ENLARGED COTTER DAM

FISH MANAGEMENT PLAN

Version Three

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Executive Summary

The delivery of this *Fish Management Plan Version 3* coincides with the completion of the Enlarged Cotter Dam construction. It is the third in a series of Fish Manage Plan reports, prepared to inform and guide the protection of threatened aquatic species throughout the construction and operation of the Enlarged Cotter Dam (ECD).

Fish Management Plan Version 1 (2009) identified risks and knowledge gaps surrounding threatened aquatic species' responses to the construction of the Enlarged Cotter Dam; and proposed a series of nine research projects to fill these knowledge gaps.

Fish Management Plan Version 2 (2010) provided a report on the progress of the nine research projects; and how those projects were supporting the protection of threatened aquatic species throughout the construction phase of the Enlarged Cotter Dam.

This Fish Management Plan Version 3 (2014) focuses on the ongoing management of threatened aquatic species during the filling and operational phase of the enlarged Cotter Dam.

The preparation and implementation of these Fish Management Plans has been underpinned by an expert panel (Fish Management Plan Steering Committee) includes Government agencies representatives, research organisations and their representatives, ecological service providers and technical experts.

As outlined in the previous Fish Management Plan versions, the successful management of threatened aquatic species relied heavily on information gathered through a suite of research projects (as identified in FMP Version 1). These projects were implemented by ACTEW Water during the planning and construction phase of the ECD project and service providers included the University of Canberra, University of Sydney and the Australian National University along with other ecological service providers.

Key successes in the protection of threatened aquatic species include:

- **Design, siting and construction of artificial rock reef habitat** – seven kilometres of rock reef habitat was provided in the enlarged Cotter Reservoir inundation zone. The rock reefs were constructed to replace fringing macrophytes used as shelter and foraging habitat by native fish species (particularly Macquarie perch) as these macrophytes will be inundated in an enlarged reservoir. Native hardwoods have been left in situ in the inundation zone and will provide additional supplementary habitat for native fish, particularly during the filling phase. The construction of the artificial rock reef habitat was underpinned by research into habitat preferences and represents cutting edge Australian fish management and applied science.
- **Pipeline Crossing fishway construction** – the construction of a fishway at Pipeline Road Crossing, upstream of Cotter Reservoir, provides a significant ecological advantage to the threatened Macquarie perch riverine population. This fishway compliments the existing Vanity's Crossing fishway (installed by the ACT Government), and opens up a substantial area of additional spawning habitat to Macquarie perch.
- **Epizootic Haematopoietic Necrosis (EHN) Virus management** – the procedures and management actions undertaken by the Bulk Water Alliance (BWA) and ACTEW Water to prevent the spread of the EHN Virus into the Cotter catchment throughout the construction period were focussed and comprehensive. Management measures included sterilisation of the area between the two dam walls; eradication of potential carrier fish (Redfin perch) in the interim area; rigorous equipment and vehicle wash-down procedures; and thorough and ongoing educational strategies.
- **Translocation of Macquarie perch** – research into the methods for successful translocation of Macquarie perch populations into local areas was undertaken throughout the construction period and is ongoing. This research underpins both the goal to expand populations of the threatened

Macquarie perch, and provides an 'out of catchment' mitigation measure should the Cotter Reservoir population be critically compromised.

- The ECD Fish Management Program won the **ACT Water Awards** 2012 Program Innovation award.

In addition to these successes, ACTEW Water has also finalised several key documents to assist in the ongoing management of threatened aquatic species throughout the filling and operation phase of the ECD project. These include:

- **Macquarie perch Filling Phase Plan** – ACTEW Water has in place a management plan to monitor and react to the biological and water quality changes likely to occur as the enlarged reservoir fills. The plan includes new online water quality infrastructure alerting staff mobile phones to water quality conditions and fully scoped management responses triggered by poor water quality conditions should they arise.
- **Alien Fish Management Plan** - With Rainbow trout and Brown trout numbers expected to rise in tandem with native fish numbers as the enlarged Cotter Reservoir fills, it was necessary for ACTEW Water to develop an Alien Fish Management Plan. This plan involves using monitoring data to inform trigger levels for the mitigation of alien fish impacts on threatened fish species. Specific management measures are still at the options analysis stage, with the comprehensive analyses and stakeholder engagement forming part of the 2014/15 FMP works package.
- **ECD Fish Monitoring Program** – ACTEW Water has recently finalised the first phase of fish monitoring baseline data collection. The program has delivered data on the Macquarie perch, and Two-spined blackfish in the Cotter Reservoir and upstream river reach. It has also reported on alien fish abundance and distribution and recorded cormorant numbers and movements in around the Cotter Reservoir. This monitoring program is ongoing and is being delivered by the University of Canberra. The data from the program is essential for the successful management of the enlarged Cotter Reservoir.
- **EHN Virus Management and Response Plan** – EHN Virus contamination of the Cotter Reservoir due to ECD construction activities was successfully avoided. ACTEW Water has developed an ongoing management plan to ensure ACTEW Water staff and contractors continue to be vigilant and avoid the contamination of the reservoir with EHN Virus or any biological carrier. This will occur through a range of education tools and policy formulation contained within the EHN Virus Management and Response Plan.

The protection of threatened aquatic species in the Cotter Reservoir from impacts arising from ACTEW Water activities is a priority. ACTEW Water would like to thank the ECD Fish Management Steering Committee and all Government agencies, research organisations, ecological service providers and individuals that have assisted in ensuring ACTEW Water meets its fish management and environmental protection objectives.

1 Introduction and Background

1.1 Structure of this report

The delivery of this *Fish Management Plan Version 3* coincides with the completion of the Enlarged Cotter Dam construction. It is the third in a series of Fish Manage Plan reports, prepared to inform and guide the protection of threatened aquatic species throughout the construction and operation of the Enlarged Cotter Dam (ECD).

Fish Management Plan Version 1 (2009) identified risks and knowledge gaps surrounding threatened aquatic species' responses to the construction of the Enlarged Cotter Dam; and proposed a series of nine research projects to fill these knowledge gaps.

Fish Management Plan Version 2 (2010) provided a report on the progress of the nine research projects; and how those projects were supporting the protection of threatened aquatic species throughout the construction phase of the Enlarged Cotter Dam.

This Fish Management Plan Version 3 (2014) focuses on the ongoing management of threatened aquatic species during the filling and operational phase of the enlarged Cotter Dam.

The preparation and implementation of these Fish Management Plans has been underpinned by an expert panel (Fish Management Plan Steering Committee) includes Government agencies representatives, research organisations and their representatives, ecological service providers and technical experts.

This report has four sections:

- Introduction and Background – provides an overview of the ECD project and associated Fish Management Plan
- Compliance with Conditions of Approval – provides details of ACTEW Water's compliance with the Commonwealth Department of Environment (DoE) and the ACT Government's Planning and Land Authority (ACTPLA) conditions of approval.
- FMP projects and ACTEW Water mitigation measures – this section describes the findings of the research projects undertaken as part of the ECD FMP and describes how these have informed ACTEW Water's management and mitigation measures.
- Protection of threatened species during filling and operation – this section includes the revised risk assessment which was undertaken to identify threats, from ACTEW Water's activities, to threatened aquatic species during the filling and operational phase of the ECD project. The section also describes ACTEW Water management measures to meet the FMP Steering Committee's agreed objective for Version 3 of the Fish Management Plan which is:

  "To ensure that the filling and operation of the Enlarged Cotter Reservoir does not compromise the maintenance and rehabilitation of native fish and crayfish species."

1.2 Enlarged Cotter Dam project description

The Enlarged Cotter Dam is one in a suite of major projects undertaken by ACTEW Water to secure the future water supply for the ACT and region. These projects have been delivered through the Bulk Water Alliance (BWA), a partnership between ACTEW Water and ActewAGL, GHD, Abigroup and John Holland Group.

1.2.1 Location

The Enlarged Cotter Dam has been constructed approximately 125 metres (m) downstream of the old Cotter Dam on the Cotter River, approximately 18 kilometres (km) due west of Canberra (Figure 1). The Enlarged Cotter Dam is located upstream of the confluence of the Cotter, Paddy's and Murrumbidgee Rivers and is in the vicinity of a range of recreational areas including Cotter Avenue, Cotter Campground and Casuarina Sands.

1.2.2 Construction method

The main dam was constructed from roller compacted concrete with two additional earth rock-fill saddle dams constructed adjacent to the right abutment of the main dam. The main dam is approximately 80 metres high with the saddle dams approximately 12 and 16 metres in height. Construction has increased the storage capacity of the reservoir from four gigalitres (GL) to approximately 78 GL, raising ACT's overall storage capacity by a third.

1.2.3 Filling of the enlarged reservoir

Modelling undertaken to inform environmental approvals has indicated that the likely timeframe for filling of the enlarged Cotter Reservoir will be between two to six years depending on rainfall.

Figure 1 - Location of the Enlarged Cotter Dam

1.2.4 Planned operating regime for the enlarged Cotter Reservoir

ACTEW Water currently extracts water for potable supply from the Cotter River (Cotter, Bendora and Corin Reservoirs), the Googong Reservoir on the Queanbeyan River and from the Upper Murrumbidgee River by pumping to the Cotter Pump Station. Extraction rules for each of these rivers are regulated by the ACT Government (and to a lesser extent the Commonwealth Government) and are based on environmental flows and water quality.

Once filled, the enlarged Cotter Reservoir will become an 'active' reservoir with fluctuating water levels, more frequent abstraction of water and a greater capacity to capture additional inflows from the upper Cotter River.

Modelling of the proposed operating regime indicates that the water level in the enlarged Cotter Reservoir will remain within three metres of full supply level (FSL) for approximately 73 per cent of the time, within five metres of FSL for approximately 90 per cent of the time and within 13 metres of FSL for approximately 98 per cent of the time (refer to Figure 2). It is important to note that the time spent at various levels is weather dependent.

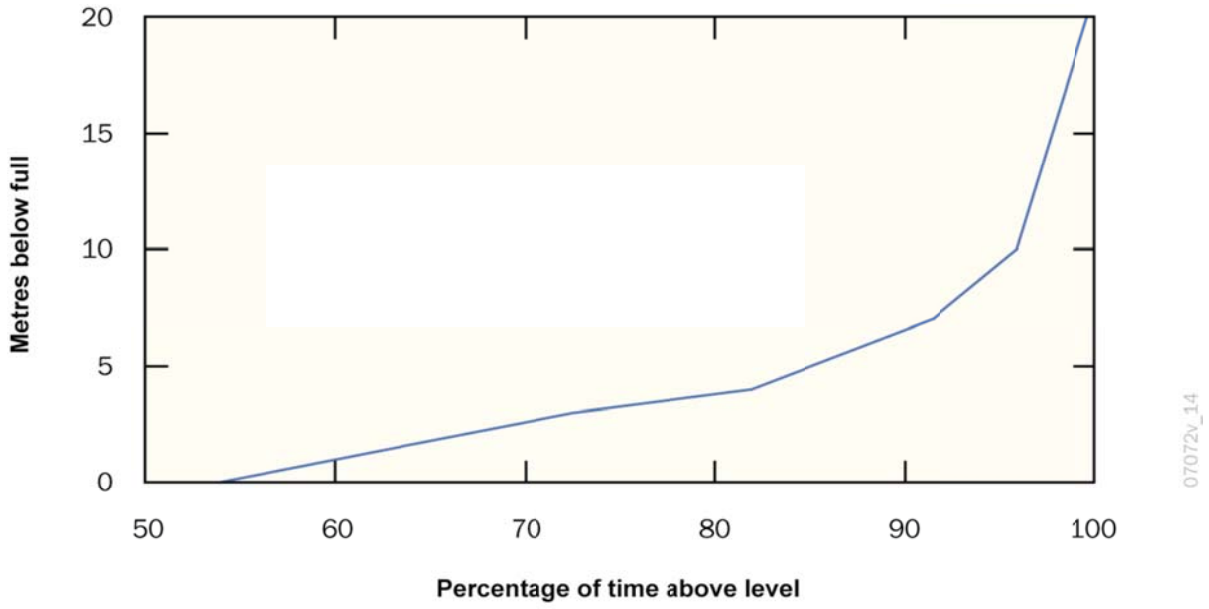


Figure 2 - Cumulative %age of time ECD water level will spend at various levels below FSL

1.2.5 Planned operating regime for ACT storages

With the Enlarged Cotter Dam complete, ACT storages will be operated in accordance with new operating rules developed using a detailed system model to maximise water supply performance and meet environmental objectives, including minimising harm to threatened aquatic species. These rules are yet to be finalised and will require endorsement by ACTEW Water before they are adopted. The operating rules are likely to be reviewed by ACTEW Water up to and after the date that the Enlarged Cotter Dam is operational as new information becomes available. This review may highlight necessary changes to the operation of the water supply systems, independent of the impacts of the Enlarged Cotter Dam. The new operating rules will also need to meet the requirements of the ACT Environment Protection Authority (ACT EPA), who issue ACTEW Water a licence under the ACT *Water Resources Act 2007*. The predicted changes in the operation of Cotter River storages as a result of the Enlarged Cotter Dam are shown in Figure 3. It is not anticipated that the operating regime for Bendora or Corin Reservoirs will change significantly from the current situation. Further, the decisions made as per Figure 3 must be made against the requirements of the environmental flow requirements required in the Cotter, Murrumbidgee and Googong systems.

Water releases from all reservoirs will be sourced from multi-level off-take towers to allow control of temperature (through regular active in situ measurements) to minimise potential impacts of cold water pollution.

