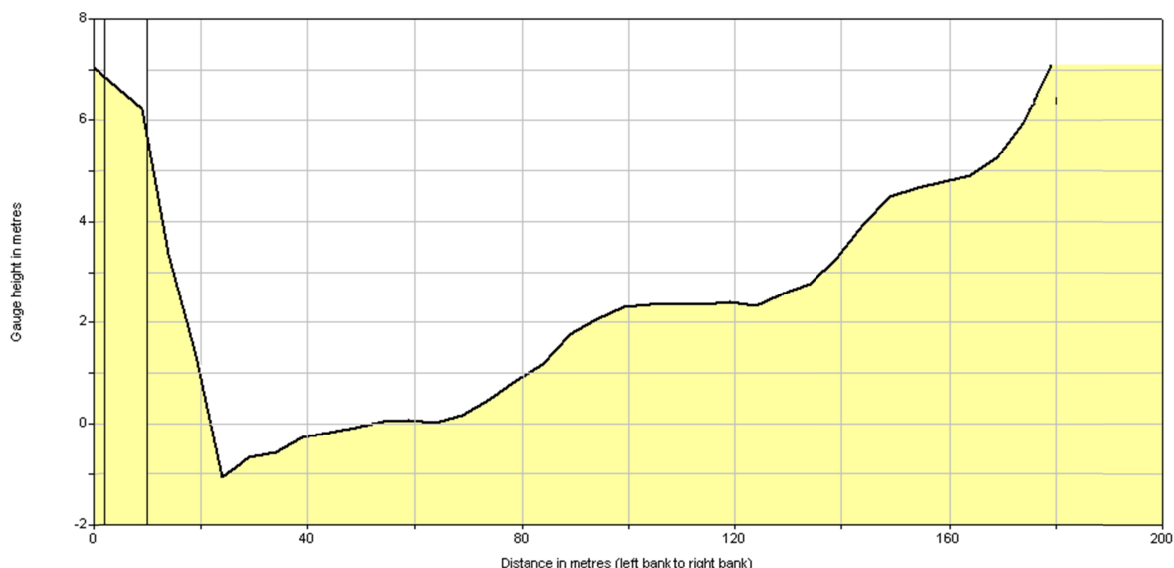


Figure 7-9 Cross Section at Farnbro Gauge (adapted from DNRW Website)

Table 7-7 presents the predicted the flow and flow depth at Farnbro for the 5%, 10% and 15% daily exceedance. This table shows that the predicted change in flow depth is in the order of 0 – 20 mm. This is considered to be a negligible change in these flow depths, which is likely to have minimal impact on water quality and instream ecological requirements.

Table 7-7 Flow Statistics – Farnbro Gauge

Daily Exceedance (%)	Scenario	Flow (ML/d)	Flow Depth (m)	Change in Flow Depth (m)
15%	Extended IQQM	152	0.38	0
	Extended IQQM with Proposed Emu Swamp Dam	144	0.38	
10%	Extended IQQM	306	0.46	- 0.01 (10 mm)
	Extended IQQM with Proposed Emu Swamp Dam	280	0.45	
5%	Extended IQQM	847	0.66	- 0.02 (20 mm)
	Extended IQQM with Proposed Emu Swamp Dam	768	0.64	

7.6. Water Resources Assessment – Climate Change Conditions

7.6.1. Yield Assessment

The performance of the proposed Emu Swamp Dam was assessed under a number of climate change scenarios, as outlined in Section 7.4.2. Table 7-8 and Table 7-9 present the performance of the urban water supply and irrigation water supply respectively, under climate change conditions.

