12 Aquatic ecology

This chapter provides a summary of the aquatic impact assessment undertaken by Biosis Research Pty Ltd and more recent investigations undertaken by the BWA. The full Biosis Research Pty Ltd reports are included in Appendices G, G1 and G2.

12.1 Methodology

The studies comprised a literature and database review and aquatic field survey and assessment.

An aquatic habitat survey was undertaken at seven locations (refer Sites 1 – 7, Figure 12.1) along Burra Creek between the outlet site and the confluence of Queanbeyan River on 6 November 2007 including fish sampling at each site.

In addition, a targeted, habitat-based aquatic survey and assessment was undertaken at 18 locations along the Murrumbidgee River (Sites A to P, Figure 12.2) between Angle Crossing and Tharwa Sandwash and in Burra Creek at the proposed outlet point at Burra Road between 14 and 16 May 2008.

The ACT Aquatic Species and Riparian Zone Conservation Strategy (Action Plan 29) takes an integrated territory-wide approach within a regional context to the protection and management of the rivers and riparian areas in the ACT that support threatened species and ecological communities. The primary focus of this *Strategy* is the rivers and larger tributary creeks and their riparian zones in the ACT that support threatened flora and fauna species, and in particular the Murrumbidgee River. Threatened species listed in this strategy that require consideration include Macquarie Perch, Murray River Crayfish, Trout Cod, Murray Cod and Silver Perch. Impacts on these species are described below.

Parameters assessed during the survey included the location and waterway type; flow types; presence of barriers; substrate composition; in-stream habitat; riparian vegetation; macrophytes; existing anthropogenic disturbances; and opportunistic observations of aquatic fauna.

There was limited data available for some key parameters at the time of this assessment, particularly the water quality in Burra Creek and the status of threatened fish populations. The project will include ongoing monitoring and adaptive management (as discussed further in Section 12.5).

12.2 Existing environment

12.2.1 Aquatic habitats

Burra Creek aquatic habitats

The aquatic habitat of Burra Creek between the outlet site and the confluence of Queanbeyan River can be divided into five main reaches for the purposes of assessing aquatic habitat; each characterised by physical features and vegetation.

Reach 1: Pipeline outlet Point to just downstream of the Burra Rd Bridge

The creek varies between 0 and 6 m wide and consists of short pools braided by infrequent, shallow riffling with pools up to 0.7 m deep. Bank structure varies from stable to actively eroding along some curves and constrictions of the channel. Stream substrates in the early part of this reach consist of soft silt and sand sediments with high cover of detritus and green filamentous algae on submerged woody debris and vegetation. Further on, stream substrates are predominantly silt and bedrock with some cobbles and sands.

Instream habitat consists of long beds of herbaceous vegetation dominated by exotic and native grasses, with rush/reed vegetation patches surrounding shallow pools consisting primarily of the emergent reeds, *Phragmites australis* and *Typha orientalis* with small sections of large woody debris and branches interspersed.

Dense beds of *Eleocharis* sp. are common throughout the early parts of the reach in the shallow pools. In pools of moderate depth (to 60 cm) dense clumps of *Chara* sp. algae and some filamentous algae are also common. Large beds of vegetation patches consisting primarily of the emergent reeds *Phragmites australis* and *Typha* sp are

common throughout the reach. Near the gauging station, creeping mats of *Ranunculus* sp. along with isolated rushes of the genus *Juncus* are present.

The riparian zone is predominantly cleared for agricultural purposes and dominated by grass or patches of exotic species such as Salix sp, Rubus fruticosa, Populus alba and P. nigra with some native trees downstream of the gauging station. Snow Gum Eucalyptus pauciflora-Candlebark E. rubida-E. bridgesiana grassy woodland occurs along Burra Creek. This community is not currently listed as an EEC although a nomination for its listing has been made. These sections were considered to be highly disturbed and in poor to moderate condition.

The reach was classified as Class 2- Moderate fish habitat, under the DPI fish habitat classification scheme (NSW Fisheries 1999)

Reach 2: Upper Burra Creek

The creek varies between 2-10 m wide and consists of short riffles or flowing sections with pools up to 0.5 m deep. The stream substrate in this section is predominantly silt and bedrock with some cobbles and sands. Instream habitat consists of small sections of large woody debris with large macrophyte patches consisting primarily of the emergent reeds, *Phragmites australis* and *Typha sp.* Creeping mats of *Ranunculus sp.* along with isolated rushes of the genus *Juncus* are present near the gauging station. The riparian zone is predominantly cleared for agricultural purposes and dominated by grass or patches of exotic species such as *Salix sp.*, *Rubus fruticosa*, *Populus alba, Chara* and *P. nigra* with some native trees present downstream of the gauging station. The reach is classified as class 2-moderate fish habitat, under the NSW Department of Primary Industries Fish Habitat Classification Scheme (NSW Fisheries 1999).

Reach 3: Upstream of London Bridge Homestead

Burra Creek above London Bridge Homestead consists of large deep pools and bedrock riffles, with the pools up to 8 m wide and 1.2 m deep. Substrate in the pools is primarily silt and bedrock, with some sand and cobbles found in the tail of pools and riffles. Instream habitats consist of isolated large woody debris, coarse particulate organic matter and large emergent beds of *Typha sp*, scattered clumps of *Myriophyllum sp.* and *Nasturtium officinale*. Clumps of *Chara sp.* algae and some filamentous algae are also present in the pools. The riparian zone is dominated by grasses and the area is considered to be moderately disturbed and in poor to moderate condition. The reach is classified as class 2-moderate fish habitat, under the NSW Department of Primary Industries Fish Habitat Classification Scheme (NSW Fisheries 1999).

