11. AQUATIC ECOLOGY

A number of submissions regarding aquatic ecology were received on the EIS. These submissions have been grouped into the following themes:

- flora and fauna, including species of conservation significance and surveys for:
  - aquatic habitat
  - aquatic plants
  - Bell's turtles *(Wollumbinia belli)*
  - fish, and
  - platypus.
- potential impacts and risk assessment (including fish passage); and
- monitoring and management.

The issues raised regarding these themes are discussed below.

11.1. Aquatic Flora and Fauna

A number of submissions required further field surveys for the assessment of aquatic flora and fauna. The key issues raised by the submissions regarding flora and fauna were: the need for additional surveys of flora and fauna during a non-drought period; a requirement for surveys of Bell's turtles (*Wollumbinia belli*); a more detailed assessment of aquatic habitat; surveys in the upper reaches of the Severn River; a more detailed assessment of aquatic plants; and further information regarding species of conservation significance.

Additional aquatic flora and fauna surveys were undertaken by frc environmental in May and September 2013. The complete technical reports are provided in Appendix F and Appendix G.

11.1.1. Survey Methodology

Survey Design

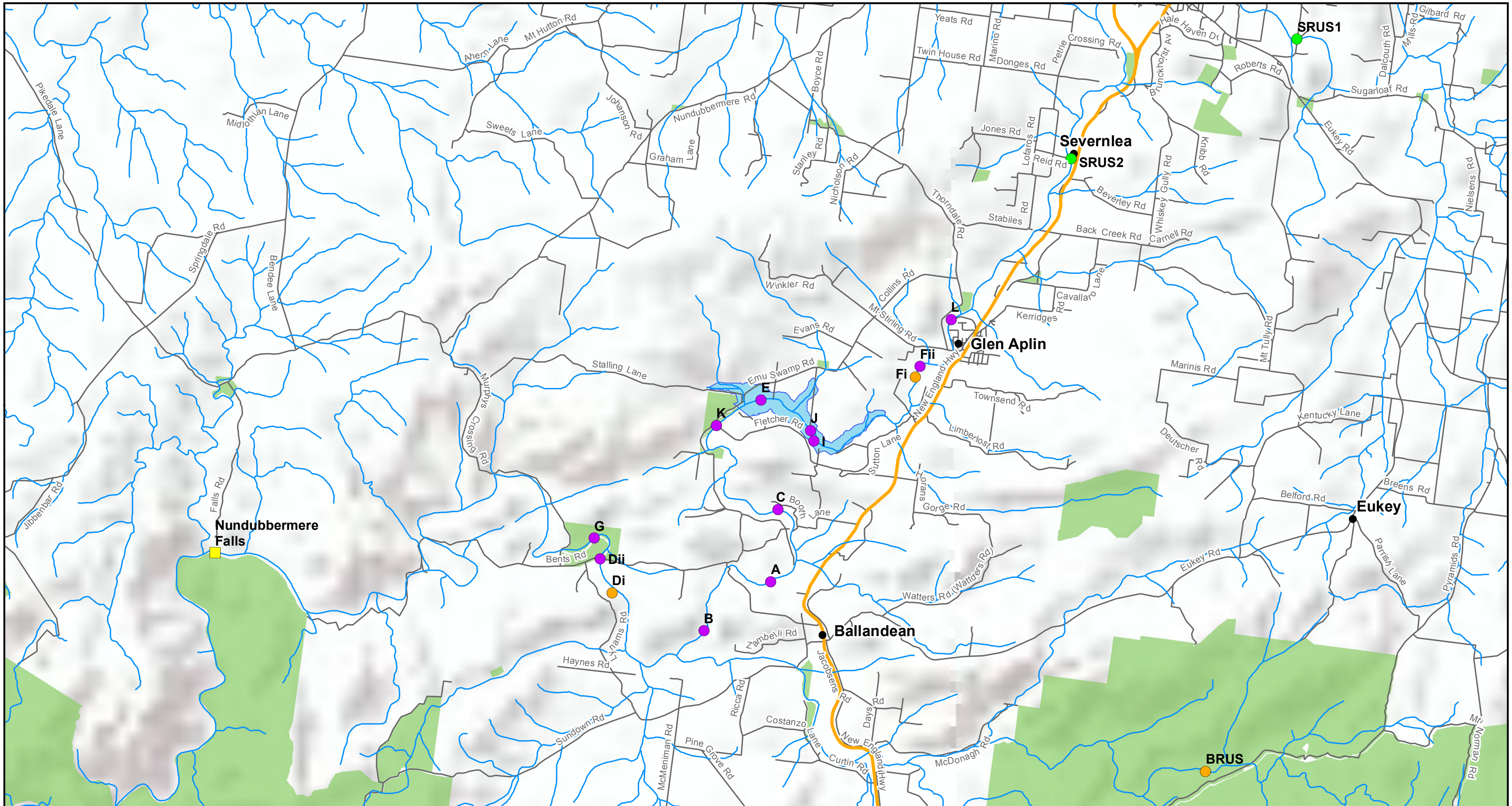
Additional field surveys were completed from 20 to 26 May 2013 and from 9 to 15 September 2013. The May survey comprised an assessment of freshwater turtles and aquatic habitat. The September survey comprised an assessment of aquatic habitat, aquatic plants, freshwater turtles, fish and platypus.

Site Details

A total of 13 sites were surveyed (Table 11.1 and Figure 11.1). Turtles were surveyed at 12 sites; aquatic habitat, aquatic plants, fish and platypus were surveyed at 13 sites. Of the sites surveyed for freshwater turtles, sites F and D were moved slightly between the May and September surveys, as access restrictions prevented a return to the locations surveyed in May. There was no accessible reference site for the turtle survey in May.

Table 11.1 Site location details.

Site	Month Surveyed	Easting	Northing	Description of Location	Surveyed for:
Upstream of the Proposed Dam Inundation area					
SRUS1	September	398403	6827832	Approximately 25 km upstream of the proposed dam site	Aquatic habitat, aquatic plants, fish and platypus
SRUS2	September	393001	6824977	Approximately 14 km upstream of the proposed dam site	Aquatic habitat, aquatic plants, fish and platypus
L	May and September	390118	6821121	Approximately 7 km upstream of the proposed dam site	Aquatic habitat, aquatic plants, turtles, fish and platypus
Fii	September	389376	6820006	Approximately 6.3 km upstream of the proposed dam site	Aquatic habitat, aquatic plants, turtles, fish and platypus
Fi	May	389263	6819746	Approximately 5.9 km upstream of the proposed dam site	Aquatic habitat, turtles
Within Proposed Dam Inundation area					
I	May and September	386835	6818211	Approximately 2.1 km upstream of the proposed dam site	Aquatic habitat, aquatic plants, turtles, fish and platypus
J	May and September	386753	6818469	Approximately 1.8 km upstream of the proposed dam site	Aquatic habitat, aquatic plants, turtles, fish and platypus
E	May and September	385571	6819198	Approximately 0.5 km upstream of the proposed dam site	Aquatic habitat, aquatic plants, turtles, fish and platypus
Downstream of the Proposed Dam					
K	May and September	384494	6818591	Approximately 1.6 km downstream of the proposed dam site	Aquatic habitat, aquatic plants, turtles, fish and platypus
C	May and September	385977	6816579	Approximately 4.7 km downstream of the proposed dam site	Aquatic habitat, aquatic plants, turtles, fish and platypus
A	May and September	385802	6814846	Approximately 7.6 km downstream of the proposed dam site	Aquatic habitat, aquatic plants, turtles, fish and platypus
B	May and September	384199	6813675	Approximately 10.2 km downstream of the proposed dam site	Aquatic habitat, aquatic plants, turtles, fish and platypus
Di	May	381996	6814586	Approximately 14.2 km downstream of the proposed dam site	Aquatic habitat, turtles
Dii	September	381710	6815393	Approximately 15.3 km downstream of the proposed dam site	Aquatic habitat, aquatic plants, turtles, fish and platypus
G	May and September	381568	6815888	Approximately 16.4 km downstream of the proposed dam site	Aquatic habitat, aquatic plants, turtles, fish and platypus
Reference area					
BRUS	September	396211	6810315	Bald Rock Creek in Girraween National Park	Aquatic habitat, turtles



LEGEND

- ● Town Names
- ■ Nundubbermere Falls

Survey Sites

- ● Aquatic habitat, aquatic plants, fish and platypus
- ● Aquatic habitat, aquatic plants, turtles, fish and platypus
- ● Aquatic habitat, freshwater turtles

- Watercourse
- Highway
- Road
- Park, Forests and Reserves
- Full Supply Level (738m AHD)

N
W E
S

0 1 2 3 4
Kilometres
Scale - 1:130,000
Projection: GDA94 MGA56

EMU SWAMP DAM
SUPPLEMENTARY REPORT
Figure 11-1
SEIS Survey Sites

SINCLAIR KNIGHT MERZ
SKM

I:\QENV2\Projects\QE06732\Spatial\ArcGIS\Figures\AQUATIC_ECOLOGY\FIGURE11_1_AquaticEcology_SEISSurveySites.mxd Produced: 1/11/2013

Aquatic Habitat Surveys

The condition of in-stream habitat at each site was assessed based on the Australian River Assessment System (AUSRIVAS) protocol described in the Queensland *AUSRIVAS Sampling and Processing Manual* (DNRM 2001), including the following parameters:

- in situ water quality
- water depth and velocity
- bank erosion
- substrate composition (silt / clay, sand, pebble, cobble and boulder)
- channel diversity (pool, riffle, run etc.), and
- in-stream habitat (in-stream vegetation, large woody debris and substrate characteristics).

The habitat at each site was also assessed for physical barriers to fish passage and the suitability for Bell's turtles and turtle nesting.

Habitat bio-assessment score datasheets (DNRM 2001) were used to produce an overall habitat condition assessment score.

Aquatic Plants Surveys

Aquatic plants were surveyed using methods similar to those outlined in the *River and Riparian Land Management Technical Guideline* (Dixon et al. 2006). Aquatic plants were assessed along two 100 x 10 m belt transects at each site: one transect in the water (in-stream) and one transect on the bank (on bank). Both transects were parallel to the water's edge. At each site, in each transect, aquatic plants were identified and the following recorded:

- species richness
- growth form of each species (submerged, free-floating, attached-floating or emergent)
- total percent cover (% of substrate [bed / bank] covered by each species), and
- whether the plant was native or exotic to Australia.

The *Census of Queensland Flora 2010* (Queensland Herbarium 2010) was used to classify aquatic vegetation as native or exotic.

Turtle Surveys

Turtle surveys were conducted as per the recommendations in the 2011 Survey Guidelines for Australia's Threatened Reptiles for Bell's turtles (DSEWPaC 2011), where site access and timing constraints allow. At each site, five cathedral turtle traps, which allow turtles to surface and breathe, were baited with meat and set at each site for between six and ten hours. In September turtles were also surveyed using a combination of muddling, dip netting, snorkelling and / or spotlighting for 1 hour at each site. In addition, a Fyke net was used at site BRUS in September, the only site with suitable conditions for fyke netting during the surveys. The sampling effort was lower in May than in September due to shorter days and less suitable conditions for turtle activity (i.e. colder water temperature). Detailed information on the sampling effort is provided in the technical report (Appendix G).

