

Appendix G

G1 Aquatic impact assessment with addendum

G2 Assessment of significance for the
Murray River Crayfish



Murrumbidgee to Googong Water Transfer Project: Aquatic Impact Assessment

June 2009

Biosis Research Pty. Ltd.

Report for: ACTEW

Murrumbidgee to Googong
Water Transfer Project: Aquatic
Impact Assessment

June 2009

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ACKNOWLEDGMENTS

Biosis Research acknowledges the contribution of the following people and organisations in preparing this report:

- Robert Suansri (GIS Operator, Biosis Research)
- Tom O’Sullivan (Queanbeyan Resource Group Manger, Biosis Research)
- Rhidian Harrington (Sydney Resource Group Manager, Biosis Research)
- Kirsten Crosby (Zoologist, Biosis Research)
- Chris Blink (Aquatic Ecologist, Biosis Research)
- Jennifer Charlton (Zoologist, Biosis Research)
- Melissa Starling (Zoologist, Biosis Research)

Background data and field surveys presented in this report are taken from two previous reports by Biosis Research: Aquatic Ecology Assessment of Burra Creek, NSW (2007); Final Draft Murrumbidgee to Googong Pipeline: Interim Aquatic Advice (2008)’, Authored by Matthew Beitzel and David Ryan.

ABBREVIATIONS AND DEFINITIONS

Alien species	Exotic fish species breeding in the wild
ANZECC	Australian and New Zealand Environment Conservation Council
ARI	Average Recurrence Interval
AUSRIVAS	Australian River Assessment System
CAAB	Census of Australian Aquatic Biota
DEWHA	Department of the Environment and Water Heritage and the Arts
DO	Dissolved Oxygen
DPI	Department of Primary Industries (Fisheries)
DWE	Department of Water and Energy
EIS	Environmental Impact Statement
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i>
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
FM Act	<i>Fisheries Management Act 1994</i>
KTP	Key Threatening Process
HLPS	High Lift Pump Station
LGA	Local Government Area
LLPS	Low Lift Pump Station

LWD	Large Woody Debris
MDBC	Murray Darling Basin Commission, recently changed to the Murray Darling Basin Authority
MNES	Matter of National Environmental Significance
NTU	Nephelometric Turbidity Units
sp.	Species (singular)
spp.	Species (plural)
ssp.	Subspecies
Study Area	Subject site and any additional areas which are likely to be affected by the proposal, either directly or indirectly
Study Site	Area directly affected by the proposal
TAMS	ACT Territory and Municipal Services
Thalweg	Deep fast-flowing section of a waterway
WM Act	<i>Water Management Act 2000</i>

CONTENTS

ACKNOWLEDGMENTS	III
ABBREVIATIONS AND DEFINITIONS	III
CONTENTS	V
1.0 SUMMARY	1
• Murrumbidgee River.....	3
• Burra Creek	3
2.0 INTRODUCTION	7
2.1 Purpose of this report	7
2.2 Project overview	7
2.3 The location of the project	8
2.4 Aims	8
2.5 Study Area	9
2.6 Proposed Works	9
2.6.1 Murrumbidgee River	10
2.6.2 Burra Creek.....	11
2.7 Legislation	12
3.0 METHODOLOGY	14
3.1 Taxonomy	14
3.2 Database Review	14
3.3 Aquatic Survey	15
3.3.1 Habitat Assessment.....	15
3.3.2 Aquatic Habitat Condition Assessment.....	16
3.3.3 DPI Fish Habitat Classification.....	16
3.3.4 Fish Survey	17
3.4 Limitations	17
4.0 RESULTS	19
4.1 Database Review	19
4.2 Aquatic Habitats	20
4.2.1 Murrumbidgee River (ACT).....	20
4.2.2 Burra Creek (NSW).....	23
4.3 Aquatic Fauna	24
4.3.1 Fish	24
4.3.2 Other Aquatic Fauna.....	29
5.0 IMPACT ASSESSMENT	30
5.1 ACT	30
5.2 NSW	30
5.2.1 Key Threatening Processes.....	30
5.2.2 Key Thresholds for Threatened Species	32
5.2.3 NSW Assessments of Significance (Part 3A)	33
5.3 Commonwealth EPBC ACT Assessments of Significance	34
5.3.1 Threatened Species.....	34

5.3.2	Commonwealth Land	34
5.3.3	Referral	35
5.4	Environmental Flows.....	36
5.4.1	Murrumbidgee River (ACT).....	36
5.4.2	Burra Creek (NSW).....	40
5.5	Fish Passage	44
5.5.1	Murrumbidgee River (ACT).....	44
5.5.2	Burra Creek (NSW).....	45
5.6	Design and Operation Impacts.....	48
5.7	Construction Impacts	49
5.7.1	Murrumbidgee River Construction Impacts (ACT).....	49
5.7.2	Burra Creek Construction Impacts (NSW).....	50
5.8	Intake Issues.....	51
5.8.1	Potential for interbasin transfer of fish	52
5.8.2	Potential for transfer of pathogens.....	54
5.9	Bank Stability and Vegetation	55
5.10	Water Quality	57
5.10.1	Turbidity	58
5.10.2	Nutrients.....	59
5.10.3	Dissolved Oxygen	60
5.10.4	pH.....	61
5.10.5	Temperature.....	62
5.10.6	Major Ions	63
5.10.7	Faecal Coliforms	64
5.10.8	Algal Blooms	65
5.10.9	Recreational Fishing	66
5.11	Noise and Vibration	67
6.0	RECOMMENDATIONS	69
6.1	Environmental Flows.....	69
6.1.1	Murrumbidgee River	69
6.1.2	Burra Creek.....	69
6.2	Fish Passage	69
6.3	Construction Impacts	70
6.4	Intake and interbasin transfers of fish and pathogens.....	71
6.5	Bank stability and vegetation	71
6.6	Water Quality	72
7.0	MONITORING.....	73
7.1	Murrumbidgee River	73
7.1.1	Pumping and screening of flows.....	74
7.2	Burra Creek.....	74
8.0	CONCLUSION.....	76
APPENDIX 1.....		97
	Flow Levels at Lobbs Hole.....	97
	Protected Low Flow Levels.....	98

APPENDIX 2	99
Part 3A of EP&A Act Assessments of Significance	99
APPENDIX 3	119
EPBC Act Significant Impact Criteria	119

TABLES

Table 1: Aquatic species listed in the FM, NC and/or EPBC Act with potential to occur in the region.	19
Table 2A: Surveyed riffle habitat between Angle Crossing and Tharwa Sandwash indicating flow type and physical attributes.	22
Table 2B: Surveyed riffle habitat between Angle Crossing and Tharwa Sandwash indicating substrate and habitat composition.....	22
Table 3: TAMS Fish Survey Results from Angle Crossing between 2000 - 2006.	25
Table 4: Fish Species Previously Recorded in the Murrumbidgee River and Googong Reservoir.	25
Table 5: Key Thresholds for Threatened species under The Part 3A Guidelines of the EP&A Act	33
Table 6: Spawning season and movements of native and alien fish species present in the Murrumbidgee River and Googong Catchment (based on Koehn, 1997; Lintermans, 2000).	47

FIGURES

Figure 1: Location of the Study Area in a regional context.	80
Figure 2: Proposed works and survey sites of the Murrumbidgee River.	81
Figure 3: Proposed works and survey sites of Burra Creek.....	82

PLATES

Plate 1: Angle Crossing facing upstream	84
Plate 2: Angle Crossing Site A; facing downstream.....	84
Plate 3: Site B; facing upstream.....	85
Plate 4: Site C; facing upstream.....	86
Plate 5: Site D; facing upstream.....	86
Plate 6: Site E; facing upstream.....	87
Plate 7: Site F; facing upstream	87
Plate 8: Site G; facing upstream.....	88
Plate 9: Site H; facing upstream.....	88
Plate 10: Site K.....	89
Plate 11: Site L; facing upstream	89
Plate 12: Site M; facing upstream	90
Plate 13: Site M; vertical view	90
Plate 14: Site N; facing upstream.....	91
Plate 15: Site O; facing downstream.....	91
Plate 16: Site P; facing upstream.....	92
Plate 17: Burra Creek downstream of Williamsdale Rd	92
Plate 18: Burra Creek at the gauging station downstream of Burra Rd	93
Plate 19: Burra Creek downstream of the gauging station	93
Plate 20: Burra Creek upstream of London Bridge Homestead.....	94

1.0 SUMMARY

Background and aims

ACTEW Corporation Limited (ACTEW) is undertaking an environmental assessment of a proposed water transfer pipeline from the Murrumbidgee River to Burra Creek and other works, known as The Murrumbidgee to Googong Water Transfer Project (herein referred to as the project or proposed works). This report focuses on the impacts to aquatic biodiversity values as a result of the project. In the context of this assessment the proposed works will be assessed in accordance with provisions of the ACT *Nature Conservation Act 1980* (NC Act); NSW *Fisheries Management Act 1994* (FM Act); NSW *Water Management Act 2000* (WM Act); Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act); and Part 3A of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) as amended by the *Environmental Planning and Assessment Amendment (Infrastructure and Other Planning Reform) Act 2005*.

Biosis Research Pty. Ltd. was commissioned by ACTEW to undertake investigations into the aquatic ecology issues associated with the proposed abstraction of up to 100ML/Day of water from the Murrumbidgee River in proximity of Angle Crossing (within the ACT) and transferring it via a pipeline to the Googong Reservoir via Burra Creek (in NSW).

The main aims of the study were to:

- Undertake relevant assessments of significance and/or significant impact criteria for threatened aquatic fauna within the Murrumbidgee River and Burra Creek under statutory NSW, ACT and Commonwealth legislations;
- Assess the aquatic habitat in the Murrumbidgee River in the vicinity of the abstraction point and within downstream habitats;
- Assess the aquatic habitat in Burra Creek in the vicinity of the discharge point and within downstream habitats;
- Investigate the potential impacts of the proposed works and abstraction on the aquatic ecology of the immediate habitat and downstream regions of the Murrumbidgee River and Burra Creek, within the Study Area;
- Determine the ecological condition of the Study Area and conduct targeted assessment of important flow features;
- Undertake a review and provide advice on fish issues; particularly threatened species, fish passage, water quality, environmental flows, inter-basin transfers and construction and operational impacts;
- Recommend mitigation measures to avoid and/or reduce the potential

impacts, based on policies and guidelines; and,

- Recommend appropriate adaptive management programs to monitor potential impacts.

Proposed Development

The proposed development involves the construction of a pipeline which would extend from above Angle Crossing on the Murrumbidgee River to Burra Creek, a distance of approximately 13 km. Two components of the proposed infrastructure have the potential to directly impact the aquatic ecology of the Study Area: the intake structure & low lift pump station (LLPS) and the discharge structure on the bank of Burra Creek. The intake and LLPS would lie within the ACT, while the discharge structure within Burra Creek lies on Commonwealth protected Googong Foreshores within NSW.

Additional infrastructure works would include: high lift pump stations (HLPS); power transmission line; pipe laydown areas, site compounds and vehicle parking areas. All plant and equipment would be stored within the subject site or within dedicated laydown areas.

The development would allow for the abstraction and transfer at a maximum of 100 ML/Day of water from the Murrumbidgee River to be pumped and discharged into Burra Creek to flow via run-of-river into Googong reservoir.

Potential Impacts of Proposed Works

The proposed works are expected to result in impacts to the aquatic ecological values of the Study Area, including direct impacts to: hydrology, fish passage, bank stability and vegetation, water quality, and non direct impacts such as noise and vibration. The potential impact of the proposed works on recreational fishing within the Study Area was also assessed.

The proposal has the potential to impact on five threatened aquatic fauna:

- Trout Cod *Maccullochella macquariensis* (FM Act and EPBC Act);
- Murray Cod *Maccullochella peelii peelii* (EPBC Act);
- Macquarie Perch *Macquaria australasica* (FM Act and EPBC Act);
- Silver Perch *Bidyanus bidyanus* (FM Act); and,
- Murray River Crayfish *Euastacus armatus* (NC Act).

The Part 3A Guidelines of the EP&A Act (DEC & DPI 2005) set out a number of questions to identify potential effects of the proposal on threatened species, populations or ecological communities, or their habitats listed under Schedules 4,

4A, & 5A of the Fisheries Management Act 1994. The implementation of the Part 3A assessments indicate that provided mitigation measures recommended in this report are implemented and comprehensive adaptive management and monitoring is undertaken, the proposed development is unlikely to have a significant impact on Trout Cod, Macquarie Perch or Silver Perch populations within NSW. Nevertheless, a Referral should be submitted to the Department of the Environment, Water, Heritage and the Arts (DEWHA) for further consideration of the predicted impacts upon listed NSW and ACT species.

Assessments of significance have been prepared according to the EPBC Act significant impact criteria for species listed under the EPBC Act that have known or potential habitat within the study area (Appendix 3). These assessments concluded that - provided that the mitigation measures outlined in this report are implemented and adaptive management and monitoring is undertaken - the project is unlikely to have a significant impact on Trout Cod, Macquarie Perch or Murray Cod. There is, however, the potential for residual impacts, including the removal of riparian vegetation, changes to hydrology and increased sedimentation, on Trout Cod and Macquarie Perch. In light of this, it is recommended the project be referred to DEWHA for further consideration.

Recommendations

The following recommendations are made to manage and minimise the potential issues to the aquatic ecology values of the area:

Environmental Flows

- Murrumbidgee River
 - 1) Ensure minimum environmental flows are protected as outlined in the ACT Government Water Resources Environmental Flow Guidelines (ACT Government 2006) (made under the *Water Resources Act* 1998).
 - 2) Continuous flow monitoring stations should be established to monitor Murrumbidgee River flows and water levels to ensure protected flows are maintained and ACT Environmental Flow Guidelines are upheld.
 - 3) Incorporate an adaptive management strategy to allow for modifications in operational regimes if impacts on environmental flow result in additional unpredicted impacts during construction and operation.

- Burra Creek
 - 4) Regular monitoring of the impacts associated with an increase of environmental flows within Burra Creek should include assessing the impacts

of increased sediment transfer through the scouring of sediment from riffles and pools, changes in thermal regime, alteration to macroinvertebrate community structures, erosion and modification of reed beds and banks and changes in the potential utilisation of Burra Creek by fish in Googong Reservoir.

- 5) Major changes in flow release should 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.

Fish Passage

- 6) If native and threatened fish species are found to be spawning within Burra Creek, flow transfers should be maintained where possible during the breeding season (typically early spring to summer) to protect the spawning populations. If flows must be altered, then the 48 hour ramping up/down operating regime must be utilised to allow fish to safely exit the creek.

Construction Impacts

- 7) Approval and/or consultation with the NSW Department of Primary Industries and Department of Water and Energy will be required in regards to water abstraction and transfer, and all near stream works in NSW under the NSW FM Act and WM Act.
- 8) During any near stream works such as trenching or excavating, water quality should be protected under sedimentation and erosion control plan policies as prescribed under government legislation including the *Protection of the Environment Operations Act (1997)* and *Environmental Planning & Assessment Act (1979)*. This should include suitably designed and maintained sediment and turbidity controls such as in-stream silt curtains, sedimentation fencing, runoff controls and geotextile fabric sand bags. The protection measures must be regularly inspected and maintained throughout the construction and rehabilitation phase. Rainfall event based turbidity monitoring should be conducted at sites located upstream and downstream of the construction area.
- 9) Avoid undertaking excavation or other works in or near the Murrumbidgee River or Burra Creek during periods of actual or predicted heavy precipitation or higher than average flows.
- 10) Appropriate sediment and erosion control measures must be employed throughout the extent of the proposed works to protect the aquatic habitats and adjoining areas supporting native vegetation. Mesh netting should 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.

- 11) Rock and earth resources utilised to construct the pile rig base should be natural and locally sourced, and removed and reinstated upon completion of the construction works.
- 12) 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.

Intake and interbasin transfers of fish and pathogens

- 13) The mesh size on the proposed screen should be at a maximum of 0.5 mm to greatly enhance the efficiency of the screening processes and prevent transfer of fish and eggs.
- 14) A skilled abstraction screen expert must be consulted to review the screen design and approve the structure before construction commences to ensure efficiency of screen design and operation.
- 15) Eggs and/or larvae of alien species of interest within the Murrumbidgee River are likely to be present from October to April. However, filtering should be undertaken at all times.
- 16) Monitor transfer flows at discharge outlet into Burra Creek for any aquatic fauna/flora that are passing through filtration at the intake screens and surviving the pumping process. Any detection of undesirable organisms within transfer flows at discharge point should trigger urgent review of operation procedures and equipment. This process will be essential in breeding period of October through April to ensure no undesirable alien fish are passing the screening process.

Bank stability and vegetation

- 17) A Vegetation Management Plan, including implementation of a riparian rehabilitation and weed management plan is recommended. Areas to be focused on include those identified by the Fluvial Geomorphic Assessment (Bulk Water Alliance 2009) as having the potential to be undercut by transfer flows within Burra Creek; and immediate construction sites for the intake and discharge points.
- 18) Macrophytes should be monitored and mapped to identify and manage any significant reductions in biomass above the low flow channel. This will ensure recolonisation rates are able to be qualitatively assessed and appropriate measures can be implemented if macrophytes are not re-establishing in the low flow channel marginal areas. Maintaining macrophyte

populations along Burra Creek will ensure water quality and pool sedimentation impacts of the discharge flows are short-lived.

Water Quality

- 19) A detailed spill and contamination plan should be prepared to protect the environmental values of the Murrumbidgee River and Burra Creek from the proposed works. The plan should contain emergency and remediation measures.
- 20) Water quality within Murrumbidgee River below the abstraction intake and within Burra Creek below the discharge point should be monitored regularly to identify and manage any adverse impacts upon water quality.
- 21) Water abstracted from the Murrumbidgee River should be released into Burra Creek without delay to reduce the chances of deoxygenisation and cooling and reduce the risk of water putrefication.

2.0 INTRODUCTION

2.1 Purpose of this report

ACTEW Corporation Limited (ACTEW) proposes to undertake the Murrumbidgee to Googong Water Transfer Project ('the project'). This report has been prepared to provide an assessment of the aquatic ecology impacts of the project as an input to the environmental impact assessment (EIA). The EIA is being prepared in accordance with the requirements of Part 3A of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and the ACT *Planning and Development Act 2007*.

The report addresses the requirements of the Director-General of the NSW Department of Planning (the Director-General's Requirements) dated October 7th 2008 and the Final Scoping Document prepared by the ACT Planning & Land Authority (the Scoping Document) dated December 16th 2008.

2.2 Project overview

In recent years the Australian Capital Territory (ACT) region has been experiencing severe drought conditions coupled with increased demand for water. Canberra and Queanbeyan have been subject to level three water restrictions since 2006. The current drought, together with predicted climate change and population growth, is driving the search for a more reliable water supply for the ACT. In response to this need, the ACT Government developed the Water Security Program, which identified a range of new water supply projects.

The project is one of the preferred options for delivering improved security to the ACT's water supply. It involves pumping water from the Murrumbidgee River (within the ACT) and transferring it via a pipeline to the Googong Reservoir via Burra Creek (in NSW). The Googong Reservoir supplies water treated to drinking quality standards to the ACT.

The project involves construction and operation of infrastructure required to transfer approximately 100 ML/Day of water a distance of approximately 13 km from the Murrumbidgee River to Burra Creek.

The infrastructure required to transfer the water includes an intake/low lift pump station (LLPS); a high lift pump station (HLPS); an underground pipeline; a discharge structure and a power supply.

2.3 The location of the project

The LLPS would be located on the east bank of the Murrumbidgee River, in the ACT, approximately 34 km south of Canberra. It would be located in an area known as Angle Crossing, approximately 4 km west of Williamsdale on the Monaro Highway.

The HLPS would be located within the ACT, approximately 290 m to the east of the LLPS.

The pipeline would cross rural land in an east/north-east direction for approximately 13 km. It is located in the vicinity of Williamsdale and Burra Roads, within the districts of Williamsdale and Burra. The majority (approximately 10.2 km) of the pipeline would be located in NSW, with approximately 2.8 km located in the ACT.

The pipeline would terminate at the discharge structure, located on the banks of Burra Creek, just downstream of an existing flow measuring station approximately 10 km south of Googong Reservoir. The discharge structure is located within land known as the Googong Foreshores, which is Commonwealth land within NSW.

2.4 Aims

The aim of this study was to determine the potential impact of the construction and operation of the proposed pipeline on aquatic habitats of the Murrumbidgee River and Burra Creek.

The specific goals of this report were to:

- Undertake relevant assessments of significance and/or significant impact criteria for threatened aquatic fauna within the Murrumbidgee River and Burra Creek under statutory NSW, ACT and Commonwealth legislations;
- Assess the aquatic habitat in the Murrumbidgee River in the vicinity of the abstraction point and within downstream habitats;
- Assess the aquatic habitat in Burra Creek in the vicinity of the discharge point and within downstream habitats;
- Investigate the potential impacts of the proposed works and abstraction on the aquatic ecology of the immediate habitat and downstream regions of the Murrumbidgee River and Burra Creek, within the Study Area;
- Determine the ecological condition of the Study Area and conduct targeted assessment of important flow features;
- Undertake a review and provide advice on fish issues; particularly threatened species, fish passage, water quality, environmental flows, inter-basin

transfers and construction and operational impacts;

- Recommend mitigation measures to avoid and/or reduce the potential impacts, based on policies and guidelines; and,
- Recommend appropriate adaptive management programs to monitor potential impacts.

2.5 Study Area

The Study Area incorporates sections of the Murrumbidgee River, Burra Creek and Googong Reservoir (Figure 1). On the Murrumbidgee River, the Study Area comprises pools upstream of Angle Crossing and downstream through the Gigerline Nature Reserve to the Tharwa Sandwash directly above the junction with the Gudgenby River (Figure 2).

Burra Creek is part of the Queanbeyan Molonglo Catchment located to the east of the Murrumbidgee River. The Study Area comprises Burra Creek downstream of the Williamsdale Road Crossing, including the Googong Foreshores and Googong Reservoir (Figure 3).

2.6 Proposed Works

Detailed design of the project construction methodologies would proceed if the project is approved and may result in some design changes. The construction incorporates five major components which include:

- An intake and LLPS on the east bank of the Murrumbidgee River upstream of Angle Crossing;
- A HLPS;
- The pipeline;
- A discharge structure on the bank of Burra Creek; and
- A power supply.

Two components of the proposed infrastructure have the potential to impact the aquatic environment of the Study Area: the intake & LLPS and the discharge structure on the bank of Burra Creek. The intake and LLPS would lie within the ACT, while the discharge structure within Burra Creek lies on Commonwealth protected Googong Foreshores within NSW.

2.6.1 Murrumbidgee River

The proposed works indicate the LLPS would be constructed upstream of the Angle Crossing causeway on the eastern bank of the Murrumbidgee River. The LLPS would take the form of a box-in-bank structure with a side inlet and incorporate four fish egg filtration units to filter fish eggs from the water and would discharge filtered water through a dividing wall into the pump module. Backwashing of the units to return filtered fish eggs to the river would occur via hoppers, jet inductors and eductor flows. The filtration units would be mounted on guide rails and the filtration module would have a removable heavy duty cover at ground level to allow removal of the filtration systems by a crane for inspection and maintenance. The intake chamber would be protected by a steel screen, which would be orientated parallel to the river flow with trash rackbars positioned across the intakes both horizontal and parallel to the river flow to prevent flotsam and limit grit from entering the intake chambers.

Mobilised sediment and silt entrained within the Murrumbidgee River flows would be screened at the LLPS by the grit collection hopper sumps. Jet inductors in each hopper sump would flush the collected grit into an eductor pipeline which would flow from the LLPS and discharge into a pit from which a 600 mm diameter culvert would run under the Angle Crossing Road approach to the causeway and end in a headwall discharge into the Murrumbidgee River.

The LLPS would require approximately 5 – 6 m excavation into the river bank, below the water table. Therefore a coffer dam would form part of the proposed works to form a dry work zone to allow for construction. The coffer dam would be designed to withstand a 1:100 ARI (Average Recurrence Interval) flood event and would be in place for the full construction period. The intake structure would consist of an open-sided box with a semi-enclosed grate to allow water flow through to the four functional modules of the intakes and LLPS, being the intake module, the filtration module, the pump module and the valve module. The top of the intake structure would be designed to include a viewing platform for the river, which would consist of handrails and educational information signs. It is also proposed to realign Angle Crossing Road to remove a tight corner near the intake site.

The proposed construction area for the LLPS is predicted to lie above bedrock, and therefore a coffer dam comprised of H-piles would be embedded into the underlying rock with horizontal walers to provide support for vertical sheet-piles. The incorporation of an earth/rock platform approximately 8 m into the Murrumbidgee River has been proposed to provide access and support for a pile rig (to be confirmed). It is proposed the platform would be constructed with the placement of 75-200 mm rocks on the river bank, which would be compacted within the river by aid of a bulldozer or excavator until the rock pad is

sufficiently stable enough to support the rig. It is expected the rock and earth resources utilised to construct the pile rig base would be natural and locally sourced, and would be removed and reinstated upon completion of the construction works. A floating silt curtain would form part of the proposed works and would surround the construction site to arrest any mobilised sediments as a result of the bank construction.

Post construction of the coffer dam it is expected the following sequence of activities would be required to construct the LLPS:

- Excavation, blasting and rock hammering;
- Piping fabrication and installation;
- Welding and hot works;
- Formwork, reinforcement and concrete placement;
- Potential placement of precast concrete elements;
- Fencing as required;
- Road works and sealing operations;
- Landscaping, revegetation etc;
- Mechanical equipment installation;
- Electrical installation; and,
- Instrument installation.

The allowance for excavation and blasting of bedrock at the site of the LLPS has been proposed to facilitate the construction. The instream coffer dam would also incorporate the continual use of pumps to extract groundwater to allow for dry working conditions for the concrete placement. The extracted water from within the coffer dam would be stored on-site for potential further treatment before being released into the Murrumbidgee River.

2.6.2 Burra Creek

The discharge structure within Burra Creek would comprise a cast in-situ concrete outfall structure where the pipeline terminates, which would be located just east of Burra Road and approximately 100 m downstream of the Burra Road Bridge. Excavation of the bank of approximately 3.5 m depth and 10 m in length would be required to install the structure. Water would flow from the pipe into

the weir discharge structure, and flow down a rock fill mattress wall to minimise the discharge energy of the flow. The rock wall would be installed across the creek bed to prevent scour and erosion in the vicinity of the outfall weir.

It is expected the following sequence of activities would be required to construct the discharge structure within Burra Creek (subject to change):

- Site preparation as required;
- Locate and mark underground services;
- Excavation, blasting and rock hammering;
- Earthworks fill;
- Formwork, reinforcement and concrete placement;
- Fencing as required; and,
- Landscaping, revegetation etc.

2.7 Legislation

Federal and State Acts and Policies that may apply to the Study Area, as they relate to aquatic flora, fauna, and environment are listed below:

Commonwealth Legislation

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in relation to Matters of National Environmental Significance (MNES) including threatened species.

New South Wales Legislation

- *Environmental Planning and Assessment Act 1979* (EP&A Act) in relation to the protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities and their habitats;
- *The Fisheries Management Act 1994* (FM Act) and *Environmental Planning and Assessment Act 1979* (EP&A Act) in relation to threatened species, populations and Endangered Ecological Communities (EECs) and approval for instream works and developments, such as dredging and blocking of passage;
- *Water Management Act 2000* (WM Act) and *Controlled Activity Provisions of the Water Management Act 2000* (previously the *Rivers and Foreshores*

Improvement Act 1948) in relation to instream and near waterway development;

- *Protection of the Environment Operations Act 1997* (POEO Act) in relation to the protection of the environment and water quality from pollution or waste discharge associated with the project;
- *Water Act 1912* in relation to the use of water, the construction of works, and the carrying out of activities in or near water sources in NSW.

Australian Capital Territory Legislation

- *The Nature Conservation Act 1980* (NC Act) in relation to threatened species, populations and EECs of the ACT; and,
- *Water Resources Act 2007* (WR Act) in relation to the controlled access and use of water and groundwater in the ACT.

3.0 METHODOLOGY

The Murrumbidgee River section of the Study Area was surveyed by two aquatic ecologists from 14-16 May 2008. The flow in the Murrumbidgee River throughout the survey was 55 ML/Day (Lobbs Hole gauge). The area inspected included Angle Crossing and Angle Bend, downstream to the Tharwa Sandwash (See Figure 2). Burra Creek was also surveyed at the proposed discharge point near Burra Road.

Burra Creek was surveyed by two aquatic ecologists on 6 November 2007. The area inspected included the proposed discharge site and a number of sites in the lower section of Burra Creek, approaching the confluence of Googong Reservoir (See Figure 3).

3.1 Taxonomy

Names of fish in this report follow the Census of Australian Aquatic Biota (CAAB) maintained by CSIRO and the Department of the Environment, Water, Heritage and the Arts (DEWHA). There is significant taxonomic and genetic uncertainty in relation to the taxonomy of Carp Gudgeon *Hypseleotris* spp. In this report Carp Gudgeon are considered together as a species complex. The names of vertebrates (excepting fish) follow the Census of Australian Vertebrates (CAVS), maintained by DEWHA. In the body of this report, animals are referred to by both their common and scientific names when first mentioned. Subsequent references cite the common name only. Common and scientific names may be included in the Tables and Appendices.

The names of plants in this report follow (1990; 1992; 1993; Harden 2002) with additional advice from the NSW and National Herbariums. Plants are referred to by their scientific names only.

3.2 Database Review

Existing information regarding the flora and fauna of the study area was obtained from a range of sources, including: databases; aerial photographs and maps; previous studies carried out in the vicinity of the study area; and, consultation with experts, government agencies, local conservation organisations and natural heritage groups.

Records of threatened species listed in the EPBC Act with potential to inhabit the Study Area were obtained from the DEWHA Protected Matters Search Tool online database (DEWHA 2009a), with the search area incorporating the aquatic habitats within the Study Area and upstream/downstream to account for fish

migration and movement. Records of fish species including threatened fish listed on the FM and NC Acts were obtained from the NSW Bionet online database (NSW Government 2008).

3.3 Aquatic Survey

The aquatic survey consisted of a targeted, habitat-based assessment. Since 1986, yearly monitoring of fish populations has been undertaken in the Murrumbidgee River at Angle Crossing (and across numerous sites up/downstream of Angle Crossing within the Murrumbidgee River) by ACT TAMs (Department of Territory and Municipal Services). Therefore, no fish sampling was undertaken in the Murrumbidgee River throughout the survey period. However, a snap shot fish survey was undertaken in Burra Creek at the crossing with Burra Road.

3.3.1 Habitat Assessment

The habitat assessment was undertaken visually at each site following a modified ACT Australian Rivers Assessment System (AUSRIVAS) habitat assessment procedure. Parameters assessed during the survey included:

- 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.

Targeted habitat assessments were undertaken on flow features such as riffles and fish barriers in the reach between Angle Crossing and Tharwa Sandwash. Parameters assessed for flow features included visual estimates of length, width, depth and fall; flow types following (Newson and Newson 2000); riparian structure and composition, substrate and in-stream habitat composition.

