EM

Ecology Management

Aquatic Ecology Impact Assessment for Emu Swamp Dam

Final Report,

December 2007

prepared for Stanthorpe Shire Council

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1. Introduction

Very little formal sampling of aquatic environments has been undertaken in the Severn River and tributaries upstream of Nundubbemere Falls. The most relevant works are described below.

Strategic Management Plan for the Severn River, Pike Creek and Tributaries (Stanthorpe Shire River Improvement Trust, 1996, referred to as SSRIT 1996). This report incorporated rapid assessments of instream habitat, riparian zones and geomorphology.

Border Rivers instream biological resources study (Boddy and Bales, 1996). This study sampled the Macintyre and Dumaresq rivers (downstream of the Severn) and tributaries within NSW but did not sample the Severn River.

An ecological and physical assessment of the condition of streams in the Border Rivers and Moonie River catchments (Johnson 1999). This statewide "State of the Rivers" (SoR) program used a rapid but formalized visual assessment process to describe aquatic and riparian habitats and included several sites within the study area.

Current ecological condition of streams in the Border Rivers catchment (DNR 1999). This was a supporting document to the water resource planning process and included literature review and rapid field assessment of condition. The latter did not extend upstream of Texas, well downstream from the study area. Existing data from sampling programs was described but only macroinvertebrate data existed for the Severn River.

Enquiries to DPI Fisheries, DNRW and the Queensland Murray Darling Committee Inc. failed to identify any further studies related to aquatic ecology. As all of the above reports used rapid assessments of habitat but did not actually sample the key biological attributes of stream condition (other than the AusRivAS program for macroinvertebrates in DNR 1999), Stanthorpe Shire Council sponsored a field sampling exercise to build on the local database. The methodology of the survey is summarised in the following section then results are combined with the literature in order to describe the existing aquatic environment in accordance with the Terms of Reference.

2. Field survey

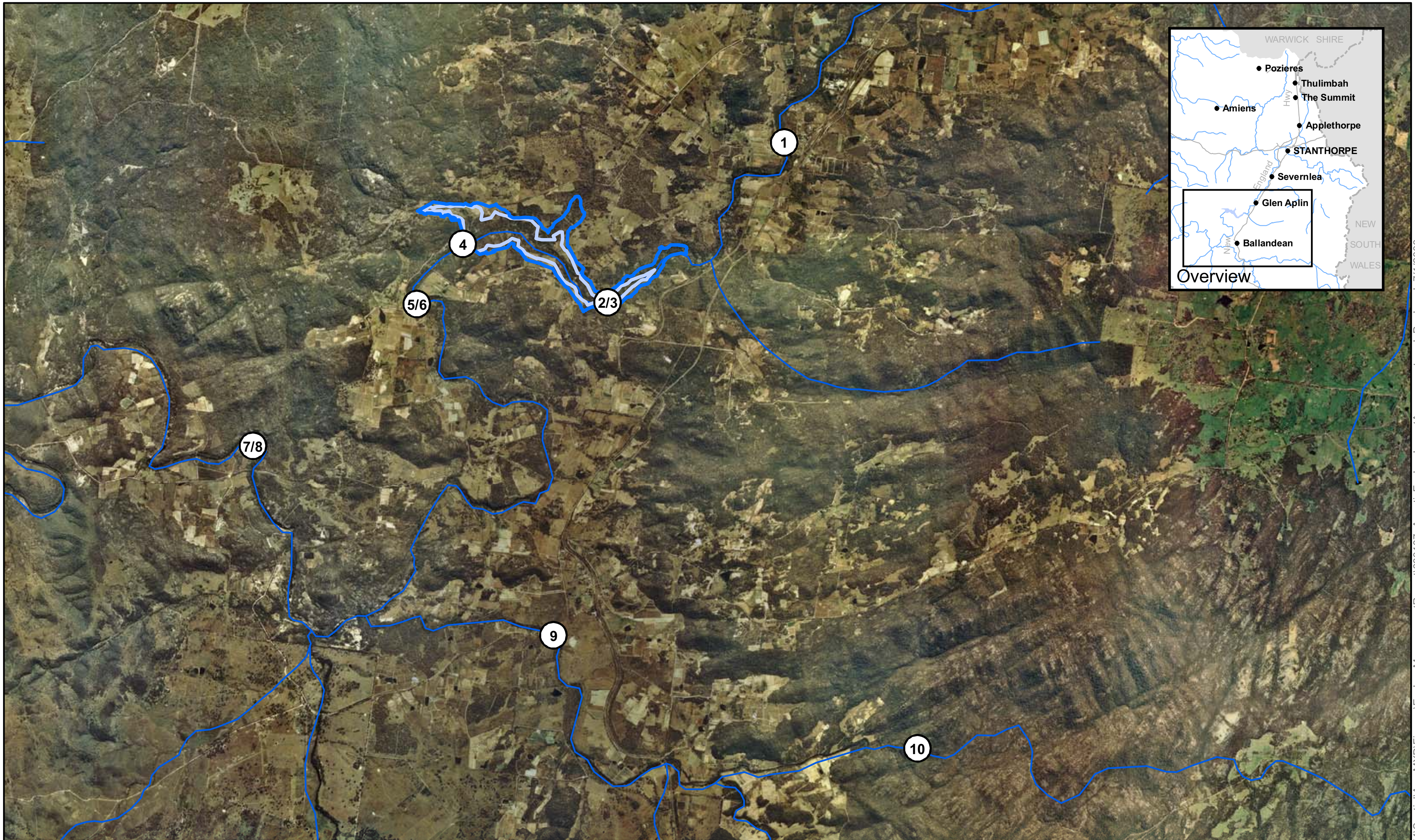
2.1 Survey design and site locations

EM (Ecology Management) Pty Ltd sampled 10 sites in late spring 2006 and early autumn 2007 (**Table 1** and **Appendix A**). The sites included locations upstream, within and downstream of the proposed dam site as well as two sites not directly affected by the development; on Accommodation Ck and Bald Rock Ck (**Figure 1**). Shallow and deep sites were sampled, the latter including both weir pools and natural pools. Detailed site descriptions and photographs are provided in **Appendix A**. The field sampling program included habitat descriptions, meter-based water quality, macroinvertebrates and fish. For macroinvertebrates, the edge habitat was sampled using replicated surber samples, specific habitats such as macrophytes were sampled with a dip net and the deep water benthos was not sampled as no suitable sampling apparatus exists for an uneven rocky bottom. Fish were sampled with a range of nets and a backpack electrofisher (in shallow wadeable waters). Full details of sampling methods are provided in **Appendix B.**

Sites were 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.

Table 1 EIS field survey sites

Site number	**Location**	**Site utility (DS-downstream, US-upstream)**
1	Severn River near Glen Aplin (Thorndale Rd)	US 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. DS of existing weir.
4	Severn River near Stalling Lane	Dam wall footprint. Shallow, natural.
5	Severn River near Somme Lane	DS dam; US Accommodation Ck. Shallow.
6	Severn River near Somme Lane	DS dam; US Accommodation Ck. Deep weir pool
7	Severn River on Bents Road ("second crossing")	DS dam; DS Accommodation Ck. Shallow
8	Severn River at Bents Weir	DS dam; DS Accommodation Ck. 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)



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

AQUATIC ECOLOGY IMPACT ASSESSMENT FOR EMU SWAMP DAM

Emu Swamp Dam Site

Figure 1

Aquatic Field Survey Sites

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2.1.2 General comments on EIS survey results

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 baseflow channel varies from just a few metres wide in places to over 25m wide in others. At times the baseflow channel can be distinctly incised, with banks often 2m in height (such as near Stalling Lane at the dam site). Beyond the baseflow 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, on both sides beyond the immediate riparian zone at the Accommodation Creek site, and on parts of one side at the Campbell’s and Bent’s weir sites. 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, which was bordered by Cumbungi (*Typha*) on one side and sedge dominated meander channels on the other.

Riffle habitat was present at Bents Rd (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. 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.

3. Existing Environment

3.1 Aquatic habitats

SSRIT (1996) noted that local streams and rivers were inherently stable and suffered little erosion because of the regional granite and traprock geologies. This geology and the local gradients also meant that significant floodplain areas were absent. As part of the report, 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. The results are shown in **Table 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.