Table 7-8 Dam Performance – Urban Water Supply

	Current Climate	Climate Change		
		10 th Percentile	50 th Percentile	90 th Percentile
Allocation Volume (ML/year)	1,500	1,500	1,500	1,500
Annual Extraction Volume (ML/year)	750	750	750	750
Mean Annual Diversion (ML)	742	743	740	738
Monthly Reliability (%)	99.9	100	99.5	99.3
Annual Reliability (%)	99.2	100	99.2	98.4

Table 7-9 Dam Performance – Irrigation Water Supply

	Current Climate	Climate Change		
		10 th Percentile	50 th Percentile	90 th Percentile
Allocation Volume (ML/year)	1,740	1,740	1,740	1,740
Annual Extraction Volume (ML/year)	1,740	1,740	1,740	1,740
Mean Annual Diversion (ML)	1,676	1,692	1,607	1,550
Monthly Reliability (%)	96.6	97.5	92.5	89.3
Annual Reliability (%)	93.5	95.1	87.0	83.7

These results show that the proposed Emu Swamp Dam is predicted to have high reliability, greater than 99% reliability, for the urban water supply under a range of climate change conditions. For urban water supply it is preferred if the reliability is more than 99%. The predicted impact of climate change on the ability of the proposed Emu Swamp Dam to meet the urban water supply is negligible, reducing from 99.9% monthly reliability under current climate conditions to 99.3% under the 90th percentile climate change conditions.

The irrigation water supply reliability is predicted to be reduced under some climate change conditions. The monthly reliability is predicted to reduce from 96.6% under the current climate to 89.3% under the 90th percentile climate change conditions. The irrigation water supply reliability is still significantly above other comparable water supply schemes, under a range of potential climate change conditions.

7.6.2. Streamflow Assessment

The assessment of climate change was undertaken on the extended IQQM model and also with the proposed Emu Swamp Dam.

7.6.2.1. Extended Model

A climate change assessment was undertaken on the potential impact on the Severn River due to climate change, without the construction of the proposed Emu Swamp Dam. This assessment was undertaken using the extended IQQM model, for the scenarios outlined in Section 7.4.2. Figure 7-10, Figure 7-11 and Figure 7-12 present the change to the flow regime as result of climate change at the three reporting locations without the construction of the Emu Swamp Dam.