3.3.2 Aquatic Habitat Condition Assessment

The three categories used to evaluate habitat condition were Good, Moderate or Poor, as detailed below:

- **Good:** Excellent instream habitat, such as Large Woody Debris (LWD), interstitial spaces, macrophytes and other sheltering or breeding habitats. Near natural hydrological condition with little evidence of sedimentation and/or snagging or bank alteration. The riparian zone is intact and predominantly undisturbed. No exotic vegetation and dominated by high diversity of native fauna species.
- **Moderate:** Defined as a waterway with some degradation to instream habitat and altered hydrological condition. Riparian zone is intact but slightly disturbed, such as minor clearing and/or exotic vegetation. The waterway provides suitable habitat for most native fauna species, with some alien fish species present.
- **Poor:** Contains very little natural substrate and is lacking instream habitat. Fish fauna is dominated by alien fish species and the riparian zones is highly disturbed. Hydrological condition is significantly altered.

Other habitat features which are considered in determining the habitat value of the waterway include barriers to fish passage, catchment condition, the presence of remnant communities or unusual ecological features such as groundwater influxes.

3.3.3 DPI Fish Habitat Classification

Aquatic habitat conditions were classified according to the Department of Primary Industries (DPI) "Fish Habitat Scheme", which classifies waterways on the basis of potential for fish habitat. The class of a waterway determines the appropriate type of crossing required and whether the inclusion of a fishway is required (NSW Fisheries 1999). These habitat classes are defined as:

- **Class 1 - Major fish habitat:** A large, named, permanently flowing stream, creek or river. The waterway provides threatened species habitat or areas of declared "critical habitat" under the threatened species provisions of the FM Act. High quality native aquatic vegetation and structural habitat is present. Known fish habitat and/or fish observed inhabiting the area.
- **Class 2 - Moderate fish habitat:** A smaller named permanent or intermittent stream, creek or watercourse with a clearly defined drainage channel. Can be permanent waters or semi-permanent pools, or connected areas with limited aquatic vegetation or structure present. Known fish habitat and/or fish observed inhabiting the area.

- **Class 3 - Minimal fish habitat:** A named or unnamed watercourse with intermittent flow. It provides potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). None to minimally defined drainage channel with semi-permanent pools, ponds, farm dams or wetlands nearby, or form in the watercourse after a rain event. The watercourse may interconnect wetlands or other stream habitats.
- **Class 4 - Unlikely fish habitat:** A named or unnamed watercourse with intermittent flow during rain events only, little or no defined drainage channel. Little or no free standing water or pools after rain (e.g. dry gully, shallow floodplain depression with no permanent wetland aquatic flora present). No aquatic or wetland vegetation present.

3.3.4 Fish Survey

Burra Creek was sampled for fish and the methods employed to survey fish at each Burra Creek site are described below. Fish collected by these methods were identified to species level following (McDowall 1996), with the exception of Carp Gudgeon (*Hypseleotris* spp.). In the Murray Darling Basin, these fish belong to a group of described and undescribed species, whose taxonomy and genetic phylogeny is unclear (Bertozzi *et al.* 2000). Consequently, all Carp Gudgeon were classified as *Hypseleotris* sp.

Electrofishing

A Smith-Root LR-24 Backpack electrofisher was utilized to collect fish from water up to 1 m deep. The sampling protocol consisted of actively fishing a section of river between 50-100 m long for approximately 200 seconds of active electrofishing, with one operator and one dip netter. Output parameters were set to maximize collection through stunning of fish and to reduce the potential for injury to fish or non target animals such as turtles and Platypuses *Ornithorhynchus anatinus*. Fish were collected by the dip netter for identification.

3.4 Limitations

This study was designed to identify potential issues in regards to aquatic ecology and to guide potential avoidance and mitigation of these issues. The Murrumbidgee River surveys were undertaken in a period of low-flow and features associated with different flow conditions may not have been identified. Given the existing annual fish survey data undertaken at Angle Crossing and at numerous sites throughout the Murrumbidgee River by ACT TAMS, fish sampling of the Murrumbidgee River was not considered necessary at this stage. The Burra Creek fish survey was undertaken at one site and on one occasion (i.e.

a snap shot). A number of additional fish species (including rare, cryptic and migratory species) are likely to occur at the site sampled and within Burra Creek. Seasonal or long term surveys at a number of sites located over an appropriate are required to adequately describe the fish community of Burra Creek.

The impact assessments undertaken under NSW (Part 3A of the EP&A Act) and Commonwealth (EPBC) assessments of significance and application of significant impact criteria recognise the commitment by ACTEW that the base flow of the Murrumbidgee River will be protected throughout the year and no water below the base flow would be removed in any month of any year.

The impact assessments are based on the understanding that ACTEW will protect the minimum percentile environmental flows of the Murrumbidgee River as prescribed in the ACT Government *Water Resources Environmental Flow Guidelines* (ACT Government 2006) throughout each month of every year, and no water below the base flow would be removed at any time. Any modifications to the water abstraction licence (if/when obtained) would require additional analysis to incorporate any impacts not addressed in this assessment. The assessments of significance and extent of impacts outlined in this report assume the mitigation measures provided in this report will be fully implemented and reviewed in accordance with the adaptive management strategy.

The available water quality data for Burra Creek is sparse as Burra Creek has experienced infrequent flows in recent years. The data comparison between the Murrumbidgee River and Burra Creek has been carefully considered as sample timeframes differ significantly. The validity of the data has been taken into account for the assessments and in lieu reliably comparable data, all conclusions drawn are approximations and do not necessarily reflect the full scope and extent of potential impacts that may arise as a consequence of the proposed development.

4.0 RESULTS

4.1 Database Review

Five threatened aquatic species listed under the NSW Fisheries Management Act 1994, the ACT Nature Conservation Act 1980 and/or the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 have the potential to occur within the local area (Table 1).

Table 1: Aquatic species listed in the FM, NC and/or EPBC Act with potential to occur in the region.

Scientific Name	Common Name	FM Act	NC Act	EPBC Act	Habitat	Potential Habitat	Potential Constraint
<i>Bidyanus bidyanus</i>	Silver Perch	V			Inhabits a variety of streams, rivers and lakes including slower sluggish rivers with LWD (NSW DPI 2005b). It can be found in fast flowing waters but is not suited in the upper reaches of streams.	Yes Recreationally stocked into Googong Reservoir	Low
<i>Euastacus armatus</i>	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 (Lintermans and Osborne 2002)	Yes Wild population occurs in the Murrumbidgee	Moderate
<i>Gadopsis bispinosus</i>	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	N/A
<i>Maccullochella macquariensis</i>	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 (Growth <i>et al.</i> 2004).	Yes Stocked into Angle Crossing for conservation, since 1996	High
<i>Maccullochella peeli peeli</i>	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 (Lintermans 2002b).	Yes Occurs in the Murrumbidgee below Gigerline Gorge. Recreationally stocked into Googong Reservoir	Low
<i>Macquaria australasica</i>	Macquarie Perch	E	E	E	Inhabits slow flowing sections of creeks rivers and impoundments with suitable aquatic vegetation, rocks and snags (NSW Fisheries Scientific Committee 1998). Requires access to flowing riffles for breeding	Yes Small wild population occurs in the Murrumbidgee	High

Key: E-Endangered, V- Vulnerable.

4.2 Aquatic Habitats

4.2.1 Murrumbidgee River (ACT)

4.2.1.1 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 was greater than 1.5 m deep with the minimum depth occurring over the crossing of 0.1 m deep. The substrate of the pools was predominantly sand, silt and gravel with occasional areas of bedrock and cobble. In-stream habitat included LWD, overhanging vegetation and overhanging banks. Occasional beds of emergent macrophytes including *Typha orientalis*, *Phragmites australis* and *Baumea articulata* were observed in shallow areas and along the banks, along with scattered clumps of submergent macrophytes, predominantly *Myriophyllum* sp. observed in the pool. The western bank was steep, 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 *Rubus fruticosus* and *Eragrostis curvula* were common on both banks. The area was considered to be in moderate condition with impacts resulting from the crossing, sedimentation and presence of exotic flora species (Plate 1). The reach was classified as Class 1-Major fish habitat, under the DPI fish habitat classification scheme.

Directly below Angle Crossing was a shallow riffle section (Site A), 35-45 m long and up to 30 m wide at the crossing (Plate 2). Depth varied from 0.1 m to 0.4 m. Substrate was comprised of pebbles, gravel and cobbles, embedded with few interstitial spaces but with several beds of submergent and emergent macrophytes. Estimates of physical, flow, substrate and habitat parameters for each riffle are shown in Table 2A and 2B.

4.2.1.2 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 consisted of a channel up to 40 m wide with sand bars and some braiding. The flow was slow overall, often with long sections of no perceptible flow. Estimate of mean depth was greater than 1 m in most sections. Fast-flowing features were limited to Site B and Site C, 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 (Plate 4).

The reach was classified as Class 1-Major fish habitat, under the DPI fish habitat classification scheme.

4.2.1.3 Reach 3: Guises Creek to Tharwa Sandwash

This section of river flows through Gigerline Gorge. It contained a large number of riffles and cascades, interspersed with slow-flowing sections and holes. The river in the upper section (Sites D-L) was fairly wide with sand and rock benches on at least one side of the channel (Plates 5 to 11). The riffles varied in length from 40 – 200 m and consisted of predominantly rippled flow with some rapids and small cascades. Substrate in most riffles was predominantly bedrock and sand, although Site H and L have a higher proportions of boulders and cobbles (Plates 9 and 11). Additional aquatic habitat was provided by some areas of submergent macrophytes, *Myriophyllum* sp. and *Vallisneria gigantea*. Between riffles the river was characterised by long pools with little observable flow. The depth in these sections was 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 (Plates 12 to 15). These cascades are characterised by chutes and free falls of 0.5 – 1 m through a bedrock gorge. The substrate was bedrock with large boulders. The cascades were interspersed with deep, slow flowing pools and runs with sand banks. This section would constitute a barrier to fish passage for most species at most flow levels, although the larger pools would also provide refuge during extremely low flow events.

Below the Gorge there is one significant riffle section, Site P (Plate 16) before the river slows and broadens and becomes dominated by sand prior to the Tharwa Sandwash and the junction with the Gudgenby River. The reach was classified as Class 1-Major fish habitat, under the DPI fish habitat classification scheme.

Table 2A: Surveyed riffle habitat between Angle Crossing and Tharwa Sandwash indicating flow type and physical attributes.

Site	Distance from Angle Crossing	Length (m)	Width (m)	Min Depth (m)	Fall (m)	Flow type (%)					
						NP	SBT	R	USW	BSW	C/FF
A	0	35	30	0.1	0.5		5	30	50	10	5
B	300	15	30	0.4	0.3	10	20	35	25	15	
C	900	100	45	1	0.2	50	30	20			
D	2600	50	40	0.2	0.5	5	30	40	10	10	5
E	2740	40	30	0.2	0.5			65	10	20	5
F	3340	40	50	0.5	0.3	15	15	40	20	10	
G	3690	180	20	0.3	1	4	15	60	10	10	1
H	4000	200	15	0.2	1		10	40	25	20	5
I	4310	100	15	0.2	1		5	40	20	25	10
J	4560	50	15	0.2	0.5		10	50	10	20	10
K	4860	120	20	0.2	0.5	5	5	40	20	20	10
L	5095	30	10	0.2	0.5		25	40	15	15	5
M - N	5695	130	10	0.2	2		20	30	10	20	20
O	5855	50	10	0.2	1.5			40	15	25	20
P	6155	45	10	0.2	1.5		40	30	10	10	10

NP=no perceptible SBT=Smooth boundary turbulent, R- rippled flow, USW-unbroken Standing Wave, BSW=Broken Standing Wave, C/FF=chute/free fall.

Table 2B: Surveyed riffle habitat between Angle Crossing and Tharwa Sandwash indicating substrate and habitat composition.

Site	Substrate (%)							Habitat (1:<5%, 2:5-35%, 3:35-65%, 4:65-90%, 5:>90%)						
	Rock	Boulder	Cobble	Pebble	Gravel	Sand	Silt	LWD	CPOM	Debris	Peri	Algae	Macro	Silt
A	-	2	3	70	10	5	10	1	2	2	2	1	3	3
B	90	5	3	2	-	-	-	1	1	2	2	1	2	2
C	20	5	-	-	-	75	-	2	1	1	1	1	2	3
D	40	30	20	-	-	10	-	1	1	1	2	2	2	3
E	50	20	5	-	-	25	-	1	1	1	2	1	2	2
F	50	20	5	-	-	25	-	1	2	2	2	1	2	4
G	80	10	5	-	-	5	-	1	1	1	3	1	2	3
H	40	40	10	5	-	5	-	1	1	2	2	2	2	2
I	80	5	5	5	-	5	-	1	1	1	2	2	2	3
J	80	10	5	-	-	5	-	1	1	1	2	2	2	3
K	75	5	-	5	5	10	-	1	1	1	3	2	1	3
L	20	60	10	-	-	-	10	1	1	2	2	2	2	3
M + N	50	30	10	5	5	-	-	2	1	1	2	1	1	1
O	90	-	-	-	-	10	-	1	1	1	2	1	1	1
P	80	5	5	-	-	10	-	1	1	1	3	1	1	2

LWD=Large Woody Debris, CPOM=Course particulate Organic Matter, Peri-Periphyton, Macro-Macrophytes.

4.2.2 Burra Creek (NSW)

4.2.2.1 Upper Burra Creek

The upper regions of Burra Creek were inspected near Williamsdale Road and the gauging station near Burra Road (Plates 17 and 18). In these sections, the creek varied between 2 and 10 m wide and consisted of short riffles or flowing sections with pools up to 0.5 m deep. Stream substrates in these sections were predominantly silt and bedrock with some cobbles and sands. Instream habitat consisted of small sections of large woody debris and branches with large vegetation patches consisting primarily of the emergent reeds *Phragmites australis* and *Typha orientalis*. Near the gauging station, creeping mats of *Ranunculus* sp. along with isolated rushes of the genus *Juncus* were recorded (Plate 19). The riparian zone was predominantly cleared for agricultural purposes and dominated by grass or patches of exotic species such as *Salix* sp., *Rubus fruticosus*, *Populus alba* and *P. nigra* with some native trees downstream of the gauging station. 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.

4.2.2.2 Upstream of London Bridge Homestead

Burra Creek above London Bridge Homestead consisted of large deep pools and bedrock riffles, with the pools up to 8 m wide and 1.2 m deep (Plate 20). Substrate in the pools was primarily silt and bedrock, with some sand and cobbles found in the tail of pools and riffles. Instream habitats consisted of isolated LWD, coarse organic matter and large emergent beds of *Typha orientalis* scattered clumps of *Myriophyllum* sp. and *Nasturtium officinale*. Clumps of *Chara* sp. algae and some filamentous algae were also present in the pools. The riparian zone was dominated by grasses and the area was considered to be moderately disturbed and in poor to moderate condition. The reach was classified as Class 2-Moderate fish habitat, under the DPI fish habitat classification scheme.

4.2.2.3 Upstream of London Bridge

Burra Creek between London Bridge and the London Bridge Homestead consisted of several large pools up to 1.8 m deep and up to 6 m in width, interspersed by shallow flowing sections (Plate 21). The substrates were primarily a mix of silt and sand in which significant amounts of cobble and boulders were partially imbedded. Bedrock outcrops were also present. Instream habitat consisted of large beds of aquatic vegetation, completely covering some areas of the river. The aquatic vegetation was dominated by emergent *Typha*

orientalis, *Eleocharis* sp. and Ranunculaceae, whilst submergent vegetation consisted of large beds of *Chara* sp., *Myriophyllum* sp. and filamentous algae. The riparian zone was dominated by grasses and the area was considered to be moderately disturbed and in poor to moderate condition. The reach was classified as a Class 2-Moderate fish habitat, under the DPI fish habitat classification scheme.

4.2.2.4 Downstream of London Bridge (Drawdown Crossing)

Drawdown Crossing is downstream of London Bridge and above the high water mark of Googong Reservoir and was characterized by long, narrow and shallow pools with occasional runs and isolated deeper pools up to 1.2 m deep, associated with bedrock features (Plate 22). The substrate was 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 was cleared of major vegetation but had a continuous cover of grass. The western bank was well vegetated with native shrubs and trees. The area was considered to be of low disturbance and in moderate condition. The reach was classified as a Class 2-Moderate fish habitat, under the DPI fish habitat classification scheme.

Near the junction with the Queanbeyan River and below the high water level of the Reservoir, Burra Creek's substrate was 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.

4.3 Aquatic Fauna

4.3.1 Fish

The Study Area provides habitat for numerous native and alien fish species. Since 1986, yearly monitoring of fish populations has been undertaken in the Murrumbidgee River at Angle Crossing (and across numerous sites up/downstream of Angle Crossing within the Murrumbidgee River) by ACT TAMS. The results of these surveys between 2000 and 2006 are provided in Table 3 (TAMS Unpublished data).

Table 3: TAMS Fish Survey Results from Angle Crossing between 2000 - 2006.

Scientific Name	Common Name	2000	2001	2002	2003	2004	2005	2006
<i>Cyprinus carpio</i>	Carp*	25	15	62	13	7	4	20
<i>Carassius auratus</i>	Goldfish*	1	0	0	0	1	1	0
<i>Galaxias olidus</i>	Mountain Galaxias	0	0	0	0	0	1	0
<i>Gambusia holbrooki</i>	Eastern Gambusia*	0	2	5	23	0	3	9
<i>Maccullochella macquariensis</i>	Trout Cod	25	11	3	19	26	21	4
<i>Macquaria australasica</i>	Macquarie Perch	0	0	2	2	1	0	0
<i>Misgurnus anguillicaudatus</i>	Oriental Weatherloach*	2	0	0	9	8	8	30
<i>Oncorhynchus mykiss</i>	Rainbow Trout*	0	0	1	0	0	0	0

Key: * - alien species. **Note:** Australian Smelt are also observed (Lisa Evans pers. comm.)

Alien species such as Oriental Weatherloach *Misgurnus anguillicaudatus* and Carp *Cyprinus carpio* are common within the Murrumbidgee River above Angle Crossing; and Trout Cod *Maccullochella macquariensis*, introduced via stocking above Angle Crossing, are also regularly collected.

Surveys are also conducted by TAMS along the length of the Murrumbidgee River and in Googong Reservoir. Fish species previously recorded in the Murrumbidgee River upstream and downstream of Angle Crossing, as well as those known in the Googong Catchment are provided in Table 4 (Lintermans 2002b; Lintermans 2001; Lintermans 2005b).

Table 4: Fish Species Previously Recorded in the Murrumbidgee River and Googong Reservoir.

Scientific Name	Common Name	Upstream of Angle Crossing	Downstream of Angle Crossing	Burra Creek and Googong Reservoir
Native fish species				
<i>Bidyanus bidyanus</i>	Silver Perch	-	X	X ¹
<i>Euastacus armatus</i>	Murray Crayfish	X	X	-
<i>Galaxias olidus</i>	Mountain Galaxias	X	X	X
<i>Hypseleotris sp.</i>	Carp Gudgeon	-	X	X
<i>Maccullochella peelii peelii</i>	Murray Cod	-	X	X ¹
<i>Maccullochella macquariensis</i>	Trout Cod	X ¹	X ¹	-
<i>Macquaria ambigua</i>	Golden Perch	-	X	X ¹
<i>Macquaria australasica</i>	Macquarie Perch	X	X	X
<i>Retropinna semoni</i>	Australian Smelt	X	X	-
Alien Fish species				
<i>Cyprinus carpio</i>	Carp	X	X	-
<i>Carassius auratus</i>	Goldfish	X	X	X
<i>Gambusia holbrooki</i>	Eastern Gambusia	X	X	X
<i>Misgurnus anguillicaudatus</i>	Oriental Weatherloach	X	X	-
<i>Oncorhynchus mykiss</i>	Rainbow Trout	X	X	X ¹
<i>Perca fluviatilis</i>	Redfin Perch	X	X	X
<i>Salmo trutta</i>	Brown Trout	X	X	X ¹

Key: 1 - stocked into waterway.

Two species of alien fish which are common in the Murrumbidgee River (Carp and Oriental Weatherloach) are not considered present in the Googong Catchment (Lintermans 2005b). 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 will become established in Googong Reservoir at some future point. 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 waterbody should continue (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 peelii peelii* and Silver Perch *Bidyanus bidyanus* (Lintermans 2005b).

In the Burra Creek surveys undertaken in November 2007, two alien fish species were captured: Eastern Gambusia *Gambusia holbrooki* and Redfin Perch *Perca fluviatilis*. Eastern Gambusia was observed in moderate numbers through all reaches of the creek, Redfin Perch were recorded above London Bridge and the London Bridge Homestead, and below London Bridge.

In the habitat assessment undertaken within the Murrumbidgee River (Biosis Research 2008) and habitat assessment/survey within Burra Creek (Biosis Research 2007), no threatened aquatic fauna were recorded. However, existing data for the region indicates that the Study Area is considered to provide potential and known habitat for the majority of these species.

The LLPS would be located on the east bank of the Murrumbidgee River, in the ACT, approximately 34 km south of Canberra. The discharge structure will be located within land known as the Googong Foreshores, which is Commonwealth land within NSW. Due to the geographical location of the proposed works, numerous legislative boundaries will be crossed and therefore threatened aquatic fauna have been considered under all relevant legislation.

4.3.1.1 ACT (NC ACT 1980)

Three threatened aquatic species listed under The Nature Conservation Act 1980 (NC Act) have known or potential habitat within the ACT region of the Study Area; including the vulnerable Murray River Crayfish, and endangered Trout Cod and Macquarie Perch. Silver Perch were known in the Murrumbidgee River below Kambah Pool in the ACT, but have not been recorded in sampling programs in many years, however there are occasional angler reporting's (Lintermans 2002b). It is likely that their natural range did not extend above Tharwa (Lintermans 2002b). Murray Cod are known to persist in the Murrumbidgee River, but are not considered to occur above Gigerline Gorge (Lintermans 2002b).

Some of the existing and potential threats to threatened species in the Upper Murrumbidgee Catchment include loss of habitat through sedimentation and removal, barriers to fish passage, alteration to flow regimes and reductions in water quality; recreational angling and alien species. Active management of a number of these threats has been undertaken in the ACT and Upper Murrumbidgee Region in an attempt to restore and protect populations of threatened species. This has included release of environmental flows, improving fish passage, protecting streamside vegetation and translocation and stocking of threatened species (ACT Government 2007).

NSW DPI has developed a number of recovery strategies for Trout Cod since the mid 1980s. Between 1996 and 2005 a total of 99,500 Trout Cod were stocked into the Murrumbidgee River above Angle Crossing as part of the national effort to re-establish this species throughout its historical range. Angle Crossing was considered a major site in the stocking program, with the latest stocking consisting of 15,000 fingerlings being released in 2004. Monitoring in this area of the Murrumbidgee River for Trout Cod has found that the species has survived to maturity, but there is no evidence of recruitment in the population at this stage. It is likely that the Trout Cod's natural range did not extend above Angle Crossing prior to stocking due to Gigerline Gorge acting as a major impediment to movement and dispersal (Lintermans 2002a).

By agreement with the ACT, NSW DPI has also stocked 44,000 Trout Cod at Kambah Pool since 2006 under the NSW recovery plan for the species (Lisa Evans, TAMS, pers. comm.). This was one of a number of sites stocked in the upper Murrumbidgee catchment when stocking at Angle Crossing was discontinued. Of the Murray-Darling Macquarie Perch only small discrete populations remain in the upper reaches of the ACT. The species is restricted to four waterways, the Murrumbidgee, Molonglo, Paddy's and Cotter River (Lintermans 2002a).

The NC ACT (1980) establishes a process for the identification and protection of threatened species and ecological communities. However, there is no prescribed formal assessment procedure akin to the assessments of significance tests outlined by the Part 3A Guidelines of the EP&A Act (DEC & DPI 2005) for listed threatened species under this legislation.

4.3.1.2 NSW (FM ACT 1994)

Three threatened aquatic species listed under The Fisheries Management Act 1994 (FM Act) have known or potential habitat within the NSW region of the Study Area; including the vulnerable Silver Perch, and endangered Trout Cod and Macquarie Perch.

Silver Perch have been known from the Murrumbidgee River in the past, but have not been recorded in some time (Lintermans 2002a). The apparent absence of the species within the Murrumbidgee River suggests the likelihood of a viable local population at Angle Crossing is low. However, the species is recreationally stocked into Googong Reservoir downstream of the Study Area.

The Macquarie Perch is known to occur in the Murrumbidgee River and there is also a small viable population in the Queanbeyan River upstream of Googong Reservoir not far from where the Queanbeyan River joins Burra Creek. It has not been formally established whether the Macquarie Perch exists in Googong Reservoir itself or the lower reaches of Burra Creek. As described in section 4.3.1.1, the Trout Cod are a valuable threatened species stocked and maintained within NSW at numerous sites along the Murrumbidgee River, both within and downstream of the Study Area.

The Part 3A Guidelines of the EP&A Act (DEC & DPI 2005) prescribe a number of questions to identify potential effects of the proposal on threatened species, populations or ecological communities, or their habitats listed under Schedules 4, 4A, & 5A of the Fisheries Management Act 1994. Assessments were undertaken for Trout Cod, Macquarie Perch and the Googong Reservoir stocked population of Silver Perch (Appendix 2).

4.3.1.3 Commonwealth (EPBC ACT 1999)

Three threatened aquatic species listed under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) have known or potential habitat within the Study Area; including the vulnerable Murray Cod, and endangered Trout Cod and Macquarie Perch.

All major New South Wales waterways within the Murray-Darling Basin encompass the natural distribution range of the Murray Cod (Kearney and Kildea 2001). Murray Cod are stocked regularly into Googong Reservoir and although they still occur in the Murrumbidgee River, are not generally considered to occur above Gigerline Gorge. Trout Cod and Macquarie Perch distribution within the Study Area is defined under Sections 4.3.1.1 and 4.3.1.2.

Threatened species listed under the EPBC Act that have known or potential habitat within the Study Area have been formally assessed according to the Significant Impact Criteria (DEH 2006), see Appendix 3.

4.3.2 Other Aquatic Fauna

The Murrumbidgee River and Burra Creek are known to provide habitat for other aquatic or semi-aquatic mammals, reptiles, amphibians, crustaceans, and aquatic invertebrates. These include 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 (Gilligan 2005; ACT Government 2008). Platypus *Ornithorhynchus anatinus* is also commonly sighted at Angle Crossing and is likely to be present through Gigerline Gorge. Reported sightings of Platypus are also well common throughout the reaches of Burra Creek. Murray River Crayfish *Euastacus armatus* and a variety of other macroinvertebrates and frogs also form an important part of the aquatic community.

5.0 IMPACT ASSESSMENT

5.1 ACT

The NC ACT (1980) establishes a process for the identification and protection of threatened species and ecological communities. However, there is no prescribed formal assessment procedure akin to the assessments of significance tests outlined by the Part 3A Guidelines of the EP&A Act (DEC & DPI 2005) for listed threatened species under this legislation. Therefore no formal assessments of significance are required for the Murray River Crayfish. However, with the nature of river systems, and the proximity of the ACT site to the NSW border will suggest actions carried out in the ACT will directly and indirectly affect populations that travel readily between the two states. Therefore all potential impacts upon the listed Trout Cod and Macquarie Perch are adequately addressed in the NSW and Commonwealth impact assessments of significance.

5.2 NSW

5.2.1 Key Threatening Processes

This section of the report provides contextual information that relates to the potential impacts of construction and operation within the NSW section for the proposed works. The extent of the following impacts on each threatened species would vary. An assessment of the likely impacts on each species is provided in the Part 3A of EP&A Act Assessments of Significance (Appendix 2). A range of key threatening processes (KTPs) are listed on Schedule 6 of the FM Act which relate to the proposed development, including: degradation of native riparian vegetation along NSW waterways (NSW DPI 2005a), the introduction of fish to fresh waters within a river catchment outside their natural range (NSW DPI 2001), and instream structures and other mechanisms that alter natural flow (NSW DPI 2002).

5.2.1.1 Degradation of native riparian vegetation along New South Wales water courses

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 (according to the FM Act, 1994). The proposed works will result in the clearing of small areas of riparian vegetation on the Murrumbidgee River and Burra Creek at the

construction points, and potential for varying short to long-term losses along the entire reach of Burra Creek.

Construction and operation related impacts upon riparian vegetation will be mitigated by the establishment and implementation of a Landscape Management Plan and this will include riparian vegetation rehabilitation, both at Murrumbidgee and Burra Creek.

5.2.1.2 The introduction of fish to fresh waters within a river catchment 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 (FM Act, 1994). Several threatened species are affected by this threatening process. The proposed works have the potential to introduce alien fish into Burra Creek via water transfer from the Murrumbidgee River. Of concern is the potential for introduction of the Oriental Weatherloach and Carp; both of which are not known to occur within Burra Creek. These two species, however, have known populations above Angle Crossing within the Murrumbidgee River. Significant impacts on water quality, aquatic habitat, native species and recreational fishing may also occur if transfer of such species occurs (Section 5.8.1).

The proposed works will incorporate an intake filter screen structure to prevent and mitigate the potential for transfer of fish, larvae and eggs. If screen design and operation is deemed appropriate and approved for use (see Section 5.8.1) the potential for transfer would be low and it is not expected the proposed works would contribute to this KTP.

5.2.1.3 Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams

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 (FM Act 1994). The proposed works will involve the use of temporary instream coffer dams to allow

construction of an instream culvert, and the LLPS upstream of Angle Crossing and a discharge point structure and rock fill mattress within Burra Creek.

5.2.2 Key Thresholds for Threatened Species

The Part 3A Guidelines of the EP&A Act (DEC & DPI 2005) set out a number of key thresholds which must be addressed to justify the impacts of the proposal on threatened species, populations or ecological communities listed under Schedules 4, 4A, & 5A of the Fisheries Management Act 1994. Table 5 below provides a summary for each of the key thresholds that relate to threatened species and communities within the NSW areas of the Study Area incorporating Burra Creek, and Googong Reservoir.. The key thresholds are:

- Whether or not the proposal, including actions to avoid or mitigate impacts or compensate to prevent unavoidable impacts, will maintain or improve biodiversity values.
- Whether or not the proposal is likely to reduce the long-term viability of a local population of the species, population or ecological community;
- Whether or not proposal is likely to accelerate the extinction of the species, population or ecological community or place it at risk of extinction; and,
- Whether or not the proposal will adversely affect critical habitat.

The proposed works are unlikely to reduce the long-term viability of; accelerate the extinction of; or adversely affect critical habitat for the Silver Perch, as there is no critical habitat within the Study Area, and the species is regularly stocked for recreation purposes and is not likely to currently utilise Burra Creek. However, due to the Trout Cod's limited distribution and the intrinsic value of stocked populations; and the Macquarie Perch's sensitivity to sedimentation and habitat alteration within the immediate construction site and wider Study Area; it is anticipated the proposed works may contribute to the reduction in the long term viability of these species.

