10. Aquatic Ecology

10.1 Introduction

This section provides an overview of the existing aquatic ecology environment within the catchment of the upper Severn River, where the proposed Emu Swamp Dam will be located. Stanthorpe Shire Council (SSC) commissioned Ecology Management to prepare an aquatic ecology assessment for the purposes of the EIS. This section summarises the findings of that assessment. Further detail on the findings of the aquatic ecology impact assessment is provided in the Supporting Technical Document – *Aquatic Ecology Impact Assessment for Emu Swamp Dam* (Ecology Management 2007).

10.2 Methodology

10.2.1 Literature Review

The following reports were reviewed to describe the existing aquatic environment

- *Strategic Management Plan for the Severn River, Pike Creek and Tributaries* (SSRIT 1996);
- *Border Rivers instream biological resources study* (Boddy and Bales, 1996);
- *An ecological and physical assessment of the condition of streams in the Border Rivers and Moonie River catchments* (Johnson 1999);
- *Current ecological condition of streams in the Border Rivers catchment* (DNRW 1999); and
- *Sustainable Rivers Audit – Pilot Audit* (MDBC 2004).

Rapid assessments of stream habitat were undertaken as part of these reports. Most of these reports did not actually sample the key biological attributes of stream condition (except DNRW (1999) and MDBC (2004)).

Enquiries to Department of Primary Industries and Fisheries (DPIF), Department of Natural Resources and Water (DNRW) and the Queensland Murray Darling Committee Inc. failed to identify any further studies related to aquatic ecology.

State and Commonwealth databases were searched in order to provide background information regarding aquatic flora and fauna species known from the region.

10.2.2 Field Survey

10.2.2.1 Survey Design

An aquatic ecology survey was undertaken by Ecology Management in late spring 2006 and early autumn 2007 as part of the Emu Swamp Dam EIS. The field sampling program included (for full details of sampling methods used refer to **Appendix F)**:

- descriptions of the aquatic habitat descriptions;
- meter-based water quality;
- macroinvertebrates surveys through surber samples for edge habitat and dip netting; and
- fish through a range of nets and a backpack electrofisher (in shallow wadeable waters).

Ten sites were sampled as part of the survey and the location and description of the sites is presented in **Section 10.2.2.2**. Each site was selected based on the general geographic spread required, an aerial reconnaissance of the system above Nundubbermere Falls and ground survey of historic rapid assessment sites.

10.2.2.2 Site Descriptions

The location of each of the survey sites is presented in sites is **Figure 10-1**. These sites included locations upstream, within and downstream of the proposed dam inundation area, as well as two sites not directly affected by

the development; on Accommodation Creek and Bald Rock Creek (**Figure 10-1**). Detailed site descriptions and photographs are provided in **Appendix F**.

Table 10-1 Field Survey Sites

Site Number	Location	Description
1	Severn River near Glen Aplin (Thorndale Rd)	Upstream of dam. Deep natural pool
2	Severn River, within Campbell's Weir	Within proposed dam area. Weir pool.
3	Severn River, below Campbell's Weir	Within proposed dam area. Shallow. Downstream of existing weir.
4	Severn River near Stalling Lane	Dam wall footprint. Shallow, natural.
5	Severn River near Somme Lane	Downstream of dam; upstream of Accommodation Creek. Shallow.
6	Severn River near Somme Lane	Downstream of dam; upstream of Accommodation Creek. Deep weir pool
7	Severn River on Bents Road ("second crossing")	Downstream of dam; downstream of Accommodation Creek. Shallow
8	Severn River at Bents Weir	Downstream of dam; downstream of Accommodation Creek. Deep weir pool
9	Accommodation Creek on Sundown Road	Reference tributary – shallow
10	Bald Rock Ck on Anderson Road	Reference tributary – deep (upstream end of weir pool)

In the region of the project, the river tends to have a bedrock/boulder base with accumulations of coarse sand and fine gravel on meander bends, in backwaters or on point bars. The base flow channel varies from just a few metres wide in places to over 25 m wide in other areas. At times the baseflow channel can be distinctly incised, with banks often 2 m in height (such as near Stalling Lane at the dam site). Beyond the base flow channel, the banks tend to slope gradually to the water and narrow, flatter flood channels are common.

In-channel terrestrial vegetation was common, including in the area of the dam wall and immediately downstream and at the Accommodation Creek site. In such areas a distinct primary channel was supported by smaller meander channels at a slightly higher elevation. Callistemon, Leptospermum, and a range of sedges and rushes were common. Riparian vegetation at most sites assessed was in reasonable condition, affording considerable overhang and providing woody debris to the channel. In times of slightly elevated flow the river would largely be anastomosing or braided, meandering through a vegetated channel. Clearing or partial clearing directly to the banks was observed on one side of the Bald Rock Creek site (site 10), on both sides beyond the immediate riparian zone at the Accommodation Creek site (site 9), and on parts of one side at the Campbell's and Bent's weir sites (sites 2 & 7 respectively). Deep water tended to be tannin stained so observation of deep features was not possible but there was generally a reasonable amount of large woody debris on the edges of most sites except the Somme Lane deep site (site 6), which was bordered by Cumbungi (Typha) on one side and sedge dominated meander channels on the other.

Riffle habitat was present at Bents Road (site 7) and at Accommodation Creek (site 9). During sampling in November 2006, both sites were flowing because Accommodation Creek was flowing at the time. No sites upstream on the Severn River were flowing during either sampling event. All sites were substantially drier in March 2007 and neither riffle was flowing. However, both riffle sites had a mixed cobble/boulder substrate with some sand and gravel.

Within the proposed inundation area the dominant habitat is pool, mostly as weir pool (Campbell's Weir). Bedrock race is present in several locations though was not flowing during inspection. Bedrock/boulder glide, or shallow pool, was common and these areas contained variable amounts of sand and gravel.

SHIRE OF STANTHORPE

Legend

- Full Supply Level 734.5m AHD
- Full Supply Level 738m AHD
- (1) Monitoring Site

N W E S

0 0.5 1 2 3

Kilometres

Scale - 1:80,000 (at A4)

Projection: Map Grid of Australia Zone 56

EMU SWAMP DAM EIS

Emu Swamp Dam Site

Figure 10-1
Aquatic Field Survey Sites

I:\QENV2\Projects\QE06454\Spatial\Arc_MXD\Figures\AquaticEcology\071218_AquaticEcology_A4.mxd Produced: 18/12/2007

10.3 Species of Conservation Significance

Searches of State and commonwealth online databases revealed several species of conservation significance, described below. The conservation status of species may be listed under:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- *Nature Conservation Act 1992* (NC Act);
- *Threatened Species Conservation Act* (NSW);
- Australian Society for Fish Biology (ASFB); and
- World Conservation Union (WCU).

10.3.1 Aquatic Flora

No aquatic plant species or communities are of listed conservation significance.

10.3.2 Aquatic Fauna

Murray Cod (*Maccullochella peelii peelii*). Vulnerable - EPBC Act

Murray Cod were originally present throughout the Murray Darling Basin, except in the upper reaches of upland zone tributaries (Jones *et al* 2007). Preferred habitat is pools with abundant cover such as logs, boulders, undercut banks and overhanging vegetation. Adults show high site fidelity, often returning to specific logs. They are a popular angling fish and have been stocked in many areas, including outside its original distribution. Spawning occurs in spring – summer and is triggered by increasing temperature, day length and possibly flow. Males guard the eggs which are laid on hard substrates, often inside hollow logs. The larvae drift downstream and a reverse movement by older fish occurs in late winter – spring and appears triggered by flow and / or temperature.

Numbers of cod in the Murray Darling basin have been significantly reduced compared to estimates of pre-European abundance, primarily as a result of over-fishing (originally commercial, but also recreational), habitat change (siltation and the removal of snags and standing dead trees to allow river navigation) barriers to movement, competition from introduced species and river regulation, particularly alteration of flooding regimes and the timing of flows with respect to temperature increases.

The Murray Cod has been introduced into the catchment and was not specifically noted on the controlled action notification for Emu Swamp Dam.

Silver Perch *(Bidyanus bidyanus).* Vulnerable – NSW, ASFB, WCU.

Like Murray Cod, Silver Perch was originally widespread in the Murray Darling Basin except in cool upland streams and like Cod has experienced a serious decline in distribution and abundance. Silver perch are known to undertake significant spring-summer upstream pre-spawning migrations with preferred spawning areas being floodplain or flooded backwaters. Adults have wide habitat tolerances but nearby macrophyte or woody debris cover is preferred. Silver perch is a popular angling fish and has been stocked in many areas.

Southern Purple –Spotted Gudgeon *(Mogurnda adspersa).* Endangered populations – NSW; Low risk-least concern – ASFB.

Southern Purple-spotted Gudgeon has a patchy distribution in the upland and mid-slope regions of the Murray Darling system and in coastal drainages from northern NSW to north Queensland. They prefer still or slow flowing waters with hard cobble or boulder substrates and aquatic macrophytes. Summer spawning is triggered by increased temperature and daylength and adhesive eggs are laid on hard substrate. The species is not known to migrate and it is popular with aquarists.

Agassiz's Glassfish *(Ambassis agassizii).* Endangered populations - NSW.

Agassiz's glassfish or Olive Perchlet is a lowland to mid-slope species distributed throughout the Murray Darling basin and coastal Queensland. It has a preference for slow flowing warm waters and significant macrophyte cover. It is not known to migrate and lays adhesive eggs amongst macrophytes. The species is thought extinct in South Australia and Victoria and very rare in NSW.

Bell's turtle (*Elseya belli*). Vulnerable - EPBC Act

Bell's Turtle is a saw-shelled turtle with a distinctive yellow stripe from the mouth to the ear. The species is known from the headwaters of the Namoi and Gwydir rivers in NSW and it has been recorded from Bald Rock Creek. It has been found in shallow to deep pools only in upper reaches or small tributaries of rivers in granite country (DEC web site). It is probably a scavenging omnivore. The DEC web site also notes that within the Stanthorpe Plateau CMA sub-region, Bell's turtle is restricted to within Bald Rock National Park or within 5 km of the park, though the basis of this distribution and restriction is a very limited data set. Darren Fiedler of the Queensland EPA has been undertaking sampling in the Bald Rock area and has captured the species at the same site in Bald Rock Ck but has not recorded any captures in the Severn River.