All turtles sighted or captured (including species other than Bell's turtle) were identified and counted, and where practical their carapace length, weight and sex were recorded.

Fish Surveys

Fish communities were surveyed using a combination of electrofishing and baited traps, where water levels were suitable. All available habitats (e.g. pool, riffle, run and bend) were fished at each site. Electrofishing was conducted using a Smith-Root LR-24 backpack electrofisher in shallow water in accordance with the Australian Code of Electrofishing Practice 1997. Where there was sufficient water, five small (2 mm mesh size) baited traps were set at each site for a minimum of two hours. Detailed information on the sampling effort is provided in the technical report (Appendix F).

To avoid the re-capture of fish, all caught fish were kept in an aerated nally bin filled with water, on the shore, until the last trap was retrieved. The life-history stage, abundance and apparent health of every fish caught were recorded and fish were returned to the water.

Platypus Surveys

Platypus were surveyed at each site using timed observational surveys at dusk and / or dawn (Appendix F). Surveys were conducted from a canoe, where water depth allowed, or from the bank at shallow sites. Surveys conducted using a canoe were timed for an hour over a distance of up to 1 km. Surveys conducted from the bank were timed for 30 minutes over a distance of up to 500 m. The number of platypus observed and the abundance by size (small, medium, large) were recorded. Brief searches of the banks were undertaken at each site for platypus burrows.

11.1.2. Aquatic Habitat

General Description

Aquatic habitat was similar throughout the Project area; a detailed description of the aquatic habitat at each site, including fish passage and suitability for Bell's turtles is provided in Table 11.2.

The reach environs at most sites had been moderately disturbed by human activities including historical vegetation clearing, cropping and grazing, and private weirs. The width of the riparian zone was generally narrow (1–15 m) with the exception of one site upstream of the proposed dam, and two sites downstream of the proposed dam, where the riparian zone was 20 m or wider. Eucalypt, melaleuca and / or casuarina trees dominated the riparian vegetation at all sites, along with native grasses and shrubs. In general, riparian vegetation was semi-continuous to continuous along the banks, with the exception of one site upstream of the proposed dam and one site downstream of the proposed dam. Riparian vegetation at these sites was scattered or clumped due to historical clearing.

Banks were moderately stable to stable at all sites due to extensive riparian vegetation and substantial areas of bedrock and boulders. Substrate composition was varied at all sites, but typically dominated by bedrock, boulders and sand.

Channel diversity was divided between sites dominated by weir pools and sites with a combination of flow types (e.g. shallow and / or deep, flowing and / or still). Sites in weir pools included:

- site Fii, upstream of the proposed dam inundation area
- site I, within the proposed dam inundation area, and
- sites C, A and G, downstream of the proposed dam site.

The downstream end of site K, downstream of the proposed dam site, was also in the upstream extent of a weir pool.

In-stream habitat at most sites comprised scattered large and small woody debris, and some detritus, overhanging vegetation and trailing bank vegetation. There were in-stream emergent aquatic plants at some sites upstream of the proposed dam, within the proposed dam inundation area, and downstream of the dam site. Submerged aquatic plants were also present in-stream at some sites upstream, within and downstream of the dam, typically in the large pools.

The results of the 2013 habitat assessment are consistent with the EIS surveys and literature review, which found that riparian vegetation, woody debris, in-stream habitat diversity and macrophyte growth were generally good in the vicinity of the Project, but that weir pools had affected the aquatic habitat at a number of locations (SKM 2008; Davies et al. 2012). The Sustainable Rivers Audit (SRA) assessment of hydrology in the Montane Zone of the Border Rivers Valley also indicated altered hydrology; with high over bank floods, flow seasonality, and low and zero flow events differing from the reference condition.

Habitat Condition

Aquatic habitat condition was moderate to good at all of the sites surveyed. With the exception of site G (downstream of the proposed dam site), aquatic habitat condition was generally better at sites within and downstream of the proposed dam than at sites upstream of the proposed inundation area. Compared to sites with high bio-assessment scores, sites with lower habitat bio-assessment scores typically had:

- lower in-stream diversity and available cover
- areas of historically cleared riparian vegetation, and
- more deposition of fine sediments (sand and silt / clay).

These results are consistent with the EIS and State of the Rivers (SOR) assessments.

Fish Passage

The existing weirs, as identified throughout the area in the EIS, restrict fish passage in periods of low and moderate / average flow. That is, fish passage is currently restricted upstream of and within the proposed inundation area, and downstream of the proposed dam site, except in periods of high flow. Passage is less restricted at the weirs at 269.9 km AMTD and 270.6 km AMTD, where there are high flow by-passes that may be used by fish. Nundubbermere Falls, which is approximately 33 km downstream of the proposed dam site and approximately 2.5 m high, also represents a natural impediment to fish passage in the Severn River, particularly during low or moderate / average flow. It would also be difficult for fish to move upstream past these falls in high flow (Figure 11.2).

Figure 11.2 Nundubbermere Falls in high flow

Photo by Michael Jeffries, 2009

Wetlands

The Department of Environment and Heritage Protection (EHP) has an advice agency role for wetlands under the IDAS and schedules of the Sustainable Planning Regulation 2009. These wetlands are identified as Wetland Protection Areas on maps of referable wetlands. There are no Wetland Protection Areas in the vicinity of the Project.

Lacustrine (i.e. lakes) and riverine systems (e.g. river and creek channels) have been mapped in the Project area in EHP's wetland mapping program (Appendix F). No mapped lacustrine wetlands are within the proposed dam inundation area, and those mapped downstream comprise a private weir on the Severn River and three offstream farm dams. No palustrine wetlands (e.g. swamps) are in the vicinity of the Project.

There were no natural off-stream wetlands in the Project area.

Habitat for Bell's Turtles

There was potentially suitable habitat on the Severn River for Bell's turtles at sites Fi and Fii (upstream of the proposed inundation area), I and J (within the proposed inundation area), and K, Di, Dii and G (downstream of the proposed dam site). At these sites there were small, isolated areas of potential nesting habitat, except at site Fi. However, no Bell's turtles were caught during the surveys and no nests or eggs were found on the banks. This is consistent with extensive surveys conducted by Fielder (2010) between 2002 and 2009, where no Bell's turtles were caught in the Severn River above or below Nundubbermere Falls. In contrast, 79 Bell's turtles were recorded in Bald Rock Creek using a similar searching effort (Fielder 2010). The results of turtle surveys are discussed in Section 11.1.4.

There was also habitat suitable for turtle nesting in isolated patches at other sites throughout the Project area. Information provided by local landholders indicated that a number of the sand deposits on the banks moved substantially during floods in early 2011, which indicates that nesting habitats in the area are subject to disturbance from high flow events.

Table 11.2 Detailed description of aquatic habitat at each site.

Site	Description	Photographs
Upstream of the Proposed Dam Inundation area		
Site SRUS1	*General Description* This site comprised a mildly sinuous and braided channel, with an average wetted width of 10 m and an average depth of 1.5 m. The right bank was sloping and low (0.2 m), and the left bank was steep to vertical and low (0.5 m). Both banks were stable. The riparian zone was ~3–5 m wide on each bank, with continuous vegetation dominated by casuarina and eucalypt trees and some shrubs. There was some shading of the river and trailing bank vegetation. In-stream habitat comprised shallow and deep pool, with scattered woody debris, detritus and tree roots. The bed substrate was dominated by sand, with some bedrock, gravel, boulders, cobbles and pebbles. *Fish Passage* There were no barriers to fish passage at this site. *Suitability for Bell's Turtle* This site was not assessed for turtles, but is considered unlikely to support Bell's turtles as there were few boulders.	 View downstream  View downstream of side channel  View upstream  Large woody debris

Site	Description	Photographs
Site SRUS2	*General Description* This site comprised a mildly sinuous channel, with an average wetted width of 10 m and an average depth of 1 m. The left bank was sloping and low (0.5 m), and the right bank was steep and concave (0.8 m). Both banks were moderately stable. The riparian zone was ~1 m wide on each bank, with vegetation dominated by trees and grasses with some shrubs. Riparian vegetation was regularly spaced or in occasional clumps. There was little overhanging vegetation shading the river. In-stream habitat comprised shallow pool, with large woody debris, some detritus and isolated trailing bank vegetation. The bed substrate was dominated by cobbles and sand, with some pebbles and silt / clay. *Fish Passage* There were no barriers to fish passage at this site. *Suitability for Bell's Turtle* This site was not assessed for turtles, but is considered unlikely to support Bell's turtles as there were few boulders.	 View upstream  View of downstream left bank  View downstream  Tree roots overhanging into water

Site	Description	Photographs
Site L	*General Description* This site comprised a mildly sinuous channel, with an average wetted width of 10 m and an average depth of 0.4 m. The banks were sloping and low (0.5 m), and stable. The riparian zone was ~20 m wide on each bank, with vegetation dominated by melaleuca and eucalypt trees and grasses with some shrubs. In-stream habitat comprised shallow pool and runs, with isolated woody debris, some detritus and beds of emergent aquatic plants. The bed substrate was dominated by bedrock and sand, with some gravel, boulders and pebbles. *Fish Passage* Fish passage may be restricted at this site during periods of low flow due to sand deposits and bedrock constricting flow in some areas. *Suitability for Bell's Turtle* This site was unlikely to be suitable for Bell's turtles as there were no undercut banks, little large woody debris and few boulders. No areas of potential nesting habitat were observed.	 View upstream  View of upstream right bank.  View downstream  Extensive reeds in shallow water

Site	Description	Photographs
Site Fi	*General Description* This site comprised a weir pool with an average width of 12 m and an average depth of 1 m. The banks were steep and low (0.5 m), and moderately stable. The riparian zone was ~10 m on each bank, with vegetation dominated by melaleuca, callistemon and eucalypt trees, as well as shrubs and grasses. In--stream habitat included shallow and deep pools, scattered large woody debris, undercut banks, isolated emergent plants and some detritus. The bed substrate was dominated by sand and silt / clay, with some bedrock, boulders, cobbles and pebbles. *Fish Passage* A private weir at the downstream end of the reach would restrict fish passage except in high flow. *Suitability for Bell's Turtle* This site is potentially suitable for Bell's turtles, but unlikely to support a stable population due to the downstream weir and anthropogenic disturbance upstream towards site L. No areas of potential nesting habitat were observed.	 View upstream from weir  Heavily vegetated bank  Weir  Overhanging vegetation and woody debris