Table 2. Stream Condition Assessment (SSRIT 1996)

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

The results show that while the majority of sites had been disturbed, most were in good or satisfactory condition. The authors concluded that the long term impacts of dredging (mainly for tin mining) and weir construction were similar in that they both created deep water environments that were likely to favour sediment deposition and macrophyte growth. Sites inspected as part of EIS surveys did not support this contention as, other than emergent macrophytes and *Myriophyllum* at some sites, the steep edge, deep water or rocky substrate of many weir pools appeared to exclude macrophytes. The extent of large woody debris in the rivers was thought (SSRIT 1996) to be less than natural, principally as a result of clearing of the riparian zone.

The geomorphology section of the report noted that 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 authors concluded that the impacts of tin mining, mainly conducted in the late 1800's, mainly did not affect modern day stream processes though many instream pits remained and were often used as water storages.

The State of the Rivers report (Johnstone 1999) used 25 survey 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
- 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 the EIS were generally rated as in better condition than those assessed by Johnstone. Riparian vegetation, instream woody debris, habitat diversity and macrophyte growth were generally good, though some weir pool sites lacked submerged or floating macrophytes. DNR (1999) rated habitat condition as generally moderate with some sites achieving reference status. DNR (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 EIS 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 (1–2m) deeply incised (1-2m) 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.

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

Water quality measured concurrent with EIS sampling showed considerable variation between sites, with depth at a site, and overnight at a site. There were also differences between sampling events. Deep sites at times showed strong vertical stratification and diurnal variation. Oxygen could at times, or at depth, be limiting (**Figure 2, Table 3, Table 4**). Turbidity was generally low (2-30NTU) except in pools with high tannin content where it could reach over 200NTU. pH was generally in the range 7 – 9 pH units.

Figure 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 4**.

Figure 2 Overnight change in dissolved oxygen at Glen Aplin and at Bent's Weir, April 2007

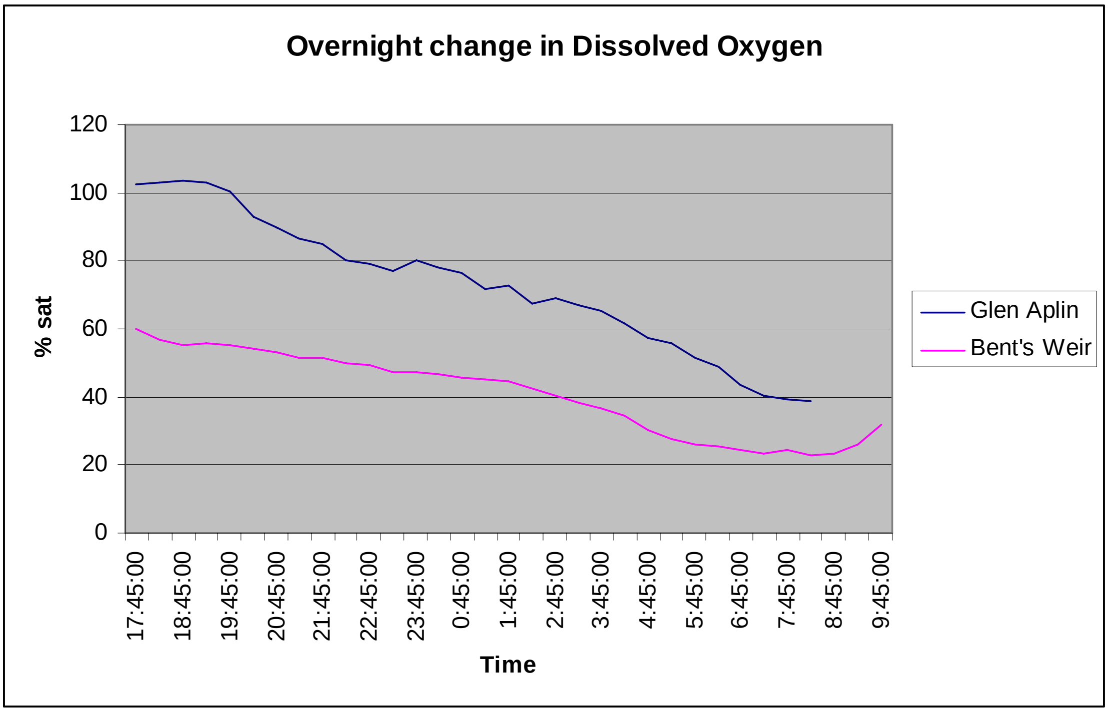


Table 3 Water Quality with Depth profile at Campbell's Weir, November 2006

Depth	Temperature ^{0}C	pH	Diss. Oxygen % 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 4 Water Quality with depth profile at Bent'sWeir, November 2006

Depth	Temperature ^{0}C	pH	Diss. Oxygen % 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

Note turbidity readings fluctuated wildly and are not shown.

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.

3.1.1 Existing Water Resource Development

Each of the reports listed above noted the extent of water resource development in the catchment in terms of direct extraction from the river, 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 **Table 5**.

The table lists 13 structures in the 19km of main river channel upstream of the Project site (on average, a weir every 1.5km) and a further 12 structures in the 30km downstream to Nundubbermere Falls (on average, a weir every 2.5km). There are many more weirs, and Storm King Dam, upstream of the upper limit of this table and on tributaries. The large number of dams and weirs upstream and on tributaries is clearly shown on Figure 6.3 of the Current Ecological Condition report (DNR 1999). It is also believed that more weirs exist in general as a fly-over of the catchment and site inspections during a ground-based survey identified weirs that did not appear in the table. The table also shows weirs that do not exist. For example there is no weir wall with a height of either 5m or 3.5m at 264.0km AMTD. It is quite possible that initial small weirs have been replaced with larger structures and may have been drowned by the weir pool of the larger structure.

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.

Table 5 Location of Weirs on the Severn River main stem (from DNRM, 2006)

AMTD * OF STRUCTURE	HEIGHT OF STRUCTURE (m)	CAPACITY OF STRUCTURE (ML)
283.0	*UPPER SEVERN RIVER SUB-CATCHMENT (Downstream of confluence of Quart Pot creek and Broadwater Creek)*	
281.0	2.5	8
279.9	1	10
278.5	1	10
276.2	1.5	15
275.2	1.5	22
274.8	2.3	64
269.9	2.4	52
267.5	3.0	5
266.2	3.5	120
265.5	1	1
264.5	1	7
264.0	3.4	10
264.0	5	5
264.0	Emu Swamp damsite	
262.7	1.2	7
262.5	1.4	0
260.5	4	140
259.3	2.9	38
256.1	3.2	220
252.0	*LOWER SEVERN RIVER SUB-CATCHMENT (downstream of confluence with Accommodation Creek)*	
251.8	1.8	22
249.9	2.2	24
245.7	4.6	67
247.6	3.0	20
247.6	1.2	20
242.8	3.6	27
242.6	1	1
234.0	Nundubbermere Falls	
220.6	Sundown national Park upper boundary	
198.6	Farnbro Gauging Station	
196.7	Sundown national Park lower boundary	
192.5	Confluence with Tenterfield Creek	

* Adopted Middle Thread Distance (km) upstream from the confluence of the Macintyre and Dumaresq Rivers

SKM has assessed the weirs closest to the site and their relative locations and heights are shown in **Table 6**. Hydraulic modelling was also undertaken to assess the drown-out characteristics of these structures.

Table 6 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 (ms^{-1})**
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

The weirs at 256.1 (upstream of Accommodation Ck) and 245.7 km AMTD (below Accommodation Ck and corresponding to the Bents Weir EIS sampling site) would also probably be impassable. While acknowledging the limitations of the modelling, it is clear that fish passage along at least 12 river kilometres below Campbell's Weir and above the junction with Accommodation Creek, is currently extremely limited and 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. Much of the habitat in this stretch is weir pools, separated by braided channels where the habitat would not be permanent.

Campbell's weir would be drowned by Emu Swamp Dam and the inundation of the smaller option would extend to approximately 267.6 km AMTD (or the base of the weir at about this distance), while that of the larger option would extend to 268.4 km AMTD. The next weir is at 269.9 km AMTD, and it is a significant structure at 2.4m in height, though a significant natural by-pass channel exists. According to **Table 5**, the next barrier is then at 274.8 km AMTD though aerial photographs suggest a barrier exists at about 270.6 though a natural high flow by-pass may also exist here.

No weirs are known to have fishways fitted though some have low flow release valves but they rarely function (DNR pers. comm.). 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 means 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 changes in habitat are therefore very significant and will have led to significant changes in the ecology of the river.