The species is listed as vulnerable under the NSW Threatened Species Conservation Act and in Queensland the EPA has identified it as of high priority under the Back on Track species prioritisation (Col Limpus (EPA) 2007). The species (then undescribed and known as the Namoi River Turtle) was the only turtle listed in the Action Plan for Australian Reptiles (Cogger *et al* 1993).

10.4 Existing Environment

10.4.1 Aquatic Habitats

10.4.1.1 Stream Condition

SSRIT (1996) noted that local streams and rivers were inherently stable and suffered little erosion because of the regional granite and traprock geologies in the area. This geology and the local gradients also meant that significant floodplain areas were absent. A rapid assessment was undertaken of instream and riparian conditions within 19 reaches. The reaches were rated according to observed level of disturbance and condition as shown in **Table 10-2**. The assessment of disturbance related to evidence of weirs, historic dredging, grazing and riparian zone clearing, while the assessment of condition related to presence and extent of macro and meso habitat variables. No actual sampling was undertaken. Five of the sites inspected were in very close proximity to sites used in the current EIS survey. The results show that while the majority of sites had been disturbed, most were in good or satisfactory condition.

Table 10-2 Stream Condition Assessment (SSRIT 1996)

Stream Condition		Number of Reaches	Percentage
Level of disturbance	Low	5	26.3%
	Medium	9	47.4%
	High	5	26.3%
Condition	Good	8	42.1%
	Satisfactory	6	31.6%
	Poor	5	26.3%

The geomorphology of the upper catchment was primarily granite bedrock and sand while further west (downstream), such as downstream of Sundown National Park, large shoals and gravel flats, formed from traprock, were more common. The impacts of tin mining generally did not affect modern day stream processes though many instream pits remained and were often used as water storages (SSRIT 1996).

Johnson (1999) surveyed 25 sites in the upper Severn River catchment, five of which correspond to sites used in the EIS survey. The majority of sites were much higher in the catchment. The report rated sites assessed in the upper Severn River as:

- predominantly very poor or poor for aquatic habitat conditions;
- very poor or poor for aquatic vegetation;
- very poor or poor for channel diversity;
- very poor or poor for riparian vegetation condition on the main channels but some headwaters were very good;
- poor or moderate for overall condition of reaches; and
- poor to very good for the immediate environs of sampled sites.

The ratings were related to existing water extraction, the level of agricultural development, the extent of land clearing and grazing, and historic tin mining. It should also be appreciated that sites with naturally low structural diversity, such as the bedrock glides often found in streams of this region, would return a generally poor rating under this particular assessment scheme. Sites surveyed for this EIS were generally rated as in better condition than those assessed by Johnson (1999).

DNRW (1999) rated habitat condition as generally moderate with some sites achieving reference status. DNRW (1999) also noted that riffle habitat was rare, particularly in the dry season.

The habitat in the area of the proposed dam is represented by aquatic survey sites 2, 3 and 4 (Campbell's Weir, below Campbell's Weir and Stalling Lane). The weir pool makes up a significant proportion of the length of the river within both proposed dam options. Natural pool and glide habitat makes up the remainder though during periods of flow a small amount of riffle would exist. The lower section of the tributary along Stalling Lane would be inundated and the habitat in this stretch consists of a very narrow (1-2 m) deeply incised (1-2 m) channel through bedrock, bedrock races and glides, and two farm dams. The riparian zone is largely intact below Emu Swamp Road but either cleared in the farming area or reduced to a strip of several metres width. Upstream of the inundation area the stream steepens and the riparian zone is largely intact. The only other tributary to be inundated constitutes a poorly defined channel in a broad depression about half way along the right bank.

10.4.1.2 Water Quality

Water quality in the sub-catchment is described as generally fair to good (DNRW 1999) but the report also noted poor (high) levels of nitrogen, presumably from agricultural fertilisers.

Water quality sampling showed considerable variation between sites, and also between sampling events. Deep sites at times showed strong vertical stratification and diurnal variation. Dissolved oxygen (DO) could at times, or at depth, be limiting (**Table 10-3** and **Table 10-4**). Turbidity was generally low (2 to 30 NTU) except in pools with high tannin content where it could reach over 200 NTU. pH was generally in the range 7 to 9 pH units.

Figure 10-2 shows the difference between a natural pool with high macrophyte and algal content and a weir pool with much less plant activity. The Glen Aplin pool was supersaturated with oxygen during the late afternoon but this declined gradually through the night. Bents Weir did not produce such high oxygen levels but did decline overnight to very low levels. As these were measured near the surface, concentrations at depth would have been very limiting, as shown for this site in **Table 10-4**.

Water quality is discussed in more detail in **Section 7** of the EIS.

- **Table 10-3 Water Quality with Depth Profile at Campbell's Weir, November 2006**

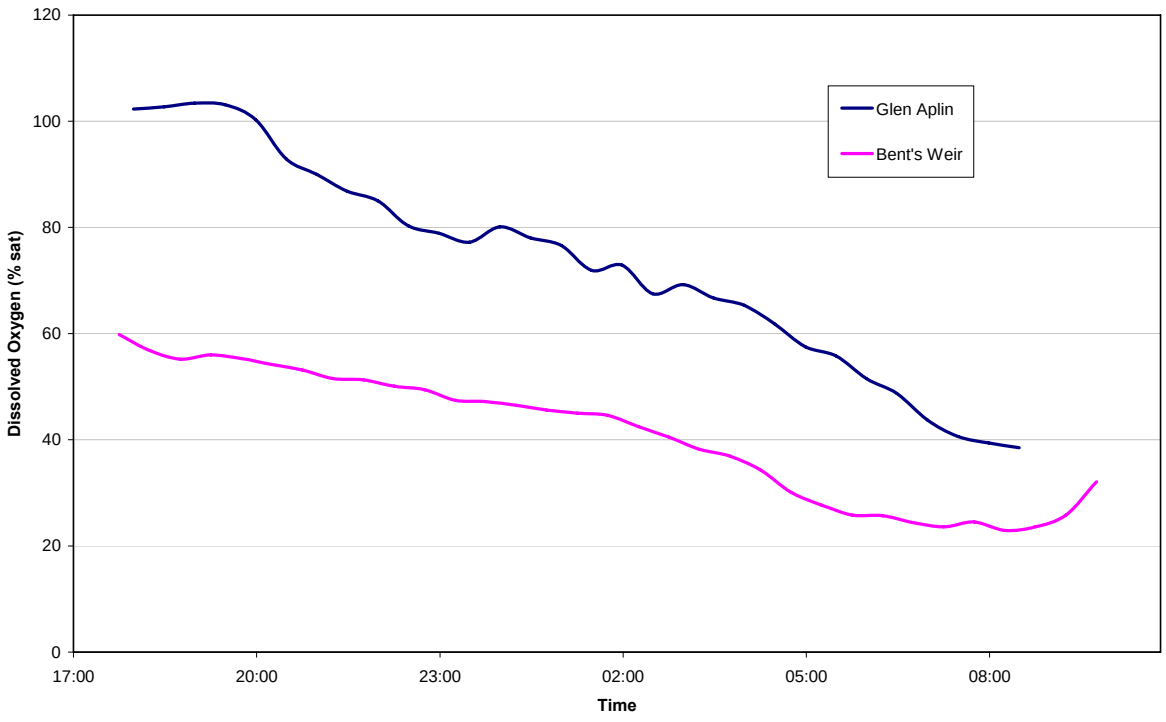
Depth	Temperature (°C)	pH	DO (% sat)	Turbidity (NTU)
Surface	26.4	7.4	96	233
0.5m	24.9	9.1	79	224
1.0m	21.3	8.4	25	240
1.5m	18.7	8.5	3	220

- **Table 10-4 Water Quality with Depth Profile at Bent's Weir, November 2006**

Depth	Temperature (°C)	pH	DO (% sat)	Conductivity (µS/cm)
Surface	23.2	6.8	54.3	197
0.5m	23.2	6.6	52.3	205
1.0m	23.1	6.5	50.8	214
2.0m	21.2	8.7	2.9	236

NB: There was significant variation in turbidity and have not been presented

- **Figure 10-2 Overnight change in DO at Glen Aplin and at Bent's Weir, April 2007**



10.4.1.3 Hydrology

The flow regime of the upper Severn River is naturally intermittent but the river has numerous permanent refuges for a considerable distance upstream on the main channel and on tributaries. However, many of the current refuges are weir pools.

As discussed in **Section 7** of the EIS, there has already been significant development of the water resource of the catchment through the construction of instream weirs, and the use of offstream storages that catch overland flow prior to it reaching the channels.

Licensed weirs on the Severn River (main channel only) are listed in **Table7-1**, with thirteen structures in the 19 km of main river channel upstream of the proposed Emu Swamp Dam (on average, a weir every 1.5 km) and a further twelve structures in the 30 km downstream to Nundubbermere Falls (on average, a weir every 2.5 km). There are many more weirs as well as Storm King Dam upstream of the upper limit of this table and on tributaries of the Severn River. A fly-over of the catchment and site inspections during a ground-based survey identified weirs that did not appear in the table.

Many of the weirs are significant structures relative to the size of the river and would represent major barriers during the majority of flow conditions. Preliminary hydraulic modelling was also undertaken to assess the drown-out characteristics of these structures closest to the proposed dam location. The locations, heights and drown out frequencies are presented in **Table 10-5**. The weirs at 266.2 and 260.5 km AMTD would have a drown out frequency of more than every 100 years. The weirs at 256.1 (upstream of Accommodation Creek) and 245.7 km AMTD (below Accommodation Creek – site 8) would also probably be impassable.

It is clear that fish passage along at least 12 km of river below Campbell's Weir and above the junction with Accommodation Creek, is currently extremely limited. The ability of fish below Bents Weir to access habitat in the upper Severn, Accommodation or Washpool catchments, is similarly limited. Fish in the latter two catchments would also have very limited opportunity to access the upper Severn catchment. This is exacerbated by the fact that this system has very little floodplain, so there would be very little opportunity to by-pass the structures in high flow events.