Site	Description	Photographs
Site Fii	*General Description* This site comprised a mildly sinuous channel, with an average wetted width of 6 m and a bank full width of ~25 m. The average depth was 1 m. The banks were sloping and low (0.5 m), and moderately stable. There was some minor bank erosion. The riparian zone was ~10 m wide on each bank, with vegetation dominated by shrubs and melaleuca and eucalypt trees. In-stream habitat comprised a shallow pool, with scattered woody debris, emergent plants, and detritus. The bed substrate was dominated by sand, with some bedrock, boulders, cobble and pebbles. *Fish Passage* Fish passage was unrestricted within the reach surveyed, but a private weir upstream of the reach would restrict passage except in high flow. *Suitability for Bell's Turtle* Habitat at this site is potentially suitable for Bell's turtles but unlikely to support a stable population due to a lack of boulders and undercut banks and the absence of deep pools. There were isolated areas of sandy banks suitable for turtle nesting.	 View upstream  Sandy bank suitable for nesting  View downstream  Extensive woody debris

Site	Description	Photographs
Within the Proposed Dam Inundation area		
Site I	*General Description* This site comprised a weir pool with an average width of 20 m and an average depth of approximately 2 m. The banks were sloping on the left bank and steep on the right bank vertical, with an average height of 0.5 to 0.8 m. Both banks were stable. The riparian zone was ~5 m on each bank, with vegetation dominated by eucalypt trees, shrubs and grass. In-stream habitat included large woody debris, overhanging vegetation, boulders, and isolated areas of submerged and emergent aquatic plants. The bed substrate was dominated by bedrock and boulders, with some sand and silt / clay. *Fish Passage* Fish passage within the reach surveyed was unrestricted, however there was a weir at the downstream end of the site that would restrict fish passage except during high flow events. *Suitability for Bell's Turtle* Habitat at the upstream end of this site is potentially suitable for Bell's turtles. There were small isolated areas of suitable nesting habitat.	 View upstream  Sandy bank suitable for nesting  View downstream  Extensive *Typha orientalis* in channel

Site	Description	Photographs
Site J	*General Description* This site comprised a mildly sinuous channel with an average width of 5 m and an average depth of 1 m. The average bank full width was 20 m. The banks were sloping, low (0.5 m), and stable. The riparian zone was ~10 m wide on each bank. Melaleuca trees dominated riparian vegetation, with some shrubs and grasses. In-stream habitat included shallow and deep pools and shallow runs, with extensive woody debris, detritus, undercut banks and overhanging vegetation. The bed substrate was varied, with some bedrock, boulder, cobble, sand and silt / clay. *Fish Passage* An upstream private weir restricted fish passage at this site. In low to moderate flow fish would not be able to pass the weir. Fish passage would be possible during high flow events. *Suitability for Bell's Turtle* The habitat at this site is potentially suitable for Bell's turtles, and there were small isolated areas of potentially suitable nesting habitat.	 View downstream  View upstream in side channel  View upstream  Scoured bank and woody debris

Site	Description	Photographs
Site E	*General Description* Site comprised an irregular channel, with an average width of 3 m and a maximum width of 10 m. A man made rock wall formed a pool in the middle of the site. The banks were sloping and low (0.5m). The banks were moderately stable. The riparian zone was ~5m wide on each bank. Melaleuca and eucalypt trees and shrubs dominated the riparian vegetation, with some grasses also abundant. In-stream habitat comprised shallow pools, runs and riffles, with sand bars. There was some detritus and little woody debris. There were isolated patches of emergent aquatic plants in-stream. The bed substrate was dominated by sand, with some bedrock and boulder. Overall disturbance was low. *Fish Passage* A man-made rock wall at this site would restrict fish passage for all fish during periods of low flow, and for large fish in periods of moderate / average flow. There would be no restrictions to fish passage during periods of high flow. *Suitability for Bell's Turtle* This site is unlikely to support a stable population of Bell's turtle due to the shallow water, which may dry during periods of low to no rain. There were small areas of sandy bank suitable for turtle nesting.	 View downstream  View downstream from upper end of reach  Small riffle at downstream end of reach  Man-made rock wall at site

Site	Description	Photographs
Downstream of the Proposed Dam		
Site K	*General Description* This site comprised an irregular channel with an average width of 15 m and an average depth of 1 m. There was a road crossing through the middle of this site and a weir at the downstream end. The banks were sloping to vertical, and low (0.5 m). Banks were undercut, but stable. The riparian zone was ~30 m wide on the left bank and ~20 m wide on the right bank. Melaleuca and eucalypt trees dominated riparian vegetation, with some shrubs and grasses. In-stream habitat included shallow and deep pools, runs and riffles, with some woody debris, detritus, undercut banks and overhanging vegetation. The bed substrate was dominated by bedrock and sand, with some boulders, cobble, pebble, gravel and silt / clay. *Fish Passage* During periods of low flow fish passage at this site would be restricted by the culvert at the road crossing and bars in the channel. A private weir also restricts fish passage at the downstream end of this site in low to moderate / average flow. *Suitability for Bell's Turtle* The habitat in the downstream end of this site is potentially suitable for Bell's turtles, and there were small isolated areas of potentially suitable nesting habitat. The upstream area is unlikely to support Bell's turtles.	 View downstream in September  Culvert in middle of site  View upstream in May  View upstream in September

Site	Description	Photographs
Site C	*General Description* This site comprised a large weir pool with an average width of 25 m and an average depth of more than 2 m. The banks were gently sloping, low (0.5 m high), and stable. The riparian zone was ~20 m on each bank, with vegetation dominated by eucalypt and callistemon trees, with shrubs and grasses. In-stream habitat consisted of a deep pool with isolated woody debris, scattered detritus and beds of submerged plants. Reeds lined the banks in many areas. The bed substrate was dominated by bedrock and boulders, with some gravel, sand and silt / clay. *Fish Passage* Fish passage was unrestricted through the reach surveyed, but limited by a weir at the downstream end of the site. Fish passage is only possible at this site in high flow. *Suitability for Bell's Turtle* Habitat at this site is unlikely to support a stable population of Bell's turtles. There was little large woody debris, trailing bank or overhanging vegetation, no undercut banks, and no flow. Suitable food sources (i.e. aquatic plants) were present. No areas of potential nesting habitat were observed.	 View downstream  Weir at downstream end of reach  View upstream  Downstream of weir

Site	Description	Photographs
Site A	*General Description* This site comprised a weir pool with an average width of 43 m, and a bank full width of approximately 70 m. The average depth was approximately 1 m. The banks were gently sloping, low (<1 m), and stable. The riparian zone was ~5 m on the left bank and ~10 m on the right bank. Grasses and discontinuous eucalypts and melaleucas dominated the riparian vegetation. There were areas of cleared on both banks for grazing and cropping. In-stream habitat consisted of a pool with no visible flow, large beds of ribbonweed and scattered woody debris. The bottom substrate was dominated by bedrock, gravel and silt / clay, with some boulder, sand, cobbles and pebbles. *Fish Passage* Fish passage at this site was restricted by a weir at the downstream end of the reach surveyed. Passage would only be possible past this weir in periods of high flow. *Suitability for Bell's Turtle* This site is unlikely to support Bell's turtles, unless in transit. There was little large woody debris or overhanging vegetation, few undercut banks or boulders, and no flow. Suitable food sources (e.g. ribbonweed) were present. No areas of potential nesting habitat were observed.	 View upstream  Weir at downstream end of reach  View downstream  Extensive reeds and grasses along bank

Site	Description	Photographs
Site B	*General Description* This site comprised a wide irregular channel, with an average wetted width of 30 m (minimum 3 m and maximum 57 m). The average depth was approximately 1.2 m. The banks were low (0.5 m) and gently sloping to steep. The banks were stable, with no undercut areas. The riparian zone was ~15 m wide on each bank. Melaleuca, eucalypt and callistemon trees dominated the riparian vegetation, with some shrubs and grasses. In-stream habitat included shallow and deep pools with areas of shallow runs and cascades. There was abundant detritus, some algal growth, isolated woody debris and no submerged vegetation. The bed substrate was dominated by bedrock and boulders, with some finer sediments. *Fish Passage* Upstream fish movement at this site may be restricted for some fish due to a bedrock shelf with a drop of approximately 0.8 m. Extensive bedrock through the site would restrict fish movement upstream and downstream during periods of low flow. *Suitability for Bell's Turtle* Habitat at this site is potentially suitable for Bell's turtles, but large woody debris was limited and there were no overhanging banks. Overhanging and trailing bank vegetation was limited. There were some isolated areas of sand on the banks, suitable for nesting.	 View downstream  Bedrock shelf restricting flow  View upstream  Isolated area of sand on the bank

Site	Description	Photographs
Site Di	*General Description* This site comprised a large weir pool with an average width of 35 m and an average depth greater than 2 m. The banks were sloping and low (0.5 m), except in areas where exposed bedrock comprised the bank. Bank stability was high. The riparian zone was ~10 m on each bank. Eucalypt, melaleuca and casuarina trees dominated the riparian vegetation, with some shrubs and grasses. There were small areas of cleared vegetation on each bank. In-stream habitat deep and shallow pools and cascades. There were isolated areas of floating and submerged aquatic plants, scattered woody debris and some detritus. The bed substrate varied, with bedrock, boulders, cobble, gravel and sand all present. *Fish Passage* Fish passage at this site was restricted by a weir at the downstream end of the reach surveyed. Passage upstream would only be possible past this weir in periods of high flow. *Suitability for Bell's Turtle* Habitat at the upstream end of this site, above the cascade is potentially suitable for Bell's turtles, but the weir pool is less suitable. There were a few small, isolated areas of sand on the banks, suitable for nesting.	 View upstream  Woody debris  View downstream  Typical bank

Site	Description	Photographs
Site Dii	*General Description* Site comprised an irregular channel, with an average wetted width of 4 m and a bank full width of 15 m. The average water depth was 0.5 m. The banks were gently sloping to vertical and low (0.5 m). The banks were moderately stable. The riparian zone was ~5 m on the left bank and ~10 m on the right bank. Melaleuca and casuarina trees and shrubs dominated the riparian vegetation. In-stream habitat comprised shallow and deep pools, with runs and undercut banks. There was scattered large and small woody debris, and no in-stream aquatic vegetation. The bed substrate was dominated by boulders, cobble and pebble, with some bedrock, gravel, sand and silt / clay. A road crossing with a culvert was in the centre of this site. *Fish Passage* During periods of low flow fish passage at this site would be restricted by the road culvert and gravel bars. There is also a private weir approximately 700 m upstream of the reach surveyed that restricts fish passage in low to moderate / average flow. *Suitability for Bell's Turtle* Upstream of the road crossing is suitable for Bell's turtles, but downstream is shallow and likely to dry out in periods of low or no rain. No areas of potential nesting habitat were observed.	 View upstream  Tree roots on bank  View downstream  Culvert at site