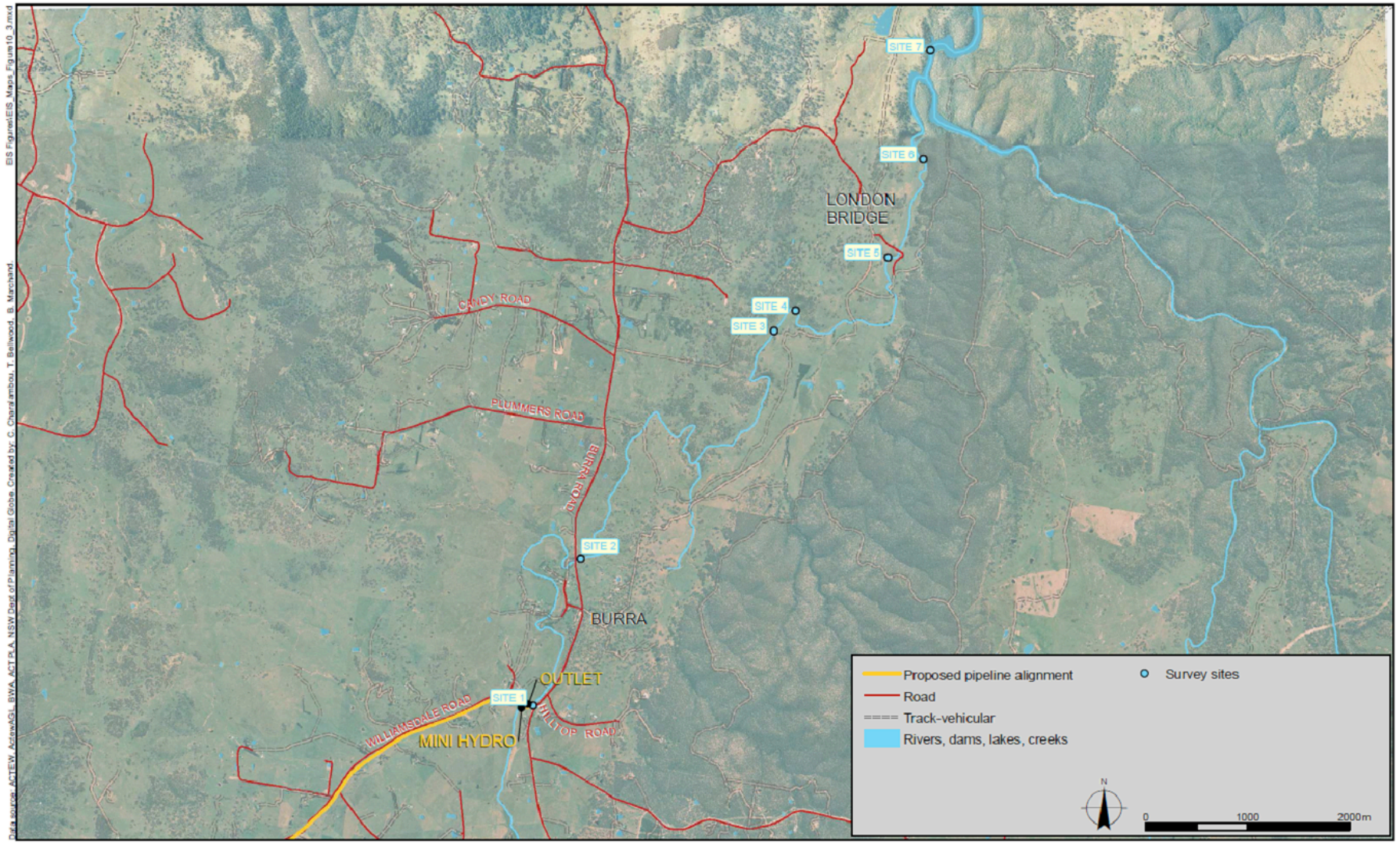

Figure 12.1 Burra Creek aquatic habitat survey sites 1 to 7

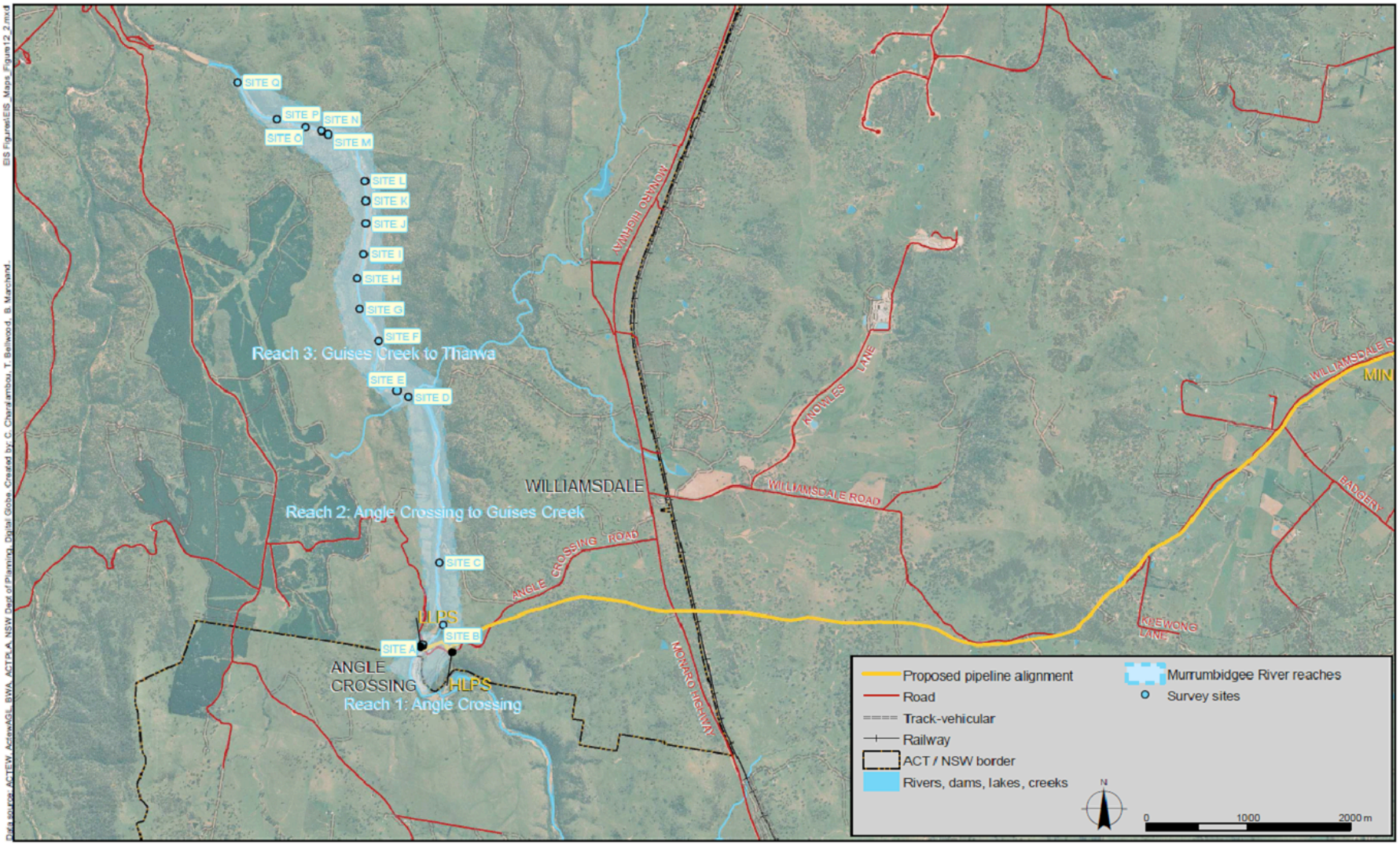

Figure 12.2 Murrumbidgee River aquatic habitat survey sites A to P

Reach 4: Upstream of London Bridge

Burra Creek between London Bridge and the London Bridge Homestead consists of several large pools up to 1.8 m deep and up to 6 m in width, interspersed by shallow flowing sections. The stream substrate primarily consists of a mix of silt and sand in which significant amounts of cobble and boulders are partially imbedded. Bedrock outcrops are also present. Instream habitat consists of large beds of aquatic vegetation, completely covering some areas of the river. The aquatic vegetation is dominated by emergent *Typha sp.*, *Eleocharis sp.* and *Ranunculaceae*, whilst submergent vegetation consists of large beds of *Chara sp.*, *Myriophyllum sp.* and filamentous algae. The riparian zone is dominated by grasses and the area is considered to be moderately disturbed and in poor to moderate condition. The reach is classified as a class 2-moderate fish habitat, under the NSW Department of Primary Industries Fish Habitat Classification Scheme (NSW Fisheries 1999).

Reach 5: Downstream of London Bridge (Drawdown Crossing)

Drawdown Crossing is located downstream of London Bridge and above the high water mark of Googong Reservoir and is characterised by long, narrow and shallow pools with occasional runs and isolated deeper pools up to 1.2 m deep, associated with bedrock features. The presence of invertebrate fauna such as gripopterygid stonefly larvae (*BWA observation*) indicates these pools have a higher than expected permanent nature, possibly due to some groundwater contribution or some subsurface flow being maintained between the pools.

The substrate is dominated by gravel and sand with minor amounts of larger pebbles and occasional bedrock outcrops. Instream habitat consisted of branch piles and log jams, presumably from high flow events, as well as some submergent macrophytes. Macrophytes observed in this section included isolated beds of *Myriophyllum sp.* and *Chara sp.* algae and filamentous algae in the shallow sections. The eastern stream bank is cleared of major vegetation but has a continuous cover of grass. The western bank is well vegetated with native shrubs and trees. The area is considered to be of low disturbance and in moderate condition. The reach is classified as a class 2-moderate fish habitat, under the NSW Department of Primary Industries Fish Habitat Classification Scheme (NSW Fisheries 1999).

Near the junction with the Queanbeyan River and below the high water level of the Reservoir, Burra Creek's substrate is heavily silted with extensive clay banks that had been colonised by *Salix sp.* and *Juncus sp.* during the periods of low water level in the Reservoir.

Overall Assessment of Exisitng Aquatic Habitats in Burra Creek

Although flow in the upper reaches is intermittent, the lower section has permanent pools possibly due to some groundwater contribution, likely with some subsurface flow being maintained between the pools.

The stream flows over several limestone outcrops of the Cappanana formation, of which London Bridge is one (Finlayson 2008, Geological Map of NSW). Karst or limestone regions frequently support springs and Gippel and Nayar (2005) suggested that Burra Creek may gain from groundwater rather than losing through seepage.

The stream has been affected by an extended period of low flows. The extensive beds of *Typha* and *Phragmites* have developed because of a long period without floods. These macrophytes are normally limited by physical factors – floods which will scour them out, droughts which can kill the plants and occasionally fires which can kill and thin the plants. Such streams progress through a cycle where these large emergent macrophytes will increase in density and extent, potentially even blocking whole stream reaches until a flood scours a proportion of the macrophytes out - the impact being dependant on flood size.

The other key vegetative components of Burra Creek are the submergent plants such as Chara, Myriophyllum and Ranunculus species. The extent of these plants is the most conspicuous and unusual element of the biota in Burra Creek. These plants also provide habitat and cover for the aquatic invertebrates, fish, turtles and other vertebrates. The abundance and diversity of the submergent macrophytes is maintained by the natural flows (excluding floods), water chemistry and seasonal variation. Significant flood events can be expected to regularly wash away much of the submergent and emeregent plants and remove potential habitat. .

Macrophytes actively grow during the summer when there is more light available and water temperatures are higher. For most of them, growth ceases during winter, and some species die off during winter.

Murrumbidgee River aquatic habitats

The Murrumbidgee River located upstream and downstream of the proposed intake/low lift pump station can be divided into three distinct reaches, each displaying unique features in habitat availability and suitability for varying species. Action Plan 29 describes the Murrumbidgee River and its tributaries as a key geomorphic, hydrological and ecological feature of the ACT.

From its headwaters the Murrumbidgee River following a south-east linear path through NSW before turning north to enter the ACT at Angle Crossing. From here it extends about 60 km in the ACT before it re-enters New South Wales north of Uriarra Crossing. The form and characteristics of the river channel relate to underlying geology, river flows, erosion and deposition and houses a diverse range of aquatic and riparian habitats. Reaches in the immediate vicinity of the proposal are described below.

Reach 1: Angle Crossing

Angle Crossing is a low level concrete road crossing located upon a natural bedrock and cobble riffle. Upstream of the crossing the river forms a series of large pools up to 300 m long and 50 m wide, with occasional braiding for approximately 1 km of river. Short riffle sections link the pools. The depth in the crossing pool is generally greater than 1.5 m deep with the minimum depth occurring over the crossing of 0.1 m deep. The substrate of the pools is predominantly sand, silt and gravel with occasional areas of bedrock and cobble. In-stream habitat includes large woody debris, overhanging vegetation and overhanging banks. Occasional beds of emergent macrophytes including *Typha sp.*, *Phragmites australis* and *Baumea articulata* occur in shallow areas and along the banks, along with scattered clumps of submergent macrophytes, predominantly *Myriophyllum sp.* in the pools. The steep western bank is comprised of rock and gravel and well covered in native shrubs and occasional trees. The eastern bank included large deposits of sand with patches of native shrubs. Patches of exotic plants, particularly *Blackberry Rubus sp.* and African Lovegrass *Eragrostis curvula* are common on both banks. The area is currently being impacted by the crossing, sedimentation and presence of exotic flora species. This reach was classified as class 1-major fish habitat under the NSW Department of Primary Industries Fish Habitat Classification Scheme (NSW Fisheries 1999).

A shallow riffle section is located directly below Angle Crossing (Figure 12.2, Site A). The riffle section is 35-45 m long and up to 30 m wide at the crossing while depth varies from 0.1 m to 0.4 m. The riffle substrate is generally comprised of a mixture of pebbles, gravel and cobbles, embedded with few interstitial spaces but with several beds of submergent and emergent macrophytes.