- **Table 10-5 Characteristics of existing weirs near the Emu Swamp dam site**

Weir AMTD	Height (m)	Drown-out flood frequency	Velocity downstream of wall in drown-out (m/s)
267.5	2.5	Q50	0.8
266.2	3.0	> Q100	> 2.3
Emu Swamp Dam 263.8	-	-	-
262.5	0.6	Q2	0.5
260.5	3.2	>Q100	>1.67
259.3	2.4	Q5	1.2

No weirs are known to have fishways fitted, though some have low flow release valves but they rarely function (DNRW personal communication). Few valves were observed during field inspections and none were functional.

The number of remaining natural barriers is unknown but many weirs were built atop natural barriers such as races or glides at bedrock outcrops thus taking their impact from what probably constituted a natural low flow barrier to what is now a barrier at moderate or high flows as well.

The abundance of weirs on the Severn and many of its tributaries now mean that long lengths of river are represented by contiguous weir pools, only separated, when the weirs are full, by the barrier of the next weir wall. The existing changes in habitat are therefore very significant and will have led to significant changes in the ecology of the river.

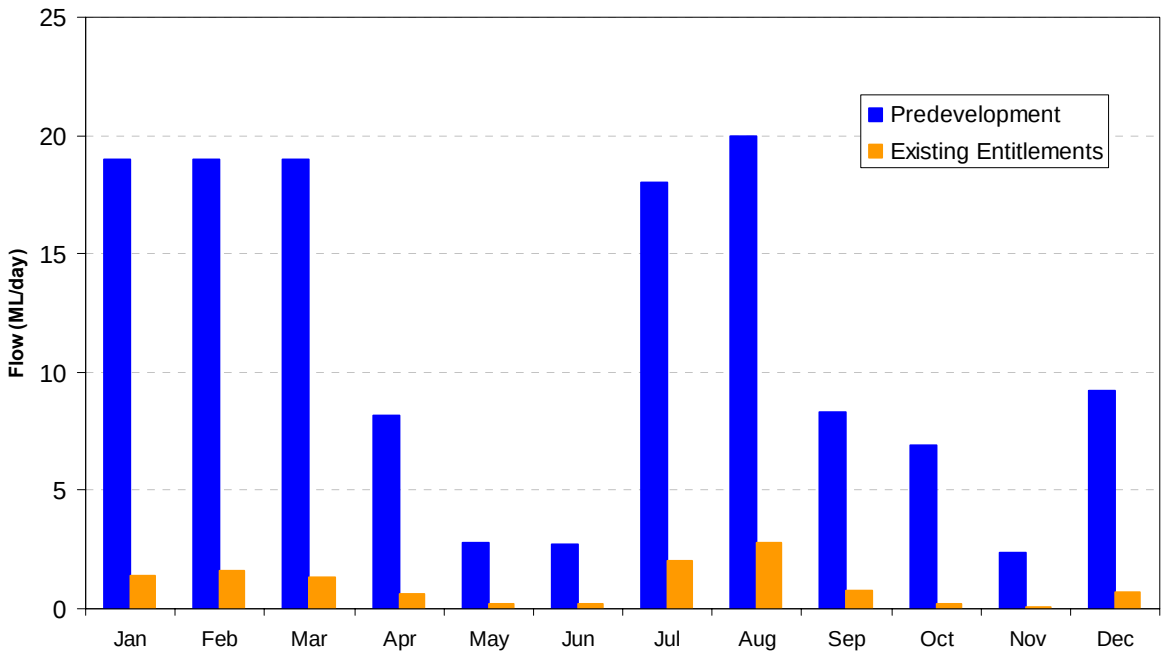
Table 10-6 presents the key flow statistics at Farnbro (Node 063) for predevelopment and existing entitlements. The table clearly shows there has been significant impact has been on low flows, with the number of low flow days increasing by 36%.

- **Table 10-6 Key flow statistics at Farnbro**

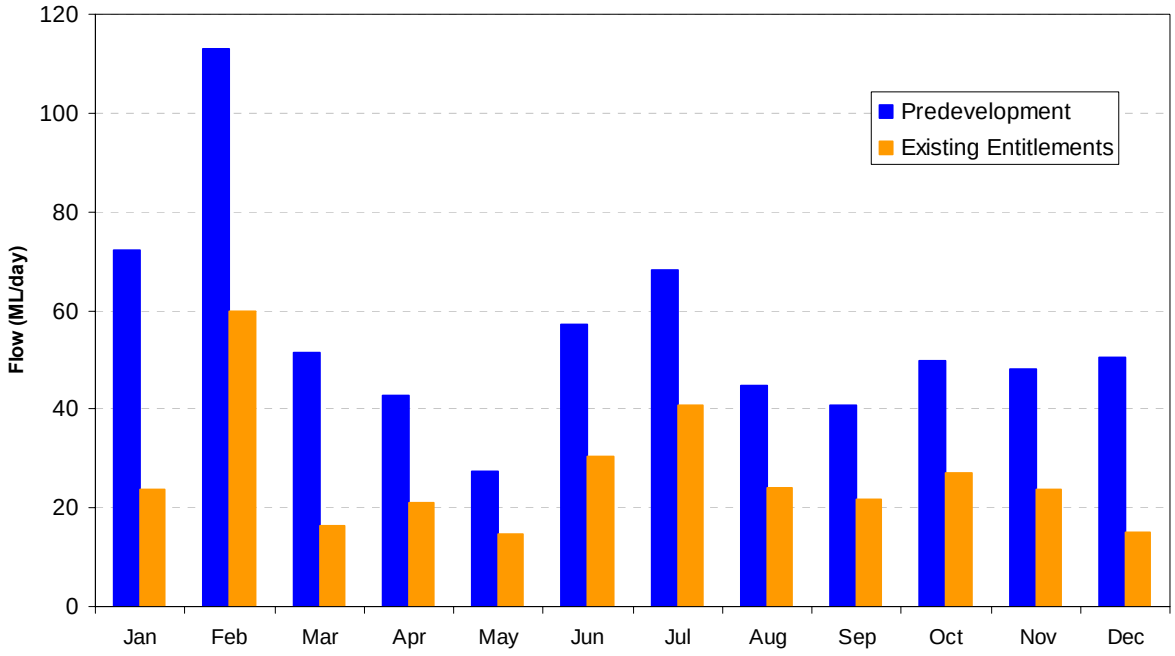
Key Flow Statistics	Predevelopment Scenario	Existing Entitlements	% change from Predevelopment
Mean annual flow (ML)	81,300	59,100	-27%
Low flow (days)	16,855	22,958	+36%
Summer flow (days)	51	33	-35%
Beneficial flooding flow (ML)	34,623	22,561	-35%
1 in 2 yr flood (ML)	4,608	2,651	-43%

The degree of change from natural is significant and is further highlighted in **Figure 10-4** and **Figure 10-3**. These show the extent of change by month for the period of record (1890-1996) at the dam site. Median monthly daily flow is simply the median of all January days (105 x 31 records) whereas the mean of median monthly daily flows takes the separate median for January 1891, then 1892 and so on, before taking the mean of those 105 median January daily flows. The latter ensures the wetter years are taken into account and seasonality will still show in the figures.

- **Figure 10-3 Median Monthly Daily Flow at the dam site**



- **Figure 10-4 Mean of median monthly daily flows at the dam site**



The current (base case) median daily flow in most months has been reduced to less than 10% of the natural figure, with the best result relative to natural being 14% in August and the worst being 3% in October. The mean of the monthly medians (taking account of the larger flows in each month) shows remaining flows of from 30% in December to 60% in July. The latter are 51% and 77% respectively at Farnbro, reflecting incoming less impacted tributaries downstream of the dam site. This reflects the irrigation demands in the area. While overall seasonality has been maintained, December, January and March show major reductions.

Elsewhere in this catchment the Water Resource Plan was based on the 2/3rd natural rule of thumb, that is, if major flow statistics remain above 2/3rd natural it is assumed that the likelihood of maintaining a healthy working river is high. The original authors (Jones *et al* 2002) also used a 50% natural threshold to separate moderate from low probabilities. In the figures above, no median figures even approach 50% but all mean of the medians between May and October inclusive, and February, are though none are above 67%.

The conclusion from the above is that the effect of existing extraction is significant on low flows in all months, but more so in warmer months, is extreme with the effect on higher flows is significant in summer. This degree of change will have led to significant impacts on ecology, particularly on fish that rely on shallow flowing areas or need a period of sustained higher flows to disperse.

10.4.2 Aquatic Flora

10.4.2.1 Current Presence, Distribution and Abundance

To date, there has been no coordinated sampling of aquatic flora in the upper Severn River. Boddy and Bales (1996) present data from six sites in the nearby Mole River classified as “upstream” so is the closest reasonable regional comparator currently available. Sainty and Jacobs (1994) sampled the sites over a three year period. Thirty-three species were recorded as noted in **Table 10-7**. A further five species were also identified as part of the aquatic ecology survey and are presented in **Table 10-7**.

During aquatic ecology surveys, Water milfoil dominated pool areas in November at Glen Aplin, Campbell’s Weir and an offstream pool at Somme Lane (shallow) but it was not noted at Bent’s Weir or Bald Rock Creek (both deep sites), but had largely disappeared by March. Water primrose was widespread but most common at deep open sites

and uncommon or rare at narrow sites with good riparian cover (most shallow sites). It was often coated with filamentous algae, as was the milfoil. Filamentous algae also provided substantial coverage of bedrock areas at all open water sites but was less prolific in shaded areas.

Cumbungi was found throughout the study area at any location where finer sediment had accumulated. It formed thick borders at some weir sites, such as Somme Lane and in patches at Campbell's Weir. Water ribbon was only observed at the Accommodation Creek and Somme Lane (shallow, offstream pool) site while watercress was only noted at the former site. It had largely died by the March 2007 survey, as the system dried. Another noticeable change as the water level dropped between November 2006 and March 2007 was colonisation of the exposed bed, such as the upstream end and edges of weir pools, by Slender knotweed, various rushes and terrestrial grasses.

Rice sedge and common rush were present at most sites, providing a near-continuous fringe near the baseflow line. A range of unidentified sedges and rushes occurred sporadically, but at times thickly on bordering alluvial areas or the anastomosing channels in shallow areas. Spikerush was not widespread but when it occurred it tended to be in a reasonable sized clump, such as at the upstream Glen Aplin pool.