Site	Description	Photographs
Site G	*General Description* This site comprised a weir pool with an average width of 18 m and an average depth of more than 2 m. The banks were sloping to steep and an average height of 1 m. Both banks were stable. The riparian zone was approximately 3 m on the left bank and 10 m on the right bank. Eucalypt and casuarina trees and shrubs dominated the riparian vegetation, with some grasses. In-stream habitat was a deep pool with some woody debris and detritus. There were no in-stream aquatic plants. The bed substrate was dominated by bedrock, with some boulders, cobble, sand and silt / clay. *Fish Passage* Fish passage at this site was restricted by a private weir. Fish movement past the weir would only be possible during periods of high flow. *Suitability for Bell's Turtle* Habitat at this site is potentially suitable for Bell's turtles, but large woody debris was limited and there were no overhanging banks. There were shallow flowing areas less than 1 km upstream. There were some isolated areas of sand on the banks, suitable for nesting.	 View downstream  Weir at downstream end of reach  View upstream  Sandy bank suitable for nesting

Site	Description	Photographs
Reference Area		
Site BRUS1	*General Description* Site comprised a mildly sinuous channel, with an average width of 10 m and an average depth of 1.5 m. The channel was wide in the lower end of the reach and narrow at the upstream end. The banks were sloping to steep and low (0.3 to 0.5 m). Bank stability was high. The riparian zone was ~5 m wide on each bank. Eucalypt and casuarina trees dominated the riparian vegetation, with some shrubs. This site was in a national park, so riparian vegetation was largely undisturbed. In-stream habitat comprised deep pools with lots of large woody debris, large boulders, trailing bank vegetation and submerged aquatic plants (i.e. red milfoil). The bed substrate was dominated by sand, bedrock and boulders, with some cobbles. *Fish Passage* This site was not assessed for fish, but there were no restrictions to fish passage. Fish passage downstream may be limited by Anderson's Weir (approximately 5 km downstream of the site). *Suitability for Bell's Turtle* This site supports Bell's turtles.	 View downstream  Typical bank habitat  View upstream  Woody debris where turtle was basking

11.1.3. Aquatic Plants

Species of Conservation Significance

No rare or threatened aquatic plant species under the EPBC Act or NCWR are known to occur in the vicinity of the Project or were recorded during the 2013 or EIS surveys.

Salvinia (*Salvinia molesta*), a Class 2 declared pest plants under Queensland's *Land Protection (Pest and Stock Management) Act 2002*, may occur in the Project area; however it was not recorded during the 2013 or EIS surveys.

Survey Results

A total of 13 species of aquatic plants were recorded in the survey area (Table 11.3 and Table 11.4). Nine species were recorded on the bank and nine species were recorded in-stream. Aquatic plants were recorded on the bank at all sites surveyed, and in-stream at all but two sites (SRUS2, upstream of the proposed dam inundation area, and Dii, downstream of the proposed dam site).

Aquatic plants with an emergent growth form were the most abundant (i.e. had the highest cover) and most widespread (i.e. recorded at more sites). Common taxa included:

- common reed
- common rush, and
- broad leaved cumbungi.

There was one floating species, red azolla, at one site downstream of the dam, and two submerged species:

- ribbonweed, at sites upstream of the dam inundation area and sites downstream of the dam, and
- water milfoil, at one site upstream of the dam inundation area.

Fewer aquatic plants were observed during the 2013 survey than the EIS surveys. With the exception of nardoo, all aquatic plants observed in 2013 were present during the EIS surveys. The results of the 2013 and EIS surveys are consistent with the SOR assessment. During the SOR surveys only submerged and emergent aquatic plants were found in the Severn River catchment, and the percent cover of aquatic plants was typically low (Johnson, 2004).

Table 11.3 Percent cover of aquatic plants in-stream.

Species Name	Common Name	Growth Form	Upstream of the Proposed Dam FSL				Within the Proposed Dam FSL			Downstream of the Proposed Dam					
			SRUS1	SRUS2	L	Fii	I	J	E	K	C	A	B	Dii	G
Azolla filiculoides	red azolla	F	–	–	–	–	–	–	–	–	0.1	–	–	–	–
Juncus usitatus	common rush	E	0.1	–	1.6	–	0.2	0.1	–	–	–	–	–	–	–
Ludwigia peploides	water primrose	E	–	–	–	–	–	–	–	–	–	–	0.3	–	–
Myriophyllum aquaticum	water milfoil	S	–	–	0.2	–	–	–	–	–	–	–	–	–	–
Persicaria hydropiper	water pepper	E	–	–	–	–	–	–	–	–	–	–	–	–	0.1
Persicaria sp.	smartweed	E	–	–	–	–	–	–	–	–	–	–	0.2	–	–
Phragmites australis	common reed	E	0.5	–	9	0.1	–	–	0.2	0.8	–	1	0.1	–	–
Typha orientalis	broad-leaved cumbungi	E	–	–	1.5	–	1.5	–	–	–	4.1	1	0.3	–	–
Vallisneria nana	ribbonweed	S	–	–	0.9	–	–	–	–	–	0.2	0.8	0.1	–	0.5
		Total Cover	0.6	–	13.2	0.1	1.7	0.1	0.2	0.8	4.4	2.8	1	–	0.6

Table 11.4 Percent cover of aquatic plants on the bank.

Species Name	Common Name	Growth Form	Upstream of the Proposed Dam FSL				Within the Proposed Dam FSL			Downstream of the Proposed Dam					
			SRUS1	SRUS2	L	Fii	I	J	E	K	C	A	B	Dii	G
Cyperus difformis	rice flat-sedge	E	–	–	0.2	–	–	–	–	0.6	–	–	–	–	0.3
Cyperus eragrostis	drain flat-sedge	E	0.3	0.1	–	–	–	0	–	–	–	–	0	–	–
Juncus usitatus	common rush	E	6.1	3.6	7.3	8.2	0.9	6.1	6.6	4.2	1.1	1.3	1	1.7	3.1
Ludwigia peploides	water primrose	E	–	–	–	–	–	–	–	–	–	–	0.4	0.2	–
Marsilea drummondii	nardoo	E	–	–	–	–	–	–	0.1	–	–	–	–	–	–
Persicaria hydropiper	water pepper	E	–	–	–	–	–	0.9	–	–	–	–	–	0.8	0.1
Phragmites australis	common reed	E	0.6	3.8	–	5.2	–	–	0.5	–	–	3.6	–	–	–
Rumex crispus	curled dock	E	–	1	0.9	1.4	1.1	1.3	1.2	–	–	0.8	–	1	0.9
Typha orientalis	broad-leaved cumbungi	E	–	–	0.5	–	–	–	–	–	2.1	0.2	–	–	–
		Total Cover	7	8.5	8.9	14.8	2	8.3	8.4	4.8	3.2	5.9	1.4	3.7	4.4

11.1.4. Turtles

Conservation Significance and Ecology of *Wollumbinia belli* (Bell's turtle)

The known populations of Bell's turtle (*W. belli*) are found in the Namoi and Gwydir Rivers in northern NSW and in Bald Rock Creek in southern Queensland, in the headwaters of the Darling River system. The EIS also reported one Bell's turtle in the Severn River near Somme Lane and one in Bald Rock Creek downstream of Anderson's weir, both of which were outside the previously known distribution of this species (Figure 11.3). The Bell's turtle population in Bald Rock Creek in Queensland was thought to potentially be a distinct species due to some morphological differences with the populations in NSW. Genetic analyses completed by Fielder (2010) did not support this theory and concluded that the separate populations are the same species.

The Bell's turtle is listed as 'vulnerable' under the EPBC Act. It is listed as 'least concern' under the NCWR and is currently listed as 'not yet assessed' for the International *IUCN Red List of Threatened Species* 2013 (IUCN 2013). However, in 2010 it was included on the IUCN Red List (Fielder 2010).

Bell's turtles only occur in riverine habitats at a minimum elevation of 700 m above sea level. They prefer permanent, cold flowing streams that are well oxygenated. The known populations of Bell's turtles are in areas where granite boulders and bedrock are common, with coarse sand deposits in slower flowing areas. The in-stream habitat is complex, with underwater caverns formed by boulders, large woody debris and overhanging banks, as well as fine silt, algal growth and / or aquatic plants. The waterways are typically 30 to 40 m wide in NSW and 10 to 20 m wide in Queensland. Permanent water is required for the Bell's turtle to persist at a local scale (Fielder 2010).

The known Bell's turtle population in Queensland is small (estimated less than 400 individuals) and occurs primarily within an 8 to 10 km reach of Bald Rock Creek. Most individuals occur in permanent pools at either end of this reach, within areas approximately 1.4 km long. There has been substantial habitat modification in the lower reaches of Bald Rock Creek. Fielder (2010) surveyed a variety of habitats, such as off-stream wetlands and private in-stream impoundments, at multiple locations in the Border Rivers catchment, including above and below Nundubbermere Falls on the Severn River, but did not catch any Bell's turtles in the Severn River.

Bell's turtles are medium-sized turtles with delayed age at first breeding, low reproductive effort (14.3 eggs per adult female) and a predicted lifespan of over 40 years. They nest between September and January, with annual breeding rates varying between years. Bell's turtles have similar diving behaviour to the Fitzroy River turtle (*Rheodytes leukops*), with extended aerobic dives of up to 15.5 days during winter hibernation. Diving patterns in spring and autumn are characterised by longer resting dives at night and shorter dives during the day, with the turtles more active during daylight hours than at night at these times. This pattern is reversed in summer with longer and deeper dives during the day than at night, with the turtles more active at night in summer compared to other seasons. There is not a lot of information on the range of distance travelled by Bell's turtles, but Fielder (2010) observed one turtle that travelled approximately 8 km within 12 months over flowing granite bed rock and granite cascades to reach the upstream large permanent waterhole.

Basking behaviour has been noted in spring and, to a lesser degree, in autumn, with turtles observed out of the water on boulders. There is evidence that Bell's turtles hibernate at submerged depth (>3 m) during winter, with extended periods of inactivity when water temperatures are lowest (range 5 – 8°C) (Fielder 2010).

Bell's turtles have a varied diet consisting of aquatic plants (semi-emergent and submerged), filamentous green algae, freshwater sponges, terrestrial fruits that overhang the stream or floating in the water (including exotic blackberries), aquatic insects, crayfish, carrion such as terrestrial insects in the water and sometimes large amounts of sediment and terrestrial leaves.

In-stream changes associated with impoundments and agricultural development have extensively modified Bell's turtle habitat across its known range. The main impacts are changes in-stream conditions from flowing to still water and loss of riparian vegetation, which reduces food resources and suitable habitat for the turtle. There are high numbers of exotic goldfish in Bald Rock Creek that also have an impact through habitat modification and predation of juvenile turtles. On-going threatening processes for Bell's turtles include:

- loss of riparian vegetation through grazing and clearing for agricultural development
- loss of in-stream habitat from water infrastructure (impoundments), through reduced flow, changed water depths and decreased oxygen
- predation from exotic fish or stocked native fish predators such as the Murray cod, and
- predation of nests by foxes and other animals.