Reach 2: Angle Crossing to Guises Creek

This reach runs approximately 2.6 km downstream from Angle Crossing to the junction with Guises Creek. It consists of a channel up to 40 m wide with sand bars and some observable braiding over the bars. The flow is generally slow in normal low flow conditions, often with long sections of no perceptible flow and an estimated mean depth of greater than 1 m in most sections. This reach was classified as class 1-major fish habitat under the NSW Department of Primary Industries Fish Habitat Classification Scheme (NSW Fisheries 1999). Fast flowing features are limited to Site B and Site C (refer to Figure 12.2), located 300 m and 600 m downstream of Angle Crossing. Site B is a long but relatively low gradient riffle section, flowing over a predominantly bedrock substrate. Site C is a long series of runs over a sand and occasionally bedrock substrate.

Reach 3: Guises Creek to Tharwa Sandwash

This section of river flows through Gigerline Gorge. It contains a large number of riffles and cascades, interspersed with slow flowing sections and holes. The river in the upper section (Sites D-L, Figure 12.2) is less confined with sand and rock benches present on at least one side of the channel. The riffles vary in length from 40-200 m and consist of predominantly rippled flow with some rapids and small cascades. Substrate in most riffles consists predominantly of bedrock and sand, although Sites H and L have higher proportions of boulders and cobbles. Areas of submergent macrophytes, *Myriophyllum sp.* and *Vallisneria*

gigantea provide habitat for aquatic species. Between riffles the river is characterised by long pools with little observable flow. The depth in these sections is estimated at being greater than 1 m.

Further down the Gorge there are a series of steep cascades approximately 10 m in width, at sites M, N and O (refer to Figure 12.2). These cascades are characterised by chutes and free falls of 0.5-1 m through a bedrock gorge. The riverbed substrate is bedrock with large boulders. The cascades are interspersed with deep, slow flowing pools and runs with sand banks. This section will constitute a barrier to fish passage for most species at most flow levels, although the larger pools will also provide refuge during extremely low flow events.

Below the gorge there is one significant riffle section, Site P (refer to Figure 12.2) before the river slows and broadens and becomes dominated by sand prior to the Tharwa Sandwash and the junction with the Gudgenby River.

This reach was classified as class 1-major fish habitat under the NSW Department of Primary Industries fish habitat classification scheme (NSW Fisheries 1999).

Table 12.1 Aquatic Plants Occurring in Burra Creek and in the Murrumbidgee River near Angle Crossing. *The list is not comprehensive, but is illustrative of the differences between the two.*

Burra Creek	Murrumbidgee River
Typha orientalis	*Typha orientalis*
Phragmites australis	*Phragmites australis*
Ranunculus sp.	*Baumea articulata*
Chara sp.	*Vallisneria gigantea*
Myriophyllum sp.	*Myriophyllum sp.*
Nasturtium officinale	
Eleocharis sp.	
Juncus sp.	

12.2.2 Aquatic fauna

Fish

The study area provides habitat for several native and alien fish species.

Table 12.2 lists native species and alien fish species recorded by the ACT's Department of Territory and Municipal Services along the length of the Murrumbidgee River and Burra Creek and in the Googong Reservoir (Lintermans 2002; Lintermans 2001; Lintermans 2005).

Table 12.2 Fish species previously recorded in the Murrumbidgee River and Googong Reservoir

Scientific name	Common name	Upstream of Angle Crossing, Murrumbidgee River	Downstream of Angle Crossing, Murrumbidgee River	Burra Creek and Googong Reservoir
Native fish species				
Bidyanus bidyanus	Silver Perch	-	X	X stocked
Euastacus armartus	Murray Crayfish	X	X	-
Galaxias olidus	Mountain Galaxias	X	X	X
Hypseleotris sp.	Carp Gudgeon	-	X	X
Maccullochella macquariensis	Trout Cod	X stocked	X stocked	-
Maccullochella peeli peeli	Murray Cod	-	X	X stocked
Macquaria ambigua	Golden Perch	-	X	X stocked
Macquaria australasica	Macquarie Perch	X	X	X
Retropinna semoni	Australian Smelt	X	X	-
Alien fish species				
Carassius auratus	Goldfish	X	X	X
Cyprinus carpio	Carp	X	X	-
Gambusia holbrooki	Eastern Gambusia	X	X	X
Misgurnus anguillicaudatus	Oriental Weatherloach	X	X	-
Oncorhynchus mykiss	Rainbow Trout	X	X	X stocked
Perca fluviatilis	Redfin Perch	X	X	X
Salmo trutta	Brown Trout	X	X	X stocked

Alien fish species, Carp *Cyprinus carpio* and Oriental Weatherloach *Misgurnus anguillicaudatus* are common in the Murrumbidgee River. These species are present in the Googong catchment but have not yet been recorded in the Googong Reservoir (Lintermans, pers. comm. 2009).

Gigerline Gorge/Angle Crossing also represents the upper extent of the normal distribution range of a number of native fish such as Golden Perch *Macquaria ambigua*, Murray Cod *Maccullochella peeli peeli* and Silver Perch *Bidyanus bidyanus* (Lintermans 2005).

Other aquatic fauna

Burra Creek and Murrumbidgee River support a diverse assemblage of aquatic organisms other than fish. These include vertebrates such as turtles, water dragons and platypus as well as invertebrates. The diverse and abundant plant assemblage mainly in the pools is particularly important for ecology of the stream. The

aquatic plant life has been noted by several stakeholders as a valued stream attribute (e.g. Skinner undated), and it is certainly the key feature supporting much of the other biota. It will provide shelter for both vertebrate and invertebrate aquatic organisms, and periphytic algae growing on the aquatic plants are probably the major energy source for invertebrates which in turn provide the energy source for many of the vertebrates.

The Murrumbidgee River also provides habitat for other aquatic or semi-aquatic fauna including Eastern Water Dragons *Physignathus lesuerii*, Eastern Water Rat *Hydromys chrysogaster* and Long-necked Turtle *Chelodina longicollis*, all of which are relatively common in the area. Platypus *Ornithorhynchus anatinus* is also commonly sighted at Angle Crossing and is likely to be present through Gigerline Gorge. Murray River Crayfish *Euastacus armatus* and a variety of other macroinvertebrates and frogs also form an important part of the aquatic community.

Burra Creek also provides habitat for a diverse range of other aquatic animals including macroinvertebrates, Long-necked Turtle, frogs, Eastern Water Rat and Platypus.

An assessment of Burra Creek, as a likely habitat for Platypus, was undertaken in January 2009 (Grant 2009). No platypus was found. Based on an assessment of the current creek habitat and hydrology and past research undertaken, it is considered likely that, being an ephemeral stream, platypuses in Burra Creek may be reduced to low numbers (or even die out) during periods of extended low and/or no flows. The stream may be repopulated by dispersal from source populations, known to persist in the Queanbeyan River and/or the headwaters of the Googong Reservoir if flows increase. Habitat quality, even when the stream is flowing between pools, is assessed as low. The paucity of foraging areas, lack of connectivity between the remnant pools and between Burra Creek and the Queanbeyan River and/or headwaters of the Googong Reservoir suggests that, if still present, platypuses occupying Burra Creek would be in very low numbers and would be under stresses from a reduced availability of foraging areas and exposure to predation.

12.2.3 Threatened aquatic species

Threatened aquatic species presented in Table 12.3 are listed under the NSW *Fisheries Management Act 1994*, the ACT *Nature Conservation Act 1980* and/or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and have the potential to occur within the local area of both the Murrumbidgee River and Burra Creek.

None of the species in Table 12.3 was observed during the field surveys undertaken by Biosis Research within the Murrumbidgee River (2008) and Burra Creek (2007). However, existing data for the region indicates that the study area is considered to provide potential or known habitat for the majority of these species. Silver Perch and Murray Cod do not occur naturally above Gigerline Gorge and are only present as a stocked recreational fish in Googong Reservoir.

Murray River Crayfish *Euastacus armatus* are likely to occur in the study area of the proposed intake water transfer pipeline at Angle Crossing on the Murrumbidgee River (an Assessment of Significance for the Murray River Crayfish is provided in Appendix G2). There are no records of *E. armatus* within Burra Creek and as such Burra Creek has not been considered in this Assessment.

The NSW Department of Primary Industries has developed a number of recovery strategies for Trout Cod since the mid 1980s. Angle Crossing was considered a primary site in the stocking program up to 2004, with the latest stocking consisting of 15,000 fingerlings released in that year. These actions have been incorporated into the Recovery Plan for the species (NSW DPI Fisheries 2006). In 2006-2007, the stocking site for Trout Cod in this section of the Murrumbidgee River was relocated from Angle Crossing to an alternative site, Kambah Pool, located on the Murrumbidgee River 30.5 km downstream of Angle Crossing (Lisa Evans TAMS pers. comm).

ACT TAMS have prepared Action Plans for the Macquarie Perch, Murray River Crayfish, Trout Cod and Two-spined Blackfish in accordance with section 23 of the ACT *Nature Conservation Act 1980*.

12.2.4 Environmentally sensitive areas

The Murrumbidgee River Corridor is protected in the ACT under the *Murrumbidgee River Corridor Management Plan 1998.* Under the plan, a number of strategies are in place to conserve and protect the endemic aquatic, riparian and riverine ecosystems and aquatic animal species within the river corridor.

12.2.5 Invasive species

Flora

Localised infestations of African Lovegrass *Eragrostis curvula* were noted at both the Angle Crossing 'beach' on the Murrumbidgee River and on the lower banks of Burra Creek below the gauging station and roadsides during surveys undertaken in the study areas. *Eragrostis curvula* is a declared class 4 locally controlled noxious weed under the NSW *Noxious Weeds Act 1993*. Patches of exotic plants, particularly Blackberry *Rubus sp.* and *Eragrostis curvula* are common on the banks of the Murrumbidgee River. No in-stream aquatic weeds were recorded in the Murrumbidgee River.