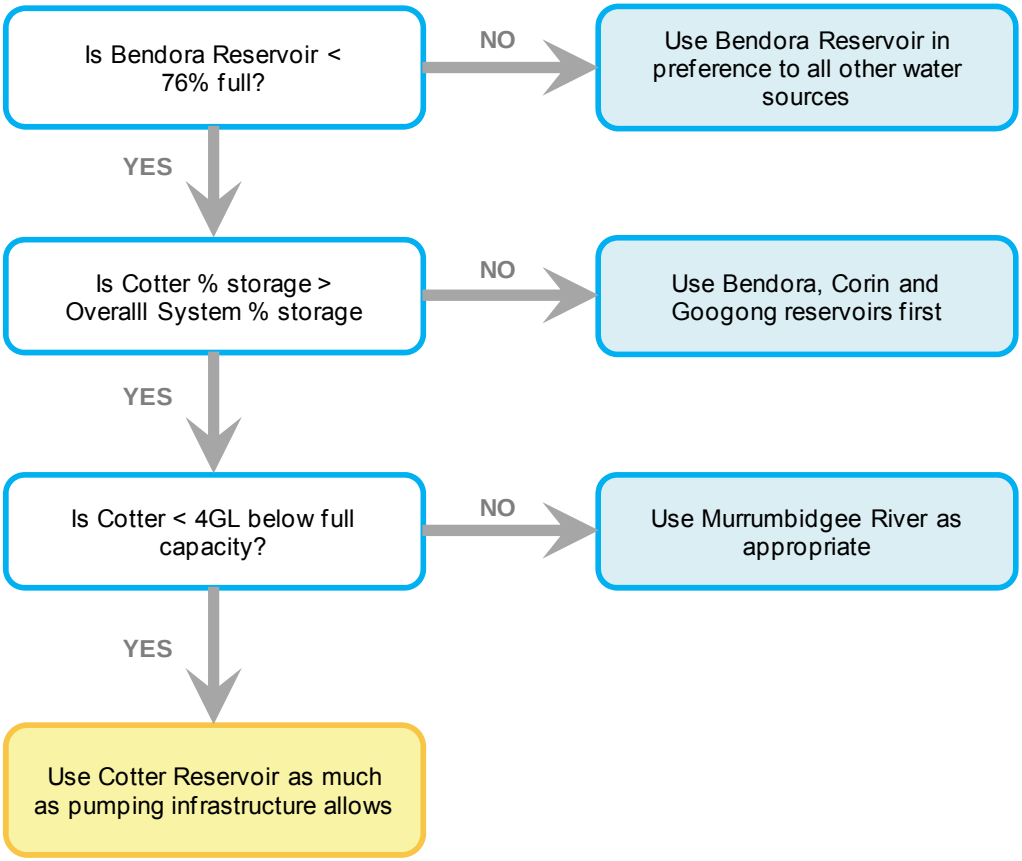


Figure 3 - Proposed operating rules for ACT storages with the Enlarged Cotter Dam

1.3 Fish Management Plan

The construction and operation of the Enlarged Cotter Dam raises concerns relating to the management of five threatened native aquatic species. These are:

- Macquarie perch (*Macquaria australasica*)
- Trout Cod (*Maccullochella macquariensis*)
- Murray Cod (*Maccullochella peelii*)
- Two-spined Blackfish *(Gadopsis bispinosus)*
- Murray River Crayfish *(Euastacus armatus)*.

This Fish Management Plan (Version 3) is the third in a series of four reports designed to provide information to guide the protection of aquatic communities in the Cotter Reservoir and the Cotter River during the construction and operation of the enlarged Cotter Reservoir. Each of the four reports focuses on protection of the species during different key program milestones for the Enlarged Cotter Dam, as detailed in Table 1.

The Fish Management Plan reports form part of the Territory and Commonwealth conditions of approval for the Enlarged Cotter Dam and must be prepared in accordance with legislative requirements. The Fish Management Plan also presents relevant information from a range of other key sources including related studies into aquatic species and their habitats.

Table 1- Updating the Fish Management Plan

Fish Management Plan Version	Key project milestones	Information sources	Fish Management Program milestones	Expected Due Date
1	EIS Submitted.	Current knowledge.	Identify projects to address knowledge gaps.	Feb 2009
2	Construction period.	• Progress reports for Fish Management Program projects. • Reports for Fish Management Program projects were available. • The Aquatic Flora and Fauna Management Plan. • Associated projects by others. • Input from regulators.	• Establish a Fish Management Program Steering Committee. • Implement all projects identified in Fish Management Plan Version 1. • Use information from Project 1 – Constructed homes for threatened fishes to inform design for constructed shelter habitats. • Lodgement of DA for installation of constructed habitats.	April 2010
3	Filling and operational phase.	• Results from Fish Management Program projects. • Results from ongoing monitoring. • Input from regulators. • Documented performance against conditions of approval.	• Complete installation of rock reef habitat • Complete Phase 1 of ECD Fish Monitoring Program • Install fish passageway at Pipeline Road Crossing. • Continue to implement/ finalise projects identified in FMP V1 • Revise ECD FMP Risk Assessment for filling and operational phase • Ongoing involvement of FMP Steering Committee	End 2013
4	Two years after Enlarged Cotter Dam construction completion. Operational phase.	• Results from ongoing monitoring. • Input from regulators.	To be determined with Fish Management Program Steering Committee	End 2015

1.3.1 Objectives

The overarching objective of the Fish Management Plan is to:

> *Ensure that the aquatic communities and habitats of the Cotter Reservoir and Cotter River are maintained or rehabilitated to support native fish and crayfish species.*

This objective was developed within the context of the *ACT Aquatic Species and Riparian Zone Conservation Strategy* (ACT Government 2007).

Version 3 of the Fish Management Plan (this report) focuses on the protection of threatened aquatic species during filling and operation of the ECD project. The FMP Steering Committee's agreed objective for Version 3 of the Fish Management Plan is:

> ***"To ensure that the filling and operation of the Enlarged Cotter Reservoir does not compromise the maintenance and rehabilitation of native fish and crayfish species."***

The Fish Management Plans are:

- Designed to prevent or mitigate risks to threatened aquatic fauna and their habitats.
- Scientifically based, using adaptive management.
- Robust in terms of stakeholder involvement, peer review and public transparency.
- Timely and updated on the basis specified in the approval conditions.
- Developed as part of the overall requirements of the Enlarged Cotter Dam.
- Effective in terms of use of resources and expertise whilst at the same time ensuring the protection of threatened species.

This plan includes trigger levels and associated management actions for the protection of threatened aquatic species.

1.3.2 Process for update

The Fish Management Plan is designed to be an iterative document which reflects a growing body of knowledge on threatened aquatic species and includes measures to minimise the potential impact which the construction and operation of the Enlarged Cotter Dam might have on these species and their habitats.

Version 1 of the Fish Management Plan established a basis for the nine research projects by identifying key knowledge gaps. Version 1 of the Fish Management Plan was included as an appendix to the ACT EIS and the Commonwealth referral documentation prepared for the Enlarged Cotter Dam project.

Version 2 of the Plan provided an update on each of the nine research projects, including any updated findings that have been provided since Version 1 was produced in February 2009. Version 2 played a key role in gaining the confidence of regulators that appropriate management and mitigation measures had been devised and ACTEW Water and the BWA were committed to enacting them. Version 2 was completed in September 2010.

Version 3 of the Plan (this report) provides further update on research projects, as well as the findings of additional fish related studies undertaken during the construction of the Enlarged Cotter Dam. It also outlines ACTEW Water's management and mitigation measures for the filling and operation phase of the ECD Project.

Version 4 of the Plan will be completed by ACTEW Water two years after completion of construction of the Enlarged Cotter Dam.

2 Compliance with conditions of approval

Approval for the construction of the Enlarged Cotter Dam was required under the Territory *Planning and Development Act 2007* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Territory matters were assessed by the ACT Planning and Land Authority (ACTPLA) through ACTEW Water's preparation of an Environmental Impact Statement (EIS) and a Development Application (DA). Commonwealth matters were assessed by the Commonwealth Department of the Environment (DoE), formerly the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) and prior to that the Department of the Environment, Water, Heritage and the Arts (DEWHA) through ACTEW Water's preparation of a Public Environment Report (PER).

Approval of the Enlarged Cotter Dam project has been conditioned by both ACTPLA and DoE. Conditions of approval relevant to the Fish Management Plan and the management of threatened aquatic species are presented in sections 2.1.1 and 2.1.2.

The full *Audit of Requirements of Conditions of Approval* prepared by Vantage Environmental Management (independent auditor) is available at Appendix A.

2.1 ACTPLA conditions of approval

Table 2 summarises the conditions of approval relevant to the management of aquatic species, as detailed in the notice of decision issued by the ACT Minister for Planning on 16 September 2009.

Table 2 - ACTPLA conditions of approval

Obligation Title	Condition	Status/ Comment
Part A: Administrative conditions		
	A3. That prior to the commencement of construction works on site, the applicant/lessee shall nominate an independent person who will be approved by ACTPLA to audit and ensure that all conditions of approval set out in the decision by ACTPLA, under the EPBC Act are fully completed in accordance with condition A4 with this decision.	**Condition met.** Vantage Environmental Management has been nominated by ACTEW and endorsed by ACTPLA as the independent person, as per correspondence 7 June 2011.
Audit of requirements of conditions of approval	A4. That prior to the completion of work, the applicant/Lessee shall submit a report prepared and endorsed by the person identified under Condition A3 of this decision to provide demonstrated evidence that the mitigation measures set out in this decision and the decision made under the EPBC Act have been fully completed to the satisfaction of ACTPLA and the Department of the Environment Water, Heritage and the Arts (DEWHA).	**Condition met.** A report has been prepared by the independent person appointed in accordance with Condition A3 using inputs from the Fish Management Program team. The report meets the conditions of A4 and A5 and can be found in Appendix A.
	A5. That prior to the completion of work, the applicant/Lessee shall submit a report prepared and endorsed by the person	

Obligation Title	Condition	Status/ Comment
	identified under Condition A3 of this decision to provide demonstrated evidence that the Commitments set out in the Environmental Impact Statement accepted by the Minister for Planning on 18 June 2009 have been fully completed to the satisfaction of ACTPLA and to the satisfaction of DEWHA.	
Part B: Prior to construction of works on site		
Map of areas of Environmental Significance	B15. A map that identifies areas of environmental significance, including areas identified for rehabilitation, offsets and for special consideration such as artificial fish habitat and research areas and endorsed by PCL, TAMS shall be submitted to and approved by ACTPLA prior to the commencement of construction works on site.	**Condition met.** ACT Government's PCL, TAMS approved the areas of environmental significance on 22 October 2009. Endorsement that this condition was satisfied was received and documented in ACTPLA correspondence 07 June 2011.
Part C: Prior to the construction of the main dam		
Fish Management Plan, Aquatic studies and results	C2. A Fish Management Plan and other aquatic ecology studies and their results and recommendations as required shall be submitted to and endorsed by PCL, TAMS and the Department of Environment, Water, Heritage and the Arts (DEWHA) (now DoE) prior to the commencement of the main dam.	**Condition met - ongoing.** FMP versions 1 and 2 and other aquatic ecology studies were submitted to relevant agencies as required via the Fish Management Program Steering Committee (FMP SC) prior to the commencement of the main dam.
	C3. That the results of condition C2. Fish Management Plan, Aquatic studies and results are implemented as required to the satisfaction of PCL, TAMS and DEWHA (now DoE).	**Condition met.** The results from FMP and aquatic ecology studies have been implemented as required following consultation with the FMP SC.

2.2 Commonwealth conditions of approval

Table 3 summarises the conditions of approval relevant to the management of aquatic species, as detailed in the notice of decision issued by the Commonwealth Minister for the Environment, Heritage and the Arts (now DoE) on 21 October 2009.

Table 3 - Commonwealth conditions of approval

Obligation	Condition	Status/ Comment
Environmental Flows		
	The person taking the action must operate the Enlarged Cotter Dam in accordance with the environmental flow requirements specified in the Environmental Flow Guidelines 2006 and the Water Resources Act 2007 (ACT) except for the prescriptive flow rates that are specified under other conditions in this approval.	**Condition met.** Condition being met as per ACT EPA Licence WU67.
Downstream Flows		
During construction and filling of the expanded Cotter Dam the person taking the action must:	a) release a minimum of 34 megalitres (ML) of water per day into the Cotter River below the dam wall (calculated over a 12month period);	**Condition met - ongoing.** Flows are released in accordance with this condition through a combination or Murrumbidgee To Cotter flows and releases from Cotter Reservoir.
	b) publish monthly reports presenting the amount of water released from the Cotter Dam;	**Condition being met.** Reports on the volume of water released into the Cotter River are published monthly on the ACTEW Water website.
	c) undertake monitoring of baseline indicators of ecological health in the Cotter River below the dam wall and the Murrumbidgee River below the junction with the Cotter River.	**Condition being met.** The Murrumbidgee Ecological Monitoring Program (MEMP), Below Dams Monitoring Program and ACTEW Water's Lower Molonglo macroinvertebrate monitoring program are in place and meet this condition.
	d) notwithstanding the requirement under paragraph 2a., the person taking the action must provide a plan to increase the long term flows of the Cotter River for the approval of the Minister within 4 years of the date of this approval. The plan must provide for increases in the minimum flow regime under paragraph 2 a. to improve the ecological health of the Cotter river below the dam wall, and the Murrumbidgee River	**Condition to be met.** ACTEW Water provided a plan to the Commonwealth to meet this condition in October 2013.