The proposed works are not expected to improve biodiversity values within the Study Area, as defined from the range of impacts assessed in Section 5.0. However, it is recognised potential benefits to fish passage within Burra Creek may constitute an improvement in habitat connectivity and breeding potential for threatened species. Recommended mitigation provided in Section 6.0 will assist in mitigating potentially significant impacts, and assist in maintaining biodiversity values within the Study Area. Continued monitoring and adaptive management well into the life of the project will reduce the impacts associated with the proposed development.

Table 5: Key Thresholds for Threatened species under The Part 3A Guidelines of the EP&A Act

THREATENED FAUNA	WILL THE PROPOSAL REDUCE THE LONG-TERM VIABILITY OF A LOCAL POPULATION OF THE SPECIES or COMMUNITY?	WILL THE PROPOSAL ACCELERATE THE EXTINCTION OF THE SPECIES/COMMUNITY OR PLACE IT AT RISK OF EXTINCTION?	WILL THE PROPOSAL ADVERSELY AFFECT CRITICAL HABITAT?
Trout Cod <i>Maccullochella macquariensis</i>	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
Macquarie Perch <i>Macquaria australasica</i>	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 <i>Bidyanus bidyanus</i>	Minimal impact to this community. Potential long term changes to habitat availability and biodiversity values within Study Area and further downstream.	Unlikely	No

5.2.3 NSW Assessments of Significance (Part 3A)

The Part 3A Guidelines of the EP&A Act (DEC & DPI 2005) set out a number of questions to identify potential effects of the proposal on threatened species, populations or ecological communities, or their habitats. Assessments were undertaken for Trout Cod, Macquarie Perch and the Googong Reservoir stocked population of Silver Perch (Appendix 2). Provided that the mitigation measures outlined in this report are implemented and adaptive management and monitoring is undertaken, the proposed development is not expected to have a significant impact on the Trout Cod, Macquarie Perch or Silver Perch populations within NSW. However, the scope of likely impacts identified in this report indicates there will be direct and indirect impacts upon all three threatened species within the Study Area. While not deemed significant according to the legislation prescribed assessments (Appendix 2); the potential exists for impacts upon NSW threatened species to occur and therefore the proposed development should be referred to DEWHA for further consideration.

5.3 Commonwealth EPBC ACT Assessments of Significance

5.3.1 Threatened Species

Species listed under the EPBC Act that have known or potential habitat within the Study Area are: Trout Cod, Murray Cod, and Macquarie Perch and impact assessments have been prepared according to the Significant Impact Criteria (DEH 2006), see Appendix 3.

Assessments of significance have been prepared according to the EPBC Act significant impact criteria for species listed under the EPBC Act that have known or potential habitat within the study area (Appendix 3). These assessments of significance concluded that - provided that the mitigation measures outlined in this report are implemented and adaptive management and monitoring is undertaken - the project is unlikely to have a significant impact on Trout Cod, Macquarie Perch or Murray Cod. There is the potential for residual impacts on Trout Cod and Macquarie Perch including removal of riparian vegetation, changes to hydrology and increased sedimentation. These species may be sensitive to these residual impacts, given Trout Cod's limited distribution and the conservation significance of local, stocked populations; and Macquarie Perch's sensitivity to sedimentation and habitat alteration. Given this potential for residual impacts upon EPBC Act listed threatened species the project should be referred to DEWHA for further consideration.

5.3.2 Commonwealth Land

Under the EPBC Act approval is required for an action taken by any person on Commonwealth land that is likely to have a significant impact on the environment on that land. The discharge structure within Burra Creek will lie on Commonwealth protected Googong Foreshores within NSW. 'Environment' is defined under the EPBC Act as follows:

- (a) Ecosystems and their constituent parts including people and communities ('ecosystem' is defined in the EPBC Act as 'a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functioning unit');
- (b) Natural and physical resources;
- (c) Qualities and characteristics of locations, places and areas;

- (d) Heritage values of places ('heritage value' is defined in the EPBC Act as including 'the place's natural and cultural environment having aesthetic, historic, scientific or social significance, or other significance, for current and future generations of Australians.' 'Indigenous heritage value' is defined as meaning 'a heritage value of the place that is of significance to Indigenous persons in accordance with their practices, observances, customs, traditions, beliefs or history'); and
- (e) The social, economic and cultural aspects of a thing mentioned in paragraphs (a), (b) or (c).

5.3.3 Referral

See referral recommendations in Section 5.2.3 and 5.3.1, above.

5.4 Environmental Flows

5.4.1 Murrumbidgee River (ACT)

5.4.1.1 Historical and current flow impacts

The Murrumbidgee River has been significantly modified by historical impacts including abstraction, diversion, road crossings and agriculture. The largest of these was the construction of Tantangara Reservoir in 1960 and subsequent diversion of flow as part of the Snowy Hydro Scheme. It is estimated that Tantangara Reservoir results in a reduction in average flow near Angle Crossing of more than 50% (ActewAGL 2009). Significant variation in flow, including high magnitude flows, is still experienced in the Murrumbidgee River in the ACT due to the large catchment area below Tantangara Reservoir. Daily flows between 1993 and 2008 for Lobbs Hole, the recording station closest to Angle Crossing, are provided in Appendix 1.

Despite preventing a high proportion of the flow, there are a number of managed environmental flow releases from Tantangara Reservoir (Andrew Nolan, Snowy Hydro, pers. comm., 2008). An environmental flow is released from the reservoir for environmental management. The flow released consists of a proportion of inflow, or up to 82 ML/Day, to maintain a flow of 32 ML/Day at Mitagang Crossing, near Cooma. In addition, since 2004, the NSW Department of Water and Energy has determined a variable release of environmental flow as part of the Montane Rivers Release. This flow is dependent upon water savings and is generally released during spring. However, these flows are not necessarily passed through the system. As mentioned above, there are other water uses in the upper Murrumbidgee, with abstraction for agricultural, residential and other rural use.

5.4.1.2 Impact of proposed works on Murrumbidgee River flows: Frequency and duration of flows

The 'Impact of the M2G (Murrumbidgee to Googong Water Transfer Project) on flows in the Murrumbidgee River and Burra Creek (2009)' (ActewAGL 2009) provided by ACTEWAGL indicates that, there is a 32% likelihood the M2G will *not* operate in any given year using stochastic model data. Current projections indicate annual average abstraction will be initially 8 GL pa, increasing to 12 GL pa in 2030 (ActewAGL 2009). However, this report assesses the current proposed operation of up to 100ML/Day. Further assessment must be undertaken if abstraction exceeds 100ML/Day.

The stochastic data trend indicates the likelihood of operating the M2G decreases as number of months increases (ActewAGL 2009). The report indicates using climate data from the past 10 years, the likelihood of not using the M2G in any given year is approximately 11% (ActewAGL 2009). The past 10 year climate data indicates a far more irregular trend (in comparison to the stochastic data) indicating the M2G operation is more likely to run in a greater number of months of the year, than in the stochastic scenario (ActewAGL 2009). The data indicates there is a less than 5% chance of operating for an entire month at 100ML/Day, while there is a 23% chance of operating all month but not always at 100ML/Day (ActewAGL 2009). Using the past 10 years of climate data, the median duration of continuous pumping is approximately 11 days (ActewAGL 2009).

5.4.1.3 Impact of proposed works on Murrumbidgee River flows: Volume of flows

It is expected the mean abstraction from above Angle Crossing will be between 8 – 10 GL/year to supply Googong Reservoir through the M2G (Murrumbidgee to Googong water transfer project) operation (ActewAGL 2009).

The average volume (ML/month) of total flows which pass through Angle Crossing is 14,477 and 8,401, while median flows are 5,127 and 122, based on stochastic and previous 10 year climate data respectively (ActewAGL 2009). It is anticipated that there will be an average loss of 4.5% - 10.3%, and median loss of 14.2 – 30.4% of total flow within the Murrumbidgee River at Angle Crossing per month, based on stochastic and past 10 year climate data respectively (ActewAGL 2009).

Total abstraction will be greatly dependent on seasonal fluctuations in water availability, and it is not clear what time of year the M2G will operate most frequently (ActewAGL 2009). It is understood demand for supply is greatest in the first six months of the year; however, climate data from the past 10 years indicates water availability is frequently lower throughout this period, and therefore abstraction will more likely occur in the second half of the year (ActewAGL 2009).

ACTEWAGL has assessed the overall impact of the M2G operation on flows leaving the ACT (ActewAGL 2009). The operation of the M2G abstraction will lead to a small decrease in mean flow leaving the system, as a consequence of increased consumption, evaporation, and higher dam storages (ActewAGL 2009).

5.4.1.4 Impact of proposed works on Murrumbidgee River flows: Depth and velocity of flows

The M2G operation is predicted to decrease median Murrumbidgee River height below Angle Crossing by 8 – 16.1%; and decrease median velocity by 7.2 – 17.4%, based on stochastic and 10 year climate data respectively (ActewAGL 2009).

5.4.1.5 Environmental flow regulations

There is a commitment in the ACT water management policies to ensure environmental flows from NSW are managed responsibly and allowed to pass through the ACT unaffected by activities within the ACT. If approved, the proposed abstraction would be controlled through ACTEW's licence to extract water, which is provided by the ACT EPA. The licence would govern the abstraction volume limits and enforce environmental flow protection as outlined in the ACT Environmental Flow Guidelines (ACT Government 2006) and will form the basis of the operating rules.

ACT TAMS has developed guidelines for the provision of environmental flow. The aim of the guidelines (ACT Government 2006) is to protect important components of the natural flow to maintain the natural environment. The important components in the flow identified by the guidelines include:

- Channel Maintenance Flow – defined as the 1 in 2 year ARI floods. Channel maintenance flows clear sediment from pools and slower flowing areas to ensure an open waterway;
- Riffle Maintenance Flow – moderate flows which inundate riffle habitat, clearing sediment from thalwegs and habitat in riffles; and,
- Base Flow – the flow in the waterway between rainfall events.

The guidelines define the Murrumbidgee River as a modified reach, with a variety of identified uses including recreation, conservation and irrigation. It is recognised that the Murrumbidgee River has become an important contingency source of domestic water supply and has potential to become an ongoing domestic water supply (ACT Government 2006).

The current guidelines for the protection of environmental flows within the ACT section of the Murrumbidgee River states that for each month of each year, the base flow and flooding flows must be protected (ACT Government 2006). The guidelines are for the protection of the 80th percentile of stream flows between November and May inclusive and the protection of the 90th percentile of flow

between June and October inclusive. The flow level for the 80th and 90th percentile flows for each month at Lobbs Hole gauge is shown in Appendix 1. In order to protect flooding flows, flow variation and particularly channel maintenance flow frequency, the guidelines restrict the abstraction of surface waters to 10% of the flow volume during events above the 80th percentile. The Environmental Flow Guidelines do not identify any requirement for riffle flow protection.

The guidelines were derived through extensive and ongoing monitoring and research. Ongoing monitoring of the Murrumbidgee River at Angle Crossing has been proposed to include the monitoring of fish species and water quality. This monitoring will be used to inform additional abstraction rules the EPA may impose through ACTEW's licence, beyond rules prescribed within the Environmental Flows Guidelines.

5.4.1.6 Impact of abstraction on aquatic fauna

As has been noted above, the alteration of flows in the Murrumbidgee has had significant existing and historical impacts. In combination with habitat degradation, this has placed considerable pressure on the remaining native fish populations within the Murrumbidgee River.

While it is considered unlikely the EPBC listed threatened species within the Study Area and downstream will be significantly impaired, as water levels will not be significantly reduced; the proposed works have the potential to compound and exacerbate existing impacts within the system. The proposed abstraction is limited from between 0 - 100 ML/Day. It has been determined that there is a 68% predicted utilisation of the pumping system in any given month; and there will be no or limited pumping at low flow in order to protect the environmental health of the river. Abstraction of 100ML/Day will only occur when there are sufficient flows within the river to maintain ecological health (minimum percentile flows).

Historical high-flow events greatly exceed 1000 ML/Day and as such, the maximum abstraction would be less than 10% of the known high-flow events. Flood length is also highlighted as an important factor for river and floodplain function. The abstraction is unlikely to significantly reduce the duration of these high flows due to the minimal amount of these higher flows that would be abstracted. At maximum abstraction, it is therefore unlikely there will be a significant effect upon channel maintenance flows or flooding flows. The protected 80th and 90th percentile environmental flows for the Murrumbidgee River will be protected under ACTEW's abstraction licence. At maximum abstraction (100 ML/Day), the water level across Angle Crossing will be reduced

by up to 4 cm during a flow of 165 ML/Day (50th percentile flow) (ActewAGL 2009). A change of 100 ML/Day has been modelled to cause 15-40 mm decrease in depth over the road crossing (ActewAGL 2009).

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 depth 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.

Flow modelling indicates minimum flows will be protected and any reduction in available flows in the downstream river system is unlikely to be significant. Riffle habitats are not expected to be significantly impacted even when the pumping is running at maximum abstraction. As defined in Section 5.4.1.2.3, The M2G operation is predicted to decrease median Murrumbidgee River height below Angle Crossing by 8 – 16.1%; and decrease median velocity by 7.2 – 17.4%, based on stochastic and 10 year climate data respectively (ActewAGL 2009). These reductions will be most significant immediately below the Angle Crossing, where the river is wide and shallow.

Abstraction of any volume of water within the Murrumbidgee River will have consequences on the aquatic ecology and habitat of the system. However, the adaptive and reactive operation of the proposed abstraction regime has been designed to ensure the optimum protection of the aquatic environment and thus greatly minimise the extent of impacts upon threatened fauna within the Study Area.

5.4.2 Burra Creek (NSW)

The proposed introduction of between 0 - 100 ML/Day from the Murrumbidgee River into Burra Creek has the potential to significantly impact flows and aquatic habitats within Burra Creek. In addition to the discharge point source, there will be at least one pipeline crossing of Burra Creek and a number of minor drainage lines. Appropriate management during the construction of these crossings such as

minimising the construction footprint, management of bank and stream habitat and protection of water quality will minimise the potential impact of the crossings.

The discharge of up to 100 ML/Day is above the 95th percentile flow for Burra Creek and the increased flow will therefore result in changes to Burra Creek's aquatic environment. These impacts will likely include:

- increased sediment transfer through the scouring of sediment from riffles and pools;
- change in thermal regime;
- change to existing emergent and submergent macrophyte beds;
- alteration to macroinvertebrate community structures;
- erosion and modification of bed and banks; and,
- changes in the potential utilisation of Burra Creek by fish in Googong Dam.

Burra Creek within the Googong Foreshores is a historically modified environment, but provides habitat for native fish, other semi aquatic vertebrates, macroinvertebrates and Platypus, which are known to occur within the Googong reservoir.

5.4.2.1 Impact of proposed works on Burra Creek flows: Frequency and duration of flows

See section 5.4.1.2 above.

5.4.2.2 Impact of proposed works on Burra Creek flows: Volume of flows

It is expected that between 8 – 10 GL/year of water will be discharged into Burra Creek to supply Googong Reservoir through the M2G operation (ActewAGL 2009). This boost in flow volume will lead to a significant increase in average and median flows in Burra Creek. However, it is expected that periods of very low to zero flow periods will continue to occur when operation of M2G is not possible (e.g.: drought, unsuitable water quality at source) (ActewAGL 2009). Large flooding flows will not be impacted as it is expected the M2G flows will be small in relation to historical flood flows, and the pumping operation can be ceased when necessary (ActewAGL 2009).

The average volume (ML/month) of flows which pass through Burra Creek is 273 and 4.7, while median flows are 42 and 1 based on stochastic and previous 10 year data respectively (ActewAGL 2009). It is anticipated that there will be an average increase of 238.5% - 598.6%, and median increase of 306.3 – 542.5% of flow within Burra Creek per month, based on stochastic and past 10 year data respectively (ActewAGL 2009).

Total discharge increase will be greatly dependent on seasonal fluctuations in water availability at the source, and it is not clear what time of year the M2G will operate most frequently (ActewAGL 2009). It is understood demand for supply is greatest in the first six months of the year; however, data from the past 10 years indicates water availability is frequently lower throughout this period, and therefore abstraction, and subsequent discharge, will more likely occur in the second half of the year (ActewAGL 2009).

5.4.2.3 Impact of proposed works on Burra Creek flows: Depth and velocity of flows

The M2G operation is predicted to increase median Burra Creek riffle habitat height by 275.3 – 425.9%; and increase median pool height by 269.5 – 403.4%, based on stochastic and 10 year data respectively (ActewAGL 2009). Median velocity within Burra Creek riffle habitat is predicted to increase by 267.5 – 395.7%; and increase pool velocity by 273.7 – 419.5%, based on stochastic and 10 year data respectively (ActewAGL 2009).

5.4.2.4 Impact of abstraction on aquatic fauna

It is likely that the increased flow will improve the suitability of Burra Creek habitat for alien species such as Brown and Golden Trout. At present, trout are likely to be limited by extended periods of low flow and high summer temperatures in Burra Creek. These limiting factors currently restrict the movement of trout from Googong Reservoir into Burra Creek. The discharge of up to 100 ML/Day may reduce average water temperatures and provide additional access and breeding habitat for exotic fish species within Burra Creek.

A number of the native, including threatened species in Googong Reservoir require flowing water to breed, particularly Macquarie, Silver and Golden Perch. These species cannot currently migrate freely upstream into the upper reaches of Burra Creek, nor can they access the downstream Queanbeyan River to find suitable spawning habitat, due to Curlys Falls, which is a barrier to fish passage. However, the proposed transfer discharge during the spring and summer

breeding periods may also provide suitable breeding habitat for these species in Burra Creek.

The proposed increase in flow has potential to impact upon Platypuses in Burra Creek. Studies undertaken by Grant (2009) indicate that any population of platypuses occurring in Burra Creek are small, subject to stressors as a consequence of poor foraging areas, high predation and isolation as a result of low connectivity between pools (Grant 2009).

While no Platypuses were encountered throughout the survey, encounters within Burra Creek have been documented. The proposed increase of up to 100ML/Day may induce a positive influence on any existing Platypus populations within Burra Creek. An increase in regular flow may provide greater access to foraging areas and decreasing the risk of predation rising from the lack of suitable habitat (Grant 2009). However, the timing and extent of flows may impact Platypuses with dependent young in nesting burrows during the breeding season, especially during the peak lactating period of November to February (Grant 2009).

Platypuses establish their breeding burrows in spring and may be impacted by any increase in water level (Grant and McDonald 1996). While the increased flow is not predicted to increase the energy requirements of the platypus when foraging; the increase in flows may result in changes to their food source, the macroinvertebrates community and populations (Grant and Bishop 1998).

Macroinvertebrate communities are likely to be directly impacted by variable increases in flow depth and velocities. Many species of macroinvertebrates are bottom-dwelling vagile organisms which live within ecologically valuable interstitial spaces and are likely to be impacted by an increase in flows and subsequent sediment entrainment and associated decreases in water quality (Scealy *et al.* 2007) (Cao *et al.* 1996). Macroinvertebrates are an integral element of the aquatic food web and a known major food source for fish and platypus, and any reduction in biomass could significantly reduce the viability and health of the system (Gooderham and Tsyrlin 2003; Barton and Metzeling 2004). It is likely the macroinvertebrate assemblages of Burra Creek will be significantly impacted by the initial increase in flow transfer, but will likely reach a state of equilibrium once the initial habitat restructuring process is stabilised. The interim loss of macroinvertebrates is likely to reduce available food sources for fish and platypus within Burra Creek. The population and species structure of the macroinvertebrate communities may be permanently altered as instream habitat conditions are transformed.

5.5 Fish Passage

5.5.1 Murrumbidgee River (ACT)

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 such as breeding and juvenile dispersal. However, different species have different passage requirements and undertake movement at different scales and times of the year or life stage. Table 6 provides guidelines to potential movement and breeding for selected species in the Murrumbidgee River at Angle Crossing and Googong Reservoir/Burra Creek based on (Koehn 1997; Lintermans 2000).

Breeding movements of many species are correlated to high flow events. Many of the fish species in the Study Area, despite having demersal or adhesive eggs, 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 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 potentially the Trout Cod. Although there are a number of significant natural barrier upstream and downstream, there are no major road crossings upstream for at least 50 km.

Quantifiable 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) would 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 according to (Lintermans Pers. comm., 2009). The Angle Crossing barrier is known to restrict movement of Macquarie Perch and potentially the Trout Cod, which are known to require, as a rule of thumb, roughly three times the body depth of the largest fish to successfully clear an instream barrier (Lintermans, pers. comm., 2009). A 350 mm Macquarie Perch with a body depth of 120 mm would likely need roughly 360 mm of water over the crossing to clear the barrier (Lintermans, pers. comm., 2009). A 360 mm depth at Angle Crossing has a flow probability of 4% (4th percentile flow) so the

likely impact of the 100 ML/Day abstraction on fish passage at Angle Crossing is anticipated to be minor (ActewAGL 2009)

5.5.2 Burra Creek (NSW)

It is likely that during water transfer periods, Burra Creek could provide improved habitat for a number of species including the alien species Rainbow Trout *Oncorhynchus mykiss* and Brown Trout *Salmo trutta*; and potentially the threatened Macquarie Perch, Silver Perch and Golden Perch. Trout migrate out of lakes and into streams to spawn, but are not expected to navigate through warm water. Flow transfers may benefit these fish through the subsequent increase in channel depth and reducing instream 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 would 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 could increase predation pressures on any surviving population of Mountain Galaxias *Galaxias olidus* and other small and juvenile native fish species.

Increased flows in Burra Creek may create access to suitable spawning sites for Macquarie Perch moving up out of Googong Reservoir. There are no known significant barriers to fish passage in Burra Creek upstream of Googong Reservoir until London Bridge, and the pools and riffle/run habitat which would be created during transfer could be suitable for Macquarie Perch, which disperse eggs in the tail of pools. This would require fairly consistent high flows between November and January. There are, however, a number of 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 could become hazardous as bird predation would probably be likely. Bird predation is a known threat to Macquarie Perch breeding migrations in the ACT region (Lintermans and Osborne 2002).

The area of known and potential habitat for the Silver Perch that may be impacted as a result of the water transfer includes creek lines, submerged riparian vegetation and LWD 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 would undertake natural spawning movements on a large scale

(Lintermans 2005b). Therefore the predicted impact on fish passage for Silver Perch is considered unknown but considered likely to be 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. If native and threatened fish species are found to be spawning, flow transfers should be maintained where possible during the breeding season (typically early spring to summer) to protect the spawning populations. If flows must be altered, then the 48 hour ramping up/down operating regime must be utilised to allow fish to safely exit the creek.

Table 6: Spawning season and movements of native and alien fish species present in the Murrumbidgee River and Googong Catchment (based on Koehn, 1997; Lintermans, 2000).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trout Cod ¹	-	-	-	-	-	-	-	Adult upstream?	Adult upstream?	Adult upstream?	Adult downstream?	Adult downstream?
Macquarie Perch ¹	Juvenile Downstream	-	-	-	-	-	-	-	Adult upstream	Adult upstream	Adult upstream	Adult upstream
Murray Cod ²	-	-	-	-	-	-	-	Adult upstream	Adult upstream	Adult upstream	Adult downstream	Adult downstream
Golden Perch ²	Adult upstream	Adult upstream	Adult upstream	Adult upstream	-	Adult downstream	Adult downstream	-	Adult upstream	Adult upstream on high flows	Adult upstream	Adult upstream
Silver Perch ²	-	-	-	-	-	-	-	-	Adult upstream	Adult upstream	Adult upstream	Adult upstream
Carp ^{1,2}	Downstream drift of larvae	-	-	-	-	-	-	-	-	Downstream drift of larvae	Downstream drift of larvae	Downstream drift of larvae
Goldfish ²	-	-	-	-	-	-	-	-	-	-	-	-
Brown Trout ^{1,2}	-	-	-	-	Adult upstream after rain	Adult upstream after rain	Adult upstream	-	-	-	-	-
Rainbow Trout ^{1,2}	-	-	-	-	-	Adult upstream after rain	Adult upstream	Adult upstream	-	-	-	-
Murray Crayfish ¹	-	-	-	-	-	-	-	-	-	-	-	-
Oriental Weatherloach ¹	Downstream colonisation known	Downstream colonisation known	Downstream colonisation known	Downstream colonisation known	Downstream colonisation known	-	-	-	Downstream colonisation known	Downstream colonisation known	Downstream colonisation known	Downstream colonisation known
Mountain Galaxias ^{1,2}	-	-	-	-	-	-	-	-	-	-	-	-

1- present in Murrumbidgee River; 2 – Present in Googong Reservoir.

5.6 Design and Operation Impacts

5.6.1.1 Intake structure and Low Lift Pump Station (ACT)

The proposed design of the LLPS is not expected to significantly impact the aquatic ecology of the Murrumbidgee River. The proposed site and design of the structure incorporates design elements which aim to minimise impact on environmental flows and the surrounding bank structure. It is proposed the gradient of the intake screen would resemble the natural river bank slope, in turn minimising river flow stream disruption and turbulence. The passive abstraction design would minimise entrainment of sediments and will prevent forced entrainment of fish and other aquatic species.

The intake screens design incorporates structural steel rectangular hollow sections installed in removable panels spaced 25mm apart. This would prevent fish > 25 mm to enter the intake chambers. The intake structure has been designed to keep intake velocities below that which would hold flotsam and fish against the bars. It is expected that velocities will be so low that material is unlikely to be drawn to the intake, and not held against it. The physical nature of the intake structure may be susceptible to sediment scouring and resulting erosion, which may become a concern 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 structure.

Mobilised sediment and silt entrained within the flows would be screened at the LLPS by the grit collection hopper sumps and flushed into an eductor pipeline. This would discharge into a pit from which a 600 mm diameter culvert running under the Angle Crossing Road approach to the causeway will end in a headwall discharge into the Murrumbidgee River. It is proposed that as a component of the operational rules for the LLPS the jet inductors would be operated by automatic valves on a timer basis and/or ultrasonic detectors that would respond to grit build up in the hopper sumps. Regular release of captured sediments from within the LLPS back into the river flows would result in frequent plumes of sediment downstream of Angle Crossing. Potential impacts may comprise:

- smothering of aquatic flora including macrophytes;
- smothering and direct damage to aquatic fauna including adult, juvenile, larval and eggs of native fish species;
- smothering and direct damage to macroinvertebrate communities; and,

- changes to the physical structure of the river bed including small pools and the loss of ecologically valuable interstitial spaces.

The automatic timer would be incorporated to ensure that the sediments are returned to the river on a frequent basis. The exact extent of the potential impacts of the sediment release is very difficult to determine, as entrained sediment levels within the Murrumbidgee River fluctuate temporally. However, continued monitoring once the system is activated would assist in identifying the impacts and minor adjustments to the timers or release volumes could be implemented to minimise potential impacts.

5.6.1.2 Discharge structure (NSW)

The discharge structure is unlikely to significantly impact habitats in Burra Creek. While the low-energy discharge design and the installation of the rock fill mattress wall will greatly minimise erosion within Burra Creek, the creek substrate (in particular fine sediments such as silts and clay) is expected to be significantly impacted by the increased volumes of flow. However, the design of the discharge structure itself aims to minimise impact upon the aquatic ecology within Burra Creek.

5.7 Construction Impacts

Two components of the proposed infrastructure construction have the potential to impact the aquatic environment of the Study Area: the LLPS and the discharge structure on the bank of Burra Creek.

5.7.1 Murrumbidgee River Construction Impacts (ACT)

The construction of the LLPS would involve excavation of up to 6 m of the eastern bank within the river. There is potential for site blasting to occur if bedrock proves difficult to excavate. Existing bank vegetation, consisting primarily of grasses and shrubs and few trees will be directly damaged, or lost. Such impacts may result in the introduction of increased sediments entering the river and flowing downstream. A floating silt curtain, which forms part of the proposed works, would surround the construction site to arrest any mobilised sediments as a result of the bank construction.

The proposed construction area for the LLPS is predicted to lie above bedrock, and therefore a coffer dam comprised of H-piles will be used to embed into the underlying rock with horizontal walers to provide support for vertical sheet-piles. The incorporation of a perpendicular earth/rock platform approximately 8m

into the Murrumbidgee River has been proposed to provide access and support for a pile rig (to be confirmed). The placement of the coffer dams and rock platform 8 m into the river, adjacent to the river bank, will temporarily and partially affect flows within the river adjacent to the construction site. 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.

The use of coffer dams would also incorporate the continual use of pumps to extract groundwater to allow for dry working conditions for the concrete placement. Extracted waters are expected to be stored on-site for potential further treatment before being released into the Murrumbidgee River. Any waters must be certified clean from contamination (oils, spills) associated with the construction before release. This construction impact may lead to fluctuations in turbidity via sediment re-suspension during the construction and coffer dam removal phases. The potential for impact is likely to be insignificant on other water quality values as long as extracted waters are kept free of pollutants and allowed to settle before release.

5.7.2 Burra Creek Construction Impacts (NSW)

The construction of the discharge weir will involve excavation of approximately 3.5 x 10 m of the right bank within the creek. There is potential for site blasting to occur if bedrock proves difficult to excavate. Existing bank vegetation, consisting primarily of grasses and shrubs would be directly damaged, or lost. Such impacts may result in the introduction of increased sediments entering the river and flowing downstream.

The proposed construction area for the discharge structure lies adjacent to Burra Creek where flow was determined to be relatively low. The introduction of excess sediments through the construction phase may exacerbate the existing level of impact to this shallow, disturbed system. Existing riparian and bank vegetation may be damaged or lost. Increased sediment loss on the bank would likely enter Burra Creek and be transferred downstream creating a number of adverse impacts on both aquatic flora and fauna, and the physical structure of the creek downstream. Potential impacts are similar to the Murrumbidgee River and may comprise smothering of aquatic flora/fauna including macrophytes, adult, juvenile, larval and eggs of fish species; macroinvertebrates and changes to the physical structure of the river bed including the loss of ecologically valuable interstitial spaces and infilling of pools. However, it is expected that the majority

of these impacts would be short-term and would not significantly alter the aquatic ecology of Burra Creek in the long term. Implementation of appropriate mitigation measures would greatly decrease the potential impacts associated with the discharge point construction.

5.8 Intake Issues

Significant mortalities of adult and juvenile fish have been recorded in association with abstraction from rivers (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 2007):

- Impingement - fish being caught on or in the pumps screens;
- Entrapment - fish getting into the pipe or channel are impacted by the effects of pumps and pressure changes in the pipe, transferred to the receiving water body or lost from the system in terms of irrigation channels; and,
- Predation – fish congregating at the intake are predated upon by other fish or other predators such as birds, humans etc.

The mitigation of adult, juvenile, larvae and eggs of fish being impinged upon or entering the pipeline is considered of high priority to reduce the impacts that the proposed works will have upon the aquatic fauna in the Murrumbidgee River, including threatened species.