The riparian zone at Burra Creek is predominantly cleared for agricultural purposes and is dominated by grass and patches of exotic species such as Willow *Salix sp.*, Blackberry, Poplar *Populus alba* and *P. nigra.* A number of Willow *Salix* sp. seedlings are established in Burra Creek below the gauging station. In-stream weeds include the Curly Pondweed *Potamogeton crispus*.

Fauna

Fish surveys undertaken by TAMS and previous studies undertaken and described by Biosis Research (2007) indicate that a number of invasive alien fish species are present in both the Murrumbidgee and Googong catchments. Table 12.4 presents the occurrence of invasive alien fish species surveyed in the catchments.

Two species of alien fish which are common in the Murrumbidgee River - Carp and Oriental Weatherloach - are not yet recorded in the Googong Reservoir. Carp *Cyprinus carpio* are however, present in many water bodies in the Googong catchment (Linetermans pers. comm. 2009). Oriental Weatherloach *Misgurnus anguillicaudatus* and Carp have been commonly recorded throughout the Angle Crossing area in the Murrumbidgee River.

Both of these species are present in the Queanbeyan River downstream of the Googong dam wall, with the spread of Oriental Weatherloach in particular related to its illegal use as bait fish by some anglers (Lintermans 1993, 2004; Lintermans and Burchmore 1996). Since the 1980s, Carp have been documented on at least two occasions from farm dams in the Googong catchment (Lintermans unpublished data).

Similarly, two large Carp individuals were recorded in the 1990 fish monitoring program for Googong Reservoir (Lintermans unpublished data), but they have not established a population. It is likely that the individuals captured in the reservoir and those detected in farm dams are the result of illegal introductions to farm dams in the catchment, and subsequent overflow events.

It is believed that this is how Redfin perch became established in Googong Reservoir (Lintermans unpublished). The increased settlement of the Googong catchment for residential housing is also likely to increase the chance of illegal introductions of undesirable fish species such as carp or Oriental Weatherloach.

Due to the invasive nature of Carp and their previous illegal introduction into farm dams within the Googong catchment, it is likely that the species may already be, or become, established in Googong Reservoir at some future point due to means other than this proposed water transfer project. . Carp are already present in farm dams within Googong system so the long term prospect of keeping them out of the reservoir is not good. However, Googong Reservoir has been maintained as a carp-free environment since its construction in the late 1970s, and efforts to exclude Carp from this water body will continue (Lintermans pers. comm., 2009).

EHN virus

The EHN virus is already well established in Googong Reservoir having first been confirmed in 1994 (Whittington et al. 1996), having previously caused fish kills. The virus is long-lived and resistant, and redfin perch are known to act as a host. To establish the presence of the virus within the reservoir now, or within Burra Creek would require the capture and collection of samples from tens, if not hundreds of fish. Detection of the virus in a single fish is proof that it is present in the system, but its absence cannot be proven. Event failure to detect the virus in 100 fish specimens would not prove it is absent.

The virus is not known to have been eliminated from any large water body in which it has been recorded, so it is most likely to still be present within the Googong Reservoir, and by extension, in Burra Creek. As it is known that viable virus has been confirmed to be present in the crop of piscivorous birds (Whittington et al. 1996) that have consumed infected fish, it is likely that the virus has spread further into the Burra creek drainage than fish movement alone would have distributed it. The exotic redfin perch (Perca fluviatilis) are a known reservoir for the virus and are present both in the Googong Pondage and in Burra Creek, and presumably, when flows are sufficient, they move between the two.

Table 12.3 Threatened aquatic species with the potential to occur in the region

Scientific name	Common Name	FM Act	NC Act	EPBC Act	Habitat	Potential habitat
Maccullochella macquariensis	Trout Cod	E	E	E	Inhabits large rivers and streams in the upper Murray Darling Basin often in fast flowing zones (NSW DPI Fisheries 2006). Associated with cover such as LWD, rock outcrops, boulders and deep holes (Growns et al. 2004).	Yes. Stocked into Angle Crossing from 1996 to 2004 for conservation purposes.
Bidyanus bidyanus	Silver Perch	V			Inhabits a variety of streams, rivers and lakes including slower sluggish rivers with LWD (NSW DPI 2005). It can be found in fast flowing waters but is not suited to the upper reaches of streams.	Yes. Recreationally stocked into Googong Reservoir.
Gadopsis bispinosus	Two-Spined Blackfish		V		Inhabits cool clear montane streams. Requires cobbles and boulders with interstitial spaces for shelter and breeding sites. Adult maintains a home range of approximately 10-15 m (Lintermans 1998).	No. Historically known from the Murrumbidgee River in the ACT.
Macquaria australasica	Macquarie Perch	E	E	E	Inhabits slow flowing sections of creeks, rivers and impoundments with suitable aquatic vegetation, rocks and snags. Requires access to flowing riffles for breeding.	Yes. Small wild population occurs in the Murrumbidgee River.
Maccullochella peeli peeli	Murray Cod			V	Inhabits a wide range of streams and rivers often in deep, slow flowing areas with good cover, such as LWD, undercut banks or overhanging vegetation.	Yes. Occurs in the Murrumbidgee River below Gigerline Gorge. Recreationally stocked into Googong Reservoir.
Euastacus armartus	Murray River Crayfish		V		Inhabits a variety of habitats from lowland rivers to streams. It prefers the faster deeper and cooler sections of the main channels of rivers. Digs burrows or utilises interstitial spaces for shelter.	Yes. Wild population occurs in the Murrumbidgee River.

Key: E-Endangered, V- Vulnerable, FM Act – NSW *Fisheries Management Act 1994*, NC Act – ACT *Nature Conservation Act 1980*, EPBC Act – Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Table 12.4 Invasive alien fish species present in the Murrumbidgee and Googong catchments

Scientific name	Common name	Upstream of Angle Crossing	Angle Crossing	Downstream of Angle Crossing	Burra Creek and Googong Reservoir
Cyprinus carpio	Carp	X	X	X	-
Carassius auratus	Goldfish	X	X	X	X
Oncorhynchus mykiss	Rainbow Trout	X	X	X	X[1]
Salmo trutta	Brown Trout	X	-	X	X (stocked)
Perca fluviatilis	Redfin Perch	X	-	X	X
Gambusia holbrooki	Eastern Gambusia	X	X	X	X
Misgurnus anguillicaudatus	Oriental Weatherloach	X	X	X	-

12.3 Impact assessment

12.3.1 Threatened species

Key thresholds -- NSW

The Part 3A Guidelines of the NSW *Environmental Planning and Assessment Act 1979* (DEC and DPI 2005) set out a number of key thresholds which need to be addressed to assess the potential impacts of the project on threatened biota. Table 12.5 provides a summary for each of the key thresholds that relate to threatened species and communities in the study area (see fig 12.2)

Table 12.5 Assessment of key thresholds

Threatened fauna	Will the project reduce the long term viability of a local population of the species or community?	Will the project accelerate the extinction of the species/community or place it at risk of extinction?	Will the project adversely affect critical habitat?
Trout Cod *Maccullochella macquariensis*	Potential for impact to this local population. Potential long term changes to flow regime, water quality and loss of instream habitat within Murrumbidgee River within study area and further downstream. Study site in close proximity to numerous valuable stocking sites.	Unlikely	No

Threatened fauna	Will the project reduce the long term viability of a local population of the species or community?	Will the project accelerate the extinction of the species/community or place it at risk of extinction?	Will the project adversely affect critical habitat?
Macquarie Perch ***Macquaria australasica***	Potential impact to this community. Potential long term changes to flow regime, water quality and loss of instream habitat within study area and further downstream.	Unlikely	No
Silver Perch ***Bidyanus bidyanus***	Minimal impact to this community. Potential long term changes to habitat availability and biodiversity values within study area and further downstream.	Unlikely	No

The fourth key threshold which applies to native biota and habitats in general is*: "Whether or not the project, including actions to avoid or mitigate impacts or compensate to prevent unavoidable impacts, will maintain or improve biodiversity values"*.

Application of the thresholds indicates that the project has the potential to result in some limited impacts on local populations in the Murrumbidgee River as described above, which will be managed by mitigation measures described in Section 12.5.

Positive impacts include potential benefits to fish passage within Burra Creek, which may constitute an improvement in habitat connectivity and breeding potential for threatened species.

Continued monitoring and adaptive management will reduce the potential for operational impacts. Overall the project is likely to maintain the biodiversity values of aquatic species and habitat in the study area.

ACT Aquatic Species and Riparian Zone Conservation Strategy (Action Plan No. 29)
ACT Action Plan 29 (The Aquatic Species and Riparian Zone Conservation Strategy) is intended to fulfill a number of roles including:

- Provide Action Plans for species listed as threatened under the Nature Conservation Act 1980;
- A multi-species strategy for the conservation of aquatic and riparian flora and fauna species, ecological communities and habitats;
- Acts as a source document on the rivers and riparian zones for ACT and Commonwealth Government agencies with responsibilities for nature conservation, planning and land management; and as
- A source document for community and other stakeholders with an interest in the conservation of aquatic and riparian flora and fauna species, ecological communities and habitats.

The central focus of this Strategy is on biodiversity and habitat conservation for the rivers and riparian zones, with some consideration of water resource management and recreation in relation to habitat and threatened species conservation. All actions have been considered as part of this environmental assessment in light of the Strategy Vision: *"The Murrumbidgee and Molonglo rivers in the ACT and their major tributaries make an outstanding contribution to the conservation of aquatic and riparian ecosystems of the upper Murrumbidgee River catchment."*

The strategy specifically lists sedimentation and reduction in flows as likely threatening processes to endangered fauna and these matters have been specifically considered in this Environmental Impact Statement.