Obligation	Condition	Status/ Comment
	below the Junction with the Cotter River.	
	e) Provide an annual report, demonstrating how the person taking action has been releasing downstream flows in accordance with the advice of Environment Flows Technical Advisory Group established by the ACT Environment Protection Authority to determine environmental flows.	**Condition met.** Annual reports detailing environmental releases have been published on the ACTEW Water website.
	The plan approved under 2 d must be implemented.	**Condition to be met** following Commonwealth Government approval of the plan.
	All plans, reports and data required under 2b, 2c 2d and 2e must be published on the ACTEW website within 1 month of finalisation.	**Condition met - ongoing.**
Fish Management Plan		
	Within 6 months of commencement of construction of the Enlarged Cotter Dam, the person taking the action must prepare and submit to the Minister for approval, a Fish Management Plan.	**Condition met.** Fish Management Plan (FMP) Version 2 was submitted to the Commonwealth within agreed timeframes.
	The person taking the action must consult with the ACT Government (Territory and Municipal Services) during the preparation and any future updating the Plan.	**Condition met.** ACTEW Water has maintained an ongoing dialogue with ACT and Commonwealth Governments through the Fish Management Program Steering Committee. The preparation of this, and future, Fish Management Plans will be undertaken in consultation with relevant Government agencies.
The Fish Management Plan must include the following:		
Ongoing management measures	a) Baseline information on the population of Macquarie Perch in the Cotter River catchment including estimates of population size, distribution and seasonal variation;	**Condition met.** The collection of baseline data forms part of the ECD Fish Monitoring Program. The Baseline Data Report is at Appendix B.
	b) A monitoring program with the ability to detect at a statistical power of 0.8 or greater, any environmental harm to the Macquarie Perch population in the Cotter River catchment.	**Condition met.** See ECD Fish Monitoring Program Appendix C.
	c) Identification of thresholds for management intervention in relation to all	**Condition met.**

Obligation	Condition	Status/ Comment
	measures implemented to manage and maintain a viable Macquarie perch population in the Cotter River catchment.	Thresholds for management intervention have been developed as part of the Macquarie Perch Filling Phase Plan, which is included in Appendix D of this report. Thresholds for management interventions will be reviewed as part of FMP V4.
	d) Identification and removal and monitoring of movement barriers for the Macquarie perch between the enlarged Cotter Dam and Bendora Dam.	**Condition being met.** A range of investigations have been undertaken to identify barriers to fish passage in the Cotter River. The priority reach investigation has been completed; above the priority reach to Bendora is still underway. Pipeline Road Crossing has been remediated with a fishway installed to allow fish passage. In addition, a risk assessment will be held at the beginning of each spawning season to identify management measures, including consideration of timed environmental flow releases, to facilitate regular successful spawning.
	e) Collection of information to describe the swimming ability of the Macquarie perch to inform the management of water levels between Bendora Dam and Cotter Dam.	**Condition met.** Research of the swimming capacity of Macquarie perch was completed in 2010; main findings are presented in Section 3.2 of this report.
	f) Identification, construction and monitoring of artificial Macquarie perch habitat in the enlarged Cotter Dam.	**Condition met.** Rock reef habitat has been constructed and endorsed by the Fish Management Program Steering Committee. Monitoring of the Macquarie perch population is being undertaken as part of ECD Fish Monitoring Program.
	g) Identification and implementation of design features, management measures and operating controls to prevent adverse impacts on the Macquarie perch population in the enlarged Cotter Dam.	**Condition met.** The dam and associated infrastructure has been designed and will be operated in a way which prevents adverse impacts on the Macquarie perch.
	h) Design, implementation and monitoring of a predator control program to protect the Macquarie perch population in the enlarged Cotter Dam.	**Condition met.** A Cormorant Management Plan has been developed by University of Canberra (endorsed by Fish Management Program Steering Committee) and will be enacted in the event that management thresholds are

Obligation	Condition	Status/ Comment
		triggered.
Construction Management Measures	a) Identification and implementation of measures to sterilise the area between the existing Cotter Dam wall and the enlarged Cotter Dam from all aquatic fauna or pathogens that would adversely impact the Macquarie Perch;	**Condition met.** Sterilisation of the area between the old and enlarged dams has been completed. Procedures were endorsed by the Fish Management Program Steering Committee in March 2011. A report detailing sterilisation measures is at Appendix E.
	b) Monitoring of the Cotter River catchment for the presence of EHN virus and the development of a response plan in the event the EHN Virus is detected;	**Condition met.** Monitoring for the EHN virus, through the presence of the known vector Redfin perch, will be conducted in the Cotter River catchment as part of the ECD Fish Monitoring Program. A response plan has been prepared and is at Appendix F.
	c) Develop and implement measures to avoid chemical spills and sedimentation impacting on water quality of the Cotter River and downstream during construction of the enlarged Cotter Dam	**Condition met.** The Construction Environmental Management Plan and Erosion and Sediment Control Plan protected water quality and the surrounding environment through the construction of the enlarged Cotter Dam.
Translocation program	a) Identification of suitable recipient sites in the ACT regions for the translocation Macquarie Perch;	**Conditions met.** The implementation the University of Canberra translocation project has identified suitable methods and recipient sites for the translocation of Macquarie perch. Results are presented in Section 3.5. The monitoring of translocated Macquarie Perch populations is ongoing.
	b) Development and implementation of suitable methods to translocate Macquarie Perch;	
	c) A monitoring program for translocated populations lasting a minimum of 20 years which includes a review at 5 years following commencement.	
Funding and Responsibilities	a) Details of funding arrangements and parties responsible for the implementation of all aspects of the Fish Management Plan.	**Condition met.** ACTEW Water is responsible for all the funding and implementation aspects of the ECD Fish Management Plan. This is the relevant funding and responsibility information referred to in Vantage Environmental Management (2013) Appendix B.
Performance against Fish Management plan annual report	The person taking the action must implement the plan. Every year the person taking the action must submit to the minister a report covering performance against the	**Condition not met (timeframe only).** The Performance Report was delivered to the Commonwealth on 18 February 2014 (due 19 January 2014). The delay on the delivery

Obligation	Condition	Status/ Comment
	Fish Management Plan. The date of the first report covering performance is to be provided on 19 January 2011, with each subsequent report to be provided 12 months from the date of the previous report.	arose primarily from the time required by ACTEW to appropriately consider and address comments from ACT Government representatives regarding the Macquarie Perch Barrier project, reported in this FMP V3. The Commonwealth was not advised of this delay due to an administrative error. Corrective actions have been established and reported to the Commonwealth.
Publication Requirements		
	Management plans, reports, systems and programs (however described) referred to in these conditions of approval must be made publicly available on the ACTEW Corporation website as determined by the Minister.	**Condition met - ongoing.** All relevant documentation identified in these conditions of approval is available on the ACTEW Water website.
Record Keeping		
	The person taking the action must maintain accurate records of activities associated with or relevant to the above conditions of approval, and make them available on request by the Department. Such documents may be subjected to audits by the Department and used to verify compliance with conditions of approval.	**Condition met - ongoing.** Records have been maintained throughout construction using an accepted compliance tracking system endorsed by the Fish Management Program Steering Committee. ACTEW Water will continue to maintain records once the Enlarged Cotter Dam becomes operational.

3 Fish Management Plan projects and related management measures

In the initial stages of the Enlarged Cotter Dam project nine research and monitoring projects were identified for implementation as part of the Fish Management Program. These projects were to fill knowledge gaps required to mitigate and manage impacts on threatened aquatic species in the Cotter River system and to inform management and mitigation measures for the Enlarged Cotter Dam project.

The nine projects involved scientists and researchers from the University of Canberra, the Australian National University, University of Sydney and Griffith University. The following sections summarise the projects and their relevance to mitigating impacts from the ECD project.

3.1 Project 1 – Constructed homes for threatened fish in the Cotter River Catchment

Enlargement of the Cotter Reservoir will inundate fringing macrophtye beds used by threatened fish as shelter habitat. This project examined the movements and habitat preferences of threatened fish to guide the provision of replacement artificial shelter habitat in an enlarged Cotter Reservoir.

The *Constructed Homes for Threatened Fish* project commenced in late 2007, with Phase 1 delivering a literature review and subsequent installation of experimental constructed habitats. The experimental habitats were PVC pipes, PVC pipes with grills and rock reefs.

The aims of Phase 2 of the project were to:

1. Determine if adult Macquarie perch will use constructed habitat for shelter in Cotter Reservoir when emergent fringing reed beds are not available.
2. Test which constructed habitat is preferred for daytime refuge by adult Macquarie perch
3. Determine whether Two-spined blackfish breed in reservoir environments, with a view to assisting in their colonising the ECD after its expansion.
4. Provide guidelines for construction of long-term habitat to sustain threatened fishes while enabling the maximum flexibility for water harvesting from an enlarged Cotter Reservoir during construction and thereafter.
5. To showcase the achievement of ecological sustainability in the construction and management of reservoirs.

To achieve the aims of Phase 2 of the project, a series of field-based studies were undertaken in the Cotter River Catchment to determine:

- Adult Macquarie perch movement and use of constructed habitats
- Adult Macquarie perch spawning migrations
- Two-spined blackfish movement and spawning in a reservoir.

Key findings of study of Adult Macquarie perch movement and use of constructed habitats:
Across four seasons Macquarie perch exhibited an average diel range (length of shoreline used in 24hrs) of 389 ± 46 m, average diel mobility (total distance moved in 24hrs) of 769 ± 93 m and occupied an average diel area (total area used in 24hrs) of 24008 ± 5595 m^2. Movements were greatest in winter for all metrics (range, mobility and area used) relative to the remaining three seasons and were not correlated with fish size. Macquarie perch inhabited deeper water in summer across the diel cycle (average = 7.2 ± 0.5m) in comparison to other seasons (spring: 3.8 ± 0.3 m, autumn: 3.0 ± 0.2 m, winter: 3.0 ± 0.3 m) and were most active around sunrise and sunset according to both remote and manual telemetry results.

Remote radio-telemetry revealed that adult Macquarie perch preferentially use constructed structure over no structure, but that preference for the structure type varied seasonally and was confounded by site and individual fish effects. Remote underwater video surveillance also revealed that adult Macquarie perch used all types of artificial reefs, but that rock reef was preferred. Underwater video also revealed that small size classes of Macquarie perch were using the rock reefs for both cover and feeding. From this study the University of Canberra concluded that Macquarie perch would use constructed habitat, and that rock reef habitat would be the habitat of choice.

Key findings of study of Adult Macquarie perch spawning migrations

The number of daily detections and the number of individuals detected coincided with rises in stream temperature over about 13ºC and elevated base-flow. Body size influenced start and finish dates of migrations, with larger fish commencing and ending migrations before smaller adults. Diel patterns in fish detection were also observed with a peak occurring around dusk, and to a lesser extent dawn. Short detection periods and frequent revisitation of the inflow zone supports earlier findings of Macquarie perch spawning in the first few riffles (1–2 km) upstream of Cotter Reservoir.

Key findings of study of Two-spined blackfish behaviour in a reservoir

Tracking revealed Two-spined blackfish are strictly nocturnal and exhibit home-shelter fidelity. Diurnal home-range estimates of Two-spined blackfish (16 m and 36 m) from manual and remote tracking respectively were much smaller than estimates encompassing both day and night time movements, from manual tracking (208 m) and remote telemetry (237 m). Rock and fallen timber, as well as fringing reed beds were used as home-shelter habitats. Two daily movement strategies were observed: daily migrations from home-shelter habitats to fringing reed beds and open water (the most common strategy), and the other, remaining within a restricted area, generally in fringing reed beds, over complete diel cycles. Two-spined blackfish undertook longest movements between 1800 and 2100 hrs and 0300 and 0600 hrs, though remote telemetry revealed that activity continued through the night. Four individuals also exhibited home-range shifts, though these were rare (n = 4).

A snorkelling survey for young of the year (< 35 mm) Two-spined blackfish was also undertaken at the most downstream end of the reservoir. Six young-of-year Two-spined blackfish were observed along a 150 m transect indicating that spawning had likely taken place in the reservoir.

Further details of this study are available in Version 2 of the Enlarged Cotter Dam Fish Management Plan (ACTEW 2010) and Constructed homes for threatened fishes in the Cotter River catchment: Phase 2 Final Report (Lintermans et al. 2010).

3.1.1 Implications for the management of threatened aquatic species

The findings from the Constructed Homes project have been used to guide the provision of replacement shelter habitat in the Cotter Reservoir, specifically:

- The project informed the design and installation of rock reef habitats to replace fringing macrophyte habitat which will be inundated by the enlarged reservoir. Without the construction of this substitute rock reef habitat the Macquarie perch would not have adequate shelter habitat to mitigate the potential impacts of increased predation from cormorants.
- The retention of the majority of timber and woody debris within the inundation zone as a form of supplementary habitat for Macquarie perch and other aquatic species, particularly during the filling phase.

Design and installation of constructed fish habitats

Rock reefs have been constructed in accordance with the following design criteria:

- Located within 5 to 28 metres below the FSL of the enlarged reservoir to provide shelter habitat for Macquarie Perch for 98 per cent of the time (refer to Section 2.1.4).
- Positioned close to the shoreline, running along and across various contours to provide shelter across a range of reservoir depths.
- Constructed from good quality, large rocks, ideally one metre in diameter to provide sufficient interstitial spaces and to resist fracture during transport, stockpiling and placement.
- Rock material to contain no or minimal fines and small rocks as these waste materials may fill the interstitial spaces, reducing the usefulness of the reef as shelter habitat for fish.
- Reefs to provide interstitial spaces (void size) between approximately 0.15 to 0.25 metres wide to allow access to adult Macquarie Perch.
- Erosion and sediment control measures and landscape rehabilitation will be undertaken to minimise sediment accumulation in interstitial spaces and transfer of sediment to watercourses.

Plate 1 - Construction of rock reef habitat on Gully Road

Peer review of provision of shelter habitat

Upon construction completion the provision of rock reef shelter habitat was reviewed by expert panel to determine whether the works undertaken by ACTEW Water were fit for purpose.

The review determined that:

- The 7km of rock reef habitat provided is more than adequate to sustain the current Macquarie perch population.
- The vegetation left in the inundation zone provides significant additional habitat beyond what is required for the current population of Macquarie perch.
- Rock reefs are enhancing the ecosystem in the ECD and in combination with inundated vegetation have the potential to sustain an increased population of Macquarie perch.

- The Fish Management Program Steering Committee acknowledged that provision of rock reef habitat was completed in November 2012.

Plates 2, 3 and 4 are aerial photographs of the constructed rock reef habitat located at Kiosk Road North, Priors Road and Kiosk Road East respectively. Figure 4 shows the final location of the artificial rock reef habitat in the enlarged Cotter Reservoir inundation zone.