Turtles in the Project Area

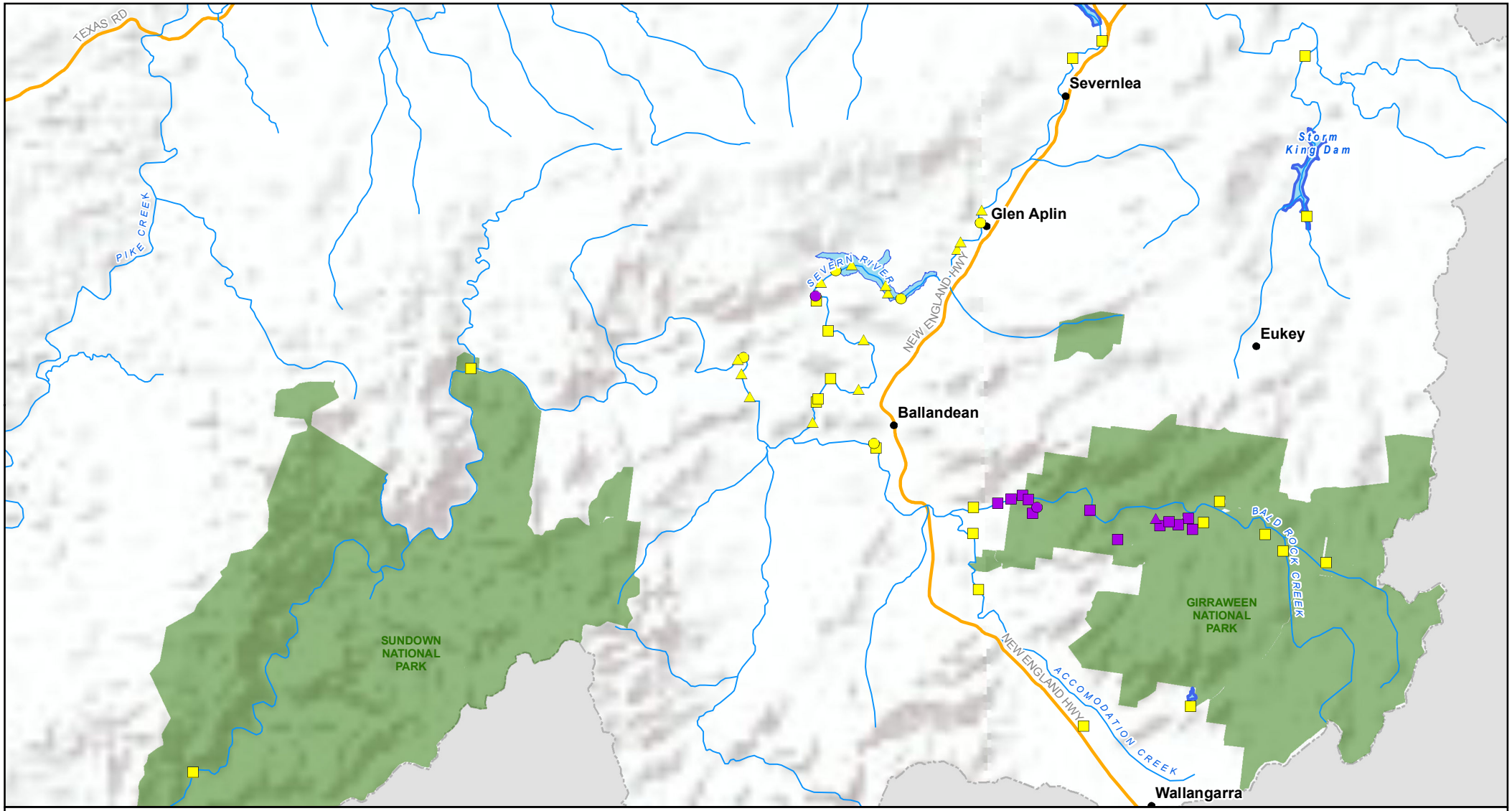
No turtles of any species were caught during the May survey.

During the September survey, a total of 26 turtles were caught. One Bell's turtle (*W. belli*) was caught at reference site BRUS, in Bald Rock Creek within the Girraween National Park (Figure 9.3). No Bell's turtles were caught in the Severn River within or downstream of the Project area. The Bell's turtle in Girraween National Park was caught in a fyke net that was set overnight as part of an extended effort to determine if Bell's turtles were active during the survey. No Bell's turtles were caught using the standard survey effort.

The Bell's turtle caught was an adult male that weighed 2.4 kg and had a shell length of 22 cm.

Eighteen eastern long-necked turtles (*Chelodina longicollis*) were caught at sites upstream, within and downstream of the proposed dam, as well as at the reference site in Girraween National Park. Seven Murray River turtles (*Emydura macquarii*) were caught at sites upstream and downstream of the proposed dam. Eastern long-necked and Murray River turtles are common turtle species that are not listed as thretened under federal or state legislation.

The Bell's turtle has not been recorded in or upstream of the proposed inundation area, and there is only one record of it in the Severn River downstream of the proposed dam site (from the EIS), despite extensive searching. In contrast, 79 Bell's turtles were recorded in Bald Rock Creek using a similar searching effort (Fielder 2010).



LEGEND

- Town Names

Fielder Surveys 2002-2009
- Present
- Not caught

Project EIS Surveys 2006-2007
- Present
- Not caught

Project SEIS Surveys 2013
- Present
- Not caught
- Watercourse
- Highway
- Full Supply Level (738m AHD)
- National Parks
- New South Wales

N
W E
S

0 1.5 3 4.5 6
Kilometres

Scale - 1:190,000

Projection: GDA94 MGA56

EMU SWAMP DAM SUPPLEMENTARY REPORT

Figure 16-2

Survey sites and records of Bell's turtle in Queensland

SINCLAIR KNIGHT MERZ
SKM

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11.1.5. Fish

Species of Conservation Significance

One threatened fish species under the EPBC Act occurs in the vicinity of the Project: the Murray cod (*M. peelii*). The Murray cod was discussed in the EIS, however information regarding its ecology has also been provided in Appendix F. The Murray cod is endemic to the Murray-Darling River System and native to the Severn River at least to Nundubbermere Falls; early settlers may have introduced this species above Nundubbermere Falls.

Survey Results

A total of five species of fish were caught in the survey: three native species and two exotic species (Table 11.5). No species listed under the EPBC Act or NCWR were caught. Carp gudgeons were the most widespread and abundant fish species during the survey. Mosquitofish, which are a noxious pest, were also abundant.

Fish species richness was low at all sites. A maximum of three species was caught, at a site within the proposed dam inundation area, however only two of these species were native. Only one fish species, carp gudgeon, was caught at site SRUS1 (upstream of the proposed dam inundation area), and at sites C, A, B and Dii (downstream of the proposed dam site). Of the sites where two fish species were caught, only sites F (upstream of the proposed dam inundation area), I (within the proposed dam inundation area), and G (downstream of the proposed dam) had no exotic species.

Fish communities were dominated by adult and intermediate life stages at all sites. Only juvenile carp gudgeons were caught. Due to the fast growth rates (i.e. maturation periods within 12 months) of most of species caught, this is the expected distribution of life history stages. That is, most species breed in autumn and summer, so in September most juveniles have developed to later life-history stages. However, the 2008 SRA survey found that recruitment of native species was considered very low in the Montane zone of the Border Rivers Valley (Davies et. al. 2012).

The results of the 2013 survey are consistent with the EIS (Table 11.6). Five fish species were caught in 2013 compared to six fish species during the EIS. Of these species, goldfish were caught in 2013 but not during the EIS, and Murray cod and silver perch were caught during the EIS, but not in 2013. Carp gudgeons were the most abundant and widespread species in both surveys. Mosquitofish were also abundant and widespread during the EIS, but were less so in 2013. Water levels were lower during the EIS surveys, which may have resulted in increased fish abundance in restricted areas, compared to 2013 when more water likely increased connectivity and fish dispersal.

Fish populations assessed in the Montane zone of the Border Rivers Valley for the SRA were classified as being in poor to very poor condition (Davies et. al. 2012). Seven native species and three exotic species were caught during this survey, however only two of seven sites in the Montane zone were within the vicinity of the Severn River. The species caught are shown in Table 11.6.

Each of the native fish species in the survey area requires some physical in-stream habitat for shelter or for reproduction. A variety of physical aquatic habitat (e.g. woody debris and substrate diversity) also supports diverse macroinvertebrate communities, which are prey to many of the fish in the survey area. Most of the species caught can tolerate a broad range of water quality conditions. Most of the native fish species caught in the Project area, or that potentially occur in the Project area, including the southern purple-spotted gudgeon,

exhibit some migratory behaviour. A detailed description of the ecology of each fish species caught in 2013 is provided in Appendix F.

11.1.6. Platypus

A total of three platypus were observed during the survey: one upstream of the proposed dam inundation area and two downstream of the proposed dam site. Two of these platypus were medium to large in size; it was not possible to assess the size of the third platypus observed. No active or inactive platypus burrows were observed on the banks.

Table 11.5 Fish species caught in the survey.

Species	Common Name	Native / Exotic	Upstream of the Proposed Dam FSL				Within the Proposed Dam FSL			Downstream of the Proposed Dam					
			SRUS1	SRUS2	L	Fii	I	J	E	K	C	A	B	Dii	G
Carassius auratus	goldfish	exotic	–	1	–	–	–	–	–	–	–	–	–	–	–
Gambusia holbrooki	mosquitofish	exotic	–	–	4	–	–	35	11	1	–	–	–	–	–
Hypseleotris sp.	carp gudgeon	native	4	15	38	17	41	22	12	11	6	30	7	62	4
Macquaria ambigua	yellow belly	native	–	–	–	–	1	–	–	–	–	–	–	–	1
Tandanus tandanus	freshwater catfish	native	–	–	–	1	–	–	2	–	–	–	–	–	–
	Total Species Richness		1	2	2	2	2	2	3	2	1	1	1	1	2
	Total Abundance		4	16	42	18	42	57	25	12	6	30	7	62	5

Table 11.6 Fish species caught in the Sustainable Rivers Audit, EIS and supplementary EIS surveys.

Species	Common Name	Native / Exotic	Sustainable Rivers Audit 2008	EIS 2006 - 2007	Supplementary EIS 2013
Carassius auratus	goldfish	exotic	✔	✔	✔
Gambusia holbrooki	mosquitofish	exotic	✔	✔	✔
Hypseleotris sp.	carp gudgeon	native	✔	✔	✔
Macquaria ambigua	yellow belly	native	✔	✔	✔
Tandanus tandanus	freshwater catfish	native	✔	✔	✔
Retropinna semoni	Australian smelt	native	✔		
Galaxias olidus	mountain galaxias	native	✔		
Mogurnda adspersa	southern purple-spotted gudgeon	native	✔		
Perca fluviatilis	redfin perch	exotic	✔		
Maccullochella peelii	Murray cod	native	✔	✔	
Bidyanus bidyanus	silver perch	native		✔	

11.2. Potential Impacts, Mitigation Measures and Risk Assessment

11.2.1. Methods

Based on the outcomes of a literature review and field surveys for the EIS and Supplementary Report, potential impacts to aquatic habitat, aquatic plants, turtles, fish and platypus have been assessed. The value of these aquatic ecology attributes in the Project area was identified, along with the magnitude of each potential impact to these attributes, and defined in accordance with the criteria outlined in Table 11.7 and Table 11.8.