Key threatening processes – ACT, NSW and Federal

Key threatening processes of relevance to the project and ACT, NSW and Federal listed species are discussed below.

Riparian vegetation degradation

Riparian vegetation is important to the aquatic values of the study area as it provides, shelter, bank protection, food and nutrients, protection from floods, potential breeding sites and is a future source of instream habitat (NSW *Fisheries Management Act 1994*). The riparian vegetation in the vicinity of the study area was considered to be in moderate condition. The project will result in the clearing of 0.02 ha of riparian vegetation along the Murrumbidgee River for construction.

Much of the riparian vegetation around rivers requires periodic inundation to reproduce and survive. Those species that benefit from periodic inundation include trees, shrubs and grasses. Other riparian species, such as *Typha* spp. and *Phragmites* spp., as well as sedges and rushes, grow at the margins of waterways, in a variable habitat that is more frequently inundated than the higher bank areas. Some species can grow in, or require, habitats below the low water level where their bases are permanently inundated.

While the waxing and waning of the emergent microphyte beds is a natural process, as the beds become very extensive they will displace other plants, and as they are not suitable habitat for all of the aquatic animal species, diversity will drop. Both *Typha* and *Phragmites* are rhizomatous, and underground rhizomes can survive droughts, floods and other stressors and resprout when conditions are suitable (Sainty and Jacobs 1981; Aston,1973).

The impact on these species of increased water depth associated with increased flows in Burra Creek is likely to be minimal, as the larger species (*Typha*, *Phragmites*) are able to grow in water up to around 1.5 m deep. The smaller species, such as *Juncus* and *Baumea* , are able to withstand periodic deep inundation, though long-term to permanent inundation of sedge and rush habitat will lead to a long-term change in species composition to submergent macrophytes, such as *Triglochin* species.

Riparian species, such as *Typha*, *Phragmites* and various sedges and rushes, have robust root and rhizome systems, which anchor them securely to the banks of waterways, as well as playing a role in increasing the size of patches of these species. Additionally, they have narrow or cylindrical stems that present minimal resistance to water movement.

These species are unlikely to be impacted by the proposed increased flows in Burra Creek. Extreme flooding events, such as those mentioned above, have the ability to impact on populations of these species, through scouring of bed and banks and directly washing away individual plants or even whole populations. However, smaller increases in flow, such as those associated with this project, are unlikely to cause the same stresses as floodwaters.

Typha and *Phragmites*, which grow mostly along the edges of the creek, dominate most of the riparian vegetation along Burra Creek. In some locations such as Pool 8 and Pool 37, as described in Chapter 10), *Typha* has grown across the width of the channel. Where *Typha* has grown across the channel, paths through the plants may develop, with water movement, but these are often associated with the plants bending and re-shaping, rather than being lost.

Besides *Typha* and *Phragmites*, the riparian zones of Burra Creek are somewhat species-depauperate, with some rushes, such as *Juncus* spp. and *Eleocharis* spp., but a lack of overstorey species and other upper-riparian species that may benefit from periodic inundation. A variable flow regime, produced by this project, may present an opportunity for revegetation efforts along the banks of Burra Creek.

There is potential for varying losses along the entire reach of Burra Creek during prolonged periods of continuous flow transfer or following large magnitude flood events, as described in Chapter 10, Section 10.3.1 and in Addendum 2 of Appendix D.

Should large areas of vegetation be removed either through natural processes such as floods, or through flow alterations remaining rootstock will recommence growing and spreading the following year, with *Typha* having been recorded as spreading from a single rhizome to cover 8 m^2 within 6 months (Sainty and Jacobs 1981).

Given the importance of riparian vegetation to aquatic habitats and fauna, the extent of coverage will be monitored and adaptively managed as described in Section 10.5

Transfer of fish outside their natural range

Fish introduced to waters outside their natural range can impact on native flora and fauna in a number of ways including predation, competition for resources, habitat degradation and by the spread of diseases (NSW *Fisheries Management Act 1994*). The project has the potential to introduce alien fish into Burra Creek from the Murrumbidgee River flows, in particular Oriental Weatherloach and Carp; both of which are not recorded within Burra Creek. However, these two species have populations above Angle Crossing within the Murrumbidgee River. Transfer of these species may have impacts on water quality, aquatic habitat, native species and recreational fishing

The potential for transferring alien species such as carp from the Murrumbidgee River to Burra Creek and Googong Reservoir is a significant risk which the proponent proposes to eliminate through the use of an effective intake screen including fish egg filtration units, with screen size of 0.5 mm, to prevent the transfer of fish, larvae and eggs. The effectiveness of this screen will also be monitored. Therefore the project is not likely to contribute to the operation of this key threatening process.

Instream structures and alteration of flow

Instream structures that modify natural flow may include dams, weirs, culverts, flow regulators, erosion control structures and causeways. Mechanisms that alter natural flow regimes include the operation of the above structures as well as water abstraction, pumping and diversion. Alteration to natural flow regimes can occur by reducing or increasing flows; altering the seasonality of flows; changing the frequency, duration, magnitude, timing, predictability and variability of flow events; altering surface and subsurface water levels; changing the rate of rise or fall of water levels; and by altering water temperatures.

The project will involve the use of temporary instream coffer dams to allow construction, an instream culvert, the low lift pump station extraction point upstream of Angle Crossing, and a outlet point within Burra Creek, which will potentially lead to an alteration to natural flow regimes.

The proposed coffer dam will be positioned around the construction site adjacent to a single bank of the Murrumbidgee River and will not interrupt flow. The proposed instream culvert at the low lift pump station will not comprise an additional barrier to fish passage beyond the obstruction that is already provided by Angle Crossing. Therefore the proposed works will not increase this key threatening process.

Impacts on environmental flows within the Murrumbidgee River, as a consequence of the abstraction at varying volume levels, were determined by ActewAGL (2009) in order to assess whether fish passage at Angle Crossing (or further downstream) will be significantly impacted. In the context of natural variation in flows the likely impact of the 100 ML/day abstraction on fish passage at Angle Crossing is anticipated to be minor (ActewAGL 2009). Therefore the proposed activity will not result in a significant increase in this key threatening process in the Murrumbidgee River.

The project will alter flows in Burra Creek, which will contribute to the operation of this key threatening process. The magnitude of adverse effects will depend on the magnitude, timing and duration of changes to the flow regime. This will result in a variety of effects on aquatic fauna, both positive and negative, as described in further detail below.

Assessment of Significance

The NSW Department of Environment and Conservation/NSW Department of Primary Industries (2005) guidelines set out criteria to identify potential effects of the project on threatened biota. Assessments of significance were undertaken for the NSW *Threatened Species Conservation Act 1995* listed Trout Cod, Macquarie Perch and the Googong Reservoir stocked population of Silver Perch and are included in Appendix 3 of Appendix G. Provided that the proposed mitigation measures are implemented and adaptive management and monitoring is undertaken, the project is not expected to have a significant impact on the Trout Cod, Macquarie Perch or Silver Perch populations within NSW.

Assessments of significance have been prepared according to the *Environment Protection and Biodiversity Conservation Act* significant impact criteria (DEH 2006) for species listed under the *Environment Protection and Biodiversity Conservation Act 1999* that have known or potential habitat within the study area. These assessments of significance concluded that provided that the proposed mitigation measures are implemented and adaptive management and monitoring is undertaken, the project is unlikely to have a significant impact on the Trout Cod, Macquarie Perch or Murray Cod (refer to Appendix 3 of Appendix G). Although there is unlikely to be a significant impact, the Trout Cod and Macquarie Perch may be sensitive to the removal of riparian vegetation, changes to hydrology and increased sedimentation. Given the *Environment Protection and Biodiversity Conservation Act 1999* listing of these threatened species, the Trout Cod's limited distribution and the conservation significance of local, stocked populations; and the Macquarie Perch's sensitivity to sedimentation and habitat alteration, the project will be referred to the Commonwealth Department of Environment, Water, Heritage and the Arts for further consideration.

The Murray River Crayfish (*Euastacus armatus*) is not listed in NSW or under Commonwealth legislation however, it is listed as Vulnerable under Section 21 of the ACT *Nature Conservation Act 1980*. No formal assessment criteria exist for assessment of the species in under the *Nature Conservation Act 1980* and as such the Assessment of Significance was developed in accordance with with s. 5A of the NSW EP & A Act. The assessment focussed on the *E armatus* populations within the study area on .the Murrumbidgee River, an area where this species is widely distributed. It has previously been recorded upstream and downstream of Angle Crossing (Lintermans 2002; Lintermans 2001; Lintermans 2005). Full details of the Assessment of Significance for the Murray River Crayfish is provided in Appendix G2.

12.3.2 Platypus

The proposed increase in flow has potential to impact upon Platypus, if present, in Burra Creek. No Platypus was encountered during the survey, but the species has been observed in Burra Creek by local residents. The proposed increase of up to 100 ML/day may induce a positive influence on any existing populations within Burra Creek. Increased flow may provide greater access to foraging areas and decreasing the risk of predation rising from the lack of suitable habitat (Grant 2009). Depending upon the timing and extent of flows, increased water levels may potentially have an impact on dependent young in nesting burrows during the breeding season (particularly November to February (Grant 2009)). The increase in flows will likely result in positive changes to Platypus food sources. Water transfers will provide additional habitat for macroinvertebrates and increase the foraging areas for Platypus by enhancing connectivity between pools (Grant and Bishop 1998; Grant 2009).

12.3.3 Fish passage

Murrumbidgee River

The Murrumbidgee River has a number of artificial and natural barriers to fish passage. These structures can impact on various species of fish by restricting movements during critical phases of their life history. Different species have different passage requirements and undertake movement at different scales and times of the year or life stage. Breeding movements of many species are correlated to high flow events. Many of the fish species in the study area have a pelagic larval stage which drifts with the flow downstream. The recruitment of larvae in downstream drift has been highly correlated to high flow events (King et al. 2005). Therefore, the upstream migration of either the adults prior to breeding or the juveniles may be important to maintaining recruitment in the local area.