Exotic (introduced) species are uncommon, though at times the proliferation of endemic species leads to them commonly being referred to as water weeds.

Table 10-7 Aquatic Species Recorded in the Severn River

Species Type	Scientific Name	Common Name	Previously Recorded	Recorded in Survey	Exotic Species
Free floating species	*Azolla filiculoides*	Pacific azolla	✓	✓	
	Azolla pinnata	Ferny azolla	✓		
	Spirodela sp.	Duckweed	✓	✓	
Floating attached	*Ludwidgia peploides*	Water primrose	✓	✓	
	Potamogetan tricarinatus	Floating pondweed			
Submerged species	*Myriophyllum verrucosum*	Red watermilfoil	✓		
	Vallisneria gigantean	Ribbonweed	✓		
	Potamogeton crispus	Curly pondweed	✓	✓	
	Potamogeton ochreatus	Blunt pondweed	✓		
	Potamogeton perfoliatus	Clasped pondweed	✓		
	Spirogyra sp.		✓	✓	
	Myriophyllum aquaticum	Water milfoil		✓	
Emergent species	*Aster subulatus*	Wild astor	✓		Yes
	Carex appressa	Tussock sedge or Tall sedge	✓		
	Cyperus difformis	Rice sedge	✓	✓	
	Cyperus erogrostis	Umbrella sedge	✓		Yes
	Cyperus exaltatus		✓		
	Cyperus gymnocaulos		✓		
	Cyperus polystachyos		✓	✓	
	Eleocharis acuta	Common spikerush	✓	✓	
	Isolepis mucronatus		✓		
	Schoenoplectus mucronatus		✓	✓	
	Echinochloa crus-galii	Barnyard grass	✓	✓	Yes
	Paspalum distichum	Water couch	✓	✓	
	Phragmites australis	Common reed	✓	✓	
	Juncus usitatus	Common rush	✓	✓	
	Persicaria decipiens	Slender knotweed	✓	✓	
	Persicaria hydropiper		✓		
	Rumex crispus	Curled dock	✓	✓	
	Ranunculus sp.		✓		
	Typha orientalis	Broadleaf cumbungi	✓	✓	
	Lomandra longifolia	Lomandra	✓	✓	
	Berula sp.		✓		Yes
	Tradescantia alba	Wandering jew	✓		Yes
	Triglochin procerum	Water ribbons		✓	
	Rorippa nasturtium-aquaticum	Watercress		✓	Yes
	Gahnia aspera			✓	

10.4.3 Aquatic Fauna

10.4.3.1 Macroinverterbrates

Boddy and Bales (1996) reported macroinvertebrate sampling in the Border Rivers conducted over three years from 1992. No sites were on the Severn River but two were in upland parts of the Mole River, a similar catchment to the south. Two different sampling approaches were used; artificial substrates and in situ habitat sampling (dip netting). The methods produced quite different results. The average number of taxa recorded from artificial substrates varied between 13 and 23 and when all sites were assessed using the Bray Curtis Similarity index, upstream sites from the Mole River tended to group with upstream sites from other subcatchments and to be separated from mid-catchment or lowland sites. The number of taxa recorded from dip net samples was similar but varied substantially between sampling events due to habitat availability. There was some suggestion that taxonomic diversity decreased in a downstream direction. A major disjunction in macroinvertebrate communities occurred at about the Macintyre – Dumaresq junction (well downstream from the proposed dam site). The report stressed the link between habitat diversity and species diversity.

DNRW (1999) reported AusRivAS results for three sites above Nundubbermere Falls. A site on Broadwater Creek upstream of Stanthorpe was sampled four times between October 1994 and June 1996. Quart Pot Creek at Storm King Dam, upstream of Stanthorpe, was sampled in May and November 1997 while a site on the Severn River at Dead Horse Gully (near the proposed dam site) was sampled in May 1997. The sites produced between 10 and 30 taxa per habitat per sampling event with marked variation between sampling events at the same site and between habitats within a site at one time. The fauna was rated as in good or excellent condition.

At the 10 sites sampled for the EIS, some 48 discrete taxa (no overlapping taxonomic levels, mainly at family level) were recorded in November, and 37 taxa in March for a cumulative total of 52 taxa (**Table 10-8**). Fourteen taxa collected in November were not collected in March and four collected in March were not recorded in November. All of these were uncommon taxa with the exception of Simuliidae, which was very common in riffles and in some dip nets in November but completely absent in March (when no flow was occurring).

In November, the 50 surber edge samples produced 45 taxa, 42 from shallow water sites and 27 from deep water sites. The nine dip net samples, primarily collected from amongst macrophytes, produced 32 taxa. In November, the number of taxa at a site detected using surber samples, varied from a maximum of 30 at Accommodation Creek and 26 at Second Crossing (both shallow and flowing at the time) to 14 at the shallow site below Campbell's weir. Other sites recorded between 16 and 21 taxa. In March, Accommodation Creek (26) and Second Crossing (21) again produced the highest number of taxa from surber samples (though the sites were not flowing) while Somme Lane (deep weir pool) recorded the lowest with 12. All other sites in March recorded either 17 or 19 taxa in total from surber samples.

As is commonly observed in macroinvertebrate communities, a small number of taxa provided the majority of individuals. Edge samples at deep sites were numerically dominated by Chironominae (midges) and microcrustacea, particularly copepods and ostracods. Dip nets amongst macrophytes were dominated by microcrustacea (copepods and cladocera) and while the same taxa were common in edge samples from shallow sites, simuliids (black fly) and leptophlebiid mayflies were common at shallow flowing sites.

Table 10-8 Percentage composition of common taxa at sites on the upper Severn River

Sampling Method	Surber Edge Samples				Dip Netting	
Sites	Shallow Sites		Deep Sites		All Sites	
Taxa	November	March	November	March	November	March
Copepoda	14.4	5.1	14.3	5.8	38.3	26.2
Chironominae	12.9	10.4	35.1	39.0	4.8	16.8
Cladocera	12.2	8.7	1.2	3.8	16.3	8.4
Simuliidae	11.5				9.1	
Leptophlebiidae	8.7	8.1			1.0	
Ostracoda	7.0	12.7	8.1	4.6	4.0	1.2
Oligochaeta	7.0	6.3	8.2	5.1	1.4	1.2
Tanypodinae	5.5	11.1	4.8	4.2	2.0	2.1
Caenidae	3.9	7.5	8.1	10.8	1.1	0.1
Nematoda	3.5	13.2	8.0	19.1	5.2	11.1
Cirolanidae	2.9					
Dytiscidae	1.8	0.9	0.7	0.5		0.3
Corixidae	1.5	0.9	3.0	1.0	1.4	0.5
Acarina	1.4	2.5	2.1	1.7	4.8	24.8
Ceratopogonidae	1.1	2.6	2.1	0.7	0.7	0.6
Baetidae	0.9	2.3	1.0	1.0	1.9	1.3
Elmidae	0.4	0.2		0.1		
Psephenidae	0.4	0.4				
Orthocladiinae	0.4	0.3		0.6	0.9	0.7
Hydropsychidae	0.3					
Corbiculidae			0.2			
Leptoceridae		0.5	1.2	1.0	0.5	0.4
Hydroptilidae		0.2	0.7	0.2	2.3	0.1
Atyidae		0.1	0.5		0.9	2.4
Ecnomidae		0.2	0.3			0.1
Gastropoda unid			0.3			
Anisoptera unid		0.1	0.1			
Planorbidae					1.4	
Zygoptera unid				0.2	0.9	0.5
Hydridae		1.7				0.1
Sialidae		1.6				0.1
Hydrophilidae				0.3		
Physidae						0.5
Total Taxa	**42**	**31**	**27**	**28**	**32**	**25**
Number of Individuals	**21,599**	**17,465**	**21,868**	**22,864**	**20,532**	**11,424**

The aquatic ecology survey for the EIS clearly showed that some species have specific habitat requirements. Leptophlebiid mayflies, simuliids and psephenid beetles were found at flowing sites or in the case of the former, when they were found at still-water sites they were elevated off the substrate on macrophytes and were in lower numbers. Hydropsychid caddisflies and grypopterygiid stoneflies were only found at the two sites with true riffle. Along with simuliids, these two riffle taxa were also not captured in March, when the riffles were sampled but they were not flowing. Baetid mayflies were less selective but were most commonly captured amongst macrophytes.

Chironominae (midges) tended to be more common at deep water sites and they were particularly abundant at the Glen Aplin natural pool site, both in edge and macrophyte samples.

Some taxa showed higher proportional abundance in November compared to March (Copepoda) or vice versa (Nematoda) with little difference between deep or shallow sites (though there was with respect to absolute abundance) while others showed strong preferences for shallow (Leptophlebiidae) or deep sites (Chironominae) but changed little with season.

19% less animals (4134 individuals) were captured at shallow edge sites in March than in November. This was due largely to the complete lack of simuliids or cirolanids in March (2,486 and 634 individuals respectively in November) but also major decreases in Cladocera (42% less), Chironominae (35%), Oligochaeta (28%) and Copepoda (26%). However other taxa increased in total abundance (Nematoda 201%, Tanypodinae 63%, and Caenidae 53%).

As would be expected, there was less difference between seasons at the deep sites, with just 5% more animals captured in March than in November, from the same number of samples. Some taxa did show marked increases in abundance: Nematoda (151%), Caenids (40%); while others showed decreases; Copepoda (57%), Ostracoda (40%).

The more common taxa were quite ubiquitous, often found wherever suitable substrate existed be it on the edge of a deep water area or a shallow area.

The larger macroinvertebrates, captured in bait traps or by electrofishing, were *Cherax destructor* (yabby), *Macrobrachium australiense* (prawn) and *Caradina* sp. (shrimps). *Caradina* was common in November but less so in March while both *Cherax* and *Macrobrachium* were present in low numbers at most sites on both sampling occasions. Small *Cherax* were common at two shallow sites in March. Shells of *Alathyria* (mussel) were common on exposed rocks at several sites, evidence of feeding by water birds.

In general the macroinvertebrate fauna appeared reasonably diverse and abundant, with representatives of all the major taxonomic groups but with perhaps a somewhat low representation of dipteran (true flies) and odonatan (dragon flies) taxa, the former possibly because of the generally coarse substrate and the latter possibly because of the cold climate as this order is much better represented in warmer areas. Culicids (mosquitoes) were not captured.