In the current design of the proposed works, the abstraction system would consist of a box-in-bank structure with a side inlet and incorporate four fish egg filtration units to filter fish eggs from the water and would discharge filtered water through a dividing wall into the pump module. Backwashing of the units to return filtered fish eggs to the river would occur via the hoppers, jet inductors and eductor flows. Potential impact of this operational procedure on impinged eggs is unknown. The passive abstraction design would prevent forced entrapment of fish and other aquatic species. It is proposed the gradient of the intake screen would resemble the natural river bank slope, in turn minimising river flow stream disruption and turbulence. The intake screens design incorporates structural steel rectangular hollow sections installed in removable panels spaced 25mm apart. This will prevent fish > 25 mm to enter the intake chambers. The intake structure has been designed to keep intake velocities below that which would hold flotsam and fish against the bars. It is expected that velocities will be so low that material

is unlikely to be drawn to the intake, and not held against it. This design will also mitigate the risks of increased predation from birds.

5.8.1 Potential for interbasin transfer of fish

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 or its catchments (Lintermans, pers. comm., 2009). The potential impact of these two alien fish in Googong Reservoir may include: reduced water quality; introduction of disease and parasites, alteration to habitat, particularly submergent macrophyte cover, by increasing turbidity; predation upon fish eggs and juveniles and competition with native species. Should these species access Googong Reservoir there is a greater potential risk of them invading the more significant conservation reaches of the upper Queanbeyan River.

It should be noted for contextual purposes that the proposed works are not the only potential vector for the introduction of these or other species and pathogens into the Googong Reservoir Catchment. Other known vectors outside the scope of the proposed works include: illegal release of aquarium pets; illegal use of live bait; stocking and overflow of household/rural ponds and dams/reservoirs and inadvertent transfer during recreational stocking, or on boats, vehicles or fishing equipment.

There are three major life stages which have potential to be transported through a pipeline: adult fish, juveniles and eggs/larvae. An intake screen with mesh size of 6.35 mm will effectively prevent adult and juvenile fish of all species from being translocated through the pipeline to Burra Creek, though, a smaller mesh size of at most 0.5 mm would be required to eliminate the transfer of eggs and larvae. However, a mesh gauge of <0.5 mm is recommended for ecological security to ensure all eggs of alien species are effectively screened. It is understood that natural variation and genetic inconsistency between individuals of a species can result in eggs which are smaller than average, which may subsequently circumvent the screening process.

The potential transfer of adult and juvenile fish would be mitigated by preventing impingement and passage through the intake as described above. There are a number of methods of minimising and/or preventing eggs and larvae from being transferred through the pipeline. These methods include:

- Limiting pumping period during breeding season;

- Treatment by sterilisation of the water including eggs; and,
- Screening or filtering, i.e. physical removal of eggs and larvae.

Limitation of pumping prevents transfer by ceasing pumping when eggs or larvae are present, however is considered a highly impractical and high-risk method of control. Carp and Oriental Weatherloach spawn during late spring and through summer (Table 6). Larva and small juveniles, which could pass through the initial screen, would be likely to present until early autumn. This period is likely to experience high demand for pumping (Section 5.4) and as such limiting the pumping period will not be feasible as a reliable method to reduce the risk of translocation.

Most fish eggs and larvae are generally highly susceptible to water treatment. Treatment of water, similar to that for human consumption would kill any eggs or larvae in the system. However, water treatment is very expensive and some chemical or treatments may have a deleterious effect at the discharge.

Filtration or screening of the eggs has been attempted in a number of management situations (Diggle *et al.* 2004). These systems can be a simple grill or can utilise water flow to macerate any material caught on the screen or a specific filtration system. A physical barrier to carp eggs has been attempted in Tasmania, as part of the control of carp in Lake Sorrell and Lake Crescent (Diggle *et al.* 2004). A series of 1.1 mm mesh weirs is used to prevent the carp from moving between lakes and escaping downstream. This mesh system has not been entirely successful from flow and containment perspectives and has had high maintenance requirements during the breeding season (Inland Fisheries Service Tasmania 2004).

Carp tend to lay their eggs in shallow bays and slow or no flow areas associated with submergent macrophytes, flooded vegetation and LWD. The eggs are adhesive and have a diameter of approximately 0.5 mm to 1.5 mm. They are laid in spring and summer and hatch in 2-6 days (Sivakumaran *et al.* 2003). Oriental Weatherloach deposit eggs on mud or submergent macrophytes during summer. The eggs have a diameter of approximately 0.8 mm to 1.5 mm and hatch in 2-3 days (Koster, 2002).

The proposed filtering system would likely be sufficient to minimise the potential risk for the transfer of fish in all their life stages. However, the risk of transfer remains constant and issues regarding periods of screen filter maintenance and replacement would remain an operating issue. It is recommended a skilled abstraction screen expert be consulted to review the screen design and approve the structure before the project commences.

5.8.2 Potential for transfer of pathogens

There are a number of pathogens known to affect fish in the ACT, however the Epizootic Haematopoietic Necrosis Virus (EHNV) is considered to pose the most significant threat. The EHNV is unique to Australia and was first isolated in 1985 in Redfin Perch. Laboratory experiments demonstrated that a number of native species were susceptible to the disease, including the threatened Macquarie Perch and Silver Perch, as well as Mountain Galaxias (Langdon 1989). The virus has been recorded from Victoria, New South Wales, South Australia and the ACT. The spread of EHNV is aided by its persistence of infectivity and can be readily transmitted via infected fish, freely in the water column, and on fomites including boats, nets, fishing lines, fishing gear, and other equipment (Lintermans 2002b; Langdon 1989). The virus can retain its infectivity after being stored dry for 113 days (Langdon 1989). It is now widely considered that once EHNV has entered a water body it is impossible to eradicate (Lintermans 2002b).

Redfin Perch are considered the main host for the virus and are predicted to be the key source of transmission within the aquatic environment (Langdon 1989). This alien fish species is widely distributed throughout the temperate portions of the Murray-Darling Basin and were first detected in the Googong Reservoir in 1988. Redfin Perch were first recorded in the Murrumbidgee River at the Casuarina Sands fish trap in 1986 but have not been recorded in the Murrumbidgee River above Tharwa (Lintermans 2002b). Other introduced or native fish may be natural hosts, subclinical carriers or susceptible to EHNV (Langdon 1989). Species which developed disease following exposure through Langdon's (1989) experiments are highly susceptible to the virus; these were Macquarie Perch, Silver Perch, Murray Cod, Eastern Gambusia and Mountain Galaxias.

The EHNV was first detected in the Canberra region in 1986, and is known to have been present in the Murrumbidgee River and Googong Reservoir since the late 1980's (Lintermans 2005b). An outbreak of EHNV occurred in the Googong Reservoir in 1994 which resulted in massive fish mortalities (Lintermans 2005b).

Brief fish sampling was undertaken in Burra Creek at a number of sites. Juvenile Redfin Perch were recorded above London Bridge and the London Bridge Homestead, and a single large adult Redfin Perch was recorded below London Bridge. It is expected the current extent of infection within Burra Creek is directly linked to the presence of Redfin Perch. Given the close proximity of Burra Creek to a known site of EHNV occurrence and the likelihood in an infected catchment (Queanbeyan River) of the virus being present wherever the

major host species (Redfin Perch) occurs, the presence of the virus within Burra Creek is almost certain (Mark Lintermans pers. comm., 2009).

The Redfin Perch is not known to occur upstream of Angle Crossing with the species upper extent of distribution range extending to the base of the Gigerline Gorge on the Murrumbidgee River (approximately 6km downstream of Angle Crossing). Yearly monitoring of fish populations is undertaken in the Murrumbidgee River at Angle Crossing by ACT TAMs. In the 2000-2006 sampling period no Redfin Perch were collected. In the absence of Redfin Perch, it is expected the risk of EHNV being introduced into Burra Creek via the abstracted Murrumbidgee River water is negligible (Mark Lintermans pers. comm., 2009).

5.9 Bank Stability and Vegetation

The results of hydrological modelling indicate that the transfer would significantly increase flows within Burra Creek, while not necessarily having a large impact upon peak flows (Bulk Water Alliance 2009). The potential morphological impacts as a result of the transfer discharges are highly likely to be within the bounds of recent variability in channel form (Bulk Water Alliance 2009).

Hydrological investigations indicate that in areas of Burra Creek bank undercutting may occur due to the higher flow operating on banks for longer durations. These adjustments could result in changes to aquatic habitats, with the degradation of macrophyte beds and margin vegetation, removal of sediments from riffles and subsequent deposition in pool zones.

The existing riffles and runs in the upper sections of Burra Creek are controlled by bedrock and as such sediment deposits are limited to small gravel and cobble bars. Large beds of vegetation have colonised instream areas following periods of low flow. An increase in smaller flow events is likely to reduce the amount of sediment available for macrophyte colonisation and destabilise existing plants (Bulk Water Alliance 2009). The majority of macrophyte beds in the upper and mid sections of Burra Creek consisted of emergent reeds such as *Phragmites australis* and *Typha orientalis*. These reeds perform several important ecological functions, providing habitat for aquatic fauna, trapping sediment and reducing the exposure of banks and stream beds to erosion. Long-term stability is expected to be restored as newly formed low flow channel margins are recolonised by fringing vegetation and a new equilibrium within the system is met (Bulk Water Alliance 2009).

Above London Bridge Homestead (where bedrock controls the channel, but to a lesser degree), the changes as a result of transfer flow discharges are expected to be limited to the establishment of a more defined low flow channel connecting pools (Bulk Water Alliance 2009). The formation of a continuous channel will result in the erosion and transport of sediment since increased flow over riffle zones will inundate and destabilise fringing vegetation. The impact of this increased turbidity is expected to be short-lived and reduce as fringing vegetation re-establishes (Bulk Water Alliance 2009).

Pools in the lower reaches of Burra Creek above and below London Bridge are likely to be subject to deposition of sediment from the low flow channel within the riffle zones. The increase in the level and width of flow within pools may reduce the distribution of fringing vegetation, exposing sediments to erosion and potentially increasing pool width. There may be a reduction in pool levels during low flow periods when transfer flows are not being discharged (Bulk Water Alliance 2009). Deep pools are important habitat for aquatic species and any loss of pool habitats would be a significant change in the availability of aquatic habitat along Burra Creek.

Phragmites australis and *Typha orientalis* are seasonal species, dying back over winter to overwintering buds under the substrate and striking new shoots in spring. Given the seasonality of these plants, their capacity to respond to larger flows also varies with season. During winter, reed beds senesce and tend to flatten or detach stems in response to strong flows. This behaviour greatly reduces shear stress and scouring effects, thus ensuring that root systems and surrounding sediments stay intact. During spring, young shoots grow quickly and strike new roots. High flows at this time can be detrimental, drowning young shoots through prolonged submersion or eroding them out before roots have had the opportunity to properly strike (Frankenberg 1997). The distribution and recolonisation ability of macrophytes will be a determining factor in the degree of morphological adjustments from the transfer discharge (Bulk Water Alliance 2009).

Most of the predicted morphological adjustments are likely to become established within the first one to two years of operations (Bulk Water Alliance 2009). If macrophytes are able to recolonise low flow channel areas the impacts on water quality and pool sedimentation as a result of the proposed works are considered to be short-lived.

5.10 Water Quality

ACTEW has supplied water quality data and a brief analysis to base the water quality component of this report for the Murrumbidgee River and Burra Creek systems as it relates to the proposed project. Water quality monitoring has been undertaken for both Murrumbidgee River near Angle Crossing since November 1993 and within Burra Creek near the confluence with Queanbeyan River since 1997 by EcoWise Environmental. Data is consistently available in both catchments between 1997 and 2002. The Burra Creek site was only monitored when inundated by Googong Reservoir, and the data assessed for this study ranged from samples between 1997 to 2007 (Actew 2008). There is currently no additional monitoring data available near the proposed discharge point, or through the extent of Burra Creek (Actew 2008). Therefore this assessment can only compare Murrumbidgee River, at the Angle Crossing site, to the Burra Creek site when inundated by Googong Reservoir (Actew 2008). The available data is inconsistent and not directly comparable as sample timeframes differ significantly. The validity of the supplied data has been taken into account for this assessment and in lieu of reliably comparable data, all conclusions drawn are approximations and do not necessarily reflect the full scope of potential impacts that may arise as a consequence of the proposed development.

The water quality and hydrology of the Murrumbidgee River is not predicted to be significantly impacted 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, it is likely degradation of banks and surrounding ground vegetation would lead to an increase in soil loss and exposure which may result in increased sedimentation within the vicinity of the Angle Crossing. The initial construction phases would likely introduce greater levels than normal of sediments increasing turbidity, and decreasing light penetration.

In contrast, it is likely that the provision of transfer flows would result in far greater changes to the hydrology and water quality of Burra Creek. As mentioned above, a recent water quality assessment was undertaken by ACTEW to determine the status and historical water quality attributes within the Murrumbidgee River and Burra Creek waterways. It was determined that a number of water quality parameters within Burra Creek are likely to be impacted by the proposed development (Actew 2008).

5.10.1 Turbidity

Data is consistently available in both catchments between 1997 and 2002. The limited water quality sample data indicates turbidity levels between this period were very similar between the two systems (Actew 2008). In recent years (between 2006 and present) data is consistently available for Murrumbidgee, but not for Burra Creek. Throughout this recent period, turbidity levels were consistently higher in the Murrumbidgee River than in earlier years (Actew 2008). The limited data available for Burra Creek in the same period did not show the same pattern (Actew 2008). The available water quality data indicates a significant difference in turbidity between the two systems with the Murrumbidgee River, in recent years having significantly higher median turbidity levels. However, due to the differing timeframes of sample data, care must be taken when interpreting this result. The historic turbidity levels within the Murrumbidgee River are not outside the normal range found within Burra Creek.

The Murrumbidgee River, overall, has a high median turbidity due to widespread clay soils in the ACT (ActewAGL 2006). The median turbidity for the Murrumbidgee River at Angle Crossing was 13 NTU throughout the sampling period of 1993 – 2008, exceeding the ACT AQUA 1 guideline 56% of the time, but within the ANZECC guidelines of 2 – 15 NTU (Actew 2008). The ACT AQUA 1 regulation limit for turbidity is <10 NTU, which has been defined in the ACT Planning and Land Authority's Water Use and General Catchment General Code (ACT Planning & Land Authority 2008). Variability in the data is increased by large, irregular increases in turbidity due to high rainfall or high sediment loading events, such as the 2006 New Years Eve storms which led to a spike in turbidity in early 2007 (ActewAGL 2006).

The median turbidity at the Burra Creek station was 3.1 NTU across the available survey period (Actew 2008). Of the available data, 60% of surveys exceeded turbidity ANZECC guidelines of 2 – 15 NTU, while 15% exceeded the ACT AQUA 1 limit (Actew 2008). Similar to the Murrumbidgee River, Burra Creek spikes in turbidity are associated with high rainfall and high sediment loading events.

Mobilised sediment and silt entrained within the Murrumbidgee River flows would be screened at the LLPS by the grit collection hopper sumps. Jet inductors in each hopper sump would flush the collected grit into an eductor pipeline which would flow from the LLPS and discharge into a pit from which a 600 mm diameter culvert will run under the Angle Crossing Road approach to the causeway and end in a headwall discharge into the Murrumbidgee River. It is expected this proposed operational regime will greatly minimise the ecological

impacts by distributing the captured sediment regularly and prohibiting the collection of large accumulations.

A significant increase in turbidity within Burra Creek as a consequence of the proposed works could result in detrimental impacts upon the aquatic ecology of the creek. Potential impacts would include the alteration and decrease in habitat heterogeneity, infill of shallow pools and streams, loss of critical cobble habitat for fish, direct damage to aquatic species (e.g. gill damage to fish, smothering of eggs and larvae), decrease in light penetration leading to a loss in aquatic vegetation and algae, an increase in mean water temperature, and a decrease in dissolved oxygen (Maddock *et al.* 2004; ANZECC 2000; Rutherford *et al.* 2000).

However, based on available turbidity data, it is unlikely the transfer of Murrumbidgee River waters to Burra Creek, would lead to a significant increase in the turbidity levels within Burra Creek. Infrequent turbid flows within the Murrumbidgee River as a result of instream construction, heavy rainfall, bushfires, flooding etc may introduce significant quantities of sediment and operational rules would need to be defined to avoid transfer of flows when turbidity in the Murrumbidgee exceeds acceptable levels, which are currently undetermined.

5.10.2 Nutrients

In freshwater ponds, lakes, reservoirs, streams and rivers, excessive algal growth resulting from high levels of nutrients, may degrade the physical habitat of the waterway and may directly affect the health of fish and other aquatic life (Harris 1996). Excessive levels of nutrients within a water column may lead to significant blooms of aquatic algae and macrophytes (Sherman *et al.* 1994). The most important nutrients affecting aquatic plant growth are nitrogen and phosphorus which typically enter the system via runoff from urban and agricultural land use (fertilisers), stormwater, industrial releases, waste and decomposition of instream vegetation and fauna (Drewry 2006). This nutrient enrichment, or eutrophication, can lead to highly undesirable changes in ecosystem structure and function (Sillman and Bertness 2004). For example, excessive growths of algae in streams may form dense mats on the water surface or on the stream bottom reducing the amount and diversity of shelter and nursery areas for small fish and aquatic macroinvertebrates (Bailey *et al.* 2002). Algae floating in the water column may decrease light penetration, thus reducing the growth of important submerged macrophytes rooted on the bottom (Bailey *et al.* 2002).

The water quality study undertaken by ACTEW (2008) identified that total phosphorus and total nitrogen levels are close to trigger levels within both systems (Actew 2008). Prior to 2004 the Murrumbidgee River regularly exceeded the trigger values for acceptable tolerances of nutrients, and since 2006 there have been a number of exceedances in levels of phosphorus (Actew 2008). The lack of sufficient data over the same period for Burra Creek restricts comparisons able to be drawn. Available data suggest there may not be a marked difference between total phosphorus and total nitrogen between the two systems (Actew 2008).

5.10.3 Dissolved Oxygen

Many aquatic organisms such as fish, invertebrates (e.g. insect larvae) and aerobic microorganisms depend on dissolved oxygen (DO) for respiration. Exposure to low oxygen may cause a slowing in growth rates, reproductive difficulties, stress, susceptibility to disease, and in severe cases of depletion, premature death (CRC Sugar 2000). DO is highly variable and is influenced by many parameters including water temperature, aeration/turbulence, chemical and microbiological reactions to wastes discharged into the systems and biological processes such as photosynthesis and respiration (Actew 2008).

The water quality study undertaken by ACTEW (2008) identified that dissolved oxygen was highly variable in both catchments throughout the available monitoring period. ANZECC guidelines for DO in moderately modified, upland freshwater streams in SE Australia indicate trigger values between 60 – 120 %Saturation (ANZECC 2000). The analysis report also identified that dissolved oxygen was regularly below ANZECC (2000) guidelines (Actew 2008). The data indicated that Murrumbidgee had consistently higher DO levels in contrast to Burra Creek (Actew 2008). Across the survey period, DO at the Burra Creek gauge station was below the ANZECC AE lower bound 56% of the time, but consistently above both the minimum values for the ACT Stock & Water Supply and Aquatic guidelines (Actew 2008). The median DO was 9.9 mg/L.

The proposed abstraction from Murrumbidgee River is unlikely to reduce existing DO levels within the Murrumbidgee River, downstream of Angle Crossing. The Murrumbidgee's wide, shallow profile with regular riffle surface water disturbance allows a far greater transfer of DO from the atmosphere.

Burra Creek is likely to experience greater levels of DO as a result of the proposed development as greater flows will increase the atmospheric exchange of oxygen (CRC Sugar 2000). An increase in DO within Burra Creek is likely to provide a long-term benefit to aquatic fauna by enhancing instream habitat and

assisting respiration and other chemical reactions (ANZECC 2000), though, in some situations high levels of DO in a water column can be dangerous to fish (ANZECC 2000). When water contains too much oxygen it is said to be supersaturated with oxygen. These conditions can occur in highly turbulent waters in turbines and at spillways (CRC Sugar 2000) causing oxygen concentrations in fishes blood rise. When the fish moves into water that has a lower DO concentration bubbles of oxygen quickly form in their blood, harming their circulation (ANZECC 2000; CRC Sugar 2000). It is unlikely supersaturation would occur as a result of the proposed works, however water quality monitoring should provide a mechanism to evaluate and respond to water quality values throughout the operational phase of the project.

Conversely, the impact of releasing deoxygenated water can be lethal to fish and other aquatic fauna (Kingsford 2000). Transfer waters may undergo deoxygenisation if held for long periods of time before release, so it is recommended any flows abstracted be drained from the pipe whenever pumping ceases (Kingsford 2000). If this procedure is followed, it is not expected DO will be negatively impacted by the proposed water transfer development.

5.10.4 pH

Most aquatic animals and plants have adapted to life in water with a specific pH and are often susceptible to stress from even the slightest change (AWT Environmental Science and Technology 1993). Even moderately acidic waters (low pH) may reduce the hatching success of fish eggs, irritate fish and aquatic insect gills and damage membranes (AWT Environmental Science and Technology 1993). Water with extremely high or low pH is deadly. A pH below 4 or above 10 will kill most fish and very few animals can tolerate waters with a pH below 3 or above 11 (AWT Environmental Science and Technology 1993).

Healthy freshwater systems typically have a pH range between 6.5 and 8.0 (Actew 2008). Low pH may affect the solubility, and thus the toxicity of contaminant metals such as aluminium, but also toxicity of ammonia and cyanide or directly harm aquatic life (Actew 2008). The water quality study undertaken by ACTEW (2008) identified that pH was found to be within the recommended ANZECC (2000) guidelines for both systems, with only few irregular exceptions throughout the available sampling period. The available data indicates that it is unlikely the pH of the two waterways would undergo any significant change as a consequence of the proposed development. However, the lack of comprehensive Burra Creek data reduces the validity of this conclusion.

5.10.5 Temperature

Water temperature has direct and indirect effects on nearly all aspects of stream ecology. Changes in the temperature of stream flows can trigger changes in physical processes such as growth, metabolism and reproduction as well as impact the reproduction and migration patterns of species within the waterway (Actew 2008). Temperature variations occur naturally both seasonally and after stochastic events such as rainfall, drought, or flood and can also be altered by anthropogenic impacts (Rutherford *et al.* 2004). Cooling of water temperatures below natural levels can influence stream ecology (Ligon *et al.* 1995). Cold water releases, often referred to as thermal pollution, can inhibit native fish spawning and reduce natural rates of metabolism and organic matter breakdown (Ligon *et al.* 1995; Kingsford 2000).

The analysis undertaken by ACTEW (2008) indicates the Murrumbidgee Rivers thermal regime is highly variable, and is not directly correlated with the seasons (Actew 2008). This is a result of the geomorphology of the river: being wide and shallow allows the impacts of the weather to have a greater impact on the temperature of the water (Turner and Erskine 1997). Greater light penetration and the high surface:volume ratio allows for greater warming from the sun and cooling from winds (Actew 2008; Turner and Erskine 1997).

Burra Creek has a more defined thermal regime, which is closely correlated to the seasonal changes in temperature (Actew 2008). The limited available data indicates Burra Creek is naturally cooler in winter, and warmer in summer with higher upper and lower limits than in the Murrumbidgee River, due primarily to the lower volumes of water (Actew 2008). While the narrow, deeper channels within Burra Creek reduce the effects of daily temperature fluctuations, the frequent shallow pools are susceptible to long periods of cooling and heating in the winter and summer months, respectively, which often leads to temperature spikes (Actew 2008).

Water temperature fluctuates in daily and seasonal cycles with variations in air temperature, currents and local hydrodynamics. Long-term monitoring of water temperature provides insight into seasonal and inter-annual temperature cycles, as well as into temperature anomalies caused by anthropogenic activities (ANZECC 2000).

Default trigger values for water temperature are not given in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. They recommend the development of local objectives for upper and lower low-risk trigger values defined by the 20th percentile and 80th percentile of the reference distribution (ANZECC 2000). However, the Australian and New Zealand Guidelines for

Fresh and Marine Water Quality report that to protect aquaculture species water temperature should not change by more than 2°C in 1 hour (ANZECC 2000).

The proposed development would abstract water from the Murrumbidgee River and pipe underground for approximately 13km before discharging into Burra Creek. The data provided indicates that temperatures are overall cooler in the Murrumbidgee River in contrast to average temperatures within Burra Creek. However, it is unlikely the flow transfers will significantly impact temperature values within Burra Creek, outside natural temperature fluctuations within the system. It is likely regular transfer flows will stabilise temperature fluctuations within Burra Creek and reduce the occurrence of temperature spikes in summer and winter, providing a more sustainable environment for aquatic fauna (Burchmore 1991).

The Murrumbidgee River temperature regime is unlikely to be affected by the proposed works. Temperature data for Burra Creek and the Murrumbidgee River provides an indication of natural variability within the system, with the maximum and minimum temperatures occurring in different months of the year in each catchment (Actew 2008). While peak maximum and minimum temperatures historically correlate with seasonal peaks (summer and winter) in Burra Creek, the Murrumbidgee River peak temperatures did not always correspond to the summer months while low temperatures did not always correspond to the winter months. It is probable that lower mean temperatures experienced at Angle Crossing during spring and early summer are the result of snow melt within the catchment (Actew 2008).

Initial transfer flows are likely to adjust the mean temperature of Burra Creek, but this will depend heavily on the season of transfer. During periods of little to no transfer, it is likely Burra Creek will revert to the natural temperature regime processes. Overall, the proposed works are predicted to modify temperature regimes of Burra Creek by stabilising the seasonal temperature oscillations and buffering the effect of natural climatic variability (Ryan *et al.* 2003).

5.10.6 Major Ions

The inorganic salts within a stream (major ions) are indicators of the salinity and conductivity, determined naturally by the substrate composition and inflows from the surrounding catchment geomorphology which can vary temporally and spatially according to broad-scale geomorphic, geological and geographic variability (Chotipuntu *et al.* 2002). Anthropogenic impacts also contribute variations in major ion levels within streams. However, given elevated

concentrations and durations of exposure, they may result in profound ecological impacts (Bond and Lake 2003)

Certain physiological effects on aquatic plants and animals are often affected by the number of available ions in the water. Since most aquatic animals can only tolerate a narrow range of salinities, significant changes in salinity often result in the inability of an animal to grow, reproduce, and survive (Murray Catchment Management Board 2002). The analysis provided by ACTEW (2008) indicates there is no significant difference in major ion concentrations between the two systems (Actew 2008). The likely impact of the proposed works on the concentrations of major ions within Burra Creek is expected to be insignificant. A reduction in mean salinity and conductivity within Burra Creek as a result of the dilution effects would not be outside the natural range of major ions concentrations, frequently altered by large rainfall flows.

5.10.7 Faecal Coliforms

The presence of faecal coliforms in aquatic environments is a distinctive indicator that water has been contaminated with faecal matter via anthropogenic releases or natural deposits within the catchment (Doyle and Erickson 2006). Faecal coliform bacteria often enters streams through urban/agricultural runoff, stormwater discharges, fauna excrements within the catchment, and from untreated human sewage point sources (Doyle and Erickson 2006). A high level of faecal coliforms can often indicate large quantities of faeces are entering the stream system, which alone does not usually result in adverse ecological impacts (ANZECC 2000). The most significant impact of high concentrations of faecal coliforms (> 150 CFU/100mL) in waterways is the potential impacts on human health. Where human contact is likely, monitoring is important, especially in systems like Burra Creek, which feeds Canberra's major drinking water storage reservoir.

The Murrumbidgee River has had consistently low faecal coliform counts throughout the sampling period (mean of 21 CFU/100mL), with occasional spikes, often associated with high rainfall events (Actew 2008). High rainfall events in agricultural regions may trigger sharp increases in faecal coliform counts within rivers as water drains grazing land and areas of high excrement deposition (Kingsford 2000). Faecal coliform levels within Burra Creek were consistently lower than those of the Murrumbidgee with an average of 6 CFU/100MI (Actew 2008). Samples taken from both waterways throughout the limited sampling period indicate both are within acceptable limits for human contact and consumption and the proposed development is unlikely to increase the levels of faecal coliforms within Burra Creek. There are no statistically

significant differences in faecal coliforms between the two catchments (Actew 2008).

5.10.8 Algal Blooms

High concentrations of algae as a result of a surge in nutrient levels, warm stream temperatures, and low levels of flow and subsequent flushing can result in blooms of algae, detrimental to the ecology of a catchment (Cullen *et al.* 1993). While typically a natural phenomenon, algal blooms can have a number of severe negative impacts on a waterway including ecological, aesthetic, and human health impacts (Cullen *et al.* 1993). Natural sources of nutrients such as phosphorus or nitrogen compounds can be supplemented by a variety of human activities such as agricultural runoff from fields can wash fertilisers into the water (Cullen *et al.* 1993). Algal blooms are frequently associated with cyanobacteria (blue-green algae) which favour poor flow conditions and will often cause toxic by-products which directly impact humans and aquatic organisms (Actew 2008).

Data supplied by ACTEW (2008) does not include cyanobacteria levels, but does analyse presence of Chlorophyll *a* and total algal activity within the two waterways. There is no specific guideline for total algae in the ACT or under the ANZECC framework. However, DEWHA (1987) recommends that chlorophyll *a* levels be kept below 5 µg/L in reservoirs used for drinking water and below 20µg/L for recreational lakes (Actew 2008) (DEWHA 1987). The data supplied indicates that the Murrumbidgee River at Angle Crossing displayed high variability, but remained lower over the sampling period than levels within Burra Creek (Actew 2008).

The introduction of flows from the Murrumbidgee River into Burra Creek will increase the volume of water discharging into the Googong Reservoir, by up to 100ML/Day. Although the dilution factor is apparent, this increase will likely lead to a boost in the available nutrient loads within the Googong Reservoir. Algal bloom potential may be significantly amplified within the reservoir as a result, which could lead to a decline in water quality, subsequently negatively impacting the ecology of the system. Additionally, increased nutrient loads may lead to localised algal blooms during periods of low/no utilisation of the transfer system, when transfer waters settle in shallow pools throughout the reach of Burra Creek downstream of the discharge structure.

5.10.9 Recreational Fishing

The likely effects of the proposed development on recreational fishing within the Study Area would be primarily from a social perspective, and thus outside the scope of this assessment. However, the proposed development has the potential to affect the fish distribution and health within the Study Area.

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. Fish stocks have been artificially created by stocking a variety of native species to enhance the recreational fishing for local anglers. Parks, Conservation and Lands stocks approximately 50,000 fish each year in Canberra lakes, and more than 2.2 million fish have been stocked since 1981 (TAMS 2009). 181,610 Murray Cod fingerlings and 306,000 Silver Perch have been stocked into Googong Reservoir by ACT TAMS since 1981. Regular stocking of Googong Reservoir allows anglers to capture threatened fish species, which is expected to relieve fishing pressure on more fragile aquatic systems in the Canberra region (TAMS 2009).