Risks to aquatic habitat, aquatic plants, turtles, fish and platypus as a result of the Project have been assessed based on the determined value and magnitude of impact. Table 11.9 illustrates how the significance of a potential impact was derived.

Table 11.7 Value criteria for aquatic ecology attributes.

Value	Definition
very high	· an internationally important site (e.g. Ramsar wetland, or a site considered worthy of such designation) · a regularly occurring population of an internationally important species · a nationally designated site (e.g. Wetland of National Significance) · smaller areas of habitat which are essential for maintaining the viability of a larger whole area of national significance · areas of habitat that may support nationally important species listed under the EPBC Act. · aquatic species or communities listed under the EPBC Act
high	· habitat of state significance (e.g. wetland protection areas, waterways within a national park) · aquatic species or communities listed under the NCA · aquatic habitat, species or communities that are rare or have a high conservation priority species within Queensland · aquatic species or communities that are considered 'iconic' species within Queensland or Australia (e.g. platypus)
medium	· aquatic habitat or site designated by a local authority as having local conservation status · aquatic habitat or species that has importance at a catchment-scale, e.g. refuge habitat or fish breeding habitat
low	· aquatic habitat not specifically protected under state or national legislation, but that supports native aquatic flora and fauna · common or widespread aquatic species or communities within the region that are not specifically protected under state or national legislation and that are relatively tolerant of a wide range of environmental conditions
negligible	· common or widespread aquatic habitat within the region that is highly disturbed and rarely supports aquatic flora and fauna · highly disturbed aquatic communities, e.g. affected by pollution or invasion of exotic species

Table 11.8 Thresholds for magnitude of impact for aquatic ecology receptors.

Magnitude of Change	Definition
major	· permanent or long-term effect on the extent or integrity of a habitat, a species or a community · likely to result in a direct effect on a habitat or a species, including mortality of a high value species that affects the viability of the population · likely to threaten the sustainability or conservation status of a habitat, a species or a community · if beneficial, likely to enhance the sustainability or conservation status of a habitat, a species or a community
moderate	· permanent or long-term effect on the extent or integrity of a habitat, a species or a community · likely to result in direct effect on a habitat or a species that does not affect the viability of the population · unlikely to threaten the sustainability of a habitat, a species or a community · if beneficial, likely to enhance the sustainability of a habitat, a species or a community
minor	· medium or short-term reversible effect on a habitat, a species or a community · may be a small but measurable indirect impact on an aquatic habitat or on a native aquatic species or community · will not threaten the sustainability of a significant habitat, species or native aquatic community
negligible	· no direct impact to an aquatic habitat or a species · short-term and reversible indirect effect on habitat that is unlikely to lead to impacts on habitat integrity or a native aquatic community
no change	· no direct or indirect impacts to aquatic ecology

Table 11.9 Matrix used to estimate the significance of potential impacts after mitigation.

Significance of Effect		Magnitude of Change				
		Major	Moderate	Minor	Negligible	No change
Attribute Value	Very high	Very Large	Large/Very Large	Moderate/ Large	Slight	Neutral
	High	Large/Very Large	Moderate/ Large	Slight/ Moderate	Slight	Neutral
	Medium	Moderate/ Large	Moderate	Slight	Neutral/ Slight	Neutral
	Low	Slight/ Moderate	Slight	Neutral/ Slight	Neutral/ Slight	Neutral
	Negligible	Slight	Neutral/ Slight	Neutral/ Slight	Neutral	Neutral

Note: Shaded boxes indicate a significant effect in terms of EIA. Where a choice of two impact significance descriptors is available, only one should be chosen. This allows for professional judgement and discrimination in assessing impacts.

11.2.2. Summary

Table 11.10 shows the risk assessment summary for potential impacts to aquatic habitat, aquatic plants, turtles, fish and platypus in the Project area. Based on the impact assessment (Appendix F and Appendix G), the following activities have the potential to result in impacts to aquatic flora and fauna without mitigation and management:

- fuel and contaminant spills to the river, affecting water quality
- works such as vegetation clearing, earthworks, quarrying and sand extraction, resulting in decreased available habitat, and
- construction, inundation and operation of the dam, leading to habitat loss and decline in habitat suitability, a reduction in food sources and isolation of populations.

Of these activities, those with the greatest potential impact are:

- inundation and operation of the dam
- obstruction of flow and passage by the dam, and
- changes to the flow regime downstream of the dam.

The potential impacts of these key activities, and the associated mitigation measures, are described in detail in Sections 11.2.3, 11.2.4 and 11.2.5. All other potential impacts are described in detail in the EIS, Appendix F and Appendix G and summarised in Table 11.10. The potential impacts from the Project on the Native Fish Strategy are described in Section 11.2.6. Cumulative impacts are discussed in Section 11.2.7.

Once mitigation measures are implemented, all residual impacts on aquatic habitat, aquatic plants, turtles, fish and platypus are considered to be slight, except in relation to the restriction of passage in the river. The restriction of passage has moderate residual impact for Murray cod, other fish of conservation significance and platypus using the impact assessment methodology; however, the restriction of passage is unlikely to threaten the sustainability of these species in the region. The restriction of passage is assessed to have moderate residual impact for Bell's turtles due to insufficient information on effectiveness of fishways for turtles; however, the restriction of passage is unlikely to threaten the sustainability of Bell's turtle, as they are not known to occur upstream of the dam site.

The residual impacts classified as slight are not considered to be significant impacts in accordance with the impact assessment methodology described above.

11.2.3. Potential Impact of Storage on Aquatic Habitat

During the filling phase, existing habitats will be inundated as the dam begins to fill. The ecosystems within the inundation water will change from riverine (lotic) to lake (lentic) habitats. Initially, the lotic ecosystems will fill to bank full widths as if in flood, but then the area above the banks will be gradually inundated until the dam is at inundation area. The length of the filling phase is dependent on the rate of inflow, and the inundation area may fill during a single flood event or it may take several years.

The inundation of the dam will result in the loss of pool, run, glide, backwater, riffle and cascade habitat along approximately 4.4 km of the Severn River. Coarse sediment (boulders, cobbles, pebbles and gravel) present within the inundation area may be smothered in fines and sands once the inundation area is filled (as suspended fine sediments are likely to settle out of the water column in the relatively still waters of the inundation area).

However, the aquatic habitat in the Severn River is similar throughout the Project area (i.e. upstream of, within, and downstream of the proposed dam site). The distance from the confluence of the Broadwater and Quart Pot Creek (i.e. the headwaters of the Severn River) to the downstream extent of the Project area (as defined in this report) is approximately 34.5 km, and field surveys indicate that aquatic habitat is similar throughout this area. As such, the inundation will result in the loss of approximately 12.8% of aquatic habitat in this section of the Severn River, but is highly unlikely to result in the loss of any unique aquatic habitat that supports aquatic flora and fauna.

The fish species recorded within the water storage area are not habitat specialists. That is, no species are expected to be lost from the dam due to the changes in habitat type. However, there will be a shift in community composition due to the expected changes in habitat and sediment type. The increased extent of shallow margins may provide ideal habitat for several species, particularly if they are colonised by aquatic plants. For example, gudgeons and catfish prefer habitats that include aquatic plants (Allen et al. 2002). Most species recorded in the study area have previously been recorded in habitats with a variety of substrates (Appendix F). However, the shift in substrate composition may result in the loss of spawning habitat for species that deposit eggs on gravel surfaces or hard surfaces, such as freshwater catfish.

The inundation area will provide a stable pool habitat for aquatic fauna. While the length of riverine sections will decrease and there will be an increase in deep areas, there may be a net increase in diversity of habitat because of that offered by the over-bank areas in the tributaries. The stability and potential diversity of the habitat created by the dam may result in an increase in fish abundance and diversity in the inundation area (frc environmental 2008). The inundation area is unlikely to be optimal habitat for platypus, as they prefer water depths of 5 m or less for optimal foraging; however, platypus have been observed in dam storages (e.g. Paradise Dam on the Burnett River) and no platypus were observed in the proposed dam inundation area during the 2013 surveys.

There are no dams or wetlands upstream of the proposed dam; however, there is one on-stream lacustrine wetland (a weir pool) and three off-stream lacustrine wetlands (farm dams) downstream of the proposed dam. These will not be affected by the inundation of the proposed dam.

During operation of the dam there is expected to be some overhanging vegetation along the margins of the water storage area at inundation area, though the likely ratio of this habitat compared with open water with no canopy cover will be substantially reduced. When water levels are below inundation area there will be little overhanging vegetation except where the storage remains in a former stream channel and surviving riparian vegetation can still perform that function or where deep areas abut existing forest. Appropriate material will be salvaged for use as 'large woody debris' fish habitat in the inundation area.

Tree and shrub vegetation provides shading to channels and aquatic habitat such as snags and overhanging vegetation. Snags provide resting, sheltering and foraging habitat for aquatic fauna. Substrate diversity and a variety of aquatic habitat such as woody debris also support more diverse and abundant macroinvertebrate communities, which are prey for many of the fish found in the study area. Each of the native fish species that may occur in the water storage area require in-stream habitat to provide shelter or for reproduction (Appendix C, in Appendix F).

The dam will provide less diversity of physical habitat, hence it is important to re-create some through strategies such as placing snags in relatively (<5 m) shallow water and not clearing to the inundation area to provide structural diversity.

11.2.4. Potential Impacts to Fauna Passage

Dams create barriers that prevent or impede movement (i.e. general movement through a waterway) and migration (i.e. movement for a specific purpose such as reproduction) of aquatic fauna, including fish, turtles and platypus, in waterways. A dam wall is, without mitigation, a complete barrier to upstream fauna movement and an almost complete barrier to downstream movement. During construction the construction site will also represent a barrier to aquatic fauna. Many of the native fish in Queensland waterways migrate upstream and downstream and between different habitats during particular stages of their life cycle. Fish passage is already restricted in the Severn River in the vicinity of the Project by weirs and, if unmitigated, the dam will further restrict fish movement and migration in the catchment. Turtles of various species will aggregate at the upstream and downstream sides of impoundment walls and attempt to move past the barriers, which can result in elevated mortality.

During construction, impacts from the obstruction of flow and passage will be mitigated through the use of a diversion channel to connect the river upstream and downstream of the construction site. Removal of the larger aquatic fauna through a carefully managed salvage program before construction begins, will also mitigate potential impacts during construction.

The impediment to passage from the dam wall has the potential to affect fish migration and breeding, isolate fish populations and, in the long-term, could decrease genetic diversity in populations upstream and downstream of the dam. However, fish communities in the vicinity of the Project are generally poor and Murray cod have typically been caught downstream of the proposed dam site.

A fishway / aquatic fauna passageway has been included in the design to accommodate movement up and downstream, and is intended to service the needs of aquatic fauna, including fish and turtles. The design of the facility will be finalised following further consultation with relevant agencies and experts, and in general accordance with the process provided by Queensland Fisheries. However, the concept design is for a fishlock arrangement, similar to that installed on Ned Churchward Weir, which will operate such that at least the current opportunity for movement is maintained, and which will include specialised design input for turtle passage.