The weirs are private structures, primarily established to provide pumping pools for irrigation supply. Key WRP related hydrological statistics are presented in **Table 7**. The hydrological model of the existing condition is referred to as the Base Case. The Pre-development case represents an approximation of the natural condition. The location shown is Farnbro, downstream of Sundown National Park (Node 063).

Table 7 Key flow statistics: Base Case as % of Pre-development

	At Farnbro
Mean annual flow	72
Median annual flow	5
Low flow days	36% increase
Summer flow days	34% decrease
Beneficial flooding flow	40% decrease
1 in 2 yr flood (daily flow)	44% decrease

These figures clearly show that the greatest impact has been on low flows, with the regular low level flood events reduced by 34 – 44% and the number of low flow days increasing by 36%. The river at Farnbro naturally ceased to flow on about 33% of days and this figure is now 50%. The difference between natural and base case flow durations decreases as the flow level increases, that is, larger flows are less impacted.

The degree of change from natural is significant and is further highlighted in **Figure 3** and **Figure 4**. 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 3 Mean of median monthly daily flows at the dam site

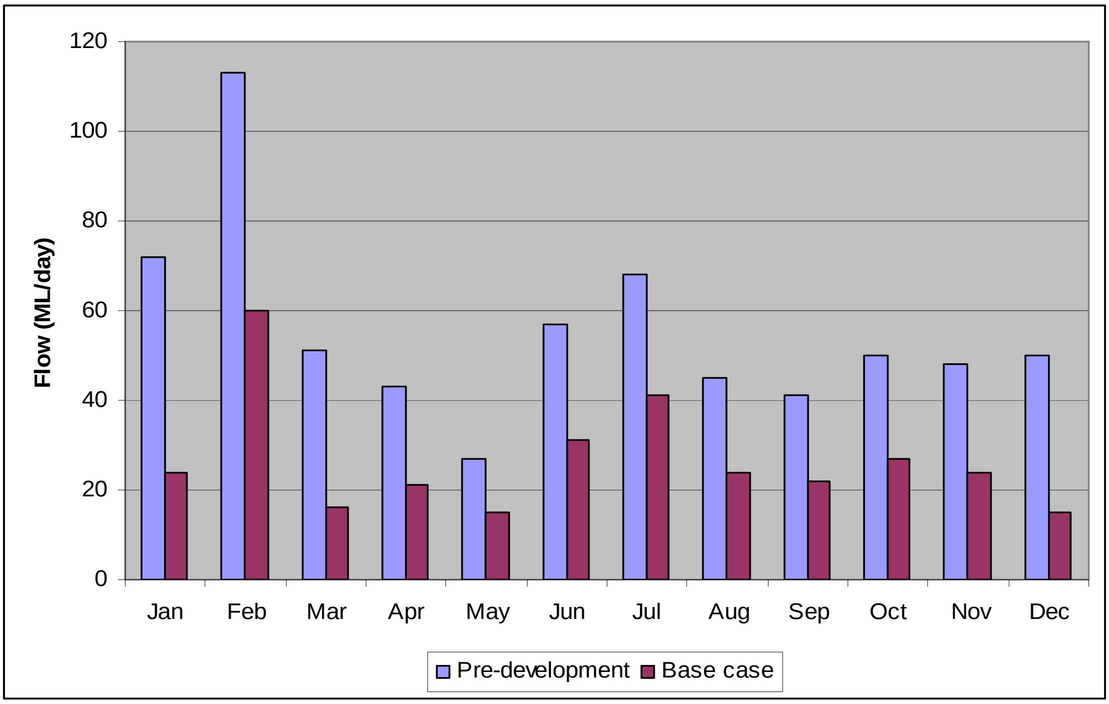
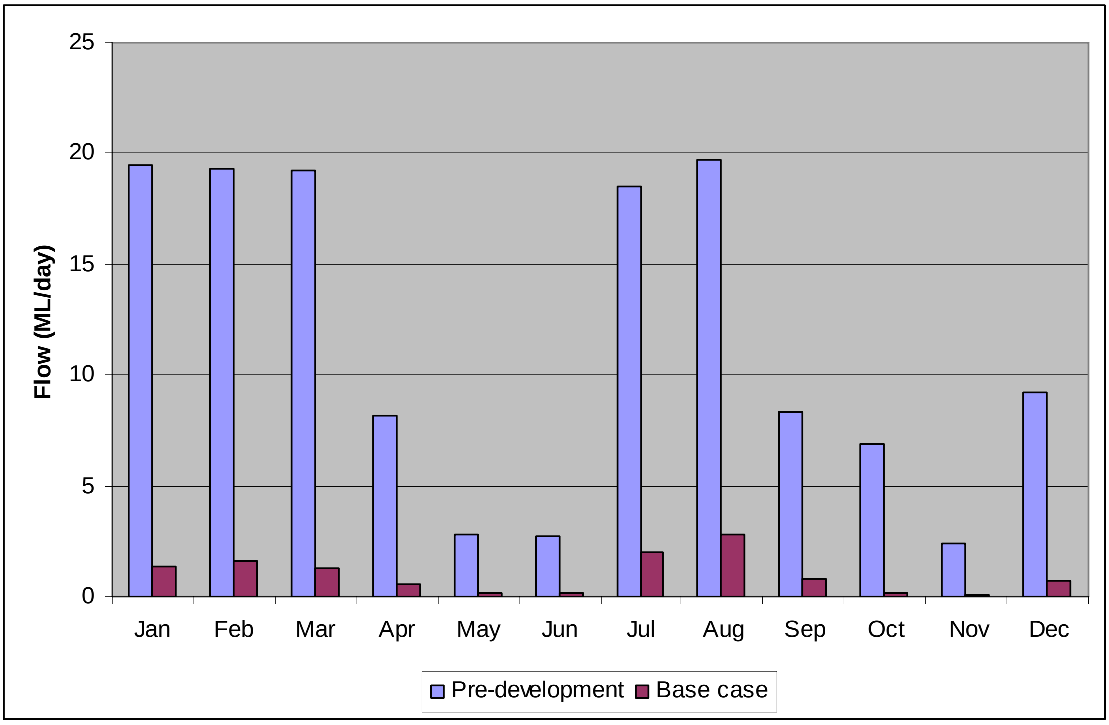


Figure 4 Median Monthly Daily Flow at the dam site



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 14.2% in August and the worst being 2.9% 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 50.5% and 76.9% 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 WRP 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 on low flows in all months, but more so in warmer months, is extreme while 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.

3.2 Aquatic flora

3.2.1 Current Presence, Distribution and Abundance

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. Sainty and Jacobs sampled the sites over three years. Thirty-three species were recorded as follows (species with a # were described as exotic, species with an asterix * were also recorded as part of EIS sampling in the Severn River):

Free floating species;

Azolla filiculoides (Pacific azolla)*
Azolla pinnata (Ferny azolla)
Spirodela sp. (Duckweed)*

Floating attached;

Ludwidgia peploides (Water primrose)*

Submerged species;

Myriophyllum verrucosum (Red watermilfoil)
Vallisneria gigantean (Ribbonweed)

Potamogeton crispus (Curly pondweed)*
Potamogeton ochreatus (Blunt pondweed)
Potamogeton perfoliatus (Clasped pondweed)
Spirogyra sp.*

Emergent species;

Hydrocotyle peduncularis#
Aster subulatus (Wild astor)#
Carex appressa (Tussock sedge or Tall sedge)*
Cyperus difformis (Rice sedge)*
Cyperus erogrostis (Umbrella sedge)#
Cyperus exaltatus
Cyperus gymnocaulos
*Cyperus polystachyos**
Eleocharis acuta (Common spikerush)*
Isolepis mucronatus
*Schoenoplectus mucronatus**
Echinochloa crus-galii (Barnyard grass)#*
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.#
Tradescantia alba (Wandering jew)#

The EIS field sampling program also recorded the following species:

*Myriophyllum aquaticum (*Water milfoil - submerged*)*
Triglochin procerum (Water ribbons - emergent)
Potamogetan tricarinatus (Floating pondweed – floating attached)
Rorippa nasturtium-aquaticum (watercress – emergent, exotic)
Gahnia aspera (emergent*).*

During EIS 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 Ck (both deep sites). It 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 March 2007 as the system dried. Another noticeable change as the water level dropped between November and March 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.

3.2.2 Species of Conservation Significance

Searches of State and Commonwealth online databases revealed no aquatic plant species or communities are of listed conservation significance.