As discussed in section 5.4.2, 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. Regular flows of up to 100ML/Day may facilitate fish movements between the lower sections of Burra Creek and areas further upstream which were previously inaccessible. The alteration of Burra Creek from a historically intermittent stream to a more permanent flowing system may open up greater areas for anglers to target fish.

The proposed development incorporates the use of screening to restrict the transfer of potentially harmful alien fish species that currently reside within the Murrumbidgee River as discussed in section 5.8. If the screening system was compromised and the potentially hazardous European Carp and Oriental Weatherloach were transported into Burra Creek, the results could be significantly detrimental to the recreational fishing value within the Googong Reservoir. However, ACTEW have a strong commitment to ensure all efforts are taken to prevent the transfer of alien fish into Googong Reservoir, and the proposed mitigative measures will greatly reduce the likelihood of inadvertent transfer.

Carp are well known for altering their environment due to their high fecundity and notorious feeding habits which involves stirring up bottom sediments while searching for food (Lintermans 2004). While feeding they will often destroy, uproot and disturb submerged aquatic vegetation causing significant damage to

native fish populations (Lintermans 2004). There is substantial evidence within Australia that Carp are the cause of permanent turbidity and loss of submergent vegetation with severe consequences for aquatic ecosystems, water quality and native fish populations (Koehn *et al.* 2000). Introduction of Carp into Burra Creek as a result of the proposed development would likely result in a significant decline in threatened fish abundance, diversity and thus reduce the viability of recreational fishing.

The introduction of the Oriental Weatherloach may also have significant impact on the health of the Googong Reservoir. Currently little is known about the impacts. The Oriental Weather Loach is a highly invasive species that is believed to predate on native fish eggs. It may also compete with native fish for food, habitat and spawning sites (Allen *et al.* 2003). Their burrowing habits may also have negative impacts on the aquatic environment by increasing turbidity and uprooting aquatic plants (Allen *et al.* 2003; Koster *et al.* 2002).

These species are of particular concern because they display many of the characteristics of previous successful invaders including a broad tolerance to many environmental parameters, low vulnerability to predation, high fecundity and a broad diet (Koster *et al.* 2002). The risk for transfer of alien species through the proposed pipeline is considered low as mitigation measures (i.e. screening) will ensure all adults, juveniles and eggs are filtered from the abstraction waters.

5.11 Noise and Vibration

Fish use sound to find prey, avoid predators and for social interaction. They can be detrimentally affected by intense noise exposure and the masking of biologically relevant sounds by ambient noise (Popper 2003). The construction of the pipeline facility would involve noise and vibration that may cause short-term (approximately 12 months) disturbance to aquatic habitats in the vicinity. The primary causes of noise and vibration would come from traffic and equipment operation and movement, clearing and excavation, rock breaking (drilling and blasting) and construction.

In response to sudden high-level sounds, as might be expected during construction, fish often display startle responses involving increased swimming speed, swimming deeper in the water column and avoidance. In the normal environment fish have the potential to escape loud noises, however those that remain stationary or are slow to move away may be affected by noise (Popper 2003). While exposure to intense noise can result in damaged sensory hair cells (Scholik and Yan 2001); such damage is expected only at short range from the

source. It is expected avoidance would occur before noise reached levels sufficient to produce hearing damage (McCauley *et al.* 2000). Fish can repair damaged hair cells and have been found to recover normal hearing levels after being exposed to intense anthropogenic underwater noise (McCauley *et al.* 2000; Smith *et al.* 2004).

Minor additional raised levels of background noise and vibration would be experienced during the operation of the LLPS and HLPS at Angle Crossing. Physiologically fish can experience an increase in stress hormones as a result of noise exposure but this response is short-lived and not apparent during longer term exposure. This indicates that rapid changes in sound characteristics may affect behaviour and elicit stress responses much more than does continual noise exposure (Smith *et al.* 2004). The design of the LLPS and HLPS facilities should incorporate measures to minimise operational noise and vibration. It is expected any impacts of noise and vibration disturbance would be temporary and short-lived, and deemed not significant in nature.

6.0 RECOMMENDATIONS

The following advice and recommendations are provided to minimise the potential impacts to the ecological communities of the Murrumbidgee River and Burra Creek catchments.

6.1 Environmental Flows

6.1.1 Murrumbidgee River

- 1) Ensure minimum environmental flows are protected as outlined in the ACT Government Water Resources Environmental Flow Guidelines (ACT Government 2006) (made under the *Water Resources Act 1998*).
- 2) Continuous flow monitoring stations should be established to monitor Murrumbidgee River flows and water levels to ensure protected flows are maintained and ACT Environmental Flow Guidelines are upheld.
- 3) Incorporate an adaptive management strategy to allow for modifications in operational regimes if impacts on environmental flow result in additional unpredicted impacts during construction and operation.

6.1.2 Burra Creek

- 4) Regular monitoring of the impacts associated with an increase of environmental flows within Burra Creek should include assessing the impacts of increased sediment transfer through the scouring of sediment from riffles and pools, changes in thermal regime, alteration to macroinvertebrate community structures, erosion and modification of reed beds and banks and changes in the potential utilisation of Burra Creek by fish in Googong Reservoir.
- 5) Major changes in flow release should 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.

6.2 Fish Passage

- 6) If native and threatened fish species are found to be spawning within Burra Creek, flow transfers should be maintained where possible during the breeding season (typically early spring to summer) to protect the spawning

populations. If flows must be altered, then the 48 hour ramping up/down operating regime must be utilised to allow fish to safely exit the creek.

6.3 Construction Impacts

- 7) Approval and/or consultation with the NSW Department of Primary Industries and Department of Water and Energy will be required in regards to water abstraction and transfer, and all near stream works in NSW under the NSW FM Act and WM Act.
- 8) During any near stream works such as trenching or excavating, water quality should be protected under sedimentation and erosion control plan policies as prescribed under government legislation including the *Protection of the Environment Operations Act (1997)* and *Environmental Planning & Assessment Act (1979)*. This should include suitably designed and maintained sediment and turbidity controls such as in-stream silt curtains, sedimentation fencing, runoff controls and geotextile fabric sand bags. The protection measures must be regularly inspected and maintained throughout the construction and rehabilitation phase. Rainfall event based turbidity monitoring should be conducted at sites located upstream and downstream of the construction area.
- 9) Avoid undertaking excavation or other works in or near the Murrumbidgee River or Burra Creek during periods of actual or predicted heavy precipitation or higher than average flows.
- 10) Appropriate sediment and erosion control measures must be employed throughout the extent of the proposed works to protect the aquatic habitats and adjoining areas supporting native vegetation. Mesh netting should 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.
- 11) Rock and earth resources utilised to construct the pile rig base should be natural and locally sourced, and removed and reinstated upon completion of the construction works.
- 12) 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.

6.4 Intake and interbasin transfers of fish and pathogens

- 13) The mesh size on the proposed screen should be at a maximum of 0.5 mm to greatly enhance the efficiency of the screening processes and prevent transfer of fish and eggs.
- 14) A skilled abstraction screen expert must be consulted to review the screen design and approve the structure before construction commences to ensure efficiency of screen design and operation.
- 15) Eggs and/or larvae of alien species of interest within the Murrumbidgee River are likely to be present from October to April. However, filtering should be undertaken at all times.
- 16) Monitor transfer flows at discharge outlet into Burra Creek for any aquatic fauna/flora that are passing through filtration at the intake screens and surviving the pumping process. Any detection of undesirable organisms within transfer flows at discharge point should trigger urgent review of operation procedures and equipment. This process will be essential in breeding period of October through April to ensure no undesirable alien fish are passing the screening process.

6.5 Bank stability and vegetation

- 17) A Vegetation Management Plan, including implementation of a riparian rehabilitation and weed management plan is recommended. Areas to be focused on include those identified by the Fluvial Geomorphic Assessment (Bulk Water Alliance 2009) as having the potential to be undercut by transfer flows within Burra Creek; and immediate construction sites for the intake and discharge points.
- 18) Macrophytes should be monitored and mapped to identify and manage any significant reductions in biomass above the low flow channel. This will ensure recolonisation rates are able to be qualitatively assessed and appropriate measures can be implemented if macrophytes are not re-establishing in the low flow channel marginal areas. Maintaining macrophyte populations along Burra Creek will ensure water quality and pool sedimentation impacts of the discharge flows are short-lived.

6.6 Water Quality

- 19) A detailed spill and contamination plan should be prepared to protect the environmental values of the Murrumbidgee River and Burra Creek from the proposed works. The plan should contain emergency and remediation measures.
- 20) Water quality within Murrumbidgee River below the abstraction intake and within Burra Creek below the discharge point should be monitored regularly to identify and manage any adverse impacts upon water quality.
- 21) Water abstracted from the Murrumbidgee River should be released into Burra Creek without delay to reduce the chances of deoxygenisation and cooling and reduce the risk of water putrefication.

7.0 MONITORING

A program should be developed to monitor and evaluate the impact to the aquatic ecological values of the Murrumbidgee and Burra Creek/Googong system. This program should aim to monitor the particular anticipated effects of the proposal with results feeding back into adaptive management of the abstraction and discharge.

7.1 Murrumbidgee River

In order to monitor the impact of the abstraction and construction on the aquatic ecosystem of the Murrumbidgee River, the following recommendations for programs and aims are suggested. The focus of the program would be to determine and inform management action for any impacts from the abstraction of flow on the available habitat and biota (particularly threatened species). It is recommended that the program include during-construction and during-operation sampling, at Angle Crossing and downstream locations. The following ecosystem components should be monitored:

Physical habitat and hydrology

Reductions in flow have potential to alter the physical habitat of the Murrumbidgee River below Angle Crossing.

Biota – Macroinvertebrates.

Changes in flow and habitat are likely to influence the macroinvertebrate community

Biota – Fish

Monitoring of fish populations may assist in determining any impact to the fish community such as impacts to fish passage, and breeding events; The development of a statistically valid monitoring program that incorporates sufficient spatial and temporal replication to provide baseline data against which change can be monitored and impact inferred should be undertaken.

The structure of the fish community through Gigerline Gorge is relatively unknown. The presence of Trout Cod and other species in this reach is inferred from habitat availability, stocking and anecdotal reports. However, the actual persistence of species in these habitats has not been assessed.

7.1.1 Pumping and screening of flows

Monitoring of the screening system as well as the pumping system is important to determine the effectiveness of the screens and identify how fish and larvae are being impacted by the system within the Murrumbidgee River. A monitoring program should assess the volume of fish, larvae and eggs that are being destroyed, impinged or otherwise being adversely impacted by the screening system. This should investigate impacts on threatened fish species specifically associated with breeding seasons to ensure minimal damage is occurring to threatened species within the upstream section of Angle Crossing.

7.2 Burra Creek

In order to monitor the impact of the change of flows on the aquatic ecology of Burra Creek the following programs are recommended:

Aquatic Habitat Changes

A program should be developed to monitor 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;

A program should also be developed to monitor the extent of change to the unique physio-chemical attributes of the Burra Creek system as the increased flow is likely to modify the water quality and hydrological values of the system.

Macroinvertebrates

The changes in microhabitat and flow are likely to alter the macroinvertebrate community. Quantitative macroinvertebrate and AUSRIVAS surveys are recommended. The effects of changes in flow may not necessarily lead to the complete removal of particular species but is very likely to result in altered abundance of filter feeders (simuliids, net building caddis and chironomids) and fast-flow dependent taxa. These changes are often not picked up by presence/absence based assessments like AUSRIVAS.

Fish

Surveys of Burra Creek to determine changes in fish community would identify if and how Burra Creek is being used by fish from Googong Reservoir and would assist in the detection of any translocations;

Monitoring of the behavioral changes in fish populations within the Googong catchment, in response to the increase in habitat connectivity between Burra

Creek and the Googong Reservoir, will determine if annual breeding migrations are initiated by threatened species and further operational control is required to protect such important events.

8.0 CONCLUSION

A number of potential aquatic impacts have been identified in regards to the proposed works. These issues include potential impacts to aquatic habitats including threatened species habitat, modifications to environmental flows, potential to alter fish passage, the potential for localised impacts from the pump design and inter-basin transfers of fauna and pathogens, modification of water quality, disturbance from noise and vibration, and impacts to recreational fishing.

The Study Area is known or likely to support a number of threatened fish species, particularly Trout Cod, Macquarie Perch, Silver Perch, and the Murray Cod. These species were assessed under the ACT, NSW and Commonwealth threatened species provisions including assessment of significance and application of significant impact criteria. The NSW Part 3A assessments indicated provided that the mitigation measures in this report are implemented and comprehensive adaptive management and monitoring is undertaken, the proposed development is considered unlikely to have a significant impact on the Trout Cod, Macquarie Perch or Silver Perch populations within NSW. Nevertheless, a Referral should be submitted to the Department of the Environment, Water, Heritage and the Arts (DEWHA) for further consideration of the predicted impacts upon listed NSW and ACT species.

Assessments of significance were prepared according to the EPBC Act significant impact criteria for species listed under the EPBC Act that have known or potential habitat within the study area (Appendix 3). These assessments concluded that - provided that the mitigation measures outlined in this report are implemented and adaptive management and monitoring is undertaken - the project is unlikely to have a significant impact on Trout Cod, Macquarie Perch or Murray Cod. There is, however, the potential for residual impacts, including the removal of riparian vegetation, changes to hydrology and increased sedimentation, on Trout Cod and Macquarie Perch. In light of this, it is recommended the project be referred to DEWHA for further consideration.

Environmental flow regulations as prescribed by the ACT Government Environmental Flow Guidelines should be followed and form the basis of the operating procedures to minimise impacts to the base and flooding flows within the Murrumbidgee River. The current guidelines for the protection of environmental flows within the ACT section of the Murrumbidgee River states that for each month of each year, the base flow and flooding flows must be protected (ACT Government 2006). The proposed abstraction would be limited to 100 ML/Day, and would only occur when sufficient flows are available within the Murrumbidgee River. Overall the predicted modelled volumes of abstraction

are unlikely to have a significant effect upon channel maintenance flows or flooding flows. The discharge of up to 100 ML/Day is above the 95th percentile flow for Burra Creek and will result in changes to Burra Creek's aquatic environment.

The passive design of the intake screen would 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 are a number of pathogens known to affect fish in the ACT, however EHNV is considered to pose the most significant threat. It is expected the risk of EHNV being introduced into Burra Creek via the abstracted Murrumbidgee River water is negligible (Mark Lintermans pers. comm., 2009).

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 or its catchments. However, Carp are known to have been historically introduced into farm dams within the Catchment and are likely to become established at some stage in the future. Googong Reservoir has been maintained as a carp-free environment since its construction in the late 1970s, and efforts to continue to exclude Carp from this waterbody should continue (Lintermans pers. comm., 2009).

The potential impact of these two alien fish in Googong Reservoir may include: reduced water quality; introduction of disease and parasites, alteration to habitat, particularly submergent macrophyte cover, by increasing turbidity; predation upon fish eggs and juveniles and competition with native species. If these species access Googong Reservoir there is a greater potential risk of them invading the more significant conservation reaches of the upper Queanbeyan River. The proposed filtering system would 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. However, the risk of transfer remains constant and issues regarding periods of screen filter maintenance and replacement will remain an operating issue.

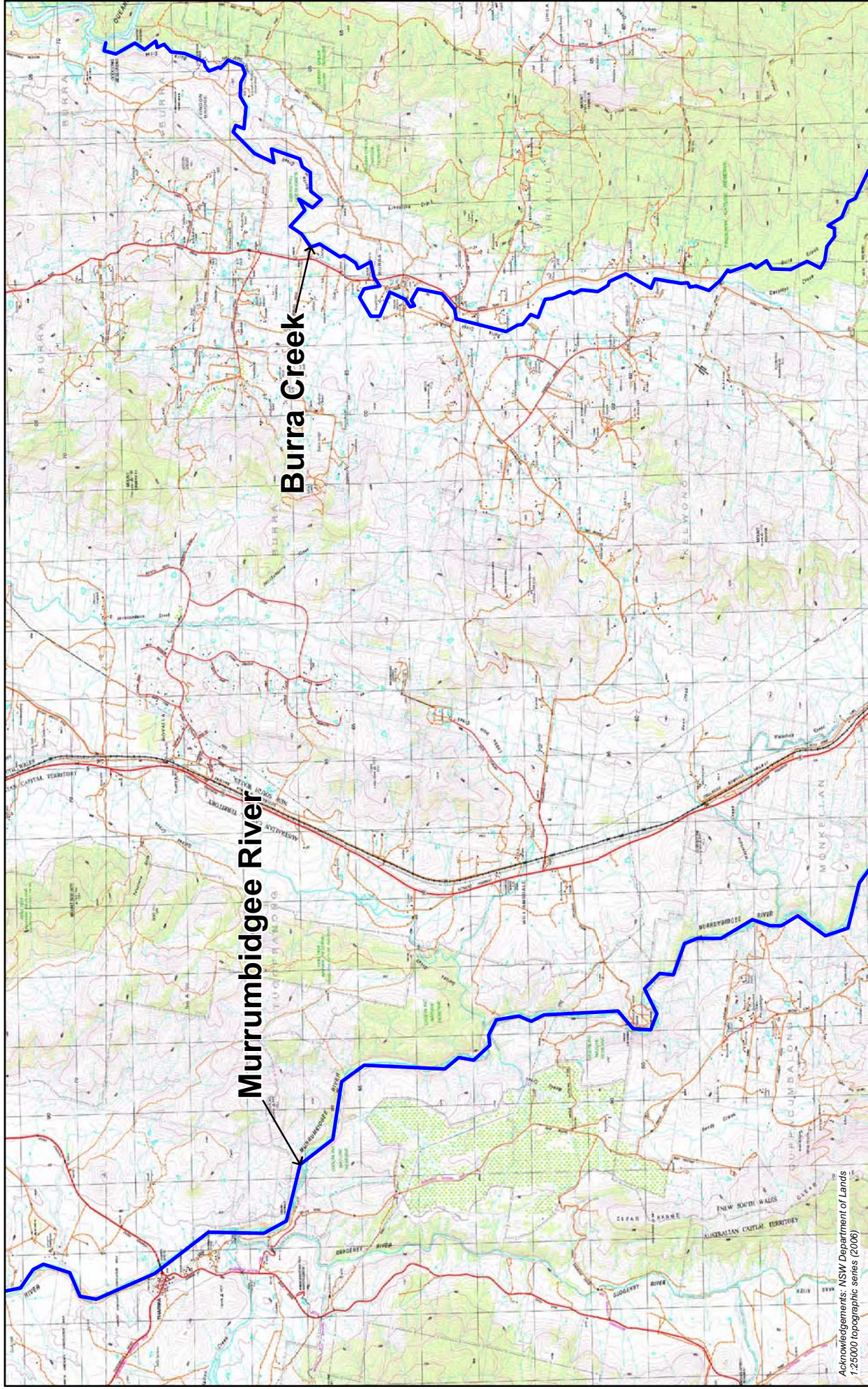
Although no threatened species were recorded during limited fish sampling, the local area is known to have potential habitat for three threatened species, with two additional species present in the Murrumbidgee River.

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. Transfers could also be expected to alter water quality in the creek,

both as a result of increased erosion and sediment transfer but also due to the volume of the transfer flow compare to the natural flow regime of Burra Creek.

The impacts on Burra Creek would include changes in natural habitat and potential impact or change to the macroinvertebrate and fish communities. The development of a detailed monitoring program is recommended with the collection of adequate during and post-operational impact monitoring .

FIGURES



Acknowledgements: NSW Department of Lands
1:25000 topographic series (2006)



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55 Lam Road (PO Box 1983)
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NEW SOUTH WALES 2620

Figure 1: Overview of Murrumbidgee River and Burra Creek.

Date: 5 December 2008

Checked by: MB

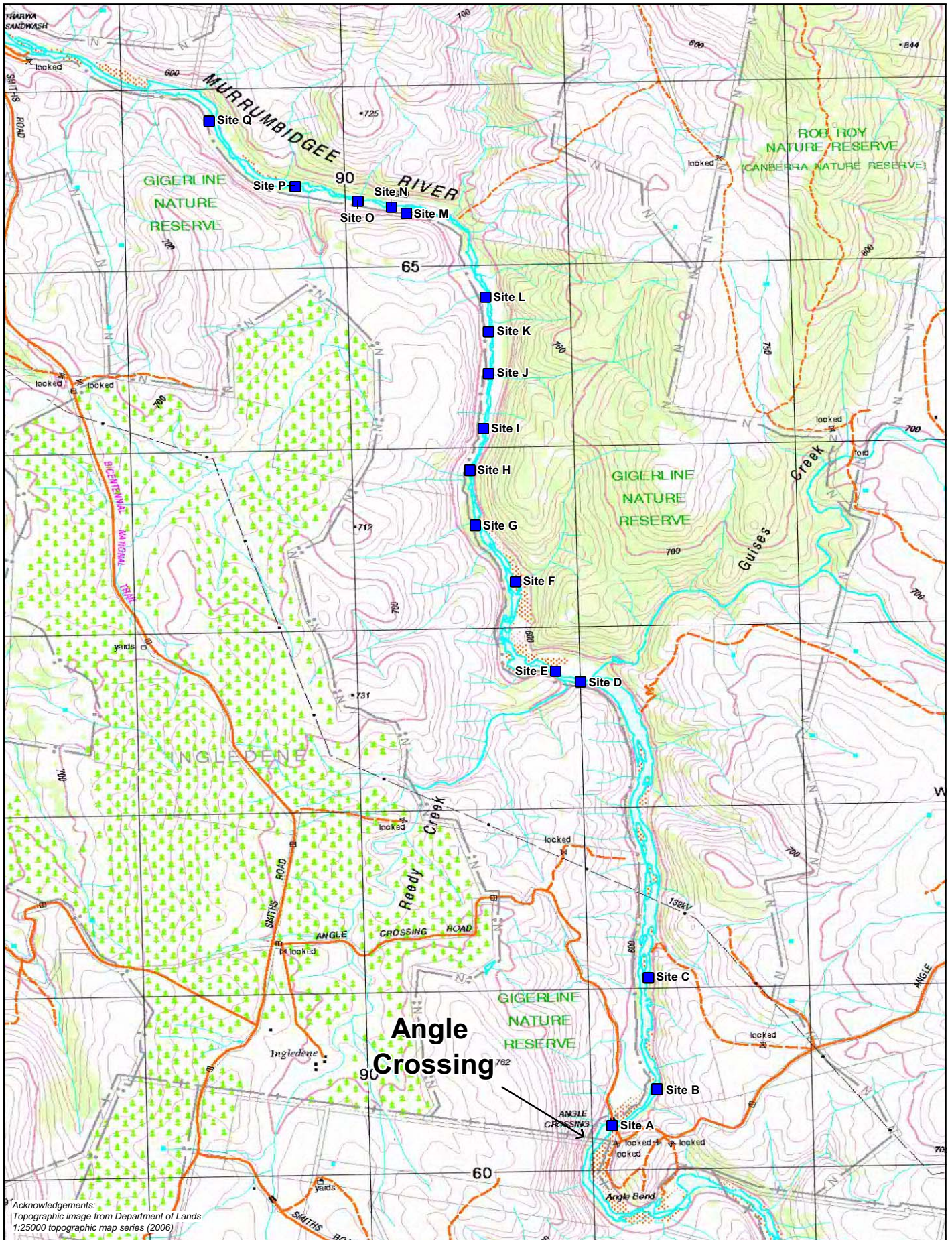
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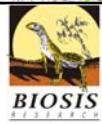
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kilometres



Figure 1: Overview of Murrumbidgee River and Burra Creek.



Acknowledgements:
 Topographic image from Department of Lands
 1:25000 topographic map series (2006)



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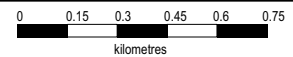
Figure 2: Location of Survey sites - Murrumbidgee River

Date: 5 December 2008

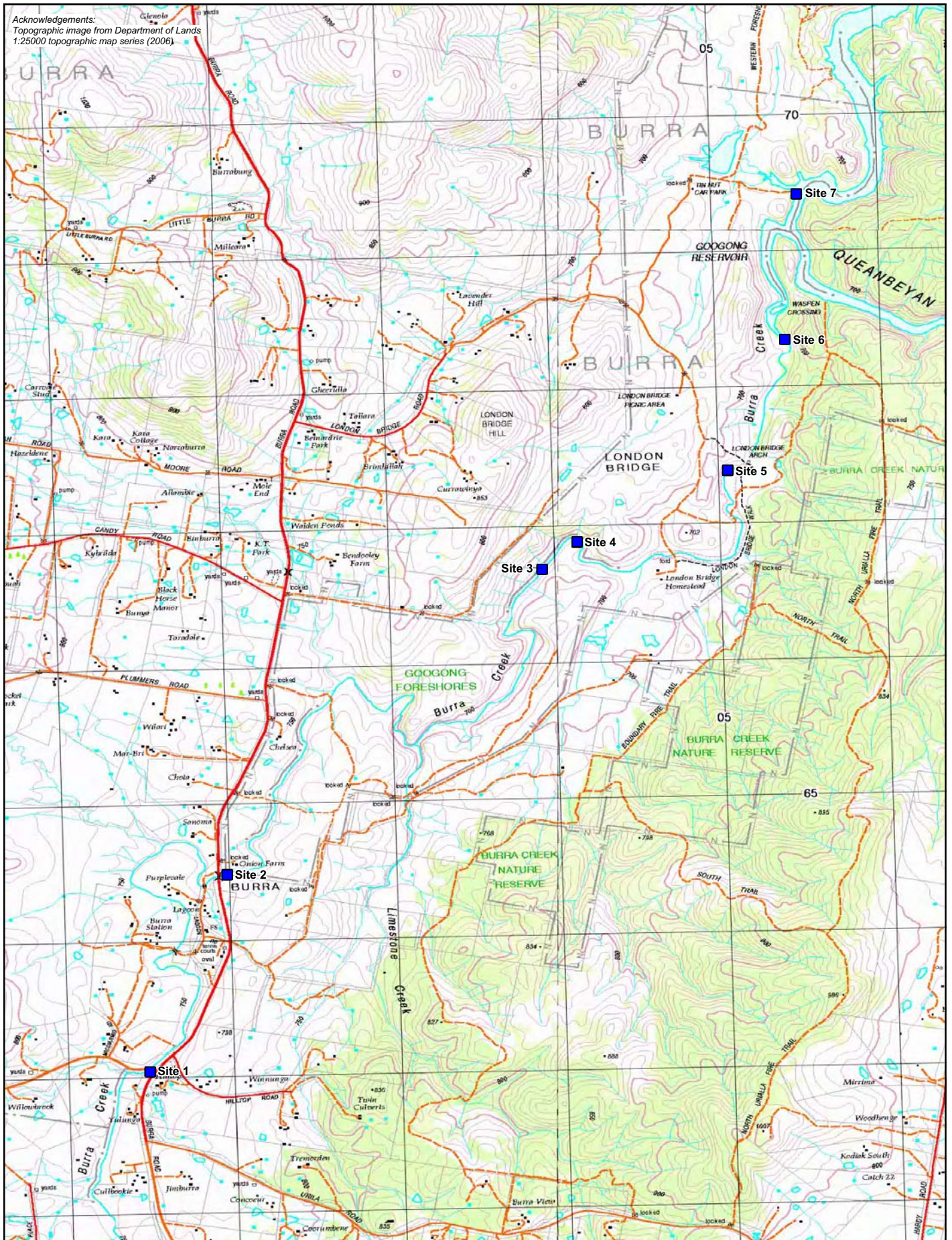
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Location: -5000\5200s\5229\Mapping\S5229_F2_sites.WOR

Scale:



Acknowledgements:
 Topographic image from Department of Lands
 1:25000 topographic map series (2006).



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Figure 3: Location of survey sites - Burra Creek

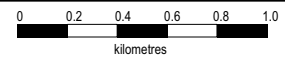
Date: 5 December 2008

Checked by: TJM

File number: S5229

Location: ...5000\5200s\5229\Mapping\S5229 F3_burra.WOR

Scale:



kilometres



PLATES



Plate 1: Angle Crossing facing upstream



Plate 2: Angle Crossing Site A; facing downstream



Plate 3: Site B; facing upstream



Plate 4: Site C; facing upstream



Plate 5: Site D; facing upstream



Plate 6: Site E; facing upstream



Plate 7: Site F; facing upstream



Plate 8: Site G; facing upstream



Plate 9: Site H; facing upstream



Plate 10: Site K



Plate 11: Site L; facing upstream



Plate 12: Site M; facing upstream



Plate 13: Site M; vertical view



Plate 14: Site N; facing upstream



Plate 15: Site O; facing downstream



Plate 16: Site P; facing upstream



Plate 17: Burra Creek downstream of Williamsdale Rd



Plate 18: Burra Creek at the gauging station downstream of Burra Rd



Plate 19: Burra Creek downstream of the gauging station



Plate 20: Burra Creek upstream of London Bridge Homestead



Plate 21: Burra Creek upstream of London Bridge

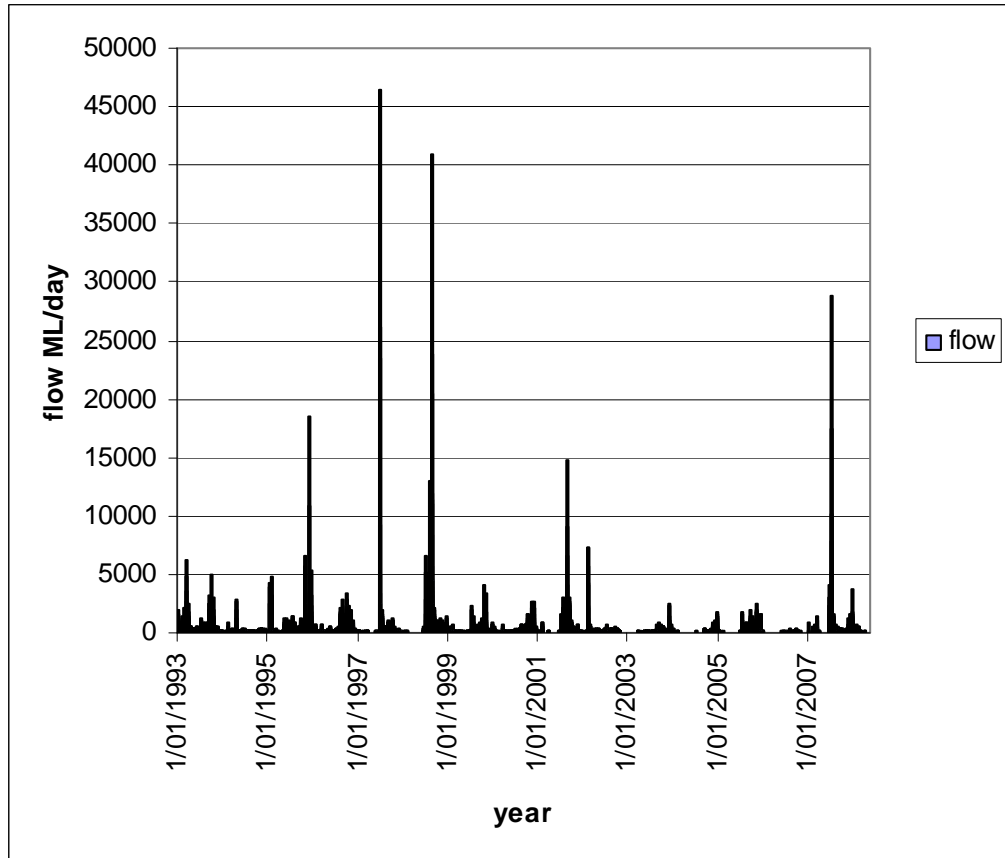


Plate 22: Burra Creek below Drawdown Crossing

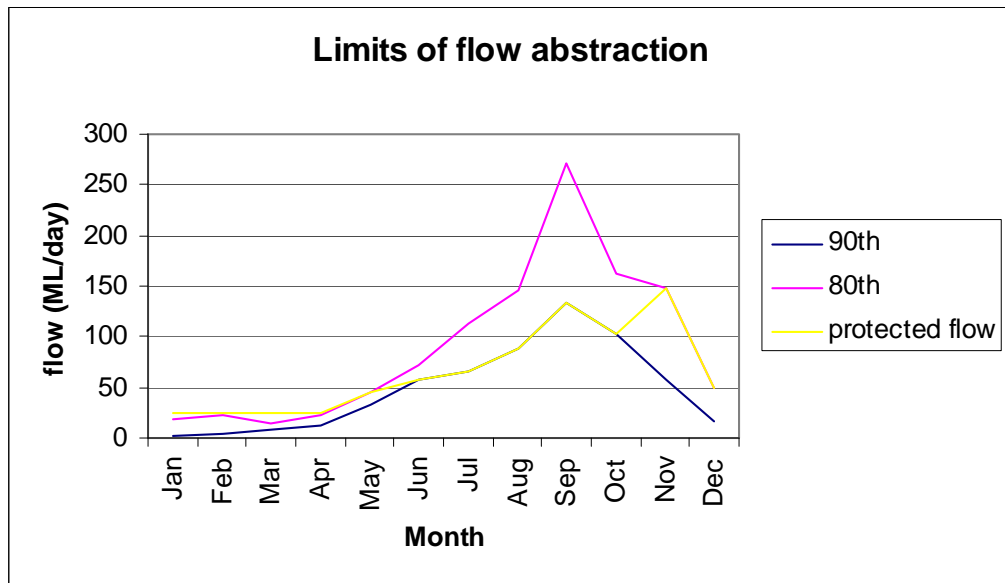
APPENDICES

APPENDIX 1

Flow Levels at Lobbs Hole



Protected Low Flow Levels



Protected flow calculated as the flow below the 80th percentile between November and May, and the flow below the 90th percentile between June to October. Lobbs Hole Gauge.