Plate 2 - View of rock reefs constructed on Kiosk Road North

Plate 3 - View of rock reefs constructed on Priors Road

Plate 4 - Completed Kiosk Road East Fish Rock Reef

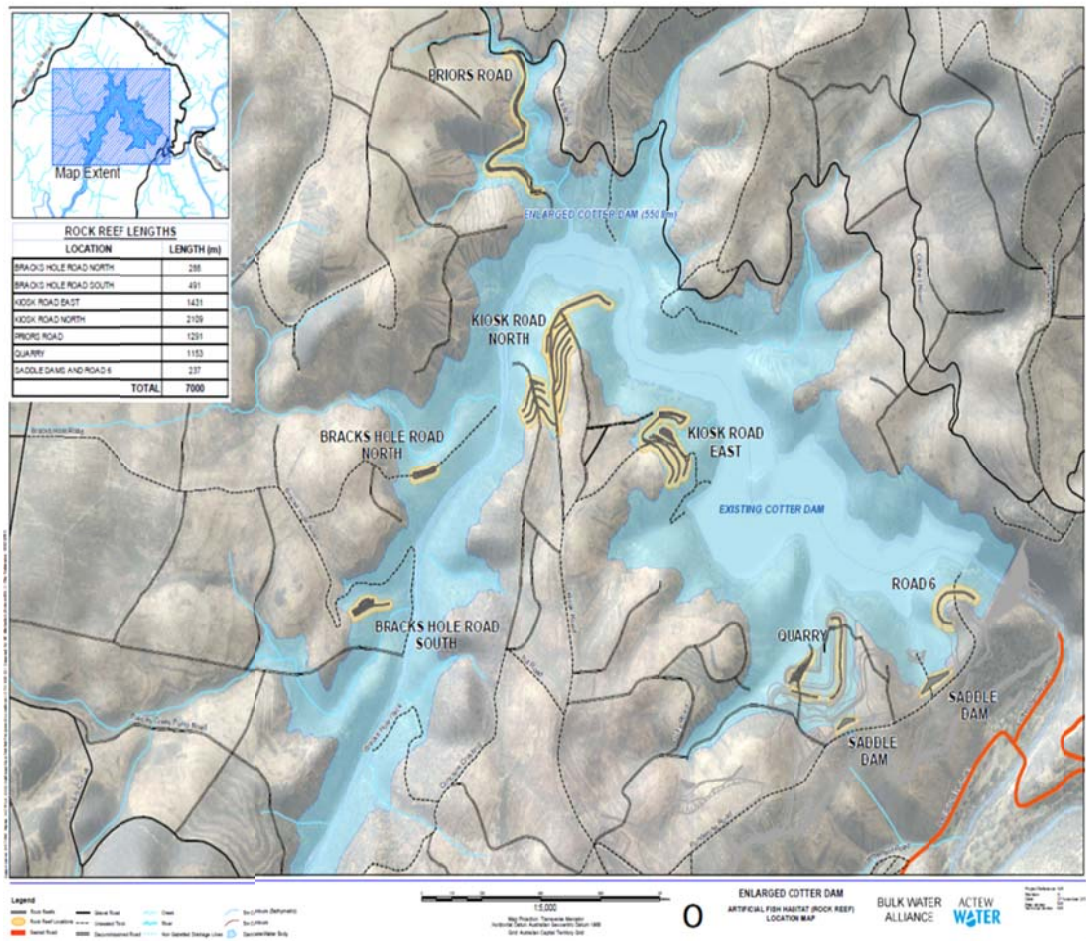


Figure 4 - Location of artificial rock reefs within ECD inundation zone

3.2 Project 2 - Predicted passage of native and alien fish based on swimming speed performance

The upstream migration of Macquarie perch is necessary to reach alternative suitable spawning habitat, given existing spawning habitat will be inundated by the enlarged Cotter Reservoir. In order to reach spawning habitat the fish must be able to overcome instream barriers in the Cotter River. To facilitate the identification and remediation of potential barriers and provide an overview of fish passage in the Cotter River, an understanding of the swimming capacity of Macquarie perch and other alien fish species was required.

The objectives of Project 2 were to:

- Assess the swimming speed performance of various size classes of Macquarie perch across a range of environmental temperatures.
- Identify potential man-made barriers to Macquarie perch in the Cotter River under various river discharge and temperature regimes by comparing swimming speed performance against measured flow velocities.
- Assess the swimming speed performance of established and potential invading alien fish species in relation to Macquarie perch to help determine whether range expansions by alien species may occur through the remediation of barriers to Macquarie perch migration within the Cotter River.

This project was completed in July 2009 (Starrs et al. 2009), key findings were:

Key findings of study of Macquarie perch swimming speed performance:

- Body size had a significant effect on swimming speed performance in Macquarie perch, with a general trend of increasing speed with increasing body size.
- Temperature also exerted an influence on swimming speed performance. While prolonged performance was significantly higher at 22 ºC than at 16 ºC, increases above 16 ºC had an insignificant effect on sprint speed performance in Macquarie perch. Both prolonged and sprint speed performance was significantly reduced at 10 ºC, with this 'coldwater' effect greater in juvenile Macquarie perch (<10 cm total length) compared to adult fish.
- The prolonged swimming speed performance of Macquarie perch (as measured via the Ucrit method) ranged from 16.7 cm s^{-1} at 10 ºC to 66.8 cm s^{-1} at 22 ºC. Sprint speed performance was an average of 116% higher than prolonged performance, with minimum sprint speeds of 37.5 cm s^{-1} at 10 ºC and a maximum of 93.1 cm s^{-1} at 22 ºC.

Key findings of barrier identification study:

- Flow velocities in two man-made structures on the Cotter River between Bendora Dam and Cotter Dam were measured across a wide range of environmental flows (river discharge rates). Vanity's Crossing fishway exhibited flow velocities that were similar to nearby natural riffle habitats across all measured river discharges. Conversely, Pipeline Road Crossing contained exceptionally high flow velocities through the culvert pipes under most discharge conditions.
- The combination of Macquarie perch swimming performance and flow velocities revealed that river discharge, temperature and Macquarie perch size were significant factors in determining likely upstream passage through in-stream obstacles.
  - Adult Macquarie perch passage through Vanities Crossing fishway is likely under discharges between 15 ML d^{-1} and 160 ML d^{-1} (river discharges of 2.7 ML d^{-1} produced sections of very shallow water likely to physically block fish passage).
  - Conversely, Pipeline Road Crossing may be a major barrier to Macquarie perch with passage unlikely over most discharges and perched outlets at low discharges (2.7 ML d^{-1}) requiring fish to leap into the pipe outlets (not a natural tendency of the species). The study predicted that only very large individuals could negotiate this pipe culvert during flows of approximately 150 ML d^{-1}.

Key findings of study of alien fish performance:

- Preliminary work on the prolonged and sprint speed performance of introduced Eastern Gambusia, Redfin perch, Goldfish and Oriental Weatherloach indicate that Macquarie perch swimming performance is intermediate compared to alien fish species in the ACT. Strong overlap is apparent in the swimming performance of Redfin perch, Goldfish and Macquarie perch, suggesting that any efforts to facilitate Macquarie perch passage through remediation of in-stream barriers may also increase the probability of upstream migration by these alien species.

3.2.1 Implications for the management of threatened aquatic species

The swimming speed project informed the remediation of Pipeline Road Crossing; an identified barrier to the upstream migration of adult Macquarie perch. This crossing has seven pipe culverts (850mm internal diameter) which, prior to remediation, generated flow velocities above the swimming capacity of all but the largest Macquarie perch for the majority of river discharges.

Plate 5 - Pipeline Crossing prior to remediation

The water velocity through the pipes is dependent on the discharge and the depth of water through the culvert; a greater depth provides a greater cross-sectional area for flow reduces the velocity.

The fishway was designed to back water up through the pipe culverts and increase depth and cross-sectional area to reduce water velocity. To enable fish passage through the pipes the water velocity needs to be less than the burst or sprint speed of Macquarie perch adults (approximately 0.88 m/s) and preferably less than the prolonged or critical swimming speed (approximately 0.55 m/s). To pass through the 3.7 m-long culvert, fish need to make forward progress against the water velocity of approximately 0.1 m/s, so the threshold velocities are likely to be within the range 0.78 – 0.45 m/s (Mallen-Cooper 2011).

The fishway was designed to allow fish passage at flows from 20 ML/d to 150 ML/d, which occur for 62 percent of the spawning season. Compromised passage by only the larger Macquarie perch is possible under flows from 150 ML/d to 250 ML/d, occurring for 11 percent of the spawning season. Once the crossing has been drowned out, fish may instead swim over the crossing, rather than through the culvert. Drown out is predicted to occur 4.4 percent of the time.

The fishway was constructed on the downstream side of the existing pipe culverts at Pipeline Road Crossing and comprises a full-width rock-ramp fishway with a low-flow channel.

The fishway was constructed according to the following guidelines:

- Rocks need to be selected, shaped and placed individually so they are packed tightly together to minimise gaps. A rotating grab is recommended for rock placement to aid in minimising gaps. Upper surfaces of the rocks should be kept rough where possible.
- Rocks in the central fishway channel need to interlock like a retaining wall so that the channel can withstand dynamic lateral forces from fast flowing water during floods, rather than static vertical forces.

- Rocks for the retaining wall sides of the fishway channel to be sized for stability in floods.
- Concrete should only be used where necessary; the intent of the design is to provide a natural riffle with interstitial spaces for transport of a range of biota.

Construction was completed in time for the 2011 Macquarie perch spawning season with the fishway commissioned with flowing water to ensure hydraulic performance.

Plate 6 - Fishway construction under high flow conditions

Plate 7 - Completed fishway under low flow conditions

Following installation fishway testing occurred under a range of discharge volumes, 30-40 ML/d and 175-200 ML/d. The fishway meets, and in some cases exceeds, the hydraulic requirements for the passage of Macquarie perch in the spawning season and will provide passage for a wide size range of fish at other times (Fishway Consulting Services 2011).

Test 1: 30-40 ML/d

The performance of the fishway under a discharge volume of 30-40 ML/d was tested against the criteria identified in Table 4.

Test 2: 175-200 ML/d

The performance of the fishway under a discharge volume of 175-200 ML/d was tested against the criteria identified in Table 5.

Table 4 - Performance of fishway during 30-40 ML/d flows

Criteria	Performance
Backwater up through pipes to upstream riffle.	**Conforms to design.**
Water velocities distributed through all pipes.	**Conforms to design.**
Majority of water directed to low-flow fishway with minimal leaks through geotextile.	**Conforms to design.**
Downstream riffle undisturbed or reinstated to maintain tailwater. It was undisturbed.	**Conforms to design.**
Head losses (difference in water upstream and downstream) between ridges of low- flow fishway evenly distributed between ridges.	**Conforms to design.**
Head losses per ridge between 60-120 mm.	**Conforms to design.**
Minimum depth of 0.3 m in fishway pools.	**Conforms to design.**
Minimum depth of 0.3 m in gaps in ridges.	**Conforms to design.**
Ridge rocks tested for stability by hand.	**Conforms to design.** One rock required further work, with additional stability support provided.

Table 5 - Performance of fishway during 175-200 ML/d flows

Criteria	Performance
Water velocities through left hand pipes (facing downstream) low to enable fish passage. □	**Exceeds design.** The left hand pipes provided lower than expected water velocities and can be expected to work at much higher flows possibly up to 350 ML/d.
High roughness within high-flow fishway provides low water velocities for fish passage.	**Conforms to design.** Note: Right-hand side at the downstream end of the fishway has bedrock which is a natural feature that has high velocities which may be impassable to Macquarie perch at higher flows. It is likely that during higher flows Macquarie perch will use the centre of the high-flow fishway. Left-hand side of downstream riffle and the centre of the high-flow fishway have continuous paths of low water velocities which would provide passage to within one metre of the channel downstream of the pipes. High water velocities preventing fish passage were present in the upper section of the high-flow rock-ramp. Rock placement was changed and rocks added to ensure that paths of low water velocities with sufficient depth and width would enable passage of Macquarie perch along the full length of the fishway.

3.3 Project 3 – Murray River Crayfish Ecology

Examination of Murray River Crayfish (MRC) distribution, abundance and habitat selection in upland rivers aimed to identify the typical habitat preferences, densities and individual space requirements of this species. This project was completed in 2010 and the information in this section was summarised from Fulton et al. 2010.

Key findings of study of Crayfish ecology and habitat preferences:

- Microhabitat availability (particularly MRC-preferred boulders, bedrock and gravel) is almost identical among the lower Cotter and Goobarragandra Rivers, indicating that existing microhabitat conditions in the lower Cotter River are sufficient to support a larger MRC population;
- A high percentage of fines (avoided by MRC in the Goobarragandra River) was present in the lower Cotter River;
- The lower Cotter River is markedly shallower than the Goobarragandra, with most glide-pools in the lower Cotter River being shallower than the preferred depth of MRC; and
- Percent cover of overhanging riparian vegetation over the lower Cotter River (<30%) is below the threshold where most MRC individuals were found in sections of the Goobarragandra River (i.e. most MRC were found in river sections with >30% overhanging riparian vegetation).
- Overall, we find that the low population sizes of MRC in the Paddys and lower Cotter rivers are unlikely to be due to microhabitat quality and availability. However, meso-habitat issues such as insufficient water depth and low percent cover of overhanging riparian vegetation could be detrimental to MRC abundances in this system.

3.3.1 Implications for the management of threatened aquatic species

The crayfish ecology study identified habitat preferences of Murray River Crayfish. The study findings can be used to inform future reviews of the Environmental Flow Guidelines, which should consider Murray River Crayfish flow preferences. The study also identifies habitat preferences for this threatened species which could be used to inform broader catchment management initiatives.

3.4 Project 4 – EHN virus management

The objective of this project was to determine if the Epizootic Haematopoietic Necrosis (EHN) virus is present in samples of the fish populations in and adjacent to the existing Cotter Reservoir.

The information in this section was summarised from Whittington (2008).

Key findings of EHN virus sampling

It is impossible to prove that the entire fish population is free from the EHN virus unless every individual of every susceptible species in the water body is tested (Whittington 2008). However it is generally accepted that testing to detect a specific prevalence (the percentage of the sampled fish that would be infected if the EHN virus was present in the population) with a given confidence limit of 95 per cent (certainty that the survey will identify infected fish) is sufficient. Actual numbers of populations sampled, sample sites and results of sampling are shown in Table 6 (based on Whittington 2008). No sampled fish tested positive for the EHN virus.