The existing low level road crossing at Angle Crossing is considered to be a barrier to fish passage (refer Figure 12.3) at moderate to low flow levels for a number of native species which are known to occur within proximity of Angle Crossing, including the Macquarie Perch and Trout Cod. Although there are a number of significant natural barriers upstream and downstream, there are no major road crossings upstream for at least 50 km.

Figure 12.3 Angle Crossing causeway (looking upstream)

Quantifiable potential impacts on environmental flows within the Murrumbidgee River, as a consequence of the abstraction at varying volume levels, have been determined in order to assess whether fish passage at Angle Crossing (or further downstream) will be significantly impacted. The depth of water required for successful fish passage is dependant on the species and age class the fish passage is being designed for. The Angle Crossing barrier is known to restrict movement of Macquarie Perch and Trout Cod, which require roughly three times the body depth of the largest fish to successfully clear an instream barrier (Lintermans, pers. comm., 2009). For example, a 350 mm Macquarie Perch with a body depth of 120 mm will require, as a minimum, 360 mm of water over the crossing to clear the barrier. A 360 mm depth at Angle Crossing has a flow probability of 4% (4th percentile flow) so the impact of the 100 ML/day abstraction on such a large flow, and therefore on fish passage at Angle Crossing, will have a minor effect on fish passage compared to the current situation (ActewAGL 2009).

Burra Creek

It is likely that during water transfer periods, Burra Creek could provide improved habitat for a number of species including the exotic Rainbow Trout and Brown Trout and potentially the Macquarie Perch, Silver Perch and Golden Perch. Trout species migrate out of lakes and into streams to spawn, but will not navigate through shallow or warm water. Flow transfers may benefit these fish through the subsequent increase in channel depth and reduced in stream temperatures, particularly if flows are released during late autumn and winter. It is also likely that during non-transfer periods any increased trout population in Burra Creek will either move back into Googong Reservoir or, if isolated, perish. Although transfer flows may benefit trout, the movement of trout into the upper reaches of Burra Creek may increase predation pressures on any surviving population of Mountain Galaxias *Galaxias olidus* (a native species although not threatened) and other small and juvenile native fish species.

Increased flows in Burra Creek may create access to suitable spawning sites for Macquarie Perch moving upstream out of Googong Reservoir. There are no known significant barriers to fish passage in Burra Creek until London Bridge and the pools and riffle/run habitat which will be created during transfer could be suitable for Macquarie Perch, which disperse eggs in the tail of pools. This will require fairly consistent high flows between November and January. There are, however, knowledge gaps and constraints to Burra Creek being suitable as a Macquarie Perch spawning site, including the presence of highly predatory fish such as Redfin Perch and trout, the viability of the population in Googong Reservoir and the species fidelity to breeding sites in the Queanbeyan River. If Macquarie Perch did migrate into Burra Creek, the shallow alluvial section below London Bridge may be hazardous through bird predation, which is a known threat to Macquarie Perch breeding migrations in the ACT region (Lintermans and Osborne 2002).

Habitat for the Silver Perch that may potentially be impacted as a result of the water transfer includes creek lines, submerged riparian vegetation and areas of large woody debris within Burra Creek and Googong Reservoir. These habitats provide foraging, sheltering and breeding resources for the Silver Perch. However, the range of habitat currently utilised by Silver Perch within Burra Creek is considered minimal and it is not certain whether the stocked Silver Perch population will undertake natural spawning movements on a large scale (Lintermans 2005). Therefore the potential impact on fish passage for Silver Perch is considered low.

Overall, fish passage in Burra Creek is likely to be positively affected by an increase in regular flows as a result of the project. Monitoring of the behavioral changes in fish populations within the catchment, in response to the increase in habitat connectivity between Burra Creek and the Googong Reservoir, will help determine if annual breeding migrations are initiated which will be managed through adaptive management processes. The proposed monitoring will inform future reviews of environmental flow guidelines and help define operating rules.

12.3.4 Bank stability and vegetation

Murrumbidgee River

The habitat survey in this report was conducted during a flow of 55 ML/day at Lobbs Hole. During this survey, potential barriers and riffle habitat were observed within the study area of the Murrumbidgee River where minimum channel depths in riffles (except Angle Crossing) were approximately 0.2 m. Structural habitat availability, particularly in riffles, is highly dependent upon channel morphology and influenced flow volume (Maddock *et al.* 2004). As well as providing important habitat variation, riffles are important breeding habitats for a number of native species including Macquarie Perch and Mountain Galaxias *Galaxias olidus*. However, shallow riffles and falls can create partial and significant barriers to fish passages at moderate and low flow levels. Minimisation of the impact to the availability of riffle habitat and reducing the exacerbation of fish barriers is considered important for the maintenance of the aquatic ecosystem through Gigerline Gorge and the Tharwa Sandwash.

The proposed volume of abstraction (limited between 0-100 ML/day) is unlikely to have a significant effect upon channel maintenance flows or flooding flows. Historical high flow events generally greatly exceed the flow rate of 100 ML/day. As such, the abstraction rate will be less than 10% of the known high flow events and is not expected to cause a significant impact to the existing aquatic habitat in the Murrumbidgee River (as discussed in Section 9.3.3).

Burra Creek

Section 10.3.2 identifies that about 12% of the total banks along Burra Creek have varying degrees of erosion potential. Damage to these banks could have adverse impacts on aquatic ecology. The monitoring and adaptive management measures proposed designed in Section 10.5 are designed to address this potential.

12.3.5 Water quality

Water chemistry has a potential influence on the aquatic ecosystems.. As discussed in Chapter 11 limited representative data is available on the chemistry of Burra Creek. However it is evident that the creek water is influenced by limestone outcrops of limited extent in the catchment and along the creek bed. Consequently Burra Creek is expected to have relatively higher electrical conductivity, lower turbidity and higher pH compared with the Murrumbidgee, and most other south-eastern Australian streams which do not have karst influences.

Transferring water from the Murrumbidgee River to Burra Creek has the potential to alter the water quality of Burra Creek, with flow-on potential impacts on the aquatic ecosystems in the creek. The responses of aquatic plants and animals to changes in water chemistry are not easily predicted.

Key components of the Burra Creek aquatic ecosystem are the submergent plants such as *Chara*, *Myriophyllum* and *Ranunculus* species. These are the most conspicuous and unusual in extent of the biota that provide structural habitat and cover for the aquatic invertebrates, fish, turtles and other vertebrates. Aquatic macrophytes actively grow during the summer when there is more light available and water temperatures are higher. For most of them, growth ceases during winter, and some species die off during winter. So the key to maintaining the submerged macrophytes will be maintaining suitable conditions for growth during the summer. Variations in water chemistry are unlikely to be an issue from April to September when the plants are not actively growing.

Over the summer growth period water transfers are pumping forecast to be intermittent with modelling suggesting pumping will occur for an average of 22 days between December and February. During periods with no pumping, groundwater inflow is expected to greatly assist flow Burra Creek to revert to it's the natural water chemistry. Such a pattern should result in minimal ecological impact on the creek.

ACTEW proposes to establish appropriate water quality trigger levels for Burra Creek in accord with the approach outlined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000). Any exceedances of water quality triggers will result in management actions to intensify monitoring of biological indicators. Any observed trends toward significant adverse impacts will trigger adjustment of the operating regimes.

The water quality within the Murrumbidgee River may be temporarily impacted during the construction and operational phases of the development, as a result of increased bank erosion and sedimentation, increased turbidity and decreased light penetration. However as noted in chapter 11, the project is unlikely to result in significant or long term impacts on the water quality of the Murrumbidgee River.

12.3.6 Abstraction impacts on fish

Abstraction from rivers may have negative effects on adult and juvenile fish (Baumgartner et al. 2007). There are three processes associated with abstraction outtakes which can result in mortality, injury, loss and/or translocation of fish (Lintermans and Phillips 2005; King and O'Connor 2007):

- Impingement – fish being caught on or in the pumps screens;
- Entrapment – fish moving through pipes or channels are harmed by pumps and pressure changes in the pipe and/or transferred to the receiving water body; and
- Predation – increased risk of predation of fish congregating at the off take.

As the off take is located in the vicinity of an existing in stream barrier it is unlikely to result in an increase in the risk of congregation and predation. Nonetheless, mitigation of these effects is a high priority to reduce the potential for impacts upon threatened species and other aquatic fauna in the Murrumbidgee River. The

proposed low flow velocities at the off take will decrease the risk of impingement. The proposed fish egg filtration units, with screen size of 0.5 mm, will prevent juvenile and adult fish passing through the screen and becoming entrained in the pipe. Based on the above considerations abstraction is unlikely to result in significant negative impacts on fish.

12.3.7 Recreational fishing

Many important fish species in urban lakes are not exposed to the necessary environmental conditions required to facilitate successful breeding and recruitment (TAMS 2009). ACT TAMS has routinely stocked lakes, streams and reservoirs to maintain populations of native fish. A total of 181,610 Murray Cod fingerlings and 306,000 Silver Perch have been stocked into Googong Reservoir by ACT TAMS since 1981.

Regular discharges of water into Burra Creek may create attractive habitat for fish currently residing within Googong Reservoir, encouraging fish (native and non-native) up stream. The alteration of Burra Creek may increase pressure from anglers on both natural and stocked populations within the Googong Reservoir and Burra Creek.