APPENDIX 2

Part 3A of EP&A Act Assessments of Significance

Silver Perch***Bidyanus bidyanus***

The Silver Perch *Bidyanus bidyanus* is listed as Vulnerable under Schedule 5 of the *Fisheries Management Act 1994* in NSW.

The Silver Perch is a moderately large freshwater fish that is native to the Murray-Darling river system (McDowall 1996). This species generally prefers flowing waters (NSW Fisheries Scientific Committee 1999) but has been found in a broad range of aquatic habitats including dams (NSW DPI 2005b).

It is expected that between 8 – 10 GL/year of water will be discharged into Burra Creek to supply Googong Reservoir through the M2G operation (ActewAGL 2009). This boost in flow volume will lead to a significant increase in average and median flows in Burra Creek. However, it is expected that periods of very low to zero flow periods will continue to occur when operation of M2G is not possible (e.g.: drought, unsuitable water quality at source) (ActewAGL 2009). Large flooding flows will not be impacted as it is expected the M2G flows will be small in relation to historical flood flows, and the pumping operation can be ceased when necessary (ActewAGL 2009).

A number of the native, including threatened species in Googong Reservoir require flowing water to breed, in particularly the Silver Perch. The species cannot currently migrate freely upstream into the upper reaches of Burra Creek, nor can they access the downstream Queanbeyan River to find suitable spawning habitat, due to Curlys Falls, which is a barrier to fish passage. However, the proposed transfer discharge during the spring and summer breeding periods may provide suitable breeding habitat for the species in Burra Creek.

This impact assessment recognises that the base flow of the Murrumbidgee River will be protected throughout the year and no water below the base flow will be removed.

Authors Note: This impact assessment is based on the understanding that ACTEW will protect the minimum percentile environmental flows of the Murrumbidgee River as prescribed in the ACT Government Water Resources Environmental Flow Guidelines (2006), throughout each month of every year and no water below the base flow will be removed at any time. Any modifications to the water abstraction licence (if/when obtained) will require additional analysis to incorporate any impacts not addressed in this assessment.

The available water quality data for Burra Creek is sparse as Burra Creek has experienced infrequent flows in recent years. The data comparison between the Murrumbidgee River and Burra Creek has been carefully considered as sample

timeframes differ significantly. The validity of the data has been taken into account for the assessments and in lieu reliably comparable data, all conclusions drawn are approximations and do not necessarily reflect the full scope and extent of potential impacts that may arise as a consequence of the proposed development.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Silver Perch have been known from the Murrumbidgee River in the past, but have not been recorded in some time (Lintermans 2002a). The apparent absence of the species within the Murrumbidgee River suggests the likelihood of a viable local population at Angle Crossing is low. However, the species is recreationally stocked into Googong Reservoir downstream of the Study Area. 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 would undertake natural spawning movements on a large scale (Lintermans 2005a).

The Silver Perch is known to undertake a migration upstream in spring/summer, prior to spawning, and juveniles are known to move in response to slightly elevated water levels (NSW DPI 2005b). This species does not reproduce until the water temperature reaches 23 degrees Celsius (NSW DPI 2005b). Females shed 300,000 or more semi-buoyant eggs that develop into free-feeding stages that drift downstream (Morris *et al.* 2001) (Astles *et al.* 2003).

The proposed works will introduce a maximum of 100ML/Day to Burra Creek just downstream of Burra Creek Bridge. This is expected to create habitat that would be suitable for spawning Silver Perch migrating from the Googong Reservoir. There are no barriers that would prevent the species from migrating into the upper reaches of Burra Creek once regular water transfers commence.

While the proposal has the potential to create breeding habitat for the Silver Perch within Burra Creek, it may also result in the loss of breeding adults and/or spawn if the water level drops while the species is breeding in the newly formed habitat. To minimise the impact of such an event, where the proposed water abstraction needs to be reduced (i.e. when the Murrumbidgee River water level is at or below its protected base flow), this reduction will occur gradually over a period of 48 hours (ramping down). This mitigation operational regime is designed to allow any Silver Perch occurring in Burra Creek the opportunity to return safely to the Queanbeyan River before the water level gets too low.

The proposed water transfer could lead to changes in water flow regimes and water quality, and hydrological changes to existing habitat. These things are

likely to define the known and potential habitat for the Silver Perch, thus changing them may render habitat unsuitable for the species. This is unlikely to affect the habitat in Burra Creek as the species is not known to occur there and current water depth may be a barrier. However, the flushing of sediment and water from Burra Creek into Googong Reservoir may have a significant impact on known habitat for the species in Googong Reservoir.

The proposed water transfer may have an indirect impact on the life cycle of the Silver Perch through altering the availability of food in downstream habitats of Burra Creek and Googong Reservoir. In turn, this may result in an initial decline in Silver Perch fecundity.

Two alien species, European Carp *Cyprinus carpio* and Oriental Weatherloach *Misgurnus anguillicaudatus* are considered a high risk for translocation as they are known to be present in reasonable numbers at Angle Crossing, breed in the Murrumbidgee and are not yet established in Googong Reservoir or its catchment. The potential impact of these two alien fish in Googong Reservoir may include: reduced water quality; alteration to habitat, particularly submergent macrophyte cover, by increasing turbidity; predation upon fish eggs and juveniles; and, competition with native species. The proposed pipeline is not the only potential vector for the introduction of these or other species and pathogens into the Googong Dam Catchment. Other known vectors outside the scope of the proposed works include: illegal release of aquarium pets; illegal use of live bait; stocking and overflow of household/rural ponds and dams; and, inadvertent transfer during recreational stocking, or on boats, vehicles or fishing equipment. There are three major life stages which have potential to be transported through the pipeline: adult fish, juveniles and eggs/larvae. However, an intake screen has been recommended in order to mitigate the potential transfer of adult and juvenile fish, eggs, pathogens and algae being translocated through the pipeline to Burra Creek.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The discharge of flows at a maximum of 100 ML/Day is above the 95th percentile flow for Burra Creek and it is expected that the increased flow will result in dramatic changes to Burra Creek's environment. These impacts will include increased sediment transfer through the scouring of sediment from riffles and pools, change in thermal regime, change to existing emergent and submergent macrophyte beds, alteration to macroinvertebrate community structures, erosion of bed and banks and changes in the potential utilisation of Burra Creek by fish in Googong Reservoir.

The proposed water transfer is expected to result in a mean channel depth increase in Burra Creek from 200 to 400 mm. Existing flow data for Burra Creek indicated that the waterway experiences occasional periods of no flow and has been subjected to several large flow events of over 1000 ML/Day between 1985 and 1999 (Ecowise Environmental and Starr 2005); (Gippel and Nayer 2005). Overall, these reports considered that although the proposed flow transfers may accelerate erosion and mobilise sediment in some locations, this would not happen to any extent outside of the natural range of these events for Burra Creek.

However, hydrological investigations indicate that in some areas of the creek active erosion and bed scouring would be increased by the transfer flow (Ecowise Environmental and Starr 2005). This scouring could result in changes to aquatic habitats currently existing at the base flow level of Burra Creek. The increased flow may result in the scouring of in-channel macrophyte beds, removal of sediments in riffles and subsequent accumulation of sediment in slow flowing zones. Silver Perch are generally tolerant of poor water quality but are known to be affected by cold water releases (Morris *et al.* 2001) (Astles *et al.* 2003). The water will be piped approximately 13 km from the Murrumbidgee River to Burra Creek and the water released will likely be cooled by the underground transfer.

The majority of existing riffles and runs in the upper sections of Burra Creek are on bedrock and as such have very little sediment, although in the lower alluvial sections of the creek, some movement of sediment would be expected. The extent of aquatic habitats that would be affected by scouring is therefore relatively low.

The majority of macrophyte beds in the upper and mid sections of the waterway consist of emergent reeds such as *Phragmites australis* and *Typha orientalis*. With a constant release of approximately 100 ML/Day there is likely to be some loss of emergent reed beds, particularly in deeper bedrock areas and the faster flowing sections of the channel. These macrophyte beds perform several important ecological functions, providing habitat for aquatic fauna, trapping sediment and significantly reducing the exposure of banks and stream beds to erosion.

Limited potential habitat exists for this species in the Murrumbidgee River, but the species has not been recorded there for some time. The abstraction of up to 100ML/Day from the Murrumbidgee is a relatively small amount from a river system adapted to cope with large fluctuations in flow. This assessment assumes that the base flow of the river would be maintained throughout the year. The protection of this flow would result in no significant change to potential habitat for this species at Angle Crossing.

Does the proposal affect any threatened species that are at the limit of its known distribution?

The Silver Perch are restricted to a stocked population in Googong Dam, and are not recognised as a viable natural population existing within Burra Creek (Lintermans 2001). Silver Perch were known, however, in the Murrumbidgee River below Kambah Pool in the ACT, but have not been recorded in many years (Lintermans 2002a). It is likely their natural range did not exist above Tharwa. Therefore, the study site is not at the limit of the Silver Perch's known distribution.

How is the proposal likely to affect the current disturbance regimes?

The proposed water transfer of Murrumbidgee River flows into Burra Creek is expected to transport up to a maximum of 100 ML/Day under normal operation resulting in a mean Burra Creek channel depth increase from 200 to 400 mm. However, existing flow data for Burra Creek indicates that the waterway experiences occasional periods of no flow and has been subjected to several large flow events of over 1000 ML/Day between 1985 and 1999 (Morris *et al.* 2001) (Astles *et al.* 2003). Predicted impact the increase in flows would have during a flooding event would be minimal as the flow is only 10% of the historical flood levels that occur in Burra Creek. Additional flows into Burra Creek will not be consistent, as only flows above the base flow can be withdrawn from the Murrumbidgee. Additional flows may impact on riparian vegetation and undercut banks in Burra Creek, which in turn may result in changes in flow velocity. This disturbance will be much more common than the large, natural floods Burra Creek has experienced in the past, so the disturbance regime is likely to be changed from its current state. No habitat exists for the Silver Perch at Burra Creek currently, but the alteration of the disturbance regime may impact on known Silver Perch habitat within Googong Reservoir and the mouth of Burra Creek.

How is the proposal likely to affect habitat connectivity?

The proposed increase in water flow is unlikely to reduce habitat connectivity for the Silver Perch. The lack of natural habitat within Burra Creek indicates that the threat of population fragmentation or loss of habitat connectivity is minimal. However, it is recognised that the increase in constant flow from Burra Creek into Googong Reservoir may in turn provide beneficial consequences to the Silver Perch in opening up habitat which facilitates the natural spawning requirements. The increase in regular flow will allow for upstream migration of

Silver Perch if its unique requirements are met (i.e. necessary environmental cues such as water temperature, flooding event) to trigger spawning (Lintermans 2002a).

How is the proposal likely to affect critical habitat?

Under the FM Act, the DPI maintains a Register of Critical Habitat. To date, no critical habitat has been declared for the Silver Perch.

The proposal will not have an adverse effect on critical habitat (directly or indirectly).

Conclusion

Although it is likely that the provision of transfer flows would result in a range of impacts upon the Silver Perch, the species is currently a stocked species into the Googong Reservoir system and do not historically rely on Burra Creek as habitat. Changes to the water quality of Burra Creek, loss of macrophyte populations, erosion of banks leading to increased turbidity, hydrological modifications, potential introduction of predatory and competitive species, and the potential for introduction of viruses and pathogens are all potentially significant impacts. Silver Perch are considered tolerant of poor water quality, but are affected by cooler water. While Silver Perch are not currently known to occur within the reaches of Burra Creek and are not predicted to rely directly on the macrophyte communities; the indirect benefits they provide may be an important determining factor in assessing the probable significant impacts their loss will have upon the Silver Perch.

Provided that best practice mitigation measures are implemented and comprehensive adaptive management and monitoring is undertaken, the proposed development is not expected to have an overall significant impact on the Silver Perch population within NSW.

Trout Cod*Maccullochella macquariensis*

The Trout Cod *Maccullochella macquariensis* is listed as Endangered under the following relevant legislation: *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth), Part 1, Schedule 4 of the *Fisheries Management Act 1994* (NSW), and Section 21 of the *Nature Conservation Act 1980* (ACT).

The Study Area for this investigation lies across the NSW and ACT borders and includes a section of the Murrumbidgee River. The Murrumbidgee River flows from NSW, through the ACT, and continues back into NSW. Within the Study Area, Angle Crossing traverses the Murrumbidgee River a short distance downstream of the NSW/ACT boundary. The last two remaining self-sufficient populations of Trout Cod are located well outside the Study Area: in the Murray River between Yarrowanga Weir and Barmah State Forest on the NSW/VIC border, and in Seven Creeks (upper Goulburn River) in VIC (Allen *et al.* 2003). Water flowing from the Study Area along the Murrumbidgee River does not reach the location of these two populations (the Murrumbidgee River joins the Murray River downstream of both the known populations). However, a stocked population occurs within the Study Area at Angle Crossing, within the ACT (and at various other locations along the Murrumbidgee River up and downstream of Angle Crossing). Therefore a precautionary approach has been taken for this species. While the species does not naturally occur within the Study Area (although it did historically) – there is potential for disturbance to any stocked Trout Cod which may freely migrate from NSW to ACT and vice versa.

As the Trout Cod does not occur within Burra Creek or Googong Reservoir (Lintermans 2001), only impacts associated with the abstraction of water from the Murrumbidgee River at Angle Crossing are assessed for this species.

The Trout Cod is a moderately large freshwater fish that is native to the Murray-Darling river system (McDowall 1996). The historical habitat preferences have never been documented, however the last two known remaining self-sufficient populations exist in highly contrasting habitats (Douglas *et al.* 1994): the Murray River population occurs in large (60-100 m wide), deep (>3 m) flowing water with a sand, silt and clay substrate that contains abundant snags and woody debris, and the Seven Creeks population occupies a relatively narrow stream (5-7 m wide) with shallow (0-2 m) pools interspersed by rapids and cascades where the water is fast-flowing over bedrock, boulder and sand-gravel substrates (DEWHA 2009b). Within the Study Area, the Murrumbidgee River is relatively calm and meandering, over a substrate of sand, silt and gravel with occasional

areas of bedrock and cobble. In general, it appears that Trout Cod adults are essentially a pool dwelling, cover-seeking fish (Lintermans and Osborne 2002).

The construction of the proposed intake/LLPS on the Murrumbidgee River will result in a direct impact to the eastern bank, a short distance upstream of Angle Crossing, and its riparian zone. The intake/LLPS would take the form of a box-in-bank structure with a side inlet and incorporate four fish egg filtration units to filter fish eggs from the water and would discharge filtered water through a dividing wall into the pump module (see section 2.6.1 for details). It is expected that at maximum utilisation, 100 ML/Day would be transferred from the Murrumbidgee River across into Burra Creek (to flow into Googong Reservoir). It is assumed the proposed water abstraction would only occur when the water level of the Murrumbidgee River was above its protected base flow, which varies seasonally (See Section 5.4.1.2 for further operational regime information) (ACT Government 2006).

This impact assessment recognises that the base flow of the Murrumbidgee River will be protected throughout the year and no water below the base flow will be removed.

Authors Note: This impact assessment is based on the understanding that ACTEW will protect the minimum percentile environmental flows of the Murrumbidgee River as prescribed in the ACT Government Water Resources Environmental Flow Guidelines (2006), throughout each month of every year and no water below the base flow will be removed at any time. Any modifications to the water abstraction licence (if/when obtained) will require additional analysis to incorporate any impacts not addressed in this assessment.

The available water quality data for Burra Creek is sparse as Burra Creek has experienced infrequent flows in recent years. The data comparison between the Murrumbidgee River and Burra Creek has been carefully considered as sample timeframes differ significantly. The validity of the data has been taken into account for the assessments and in lieu reliably comparable data, all conclusions drawn are approximations and do not necessarily reflect the full scope and extent of potential impacts that may arise as a consequence of the proposed development.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The Trout Cod breeding cycle is predicted to be similar to the Murray Cod (*Maccullochella peeli peeli*) in that it spawns annually in spring, where the eggs are laid on a hard substrate such as submerged logs, clay banks or rocks (Lintermans and Osborne 2002)).

NSW DPI has developed a number of recovery strategies for Trout Cod since the mid 1980s. This has included stocking in a number of locations across the historic range of the species. Angle Crossing was considered a major site in the stocking program, with the latest stocking consisting of 15,000 fingerlings being released in 2004. In 2006-2007, the stocking site for Trout Cod in this section of the Murrumbidgee River was relocated from Angle Crossing to Kambah Pool; a little further downstream (Lisa Evans, TAMS, pers. comm.). These actions have been incorporated into the Recovery Plan for the species (NSW DPI Fisheries 2006). Prior to stocking, the last recorded capture of Trout Cod in the Canberra region was from the Gigerline Gorge on the Murrumbidgee River in the late 1970's.

There are now only two known self-supporting (not stocked) populations remaining, one in the Murray River between Yarrawanga Weir and Barmah State Forest on the NSW/VIC border and the other in Seven Creeks above Euroa in VIC. The Seven Creeks population is the result of translocations of "cod" from the Goulburn River in 1921 and 1922 (Douglas *et al.* 1994). There is no known Trout Cod population within Burra Creek or Googong Reservoir and it is assumed that they do not exist within this system (Lintermans 2001).

The Murrumbidgee River discharges into the Murray River downstream of both self-supporting Trout Cod populations and any impacts arising from the proposed works is highly unlikely to impact these populations. However, as the species has been artificially stocked at Angle Crossing, directly adjacent to the proposed intake pump, there is potential for both direct and indirect impacts on the species.

Direct impacts to the Trout Cod (individuals and population) are possible and it is likely these impacts would also affect potential breeding habitat. The proposed water abstraction from the Murrumbidgee River could lead to changes in the water flow regime (listed as a Key Threatening Process under Schedule 6 of the FM Act) and water quality, both of which are likely to impact on the life cycle of the species. In addition, construction of the intake/LLPS would disturb riparian vegetation (also listed as a KTP under the FM Act).

The construction of the proposed intake/LLPS on the Murrumbidgee River will result in a direct impact to the river along the eastern bank, a short distance upstream of Angle Crossing. The intake/LLPS would take the form of a box-in-bank structure with a side inlet and incorporate four fish egg filtration units to filter fish eggs from the water and would discharge filtered water through a dividing wall into the pump module (see section 2.6.1 for details). Section 5.4.1.2 defines the predicted operating regime and impacts on flows. However, at maximum utilisation, 100 ML/Day would be transferred from the Murrumbidgee River across into Burra Creek (to flow into Googong Reservoir). It is assumed the proposed water abstraction would only occur when the water level of the Murrumbidgee River was above its protected base flow, which varies seasonally (ACT Government 2006).

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Murrumbidgee River has been significantly modified by historical impacts including abstraction, diversion, road crossings and agriculture. The largest of these was the construction of Tantangara Dam in 1960 and subsequent diversion of flow as part of the Snowy Hydro Scheme. It is estimated that Tantangara Dam results in a reduction in average flow near Angle Crossing of more than 50% (Tim Purves, ACTEW AGL, pers. comm.). The reduction in flow is likely to be higher during periods of median and low flow. Significant variation in flows including high magnitude flows are still experienced in the Murrumbidgee River in the ACT due to the large catchment area below Tantangara Dam.

As mentioned previously, the historical habitat preferences of the Trout Cod have never been documented and the last two remaining self-sufficient populations exist in highly contrasting habitats (Douglas *et al.* 1994). Within the Study Area, the Murrumbidgee River is relatively calm and meandering, over a substrate of sand, silt and gravel with occasional areas of bedrock and cobble. In general, it appears that Trout Cod adults are essentially a pool dwelling, cover-seeking fish.

The construction of the proposed intake/LLPS on the Murrumbidgee River will result in a direct impact to the eastern bank, a short distance upstream of Angle Crossing, and its riparian zone. Construction of the intake/LLPS would disturb riparian vegetation which is listed as a KTP under the FM Act. Riparian vegetation may provide protection/cover and a food source for the Trout Cod. However, only a relatively small area of riparian vegetation would be disturbed by the proposal, and is not predicted to significantly reduce resources for the species within the Study Area.

The proposed abstraction is limited to 100 ML/Day. This volume is unlikely to have a significant effect upon channel maintenance flows or flooding flows within the Murrumbidgee River. Such flows are high and greatly exceed 1000 ML/Day; the proposed abstraction would be less than 10% of such a flow. Flood length is also highlighted as an important factor for river and floodplain function. The proposed abstraction is unlikely to significantly reduce the duration of these high flows given its small proportion of total flow.

However, other components of the flow regime could be impacted by pumping out up to 100 ML/Day. Particularly at risk are low and moderate flows, in terms of both volume and natural variation. Given the above, Trout Cod habitat maintained by channel maintenance flows or flooding flows (i.e. high flows) is unlikely to be significantly impacted by the proposed works. However, Trout Cod habitat maintained by low and moderate flows (e.g. pools) may be impacted to a greater extent.

It is not expected that water level or flows above Angle Crossing will be significantly impacted by the construction and operation of the proposed works. Instream habitat both within the immediate Study Site and wider Study Area will only be affected by minor reductions in flow, and therefore instream habitat and resources will not be significantly reduced. Therefore the action is not predicted to modify, destroy, remove, isolate or decrease the availability or quality of habitat for the species, nor is the population expected to significantly decline.

Does the proposal affect any threatened species that are at the limit of its known distribution?

Stocked populations of the Trout Cod occur along the Murrumbidgee River within, upstream and downstream of the Study Area. Trout Cod are also known, as described above, in the Murray River between Yarrowanga Weir and Barmah State Forest on the NSW/VIC border and in Seven Creeks above Euroa in VIC. Therefore, the Study Area is not at the limit of the Trout Cod's known distribution.

How is the proposal likely to affect the current disturbance regimes?

The Murrumbidgee River has been significantly modified by historical impacts including abstraction, diversion, road crossings and agriculture. The proposed works are not likely to affect current traffic and/or grazing regimes however, the proposal is likely to affect the current water flow regime.

Although the current water flow regime for the Murrumbidgee River is influenced by historical disturbances (e.g. construction of Tantangara Dam) and subject to on-going disturbances (e.g. water abstraction for agricultural

purposes), and hence may be considered unnatural, it has shaped the aquatic system into its present state and is what the aquatic species have adapted to.

It is assumed that the proposed water abstraction (up to 100 ML/Day) would only occur when the water level of the Murrumbidgee River was above its protected base flow (ACT Government 2006). It is anticipated that there will be an average loss of 4.5% - 10.3%, and median loss of 14.2 – 30.4% of environmental flow within the Murrumbidgee River at Angle Crossing per month, based on stochastic and past 10 year climate data respectively (ActewAGL 2009). The M2G operation is predicted to decrease median Murrumbidgee River height below Angle Crossing by 8 – 16.1%; and decrease median velocity by 7.2 – 17.4%, based on stochastic and 10 year climate data respectively (ActewAGL 2009).

This modification of flows within the river are not predicted to cause a significant impact to current disturbance regimes, as abstraction will only occur when the water levels are naturally higher in the system. Therefore additional confounding upon disturbance is considered unlikely.

Minor additional raised levels of background noise and vibration would be experienced during the operation of the LLPS and HLPS at Angle Crossing. Physiologically fish can experience an increase in stress hormones as a result of noise exposure but this response is short-lived and not apparent during longer term exposure. This indicates that rapid changes in sound characteristics may affect behaviour and elicit stress responses much more than does continual noise exposure (Smith et al. 2004). The design of the LLPS and HLPS facilities should incorporate measures to minimise operational noise and vibration. It is expected any impacts of noise and vibration disturbance would be temporary and short-lived, and deemed not significant in nature.

How is the proposal likely to affect habitat connectivity?

Wild populations of Trout Cod have been severely reduced within the Murray Darling Basin in recent years, and it is expected that the naturally occurring habitat has been drastically modified in recent times since the species inhabited them (Harris and Gehrke 1997). The Murrumbidgee River has been significantly modified by historical impacts including abstraction, diversion, road crossings and agriculture. Notwithstanding the above, the Murrumbidgee River provides limited potential habitat for stocked populations of the species during flow periods.

Flow modelling indicates minimum flows will be protected and any reduction in available environmental flows in the downstream river system is unlikely to be

significant. Riffle habitats are not expected to be significantly impacted even when the pumping is running at maximum abstraction. As defined in Section 5.4.1, The M2G operation is predicted to decrease median Murrumbidgee River height below Angle Crossing by 8 – 16.1%; and decrease median velocity by 7.2 – 17.4%, based on stochastic and 10 year climate data respectively (ActewAGL 2009). These reductions will be most significant immediately below the Angle Crossing, where the river is wide and shallow. The effects will dissipate as the water depth and velocity increases as the river passes through narrower channels as it moves downstream.

It is assumed the proposed water abstraction would only occur when the water level of the Murrumbidgee River was above its protected base flow, which varies seasonally (ACT Government 2006). Provided this remains the case, the proposed works is considered unlikely to significantly impact habitat connectivity for the Trout Cod.

How is the proposal likely to affect critical habitat?

Under the FM Act, the DPI maintains a Register of Critical Habitat. To date, no critical habitat has been declared for the Trout Cod. The proposal will not have an adverse effect on critical habitat (directly or indirectly).

Conclusion

The proposal has the potential to impact stocked Trout Cod populations occurring in the Murrumbidgee River. Provided that best practice mitigation measures are implemented and comprehensive adaptive management and monitoring is undertaken, the proposed development is not expected to have a significant impact on the Trout Cod population within NSW. However, the scope of likely impacts identified in Section 5.0 has indicated there will be direct and indirect impacts upon the species within the Study Area. Therefore the proposed development should be referred to DEWHA for further consideration.

Macquarie Perch *australasica*

Macquaria

The Macquarie Perch is listed as Endangered under the following relevant legislation: *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth), Part 1, Schedule 4 of the *Fisheries Management Act 1994* (NSW) and Section 21 of the *Nature Conservation Act 1980* (ACT).

The Macquarie Perch is a native Australian fish that spends its entire life in freshwater streams, migrating between deep pools and fast flowing riffle habitats (McDowall 1996). Preferred habitat is cool, shaded upland streams with deep rocky pools and substantial cover and though they can live and feed in still waters, they must move into flowing waters to breed (Lintermans 2008). The Murray-Darling form of the Macquarie Perch is considered a different subspecies to the coastal form, though this has not been officially described (Lintermans 2006). The Murray darling form is found in the cool upper reaches of the Murray, Lachlan and Murrumbidgee rivers.

This impact assessment covers areas in the ACT as well as NSW, as the nature of river systems and the proximity of the ACT site to the NSW border will mean the action carried out in the ACT will directly and indirectly affect populations that travel readily between the two states.

This impact assessment recognises that the base flow of the Murrumbidgee River will be protected throughout the year and no water below the base flow will be removed.

Authors Note: This impact assessment is based on the understanding that ACTEW will protect the minimum percentile environmental flows of the Murrumbidgee River as prescribed in the ACT Government Water Resources Environmental Flow Guidelines (2006), throughout each month of every year and no water below the base flow will be removed at any time. Any modifications to the water abstraction licence (if/when obtained) will require additional analysis to incorporate any impacts not addressed in this assessment.

The available water quality data for Burra Creek is sparse as Burra Creek has experienced infrequent flows in recent years. The data comparison between the Murrumbidgee River and Burra Creek has been carefully considered as sample timeframes differ significantly. The validity of the data has been taken into account for the assessments and in lieu reliably comparable data, all conclusions drawn are approximations and do not necessarily reflect the full scope and extent

of potential impacts that may arise as a consequence of the proposed development.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Macquarie Perch spawning occurs in October/November at the foot of pools with the eggs drifting downstream and lodging amongst gravel and cobble in riffles. Hatching usually occurs after 10–11 days at water temperatures of 15–17°C (Lintermans 2006). The Macquarie Perch is known to occur in the Murrumbidgee River at Angle Crossing and within a 16 kilometre stretch of the Queanbeyan River upstream of Googong Reservoir (Lintermans 2002a) not far from where the Queanbeyan River joins Burra Creek. It has not been formally established whether the Macquarie Perch exists in Googong Reservoir itself or the lower reaches of Burra Creek.

Presently, Burra Creek is not expected to host a population of Macquarie Perch due to the low water level. The proposal will introduce a maximum of 100ML/Day to Burra Creek just downstream of Burra Creek Bridge. This is expected to create habitat that will be suitable for spawning Macquarie Perch migrating from the Queanbeyan River. There are no barriers that would prevent the species from migrating into the upper reaches of Burra Creek once regular water transfers commence.