Table 6 - EHN virus sampling results

Species	Sample site	Number of individual fish	Number of positive test results	Estimated population size
Eastern Gambusia	Above Cotter Dam	200	0	10,000
	Below Cotter Dam	200	0	10,000
Mountain Galaxias	Above Cotter Dam	59	0	1,000
Rainbow Trout	Above Cotter Dam	114	0	5,000
Redfin Perch	Below Cotter Dam	19	0	5,000

3.4.1 Implications for the management of threatened aquatic species

Given that this project confirmed that EHN virus was not present in sampled fish from the Cotter Reservoir ACTEW Water, and the Bulk Water Alliance, put in place mitigation measures to ensure that the virus did not enter the reservoir as a result of ECD construction. These measures included:

- No connectivity between the Cotter Reservoir and the Cotter River downstream of the Cotter Dam during construction.
- Appropriate disinfection procedures for all vehicles and plant operating in zones, which have the potential to contain the EHN virus, prior to use in areas of the Cotter Reservoir Catchment.
- Onsite disinfection wash bay for vehicles and plant.
- Regular documented audits by environment personnel onsite to ensure disinfection procedures are being implemented effectively.
- Appropriate signage onsite to delineate disinfection zones where there is considered to be a high risk that the EHN virus is present.
- Water used onsite will only be sourced from the Cotter Reservoir via installed standpipes or approved ACTEW Water standpipes. No water will be extracted and used from the Cotter River downstream of the existing Cotter Dam, given that Redfin perch, a primary indicator of the presence of the EHN virus, have been commonly found in the Cotter River downstream of the existing Cotter Dam.
- Appropriate training and awareness of site personnel regarding the potential transfer of the EHN virus through onsite activities (including illegal fishing) and potential impact on sensitive fish species.
- Removal of aquatic vertebrae fauna from the stilling basin and Cotter River between the existing Cotter Dam and the downstream coffer dam prior to work in the Cotter River commencing.
- Removal of all water between the existing Cotter Dam and downstream coffer dam.
- Chemical treatment of the area between the old and enlarged Cotter Dams.

Ongoing management of the risk of the EHN will include:

- Monitoring for the presence of Redfin perch (as vector for the EHN virus).
- Notifying the appropriate authorities if the presence of the EHN virus in the Cotter Reservoir is confirmed.
- Training of ACTEW Water personnel working in the Cotter Catchment.

Further details are included in the EHN Disinfection Report and the EHN Management and Response Plan, contained in Appendix E and Appendix F respectively.

3.5 Project 5 – Translocation of threatened fish species

To spread the risk of adverse consequences for Macquarie perch from the construction of the Enlarged Cotter Dam the translocation of Macquarie Perch has been investigated. Translocation requirements for Two-spined blackfish and Trout cod were also assessed.

The aims of this project were to:

- Continue the translocation program for Macquarie Perch to existing translocation sites.
- Monitor the success of translocation efforts for Macquarie Perch.
- Identify potential additional translocation sites for Macquarie Perch.
- Investigate the existing fish fauna at high priority potential translocation sites.
- Construct a preliminary population model for Macquarie Perch to guide translocation efforts.
- Construct a preliminary population model for Two-spined Blackfish to assess risk to the lower Cotter River population.
- Review the translocation requirements for Two-spined Blackfish and Trout Cod.
- Provide guidelines for future translocation and monitoring programs for threatened fish species in the Cotter River Catchment.

The information in this section is summarised from Lintermans (2013).

Key findings of translocation of Macquarie perch from Cotter Reservoir

A total of 1,057 Macquarie perch were translocated to 3 sites between 2008 and 2012, including:

- Upper Cotter River (above Corin Reservoir) (560 fish)
- Molonglo River (above Molonglo Gorge) (275 fish).
- Paddys River (222 fish). This represented a rescue translocation where Macquarie perch collected from the stilling basin were relocated prior to and during ECD works. As fish downstream of the old dam have potentially been exposed to the EHN virus, Paddys River was selected as a translocation site to avoid the introduction of potentially infected fish to areas which are currently disease free.

In the upper Cotter River fish between 100 and 150 mm total length (TL) were translocated (Age 1+) and in the Molonglo River young of year (YOY) fish (75-99 mm TL) were translocated. The Paddys River site received a mix of sizes and age classes. Monitoring at all translocation sites has demonstrated survival of translocated fish, but no recruitment as yet.

Key findings of population modelling for Macquarie perch and Two-spined blackfish

To assist in trialling translocation scenarios, an age-structured population model for Macquarie perch was constructed. The model allowed a variety of translocation scenarios to be investigated with a range of user-defined parameters that could be manipulated.

Parameters included:

- carrying capacity of release rivers
- number and age of fish to be translocated
- duration of translocation program

- maximum size of translocated Macquarie perch (and hence egg output)
- varying levels of Allee effects, and recruitment failure.

Examining a range of translocation scenarios using 1,000 population trajectories for each scenario revealed that existing translocation attempts (2006-2011) could result in establishing small populations of the species, but that the Molonglo River translocations had a number of population trajectories that failed. As expected, the more fish released per event, the older the fish, and the longer the translocation period (years of operation), all positively influenced the chance of establishment and the size of the resulting population.

An age-structured population model was also constructed for Two-spined blackfish to investigate the threats posed by environmental changes associated with the filling of the enlarged Cotter Reservoir.

Key findings of investigations of translocation requirements for Two-spined blackfish and Trout cod
Translocation is a management option for both Two-spined blackfish and Trout cod, in the ACT and was investigated and potential options reviewed from a need, feasibility and cost-benefit perspective.

Translocations of Two-spined blackfish were assessed as feasible, but not required, as there are still secure populations in the middle and upper Cotter River.

Translocation of Trout cod was assessed as currently unfeasible, as there is no self-sustaining donor population capable of sustaining a harvest of individuals for translocation.

3.5.1 Implications for the management of threatened aquatic species

ACTEW Water will use the results of this translocation project and the ECD Fish Monitoring Program to inform future translocation efforts for Macquarie perch.

Translocation and monitoring will continue dependent on availability of Macquarie perch.

3.6 Project 6 – Alien Fish Management Plan

The Cotter Dam Enlargement Fish Risk Assessment (2013) and previous assessments (e.g. Environmental Impact Statement) identified that an increase in the abundance of alien fish (in particular trout) has the potential to result in an increase in the rates of predation on and competition with native fish. The development and implementation of an Alien Fish Management Plan is crucial to mitigate the impacts of expected expanded populations of alien fish species in an enlarged Cotter Reservoir.

Redfin perch are a particular threat to Macquarie perch and are not currently in the Cotter catchment (upstream of the Cotter Dam). This alien fish species has the greatest potential to impact native fish species through the introduction of the EHN virus. ACTEW Water's management of EHN is dealt with through a separate plan (EHN Virus Management & Response Plan).

The purpose of the Alien Fish Management Plan, provided in Appendix G, is to outline an adaptive framework and schedule for the management of the impacts of alien fish (as a result of the ECD project) to threatened fish species in the enlarged Cotter Reservoir. The Alien Fish Management Plan involves the ongoing monitoring of alien fish species and the implementation of management measures when trigger levels are reached.

This monitoring is being undertaken through the Enlarged Cotter Dam Fish Monitoring Program which commenced in early 2010 and includes the monitoring of alien fish abundance and distribution (Lintermans et al. 2013). The current baseline monitoring program dataset is highly variable, as it collected data through both drought and flood years. Further collection of data as the ECD fills will allow more robust estimates of baseline levels of alien fish abundance, and will facilitate the setting of trigger levels for management

actions. The setting of trigger levels and management actions will be done in consultation with the ACT Government, the FMP Steering Committee and expert panel as required.

While data are being collected to provide a robust data set for alien fish, ACTEW Water will compile information on management options for the management of negative alien fish impacts in the Cotter reservoir and river.

3.7 Project 7 - Food sources for Macquarie Perch

With the construction of the ECD and reservoir expansion, shifts in reservoir food resources for Macquarie perch are expected for a number of reasons. Firstly, the enlarged reservoir will inundate fringing macrophyte beds which are unlikely to re-establish in the event of fluctuating water levels under a changed water supply management regime. Secondly, the productivity of the reservoir is likely to change substantially following flooding, as trophic upsurge followed by trophic depression likely occurs. Both scenarios could lead to changes in invertebrate communities, and are of primary concern as they are predominantly preyed on by Macquarie perch in rivers and reservoirs.

In this study, sampling of Macquarie perch diet and food availability was conducted in the stable Cotter Reservoir, prior to expansion, and nearby established fluctuating reservoirs (Googong, Corin and Cataract) to assess:

- the main food of adult Macquarie Perch
- the habitat features that influence invertebrate production
- food resources between stable (Cotter Reservoir) and established, variable water level reservoirs (Cataract, Corin and Googong reservoirs).

The information in this section was summarised from Norris et al. (2012).

Key findings of investigation of Macquarie Perch diet

Adult Macquarie perch appear to be generalist predators and exhibit adaptive flexibility in feeding behaviour characteristic of *percichthyids* (Allen et al. 2002, Howell et al. 2004, Sternberg et al. 2008, Smith et al. 2011). Reservoir Macquarie perch preyed on diverse invertebrate groups with main food items varying across sampling periods. Invertebrate composition in fish stomachs and in edge habitats varied between sampling events and reservoirs, implying fish shifted feeding strategies to approximate optimal foraging behaviour based on ambient prey levels (Schoener 1971).

Macro-crustacean *Decapoda* prey (mainly freshwater shrimp *Paratya australiensis* and freshwater prawns *Machrobrachium australiense*) was a major food source for Macquarie perch in the old Cotter Reservoir. The selection of *Decapoda* is likely encouraged by its larger size enabling greater visibility, faster encounter rates, and increased energetic return per individual (Schoener 1971).

At the fluctuating Cataract Reservoir, *Diptera* were the most important food item and characterised diet of Cataract Macquarie perch.

In both reservoirs, there was a correlation between the composition of Macquarie perch diet and the relative abundance of macroinvertebrates, indicating that the fish are not selective feeders and will consume food items that are readily accessible. As a dietary generalist (Cadwallader and Eden 1979, Cadwallader and Douglas 1986, Douglas et al. 2002, Lintermans 2006), it is unlikely that Macquarie perch could be supported by a single taxon, and rather relies on a mixed diet which is known to improve fish growth and survival (Lobel and Ogden 1981, Bernays et al. 1994).

Key findings on habitat of macroinvertebrates

Habitat effects on invertebrate communities across all study reservoirs were only identified for coarse scale invertebrate composition and were best explained by greater *Decapoda* abundance at rock compared to

bare shore. Elevated levels of *Decapoda* abundance at rock shore habitats may be explained by greater habitat complexity which affects biomass and distribution of macroinvertebrates in lentic waterbodies (Schmude et al. 1998). *Decapoda*, such as *M. australiense*, exhibit predator refuge seeking behaviour and are even capable of selecting vegetated areas of greatest complexity (Lammers et al. 2009), and may account for greater densities of this taxon at interstitial rock than bare shores.

Key findings on availability of macroinvertebrates

Time of year influenced composition and biomass of invertebrates available in reservoirs and appeared to affect prey selection by Macquarie perch at Cotter Reservoir across sampling periods, noting that seasonal variation in fish diet at Cotter Reservoir was not fully tested so to avoid impacting fish during the spring to summer Macquarie perch spawning period (Wharton 1968, Cadwallader and Rogan 1977, Lintermans et al. 2010).

Decapoda was characteristic and had consistently high presence at Cotter Reservoir.

At Cataract, Corin and Googong reservoirs, *Diptera* was most typical (28–62% contribution to total similarities across reservoirs), although this taxon did not have a consistently large presence.

Increases were observed in ambient *Decapoda* biomass in autumn compared to spring across all reservoirs in 2009. This suggests recruitment and growth of decapods such as freshwater shrimp over summer (Gooderham and Tsyrlin 2002) seasonally increases their availability and possibly affects seasonal prey selection by Macquarie perch. Open water tows also indicated that the ambient zooplankton (*Cladocera* and *Copepoda*) abundance levels in the Cotter Reservoir were highest during autumn, rather than winter or spring. This explains patterns in *Cladocera* feeding by Cotter Macquarie perch, with presence of *Cladocera* in fish diet in autumn 2009 and 2010, but not in winter 2011 when lowest levels of zooplankton from open water tows were observed. *Decapoda* abundance in edge habitats was also lowest in winter 2011 at Cotter Reservoir, and although Macquarie perch still fed on this taxon, heightened predation on *Diptera* was observed.

Lintermans et al. (2010) found Macquarie perch move greater distances in winter and postulated individuals may travel greater distances to meet energetic requirements in this season because of more sparsely distributed food resources. Winter or less productive periods through annual cycles may seriously affect Macquarie perch nutrition, particularly in variable water-level reservoirs where food resources are reduced (Gray et al. 2000).

Key findings on effects of drawdown

Decapoda abundance was highest in autumn 2010 following a drawdown event at Cotter Reservoir, and may be attributed to increased catch rates of these organisms when complex habitats, possibly used for shelter, were not available. This suggests *Decapoda* are more vulnerable to predation during drawdown events, particularly in mature, variable water-level reservoirs where limited complex habitat occur.

Provision of rock reefs to accommodate daytime refuge habitat requirements for Macquarie perch at a range of water levels in the enlarged Cotter Reservoir (Lintermans et al. 2010) will also provide complex habitat for invertebrates and may mitigate some of the negative effects on *Decapoda* and total invertebrate production expected in a mature fluctuating water body.

3.7.1 Implications for the management of threatened aquatic species

The food project confirmed that Macquarie perch are opportunistic feeders, however, the source of their preferred prey might decline in the enlarged Cotter Reservoir. This project highlighted the need to include Macquarie perch condition measurements as part of the ECD ongoing monitoring program

3.8 Project 8 – Barriers and spawning habitat identification

The enlargement of the Cotter Reservoir will flood approximately 4.5 kilometres of the Cotter River, inundating known spawning and early recruitment habitat of the reservoir population of the Macquarie perch.