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

3.2.3 Habitat requirements and Sensitivity to Change

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.

3.3 Aquatic Fauna

3.3.1 Fish

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

Frankenberg and Humphries (SSRIT 1996) undertook a literature review then assessed fish habitat at 19 sites on one occasion in 1996 (after a significant flush event). No actual fish sampling was undertaken. From museum records and anecdotal comment they suggested that 15 species probably existed in the system, including 3 alien species and 3 introduced native species (**Table 8**).

Schiller (DNR 1999) assessed 14 sites in the mid- and lower reaches of the catchment (downstream of Texas) but did not sample fish, again assessing only habitat. The only fish survey data acknowledged in Schiller's report (though not formally referenced) was that of Moffatt, collected from 4 sites between 1996 and 1998. The most upstream site was at Farnbro, which is over 35 river kilometres below Nundubbermere Falls and nearly 66 km below the dam site. The site was sampled 6 times over the three years (it was dry on two other occasions visited). Seven species of native fish were recorded and the site was classified as in Good condition. A species list was not provided. The significance of Nundubbermere Falls is that it is a 6m rocky outcrop barrier which according to DNRW (Elway pers. comm.) "*represents a natural impediment and historically appears to have hindered access by fish to upstream reaches of the Severn River*." Given the size of the barrier and the hydraulic assessments of existing weirs by SKM, Nundubbermere Falls would be impassable in any flow.

Moffatt and Voller (2002) put forward fish-based ecological zones for Queensland tributaries of the upper Darling River but the data behind the delineations is not given or formally referenced. The authors describe the area near the proposed dam as Upper Foothill zone with the change to Upland zone occurring a short distance upstream around Stanthorpe. The boundaries between zones are not expected to be distinct and the zones would overlap. The key differences between the Upland and Upper Foothill zones are:

- bedrock or boulder substrate rather than cobble and gravel;
- altitude > 600m or between 400 and 600m
- naturally rarely ceases to flow, may cease to flow.

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.

The Sustainable Rivers Audit Pilot Audit (2004) used two sites in the upper Severn River as "best available" comparators for the "source" zone of the Condamine River. One site was very much an upstream site on Bald Rock Ck within Girraween National Park, a tributary of Accommodation Ck, which in turns joins the Severn River downstream from the proposed dam site. The other site was on the Severn River in Sundown National Park and below Nundubbermere Falls. At the Bald Rock Ck site only one species was captured, River Blackfish (30 individuals) while at the Severn River site the catch comprised Fly specked hardyhead (2), *Hypseleotris* spp (63), Yellowbelly (2), Murray Cod (5), Smelt (6) Eel-tailed catfish (3) and Carp (10). Carp are known downstream of the falls but they are not known to be upstream. One other "best available" site of similar latitude and altitude in the source zone was on the Condamine River (site SRA042). This site recorded three species (Mountain Galaxius (36), *Hypseleotris* spp (19) and Goldfish (2)). The Audit sampled three source zone assessment sites in the Condamine Balonne and these varied in altitude from 418m to 511m and in catchment area from 5990km^2 to142km^2. Six species were recorded at the most upstream site (Olive Perchlet (6), Fly specked hardyhead (45), *Hypseleotris* spp (560), Rainbowfish (55), Southern Purple spotted gudgeon (88 – the only record in the entire pilot SRA) and Eel-tailed catfish (19 – the largest catch from any site in the SRA). While recorded at the more downstream source zone sites, the following were not recorded at the most upstream site; Goldfish, Carp, Mosquitofish, Spangled perch, Yellowbelly (Golden perch), Bony bream and Smelt.

Fishing clubs have been active in the upper Severn area since at least 1925 (Graeme Moore, 2006). At that time it was thought that no fish naturally existed above Nundubbermere Falls except perhaps small bodied species. Even River Blackfish, generally recognised as strongly favouring upland environments, was thought to be introduced before 1900. The Queensland State Government closed the area to all fishing from 1925 for 10 years and during that time local fisherman translocated adults of at least 4 angling species into the system (203 Eel-tailed catfish, 54 Murray cod, 24 Golden perch and 126 Silver perch). All but the Silver perch were presumed to have established breeding populations. Stocking of adults continued till fingerlings became available in 1983 and at that time 2000 Murray Cod were released. Re-stocking still continues on an annual basis with the preferred ratio being 40% Murray cod: 40% Golden perch: 20% Silver perch, though no Silver perch have been released since about 1998.

Mr Moore also noted "*It is interesting to note that since the various clubs began stocking natives in large numbers that the number of River Blackfish has deteriorated to the point where they are no longer found*."

As little historic sampling has been undertaken in the upper Severn River, it is difficult to predict the natural species complement. This is not a simple task for despite having the

SRA results and predictions available, the 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. Using the documents discussed above, the species that may potentially occur in the Project area, either naturally or via introductions, are shown in **Table 8**.

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. Also shown is the catch from specific EIS surveys.

Table 8. Fish potentially present in the upper Severn River and actually captured in EIS surveys (% comp; N=November; M=March)

Fish species potentially present	Common Name	% comp (N)	% comp (M)
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	4.66	2.30
Craterocephalus stercusmuscarum	Fly-specked hardyhead		
Hypseleotris klunzingeri	Western carp gudgeon	**+**	**+**
Hypseleotris galii	Firetail gudgeon	76.07*****	69.00
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**	0.07	0.06
Macquaria ambigua	**Yellowbelly**	0.11	0.28
Bidyanus bidyanus	**Silver Perch**	0.18	0.18
Carassius auratus#	**Goldfish**		
Gambusia holbrooki#	**Mosquito fish**	18.9	28.17

* The figure is for *Hypseleotris* spp and while 4 species were identified (marked with +), the catch was dominated by *H. galii* in spring and *H. klunzingeri* in autumn. Species known to be introduced are in bold. Exotic species marked #.

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 20m of 4” gill net when set overnight in weir pools. The Silver perch captured were very large, healthy fish, often measuring over 500mm fork length.

In the tables below, deep sites are presented first (shaded), then shallow. Sites are presented from upstream to downstream. Note that *Hypseleotris* spp includes H. *galii*, H. *klunzingeri*, H. sp4 and H. sp 5.

Table 9 Fish captured in November 2006

Site	*Mucullochella peeli peeli*	*Macquaria ambigua*	*Bidyanus bidyanus*	*Tandanus tandanus*	*Hypseleotris spp*	*Gambusia holbrooki*	**Total catch**	**Native species**	**Exotic species**
Glen Aplin				17	202	9	228	2	1
Campbell's Weir		2	2	24	341	16	385	4	1
Somme Ln Weir		1	3	45	882	9	940	3	1
Bent's Weir	2			23	173	182	380	3	1
Bald Rock Ck				19	141	30	190	2	1
Campbell's shallow					100	68	168	1	1
Stalling Lane					84	21	105	1	1
Somme Ln shallow					83	81	164	1	1
Bent's Rd (2nd xing)					55	15	70	1	1
Accommodation Ck					28	88	116	1	1
Total	**2**	**3**	**5**	**128**	**2089**	**519**	**2746**	**5**	**1**

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

Table 10 Fish captured in April 2007

Site	*Mucullochella peeli peeli*	*Macquaria ambigua*	*Bidyanus bidyanus*	*Tandanus tandanus*	*Hypseleotris spp*	*Gambusia holbrooki*	**Total catch**	**Native species**	**Exotic species**
Glen Aplin US				13	202	38	253	2	1
Campbell's Weir		1	6	15	133	14	169	4	1
Somme Ln Weir				17	519	7	543	2	1
Bent's Weir		2		21	508		531	3	0
Bald Rock Ck	2	6		9	385	13	415	4	1
Campbell's shallow					7	61	68	1	1
Stalling Lane					219	69	288	1	1
Somme Ln shallow					127	225	352	1	1
Bent's Rd (2nd xing)					46	116	162	1	1
Accommodation Ck					100	374	474	1	1
Total	**2**	**9**	**6**	**75**	**2246**	**917**	**3255**	**5**	**1**

The EIS sampling captured the same suite of fish on both occasions (5 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).

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. Frankenburg and Humphries

(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.

3.3.1.1 Species of Conservation Significance

Searches of State and commonwealth online databases revealed several species of conservation significance, described below. (Abbreviations are ASFB = Australian Society for Fish Biology; WCU = World Conservation Union). The EPBC listed Murray Cod was not specifically noted on the controlled action notification received by Council from DEWR but have been introduced to the catchment.