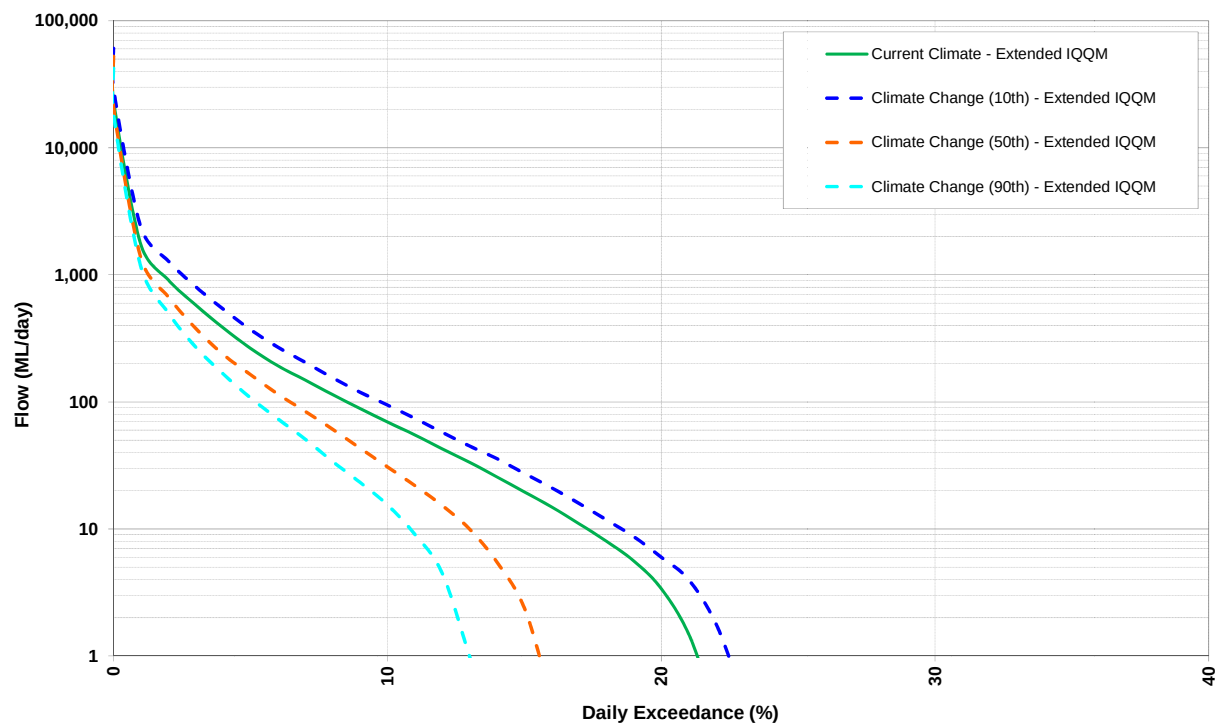


Figure 7-10 Flow Duration Curve – Downstream of the Dam Site

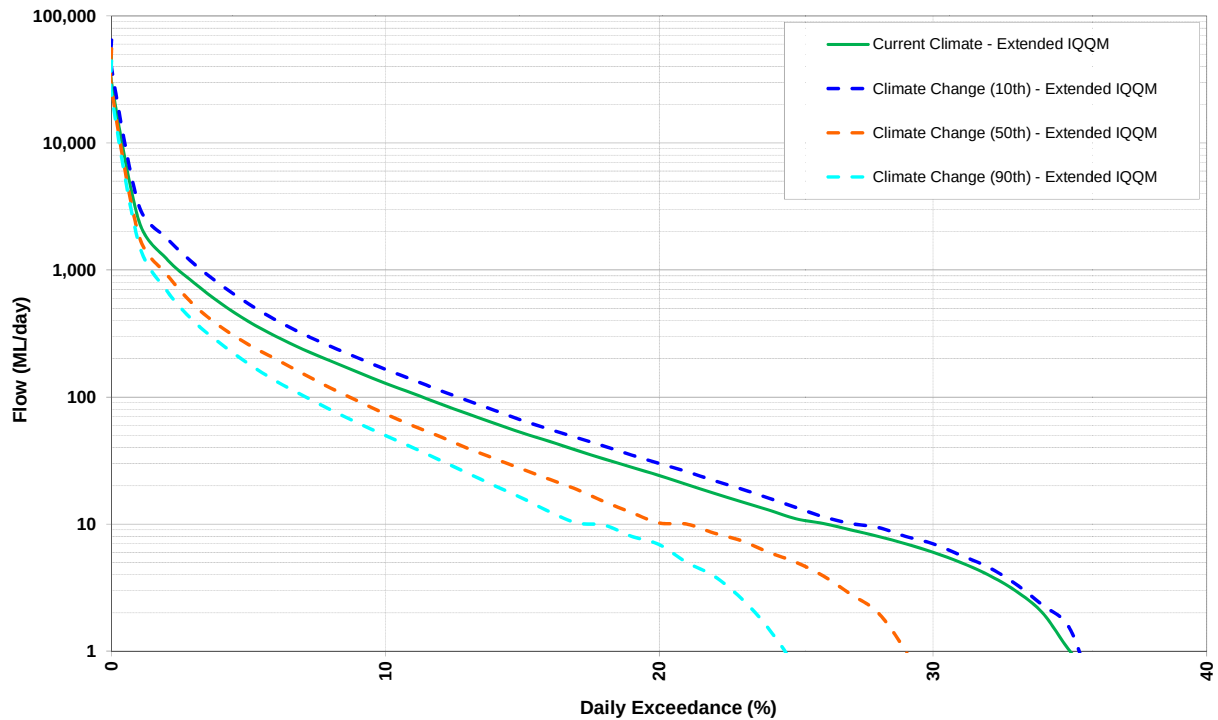


Figure 7-11 Flow Duration Curve – Downstream of the Accommodation Creek Confluence