Each spring Macquarie perch in the Cotter Reservoir migrate upstream into the Cotter River to spawn. In order to ensure successful spawning and recruitment, Macquarie perch needs flowing water. Knowledge of the location of current and potential spawning grounds and in-stream barriers to fish passage is paramount to effective management of Macquarie perch recruitment and ultimately long term survival of the enlarged Cotter Reservoir population (Broadhurst et al. 2013).

An on ground barrier and potential spawning habitat identification project was initiated in early 2013, and is being implemented by the University of Canberra. This project aimed to:

1. Identify potential barriers to fish passage in the Cotter River under three different flow range scenarios. Flow range scenarios would be low (approx. 10-40ML/day), medium (approx. 40-80ML/day) and high (80-150ML/day).
2. Given that the habitat characteristics of spawning areas are broadly known, identify potential spawning habitat between RL518 and Bendora Dam.

Key study findings into potential barriers to upstream migration of Macquarie perch

Project research has identified the manipulation of river flow events and maintaining high reservoir levels can mitigate most in-stream barriers to upstream Macquarie perch spawning movements. Initial survey of the Cotter River between Cotter and Bendora Reservoirs has identified more than 130 potential natural barriers to Macquarie perch passage in the Priority Reach (Cotter Reservoir to Vanitys Crossing). In the Priority Reach 34 of these barriers will be inundated at predicted full supply level of the ECD. In the secondary Reach (Vanitys Crossing to Spur Hole) additional barriers were identified, although at a much lower density and severity than the Priority Reach. The areas upstream of predicted ECD full supply exhibit characteristics of suitable spawning habitat (i.e. suitable pool habitat), although barriers large enough to restrict passage are present.

In-stream barriers are complex and individual in nature. Under low flows in the Cotter River (less than 35ML/day) barriers become increasingly difficult to pass. In high flows, while velocities increase, there is likelihood that additional movement paths upstream are created as the river widens and potentially creates slower moving flood channels near the banks. However nine of the 17 identified 'medium' barriers that were monitored and 15 of the 16 'large' barriers monitored could not be mitigated by high flows (150-204 Ml/Day).

Monitoring of a subset of barriers in a priority reach of the Cotter River (from the current Cotter Reservoir to 9.6km upstream) under different flow releases from Bendora has revealed that Macquarie perch passage can be facilitated at all of the 'small' barriers and 8 of the 'medium' barriers by increasing river discharge, in turn providing access to critical spawning habitat.

There are small and medium barriers just above predicted full supply level of the ECD. An important finding of the barriers research shows that fish passage past all but one of the small barriers, and some of the medium barriers, can be mitigated with multiple periods of high water flow events greater than 150 ML per day during the spawning season (October – January). These high flow events can be facilitated by natural and planned releases from Bendora Reservoir under existing environmental flow legislative requirements. The potentially insurmountable barrier to Macquarie perch passage shown below will be inundated to around 10m deep when the ECD is at full supply.

Plate 8 - High flows over a large barrier at reservoir level 541.1m

Ongoing monitoring through the ECD Fish Monitoring Program includes sampling of Macquarie perch recruitment success. Monitoring includes snorkelling at pools to identify fish larvae, as well as sampling juvenile fish through fyke netting. This monitoring will also be used to evaluate the effectiveness of river flow and reservoir water level regimes, ensuring that mitigating in-stream barriers to fish passage is adaptively managed.

Longitudinal section of barriers and potential spawning habitat location

Using a high accuracy Global Positioning System (GPS) and information from the abovementioned project, precise elevations were generated for in-stream barriers and potential spawning habitat in the Priority Reach between the current reservoir level (525.7m as of October 2013) and Vanitys Crossing. This elevation data was put into a longitudinal section showing the reservoir levels at each barrier and potential spawning area as well as the exact location of barriers directly above the ECD predicted full supply level (see Figure 5).

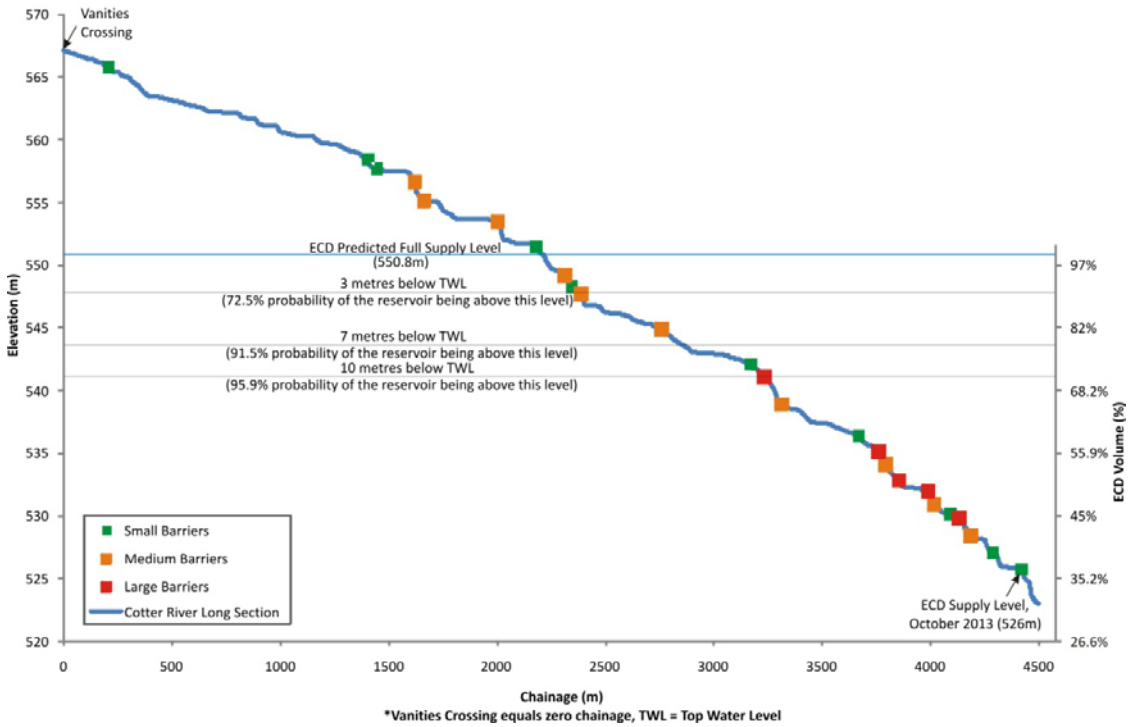


Figure 5 - Cotter River long section (Vanity's Crossing to ECD FSL)

3.8.1 Implications for the management of threatened aquatic species

Information collected and as part the on-ground barriers and spawning habitat identification project and the complimentary longitudinal section will be used to inform the annual spawning risk assessment.

3.9 Project 9 – Enlarged Cotter Dam Fish Monitoring Program

The enlarged Cotter Dam fish monitoring program was initiated in autumn 2010. The research questions originally proposed for the program were slightly refined at the end of 2012 following a review of the risk assessment of potential impacts of the enlarged Cotter Dam during the filing and operation phase. The usefulness of the previous baseline data set (collected during the construction phase) has not been compromised by the refinement of the research questions. The ten revised monitoring questions are:

1. Has there been a significant change in the abundance and body condition of Macquarie perch (young-of-year, juveniles and adults) in the enlarged Cotter Reservoir as a result of the filling and operation of the ECD?
2. Has there been a significant change in the abundance, body condition and distribution of the Macquarie perch (young-of-year, juveniles and adults) in the Cotter River above and below Vanitys Crossing as a result of the filling and operation of the ECD?
3. Have Two-spined Blackfish established a reproducing population in the enlarged Cotter Reservoir and are they persisting in the newly inundated section of the Cotter River?
4. Has there been a significant change in the abundance, distribution and size composition of adult trout in the enlarged Cotter Reservoir as a result of the filling and operation of ECD?
5. Has there been a significant change in the abundance and size composition of trout in the Cotter River upstream of the enlarged Cotter Reservoir as a result of the filling and operation of ECD?
6. Are Two-spined blackfish and Macquarie perch present in trout stomachs in the Cotter River?

7. Has there been a significant change in the abundance and distribution of non-native fish species in the enlarged Cotter Reservoir as a result of the filling and operation of the ECD?
8. Has there been a significant change in the abundance, distribution and species composition of piscivorous birds in the vicinity of the enlarged Cotter Reservoir as a result of the filling and operation of the ECD?
9. Have macrophyte beds re-established in the enlarged Cotter Reservoir?
10. Are there adequate food resources (particularly decapods) for the Macquarie perch following the filling and operation of the enlarged Cotter Reservoir?

The assessment program was designed to be conducted in three broad phases; baseline (before the ECD starts to fill), filling (as the ECD fills) and operation (once the ECD has filled and began operation as a water supply reservoir). Where possible the assessment program employs a before after control impact (BACI) study design to provide a robust regime for detecting change associated with the ECD. The study design is also field integrated with many of the field survey activities addressing multiple research questions. The assessment program has now been in operation for three years collecting baseline data. Despite adverse climatic conditions in the final two years of the project, the field survey component has been completed with very few missing data points. High flow associated with heavy rains prevented some sampling events in 2011 and 2012 (Lintermans 2013).

3.9.1 Implications for the management of threatened aquatic species

Data from the Enlarged Cotter Dam Fish Monitoring Program will be used to further inform and update trigger levels for the ongoing management of threatened fish species. Data from the monitoring program is already being used to inform management actions. For example data to determine whether there will be significant changes in the abundance, distribution and species composition of piscivorous birds (cormorants) in the ECD is used to inform trigger levels for the Cormorant Management Plan (Macquarie Perch Filling Phase Plan).

The Baseline Data report for the first three years of the ECD Fish Monitoring Program is included in Appendix B.

4 Risk assessment – filling and operational phase

Given the ECD FMP is moving from the construction (FMP V2) to the filling and operational phase (FMP V3) an update of the risk assessment was required to ensure all risks to threatened aquatic species for the next phase of the ECD project were identified.

The main purpose of the risk assessment is to guide ACTEW Water's mitigation actions for the filling and operation phase of the ECD project. To do this it was important to distinguish between risks to threatened species directly associated with reservoir filling and operation and those that are more broadly associated with catchment management and other impacts.

The project objectives for the risk assessment were:

- Review the scientific literature and outputs from FMP research projects to provide the evidence base for a review of threats and risks.
- Through a collaborative stakeholder workshop, focus on threats which can be attributed directly or indirectly to the ECD and revise the previous risk assessment, including the management and mitigation measures, for inclusion in FMP V3.

Background paper preparation and workshop facilitation for the risk assessment was undertaken and by Sinclair Knight Merz (SKM). The Final Report for the *Cotter Dam Enlargement Fish Risk Assessment* is presented in Appendix G; the information in the section is drawn from this report.

4.1 Conceptual models for assessing risks to aquatic ecology

Conceptual models were developed to describe the key threats to Macquarie perch and Two-spined blackfish in the study area. The main threats to the Macquarie perch population in the Cotter Reservoir, as a result of ECD, are related to loss of habitat and alteration to primary food resources, increased predation, especially from cormorants, loss of spawning habitat through inundation of existing habitat and restricted access to alternative habitat and impacts associated with competition and predation by alien fish species. Therefore, for Macquarie perch, conceptual models were developed for habitat and food resources, cormorant predation, spawning requirements and alien fish impacts.

Two-spined blackfish inhabit the Cotter River and were not found in the old Cotter Reservoir. The reach of the river upstream of the old reservoir provided suitable spawning habitat for Two-spined blackfish and their absence from the old reservoir is thought to be related to excessive sedimentation. A conceptual model for the sustainability of Two-spined blackfish in the Cotter Reservoir was also developed.

4.2 Revised risk assessment

The conceptual models were used to inform the risk assessment during a stakeholder workshop which was held by ACTEW Water in May 2013. Key stakeholders in attendance at the workshop were:

- aquatic ecologists from the ACT Government's Environment and Sustainable Development Directorate, Conservation Planning and Research Unit
- University of Canberra Fish Biologists, including ACTEW Water's Fish Advisor
- representative from ACT Government's Environment and Sustainable Development Directorate, Water Regulation section
- independent freshwater ecologist and fisheries scientist

- SKM Freshwater ecologists
- ACTEW Water's Manager, ECD Fish Management Program
- ACTEW Water's Manager, Ecological Monitoring and Biodiversity

The workshop participants agreed on the current (without mitigation measures) and residual (with mitigation measures) risks for threatened aquatic species presented in the following sections.