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 (MDBC 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.

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.

3.3.2 Macroinvertebrates

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.

DNR (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 (O/E scores of 0.9 – 1.1, where 1.0 equates to reference 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 11**). Fourteen taxa collected in November where 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 11 Percentage composition of common taxa at sites on the upper Severn River sampled in November 2006 (N) and March 2007 (M) by surber sampler or dip net.

Taxa	Shallow N	Shallow M	Deep N	Deep M	Dip N (n=9)	Dip M (n=7)
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**
No. of Individuals	**21599**	**17465**	**21868**	**22864**	**20532**	**11424**

Note: Bracketed number for dip nets = number of samples.

The EIS sampling program 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.

Nineteen per cent 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 (2486 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%). Interpreting the significance of these changes should always be tempered by an understanding of the variation between samples at a site on a single sampling occasion. For example the number of copepods in replicated samples from Stalling Lane in November varied between 180 and 4000. Standard deviation was commonly equal to or greater than the mean for the number of individuals per surber sample.

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.

3.3.3 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 Ck 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.

3.3.3.1 Species of Conservation Significance

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

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

The species is also 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 pers comm.). It 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 Ck. It has been found in shallow to deep pools only in upper reaches or small tributaries of rivers in granite country (Dept of Environment and Climate Change (DEC) NSW web site). It is probably a scavenging omnivore. 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). 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 5km of the park, though the basis of this distribution and restriction is a very limited data set. Darren Fiedler of the Qld 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.

3.3.4 Habitat requirements and Sensitivity to Change

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 6** 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 30m. 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.

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.

4 Potential Impacts and Mitigation Measures

4.1 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 is discussed below.

4.1.1 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, if fitted, and the flow release point, and in upstream areas associated with quarrying and filter sand borrow works. 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 – 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 200m 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.

4.1.2 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 should 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, should be drained frequently to prevent completion of the life cycle should any egg laying occur.

4.1.3 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.

4.2 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 should 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 should 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.

4.2.1 Impacts in the Inundation area

Key statistics of the storage are given in **Table 11** and **Table 12**.

Table 11 Key statistics of the storage (5000ML capacity)

	100% capacity	50% capacity
Length of river inundated km	3.8	2.6
Length of tributaries inundated km	1.5	0.8
Max depth m	13.5	9.5
Surface area ha	111	64
% of surface <1m deep	21	11
% of surface <2m deep	37	20
% of surface <5m deep	67	40
% of surface >5m deep	44	24

Table 12 Key statistics of the storage (10,500ML capacity)

	100% capacity	50% capacity
Length of river inundated km	4.6	3.8
Length of tributaries inundated km	2.0	1.5
Max depth m	17.0	13.5
Surface area ha	196	111
% of surface <1m deep	20	21
% of surface <2m deep	42	37
% of surface <5m deep	117	67
% of surface >5m deep	79	44

As can be seen from the figures above, much of the dam will be greater than 2m 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.

Figure 5 Dam water storage levels during a dry period

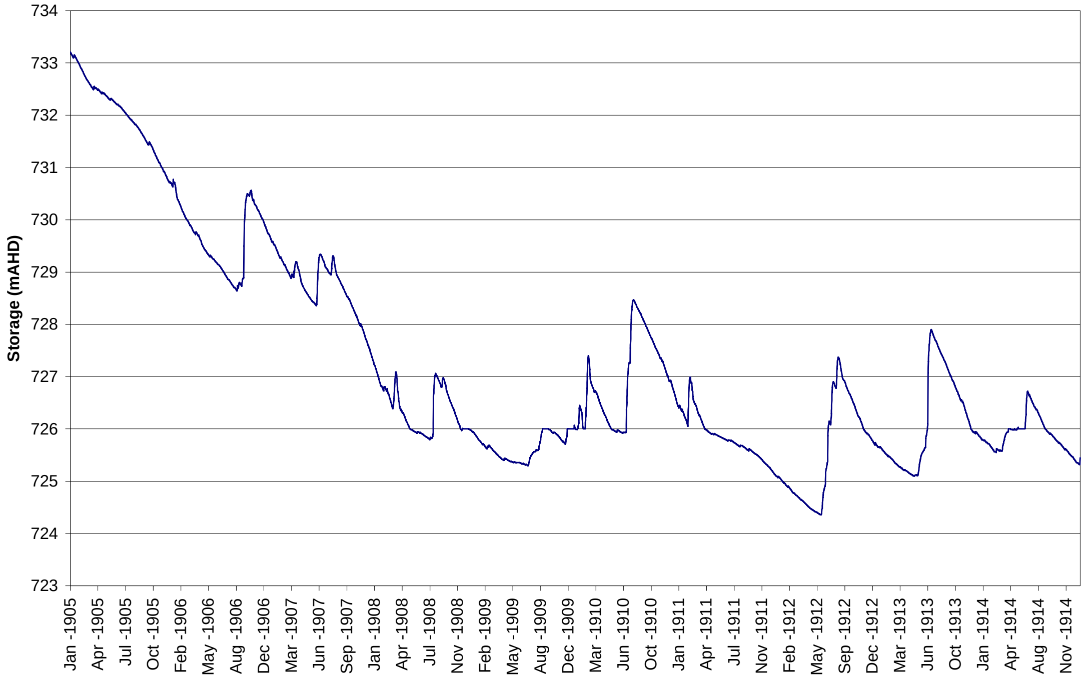


Figure 6 Dam water storage levels during a wet period

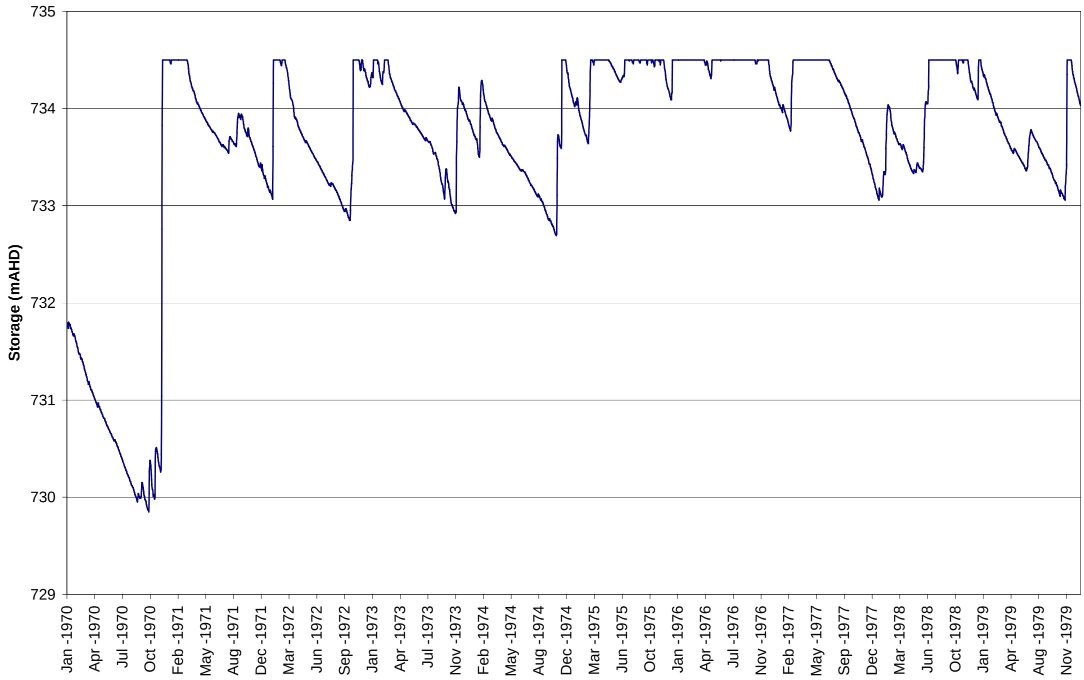
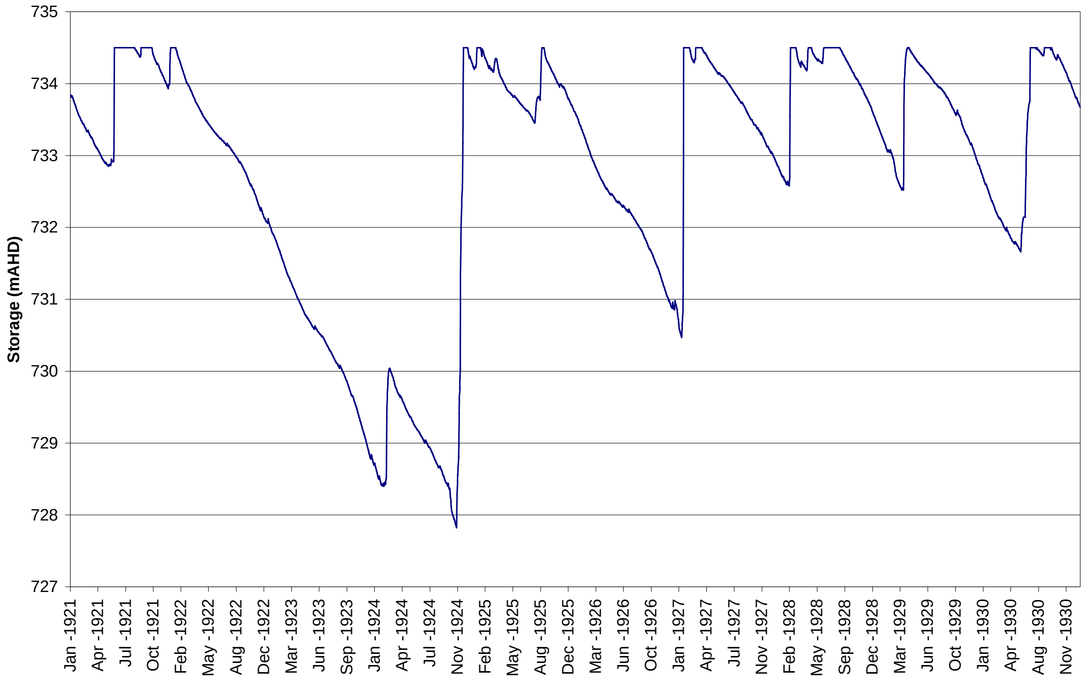