12.3.8 Alien species

Two alien species, Carp and Oriental Weatherloach are considered a high risk for translocation as they are known or suspected to be present in reasonable numbers at Angle Crossing, are hardy, known to impact native fish communities, breed in the Murrumbidgee River and are not yet established in Googong Reservoir (Lintermans, pers. comm., 2009). Potential impacts on Googong Reservoir may include: reduced water quality; introduction of disease and parasites, alteration to habitat; predation upon fish eggs and juveniles and competition with native species. Access to Googong Reservoir will increase the risk of them invading the more significant conservation reaches of the upper Queanbeyan River.

The proposed pipeline is not the only potential vector for the introduction of these or other species and pathogens into the Googong Reservoir Catchment. Carp are known to be present in the Googong catchment (Lintermans pers. comm. 2009) and so there is already a risk of their transfer to the reservoir independent of the pipeline's operation.

A mesh size of 0.5 mm on the proposed intake screen to prevent transfer of fish and eggs is proposed to manage and mitigate the risk (as described in Chapter 6).

This system and screen size is similar to a carp exclusion screen in operation at NSW Department of Primary Industries Narrandera Fisheries Research Centre. NSW Department of Primary Industries experience indicates that this filter will effectively prevent transfer of viable carp and Oriental Weatherloach eggs. Their experience covers an 18 year period with a filter which operates at similar velocities to the one proposed. This finding is supported by research at the Cooperative Research Centre for Freshwater Ecology by Smith, BB and Walker KF (Journal of Fish Biology 2004 64, 336 - 354) who investigated egg size for carp in the River Murray. They found immature carp eggs (oocytes) to be 0.5-1 mm diameter, developing oocytes to be around 1 mm, but all hydrated eggs (the ones that are released during spawning for fertilisation) to be >1 mm and up to around 1.2 mm. Therefore a 0.5 mm screen should be particularly safe since smaller immature eggs are not fertilised or released and therefore present no problem. Work at Rocklands reservoir (Briefing Paper 4, URS Australia Pty Ltd, Lloyds Environmental Consultants, Oct 2003) further indicates viable carp eggs are greater than 0.8 mm diameter and therefore will be eliminated by a 0.5 mm screen.

The proponent has also investigated the likelihood of fish larvae crossing the filter screens. The research concludes that carp larvae may exist down to a width of 0.64 mm, which indicates that the screens should also effectively prevent larvae transfer (Rockland res reference, and pers comm, Dr P Humphries, School of Environmental Sciences, Charles Sturt Uni).

The proposed filtering system will likely be sufficient to ensure that best practice methods are employed to minimise the potential risk for the transfer of fish in all their life stages. The pumps and pipeline may provide further barrier. Given the significant environmental risk associated with transferring alien species such as carp from the Murrumbidgee River to Burra Creek and Googong Reservoir the proponent is planning to do further research on this subject

12.3.9 Environmentally sensitive areas

The Murrumbidgee River Corridor is defined as an environmentally sensitive area under the ACT *Planning and Development Act 2007*.

Design impacts

The proposed design of the intake and low lift pump station is not expected to significantly impact the aquatic ecology of the Murrumbidgee River. The design and proposed site of the structure incorporates design elements which aim to minimise impact on environmental flows and the surrounding bank structure.

Construction impacts

Construction of the intake/low lift pump station will involve excavation within the river bank. There is potential for site blasting to occur. Existing bank vegetation, primarily grasses and shrubs and few trees will be removed. Such potential impacts may result in the introduction of increased sediments entering the river and flowing downstream. Erosion and sediment control measures manage and mitigate such events.

The proposed construction area is predicted to lie above bedrock, and therefore a coffer dam comprising H-piles will be driven into bedrock. The construction and removal of the rock platform may temporarily impact natural flow movement within the river and lead to small-scale and localised erosion of sediments as flow patterns are altered by the construction. However, due to the large width and shallow depths of the river, the impact is likely to be small-scaled and not significant.

Operational impacts

The off take screens design incorporates structural steel rectangular hollow sections installed in removable panels spaced 25 mm apart. This will prevent fish >25 mm entering the intake chambers. The intake/low lift pump station has been designed to keep intake velocities below that which will hold flotsam and fish against the bars. The physical nature of the intake/low lift pump station may be susceptible to sediment scouring and resulting erosion, particularly during high flow and flood events. Such scouring may entrain undesirable levels of sediment within the river or create potential hazards to aquatic fauna and riparian vegetation as softer, unconsolidated bank structures erode around the intake/low lift pump station.

Mobilised sediment and silt entrained within the flows will be screened at the intake and flushed into an eductor pipeline which will discharge into the Murrumbidgee River. The proposed regular release of captured sediments from within the intake back into the river flows will result in frequent plumes of sediment downstream of Angle Crossing. Potential impacts may comprise smothering of aquatic species and changes to the physical structure of the river bed including the loss of ecologically valuable interstitial spaces. The exact extent of the potential impacts of the sediment release cannot be determined, as entrained sediment levels within the Murrumbidgee River fluctuate temporally. However, continued monitoring once the system is activated will assist in identifying the residual impacts and minor adjustments to the timers or release volumes could be implemented to further reduce potential impacts.

12.3.10 Noise and vibration impacts

Fish can be affected by intense noise exposure and the masking of biologically relevant sounds by ambient noise (Popper 2003). The construction phase of the project will involve noise and vibration that may cause temporary disturbance to aquatic habitats in the vicinity of the works. It is expected that avoidance will occur as a first reaction. Minor additional raised levels of background noise and vibration will be experienced during the operation of the intake/low lift pump station and high lift pump station at Angle Crossing. The design of the intake/low lift pump station and high lift pump station will incorporate measures to minimise operational noise and vibration. Therefore the proposed activity is unlikely to result in significant noise and vibration impacts on aquatic environments.

12.3.11 Murray River Crayfish

E armatus has been recorded throughout the greater Murray-Darling River System and specifically along the Murrumbidgee River both upstream and downstream of the Study Area. The area impacted upon by the project does not constitute the limit of the species distribution within this river system.

The preferred project has the potential to impact *Euastacus armatus* populations occurring in the Murrumbidgee River and it is likely to impact upon the Murray River Crayfish lifecycle in the immediate vicinity of the offtake structure. As extraction will be limited to protect base level flows within the Murrumbidgee River (in accordance with the ACT environmental flow guidelines) and modelling indicates downstream flows are unlikely to be significantly altered, the project is not likely cause significant adverse impacts upon the lifecycle of *E armatus* that could threaten the survival of the species at a state-wide level.

Flow modelling undertaken indicates that minimum flows will be protected and any reduction in available flows in the downstream river system wil not be significant. Riffle habitats used by *E armatus* are not expected to be significantly impacted upon, even at maximum abstraction as the flow reductions will be most significant immediately below the Angle Crossing, where the river is wide and shallow and the associated impact therefore will be low.

The water quality and hydrology of the Murrumbidgee River is not predicted to be significantly impacted upon in the long term as a result of the proposed works. It is predicted the water quality within the Murrumbidgee River may see a temporary decline during the construction and operational phases of the development. With movement of heavy equipment and materials, there is potential to cause degradation of banks and surrounding ground vegetation that could lead to an increase in soil loss and exposure. This may result in increased sedimentation within the vicinity of the Angle Crossing and the initial construction phases would likely introduce greater levels than normal of sediments increasing turbidity, and decreasing light penetration.

If sediment is introduced to the river at a significant level the project is likely to impact upon habitat availability for this species to the extent of the infilling of interstitial spacing between rocks within the Murrumbidgee River. This will also be the case if water levels decline significantly downstream of the extraction point. Modelling of water levels downstream and suggested management strategies (i.e. containment of sediment during construction) indicate that both these impacts will be managed so that impacts upon habitats for *E armatus* will be temporary at worst and therefore should not be significant.

The extent of impact upon habitats is unknown due to gaps in knowledge relating to the species exploitation of micro-habitats. Providing sedimentation, which potentially impacts upon both habitat availability and food supply, is suitably contained, and reduced downstream water levels remain adequate to sustain interstitial spaces between boulders and cobbles on the riverbed, adverse impacts upon this species should be largely limited.

The pipeline has the potential to impart some direct and indirect adverse impacts upon habitat at the offtake site and downstream during construction and rehabilitation project stages as a result of increased turbidity in waterways in the vicinity of the project. In addition construction in the vicinity of permanent waterways, construction through ephemeral waterways and minor gullies and the construction of haul roads also has the potential to generate suspended solids and increased turbidity in downstream waterways if significant rainfall occurs during the construction period. There is considerable opportunity to limit these impacts via implementation of mitigation strategies to be developed as part of the Construction Environmental Management Plan.

12.4 Summary of results

The study area is known or likely to support a number of threatened fish species including Trout Cod, Macquarie Perch, Silver Perch, and the Murray Cod. These species were assessed under the ACT, NSW and Federal threatened species provisions including assessment of significance and application of significant impact criteria. The outcome of these assessments is that it is unlikely that the project will cause a significant impact on any populations of the Macquarie Perch, Silver Perch, Trout Cod or the Murray Cod. There is the potential for residual impacts on the *Environment Protection and Biodiversity Conservation Act* listed Trout Cod and Macquarie Perch and so the project was referred to Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) for further consideration.

Proposed mitigating actions during construction will minimise the effect of silt and suspended particles in the near vicinity of the work. In view of the negligible impact on Murrumbidgee water quality as a result of water extraction, the proposed mitigation measures to control suspended particles and sediment during construction, and the construction's temporary nature, the overall potential impact of the project on the Murrumbidgee River water quality and the River's aquatic ecosystems is assessed as being low.

The change in depth at Angle Crossing causeway during most flow conditions will have negligible impact on its current status as a significant man made obstruction to fish passage. When fish passage is possible, during very high flow events, any abstraction will have a minimal impact on flow depths and hence on fish passage.

The off take screen will be designed to prevent adult and juvenile fish as well as eggs being impinged or transferred through the pipeline and is not expected to significantly impact threatened fish species within the Murrumbidgee River.