4.2.1 Macquarie perch

The current and residual risks to Macquarie perch from threats associated with the ECD projects filling and operational phases are described below and summarised in Table 7:

1) The filling of the enlarged Cotter Reservoir has the potential to result in a short-term reduction of dissolved oxygen (DO) as organic matter is inundated and decomposed. If DO falls below 4 mg/L in the surface waters there is a potential for a short-term impact on the health of Macquarie perch, however, the population would not be lost (**moderate** consequence). Mitigation measures are described in the Macquarie Perch Filling Phase Plan, which include the operation of a destratification system that will help mix the water column and reduce the likelihood of widespread low DO conditions occurring to **unlikely**. The residual risk to Macquarie perch is considered **low**.
2) There is also a risk of rapid oxygen depletion if the reservoir is stratified and then "turns over" where deoxygenated water is brought to the surface. The consequences of rapid oxygen depletion are considered **major**, because it can result in fish kills if DO falls below 2 mg/L. However, the current Cotter Dam is known to stratify and periods of low DO have occurred in the past with no detected impact on the native fish population, so such an event is considered **remote** and can be managed through the Macquarie Perch Filling Phase Plan, so overall risk is **low**.
3) The filling of the enlarged Cotter Reservoir is **almost certain** to result in the loss of Macquarie perch habitat in the form of existing macrophytes beds. The macrophyte beds are currently critical habitat for juvenile and adult fish and their preferred food resource, decapod crustacean. The loss of this habitat is predicted to a have a **major** impact in the abundance and condition of Macquarie perch, but is unlikely to result in the complete loss of the population. Extensive work has been completed on the provision of alternative habitat in the form of rocky reefs and the retention of native hardwood in the newly inundated zone. This is expected to compensate for the loss of macrophyte habitat so that the overall likelihood of net habitat loss is **unlikely**. This reduces risks associated with habitat loss to **medium**. This risk may be further reduced if macrophytes re-establish at the new full supply level, however this will depend on dam operations and the substrate available to the macrophytes at the new water levels.
4) The loss of macrophyte beds is also expected to result in a reduction in the abundance of decapod crustaceans, the preferred food resource of Macquarie perch. This has the potential to result in a reduction in the abundance and condition of Macquarie perch, but not a loss of the population, as Macquarie perch do exist in reservoirs where there is very low decapod abundance (**moderate** consequence). The provision of rocky reef habitat and retention of native hardwood in the inundation zone may provide suitable habitat (including biofilm development) for decapods to persist in the reservoir, although the rocky reef habitat was not specifically designed for decapods, so the overall risk remains at **medium.**
5) As the enlarged Cotter Reservoir fills it is likely that the decomposition of inundated organic material will increase overall reservoir productivity for a period of time (termed trophic upsurge). This is **likely** to result in a short-term increase in the abundance of both native and alien fish species while the trophic upsurge persists (3-5+ years). An increase in the abundance of alien fish (e.g. trout and goldfish) has the potential to result in an increase in the rates of predation on and competition with native fish, which could have **moderate** consequences for the native fish population, but is unlikely to result in the loss of a sustainable population. The development and implementation of an Alien Fish Management Strategy will include mitigation measures that are expected to reduce the likelihood of impacts from competition and predation to **unlikely** and result in an overall **low** risk.

6) An increase in abundance of alien fish may result in an increase in cormorant numbers on the reservoir with a resultant **possible** increase in predation rates by cormorants on Macquarie perch. Cormorants frequent the reservoir when Macquarie perch are commencing their spawning run into the lower Cotter River and are particularly vulnerable to predation at this time, so the consequence to the population is considered **major** and overall risk **high.** The provision of rocky reef habitat is expected to help provide refuge for Macquarie perch from cormorant predation. Furthermore, the Macquarie Perch Filling Phase Plan contains actions to reduce the cormorant population if necessary, which will reduce the likelihood of predation to **unlikely** and the risk to **medium**. Cormorant management actions are included in the Cormorant Management Plan.

7) The filling of the enlarged Cotter Reservoir is **almost certain** to inundate existing spawning habitat for Macquarie perch in the lower Cotter River. The loss of this habitat has the potential for a **major** impact on the reservoir population of the Macquarie perch with a resultant **significant** risk if alternative spawning sites cannot be accessed (see threat 8). An annual spawning risk assessment is required for assessment by the EPA (regulatory requirement). It will identify actions for reservoir level and river flow manipulation aimed at maintaining access to suitable spawning habitat in the lower Cotter River, hence reducing the risk to **medium**.

8) In addition to loss of spawning habitat due to inundation, it is **possible** that there will be a reduction in fish passage, which will limit access to spawning sites further upstream in the lower Cotter River with **major** consequences to the Macquarie perch population. The annual spawning risk assessment and outcomes from the current barriers identification project will provide mitigation measures aimed at ensuring access to suitable spawning sites is maintained, reducing the risk to **medium.**

9) Furthermore, cold water releases from Bendora Reservoir to the lower Cotter River during the spawning season could disrupt spawning by providing the wrong temperature signal. The consequence of disrupted spawning is considered **moderate**, however the likelihood is **remote** if ACTEW operate the reservoir in accordance with their current licence to take water, so the residual risk is **low**.

10) In addition to an increase in the abundance of alien fish already present in the reservoir (threat 5), there is potential for Redfin perch and common carp to be introduced into the enlarged Cotter Reservoir, either accidently or illegally. This has the potential to further increase competition and/or predation with native species with **moderate** consequences for Macquarie perch. The introduction of Redfin perch also poses the risk of introducing the EHN virus (Threat 11). ACTEW Water have in place an employee and contractor awareness and training scheme to reduce the likelihood of alien fish introduction due to ACTEW Water activities, so specific risk is **low**, however, illegal introductions are also a risk. ACTEW Water will advise the ACT Government of any illegal fish activities in an attempt to limit access to the reservoir and the potential for illegal fish introductions and will also work with land managers to promote community education of the risks.

11) If Redfin perch were introduced to the Cotter Reservoir there is a potential **catastrophic** consequence for Macquarie perch through the transmission of the EHN virus. The likelihood of introduction due to ACTEW Water activities is considered **remote** and the risk **medium.** However, ACTEW Water has still prepared an EHN Virus Management and Response Plan, and will provide employee and contractor awareness and training. ACTEW Water will work with ACT land managers to promote community education. In addition, ACTEW Water will provide ongoing support to Macquarie perch translocation programs outside of the Cotter Catchment in a bid to ensure that Macquarie perch populations are not lost to the ACT in general.

12) There are localised threats from accidental fuel spills, oils and other contaminants entering the aquatic environment during filling and operation. However, likelihood is considered **remote** and consequence **minimal**, so risk is **negligible**.

Table 7 - Current and residual risk to Macquarie perch

#	Potential threat	Current risk			Management and mitigation measures	Residual risk		
		Likelihood	Consequence	Risk rating		Likelihood	Consequence	Risk rating
1	Short term oxygen depletion during filling (days/weeks <4mg/L in the 0-7m zone) as a result of inundation of vegetation.	C	3	Med.	• Macquarie Perch Filling Phase Plan and De-stratification system. • The ECD Filling Plan includes management measures for implementation when low DO trigger levels are reached	D	3	Low
2	Rapid oxygen depletion (< 2.0mg/L in the 0-3m zone) as a result of turnover.	E	4	Low	• Macquarie Perch Filling Phase Plan and De-stratification system. • The Macquarie Perch Filling Phase Plan includes management measures for implementation when low DO trigger levels are reached.	E	4	Low
3	Loss of fish habitats (loss or reduced survival of macrophyte beds and/or altered condition of edge-boulder environments).	A	4	Sig.	• Constructed rock reef habitat has been provided. • Native hardwood habitat left in-situ.	D	4	Med
4	Reduction in decapod crustaceans due to loss of macrophyte habitat	C	3	Med	• Constructed rock reef habitat has been provided. • Native hardwood habitat left in-situ	C	3	Med
5	Increased abundance of existing alien fish species in the lower Cotter River and reservoir.	B	3	High	• Implementation of the alien fish management strategy.	D	3	Low
6	Increase in cormorant predation.	C	4	High	• Constructed rock reef habitat has been provided. • Native hardwood habitat left in-situ. • The Macquarie Perch Filling Phase Plan includes management measures for cormorant population increases.	D	4	Med.

#	Potential threat	Current risk			Management and mitigation measures	Residual risk		
		Likelihood	Consequence	Risk rating		Likelihood	Consequence	Risk rating
7	Loss of spawning areas in the Cotter River due to inundation.	A	4	Sig.	• Water level and inflow management during spawning informed by annual spawning risk assessment. • Results of barriers identification project will be used to inform the annual spawning risk assessment.	D	4	Med.
8	Reduced fish passage limiting access to spawning sites in Cotter River.	C	4	High	• Water level and inflow management during spawning informed by annual spawning risk assessment. • Results of barriers identification project will be used to inform the annual spawning risk assessment.	D	4	Med.
9	Cold water releases from Bendora Reservoir during the spawning season providing the wrong temperature signal.	E	3	Low	• Continue to manage temperature of environmental releases from Bendora Reservoir in accordance with ACTEW Water's Licence to Take Water.	E	3	Low
10	Introduction of new alien fish to the aquatic environment as a result of ACTEW Water's operations.	E	3	Low	• ACTEW Water will advise ACT Government of any illegal fishing activities identified during the filling and operation (as described in ACTEW's EHN management and response plan). • Awareness training/ inductions for ACTEW Water employees and contractors. • ACTEW Water will work with ACT land managers to promote community education.	E	3	Low
11	Introduction of EHN virus plus Redfin Perch into Cotter Reservoir as a result of ACTEW Water's operations.	E	5	Med.	• Development of an EHN Virus Response Plan. • ACTEW Water will advise ACT Government of any illegal fishing activities identified during the filling and operation. • Awareness training/ inductions for ACTEW Water employees and contractors.	E	5	Med.

#	Potential threat	Current risk			Management and mitigation measures	Residual risk		
		Likelihood	Consequence	Risk rating		Likelihood	Consequence	Risk rating
					• Ongoing support of translocation programs outside of the Lower Cotter catchment. • ACTEW will work with ACT land managers to promote community education.			
12	Major fuel spill, oils and other contaminants entering the aquatic environment during filling and operation.	E	1	Neg.	• Environmental Management Procedures, training and awareness (ACTEW Water)	E	1	Neg.

4.2.2 Two-spined blackfish

The current and residual risks to Two-spined blackfish from threats associated with the enlarged Cotter Reservoir filling and operation are described below and summarised in Table 8:

1) The filling of the enlarged Cotter Reservoir has the potential to result in a short-term reduction of dissolved oxygen (DO) as organic matter is inundated and decomposed. If DO falls below 4 mg/L in the surface waters there is a potential for a short term impact on the health of fish. However, two-spined blackfish are not currently present in the Cotter Reservoir, so they are unlikely to be impacted by a reduction in DO, even if it does occur, hence the consequence to Two-spined blackfish is at worst **minor**. Mitigation measures are described in the Macquarie Perch Filling Phase Plan, which include the operation of a destratification system that will help mix the water column and reduce the likelihood of widespread low DO conditions occurring to **unlikely**. The residual risk is considered **low**.

2) There is also a risk of rapid oxygen depletion if the reservoir is stratified and then "turns over" where deoxygenated water is brought to the surface. As with the previous threat, two-spined blackfish, are not currently present in the Cotter Reservoir, so they are unlikely to be impacted by a reduction in DO, even if it does occur, hence the consequence to two-spined blackfish is at worst **minor**. Furthermore, the current Cotter Dam is known to stratify and periods of low DO have occurred in the past with no detected impact on the native fish population, so such an event is considered **remote** and can be managed through the Macquarie Perch Filling Phase Plan, so overall risk to two-spined blackfish is **negligible**.

3) The filling of the enlarged Cotter Reservoir will inundate existing Two-spined blackfish habitat in the lower Cotter River and is **likely** to result in habitat loss through sedimentation of this habitat in the inlet zone. The consequences to two-spined blackfish are considered **moderate** and the risk **high.** There may be a reduction in the population in the immediate vicinity of the inundation zone, but the population will persist further upstream. Furthermore, the provision of alternative habitat for Macquarie perch (rocky reefs and the retention of native hardwood) is also likely to favour Two-spined blackfish, which may subsequently colonise the ECD, reducing the risk to **medium.**

4) If Two-spined blackfish do colonise the enlarged Cotter Reservoir and spawn amongst the newly created rocky reef and submerged timber habitats it is **possible** that fluctuating water levels during the spawning period (late spring through summer) could expose eggs adhered to these substrates. This could threaten recruitment success in that year for a number of individuals, but is of only **minor** consequence to the overall population. Water level and inflow management during the spawning season to maintain stable water levels and prevent rapid drawdown would mitigate this threat so that residual risk is considered **low**.

5) Cold water releases from Bendora Reservoir during the spawning season could disrupt spawning of fish in the lower Cotter River by providing the wrong temperature signal. The consequence of disrupted spawning is considered **moderate**, however the likelihood is **remote** if ACTEW Water operate the reservoir in accordance with their current licence to take water, so the residual risk is **low**.

6) Furthermore, there is the potential for water to be released from Bendora Reservoir to help manage water quality in the enlarged Cotter Reservoir during the filling stage which could impact on Two-spined blackfish populations in Bendora Reservoir itself. The need for any releases is **remote** and the overall operating regime of Bendora Reservoir is not expected to be significantly altered so risk is considered **negligible**.

7) As the enlarged Cotter Reservoir fills it is likely that the decomposition of inundated organic material will increase overall reservoir productivity for a period of time (termed trophic upsurge). This is **likely** to result in a short-term increase in the abundance of both native and alien fish species while the trophic upsurge persist (3-5+ years). An increase in the abundance of alien fish (e.g. trout and goldfish) has the potential to result in an increase in the rates of predation on and competition with native fish, which could have **moderate** consequences for the native fish population, but is unlikely to result in the loss of a sustainable population. In particular, trout and Two-spined blackfish co-exist in many locations. The development and implementation of an Alien Fish Management Plan will include mitigation measures

that are expected to reduce the likelihood of impacts from competition and predation to **unlikely** and result in an overall **low** risk.

8) In addition to an increase in the abundance of alien fish already present in the reservoir (threat 5), there is potential for Redfin perch and common carp to be introduced into the enlarged Cotter Reservoir, either accidently or illegally. This has the potential to further increase competition and/or predation with native species with **moderate** consequences for Two-spined blackfish. The introduction of Redfin perch also poses the risk of introducing the EHN virus (Threat 9). ACTEW Water have in place an employee and contractor awareness and training scheme to reduce the likelihood of alien fish introduction due to ACTEW Water activities, so specific risk is **low**, however, illegal introductions are also a risk. ACTEW Water will advise the ACT Government of any illegal fish activities and will work with land managers to promote community education of the risks.

9) If Redfin perch specifically were introduced to the Cotter Reservoir there is a potential for the introduction of the EHN virus. Two-spined blackfish are unlikely to be susceptible to EHN Virus because they co-exist with Redfin perch in other locations, so the consequence of EHN Virus for Two-spined blackfish is **minor**. The likelihood of introduction due to ACTEW Water activities is considered **remote** and the risk **negligible.** However, ACTEW Water will still prepare an EHN Virus response plan, provide employee and contractor awareness and training and community education.

10) There are localised threats from accidental fuel spills, oils and other contaminants entering the aquatic environment during filling and operation. However, likelihood is considered **remote** and consequence **minimal**, so risk is **negligible**. Even so, ACTEW will implement management procedures, training and awareness so that any event is managed appropriately.