10.4.3.2 Fish

The region of the proposed dam has many affinities with the Upland zone whereas what might be considered more characteristic of Upper Foothill areas can be found further downstream, including Moffatt's site at Farnbro. Fish characteristic of the Upland zone include Mountain Galaxias, River Blackfish, Eel-tailed catfish, Carp gudgeons and Spangled perch. A much wider range of species would be expected in the Upper Foothill zone, at least in areas without significant natural barriers.

Existing information on fish of the upper Severn River is sparse. Enquires to DPIF failed to yield any reported survey work, other than that related to the success of stocking activities in Storm King Dam.

MDBC (2004) used two sites in the upper Severn River as "best available" comparators for the "source" zone of the Condamine River:

- an upstream site on Bald Rock Creek within Girraween National Park, a tributary of Accommodation Creek, which in turns joins the Severn River downstream from the proposed dam site.
- a site was on the Severn River in Sundown National Park and below Nundubbermere Falls.
- one other "best available" site of similar latitude and altitude in the source zone on the Condamine River.

From museum records and anecdotal comment they suggested that 15 species probably existed in the system, including three alien species and three introduced native species. The fish species that may potentially occur in the Project area, either naturally or by introduction, are presented in **Table 10-9**. The list includes species that are

probably native to the system and species, both native and exotic, that have been introduced. The three stocked native species are popular with recreational anglers and were introduced for that purpose. River Blackfish and Spangled Perch may also at times be targeted though more for sport than consumption. Many of the smaller species are popular aquarium fish.

It is difficult to predict the natural species complement because number of comparable upper foothill or upland sites historically sampled in the northern Murray Darling basin is very low and the presence of Nudubbermere Falls undoubtedly imposes a significant natural influence on distributions.

- **Table 10-9 Fish Species Potentially Present in the upper Severn River Catchment**

Fish species potentially present	Common Name	Known Introduced Species	Exotic Species
Galaxias olidus	Mountain galaxias		
Melanotaenia fluviatilis	Crimson spotted rainbowfish		
Gadopsis maramoratus	River Blackfish		
Ambassis agassizii	Olive perchlet		
Retropinna semoni	Australian Smelt		
Tandanus tandanus	Eel-tailed catfish		
Craterocephalus stercusmuscarum	Fly-specked hardyhead		
Hypseleotris klunzingeri	Western carp gudgeon		
Hypseleotris galii	Firetail gudgeon		
Hypseleotris sp4	Carp gudgeon		
Hypseleotris sp5	Carp gudgeon		
Mogurnda adspersa	Purple-spotted gudgeon		
Leiopotherapon unicolor	Spangled perch		
Nematolosa erebi	Bony bream		
Mucullochella peeli peeli	Murray Cod	Yes	
Macquaria ambigua	Yellowbelly	Yes	
Bidyanus bidyanus	Silver Perch	Yes	
Carassius auratus	Goldfish	Yes	Yes
Gambusia holbrooki	Mosquito fish	Yes	Yes

The EIS catch reflects the habitats sampled (a number of weir pools and a number of shallow water sections), the suite of sampling apparatus used at particular sites and the fish fauna of the individual sites. It cannot be assumed that species not captured were not present though if they were present it is likely that they were in very low numbers. Percentage abundance figures hide true abundance as the number of catfish was considered very good, for example up to 45 catfish were captured in 20 m of 4-inch gill net when set overnight in weir pools. The Silver perch captured were very large, healthy fish, often measuring over 500 mm fork length.

The number of each fish species captured during the aquatic ecology survey is presented in **Table 10-10**. Deep sites and shallow sites have been presented separately in order. Sites are presented from upstream to downstream. *Hypseleotris spp* includes *H. galii*, *H. klunzingeri*, *H. sp4* and *H. sp5*.

The EIS sampling captured the same suite of fish on both occasions (five native species and one exotic). The species captured overall were:

- Eel-tailed catfish (reasonable numbers in weirs and natural pools);

- four species of native carp gudgeon (at times highly abundant on the edges of pools or sluggish water habitats);
- the three species on translocated native predators (Murray cod – uncommon and found in weir pools; Silver perch and Yellowbelly - uncommon but often large specimens found in weir pools); and
- introduced Mosquito fish (widespread and at times abundant).

Table 10-10 Number of Fish Captured in Aquatic Ecology Survey

Monitoring Period	Species	Deep Sites			Shallow Sites							Total
		1	2	6	8	10	3	4	5	7	9	
November 2006	*Mucullochella peeli peeli*				2							2
	Macquaria ambigua		2	1								3
	Bidyanus bidyanus		2	3								5
	Tandanus tandanus	17	24	45	23	19						128
	Hypseleotris spp	202	341	882	173	141	100	84	83	55	28	2,089
	Gambusia holbrooki	9	16	9	182	30	68	21	81	15	88	519
	Total catch	228	385	940	380	190	168	105	164	70	116	2,746
	Native species	2	4	3	3	2	1	1	1	1	1	5
	Exotic species	1	1	1	1	1	1	1	1	1	1	1
April 2007	*Mucullochella peeli peeli*					2						2
	Macquaria ambigua		1		2	6						9
	Bidyanus bidyanus		6									6
	Tandanus tandanus	13	15	17	21	9						75
	Hypseleotris spp	202	133	519	508	385	7	219	127	46	100	2,246
	Gambusia holbrooki	38	14	7		13	61	69	225	116	374	917
	Total catch	253	169	543	531	415	68	288	352	162	474	3,255
	Native species	2	4	2	3	4	1	1	1	1	1	5
	Exotic species	1	1	1	0	1	1	1	1	1	1	1

Differences between sites and between sampling events were noted. For example cod and Yellowbelly were caught at Bald Rock Creek in April but not in November and the number of both gudgeons and mosquitofish was much higher at shallow sites in April.

At shallow sites only *Hypseleotris* spp and *Gambusia* were captured whereas the deep sites (natural or weir pool) produced the larger bodied species as well.

The lack of capture of many of the potential small-bodied native species is the most notable result. Local fishing club members and aquarists commented that *Mogurnda* was historically found in the system but many of the others have not been confirmed. It is possible that the natural fish fauna was very limited and while it certainly did not include all the species marked as introduced, also quite probably may not have, and still does not, include Bony bream, Smelt, Spangled perch and perhaps others listed above.

A number of fishing enthusiasts suggested that numbers of the smaller species, particularly River Blackfish and Southern Purple Spotted Gudgeon, had declined as a result of the introduction of the large predatory native fish. SSRIT (1996) also raised this issue and cautioned against further stocking. Another commonly suspected reason for the apparent decline is the drying of pools through excessive water extraction. The section above Storm King Dam was noted as an example of where this had occurred and the fish had not been able to recolonise because of the barrier effect of the dam. While the accuracy of these comments cannot be verified, they do not appear

unreasonable, particularly given the flow statistics presented above. As an example, water levels significantly decreased between EIS sampling events, mainly as a result of extraction for irrigation. The nests of Eel-tailed catfish could be clearly seen on the exposed substrate of sites where such extraction was occurring, with one irrigator blaming another for excessive pumping.

10.4.3.2.1 Species of Conservation Significance

10.4.3.3 Turtles

Only four individual turtles were captured during the surveys; two long-necked turtles (*Chelodina longicollis*) and two Bell's turtle (*Elseya belli*). The former are regarded as common and widespread, whereas the latter is a rare species of restricted known distribution. It was captured in Bald Rock Creek but further downstream than the only known record in the region, and in the Severn River near Somme Lane, downstream from the proposed dam site. *Emydura macquarii*, the Murray River Turtle, would also be expected to occur in the region.

10.4.3.3.1 Species of Conservation Significance

Searches of State and commonwealth online databases revealed one species of conservation significance, Bell's turtle, described below.

10.4.4 Habitat Requirements and Sensitivity to Change

Aquatic Flora

The key habitat requirements that determine the ability of aquatic flora species to survive in riverine environments are permanence of standing water, the frequency and strength of flow periods and the availability of suitable substrate in which to set roots. It is likely that the abundance of species that prefer still waters and soft substrate has increased relative to the natural situation in line with weir construction and water extraction. Such species would include Cumbungi, Common reed, Slender knotweed, Spikerush, Water milfoil, Pondweed, *Azolla* and filamentous algae. Once established, the larger reeds and rushes are capable of surviving significant periods without standing water.

Fluctuating water levels can lead to desiccation if species are stranded for lengthy periods. Rushes, sedges, reeds and grasses can colonise the newly available wet habitat but will drown when higher water levels return for extended periods. The duration of lower water levels therefore may be critical to the extent of colonisation and the potential for weeds to spread.

Aquatic flora can proliferate in suitable water quality conditions, particularly clear water with higher than natural nutrient loads. The extent of milfoil and filamentous algal growth observed during field sampling at some sites was prolific. The relationship of aquatic plants to nutrient loads can be both beneficial and detrimental to humans. Excessive growth of submerged species can be potentially dangerous to swimmers whereas in some locations (sewage treatment ponds or lakes specifically designed to treat urban run-off) such growth is encouraged in order to remove nutrients.

Flushing flows will strip many species from a site and redistribute them downstream, particularly those that can grow vegetatively. Free floating species are very susceptible to flow and this may explain the low diversity observed, though duckweed was observed as extensive on some weirs during aerial reconnaissance.

Macroinvertebrates

At the level of taxonomic discrimination used in macroinvertebrate studies (usually family), it is not possible to comment on other than coarse requirements. At the levels used, the more common taxa inhabit the range of available habitats and are generally not greatly affected by even quite significant habitat change. The exception is the fauna of riffles. This is the most distinct fauna and it was of very restricted distribution during the sampling program. This may not always be the case as the potential development of riffle habitat during periods of baseflow is quite reasonable, particularly in the areas of braided or anostomising channels that commonly occur between

major pools, such as immediately downstream of the proposed dam wall or below the weir sampled near Somme Lane.

Given the number of existing weirs on the system it is highly likely that the original extent of riffle habitat has already been substantially reduced, though much of the now flooded habitat would always have been pool. Reduction in flow as a result of extraction will have reduced the period in which riffles flow, reducing their productivity. Tributaries upstream of weirs, such as in Girraween National Park, will still contain the same proportion of riffle so can supply colonists to downstream areas when they flow.