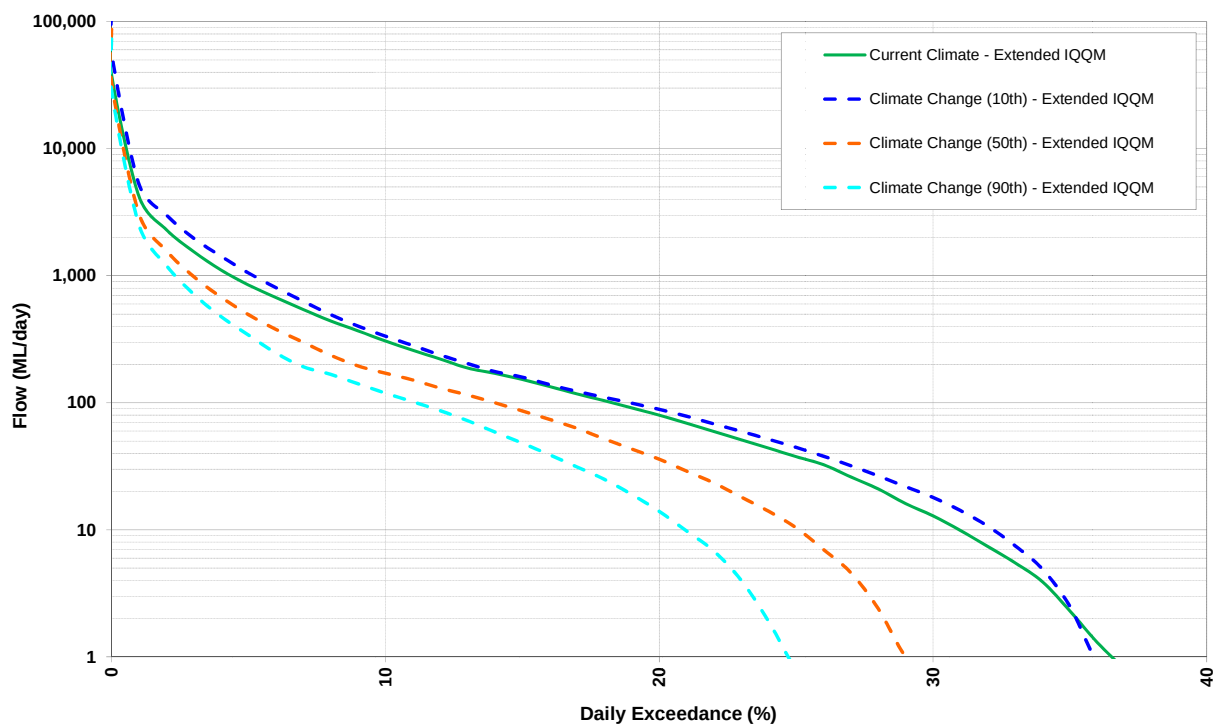


Figure 7-12 Flow Duration Curve – Farnbro

These results show the potential change to the flow regime in the Severn River from the three climate change scenarios. These changes range from an increase in flow in the 10th percentile scenario, to a reduction in flow in

both the 50th and 90th percentile scenarios. Therefore, there are predicted to be changes to the flow regime of the river as a result of climate change.

7.6.2.2. *Proposed Emu Swamp Dam*

A climate change assessment was undertaken on the potential impact on the Severn River due to climate change, with the proposed Emu Swamp Dam. This assessment was undertaken using the extended IQQM model for the scenarios outlined in Section 7.4.2. Figure 7-13, Figure 7-14 and Figure 7-15 present the flow regime at the three reporting locations assessed under the climate change scenarios, with the proposed Emu Swamp Dam.