The dam will affect fish species differently, depending on their need to move and migrate and their ability to navigate fishways. Most of the fish caught move throughout the freshwater reaches of rivers over the course of their lifetimes. The timing of these movements and migrations in Australian fishes is often unpredictable. In some species, migrations occur during periods of low flow, while others migrate in response to periods of high flow, either upstream or downstream. The use of fish locks by fish within a particular family or even genus is not always consistent. Therefore, generalisations made about the behaviour of related groups of fishes may not be accurate.

Turtles prefer to walk upstream rather than use fishways, and fish locks can be detrimental to turtles if they drown or become trapped in the hydraulic mechanisms of the lock, as has been observed at the Ned Churchward Weir fish lock (Hamann et al. 2004). Never-the-less turtles have been observed passing through fish locks, such as the Paradise Dam fish lock, however these were predominantly Krefft's river turtle (*Emydura macquarii krefftii*). Other species that used the river near the dam, including *Elseya* and *Chelodina* species, either did not use the fishway, or used it in very low numbers (QPIF 2009; DEEDI 2012). Where measures are taken to prevent turtles from accessing high velocity water release sites and the hydraulic mechanism, negative impacts associated with fish locks will be minimised, and some turtle passage will be maintained. Specific

features to enable passage for turtle species that may occur in the area, including Bell's turtle, will be designed in collaboration with appropriate experts, and agencies (including the EHP and Queensland Fisheries) and incorporate into the proposed dam. As no Bell's turtles have been recorded upstream of the proposed dam site, the risk of impacts to passage of this species are considered to be low. The proposed fish lock and aquatic fauna passage will provide opportunity for passage of other turtle species. As the other turtle species recorded in the area are common, the risk of impacts of altered passage on the population of these species is also considered to be low.

Fish locks and fish lift structures are likely to provide adequate passage for most fish species present, if they are designed to mitigate the flaws found in previous structures, maintained in working order, monitored and fine-tuned to improve performance. Platypus have also been known to use fish locks (DEEDI 2012). Impediments to fish movement at the dam wall will be reduced by constructing fishway structures that (from Stuart et al. 2007):

- use an impassable downstream barrier to direct fish away from the spillway towards the fish lock opening, and/or have a downstream entrance near the spillway to allow the passage of larger fish attracted to large flows;
- have upstream structures that direct fish migrating downstream towards the lock;
- can vary attraction flows in accordance with river flows;
- can operate over a range of head and tailwater levels;
- use high quality water (surface) as attractant provided with little turbulence;
- provide attractant flows and lock cycles for fish migrating downstream;
- use a sloping lock chamber rather than a follower cage to encourage exit from the lock;
- are maintained in working order, monitored and fine-tuned to improve performance;
- are remotely operated and functional year round; and
- reduce the chances of fish migrating upstream passing back over the spillway.

Restrictions to fish passage and associated impacts (e.g. decreased recruitment) may be offset where fish habitat and movement is enhanced by:

- restoration of passage at existing barriers through their removal and / or installation of fishways at existing weirs in the Project area;
- habitat restoration and / or protection in the Project area (for example, placement of woody debris in dam margins); and
- allocation of water specifically to enhance aquatic habitat downstream of the dam over and above the proposed environmental releases.

Fisheries Queensland will be consulted to design a suitable offset package for the Project. It is proposed a survey will be undertaken of the existing privately owned weirs upstream and downstream of the proposed dam. The team of specialist ecologists in consultation with Queensland Fisheries will develop concept designs to improve fish passage at existing weirs. The team will engage with the weir owners and make the concept designs available. A demonstration fishway will be constructed at one of the existing weirs, with the owner's permission, as part of the Project.

11.2.5. Potential Impacts of a Changed Flow Regime

The proposed dam may change the current flow regime in the river by reducing flow in the river downstream of the dam site and altering the timing, frequency and size of seasonal flow events. The number of weirs downstream of the dam site could also exacerbate any decrease in flow downstream of the proposed dam. Potential impacts associated with a change in the existing flow regime may include: a decrease in the persistence of and connectivity between some pool – run / riffle habitat sequences; a reduction in the availability and suitability of aquatic habitat for native flora and fauna; and altered migratory or breeding cues for some aquatic fauna (particularly fish). However, the proposed release regime from the dam includes environmental releases and modelling indicates the decrease in water depth will be small.

Environmental flows from the dam will comprise a release equivalent to the inflow, up to 30 ML/day, in order to maintain the natural flow regime for low flows and the ephemeral nature of the Severn River. For example, if 8 ML/day enters the storage then 8 ML/day will be released downstream, but if flow greater than 30 ML/day enters the storage then 30 ML/day will be released downstream. Modelling for the SEIS indicates that the dam will spill for 46 days of the year, with an average of 0.4 of a year (i.e. 4-5 months) between spills. The average duration of spills is predicted to be 14 days. The proposed combination of environmental releases and spills will contribute to maintaining a flow regime consistent with the current flow regime and will mitigate impacts to flora and fauna. In particular, the combination of low flow releases and high spills are expected to provide suitable conditions to trigger migration and reproduction in aquatic fauna.

Modelling undertaken for the SEIS indicates that between the proposed dam site and the confluence of the Severn River and Accommodation Creek, changes to the stream flow would only represent a decrease in water depth of up to 100 mm. This change in water depth is unlikely to have a substantial impact on the availability and suitability of aquatic habitat, except during periods of very low flow, in areas not within existing weir pools. Loss of habitat during periods of low flow will be mitigated by the proposed environmental releases. Impacts to aquatic habitat, flora and fauna from altered flows, are therefore expected to be minimal, as habitat persistence and connectivity downstream of the dam will be maintained.

Changes to the downstream flow regime could potentially affect the downstream lacustrine wetlands (farm dams) through a decrease in the depth and persistence of water in these reservoirs. However, based on the proposed release regime and water modelling, this is considered unlikely to occur, and if the combined urban and irrigation dam is developed, supply from the proposed dam may supplement any loss of water in the farm dams.

11.2.6. Native Fish Strategy for the Murray-Darling Basin 2003-2013

The Native Fish Strategy for the Murray-Darling Basin 2003–2013 (the Native Fish Strategy) is part of the Integrated Catchment Management Policy Statement for the Murray-Darling Basin, and targets the causes and symptoms of declining native fish species. Its focus is on long-term rehabilitation rather than restoration and the strategy's vision is that the Murray-Darling Basin sustains viable fish populations and communities throughout its rivers. To achieve this vision, 13 objectives have been established. The Project could counteract these objectives through changes to aquatic habitat, fish passage and flow that may have impacts on native fish species and communities in the Severn River. However where appropriate mitigation measures and offsets are implemented, the Native Fish Strategy objectives can be maintained.

11.2.7. Cumulative Impacts

Cumulative impacts of the Project on aquatic ecology were considered in relation to the surrounding land uses and other major projects underway or planned in the local area.

The lands in the vicinity of the Project are predominately used for agricultural activities, dominated by grazing and cropping, with some rural and urban residential areas (Henderson 2000; Johnson 2004). Numerous weirs, as described in the EIS, are also located on the Severn River in the vicinity of the Project. These activities have the potential to affect, or have affected, aquatic ecology through vegetation clearing, earthworks, water extraction, application of fertilisers and/or pesticides, and water impoundment and flow regime modification.

The proposed dam represents a substantial impact to fish passage and the flow regime in the Severn River, and may also impact the passage of turtles. However, where the appropriate mitigation measures are in place, including a fishway and environmental releases, it is considered unlikely that the Project will result in a significant increase in cumulative adverse impacts on aquatic ecosystems when compared to the existing impacts of river regulation and on-going regional agricultural activities. Furthermore, where offsets to improve aquatic fauna passage are implemented, the likelihood of cumulative impacts will be reduced.

To mitigate cumulative impacts associated with fauna passage, a survey will be undertaken of the existing privately owned weirs upstream and downstream of the proposed dam and a team of specialist ecologists in consultation with Queensland Fisheries will develop concept designs to improve fish passage at existing weirs. This team will engage with the weir owners and make the concept designs available and a demonstration fishway will be constructed at one of the existing weirs, with the owner's permission, as part of the Project.

Table 11.10 Summary of the potential impacts of the Emu Swamp Dam Project on aquatic ecology, the relevant mitigation and management measures and the residual risk

Aquatic Ecology Attribute by Value Criteria	Potential Impact	Mitigation Measures	Objective	Magnitude of Change After Mitigation	Residual Impact
Very High					
Bell's turtle	increased turbidity and sedimentation, and input of nutrients or other contaminants from works including vegetation clearing, earthworks, quarrying and sand extraction	· an erosion and sediment control plan developed and implemented during works and operation · sediment dams constructed before works begin · works occur in the dry season, if possible · vegetated buffer area around inundation area to reduce water quality impacts from local runoff	no increase in turbidity or general decline in water quality	negligible	slight
	loss of in-stream and nesting habitat from works including vegetation clearing, earthworks, quarrying and sand extraction	· locations directly affected by works are assessed for Bell's turtles and nests by a qualified professional before work begins · a localised impact assessment completed if Bell's turtles or nests are present	no direct or indirect impacts to listed threatened or near-threatened species	negligible	slight
	loss of in-stream and nesting habitat from dam inundation	· nil – not known to occur in this area	–	negligible	slight
	restriction of passage and isolation of populations by the dam wall	· inclusion of aquatic fauna passageways specifically designed to enable passage of Bell's turtle as proposed, with measures to restrict access to high velocity water release sites and the hydraulic mechanism	minimise restriction of passage in river	minor	moderate
	loss of in-stream and nesting habitat due to a changed flow regime downstream of the dam	· managed environmental releases to maintain connectivity consistent with current conditions	no reduction in the number of existing pool-run/riffle sequences or connectivity	negligible	slight
	improved conditions for predators from dam inundation and a changed flow regime downstream of the dam	· management plan to control exotic and pest species such as goldfish within and downstream of the dam.	no increase in the populations of exotic or pest species	negligible	slight
	reduction in food sources from changed water quality and flow conditions	· managed environmental releases to maintain connectivity consistent with current conditions · management plan for water quality in the storage and environmental releases	no direct or indirect impacts to listed threatened or near-threatened species	negligible	slight