The increased amount of deep water and macrophyte habitat has probably resulted in a change in the relative abundance of common taxa with an increase in the abundance of shrimps, snails, certain caddisflies and ostracods at the expense of cladocerans and some riffle species.

Very deep water (greater than a few metres) was only seen in weir pools and was probably not common historically. While it could not be sampled, given the water quality results it is expected that the fauna of this environment would not be diverse and would be dominated by oligochaetes, nematodes and chironomids.

Fish

Each species of fish has habitat requirements related to feeding, cover, spawning and juvenile development. Any or all of these may be linked to a need to move or to migrate. The smaller species; carp gudgeons, Purple spotted gudgeon, Olive perchlet and hardyheads feed primarily on microcrustacea and insect larvae and hide and / or lay eggs in algae or macrophytes and sometimes in logs, leaves or caves. Males often guard the eggs till hatching. The natural attributes of the Severn system would have favoured these species, particularly the sluggish or pool edge environments, depending on the extent of algal growth. As the latter has probably increased over time the habitat for some, such as the carp gudgeons, has become more favourable.

The larger species tend to prefer pool environments with abundant shelter in the form of logs, undercut banks or boulder caves. These also tend to eat larger prey, including crustaceans and other fish. Purple spotted gudgeon prefers quietly flowing rocky (cobble) areas.

Mountain galaxius and River blackfish prefer clear water, the former predominately in upland pools. Yellowbelly, along with Bony bream and Smelt, are known to tolerate more turbid conditions.

With respect to habitat and feeding opportunities, the existing changes in the Severn River system have favoured some species, including the introduced predators, but probably not Purple spotted gudgeon, River blackfish or Mountain galaxius.

The existing weirs will provide barriers to movement. Movements will always have been restricted to an extent because of the seasonal low or no flow period and the isolation of remaining pools. Small weirs will act as barriers only in low flow events while the larger weirs are essentially impassable at any flow. The data presented in **Table 10-5** clearly indicates that the more significant barriers are totally impassable in an upstream direction. This will affect the ability of fish to move from less to more favourable habitat and therefore may prevent attaining maximum population size. Reasonable flows and weir overtopping will allow some successful downstream dispersal of eggs, juveniles or adults but upstream dispersal will be very limited and with respect to several existing weirs, non-existent. This one-way movement may eventually isolate gene pools and place local populations in jeopardy with respect to susceptibility to any particular stress.

In the current situation, the river is broken into several isolated reaches below the dam and near the dam (Campbell's Weir). Accommodation Creek is the first significant tributary downstream from Campbell's and there are several essentially impassable barriers in this reach. Fish cannot move between the subcatchments to any great extent. Unfortunately the situation is probably no better within the Accommodation Creek system because significant weirs exist here also and probably stop, to a significant extent, movement between Accommodation Creek and Bald Rock Creek. The impact of the existing weirs on the system is undoubtedly very significant, irrespective of changes to the flow regime.

Most fish can breed without the facultative need to migrate but some are stimulated to do so and the primary benefit is the dispersal of the species and perhaps the location of juveniles in more suitable habitat. Silver perch and Spangled perch are the best known in terms of undertaking major upstream migrations linked to significant flow events. Yellowbelly have also been recorded undertaking such migrations but they can also successfully breed without migrating. Distribution of Murray Cod fingerlings is aided by flow and the juveniles are thought to move upstream to compensate. Adults tend to have a home range (tens of kilometres) and to favour certain logs. The home range of River blackfish is much smaller, thought to be about 30 m. Thus the only fish that need to migrate for spawning purposes in the Severn are species that have been introduced to the system.

Australian native fish tend to be reasonably tolerant of variations in flow and water quality, as this is a natural phenomenon linked to flood and drought cycles. However the secondary effects of water quality changes can be significant. The anoxic near-bottom environment of deep pools and weir pools favours no species and while increased algal productivity as a result of increased nutrient levels can provide benefits to some species, the overnight depletion of oxygen can be limiting as can movement and visibility restrictions. The drying of river sections or of weir pools as a result of excessive water extraction can lead to direct mortality, overcrowding or to the exposure of eggs, such as those of catfish or any laid on algae in shallow water.

Recreational fishing is popular in the area with the targeted species being primarily the introduced predators.

There is considerable doubt over what constituted the natural fish fauna in this system but very little doubt that the fish surviving in it today are strongly influenced by:

- loss of riffle, run and glide habitat
- presence of deep pool habitat in the form of weir pools
- reduced flows, particularly low flows and small flood flows
- increased frequency and extent of dry periods
- isolation, because many of the barriers are largely impassable, and
- a range of non-water resource development related impacts, largely linked to the agricultural catchment.

These influences result in a substantially modified system where it is highly probable that the originally dominant species are now rare or restricted to upland habitats while translocated and exotic species and some of the original species (carp gudgeons) have been suited by the changes.

10.5 Potential Impacts and Mitigation Measures

10.5.1 Construction Phase

The main mechanisms of impact in the construction phase relate to the physical disturbance of the stream bed in the works area, water quality impacts related to runoff from disturbed areas or to spillages, and to the impacts of any temporary barriers. These are limited to the period of works and largely to the footprint of development or, given implementation of common and accepted mitigation strategies, a short distance downstream. Each are discussed below.

10.5.1.1 Physical Disturbance

Physical disturbance to aquatic habitat will occur within the footprint of the dam wall and works buffer area; with respect to downstream works such as the entry to the fish transfer device and the flow release point, and in upstream areas associated with quarrying and filter sand extraction. The river will be routed around right abutment works for about three months then diverted through a conduit while all other works are completed over a 7 to 8 month period. The area to be disturbed is primarily shallow glide or pool with some riffle. During EIS inspections macrophyte cover in the area was low and large fish were not encountered nor are they expected except in periods of substantial flow. The disturbance will cover approximately 200 m of river and stream bed, mostly upstream of the wall or in its footprint so this area will be permanently changed in any case. The loss of aquatic flora and fauna

through direct physical disturbance is assessed as minor and temporary, with most affected areas being later affected by inundation.

10.5.1.2 Temporary Barriers and Habitat Changes

The works include temporary stream diversions and the construction of coffer dams and temporary ponds to trap runoff water. These structures may, and in some cases will, block fish movement at least temporarily. They may also entrap fish. Aquatic fauna will be given the opportunity to move from the works area by progressing works from one direction, rather than working from both ends and potentially trapping fauna.

These pondages may also provide breeding habitat for biting and nuisance insect species though no culicids (mosquitoes) were captured during field sampling. Temporary pondages, including sediment traps or areas of uneven ground, will be drained frequently to prevent completion of the life cycle should any egg laying occur.

10.5.1.3 Water Quality

Various pads for construction activities (batch plants, laydown areas, crushers and stockpiles) will be established below the eventual FSL but above current flood levels. While best practice sediment and erosion control structures and procedures are to be included, it is likely that some increase in turbidity will be recorded at and downstream from the dam and road works area and also as a result of vegetation clearing activities. During no or low flow periods this is unlikely to be a significant issue but if any flushes occur during the construction period it is likely that some sediment will find its way downstream. Depending on the size of the flow this may settle in the shallow meander section between Fletcher Rd and upstream of Somme Lane or it will be trapped in the first weir pool near Somme Lane. The number of weir pools downstream will effectively add to the sediment control procedures and minimise the length of river impacted by elevated turbidity.

Other influences on water quality include grout washings, cement additives and the potential for spills, particularly of fuels and lubricants. Emergency and spill response procedures will need to be ready for rapid mobilisation should such an event occur. Again the downstream weir pools will assist with trapping and minimising the downstream extent of impact.

10.5.2 Operations Phase

Once the dam wall is closed the impoundment will begin to fill. The rate of fill will depend on climatic conditions at the time.

On commencing to fill, the disturbed sediment in the storage area, and that carried from upstream, will move to the lowest parts of the storage and fill the existing channel and low points, creating a less diverse bottom profile. The quarry and sand extraction areas will be re-contoured to a smooth profile when works cease to avoid deep pockets of still water in the dam. Areas nearer the edge are likely to maintain a relatively rough profile of bedrock and boulder with intermittent gravel. Organic matter within the storage will commence to rot and may lead to severe oxygen depletion in the short term. The initial clearing of the site will assist in reducing this effect. If initial filling is slow it may be advisable to allow significant proportions of reasonable flow events to pass through the dam in the early phases of filling, moving organic matter and diluting the poor quality water by flushing downstream. The procedure will be based on a water quality monitoring program with pre-set thresholds for particular management actions. However it would prudent to not damage downstream established ecosystems in order to protect one, the new dam, that is not yet established.

After a period of stabilisation, the long term operational changes will commence with colonisation of the storage by aquatic plants and animals. Expected communities within the impoundment and downstream are described below in **Section 10.5.2.1**.

10.5.2.1 Impacts in the Inundation Area

Key statistics of the storage are given in **Table 10-11**..