Figure 7 Dam water storage levels during a median period



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 3.5-4.0m, depending on the size of storage, and this range is often fully utilised over short periods. **Figures 5, 6 and 7** show the water level in storage in wet, median and dry periods. The dry period includes a 2 year period from about January 1908 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 metres. There would also be little colonisation over the following four years because water level fluctuations of over 2m 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.

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 noxious 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 is 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 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 FSL to a depth of about 8m. 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.

4.2.2 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. While it is understood that from a water resource planning perspective the base case may be the flow conditions immediately prior to dam construction, from an ecological perspective it is the pre-development case that is most relevant. The Border Rivers WRP uses the 2/3rd natural rule of thumb as its basis. Other than for the end of system flow, as long as flow statistics achieve no worse than one third less, or one third more, than pre-development, they are deemed acceptable. The statistic is based on the premise that maintaining this level of change will support maintenance of a healthy working river (Jones et al 2002).

An outcome of the WRP (Section 9f) is "*to achieve ecological outcomes consistent with maintaining a healthy riverine environment, floodplains and wetlands*". Sub-clauses refer to "*maintaining natural riverine habitats*" and "*maintaining the natural abundance and species richness of native plants and animals*" (underline added).

The flow statistics presented in Figures 3 and 4 and Table 7 show that end of system flow and average summer flow will be decreased by the maximum amount permissible (33%) while the low flow will be increased by about the same amount. Small floods (beneficial flooding flow and 1 in 2 year flood) will be decreased by 49 and 59% respectively, well beyond the target level of change. Median flow will be just 5% of pre-development levels, which is similar to what it is under current conditions. This is a major reduction in flow.

Table 13 Mean of median daily flows (megalitres) at Sundown National Park

	Pre-development	Base Case	With 5000ML dam	With 10,500ML dam
January	149.5	82.6	81.2	72.0
February	239.0	167.0	164.2	160.2
March	107.0	57.4	56.7	56.0
April	88.8	60.5	59.0	58.5
May	57.1	39.5	39.1	36.8
June	120.8	88.0	86.1	82.3
July	145.8	112.1	108.4	106.8
August	95.0	69.3	68.3	66.7
September	85.1	58.6	58.4	57.0
October	104.8	72.6	71.2	69.7
November	100.1	66.7	64.8	63.7
December	104.8	52.9	51.7	49.7

Table 14 Median daily flows (megalitres) at Sundown National Park

	Pre-development	Base Case	With 5000ML dam	With 10,500ML dam
January	42.5	1.3	1.3	1.3
February	39.3	3.2	3.2	3.2
March	40.5	5.0	4.8	4.8
April	17.5	2.0	2.0	2.0
May	6.0	0.2	0.2	0.2
June	5.5	0.7	0.7	0.7
July	39.5	13.6	13.4	13.1
August	41.5	13.5	14.2	14.2
September	18.5	1.1	1.2	1.2
October	16.0	0.4	0.3	0.3
November	5.0	0.1	0.1	0.1
December	20.0	0.4	0.4	0.4

In the pre-development situation, the river at Farnbro would cease to flow for approximately 33% of the time and in both the base case and the Emu Swamp dam case, this extends to approximately 50%. This suggests that flora and fauna that prefer flowing water will be disadvantaged and that smaller pools will dry more often, making weir pools significant refuges.

The flow statistics at Farnbro represent Node J in the Border Rivers WRP and also the inflow to the Sundown National Park. At Sundown National Park the degree of change with the dam in place is small compared to the change that has already taken place but it is incremental upon it. It is unlikely to lead to significant change in the existing habitat.

4.2.3 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. This said though, many of the weirs are very low structures. 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.

Appendix 2 of Moffatt and Voller (2002) notes "migratory" species and uses Mallen-Cooper (1999) as the source. When discussing fish migration and the potential need for fish transfer devices it is important that the term migration is used correctly. That appendix lists species that are known to migrate but the document notes "*however it is likely that all species undertake some form of migration during their lifetime*". This is not correct. All fish will move but not all species will migrate. The Mallen-Cooper reference is to a workshop entitled "*Fish Movement and Migration*", the title itself clearly showing that not all movements can be considered as migrations. Commonly accepted definitions of migration include two key attributes:

- a regular periodicity; and
- a large proportion of the population (Northcote 1997 quoted in Mallen-Cooper, 1999).

As such, dispersal or regular feeding movements are not included in "migration".

Moffatt and Voller make a similar error when, under the heading "migration" it only discusses the ability of a species to use a fishway and such an observation in itself tells us nothing about whether the fish were migrating or not.

Based on Schiller and Harris (in Young 2001) and Allen, Midgely and Allen (2002) none of the native and likely naturally occurring fish species in the upper Severn have a need to undertake significant migrations for reproductive purposes.

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 EIS surveys 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.

That said, it appears reasonable to assume that the existing system has been detrimental to some endemic species and the dam will exacerbate that problem. It is suggested that instead of funding a fish transfer device of probable limited benefit, that Council 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. 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.

4.2.4 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 Ck. In the EIS survey, an individual was recorded in Bald Rock Ck and one in the weir pool at Somme Lane, downstream from the dam site. As Darren Fiedler of the Qld EPA has been monitoring the species over a few years but has not found it in the Severn

River, the capture 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).

4.2.5 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.

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Appendix A EIS survey site descriptions

Site 1, Severn River upstream Glen Aplin

This site was on Thorndale Rd immediately upstream of Council gravel reserve 147. The site consisted of two pools, joined at times of flow by a short section of riffle / run approximately 1-2m wide. A rough vehicle track crossed the river between the pools. Evidence of fossicking was present in the dry and well vegetated river bed between the pools. The downstream pool was bordered by the gravel reserve on the right bank and an orchard on the left. This pool was about 50m in width and length and reached over 3m deep when sampled in November 2006. The gravel reserve was will treed with eucalypt woodland but impacted by a number of vehicle tracks. The riparian zone included melaleuca, *Leptospermum* and some *Callistemon* and *Callitrus*. The left bank was steep and incised with sparse vegetation. The upstream pool was bordered on the right bank by cleared land containing accommodation cottages or horticultural crops. A band of intact riparian zone and woodland about 50m wide fringed the crops. An irrigation pump (2”) serviced the crops. The left bank was a partially cleared flood terrace up to 30m wide. The river was a series of boulder / bedrock pools with a very uneven bottom and at baseflow level varied between 8 and 15m wide. Bars of gravel and coarse sand were common, particularly between the pools and on the left bank.