Aquatic Ecology Attribute by Value Criteria	Potential Impact	Mitigation Measures	Objective	Magnitude of Change After Mitigation	Residual Impact
Listed threatened or near-threatened species – Murray cod	increased turbidity and sedimentation, and input of nutrients or other contaminants associated with the soil from works including vegetation clearing, earthworks, quarrying and sand extraction	· an erosion and sediment control plan developed and implemented during works and operation · sediment dams constructed before works begin · works occur in the dry season, if possible · vegetated buffer area around inundation area to reduce water quality impacts from local runoff	no increase in turbidity or general decline in water quality	negligible	slight
	loss of in-stream habitat from works including vegetation clearing, earthworks, quarrying and sand extraction	· fauna are translocated from in-stream areas directly affected by works by qualified professionals before work begins	no direct or indirect impacts to listed threatened or near-threatened species	negligible	slight
	loss of in-stream habitat from dam inundation	· maintain riparian vegetation and in-stream woody debris along dam margins	no change to Murray cod population	negligible	slight
	restriction of passage and isolation of populations by the dam wall and during construction	· inclusion of fishlock on dam, with screens to re-direct large fauna towards the fishlock and away from off-takes · maintain passage for aquatic fauna during construction using diversion channels	no change to Murray cod population	minor	moderate
	loss of in-stream habitat due to a changed flow regime downstream of the dam	· managed environmental releases and spills to maintain connectivity and flow regime consistent with current conditions	no reduction in the number of existing pool-run/riffle sequences or connectivity	negligible	slight
	improved conditions for exotic species from dam inundation and a changed flow regime downstream of the dam	· management plan to control exotic and pest species such as mosquitofish and goldfish within and downstream of the dam	no increase in the populations of exotic or pest species	negligible	slight
	reduction in food sources from changed water quality and flow conditions	· managed environmental releases and spills to maintain connectivity and flow regime consistent with current conditions · management plan for water quality in the storage and environmental releases	no direct or indirect impacts to Murray cod	negligible	slight
High					
Iconic and protected aquatic species – platypus, river blackfish, southern purple-spotted gudgeon, freshwater catfish	increased turbidity and sedimentation, and input of nutrients or other contaminants associated with the soil from works including vegetation clearing, earthworks, quarrying and sand extraction	· an erosion and sediment control plan is developed and implemented during works and operation · sediment dams are constructed before works begin · works occur in the dry season, if possible · vegetated buffer area around inundation area to reduce water quality impacts from local runoff	no overall decrease in water quality	negligible	slight
	loss of in-stream and riparian habitat from works including vegetation clearing, earthworks, quarrying and sand extraction	· fauna are translocated from in-stream areas directly affected by works by qualified professionals before work begins · riparian vegetation is preserved and maintained, where possible	no direct or indirect impacts to iconic and protected species	negligible	slight

Aquatic Ecology Attribute by Value Criteria	Potential Impact	Mitigation Measures	Objective	Magnitude of Change After Mitigation	Residual Impact
	loss of in-stream and riparian habitat from dam inundation	· fauna are translocated from in-stream areas directly affected by works by qualified professionals before work begins	no change to populations of iconic and protected species	negligible	slight
	restriction of passage and isolation of populations by the dam wall and during construction	· inclusion of fishlock on dam, with screens to re-direct large fauna towards the fishlock and away from off-takes · maintain passage for aquatic fauna during construction using diversion channels	no change to populations of iconic and protected species	minor	moderate
	loss of in-stream habitat due to a changed flow regime downstream of the dam	· managed environmental releases and spills to maintain connectivity and flow regime consistent with current conditions	no reduction in the number of existing pool-run/riffle sequences or connectivity	negligible	slight
	improved conditions for exotic species from dam inundation and a changed flow regime downstream of the dam	· management plan to control exotic and pest species such as goldfish within and downstream of the dam.	no increase in the populations of exotic or pest species	negligible	slight
	reduction in food sources from changed water quality and flow conditions	· managed environmental releases and spills to maintain connectivity and flow regime consistent with current conditions · management plan for water quality in the storage and environmental releases	no change to populations of iconic and protected species	negligible	slight
Medium - Low					
Murray River turtle and eastern long-necked turtle	increased turbidity and sedimentation, and input of nutrients or other contaminants associated with the soil from works including vegetation clearing, earthworks, quarrying and sand extraction	· an erosion and sediment control plan is developed and implemented during works and operation · sediment dams are constructed before works begin · works occur in the dry season, if possible · vegetated buffer area around inundation area to reduce water quality impacts from local runoff	no overall decrease in water quality	negligible	slight
	loss of in-stream and nesting habitat from works including vegetation clearing, earthworks, quarrying and sand extraction	· locations directly affected by works are assessed for turtles and nests before work begins · turtles are relocated from areas of direct impact by qualified professionals before work begins in the area	minimise impacts to aquatic habitat and turtle species	negligible	slight
	loss of in-stream and nesting habitat from dam inundation	· maintain riparian vegetation and in-stream woody debris along dam margins to provide shelter and basking habitat for turtles · check areas of nesting habitat yet to be inundated for nests once during each breeding season until the full supply level is reached; relocate nests if present.	–	moderate	slight
	restriction of passage and isolation of populations by the dam wall	· inclusion of fishway and / or moistened turtle passages and / or other features specifically designed to enable passage of these species.	minimise restriction of passage in river	moderate	slight

Aquatic Ecology Attribute by Value Criteria	Potential Impact	Mitigation Measures	Objective	Magnitude of Change After Mitigation	Residual Impact
	loss of in-stream and nesting habitat due to a changed flow regime downstream of the dam	· managed environmental releases to maintain connectivity consistent with current conditions	minimise any reduction in the number of existing pool-run/riffle sequences or connectivity	negligible	neutral
	improved conditions for predators from dam inundation and a changed flow regime downstream of the dam	· management plan to control exotic and pest species such as goldfish within and downstream of the dam.	no increase in the populations of exotic or pest species	negligible	slight
	reduction in food sources from changed water quality and flow conditions	· managed environmental releases to maintain connectivity consistent with current conditions · management plan for water quality in the storage and environmental releases	minimise changes to flow regime and water quality	negligible	slight
All aquatic habitat, flora and fauna in the Severn River	increased turbidity and sedimentation, and input of nutrients or other contaminants from works including vegetation clearing, earthworks, quarrying and sand extraction	· an erosion and sediment control plan is developed and implemented during works and operation · sediment dams are constructed before works begin · works occur in the dry season, if possible	no overall decrease in water quality	negligible	slight
	loss of in-stream and riparian habitat from works including vegetation clearing, earthworks, quarrying and sand extraction	· fauna are translocated from in-stream areas directly affected by works by qualified professionals before work begins	minimise direct impacts to fauna	negligible	slight
	loss of in-stream and riparian habitat from dam inundation	· maintain riparian vegetation and in-stream woody debris along dam margins	maintain riparian and in-stream habitat in margins of dam	moderate	slight
	restriction of passage and isolation of populations by the dam wall and during construction	· inclusion of fishlock on dam, with screens to re-direct large fauna towards the fishlock and away from off-takes · maintain passage for aquatic fauna during construction using diversion channels	minimise restriction of passage in river	moderate	slight
	loss of in-stream due to a changed flow regime downstream of the dam	· managed environmental releases and spills to maintain connectivity and flow regime consistent with current conditions	no reduction in the number of existing pool-run/riffle sequences or connectivity	negligible	neutral
	improved conditions for exotic species from dam inundation and a changed flow regime downstream of the dam	· management plan to control exotic and pest species such as goldfish within and downstream of the dam	no increase in the populations of exotic or pest species	negligible	slight
	reduction in food sources from changed water quality and flow conditions	· managed environmental releases and spills to maintain connectivity and flow regime consistent with current conditions · management plan for water quality in the storage and environmental releases	minimise changes to flow regime and water quality	negligible	slight

11.3. Monitoring and Management

The monitoring of aquatic ecosystems is recommended to:

- monitor the impacts of the proposed dam on downstream aquatic ecology;
- monitor the impacts on threatened, near-threatened and iconic species;
- monitor the efficacy of the fish and aquatic fauna passageway;
- inform the continual improvement of the dam's operations; and
- trigger the requirement for remedial action should an impact be detected.

The monitoring should include:

- a comparison of the condition of aquatic ecology in the Severn River upstream of, within and downstream of the proposed dam
- an assessment of impacts, if any, to key aquatic species and aquatic habitat (including a comparison of fish populations upstream, within and downstream of the dam)
- recommendations for monitoring and management of impacts, if any
- a statistically-robust, quantitative design in order to reliably describe background condition and detect impacts
- be approved by the administering authority before implementation, and
- be implemented by qualified aquatic biologists.

The monitoring program for key aquatic species should be designed and implemented by an appropriately qualified professional, and consider:

- completion of at least two baseline surveys before commissioning works, and at least two surveys after works begin (with the need for further surveys to be determined based on the results)
- survey of fauna using equipment appropriate to the conditions at each site

The monitoring of freshwater turtles is recommended to:

- minimise impacts due to construction works;
- monitor the potential presence of Bell's turtles;
- monitor the efficacy of the fishway;
- inform the continual improvement of the dam's operations, and
- trigger the requirement for remedial action should an impact be detected.

The monitoring should include:

- localised site assessments to assess the presence of turtles and turtle nests before works begin in construction zones, and to enable relocation if necessary;
- an assessment of the turtle populations in the Severn River upstream of, within and downstream of the proposed dam;
- a targeted survey of Bell's turtles during a period of high activity (i.e. October–December); and
- recommendations for monitoring and management of impacts, if any.

The monitoring program should be designed and implemented by an appropriately qualified professional, and consider:

- completion of at least one more baseline survey before commissioning works, and at least two surveys after works begin (with the need for further surveys to be determined based on the results);
- survey of turtles using equipment appropriate to the conditions at each site, and in periods of high turtle activity;
- the life-history stage (juvenile, intermediate, adult) of each species, along with the apparent health of individuals; and
- the richness, total abundance, abundance of key species.

General Fisheries and Animal Ethics permits will be required to complete the monitoring.

Where offsets are implemented to mitigate potential impacts, the performance of these management measures will also be monitored. That is, fish communities near areas of habitat rehabilitation will be monitored, as will fish communities upstream and downstream of weirs where passage has been improved.

11.4. Conclusion

Turtle species recorded in or downstream of the proposed dam site include Bell's turtles, Murray River turtles and eastern long-necked turtles. Of these species, Murray River turtles and eastern long-necked turtles were caught upstream of the proposed full supply level, within the full supply level, and downstream of the proposed dam site. Only one Bell's turtle has been reported in the Project area: in the Severn River near Somme Lane, downstream of the proposed dam site, during the Project EIS in 2007. No Bell's turtles were caught by Fielder (2010) in the Severn River between 2002 and 2009, or during the 2013 surveys for the supplementary EIS.

Freshwater turtles in the proposed Project area may be affected by the Project through:

- the operation and maintenance of vehicles and other equipment;
- works including vegetation clearing, earthworks, quarrying and sand extraction;
- inundation and operation of the dam;
- obstruction of flow and passage by the dam; and
- changes to the flow regime downstream of the dam.

Of the potential impacts, the inundation and operation of the dam, obstruction of flow and passage by the dam and changes to the downstream flow regime may have the greatest impact on turtles. Potential impacts of these, and other Project activities, can be minimised where mitigation measures are implemented.

Where the recommended mitigation measures are applied, including incorporation of passage for Bell's turtle designed in collaboration with appropriate experts including EHP, there are unlikely to be any significant impact on this EPBC listed species.

Overall, the risk assessment indicates that there will only be a slight impact to turtles where appropriate mitigation measures are implemented.