- **Table 10-11 Key statistics for Emu Swamp Dam**

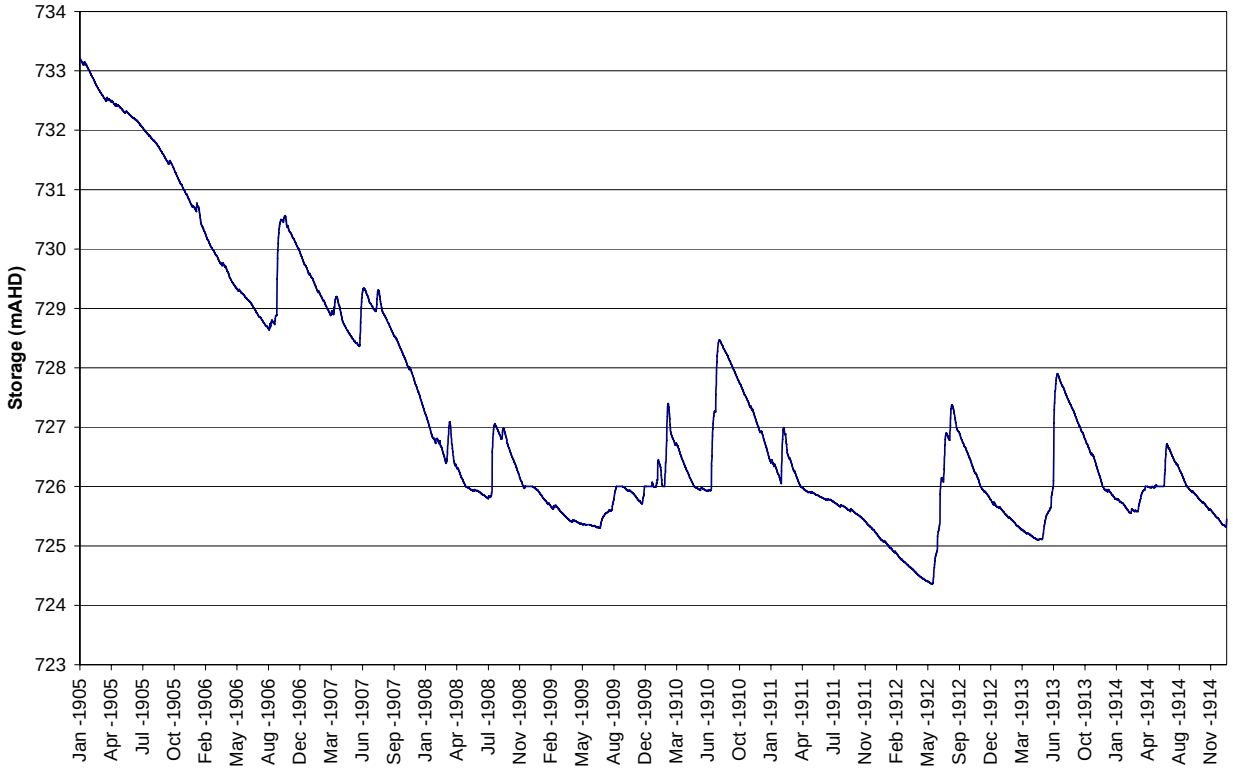
Key Statistics	Urban Water Supply Dam		Combined Urban and Irrigation Dam	
	100% capacity	50% capacity	100% capacity	50% capacity
Length of river inundated	3.8 km	2.6 km	4.6 km	3.8 km
Length of tributaries inundated	1.5 km	0.8 km	2.0 km	1.5 km
Max depth	13.5 m	10.5 m	17.0 m	13.5 m
Surface area ha	110 ha	64 ha	196 ha	111 ha
% of surface <1m deep	21%	11%	20%	21%
% of surface <2m deep	37%	20%	42%	37%
% of surface <5m deep	67%	40%	117%	67%
% of surface >5m deep	44%	24%	79%	44%

As can be seen from the figures above, much of the dam will be greater than 2 m deep and often greater than 5m deep as it is relatively steep sided. The benthos in these depths will largely be unavailable to flora and fauna due to low dissolved oxygen and light levels. This is also true of natural deep pools. However, many of the existing natural and weir pools are relatively shallow so that the deeper areas are often still available for use, even by catfish.

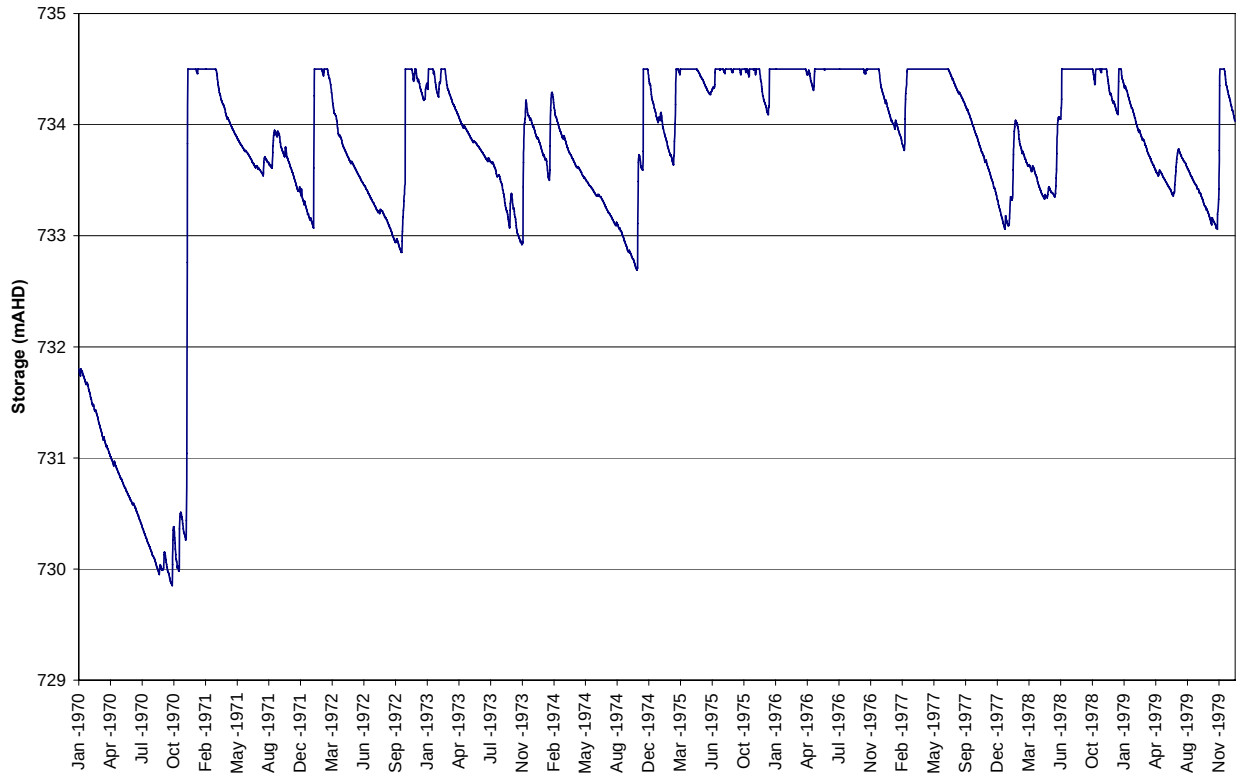
The shallower areas on the dam margins, mainly in tributaries on the northern side and at the upstream extent, will develop significant macrophyte communities depending on the stability of water levels. The change in depth from full supply to 50% capacity is approximately 3.5 m and this range is often fully utilised over short periods.

The water level within the storage in dry, wet and median periods is presented in **Figure 10-5**, **Figure 10-6** and **Figure 10-7** for the Urban Water Supply Dam. The dry period includes a two year period from about January 2008 with little change in water level and macrophytes would do very well at this time. Those which established at that water level would be completely drowned when the water level rose quickly over more than 2 m. There would also be little colonisation over the following four years because water level fluctuations of over 2 m occur over relatively short periods. During the wet period, the rate and scale of change is often slow enough for macrophytes to establish and proliferate, for example in the June 1975 to September 1977 period. Rapid rises in water level in early 1971, December 1974 and June 1978 would be sufficient to drown most if not all macrophytes. The median period shows quite extreme fluctuations offering little chance for macrophytes to proliferate.

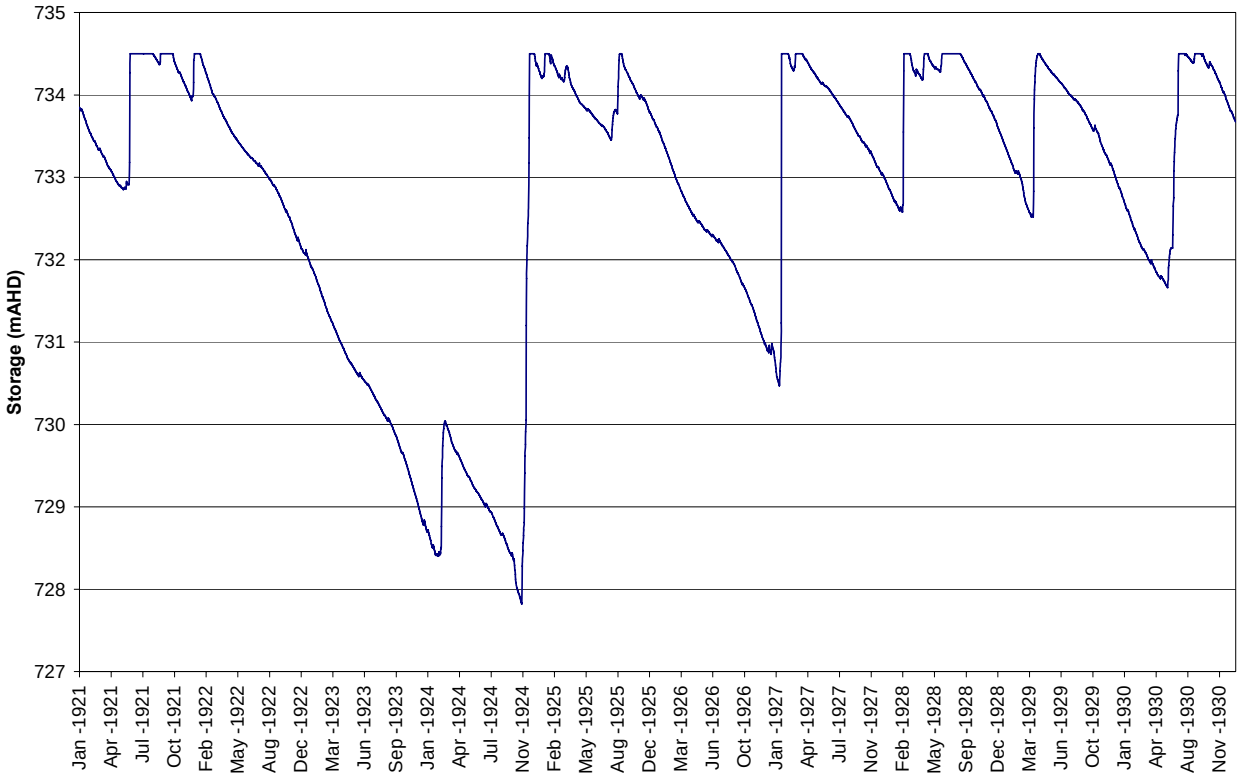
- **Figure 10-5 Dam water storage levels during a dry period**



- **Figure 10-6 Dam water storage levels during a wet period**



- **Figure 10-7 Dam water storage levels during a median period**



The flora is expected to be similar to that which occurs in natural pools or weir pools at present. This flora is diverse and components can become prolific given the right conditions of light, temperature and nutrient supply. While there are no declared weed species present, the community will include a number of introduced species. Emergent species will rapidly colonise the margins, particularly where lower gradients produce wet areas. Any such areas are potential cumbungi banks. The hardier sedges and rushes are expected to be most favoured, with submerged species only becoming abundant in periods of relatively stable water levels. Floating species will also be favoured as they are least affected by fluctuating water levels. Species such as duckweed or Azolla could occasionally cover the water surface, as they have done on Campbell's Weir within the proposed pondage. The existence of most of the regional species within the existing storage area, either in Campbell's Weir or the two farm dams on the creek on Stalling Road, will ensure rapid colonisation.