While the proposal has the potential to create breeding habitat for the Macquarie Perch within Burra Creek, it may also result in the loss of breeding adults and/or spawn if the water level drops while the species is breeding in the newly formed habitat. To minimise the impact of such an event, where the proposed water abstraction needs to be reduced (i.e. when the Murrumbidgee River water level is at or below its protected base flow), this reduction will occur gradually over a period of 48 hours (ramping down). This mitigation operational regime is designed to allow any Macquarie Perch occurring in Burra Creek the opportunity to return safely to the Queanbeyan River before the water level gets too low.

Increased flows coming down Burra Creek may open the area up to other fish species movement from Googong Reservoir as well. Brown Trout, Rainbow Trout and Redfin are introduced species that occur in Googong Reservoir and may move up into Burra Creek and the Queanbeyan River with increased flow coming down Burra Creek. This could impact the Macquarie Perch population in the Queanbeyan River, but there is no evidence available at present to suggest that these species don't already occur in the Queanbeyan River.

A decline in environmental flow beyond Angle Crossing due to the abstraction of water (Section 5.4.1.2) is not expected to significantly impact on the Macquarie

Perch's available habitat, or further expose them to predation and increased competition for food, spawning habitat, and other resources. At maximum abstraction (100 ML/Day), the water level across Angle Crossing will be reduced by up to 4cm during a flow of 165 ML/Day (50th percentile flow) (Ian Ross, pers. comm., 2009). The abstraction of 100 ML/Day will not have a significant impact upon water levels at Angle Crossing.

As water levels above Angle Crossing will not be significantly reduced, available habitat and resources should remain unaffected by flow modification. Available data indicates localised impacts from construction of the LLPS will not significantly impact the species either. If approved, the proposed abstraction would be controlled through ACTEW's licence to extract water, which is provided by the ACT EPA. It is not expected the action will lead to a long-term decrease in the size of a population provided the minimum flows are protected,

Overall, the proposed action is unlikely to lead to a long-term impact to the life cycle of the Macquarie Perch.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Preferred habitat of Macquarie Perch is cool, shaded, upland streams with deep rocky pools and substantial cover. They can live and feed in still waters, but they must move into flowing waters to breed (Lintermans 2008).

The proposed abstraction is limited to 100 ML/Day. This volume is unlikely to have a significant effect upon channel maintenance flows or flooding flows within the Murrumbidgee River. Such flows are high and greatly exceed 1000 ML/Day; the proposed abstraction would be less than 10% of such a flow. The proposed abstraction is unlikely to significantly reduce the duration of these high flows given its small proportion of total flow. The proposed abstraction is unlikely to decrease the availability or the quality of the habitat for the Macquarie Perch in the Murrumbidgee River.

The base flow of the river – which is the flow that is required to maintain river health for the continued health of all dependent species – changes from month to month and is protected and therefore the flow required by the Macquarie Perch should be maintained, even with the changing requirements of the species throughout the year. Thus, there will be no significant change to the habitat for this species at Angle Crossing such that the species is likely to decline.

However, other components of the flow regime could be impacted by pumping out up to 100 ML/Day. Particularly at risk are low and moderate flows, in terms of

both volume and natural variation. Given the above, Macquarie Perch habitat maintained by channel maintenance flows or flooding flows (i.e. high flows) is unlikely to be significantly impacted by the proposed works. However, Macquarie Perch habitat maintained by low and moderate flows (e.g. pools) may be impacted to a greater extent.

It is expected that there are currently no Macquarie Perch in Burra Creek as there is not enough habitat to support them. The addition of up to 100ML/Day into Burra Creek will change this environment so that in favourable conditions Macquarie Perch may travel up the creek from the Queanbeyan River to spawn. Thus, the proposal may increase habitat for this species, but is unlikely to decrease or change available habitat to the extent that the species is likely to decline.

Does the proposal affect any threatened species that are at the limit of its known distribution?

While the distribution of Macquarie Perch in the Murrumbidgee catchment has undergone significant decline (Gilligan 2005), (Lintermans 2000) reports Macquarie Perch in the entire ACT length of the Murrumbidgee. Macquarie Perch have previously been recorded from Angle Crossing, though it has been absent at this site in recent surveys (Gilligan 2005). As such, the Study Area is not considered to be at the limits of distribution for this species within the Murrumbidgee catchment.

57 individuals were moved from the impoundment into the Queanbeyan River upstream of Curley's Falls (Lintermans and Osborne 2002) following decline of the Queanbeyan River population of Macquarie Perch after construction of the Googong Dam in 1978. Since this translocation no individuals have been recorded from Queanbeyan River downstream of Googong Dam (Lintermans and Osborne 2002). This species is known to occur in the upper reaches of the Lachlan and Murrumbidgee rivers in southern NSW (Ingram *et al.* 1990; Ingram *et al.* 1990; Ingram *et al.* 1990). In the ACT it is restricted to four waterways, the Murrumbidgee, Molongo, Paddys and Cotter river (Lintermans 2002a). The Study Area is close to the limits of distribution for this species within the Queanbeyan region.

How is the proposal likely to affect the current disturbance regimes?

Existing flow data for Burra Creek indicates that the waterway experiences occasional periods of no flow and has been subjected to several large flow events of over 1000 ML/Day between 1985 and 1999 (Ecowise Environmental and Starr 2005); (Gippel and Nayer 2005). The proposal to pump a maximum of

100ML/Day will affect the low flow levels of Burra Creek. An increase of 400mm to the current typical creek flow level (at flow of 5 ML/Day) is predicted. However this higher flow is contained within the existing channel section and flow velocities will remain low. The predicted impact the increase in flows would have during a flooding event would be minimal as the flow is only 10% of the historical flood levels that occur in Burra Creek. Additional flows into Burra Creek will not be consistent, as only flows above the base flow of the Murrumbidgee can be harvested. Additional flows may impact on riparian vegetation and undercut banks in Burra Creek, which in turn may result in changes in flow velocity. This disturbance will be much more common than the large, natural floods Burra Creek has experienced in the past, so the disturbance regime is likely to be changed from its current state. No habitat exists for the Macquarie Perch at Burra Creek currently, but the alteration of the disturbance regime may impact on potential Macquarie Perch habitat where the Queanbeyan River meets Burra Creek.

How is the proposal likely to affect habitat connectivity?

Connectivity between the areas of habitat for Macquarie Perch is already prevented by natural barriers, for example Gigerline Gorge and artificial barriers, such as Googong Dam wall. The proposed works would not further affect habitat connectivity for this species, although it may open up areas of Burra Creek that were not previously available to them for use.

Flow modelling indicates minimum flows will be protected and any reduction in available environmental flows in the downstream river system is unlikely to be significant. Riffle habitats are not expected to be significantly impacted even when the pumping is running at maximum abstraction. As defined in Section 5.4.1.2, The M2G operation is predicted to decrease median Murrumbidgee River height below Angle Crossing by 8 – 16.1%; and decrease median velocity by 7.2 – 17.4%, based on stochastic and 10 year climate data respectively (ActewAGL 2009). These reductions will be most significant immediately below the Angle Crossing, where the river is wide and shallow. The effects will dissipate as the water depth and velocity increases as the river passes through narrower channels as it moves downstream.

It is assumed the proposed water abstraction would only occur when the water level of the Murrumbidgee River was above its protected base flow, which varies seasonally (ACT Government 2006). Provided this remains the case, the proposed works is considered unlikely to significantly impact habitat connectivity for the Macquarie Perch.

How is the proposal likely to affect critical habitat?

To date, no critical habitat has been declared for the Macquarie Perch.

Conclusion

The proposal has the potential to impact stocked Macquarie Perch populations occurring in the Murrumbidgee River. Provided that best practice mitigation measures are implemented and comprehensive adaptive management and monitoring is undertaken, the proposed development is not expected to have a significant impact on the Macquarie Perch population within NSW. However, the scope of likely impacts identified in Section 5.0 has indicated there will be direct and indirect impacts upon the species within the Study Area. Therefore the proposed development should be referred to DEWHA for further consideration.

APPENDIX 3

EPBC Act Significant Impact Criteria

Vulnerable Species

Under the EPBC Act, an ‘important population’ is a population that is necessary for a species’ long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- key source populations either for breeding or dispersal;
- populations that are necessary for maintaining genetic diversity; and/or
- populations that are near the limit of the species range.

The Murray Cod population in the Murrumbidgee River is considered an important population for the purposes of the Act.

Murray Cod

Maccullochella peelii peelii

The Murray Cod is listed as Vulnerable under the EPBC Act. This species prefers large, slow flowing rivers and is often associated with instream structures such as LWD, undercut banks and boulders (Koehn 1994). Murray Cod were plentiful in much of the Murray Darling Basin; however, in recent years there has been a reduction, with fish recorded in reduced numbers with a patchy distribution (Fisheries 1997).

All major New South Wales waterways within the Murray-Darling Basin encompass the natural distribution range of the Murray Cod (Kearney and Kildea 2001). Murray Cod are stocked regularly into Googong Reservoir and although they still occur in the Murrumbidgee River, are not generally considered to occur above Gigerline Gorge.

Murray Cod mature at 4-6 years old and can undertake a breeding migration of 80-100 km, often into tributaries and anabranches (Koehn 1997). Breeding generally requires an increase flow when temperatures are greater than 20°C. Eggs are usually laid in hollow logs, LWD or undercut banks. Adults return to the original home range after breeding. Larvae drift downstream once hatched and recruitment level is highly correlated with moderate to long duration floods (Morris *et al.* 2001) (Sinclair 2005). Potential threats to Murray Cod include river regulation, desnagging, overfishing and predation of young by alien species, particularly Redfin Perch *Perca fluviatilis* (Morris *et al.* 2001).

The intake/LLPS would take the form of a box-in-bank structure with a side inlet and incorporate four fish egg filtration units to filter fish eggs from the water and would discharge filtered water through a dividing wall into the pump module

(see section 2.6.1 for details). Section 5.4.1.2 defines the predicted operating regime and impacts on flows. However, at maximum utilisation, 100 ML/Day would be transferred from the Murrumbidgee River across into Burra Creek (to flow into Googong Reservoir). It is assumed the proposed water abstraction would only occur when the water level of the Murrumbidgee River was above its protected base flow, which varies seasonally (ACT Government 2006).

This impact assessment recognises that the base flow of the Murrumbidgee River will be protected throughout the year and no water below the base flow will be removed.

Authors Note: This impact assessment is based on the understanding that ACTEW will protect the minimum percentile environmental flows of the Murrumbidgee River as prescribed in the ACT Government Water Resources Environmental Flow Guidelines (2006), throughout each month of every year and no water below the base flow will be removed at any time. Any modifications to the water abstraction licence (if/when obtained) will require additional analysis to incorporate any impacts not addressed in this assessment.

The available water quality data for Burra Creek is sparse as Burra Creek has experienced infrequent flows in recent years. The data comparison between the Murrumbidgee River and Burra Creek has been carefully considered as sample timeframes differ significantly. The validity of the data has been taken into account for the assessments and in lieu reliably comparable data, all conclusions drawn are approximations and do not necessarily reflect the full scope and extent of potential impacts that may arise as a consequence of the proposed development.

Is there a real chance or a possibility that the action will lead to a long-term decrease in the size of an important population of a species?

An important population is defined in the EPBC Act as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as important populations in recovery plans, or populations that are a key source either for breeding or dispersal, populations that are necessary for maintaining genetic diversity; and/or populations that are near the limit of the species' range. The population within the Study Area is not currently considered to be an important population.

A decline in environmental flow beyond Angle Crossing due to the abstraction of water (Section 5.4.1.2) is not expected to significantly impact on the Murray Cod's available habitat, or further expose them to predation and increased competition for food, spawning habitat, and other resources. Flow modelling

indicates minimum flows will be protected and any reduction in available environmental flows in the downstream river system is unlikely to be significant. Riffle habitats are not expected to be significantly impacted even when the pumping is running at maximum abstraction. As defined in Section 5.4.1.2.3, The M2G operation is predicted to decrease median Murrumbidgee River height below Angle Crossing by 8 – 16.1%; and decrease median velocity by 7.2 – 17.4%, based on stochastic and 10 year climate data respectively (ActewAGL 2009). These reductions will be most significant immediately below the Angle Crossing, where the river is wide and shallow. The effects will dissipate as the water depth and velocity increases as the river passes through narrower channels as it moves downstream.

As water levels below Angle Crossing will not be significantly reduced, available habitat and resources should remain unaffected by flow modification downstream for the Murray Cod. Available data indicates localised impacts from construction of the LLPS will not significantly impact the species either. If approved, the proposed abstraction would be controlled through ACTEW's licence to extract water, which is provided by the ACT EPA. It is not expected the action will lead to a long-term decrease in the size of a population provided the minimum flows are protected.

The Murray Cod is regularly stocked into Googong Reservoir for recreational purposes by ACT TAMS. It is not expected the transfer of additional flows into the reservoir would significantly decrease the existing stocked population. Overall, the proposed action is unlikely to lead to a long-term decrease in a population of the Murray Cod within the Study Area.

Is there a real chance or a possibility that the action will reduce the area of occupancy of an important population?

The population within the Study Area is not currently considered to be an important population. The proposal is likely to modify or remove a small area of potential habitat within the Study Area; however this is unlikely to be significant given the extent of similar habitat in the local area.

Is there a real chance or a possibility that the action will fragment an existing important population into two or more populations?

The Murray Cod is known to migrate upstream, especially prior to spawning and when water levels are elevated. Wild populations of Murray Cod have been greatly reduced within the Murray Darling Basin in recent years, and it is expected that the naturally occurring habitat has been drastically modified in recent times since the species inhabited them (Harris and Gehrke 1997). The

Murrumbidgee River has been significantly modified by historical impacts including abstraction, diversion, road crossings and agriculture. Notwithstanding the above, the Murrumbidgee River provides limited potential habitat for stocked populations of the species during flow periods.

Murray Cod have been routinely stocked into the Googong Reservoir in recent years for recreational purposes. Due to the abundance of natural barriers within the Murrumbidgee River, Murray Cod populations are not predicted to extend above Gigerline Gorge. The impact of abstraction is not expected to fragment stocked populations within Googong Reservoir.

It is assumed the proposed water abstraction would only occur when the water level of the Murrumbidgee River was above its protected base flow (ACT Government 2006). Provided this remains the case, the proposed works is considered unlikely to significantly impact habitat connectivity for the Murray Cod (and therefore be unlikely to fragment an existing population). There is potential for fragmentation of a population if parts of the river become unsuitable for the species. However, current operational rules will restrict abstraction of flows below the prescribed ACT flow guidelines.

Is there a real chance or a possibility that the action will adversely affect habitat critical to the survival of a species?

The Commonwealth Environment Minister may identify and list habitat critical to the survival of a listed threatened species or ecological community. Details of this identified habitat will be recorded in a Register of Critical Habitat. To date, no areas of critical habitat have been listed for Murray Cod.

Is there a real chance or a possibility that the action will disrupt the breeding cycle of an important population?

Murray Cod undertake upstream migrations during high flow periods in spring and summer to lay eggs on instream habitat, particularly LWD. The proposed actions have the potential to impact a small area of habitat which may contain LWD. The design of the water abstraction and input pump and the proposed mitigation measures minimise the impact to flow, fish passage and instream habitat such that it is unlikely that the breeding cycle of the species would be affected. It is possible that the transfer of flow from the Murrumbidgee River to Burra Creek may potentially increase available spawning habitat for the Murray Cod. The transfer of Burra Creek from an ephemeral system to a running lotic system will open up migration routes to spawn. This may also result in the stranding of adults and/or eggs if flow levels are reduced again, however this will

be guarded against by utilising ramping up/down methods to alter flow over a 48 hour period (see Section 5.5.2 for further detail).

Is there a real chance or a possibility that the action will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The proposed abstraction is limited to 100 ML/Day. This volume is unlikely to have a significant effect upon channel maintenance flows or flooding flows within the Murrumbidgee River. Such flows are high and greatly exceed 1000 ML/Day; the proposed abstraction would be less than 10% of such a flow. The proposed abstraction is unlikely to significantly reduce the duration of these high flows given its small proportion of total flow. The proposed abstraction is unlikely to decrease the availability or the quality of the habitat for the Murray Cod in the Murrumbidgee River or Googong Reservoir.

The base flow of the Murrumbidgee River – which is the flow that is required to maintain river health for the continued health of all dependent species – changes from month to month and is protected and therefore the flow required by the Murray Cod should be maintained, even with the changing requirements of the species throughout the year. Thus, there will be no significant change to the habitat for this species in the river such that the species is likely to decline.

Currently Burra Creek is unsuitable habitat for the Murray Cod due to low and irregular flows creating a barrier for fish movement. Transfer of flows may increase available habitat for the species, but may temporarily reduce the quality of aquatic habitat within the reservoir. Increased turbidity from entrained sediment from Burra Creek flows may decrease water quality. However, these effects are expected to be short lived and not significant in the long term.

Is there a real chance or a possibility that the action will result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?

Alien fish and invasive plant species are well established in the Murrumbidgee River and some species are known to be a threat to juvenile Murray Cod. The proposed works have the known potential to introduce exotic species into the Googong Reservoir via water transfer from the Murrumbidgee River to Burra Creek. However, it has been recommended that a screen filtration system be installed on the abstraction pump to remove all fish including adults, juveniles and eggs as well as any algae before the water is transferred.

Two alien species, Carp and Oriental Weatherloach are considered a high risk for translocation as they are known to be present in reasonable numbers at Angle

Crossing, are hardy, known to impact native fish communities, breed in the Murrumbidgee and are not yet established in Googong Dam or its catchment. The potential impact of these two alien fish in Googong Dam may include: reduced water quality; alteration to habitat, particularly submergent macrophyte cover, by increasing turbidity; predation upon fish eggs and juveniles and competition with native species. Once these species access Googong Dam there is a greater potential risk of them invading the more significant conservation reaches of the upper Queanbeyan River. The potential transfer of adult and juvenile fish would basically be mitigated by preventing impingement and passage through the intake screen described above.

Is there a real chance or a possibility that the action will introduce disease that may cause the species to decline?

The risk of introducing pathogens and other organisms such as algae through water transfer is also apparent. There are a number of pathogens known to affect fish in the ACT, however EHN Virus is considered to pose the most significant threat. EHN Virus is known to cause significant mortality in Murray Cod and other native fish (Langdon 1989). It is carried by many species of alien fish including Redfin Perch and Trout and can survive free in the water column for a significant period of time. However, EHN virus is known to have been present in the Murrumbidgee River and Googong Dam since the late 1980 (2005) and therefore does not present a potential issue to this project.

The risk of other known or unknown pathogens is difficult to determine. Although the proposed works will link the Murrumbidgee River to the Queanbeyan River, they are both part of the upper Murrumbidgee Catchment. Given the other potential vectors for pathogens to enter both waterways, the risk posed by the project in terms of known and unknown pathogens is likely to be low.

Is there a real chance or a possibility that the action will interfere substantially with the recovery of the species?

The Australian Government Minister for the Environment and Heritage may make or adopt and implement recovery plans for threatened fauna, threatened flora (other than conservation dependent species) and threatened ecological communities listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

To date, there is no recovery plan for Murray Cod. Given the small area of impact, the low probability of impact of fish passage and the mitigation measures

to manage instream habitat and water quality, it is unlikely that the proposed actions would interfere with the recovery of the species.

Conclusion

Based on the above assessment, the proposal is **unlikely** to have a significant impact on Murray Cod in the Study Area. Referral to the Minister is not required for this species.

Endangered Species

Trout Cod

Maccullochella macquariensis

The Trout Cod *Maccullochella macquariensis* is listed as Endangered under the following relevant legislation: *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth), Part 1, Schedule 4 of the *Fisheries Management Act 1994* (NSW), and Section 21 of the *Nature Conservation Act 1980* (ACT).

The Study Area for this investigation lies across the NSW and ACT borders and includes a section of the Murrumbidgee River. The Murrumbidgee River flows from NSW, through the ACT, and continues back into NSW. Within the Study Area, Angle Crossing traverses the Murrumbidgee River a short distance downstream of the NSW/ACT boundary. The last two remaining self-sufficient populations of Trout Cod are located well outside the Study Area: in the Murray River between Yarrowanga Weir and Barmah State Forest on the NSW/VIC border, and in Seven Creeks (upper Goulburn River) in VIC (Allen *et al.* 2003). Water flowing from the Study Area along the Murrumbidgee River does not reach the location of these two populations (the Murrumbidgee River joins the Murray River downstream of both the known populations). However, a stocked population occurs within the Study Area at Angle Crossing, within the ACT (and at various other locations along the Murrumbidgee River up and downstream of Angle Crossing). Therefore a precautionary approach has been taken for this species. While the species does not naturally occur within the Study Area (although it did historically) – there is potential for disturbance to any stocked Trout Cod which may freely migrate from NSW to ACT and vice versa.

As the Trout Cod does not occur within Burra Creek or Googong Reservoir (Lintermans 2001), only impacts associated with the construction and abstraction of water from the Murrumbidgee River at Angle Crossing are assessed for this species.

The Trout Cod is a moderately large freshwater fish that is native to the Murray-Darling river system (McDowall 1996). The historical habitat preferences have never been documented, however the last two known remaining self-sufficient populations exist in highly contrasting habitats (Douglas *et al.* 1994): the Murray River population occurs in large (60-100 m wide), deep (>3 m) flowing water with a sand, silt and clay substrate that contains abundant snags and woody debris, and the Seven Creeks population occupies a relatively narrow stream (5-7 m wide) with shallow (0-2 m) pools interspersed by rapids and cascades where the water is fast-flowing over bedrock, boulder and sand-gravel substrates

(DEWHA 2009b). Within the Study Area, the Murrumbidgee River is relatively calm and meandering, over a substrate of sand, silt and gravel with occasional areas of bedrock and cobble. In general, it appears that Trout Cod adults are essentially a pool dwelling, cover-seeking fish (Lintermans and Osborne 2002).

The construction of the proposed intake/LLPS on the Murrumbidgee River will result in a direct impact to the river along the eastern bank, a short distance upstream of Angle Crossing. The intake/LLPS would take the form of a box-in-bank structure with a side inlet and incorporate four fish egg filtration units to filter fish eggs from the water and would discharge filtered water through a dividing wall into the pump module (see section 2.6.1 for details). Section 5.4.1.2 defines the predicted operating regime and impacts on flows. However, at maximum utilisation, 100 ML/Day would be transferred from the Murrumbidgee River across into Burra Creek (to flow into Googong Reservoir). It is assumed the proposed water abstraction would only occur when the water level of the Murrumbidgee River was above its protected base flow, which varies seasonally (ACT Government 2006).

This impact assessment recognises that the base flow of the Murrumbidgee River will be protected throughout the year and no water below the base flow will be removed.

Authors Note: This impact assessment is based on the understanding that ACTEW will protect the minimum percentile environmental flows of the Murrumbidgee River as prescribed in the ACT Government Water Resources Environmental Flow Guidelines (2006), throughout each month of every year and no water below the base flow will be removed at any time. Any modifications to the water abstraction licence (if/when obtained) will require additional analysis to incorporate any impacts not addressed in this assessment.

The available water quality data for Burra Creek is sparse as Burra Creek has experienced infrequent flows in recent years. The data comparison between the Murrumbidgee River and Burra Creek has been carefully considered as sample timeframes differ significantly. The validity of the data has been taken into account for the assessments and in lieu reliably comparable data, all conclusions drawn are approximations and do not necessarily reflect the full scope and extent of potential impacts that may arise as a consequence of the proposed development.

Is there a real chance or a possibility that the action will lead to a long-term decrease in the size of a population?

The proposed works have the potential to directly and indirectly affect stocked populations of Trout Cod occurring within the Study Area. The proposed water abstraction from the Murrumbidgee River will lead to changes in the natural water flow regime (listed as a Key Threatening Process under Schedule 6 of the FM Act) and water quality, both of which are likely to impact on the life cycle of the species.

The Trout Cod population of Angle Crossing results from previous stocking efforts by ACT TAMS. The species has not been identified as a viable breeding population; however, they are known to persist within the Study Site. The Study Area provides known historical habitat for the Trout Cod, which is naturally fragmented by Gigerline George. A decline in environmental flow beyond Angle Crossing due to the abstraction of water (Section 5.4.1.2) is not expected to impair the Trout Cod's abarriers of the Gigerline Gorge downstream greatly restrictreased competition for food, spawning habitat, and other resources. At maximum abstraction (100 ML/Day), the water level across Angle Crossing will be reduced by up to 4cm during a flow of 165 ML/Day (50th percentile flow) (Ian Ross, pers. comm., 2009). The abstraction of 100 ML/Day will not have a significant impact upon water levels at Angle Crossing.

Water levels above Angle Crossing will not be significantly reduced, so available habitat and resources should remain unaffected by flow modification. Available data indicates localised impacts from construction of the LLPS will not significantly impact the species either. If approved, the proposed abstraction would be controlled through ACTEW's licence to extract water, which is provided by the ACT EPA. If the minimum flows are protected, it is not expected the action will lead to a long-term decrease in the size of a population.

Is there a real chance or a possibility that the action will reduce the area of occupancy of the species?

It is assumed the proposed water abstraction would only occur when the water level of the Murrumbidgee River was above its protected base flow, which varies seasonally (ACT Government 2006). Provided this remains the case, the proposed works is considered unlikely to significantly impact habitat for the Trout Cod (and therefore be unlikely to reduce the area of occupancy of the species). Model flow data indicates the extent of impacts on the current water flow and level regime of the Murrumbidgee River within the Study Area will be insignificant.

Throughout the construction phase there is expected to be regular noise and vibration disturbance to the aquatic habitat in proximity of the construction footprint of the LLPS. However, while this may lead to short-term reduction in favourable habitat for Trout Cod, it is not expected to result in significant long term reductions in area of occupancy for the species.

The natural barriers of the Gigerline Gorge downstream greatly restrict the movement of the Trout Cod below Angle Crossing. An insignificant reduction in flows will not decrease available habitat for the species or limit their distribution potential. It is not predicted area of occupancy for this species will be significantly altered as a result of the proposed works.

Is there a real chance or a possibility that the action will fragment an existing population into two or more populations?

Wild populations of Trout Cod have been severely reduced within the Murray Darling Basin in recent years, and it is expected that the naturally occurring habitat has been drastically modified in recent times since the species inhabited them (Harris and Gehrke 1997). The Murrumbidgee River has been significantly modified by historical impacts including abstraction, diversion, road crossings and agriculture. Notwithstanding the above, the Murrumbidgee River provides limited potential habitat for stocked populations of the species during flow periods.

Trout Cod have been routinely stocked into areas of the Murrumbidgee River both up and downstream of Angle Crossing in recent years. Due to the abundance of natural barriers within the Murrumbidgee River (particularly Gigerline Gorge), stocked populations are not predicted to spread far beyond their original stocking locations.

It is assumed the proposed water abstraction would only occur when the water level of the Murrumbidgee River was above its protected base flow (ACT Government 2006). Provided this remains the case, the proposed works is considered unlikely to significantly impact habitat connectivity for the Trout Cod (and therefore be unlikely to fragment an existing population). There is potential for fragmentation of a population if parts of the river become unsuitable for the species. However, current operational rules will restrict abstraction of flows below the prescribed ACT flow guidelines.

Is there a real chance or a possibility that the action will adversely affect habitat critical to the survival of a species?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. A Register of Critical

Habitat is maintained by the Minister under the EPBC Act. To date, no critical habitat has been declared for the Trout Cod (DEWHA 2008).

Is there a real chance or a possibility that the action will disrupt the breeding cycle of a population?

The breeding habitat of Trout Cod is unknown, with no wild spawning sites known. The Trout Cod is assumed to form breeding pairs and spawn annually in spring, much like other Australian freshwater cod species (Lintermans, pers. comm., 2009) (Douglas *et al.* 1994), when water temperatures are between 14-22°C. Spawning appears to be triggered by increasing day length and increasing water temperatures (DEWHA 2009b). It is believed that the eggs are deposited on a hard surface, possibly logs, rocks, bedrock, LWD, etc (Douglas *et al.* 1994).

The proposed actions have the potential to impact the artificially stocked population at Angle Crossing, directly adjacent to the proposed intake/LLPS, including potential breeding habitat. However, it is understood the stocked populations within Angle Crossing are not a viable breeding population despite regular monitoring, and do not rely on breeding habitat within the Study Area.

The reduction in water availability is not expected to significantly disrupt the breeding cycle of the populations of Trout Cod within the Study Area.

Is there a real chance or a possibility that the action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The construction of the proposed intake/LLPS on the Murrumbidgee River will result in a direct impact to the eastern bank, a short distance upstream of Angle Crossing, and its riparian zone. Construction of the intake/LLPS would disturb riparian vegetation which is listed as a KTP under the FM Act. Riparian vegetation may provide protection/cover and a food source for the Trout Cod. However, only a relatively small area of riparian vegetation would be disturbed by the proposal, and is not predicted to significantly reduce resources for the species within the Study Area.

The proposed abstraction is limited to 100 ML/Day. This volume is unlikely to have a significant effect upon channel maintenance flows or flooding flows within the Murrumbidgee River. Such flows are high and greatly exceed 1000 ML/Day; the proposed abstraction would be less than 10% of such a flow. Flood length is also highlighted as an important factor for river and floodplain function. The proposed abstraction is unlikely to significantly reduce the duration of these high flows given its small proportion of total flow.

However, other components of the flow regime could be impacted by pumping out up to 100 ML/Day. Particularly at risk are low and moderate flows, in terms of both volume and natural variation. Given the above, Trout Cod habitat maintained by channel maintenance flows or flooding flows (i.e. high flows) is unlikely to be significantly impacted by the proposed works. However, Trout Cod habitat maintained by low and moderate flows (e.g. pools) may be impacted to a greater extent.

It is not expected that water level or flows above Angle Crossing will be significantly impacted by the construction and operation of the proposed works. Instream habitat both within the immediate Study Site and wider Study Area will only be affected by minor reductions in flow, and therefore instream habitat and resources will not be significantly reduced. Therefore the action is not predicted to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

Is there a real chance or a possibility that the action will result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat?

Alien fish and invasive plant species are already well established in the Murrumbidgee River and some species are known to be a threat to juvenile Trout Cod. Two alien species, Carp (*Cyprinus carpio*) and Oriental Weather Loach (*Misgurnus anguillicaudatus*), are common in the Murrumbidgee River and are considered a high risk for Trout Cod juveniles as they are known to be present in reasonable numbers at Angle Crossing, are hardy, and known to impact native fish communities.

If water levels were significantly reduced within the Murrumbidgee River, the potential impacts of these two alien fish may include (but not be limited to): reduced water quality; alteration to habitat, particularly submergent macrophyte cover, by increasing turbidity; predation upon fish eggs and juveniles; and, competition with native species. However, the predicted operational regime will prevent the reduction of flows below minimal environmental flows to protect aquatic biodiversity within the river. It is unlikely the proposed works will result in or exacerbate the establishment of invasive species within the Murrumbidgee River Study Area.