There were few snags of any size but significant amounts of leaf litter accumulated in patches.

Fringing aquatic plants were diverse and, in patches, abundant, including *Typha domingensis, Eleocharis* sp., *Phragmites australis, Juncus usitatus, Juncus* spp. *Persicaria* sp. (*attenuata*?) and *Ludwidgia peploides*. The only floating macrophyte noted was *Azolla fuliculoides* while *Myriophyllum aquaticus* dominated the submerged environment. Filamentous alga grew strongly on submerged boulders and the stems of aquatic plants.

Site 1 Glen Aplin downstream pool

Site 1 Glen Aplin upstream pool

Site 2, Severn River at Campbell's Weir.
This site is within the inundation area and adjoins a small area of irrigated grapes. The water surface was generally about 30m wide but more like 60m at the weir. The weir is a Besser block construction about 2.5m high and was built atop a bedrock race. It had a slow leak to downstream. The weir pool was nearly 1km long. The banks generally dropped sharply to the water over a distance of about 1.5m. The edge was mainly soil with occasional bedrock and boulder. The left bank was cleared for about 60m near the pump then to within 10-15m for another 50m. It was then natural in both directions consisting of wattles, sparse eucalypts and short tea tree that sometimes reached 5m over the water. The right bank was essentially natural and consisted of a thin band of tea tree over sedges which quickly merged with eucalypt woodland. A few willow and blackberry patches were also present on the left bank. Some undercutting was observed just above the water line.

The water was dark and tannin stained. A large patch of *Typha* lined the right bank near the weir wall; a small patch of *Eleocharis* sat on an island in the centre near the wall, *Ludgwidgia* occurred in several small patches as did *Potomogeton tricarinatus* and *Azolla fuliculoides*. Earlier aerial reconnaissance showed this pool completely covered with *Azolla*. Filamentous algae grew strongly on shallow bedrock. *Myriophyllum*, with stems covered in filamentous algae, was very common in November but not so in April. Large woody debris was common. The site has been stocked and is fished by the local fishing club.

Site 2 Campbell's Weir upstream

Site 3. Severn River below Campbell's Weir

This site is within the inundation area approximately 200m downstream from Campbell's Weir. The river varies from 5 – 8m wide and has a boulder / bedrock base with coarse gravel in patches. Depth rarely exceeded 0.5m. The banks were near vertical for 1-2m and the adjoining landscape was flat to the north (right bank) and gently rising on the left bank. A number of backwaters existed on the left bank and these contained significant amounts of *Typha*. Large sedges and grasses lined the waterway and overhung the banks. The canopy was closed overhead, consisting of tea tree, *Leptospermum*, wattle, eucalypt and belah. Large amounts of fallen timber existed in the riparian zone and some had entered the river.

Small amounts of *Lemna* and *Ludwidgia* were observed and filamentous algal growth was limited.

Site 3 Campbell's shallow

Site 4. Severn River at Stalling Lane
The downstream end of this site was marked by the dam axis geotechnical drilling causeway. The site consisted of a shallow pool about 80m long up to a bedrock race where Stalling Creek entered from the western side. A small weir (<1m maximum height) sat atop the race and below another long shallow pool. In flow, both of the pools would constitute glide habitat. Maximum depth of the sampled pool reached 1.3m but this was very uncommon. Maximum width reached approximately 15m. The channel shape was rectangular, with the sides almost vertical to approximately 2m in height. These banks were covered in maiden hair fern, moss, tree roots and some sedges. Undercutting was common but slight and vegetation overhang of the water was common. The substrate was primarily smooth bedrock or boulders with angular sides, creating an uneven and varied bottom. Coarse sand was common in the main channel with finer sand on the edges. Small branches and leaf litter piles were common and filamentous algae covered much of the shallow rock and wood surfaces.

The left bank was a floodway generally about 25m wide and the right was about 50m wide and bordered by Emu Swamp Road. Physical form and vegetation was similar on both banks and consisted of irregular flood channels which were thickly vegetated with sedges (*Carex*, *Lomandra* and *Gahnia*) under a canopy of tea tree, *Leptospermum*, *Callistemon* and *Acacia*. Eucalypts were sparse and generally set back.

No macrophytes grew in the channel and the river was not flowing during either sampling event. *Alathyria* shells were common in March.

Site 4 Severn River at Stalling Lane

Site 5. Severn River near Somme Lane (Shallow)
This site was at the upstream end of the Site 6 weir pool and immediately below another small (1.5m) weir. It appears that the Site 6 pool would inundate the area when full. The line of *Juncus*, indicating the waterline, was about 1.5m above the water level when sampled. Above the weir pool pump the river was a series of disconnected small pools. The river had a bedrock (angular), boulder and cobble base with some gravel and sand. Fine sediment levels were high and the water was dark. Width of the base channel was about 5m then rose sharply for about 1.5m to, on the left bank, a broad alluvial floodplain with various channels and a backwater pool that contained *Phragmites, Potamogeton tricarinatus*, *Eleocharis* and *Myriophyllum*. *Typha* occurred in patches on the right bank. The left bank vegetation was tea tree over clumps of sedge and had recently been damaged by fire. The right bank vegetation was also dominated by tea tree but with eucalypts a short distance from the water and Juncus making up the bulk of the understorey.

Depth during sampling was generally less than 30cm. An oily scum was observed on the surface on both sampling occasions and in April, after the water level had dropped, the bed was colonised by various terrestrial grasses along with *Persicaria* and *Juncus*.

Filamentous algae grew strongly on the bedrock at this time and tea tree litter patches were at times significant. *Alathyria* shells were common along the edge.

Site 5 Severn River near Somme Lane (shallow)

Site 6. Severn River near Somme Lane (Deep)

This weir pool is about 800m long, has a wall 3.5m high and a capacity of 36ML. Width in November was up to 30m. The substrate was steep sloping bedrock or gravel/coarse sand. The right bank sloped steeply from the water to a thick band of *Typha* covering 90% of the length of the bank. Behind the *Typha* were tea tree and eucalypts with a sedge understorey. The left bank was 40% *Typha*, slightly more *Juncus*, occasional tea trees and eucalypts and some of the latter were dead. The left bank was an alluvial floodplain area that had been partly excavated to increase the storage volume of the weir. There were very few logs in the water and no floating or rooted macrophytes. When sampled in November, the water level was about 0.5m below the *Typha* and 1 -1.5m from the *Juncus*. The water level fell 20cm overnight as a result of pumping. When sampled in April 2007 the water level had dropped about 1.5m so that the site consisted of three separate pools and catfish nests were exposed. A fine black sludge was common under the surface gravel. The exposed substrate had been colonised by *Persicaria* which had seeded. The *Typha* has also seeded and senesced. *Alathyria* shells were common on the rocky edge.

Site 6. Severn River near Somme Lane (Deep)

Site 6. Severn River near Somme Lane (Deep) April 2007

Site 7. Severn River at Second Crossing
This site is downstream of the confluence of Severn River and Accommodation Creek. The site sampled was below a causeway which had two separate box culverts to pass flow. The upstream side of each culvert was largely blocked with branches and leaves but flow still passed, and passed over the causeway. Upstream of the causeway the river was about 20m wide and constituted a cobble run habitat. Flow downstream started as two steep channels of cobble and small boulder below the culverts. Small cascades and rapids separated shallow flowing run habitat. The channels combined approximately 30m downstream of the causeway and the channel was then generally less than 5m wide and 0.5m deep. The substrate was mainly cobble / boulder with coarse sand and gravel. A few strands of *Ludwidgia* were noted and *Juncus usitatus* and *Persicaria* colonised the wetted edges. Very little filamentous alga was present and branch or leaf litter patches were also sparse.

The surrounding vegetation was mainly Belah with an understorey of wattles, leptospermum and callistemon over a ground cover of sedges and grasses. The riparian zone was intact and broad. Downstream areas of the stream were fully covered by overhead vegetation. The riffles were flowing well in November 2006 but not at all in April 2007.