The variable profile edge, the merge into riverine habitat in the upper main channel and in tributaries, and the macrophytes when they are present, will provide good habitat for a range of macroinvertebrates. The current dominant species can move and recolonise quickly so will not be greatly impacted by the varying water levels. The footprint contains very little riffle and is dominated by an existing weir pool and natural shallow pools so the existing fauna will suit the inundation area, though the deep benthos will not be productive. A period of recolonisation will occur following each rapid fill sequence.

The fish fauna are likely to resemble that in weir pools currently in the system. The edge in rocky areas where filamentous algae is likely, will be dominated by carp gudgeons and gambusia while eel tailed catfish will likely be able to nest in the northern tributaries, particularly if the existing weirs near Stalling Lane are left in place as they will be below the FSL so will provide an even sandy bottom and will retain water as the dam water level drops. The populations of larger predators could be enhanced, if thought beneficial, by the provision of piles of large woody debris, preferably dried hollow logs placed from near the FSL to a depth of about 8 m. Waste concrete pipes can serve a similar role. These substrates will also be used by turtles as resting or basking areas when they protrude above the water surface.

It is unlikely that the riparian zone will need to be enhanced to assist the needs of fish or macroinvertebrates because the forest which will form the edge has a number of suitable species and will be rapidly colonised by more specialist species (callistemons and the like).

The habitat would not favour those fish species that are already under pressure such as River blackfish, Purple spotted gudgeon or Mountain galaxius. They were not collected during EIS surveys and are expected to be found in less regulated sections with remaining riffle and run habitat in headwaters or downstream around Sundown National Park area.

From the upstream limit of impoundment to the first significant weir is a distance of just 600 m but there may be only one other weir in the next approximately 5 km. Several fish species will attempt to move upstream from the dam into this section during periods of flow in order to spawn or to satisfy natural urges to disperse upstream. In other than significant flows, further upstream movement will be essentially blocked. Further small weirs exist every one to two kilometres from just upstream of Glen Aplin and none are fitted with fish passage devices.

10.5.2.2 Impacts Downstream

As the water extracted from the dam will be piped upstream to Stanthorpe, it is essentially lost to the downstream system. Regulated flows will pass the dam for downstream use. Downstream flows will otherwise be limited to spills and a baseflow environmental release that will pass through a fish transfer device, if fitted, or through a multi-level offtake.

The Environmental Flow Objectives (EFO) performance indicators at Farnbro for predevelopment, existing entitlements and with Emu Swamp Dam are presented in **Section 7.1** of the EIS. These figures show:

- there is significant reduction from predevelopment to the existing entitlements scenario;
- the Urban Water Supply Dam has no impact on the low flow days and the summer flow days compared to existing entitlements. The Urban Water Supply Dam reduces the existing beneficial flooding flow by 9% and the 1 in 2 year flood by 14%; and
- the Combined Urban and Irrigation Dam has no impact on the low flow days and the summer flow days compared to existing entitlements. The Combined Urban and Irrigation Dam reduces the existing beneficial flooding flow by 18% and the 1 in 2 year flood by 22%.

Downstream of the Accommodation Creek confluence there is minimal impact on the existing entitlements scenario. The impact of the dam on the flow regime of the Sundown National Park is negligible due to the significant inflows between the proposed dam location and the National Park.

The degree of change for both the Urban Water Supply Dam and the Combined Urban and Irrigation Dam is small compared to the changes from predevelopment to the existing entitlements. It is unlikely to lead to significant change in the existing habitat.

10.5.2.3 Barrier effects

This section is of high ecological concern because numerous weirs already exist on the system, none have fish passage devices and many of the outlet release valves apparently do not function. Fish passage is only possible during times of weir drown out. Weir drown out does not automatically mean that all species of fish can pass the barrier. The number and size of weirs also means that the bottom profile of the river is now likely to contain more pools that are deeper than natural and this may have affected the ecology through altering the dynamics of flow, sediment and temperature. The cumulative impact of existing dams and weirs is a major issue in this system.

The location of Nundubbermere Falls some 30 km below the proposed dam site and 14 km upstream from Sundown National Park is beneficial to the assessment of impact of the project because it precludes the necessity to address many of the potential migratory fish species as they are naturally not upstream of this barrier. The distance to the park is also significant in that it would be unlikely that any water quality impacts derived from the dam, should there be such impacts, would persist over this distance.

Spangle perch is known to move significantly on flood events but its presence is yet to be confirmed and it is more commonly regarded as a lowland or midslope species. The Mountain Galaxias is thought to move short distances upstream to riffle areas to breed. Several of the species are known to have stable home ranges. As a headwater of a western flowing system, no fish species need to migrate to or from the coast. The upper catchment is completely isolated from lower regions by Nundubbermere Falls, some 30 km downstream from the site of the proposed dam. It is logical that this location be used as the demarcation between Upland and Foothill zones in this catchment.

The stocked predatory fish are generally considered to have more significant movement / migratory needs in their natural environment but as these fish are not native to the system and there is a reasonable probability that they are having a detrimental effect on the endemic species, it would be difficult to justify potentially enhancing their impact through provision of a fish transfer device. These species are currently stocked so stocking in locations upstream of the proposed dam would appear to satisfy the species distribution criteria of local anglers. It may also be that the breeding cycle of these species would be naturally constrained by low water temperatures in this system in any case hence the benefit of enhanced movement may be less than is normally targeted. There are also no floodplain areas as such for the migratory species such as Silver perch to access as they normally would in more western lowland areas. The low numbers and large size of Silver Perch caught in aquatic ecology surveys for the EIS indicated they may not be breeding.

All fish however need to move to some extent in order to disperse from areas of concentration, to find suitable habitat or avoid unsuitable areas, to find food resources or to find suitable breeding and egg laying habitat. In the upper reaches of a catchment there is a risk that if upstream movement is significantly hindered then the gene pool of the population will become very isolated and therefore vulnerable to disease.

Within the dam footprint, Campbell's Weir is an existing significant barrier that would only be passable in high flows and many species may not be able to pass at all. The dam could therefore be seen as representing little change from the existing situation, though it will be totally impassable without a fish transfer device.

Within a few kilometres downstream of the dam is the weir near Somme Lane, closely followed by Mungall's Weir, Booths and several others. Many of these represent significant barriers so it is probable that if a fish transfer device were fitted to the Emu Swamp Dam that it would only draw fish from a short distance downstream. Similarly no fish could move between the major sub-catchments and the dam location in current circumstances because of the location of significant weirs downstream and upstream of significant junctions and within the tributaries themselves.

Similarly there are further significant barriers just upstream of the proposed site so any fish that did pass the dam wall would be unable to progress much further upstream.

Given the highly modified nature of the existing catchment, the limited need of (likely) naturally occurring species in the system to move, the minimal benefit if they did move past the dam and the potentially detrimental effect of fostering the movement of translocated predators, non-selective fish transfer is not recommended.

It appears reasonable to assume that the existing system has been detrimental to some endemic species and the dam will exacerbate that problem. The benefit of a fish transfer device at Emu Swamp Dam would probably be limited.

SSC propose to fund a study of the present distribution and abundance of those endemic species that are currently impacted and develops a management plan to repopulate areas of remaining suitable habitat. Detailed design of the dam will allow for retrofitting of a fish transfer device if monitoring indicates that a fish transfer device would be beneficial for the endemic dish species.

Given the existence of a local hatchery and keen fishing clubs with members interested in these aquarium species, community support for the initiative should be forthcoming.

10.5.2.4 Species of Conservation Significance

The only species native to the upper Severn River of listed conservation significance is Bell's Turtle (Vulnerable, EPBC Act). This relatively recently described turtle is known mainly from the headwaters of the Namoi and Gwydir Rivers in NSW and from Bald Rock Creek. In the EIS survey, an individual was recorded in Bald Rock Creek and one in the weir pool at Somme Lane, downstream from the dam site. As Darren Fiedler of the Queensland EPA has been monitoring the species over a few years but has not found it in the Severn River. The capture of an individual at Somme Lane probably represents an itinerant, rather than being indicative of a resident population.

Little is known about the species but it appears to favour upland pools and to be a scavenging omnivore. It also appears to be rare in the system and may prefer more upland habitats. The impact of the dam is not likely to be significant given the very low probability of occurrence in the area and the higher probability that the area is not used for nesting. Of probably greater potential impact is the introduction of large predatory fish that would likely prey on hatchlings. As with other turtles, the major current impacts are probably related to predation of eggs by goannas and feral animals (foxes and pigs) or damage to nest banks by cattle (Young, in Young 2001).

SSC propose to undertake further monitoring to determine the distribution and abundance of Bell's Turtle to determine the need for further investment in infrastructure which permits free movement of turtles upstream and downstream of the dam.

10.5.2.5 Cumulative Impacts

The Severn River and tributaries are currently significantly impacted by agricultural, and to some extent, urban development and associated water resource development. Significant habitat changes have occurred by way of the construction of numerous weirs and through clearing of land for agricultural purposes. Water extraction from low flows is very significant but the higher flows remain at reasonable though reduced levels. The proposed dam, at any capacity, will add to these existing stresses through "more of the same"; it is not a different form of impact. The proposal will replace more riverine habitat with relatively deep pool and will lead to greater regulation of the river downstream. It will have minimal further impact on the low flow regime but will reduce the small the moderate floods and flushes. The dam wall will add another significant barrier to movement of fauna in the system and will trap sediment that would normally move downstream.