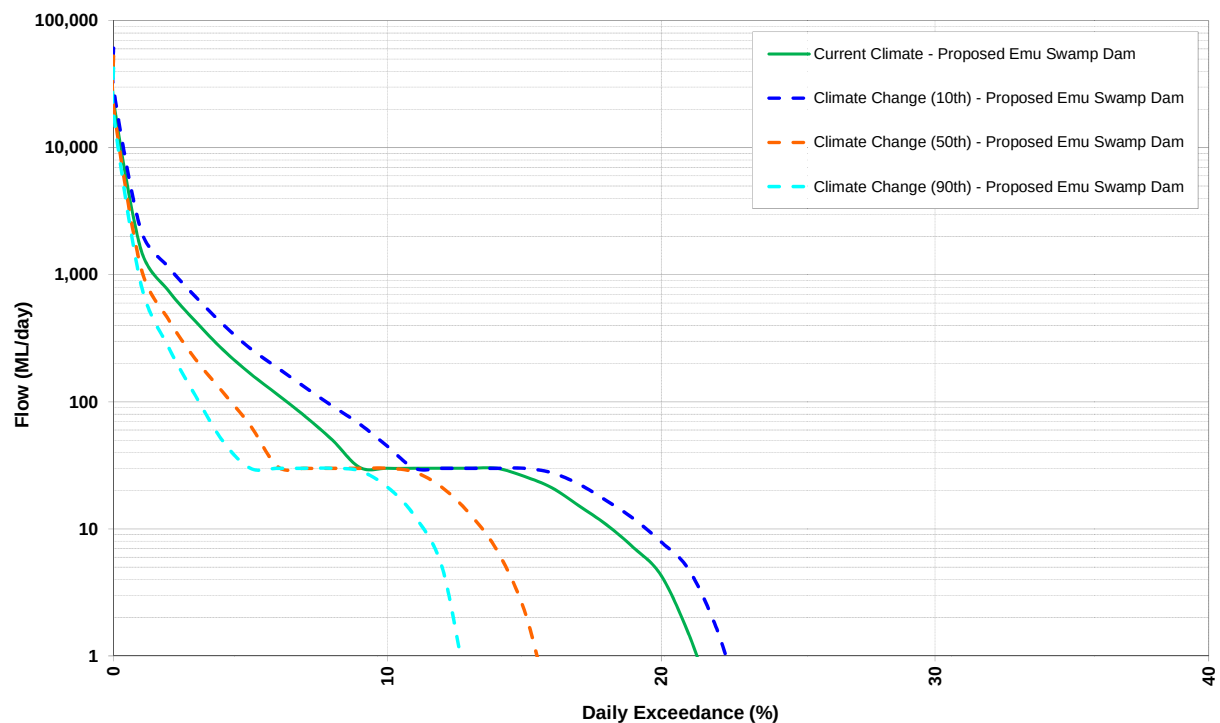


Figure 7-13 Flow Duration Curve – Downstream of the Dam Site

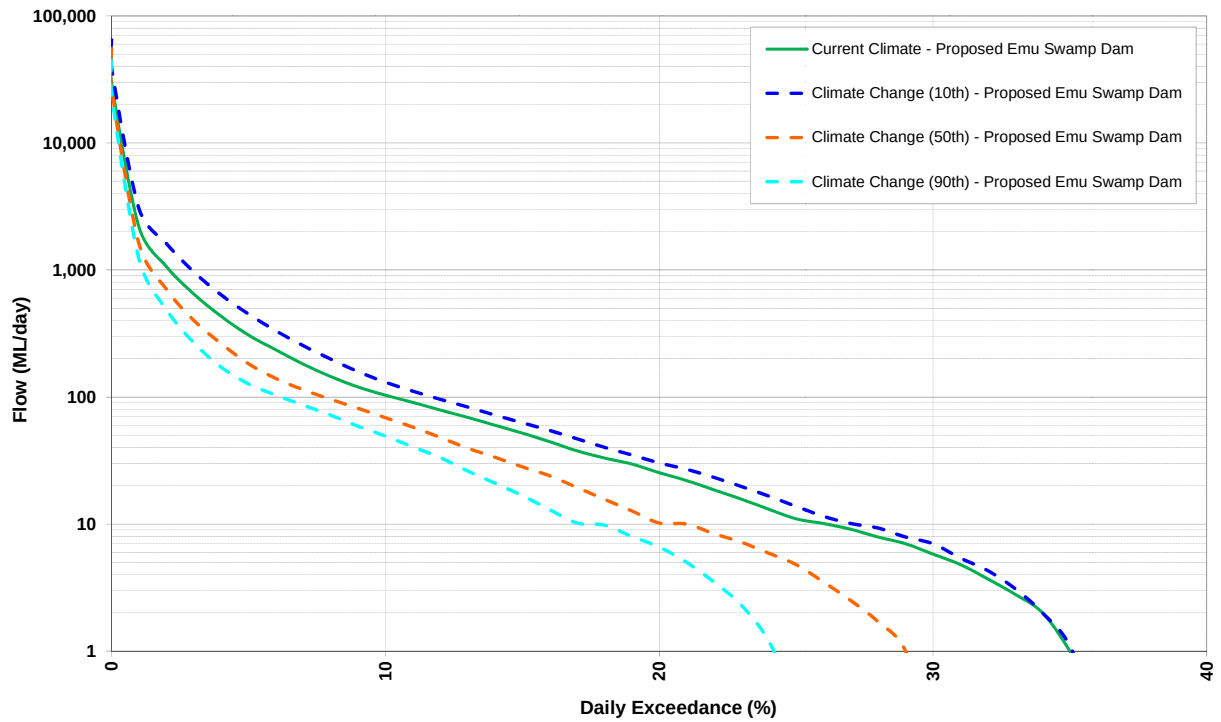


Figure 7-14 Flow Duration Curve – Downstream of the Accommodation Creek Confluence

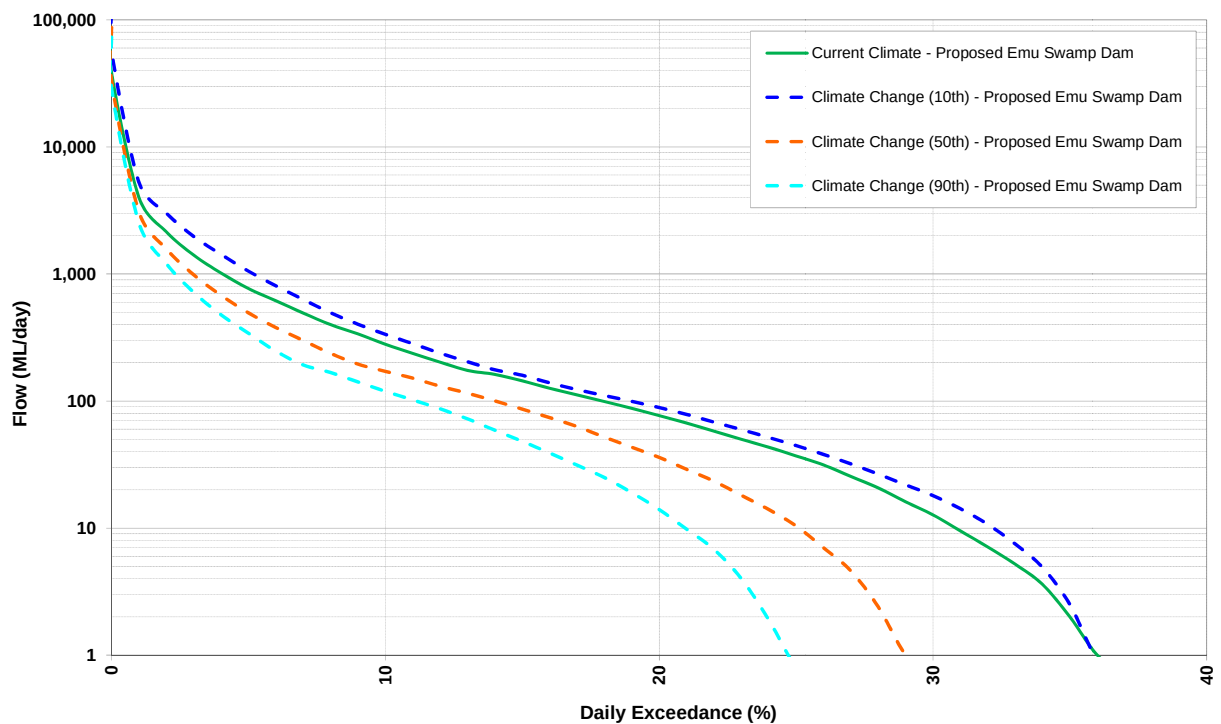


Figure 7-15 Flow Duration Curve – Farnbro

These results show a potential range of impacts due to climate change conditions, consistent with the results outlined in Section 7.6.2.1. These changes range from an increase in flow in the 10th percentile scenario to a reduction in flow in both the 50th and 90th percentile scenarios. The results show that the Severn River is predicted to have similar impacts to the flow regime due to climate change with or without the proposed Emu Swamp Dam. Therefore, with the environmental release strategy in place, the proposed Emu Swamp Dam is not predicted to exacerbate changes to the Severn River caused by climate change.