Site 7. Severn River at Second Crossing

Site 7. Severn River at Second Crossing

Site 8. Severn River at Bent's Weir

The upstream end of this weir pool reached to within a few hundred metres of site 7. The weir itself is at least 3m high and backs up over a few kilometres. The channel was generally 30 – 40m wide and spit into three at the upper end though they rejoined a few hundred metres upstream. The right bank was a flat, sedge/grass floodplain with a few eucalypts and belah. Some near the water has drowned. The very edge was a thick row of sedges. The banks were near vertical for about 0.5m on the right bank to more like 1.5m on the left. The left bank riparian zone was then a steep grassy slope with occasional eucalypts and wattles. It had an access track and an informal camping area. Beyond the access track was natural woodland except in the area cleared to provide access. A small patch of *Typha* occurred on the left bank upstream from an irrigation pump but this was the only macrophyte noted on either sampling occasion. The smooth bedrock at the upstream extent of the left bank had a thin cover of filamentous algae.

Large woody debris was common and the water was darkly tannin stained.

Site 8. Severn River at Bent's Weir

Site 9. Accommodation Creek on Sundown Rd

This site is approximately 1km upstream from the gauging station. The stream was braided, covering a total width of approximately 60m, with the main flowing channel being 1 – 2m wide in the riffles and up to 5m wide in the glides. While only one channel was flowing when sampled in November, another two would commence to flow with a slight rise in water level. The substrate was alluvium, mainly sand and cobble with occasional bedrock. The channel sides were steep, often rising 2m from the stream bed. Depth in the glides in November was generally <0.5m but reached 1m in places. In riffles it was often a smear over the rocks and reached 15cm.

Vegetation covered the full width of the braided channel and consisted of Belah with some *Leptospermum* and tea tree over *Gahnia* and grasses with *Juncus* and *Cyperus* near the water's edge. Several dead standing eucalypts were observed. Beyond the channel itself the vegetation on the right bank was cleared for cattle grazing. The left bank was more intact except for the odd paddock and a new fence line that had been cleared for a width of approximately 15m to the top bank of the channel. In stream vegetation was limited to a few *Triglochin* in the glides, a small patch of water cress in a riffle and occasional strands of *Ludwidgia*. The water was clear despite unfettered access by cattle and a graded track through the creek. When sampled in April the site was not flowing and consisted of shallow pools with significantly greater cattle pugging.

Site 9. Accommodation Creek on Sundown Rd

Site 9. Accommodation Creek on Sundown Rd

Site 10. Bald Rock Ck on Anderson Rd.
This site is accessed through the Sirromet property and the upstream end is marked by a causeway that accesses Day’s Rd. This causeway has no culvert or pipe. Day’s Road runs approximately 10m from the right bank for the length of the site. In between the vegetation was mainly wattle and eucalypts with a grassy understorey. The left bank was maintained as a grassy verge with a few mature eucalypts. An unsealed farm road then separated the verge from the grape vines. The grass abutting the water was long and trailed. Giant reed was common on both banks. A few strands of *Ludwidgia* were observed along with small areas of *Persicaria*. The substrate was gravel / coarse sand with occasional bedrock boulders. The site is a weir pool up to 15m wide and several hundred metres long. When sampled, it rarely exceeded 1m in depth. Twigs and leaves were common on the bottom but large wood was rare. By April the water level had dropped such that the width was generally <8m. Local fishers have captured cod in this pool and historically, though not recently, River Blackfish.

Site 10. Bald Rock Ck on Anderson Rd.

Appendix B Field survey methods

Assessments at each site included:

- aquatic habitat
- water quality
- aquatic plants
- macroinvertebrates, and
- fish.

The methodology for each is described below.

Aquatic habitat

Aquatic habitat was assessed using "State of the Rivers" (SOR) survey protocols and field sheets (Anderson 1993), particularly sheets 4, 5, 9 and 10. These were supplemented by detailed notes entered on field data sheets. Photographs were taken of all sites in upstream and downstream directions and to capture significant features.

Water Quality

Spot water quality data were collected at each site using a YSI 611 multiparameter datalogger fitted with sensors to record depth, temperature, pH, dissolved oxygen, conductivity and turbidity. Standard laboratory calibration was undertaken prior to surveys and field calibration was undertaken several times during the surveys. It was not possible to keep the time of sample collection the same. The probe was deployed in the deepest water and spot measurements were made at 0.5 m depth intervals, if possible. In shallow water the probe was walked out to a central position. Care was taken to minimise disturbance to the substrate prior to sampling though some disturbance was unavoidable.

The datalogger was also deployed at selected sites to record overnight water quality. The logger was set to record each parameter at 15-minute intervals. The datalogger was suspended from a log / tree within the river or located along the edge. The sensors sat at approximately 25cm depth. Overnight deployment as opposed to 24hr deployment means that the daytime peaks in temperature or other parameters are generally not recorded while night-time minima are.

Results presented in tables in this report are overnight ranges from logged data unless a time is noted in which case this refers to the time of day at which surface spot data were collected.

Aquatic Plants

Aquatic plants were initially assessed using State of the Rivers methodology, in particular Sheet 9. This assessment covers submerged, floating and emergent vegetation separately and describes each in terms of total cover and percentage of exotic and native species. At many sites, substrates could not be thoroughly assessed due to the highly tannin stained nature of the water. Combined with the latter point, as the region shows a limited submerged macrophyte community, the assessments were reduced to descriptions of visible components. Identifications were based on Stephens and Dowling (2002) and Sainty and Jacobs (1994)

Macroinvertebrates

The sampling approach aimed to clearly separate the available habitats. Five surber samples were collected from the edge at deep sites and from shallow habitat at riffle or glide sites where the edge was often an undercut. AusRivAS dip net sampling methods were not preferred because it is qualitative and unreplicated.

Dip net samples were also collected independently from macrophytes, tree root or undercut habitats when present. When habitat was abundant, dip net sampling was restricted to approximately 20 seconds. When habitat was limited the full area may be sampled in less than 20 seconds. No benthic samples were collected from deep water because the uneven and mainly rocky substrate does not suit any known sampling apparatus.

All samples were wholly preserved in isopropyl alcohol and returned to the laboratory for sorting. Macroinvertebrates were sorted by staff in the EM/Hydrobiology laboratory. The subsampling technique of Wrona *et al* (1982) was employed for larger samples. The fauna from sorted samples was identified and counted by staff of Applied Freshwater Science. Identification was to the level used by DNR in AusRivAS, meaning family for insects except Chironomidae which was taken to sub-family and higher levels for other groups such as micro-crustacea, oligochaetes, molluscs, nematodes and acarina.

Fish

Fish were sampled using equipment and methods to accord with those used in the northern Murray Darling region by David Moffat (DNRW pers. comm. 2000). Additional gear included a back pack electrofisher. Fishing gear included:

- Four 2 m drop x 15 m gill nets, each comprised of 3 x 5 m panels (one each of 3, 4 and 5 inch nylon monofilament mesh randomly arranged within the net), with floating head-line and sinking foot-line.
- Two 19mm and 25mm gill nets were also used in March 2007
- 10 x collapsible baitfish traps each baited with cat biscuits.
- Backpack electrofisher

Fyke and seine nets could not be used because of the substrate was often uneven boulders in shallow areas or the water was too deep in pools.

The method of fishing is described below:

- gear was set over a length of river of approximately 100 m.
- gear was set to fish as independently as possible (that is, one net did not channel fish into another).
- gill nets were generally set oblique to the river bank.
- bait fish traps were set from the bank and adjacent to cover (vegetation, snags etc) when present.

All gear was set to fish overnight, a soak time of between 14 and 18 hrs. All gill nets were set at least 15 m apart, up to a maximum distance of 25 m. The exception to this was in small pools where nets had to be separated by a smaller distance or fewer nets were placed due to restricted space. Small shallow pools (< 0.5m depth) were not sampled with gill nets. These areas were often most effectively sampled with the electrofisher and bait traps.

All fish caught were counted, measured (fork length) and wounds, lesions and deformities were recorded if present. Native fish were released alive wherever possible. Introduced fish were euthenased. Identifications were based on Allen (1989), McDowall (1996) and Allen, Midgely and Allen (2002). Where identification was difficult in the field, one or two specimens were retained for identification in the laboratory.

Any fish, prawns or crayfish caught in the bait traps were identified and the number of each species was recorded. Catches from each trap were recorded separately.

The electrofisher used was a Smith Root LR24 model backpack electrofisher with a net sewn into the anode pole. The voltage, frequency and waveform settings used on the electrofisher were adjusted to achieve the best response from the fish and crustaceans at the time of sampling, but were typically set to standard pulse waveform of 30Hz frequency at 600 volts.

Ten replicate passes were made through the range of habitats over a timed duration (50 sec each).

Fishing was conducted under General Fisheries Permit number 55850.