Is there a real chance or a possibility that the action will introduce disease that may cause the species to decline?

The risk of introducing pathogens and other organisms such as algae through the construction of the proposed intake/LLPS is already apparent. There are a number of pathogens known to affect fish in the ACT, however EHN Virus (EHNV) is considered to pose the most significant threat. EHNV is known to cause significant mortality in Trout Cod and other native fish (Langdon 1989). The virus is carried by many species of alien fish including Redfin Perch (*Perca fluviatilis*) and Trout spp. (*Oncorhynchus mykiss* and *Salmo trutta*), which are known to occur in the Murrumbidgee River, and can survive free in the water column for a significant period of time. However, EHNV is known to have been present in the Murrumbidgee River since the late 1980's (Lintermans 2005b) and therefore cannot be introduced by the current proposal.

The risk of other known or unknown pathogens is difficult to determine. Although the proposed works will link the Murrumbidgee River to the Googong Reservoir, they are both part of the upper Murrumbidgee Catchment. Given the other potential vectors for pathogens to enter both waterways, the risk posed by the proposal in terms of known and unknown pathogens is likely to be low.

Is there a real chance or a possibility that the action will interfere with the recovery of the species?

NSW DPI has developed a number of recovery strategies for Trout Cod since the mid 1980s. This has included stocking in a number of locations across the historic range of the species. Angle Crossing was considered a major site in the stocking program, with the latest stocking consisting of 15,000 fingerlings being released in 2004. In 2006-2007, the stocking site for Trout Cod in this section of the Murrumbidgee River was relocated from Angle Crossing to Kambah Pool, a little further downstream (Lisa Evans, TAMS, pers. comm.). These actions have been incorporated into the Recovery Plan for the species (NSW DPI Fisheries 2006). Prior to stocking, the last recorded capture of Trout Cod in the Canberra region was from the Gigerline Gorge on the Murrumbidgee River in the late 1970's (Lintermans and Osborne 2002).

The specific objectives of the Recovery Plan (NSW DPI Fisheries 2006) are to:

- Ensure the security of the existing Trout Cod population in the Murray River by maintaining and restoring, where necessary, the aquatic habitat in that locality, and through habitat protection mechanisms;
- Establish and protect a minimum of two new self-sustaining populations of Trout Cod at selected locations throughout the species' former range;

- Reduce fishing related mortality of Trout Cod by setting appropriate regulatory controls and by maximising angler compliance;
- Increase scientific knowledge of the distribution, population size, ecological requirements and historical and existing genetic status of Trout Cod;
- Improve our understanding of the threats to the survival of Trout Cod, and contribute to management actions to ameliorate identified threats;
- Coordinate and initiate new community awareness and education programs relating to Trout Cod;
- Coordinate and support appropriate actions by the community and government to provide a strategic, regional approach to Trout Cod survival and effective threat management;
- Increase awareness of the status of and threats to Trout Cod, and enhance community support for recovery actions; and,
- Assess the outcomes of past and current recovery actions and the species' conservation status.

If the proposed maximum abstraction rate of 100ML/Day follows the Environmental Flows Guidelines set out by the ACT Government (ACT Government 2006), and only takes water from the river when the water level is above the protected base flow, it is less likely to result in a significant impact to the Trout Cod occurring in the Study Area. Although the probable frequency of utilisation is only 32% and there will be no or limited pumping at low flow in order to protect the environmental health of the river.

Given that the two known self-supporting populations (in the Murray River between Yarrowanga Weir and Barmah State Forest on the NSW/VIC border, and in Seven Creeks (upper Goulburn River) in VIC (Allen *et al.* 2003)) would not be impacted by the proposal, it is considered unlikely that the proposed action would interfere with the recovery of the species.

Conclusion

While application of the EPBC Significant Impact Criteria indicates that the proposed development is overall **unlikely** to have a significant impact on the EPBC listed Trout Cod; uncertainty in regards to the extent of likely impacts upon this species within the Study Area remains.

Due to the Trout Cod's limited distribution and the intrinsic value of locally stocked populations; it is predicted the proposed works may cause a significant

impact to local populations but not one that would be considered under the EPBC Act Matters of National Environmental Significance (MNES) guidelines. While there is known potential for impacts upon Commonwealth listed threatened species, as a precaution the proposed development should be referred to the Minister for the Environment for further consideration.

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Macquarie Perch***Macquaria australasica***

The Macquarie Perch is listed as Endangered under the following relevant legislation: *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth), Part 1, Schedule 4 of the *Fisheries Management Act 1994* (NSW) and Section 21 of the *Nature Conservation Act 1980* (ACT).

The Macquarie Perch is a native Australian fish that spends its entire life in freshwater streams, migrating between deep pools and fast flowing riffle habitats (McDowall 1996). Preferred habitat is cool, shaded upland streams with deep rocky pools and substantial cover and though they can live and feed in still waters, they must move into flowing waters to breed (Lintermans 2007).

The Murray-Darling form of the Macquarie Perch is considered a different subspecies to the coastal form, though this has not been officially described (Lintermans 2006). The Murray darling form is found in the cool upper reaches of the Murray, Lachlan and Murrumbidgee rivers.

The intake/LLPS would take the form of a box-in-bank structure with a side inlet and incorporate four fish egg filtration units to filter fish eggs from the water and would discharge filtered water through a dividing wall into the pump module (see section 2.6.1 for details). Section 5.4.1.2 defines the predicted operating regime and impacts on flows. However, at maximum utilisation, 100 ML/Day would be transferred from the Murrumbidgee River across into Burra Creek (to flow into Googong Reservoir). It is assumed the proposed water abstraction would only occur when the water level of the Murrumbidgee River was above its protected base flow, which varies seasonally (ACT Government 2006).

This impact assessment assumes that the base flow of the Murrumbidgee River will be protected throughout the year and no water below the base flow will be removed.

Authors Note: This impact assessment is based on the understanding that ACTEW will protect the minimum percentile environmental flows of the Murrumbidgee River as prescribed in the ACT Government Water Resources Environmental Flow Guidelines (2006), throughout each month of every year and no water below the base flow will be removed at any time. Any modifications to the water abstraction licence (if/when obtained) will require additional analysis to incorporate any impacts not addressed in this assessment. The available historical water quality data and analysis provided by ACTEW is inconsistent and not directly comparable as sample timeframes differ significantly. The validity of the supplied data has been taken into account for this assessment and in lieu of finalised and reliably comparable data, all conclusions drawn are approximations

and do not necessarily reflect the full scope of potential impacts that may arise as a consequence of the proposed development. However, the total extent of impacts is difficult to determine and quantify. Therefore, a conservative approach to this assessment has been undertaken.

Is there a real chance or possibility that the action will lead to a long-term decrease in the size of a population of the species?

The Macquarie Perch is known to occur in the Murrumbidgee River at Angle Crossing and within a 16 kilometre stretch of the Queanbeyan River upstream of Googong Reservoir (Lintermans 2002a) not far from where the Queanbeyan River joins Burra Creek. It has not been formally established whether the Macquarie Perch exists in Googong Reservoir itself or the lower reaches of Burra Creek.

Presently, Burra Creek is not expected to host a population of Macquarie Perch due to the low water level. The proposal will introduce a maximum of 100ML/Day to Burra Creek just downstream of Burra Creek Bridge. This is expected to create habitat that will be suitable for spawning Macquarie Perch migrating from the Queanbeyan River. There are no barriers that would prevent the species from migrating into the upper reaches of Burra Creek once regular water transfers commence.

While the proposal has the potential to create breeding habitat for the Macquarie Perch within Burra Creek, it may also result in the loss of breeding adults and/or spawn if the water level drops while the species is breeding in the newly formed habitat. To minimise the impact of such an event, where the proposed water abstraction needs to be reduced (i.e. when the Murrumbidgee River water level is at or below its protected base flow), this reduction will occur gradually over a period of 48 hours (ramping down). This mitigation operational regime is designed to allow any Macquarie Perch occurring in Burra Creek the opportunity to return safely to the Queanbeyan River before the water level gets too low.

Increased flows coming down Burra Creek may open the area up to other fish species movement from Googong Reservoir as well. Brown Trout, Rainbow Trout and Redfin are introduced species that occur in Googong Reservoir and may move up into Burra Creek and the Queanbeyan River with increased flow coming down Burra Creek. This could impact the Macquarie Perch population in the Queanbeyan River, but there is no evidence available at present to suggest that these species don't already occur in the Queanbeyan River.

A decline in environmental flow beyond Angle Crossing due to the abstraction of water (Section 5.4.1.2) is not expected to significantly impact on the Macquarie Perch's available habitat, or further expose them to predation and increased competition for food, spawning habitat, and other resources. At maximum

abstraction (100 ML/Day), the water level across Angle Crossing will be reduced by up to 4cm during a flow of 165 ML/Day (50th percentile flow) (Ian Ross, pers. comm., 2009). The abstraction of 100 ML/Day will not have a significant impact upon water levels at Angle Crossing.

As water levels above Angle Crossing will not be significantly reduced, available habitat and resources should remain unaffected by flow modification. Available data indicates localised impacts from construction of the LLPS will not significantly impact the species either. If approved, the proposed abstraction would be controlled through ACTEW's licence to extract water, which is provided by the ACT EPA. It is not expected the action will lead to a long-term decrease in the size of a population provided the minimum flows are protected,

Overall, the proposed action is unlikely to lead to a long-term decrease in a population of the Macquarie Perch.

Is there a real chance or possibility that the action will reduce the area of occupancy of the species?

Proposed works at Angle Crossing may affect potential breeding habitat of Macquarie Perch. Macquarie Perch are particularly susceptible to sedimentation in streams because they deposit their adhesive demersal eggs amongst rocks and gravel (Lintermans 2006). There is potential for increased sediment entering the Murrumbidgee from the construction of the Low Lift Pump Station beside Angle Crossing. Sediment can smother spawning beds, cover the eggs themselves, and can also fill deep pools, making them undesirable as habitat. The preliminary construction methodology for the Angle Crossing works suggests settlement dams will capture runoff and groundwater at the Low Lift Pump Station, minimising the impact of sediment introduction to the waterway. The proposal is unlikely to reduce the area of occupancy of the species in the Murrumbidgee River provided appropriate sediment control is put in place.

Presently, Burra Creek is not expected to host a population of Macquarie Perch due to the low water level. Increased flows in Burra Creek may create access to suitable spawning sites for Macquarie Perch moving up out of the adjoining Queanbeyan River close to where Burra Creek enters Googong Dam. There are no significant barriers to fish passage in Burra Creek and the pools and riffle habitat which would be created during transfer could be suitable for Macquarie Perch. Overall, the proposed works are likely to create potential habitat for this species in Burra Creek rather than reduce the area of occupancy in the Googong Reservoir system.

Is there a real chance or possibility that the action will fragment an existing population of the species?

Connectivity between the areas of habitat for Macquarie Perch in the Murrumbidgee River and Googong Reservoir is already prevented by natural barriers, for example Gigerline Gorge in the Murrumbidgee River and artificial barriers, such as Googong Dam wall. The proposed works would not further affect habitat connectivity for this species, although it may open up areas of Burra Creek that were not previously available to them for use in migration and spawning.

Is there a real chance or possibility that the action will adversely affect habitat critical to the survival of a species?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. A Register of Critical Habitat is maintained by the Minister under the EPBC Act. To date, no critical habitat has been declared for the Macquarie Perch (DEWHA 2008).

Is there a real chance or possibility that the action will disrupt the breeding cycle of a population of the species?

Macquarie Perch spawning occurs in October/November at sites at the foot of pools, with the eggs drifting downstream and lodging amongst gravel and cobble in riffles. Hatching usually occurs after 10–11 days at water temperatures of 15–17°C (Lintermans 2006).

The spawning effort of Macquarie Perch below the abstraction point on the Murrumbidgee would likely be affected if the abstraction of flow reduces the riffle habitat available and the level of flow. The abstraction of a maximum of 100ML/Day is deemed unlikely to have a significant effect on channel maintenance flows or flooding flows. Flow modelling indicates minimum flows will be protected and any reduction in available environmental flows in the downstream river system is unlikely to be significant. Riffle habitats are not expected to be significantly impacted even when the pumping is running at maximum abstraction. As defined in Section 5.4.1.2.3, The M2G operation is predicted to decrease median Murrumbidgee River height below Angle Crossing by 8 – 16.1%; and decrease median velocity by 7.2 – 17.4%, based on stochastic and 10 year climate data respectively (ActewAGL 2009). These reductions will be most significant immediately below the Angle Crossing, where the river is wide and shallow. The effects will dissipate as the water depth and velocity increases as the river passes through narrower channels as it moves downstream.

Increased flows coming down Burra Creek during spring may enable further movement by the Macquarie Perch and prompt the species to travel upstream and

spawn in Burra Creek where adult individuals or juveniles may become isolated if flows are subsequently cut off in an emergency situation. However, the chances of these two events colliding are minimal. The transference of water from the Murrumbidgee to Burra Creek may also increase spawning effort in the Queanbeyan River population of Macquarie Perch.

Is there a real chance or possibility that the action will modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The proposed abstraction is limited to 100 ML/Day. This volume is unlikely to have a significant effect upon channel maintenance flows or flooding flows within the Murrumbidgee River. Such flows are high and greatly exceed 1000 ML/Day; the proposed abstraction would be less than 10% of such a flow. The proposed abstraction is unlikely to significantly reduce the duration of these high flows given its small proportion of total flow. The proposed abstraction is unlikely to decrease the availability or the quality of the habitat for the Macquarie Perch in the Murrumbidgee River.

The base flow of the river – which is the flow that is required to maintain river health for the continued health of all dependent species – changes from month to month and is protected and therefore the flow required by the Macquarie Perch should be maintained, even with the changing requirements of the species throughout the year. Thus, there will be no significant change to the habitat for this species at Angle Crossing such that the species is likely to decline.

However, other components of the flow regime could be impacted by pumping out up to 100 ML/Day. Particularly at risk are low and moderate flows, in terms of both volume and natural variation. Given the above, Macquarie Perch habitat maintained by channel maintenance flows or flooding flows (i.e. high flows) is unlikely to be significantly impacted by the proposed works. However, Macquarie Perch habitat maintained by low and moderate flows (e.g. pools) may be impacted to a greater extent.

It is expected that there are currently no Macquarie Perch in Burra Creek as there is not enough habitat to support them. The addition of up to 100ML/Day into Burra Creek will change this environment so that in favourable conditions Macquarie Perch may travel up the creek from the Queanbeyan River to spawn. Thus, the proposal may increase habitat for this species, but is unlikely to decrease or change available habitat to the extent that the species is likely to decline.

Is there a real chance or a possibility that the action will result in invasive species that are harmful to a critically Endangered or Endangered species

becoming established in the Endangered or critically Endangered species' habitat?

Two alien species, Carp *Cyprinus carpio* and Oriental Weather Loach *Misgurnus anguillicaudatus* are considered a high risk for translocation as they are known to be present in reasonable numbers at Angle Crossing, breed in the Murrumbidgee River and are not yet established in Googong Reservoir or its catchment. The potential impact of these two alien fish in Googong Reservoir may include: reduced water quality; alteration to habitat, particularly submergent macrophyte cover, by increasing turbidity; predation upon fish eggs and juveniles; and, competition with native species. There are three major life stages which have potential to be transported through the pipeline: adult fish, juveniles and eggs/larvae. However, an intake screen has been recommended in order to mitigate the potential transfer of adult and juvenile fish, eggs, and pathogens being translocated through the pipeline to Burra Creek.

Increased flows coming down Burra Creek may open the area up to fish movement from Googong Reservoir as well. Brown Trout, Rainbow Trout and Redfin are introduced species that occur in Googong Reservoir and may move up into Burra Creek and Queanbeyan River with increased flow coming down Burra Creek. This could impact the Macquarie Perch population in Queanbeyan River, but there is no evidence that these species don't already occur in the Queanbeyan River.

Is there a real chance or a possibility that the action will introduce disease that may cause the species to decline?

The risk of introducing pathogens and other organisms such as algae through the construction of the proposed intake/LLPS is already apparent. There are a number of pathogens known to affect fish in the ACT, however EHN Virus (EHNV) is considered to pose the most significant threat. EHNV is known to cause significant mortality in Macquarie Perch and other native fish (Langdon 1989). The virus is carried by many species of alien fish including Redfin Perch (*Perca fluviatilis*) and Trout spp. (*Oncorhynchus mykiss* and *Salmo trutta*), which are known to occur in the Murrumbidgee River, Burra Creek and Googong Reservoir, and can survive free in the water column for a significant period of time. However, EHNV is known to have been present in the Murrumbidgee River since the late 1980's (Lintermans 2005b) and therefore cannot be introduced by the current proposal.

The risk of other known or unknown pathogens is difficult to determine. Although the proposed works will link the Murrumbidgee River to the Googong Reservoir, they are both part of the upper Murrumbidgee Catchment. Given the other

potential vectors for pathogens to enter both waterways, the risk posed by the proposal in terms of known and unknown pathogens is likely to be low.

Is there a real chance or a possibility that the action will interfere with the recovery of the species?

There is currently no national or state recovery plan for the Macquarie Perch, however, a draft recovery plan is in preparation by both DEWHA and DPI. In the absence of a recovery plan, the DPI lists a number of recovery strategies to help recover the species within NSW; those most relevant to the proposal include:

- Conduct targeted surveys to improve understanding of the size, distribution and ecological requirements of Macquarie Perch;
- Implement legislative options for providing increased protection for Macquarie Perch habitat;
- Undertake pest species eradication and control programs at key sites;
- Prevent sedimentation and poor water quality by improving land management practices, conserving and restoring riparian (river bank) vegetation and using effective siltation control measures;
- Protect genetically distinct populations of Macquarie Perch by preventing their translocation and introduction into new waters;
- Control the translocation of alien species to prevent the spread of EHNW; and,
- Improve in-stream habitats and remove barriers to passage.

The proposal has the potential to disturb in-stream habitats and water quality and translocate alien fish and diseases, however, measures have been taken to minimise these possibilities. For example, an intake screen has been recommended in order to mitigate the potential transfer of adult and juvenile fish, eggs, and pathogens being translocated through the pipeline to Burra Creek. Further, it is assumed the proposed water abstraction would only occur when the water level of the Murrumbidgee River was above its protected base flow (ACT Government 2006). Given the above, the proposal is unlikely to interfere with the recovery of the species.

Conclusion:

While application of the EPBC Significant Impact Criteria indicates that the proposed development is overall **unlikely** to have a significant impact on the

EPBC listed Macquarie Perch; uncertainty in regards to the extent of likely impacts upon this species within the Study Area remains.

Due to the Macquarie sensitivity to sedimentation and habitat alteration within Study Area; it is predicted the proposed works may cause a significant impact to local populations but not one that would be considered under the EPBC Act Matters of National Environmental Significance (MNES) guidelines. While there is known potential for impacts upon Commonwealth listed threatened species, as a precaution the proposed development should be referred to the Minister for the Environment for further consideration.

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Murrumbidgee to Googong Water Transfer

Assessment of Significance for the Murray River Crayfish

December 2009

Contents

1	INTRODUCTION	
1.1	Assumptions	1
2	SIGNIFICANCE ASSESSMENT	2
3	CONCLUSION	6
4	REFERENCES	7

1 Introduction

Studies have confirmed that the 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. 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 (NC Act). There is no prescribed formal assessment procedure applied to threatened species under the NC Act and as such this Assessment of Significance has been developed in accordance with s. 5A of the NSW EP & A Act. The assessment is focussed on the *E armatus* populations associated with the study area on the Murrumbidgee River where this species is widely distributed and has previously been recorded upstream and downstream of Angle Crossing (Lintermans 2002; Lintermans 2001; Lintermans 2005). There are no records of *E. armatus* within Burra Creek and as such Burra Creek has not been considered in this Assessment.

1.1 Assumptions

This Assessment is based on the assumption that the base flow of the Murrumbidgee River will be protected throughout the year and no water below the base flow will be removed. Water extraction will be limited to 100 ML/Day.. It has been stated that ACTEW will protect the minimum percentile environmental flows of the Murrumbidgee River as prescribed in the ACT Government Water Resources Environmental Flow Guidelines (2006), throughout each month of every year and no water below assumed¹ environmental flow requirements will be removed at any time. Any modifications to the water abstraction licence (if/when obtained) will require additional analysis to incorporate any impacts not addressed in this assessment.

¹ Environmental flow guidelines for the Murrumbidgee River are intended to ensure that aquatic ecosystems of the Murrumbidgee, including crayfish populations, are not compromised. Environmental flows are assumed as per the current *Licence to Take Water*, with the following exceptions:

- The environmental flow in the Murrumbidgee at the Cotter Pump Station is set to 20 ML/day in any level of water restrictions and the 80th or 90th percentile flow when water restrictions do not apply. The Licence proposes a lower flow requirement in unrestricted conditions, but it is believed that this more lenient rule may not be maintained in later Licences.
- The environmental flow in the Murrumbidgee at Angle Crossing is not specified in the Licence because Angle Crossing is not currently subject to any abstractions. The environmental flow has been modelled as the 80th percentile flow between November and May and the 90th percentile flow between June and October. No reduction is applied in drought conditions.

2 Significance assessment

Will the proposed pipeline be likely to have an adverse effect on the lifecycle of *Euastacus armatus*?

E armatus are slow growing and take six to nine years to reach sexual maturity (DSE 2003). The breeding success of this species has been shown to be highly variable and attributed to relationships with food abundance, depth, light and temperature (Potts and Todd) and as such changes to the flow regime has potential to impact upon this species within the Study Area.

The females spawn annually in late autumn (possibly in response to declining water temperatures) laying approximately 100 to 500 eggs that are carried under the tail throughout the winter and hatch in late spring to early summer. The newly hatched juveniles remain attached to the female's abdomen for another one to three months until they are of size to become independent. The timing of maturation at this life stage is thought to be largely dependent upon temperature. Once settled, individuals are relatively sedentary with home ranges seldom extending beyond one km from their original point of deposition (Gilligan et al., 2007). As such the issues that are likely to impact on the lifecycle of *E armatus* will relate to changes in temperature in response to changed flow conditions, and direct impact on the study site from construction and operation of the intake.

Abstraction of any volume of water within the Murrumbidgee River will have consequences on the aquatic ecology and habitat of the system. However, the adaptive and reactive operation of the proposed abstraction regime has been designed to ensure the optimum protection of the aquatic environment and thus greatly minimise the extent of impacts on the lifecycle of *E armatus* within the Study Area. A monitoring program will need to be instated to ensure that key threatening processes are adequately managed, namely;

- Control of sediment input downstream of the extraction point;
- Rehabilitation and maintenance of riparian vegetation affected as a result of construction and operation of the pipeline;
- The maintenance of natural flow and thermal regimes downstream of the extraction point;
- The containment of pollution that may be exacerbated as a result of increased terrestrial run-off; and
- The maintenance of free passage between upstream and downstream habitats that aligns with natural flow regimes.

The life cycle of *E armatus* has the potential to be impacted upon by changes to the thermal regimes of changed flow conditions. The analysis undertaken by ACTEW (2008) indicates the Murrumbidgee Rivers thermal regime is highly variable, and is not directly correlated with the seasons (Actew 2008). This is a result of the geomorphology of the river: being wide and shallow allowing the impacts of the weather to have a greater impact on the temperature of the water (Turner and Erskine 1997). Greater light penetration and the high surface: volume ratio allows for greater warming from the sun and cooling from winds (Actew 2008; Turner and Erskine 1997).

The Murrumbidgee River temperature regime is unlikely to be affected by the proposed works. Temperature data for Burra Creek and the Murrumbidgee River provides an indication of natural variability within the system, with the maximum and minimum temperatures occurring in different months of the year in each catchment (Actew 2008). The Murrumbidgee River peak temperatures do not always correspond to the summer months while low temperatures did not always correspond to the winter months. It is probable that lower mean temperatures experienced at Angle Crossing during spring and early summer are the result of snow melt within the catchment (Actew 2008).

The construction of the new intake water transfer pipeline at Angle Crossing on the Murrumbidgee River will result in a direct permanent impact to approximately 20 x 50 m of the Murrumbidgee River and its riparian zone directly upstream of the existing Angle Crossing. *E armatus* is endemic to Australia and has a broad distribution in Eastern Australia, which extends to the warmer lower reaches of the Murray Darling Basin (excluding the Darling River) (Morgan 1986). The species was abundant along most of the Murray River until the 1950s however since then numbers have significantly declined (Geddes 1990) and anecdotal evidence suggests distribution has declined throughout the Murrumbidgee River however, no primary data exists to verify these claims (Gilligan et al., 2007). Despite population numbers and geographic presence declining and given the localised home range of the species, the removal of an area of 20 x 50 on the Murrumbidgee is considered unlikely to have a significant impact of the lifecycle of local populations of *E armatus* such that it will place the species near extinction. It will likely impact upon the population in the study site, however the species are widespread throughout the river system and loss of this immediate community is likely to be a localised impact.

There is a risk of impingement and entrainment of individuals in the offtake. This risk will to be managed during the design and engineering of the offtake structure. The intake/LLPS would take the form of a box-in-bank structure with a side inlet and incorporate four fish egg filtration units to filter fish eggs from the water and would discharge filtered water through a dividing wall into the pump module.

In summary, the project is likely to impact upon the species lifecycle in the immediate vicinity of the offtake structure. As extraction will be limited to protect base level flows within the Murrumbidgee River¹ and modelling indicates downstream flows are unlikely to be significantly altered, the project is not likely to impart significant adverse impacts upon the lifecycle of *E armatus* that threaten the survival of the species at a state-wide level.

Will the proposed pipeline be likely to have an adverse effect on the habitat of *Euastacus armatus*?

Generally crayfish, can be found in a variety of freshwater habitats such as rivers, streams, dams, lakes and swamps. *E armatus* tend to inhabit streams containing abundant instream debris and vegetation and will burrow underground during the warmer months. This species inhabits large and small streams and waterways intersecting open cleared pastures to dry sclerophyll forests ranging from altitudes of 700m to sea level (DSE 2003). *E armatus* is commonly associated with flowing cool water habitats of temperatures below 20°C with soft banks into which they can dig burrows (Horwitz 1990, ACT Government 1999). Where soft banks are not available, the species uses the interstitial spaces between boulders and cobbles on the riverbed for shelter (ACT Government 1999).

They are principally vegetarians and are generally most active at night (nocturnal) where they spend their time foraging on the stream bed, eating water weeds and the decaying roots and leaves. The species however are opportunistic omnivores.

Flow modelling indicates minimum flows will be protected and any reduction in available flows in the downstream river system is unlikely to be significant. Riffle habitats used by *E armatus* are not expected to be significantly impacted even when the pumping is running at maximum abstraction. The flow reductions will be most significant immediately below the Angle Crossing, where the river is wide and shallow.

The proposed water abstraction from the Murrumbidgee River will remove bank and instream habitat suitable for *E armatus* within the immediate study site and downstream within the wider study area by way of changed flow conditions which will alter bank structure, stability and river bed width and composition. For example down stream areas may experience higher levels of sedimentation as a result of reduced flows which may smother bed habitat.

The water quality and hydrology of the Murrumbidgee River is not predicted to be significantly impacted 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, it is likely degradation of banks and surrounding ground vegetation would lead to an increase in soil loss and exposure which may result in increased sedimentation within the vicinity of the Angle Crossing. 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 and therefore should not be significant.

Will the proposed pipeline affect the limit of the known distribution of *Euastacus armatus*?

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

How is the proposed pipeline likely to affect the current disturbance regimes of the Murrumbidgee River?

Historically the Murrumbidgee River has been significantly modified by abstraction, diversion, road crossings and agriculture and current conditions are far from those naturally expected to occur. The study area currently experiences ongoing extraction and impediment to flow (i.e. via construction of Tantangara Dam) and abstraction for the pipeline will further reduce flow to the river. The modification of flows within the river are not predicted to cause significant impact to current disturbance regimes, however additional disturbance may be exaggerated during increased drought-like conditions.

Minor additional raised levels of background noise and vibration would be experienced during the operation of the LLPS and HLPS at Angle Crossing which may encourage the relocation of individuals impacted. The design of the LLPS and HLPS facilities will incorporate measures to minimise operational noise and vibration. It is expected any impacts of noise and vibration disturbance would be temporary, and deemed not significant in nature.

Infrequent turbid flows within the Murrumbidgee River as a result of instream construction, heavy rainfall, bushfires, flooding etc may introduce significant quantities of sediment and operational rules would need to be defined to avoid transfer of flows when turbidity in the Murrumbidgee exceeds acceptable levels, which are currently undetermined.

How is the proposed pipeline likely to affect *Euastacus armatus* habitat connectivity?

E armatus are widely distributed throughout eastern Australia and they typically favour cooler flowing streams with soft banks though are present across a range of habitat types. The reduction of flows downstream of the study site has potential to increase temperatures, reduce flow and bank habitat. This species are already exposed to a number of threats associated with stock and supply of water for domestic

and irrigation uses including habitat modification which is listed as a key threatening process under Species Action Plan No. 14 (ACT Government, 1999). The species is likely to have been severely affected by in-stream alterations on the Murrumbidgee and other river systems such as desnagging, culverts, weirs and river regulation and saltation.

Provided base level flows are protected to ensure instream habitats (interstitial spacing between rocks and boulders) are not significantly reduced habitat connectivity is unlikely to be significantly impacted. Range of adult *E armatus* are relatively small (ie generally not greater than 1km either in either direction of their territory). However, the recruitment strategy of juveniles is not clearly understood and it is likely that it is reliant on upstream or downstream migration as a mode of dispersal. Monitoring and adaptive management plans will need to be designed to protect instream habitat such that free instream passage that aligns with natural flow regimes is maintained between habitats upstream and downstream of the extraction point.

How is the proposal likely to affect critical habitat of *Euastacus armatus*?

There is a general understanding of the broader habitat requirements of this species however, there is paucity of knowledge regarding *E armatus* exploitation of micro-habitats (ACT Government, 1999). It has already been established that habitat provided by gaps between rocks within the Murrumbidgee River is critical habitat for this species (ACT Government, 1999; Lintermans 2002; Lintermans 2001; Lintermans 2005). The immediate study site is unlikely to constitute critical habitat for the species however it is unknown how far downstream the impacts of reduced flow levels will reach.

The operation of the pipeline will include the extraction of 100 ML/d which has potential to result in decreases in river level downstream of the extraction point. The extent of impact upon critical 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 critical 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.

3 Conclusion

The proposal has the potential to impact *Euastacus armatus* populations occurring in the Murrumbidgee River. Provided that best practice mitigation measures are implemented and comprehensive adaptive management particularly the preservation of low flows and monitoring is undertaken, 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 need to include:

- Turbidity controls to ensure water quality standards comply with the relevant guideline;
- Monitoring and reporting of turbidity upstream and downstream of construction locations;
- All stream bed and banks to be reinstated and revegetated with appropriate species to ensure long term bank stability;
- 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.

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