There is a risk that two alien species, Carp and Oriental Weatherloach could be transferred via the pipeline as they are known or suspected to be present in reasonable numbers at Angle Crossing, are hardy, known to impact native fish communities, breed in the Murrumbidgee River and are not yet established in Googong Reservoir. Carp is, however present elsewhere in the Googong catchment (Lintermans pers. comm.). The potential impact of these two alien fish in Googong Reservoir if their transfer is not prevented may include: reduced water quality; introduction of disease and parasites, alteration to habitat, predation upon fish eggs and juveniles and competition with native species. Access to Googong Reservoir will increase the risk of them invading the more significant conservation reaches of the upper Queanbeyan River. The proponent proposes to prevent transfer of alien species through the use of an effective intake screen with a mesh size of 0.5 mm.

The fish disease EHN virus is known to exist within the Googong Reservoir. The current degree of infection within Burra Creek is unknown but the presence of the virus is considered highly likely (M Lintermans pers. comm. 2009).

Given the relatively low amount of water to be abstracted from the Murrumbidgee River and ACTEW's requirement to protect environmental flows in the river, and applying an adaptive management approach to monitoring results during the operation of the project, it is unlikely that there will be a significant impact on the flora and fauna of the river under projected operating conditions.

The aquatic ecosystems of Burra Creek were considered to be in a poor condition in the upper sections and moderate condition in the lower section. Despite this the waterway supports, or has the potential to support, a number of fish and other aquatic fauna including platypus and turtles. Although no threatened species were recorded during fish sampling, the local area is known to have potential habitat for three threatened species, with two additional species present in the Murrumbidgee River.

The use of Burra Creek for run-of-river transfers has the potential to modify habitat through adverse impacts to macrophyte beds and increased mobilisation of sediment. The additional flow in Burra Creek will impact on the narrow channel in which the flow is contained by scouring some sediment from the channel reducing the extent of reed beds and impacting on macroinvertebrate communities. Given the relatively low flow velocities and depths, and the intermittent nature of flow it is expected this impact will be low to moderate. Submergent macrophytes, are a key component of the Burra Creek ecosystem. They will be monitored and impact will trigger adjustment of operating regimes.

12.5 Mitigation measures

12.5.1 Design

Design measures into the project, to prevent the spread of invasive fish species including:

- Undertake additional research into viable carp egg size to make certain the mesh size is small enough to prevent the transfer of fish and eggs;
- Research additional practical fish egg screening experience in the USA;
- A proposed mesh size on the intake screen of 0.5 mm to prevent transfer of fish and eggs;
- Provide continuous filtering and monitoring of transfer flows at the outlet into Burra Creek;
- Use the filters year round, rather than only during the spawning season; and
- Investigate the known current presence of carp in the near vicinity of Googong Reservoir, within the Googong catchment.

12.5.2 Construction

An aquatic ecology management sub-plan will be prepared as part of the construction environmental management plan (CEMP), outlining the procedures to manage and minimise the potential for impact to aquatic environments. The plan will include the following:

- During any near stream works such as trenching or excavating, water quality will be protected under a the construction environmental management plan, including suitably designed and maintained sediment and turbidity controls designed to cope with a greater than average rainfall and/or flow event and regularly inspected and maintained throughout the construction and rehabilitation phase;
- Avoid undertaking excavation or other works in or near the Murrumbidgee River or Burra Creek during periods of actual or predicted heavy rain or higher than average flows;
- Appropriate sediment and erosion control measures must be employed throughout the extent of the project to protect the aquatic habitats and adjoining areas supporting native vegetation. Mesh netting will not be used as part of the sediment and erosion control measures as it has the ability to trap, kill and/or injure fauna trying to pass through;
- Rock and earth resources utilised to construct the pile rig base will be natural and locally sourced, and removed and reinstated upon completion of the construction works;
- Any waters extracted from the proposed coffer dams must be certified clean from contamination (oils, spills) associated with the construction before release back into the Murrumbidgee River;
- A detailed spill and contamination measures and emergency and remediation measures will be included in the construction environment monitoring plan;
- Inspection of river and creek banks within the construction footprint for Platypus burrow entrances and careful excavation in small scoops with an un-toothed bucket in case a lactating female and/or dependent young are present;
- Arrangements for the transfer of any dependent Platypus young to an establishment with established protocols for rearing platypus young (e.g. Taronga Zoo, Sydney) and any adults found in burrow to be left to return to the stream or to be captured and released; and
- Rehabilitation of aquatic ecology impacted by pipeline construction at waterway crossings will be undertaken as soon as practical following the completion of construction, in particular at Crossing No. 6 (as identified in chapter 9) which contains riparian vegetation and aquatic macrophytes in stream.

The proposed development is not expected to have a significant impact on the *E armatus* Murray River Crayfish population within the ACT. As minimum standard, to comply with species recovery plans management strategies will include:

- Turbidity controls to ensure water quality standards comply with the relevant guideline/ agreed standards;
- Monitoring and reporting of turbidity upstream and downstream of construction locations;
- All stream bed and banks will be reinstated and revegetated with appropriate species to ensure long term bank stability;
- The Inlet structure is designed to minimise the potential entrainment of Murray Spiny Cray into the flow of the pipe. This will be achieved by limiting the inlet velocity to less than 0.5 m/s, and preferably 0.1 m/s;
- The inlet structure has the potential to accumulate silt in the base of structure. During occasional maintenance operations this silt may need to be removed. If silt is to be discharged back to the Murrumbidgee River it should not be done so in a concentrated plume;
- Remove individuals in the vicinity of the intake structure during construction and relocate them immediately upstream of the work site.

12.5.3 Operation

Aquatic environments

An aquatic ecology management sub-plan will be prepared as part of the operation environmental management plan, outlining the procedures to manage and minimise the potential for impact to aquatic environments. The plan will include the following:

- Monitoring of Murrumbidgee River minimum environmental flows against ACT Environmental Flow Guidelines;
- Major changes in flow release into Burra Creek will be stepped up and down over a period of 48 hours to reduce the likelihood of stranding, drowning or washing aquatic and semi aquatic fauna downstream;
- The rehabilitation plan will include implementation of a riparian rehabilitation and weed management measures. Areas to be focused on include those identified by the fluvial geomorphic assessment (Appendix D, Addendum 2) as having the potential to be undercut by transfer flows; and

Monitoring programs linked to an adaptive management strategy. The following additional mitigation measures will be implemented during operation at both the Murrumbidgee River and Burra Creek to mitigate potential impacts:

- When the project is in standby mode, the pumps will be exercised on a monthly basis, which will result in a progressive turnover of water in the pipeline;
- Installation of grit collection hopper at the low lift pump station and discharge of captured sediments back to the Murrumbidgee River to reduce the turbidity of water transferred to Burra Creek. Use of an automatic timer on the grit collection hopper to ensure that relatively small volumes of sediments are discharged on a frequent basis to reduce impacts on the Murrumbidgee River downstream. Ongoing monitoring and appropriate adjustments to the timers or release volumes to minimise potential impacts; and
- If threatened fish species were found to be spawning within Burra Creek, flow transfers will be maintained where possible during the breeding season to protect the spawning populations. If flows must be altered, the 48 hour step up/down operating regime will be utilised to allow fish to exit the creek.

Monitoring and adaptive management program

A more intensive monitoring program has commenced to monitor and evaluate the construction and operational impacts to the aquatic ecological values with results feeding back into adaptive management of the abstraction and discharge. Monitoring outcomes will be used to inform reviews of future environmental flow objectives and guidelines, as well as, to inform the operating rules for the system.

Establishment of appropriate water quality trigger levels for Burra Creek in accord with the approach outlined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000). Exceedances of water quality triggers will result in management actions to intensify monitoring of key ecological indicators. Any observed trends toward significant adverse impacts will further trigger adjustment of the operating regimes. The modified "Burra Creek" triggers may be applied to assess compliance with the Protection of the Environment Operations Act 1997, or as conditions of any Environment Protection Licence issued under that Act.

The monitoring programs for the Murrumbidgee includes the following:

- *Physical habitat and hydrology:* Physical habitat and hydrology monitoring to assess the potential impacts of reductions in flow below Angle Crossing;
- *Water quality:* within Murrumbidgee River below the abstraction intake, notably to detect any increases in turbidity arising from the operation of the low lift pump station grit collection hopper sumps;
- *Macroinvertebrates:* Australian River Assessment System (AusRivAS) monitoring to assess the potential impact of changes in habitat and flow on the macroinvertebrate community; and
- *Fish:* Fish monitoring programs to determine the potential impacts to the fish community such as fish passage and breeding events.

Monitoring of Burra Creek includes the following:

- *Aquatic habitat changes*: Monitoring the extent of change to macrophyte beds as the increased flow is likely to reduce the area of occupancy via scouring, changed substrate and microhabitat availability;
- *Water quality*: Monitor the extent of change to the specific physio-chemical attributes of the Burra Creek system as the increased flow is likely to reduce the mean temperature, alkalinity and pH, and increase turbidity;
- *Macroinvertebrates*: Quantitative macroinvertebrate in addition to AusRivAS surveys as altered abundance of some sensitive species may not be picked up by presence/absence based assessments like AusRivAS;
- *Fish:* Surveys of Burra Creek to determine changes in fish community will identify if and how Burra Creek is being used by fish from Googong Reservoir and will assist in the detection of any translocations of alien species; and
- Alien fish / fish egg transfer, to determine if fish eggs are being transferred through the pipeline into Burra Creek (particularly during the breeding season from October through April).

The monitoring and management of the Murrumbidgee will be conducted in consultation with the relevant government agencies and will have regard to the conservation strategy for the Murrumbidgee River downstream from Angle Crossing as described in Chapter 5 of the ACT Aquatic Species and Riparian Zone Conservation Strategy (Action Plan No. 29).