Table 8 - Current and residual risk to Two-spined blackfish

#	Potential threat	Current risk			Management and mitigation measures	Residual risk		
		Likelihood	Consequence	Risk rating		Likelihood	Consequence	Risk rating
1	Short term oxygen depletion during filling (days/weeks <4mg/L in the 0-7m zone) as a result of inundation of vegetation.	C	2	Low	• Macquarie Perch Filling Phase Plan and De-stratification system. • The ECD Filling Plan includes management measures for implementation when low DO trigger levels are reached	D	2	Low
2	Rapid oxygen depletion (< 2.0mg/L in the 0-3m zone) as a result of turnover.	E	2	Neg.	• Macquarie Perch Filling Phase Plan and De-stratification system. • The Macquarie Perch Filling Phase Plan includes management measures for implementation when low DO trigger levels are reached.	E	2	Neg.
3	Habitat loss in newly inundated areas due to sedimentation of habitat	B	3	High	• Catchment management and remediation. • Constructed rock reef habitat has been provided. • Native hardwood habitat left in-situ.	C	3	Med
4	Fluctuating water levels expose deposited eggs in the enlarged Cotter Reservoir	C	2	Low	• Water level and flow manipulation during spawning season	D	2	Low
5	Cold water releases from Bendora Reservoir during the spawning season providing the wrong temperature signal.	E	3	Low	• Continue to manage temperature of environmental releases from Bendora Reservoir in accordance with ACTEW Water's Licence to Take Water.	E	3	Low
6	Change in operating regime of Bendora Reservoir	E	2	Neg.	• The operating regime of Bendora Reservoir is not expected to be significantly altered – no specific management or mitigation measures are required	E	2	Neg.
7	Increased abundance of existing alien fish species in the lower Cotter River and reservoir.	B	3	High	• Implementation of the alien fish management strategy.	D	3	Low

#	Potential threat	Current risk			Management and mitigation measures	Residual risk		
		Likelihood	Consequence	Risk rating		Likelihood	Consequence	Risk rating
8	Introduction of new alien fish to the aquatic environment as a result of ACTEW Water's operations.	E	3	Low	• ACTEW Water will advise ACT Government of any illegal fishing activities identified during the filling and operation. • Awareness training/ inductions for ACTEW Water employees and contractors. • ACTEW Water will work with ACT land managers to promote community education.	E	3	Low
9	Introduction of EHN virus plus Redfin Perch into Cotter Reservoir as a result of ACTEW Water's operations.	E	2	Neg.	• Development of an EHN Virus Response Plan. • ACTEW Water will advise ACT Government of any illegal fishing activities identified during the filling and operation. • Awareness training/ inductions for ACTEW Water employees and contractors. • ACTEW Water will work with ACT land managers to promote community education.	E	2	Neg.
10	Major fuel spill, oils and other contaminants entering the aquatic environment during filling and operation.	E	1	Neg.	• Environmental Management Procedures, training and awareness (ACTEW Water)	E	1	Neg.

4.2.3 Other species

A number of other species (Murray cod, Trout cod and Murray River crayfish) have been identified as potentially threatened, due to ECD project impacts, in previous risks assessments. For the filling and operational phases of the ECD project residual risks have been assessed as negligible(refer to Table 9).

Trout cod are located in the Bendora Reservoir and possibly in the Cotter River upstream and downstream of Bendora Dam, but not in the Cotter Reservoir. Although water may be released from Bendora Reservoir to help manage water quality in the Cotter Reservoir during filling, the operating regime of Bendora Reservoir is not expected to change significantly, so risks to Trout cod in the reservoir or in the Cotter River downstream of Bendora Reservoir are considered **negligible**.

Murray cod are located in the Murrumbidgee River downstream of the ECD. The environmental flow regime downstream of the ECD is managed as required by the Environmental Flow guidelines (ACT Government 2006), ACTEW Water's Licence to Take Water and the ECD Commonwealth Conditions of Approval. On this basis, any risk to Murray cod as a result of flow releases from the ECD is considered **negligible**.

Murray River crayfish are located in the Cotter River upstream and downstream of Cotter Dam and in the Murrumbidgee River downstream of the Cotter River. The main threats to Murray River crayfish are increased predation by alien fish, sedimentation of benthic habitat and changed flow regime downstream of the ECD. All these threats are considered **negligible** given the recommended management actions.

Table 9 - Current and residual risk to Trout cod, Murray cod and Murray River crayfish

	Potential threat	Current risk			Management and mitigation measures	Residual risk		
		Likelihood	Consequence	Risk rating		Likelihood	Consequence	Risk rating
Trout cod								
1	Change in operating regime of Bendora Reservoir	E	2	Neg.	• The operating regime of Bendora Reservoir is not expected to be significantly altered – no specific management or mitigation measures are required	E	2	Neg.
Murray cod								
1	Change in flow regime in Cotter River downstream of ECD	E	2	Neg.	• Environmental flow regimes downstream of ECD are managed as required by the Environmental Flow guidelines (ACT Government 2006), ACTEW Water's Licence to Take Water and the ECD Commonwealth Conditions of Approval	E	2	Neg.
Murray River crayfish								
1	Increased abundance of alien fish in the enlarged Cotter Reservoir	E	1	Neg.	• Implementation of the alien fish management strategy.	E	1	Neg.
2	Operation of the enlarged Cotter Reservoir reduces sustainability of downstream habitat in the long term.	E	2	Neg.	• Environmental flow regimes downstream of ECD are managed as required by the Environmental Flow Guidelines (ACT Government 2006), ACTEW Water's Licence to Take Water and ECD Commonwealth Conditions of Approval.	E	2	Neg.
3	Sedimentation of habitat	E	2	Neg.	• Installation of related erosion and sediment control measures as required.	E	2	Neg.
4	Major fuel spill, oils and other contaminants entering the aquatic environment during filling and operation.	E	1	Neg.	• Environmental Management Procedures, training and awareness (ACTEW Water)	E	1	Neg.

4.3 Implications of Risk Assessment on management of threatened species

Based on the risk assessment undertaken on 28 May 2013 ACTEW Water has sufficient monitoring and management systems in place to adequately mitigate known risks to threatened aquatic species resulting from the enlargement of the Cotter Reservoir.

For all residual risks that were Low and above ACTEW Water has developed mitigation and management actions, as shown in Table 10 and Table 11 below. Those underlined are discussed in more detail in the following Section.

Table 10 - Current and residual risk to Macquarie perch

#	Potential threat	Management and mitigation measures	Residual risk	Management and mitigation measure status
1	Short term oxygen depletion during filling (days/weeks <4mg/L in the 0-7m zone) as a result of inundation of vegetation.	• ECD Macquarie Perch Filling Phase Plan and De-stratification system. • The ECD Filling Plan includes management measures for implementation when low DO trigger levels are reached	Low	Macquarie Perch Filling Phase Plan is completed and includes actions when low DO triggers levels are reached (see Appendix D). Five de-stratification units were placed on the Cotter Reservoir in September 2013 and are ready for use pending floating log removal (scheduled for December 2013)
2	Rapid oxygen depletion (< 2.0mg/L in the 0-3m zone) as a result of turnover.	• Macquarie Perch Filling Phase Plan and De-stratification system. • The Macquarie Perch Filling Phase Plan includes management measures for implementation when low DO trigger levels are reached.	Low	
3	Loss of fish habitats (loss or reduced survival of macrophyte beds and/or altered condition of edge-boulder environments).	• Constructed rock reef habitat has been provided. • Native hardwood habitat left in-situ.	Medium	Seven kilometres of rock reef placement complete Native hardwood habitat left in situ Monitoring of Macquarie perch condition in included in ECD Fish Monitoring Program
4	Reduction in decapod crustaceans due to loss of macrophyte habitat	• Constructed rock reef habitat has been provided. • Native hardwood habitat left in-situ	Medium	
5	Increased abundance of existing alien fish species in the lower Cotter River and reservoir.	• Implementation of the alien fish management strategy.	Low	Alien Fish Management Plan prepared (see Appendix G)
6	Increase in cormorant predation.	• Constructed rock reef habitat has been provided. • Native hardwood habitat left in-situ. • The Macquarie Perch Filling	Medium	Seven kilometres of rock reef placement complete Native hardwood habitat left in situ

#	Potential threat	Management and mitigation measures	Residual risk	Management and mitigation measure status
		Phase Plan includes management measures for cormorant population increases.		Macquarie Perch Filling Phase Plan is completed and includes triggers for cormorant population increases
7	Loss of spawning areas in the Cotter River due to inundation.	• Water level and inflow management during spawning informed by annual spawning risk assessment. • Results of barriers identification project will be used to inform the annual spawning risk assessment.	Medium	EPA Licence condition to undertake annual Spawning Risk Assessment. Barriers project currently being implemented
8	Reduced fish passage limiting access to spawning sites in Cotter River.	• Water level and inflow management during spawning informed by annual spawning risk assessment. • Results of barriers identification project will be used to inform the annual spawning risk assessment.	Medium	
9	Cold water releases from Bendora Reservoir during the spawning season providing the wrong temperature signal.	• Continue to manage temperature of environmental releases from Bendora Reservoir in accordance with ACTEW Water's Licence to Take Water.	Low	EPA Licence condition to manage temperature of environmental flow releases
10	Introduction of new alien fish to the aquatic environment as a result of ACTEW's operations.	• ACTEW Water will advise ACT Government of any illegal fishing activities identified during the filling and operation. • Awareness training/ inductions for ACTEW Water employees and contractors. • ACTEW Water will work with ACT land managers to promote community education.	Low	Training being implemented to all relevant ACTEW Water staff Training being implemented to all relevant ACTEW Water staff; this will include procedures for notifying ACT Government of illegal fishing activities. ACTEW Water is working with ACT Land Managers as part of the Source Water Protection program.
11	Introduction of EHN virus plus Redfin Perch into Cotter Reservoir as a result of ACTEW's operations.	• Development of an EHN Virus Response Plan. • ACTEW Water will advise ACT Government of any illegal fishing activities identified during the filling and operation. • Awareness training/ inductions for ACTEW Water employees and contractors. • Ongoing support of translocation programs outside of the Lower Cotter catchment. • ACTEW will work with ACT land managers to promote community education.	Medium	EHN Virus Response Plan complete (see Appendix F) Training being implemented to all relevant ACTEW Water staff Translocation program being implemented Training being implemented to all relevant ACTEW Water staff; this will include procedures for notifying ACT Government of illegal fishing activities. ACTEW Water is working with ACT Land Managers as part of the Source Water Protection program.

Table 11 - Current and residual risk to Two-spined blackfish

#	Potential threat	Management and mitigation measures	Residual risk	
1	Short term oxygen depletion during filling (days/weeks <4mg/L in the 0-7m zone) as a result of inundation of vegetation.	• Macquarie Perch Filling Phase Plan and De-stratification system. • The Macquarie Perch Filling Phase Plan includes management measures for implementation when low DO trigger levels are reached	Low	Macquarie Perch Filling Phase Plan is completed (See Appendix D). Five de-stratification units were placed on the Cotter Reservoir in September 2013 and are ready for use pending floating log removal (scheduled for December 2013
3	Habitat loss in newly inundated areas due to sedimentation of habitat	• Catchment management and remediation. • Constructed rock reef habitat has been provided. • Native hardwood habitat left in-situ.	Medium	ACTEW Water actively supports land management in the Cotter catchment Seven kilometres of rock reef placement complete Native hardwood habitat left in situ
4	Fluctuating water levels expose deposited eggs in the ECD	• Water level and flow manipulation during spawning season	Low	Two-spined blackfish spawning risks to be assessed as part of the Macquarie perch annual spawning risk assessment
5	Cold water releases from Bendora Reservoir during the spawning season providing the wrong temperature signal.	• Continue to manage temperature of environmental releases from Bendora Reservoir in accordance with ACTEW Water's Licence to Take Water.	Low	EPA Licence condition
7	Increased abundance of existing alien fish species in the lower Cotter River and reservoir.	• Implementation of the alien fish management strategy.	Low	Alien Fish Management Strategy prepared
8	Introduction of new alien fish to the aquatic environment as a result of ACTEW's operations.	• ACTEW Water will advise ACT Government of any illegal fishing activities identified during the filling and operation. • Awareness training/ inductions for ACTEW Water employees and contractors. • ACTEW Water will work with ACT land managers to promote community education.	Low	Training being implemented to all relevant ACTEW Water staff; this will include procedures for notifying ACT Government of illegal fishing activities. ACTEW Water is working with ACT Land Managers as part of the Source Water Protection program.

Actions identified to mitigate risks from the ECD project on native fish will be documented in a number of management plans and other documents, namely:

- Macquarie Perch Filling Phase Plan
- Alien Fish Management Plan
- EHN Virus Management and Response Plan
- Annual spawning risk assessment (to be conducted each year prior to the spawning season)
- Environmental Flow Guidelines (ACT Government 2006)
- ACTEW Water's Licence to Take Water
- Environmental management procedures, training and awareness.

Furthermore, the ECD Fish Monitoring Program will monitor trends in native and alien fish abundance and recruitment success. Data from this monitoring program will be used to inform and further develop trigger levels for management actions contained within the abovementioned plans.

5 Management during filling and operation

5.1 Management strategy, monitoring and active management

The strategy for threatened fish management in the enlarged Cotter Reservoir is shown at Figure 6 below. Key elements the strategy includes:

- 100% compliance with ECD regulatory requirements.
- The preparation of an overarching management plan (this *ECD Fish Management Plan*) with input and review from relevant stakeholders.
- Meeting the objectives of the FMP for each of the phases of the ECD project.
- Regular identification of the risks to threatened aquatic species arising from ACTEW Water's operations (*ECD FMP Risk Assessment*) with advice and review from relevant stakeholders.
- Identification of appropriate management and mitigation measures, with plans and trigger levels to guide their implementation (*e.g. Alien Fish Management Plan; EHN Virus Management and Response Plan).*
- A fish monitoring program to deliver ecological data to ACTEW Water and stakeholders to assist and inform the management of threatened aquatic species
- Ongoing involvement of a Fish Management Plan Steering Committee with input from expert panels and other key stakeholders as required.

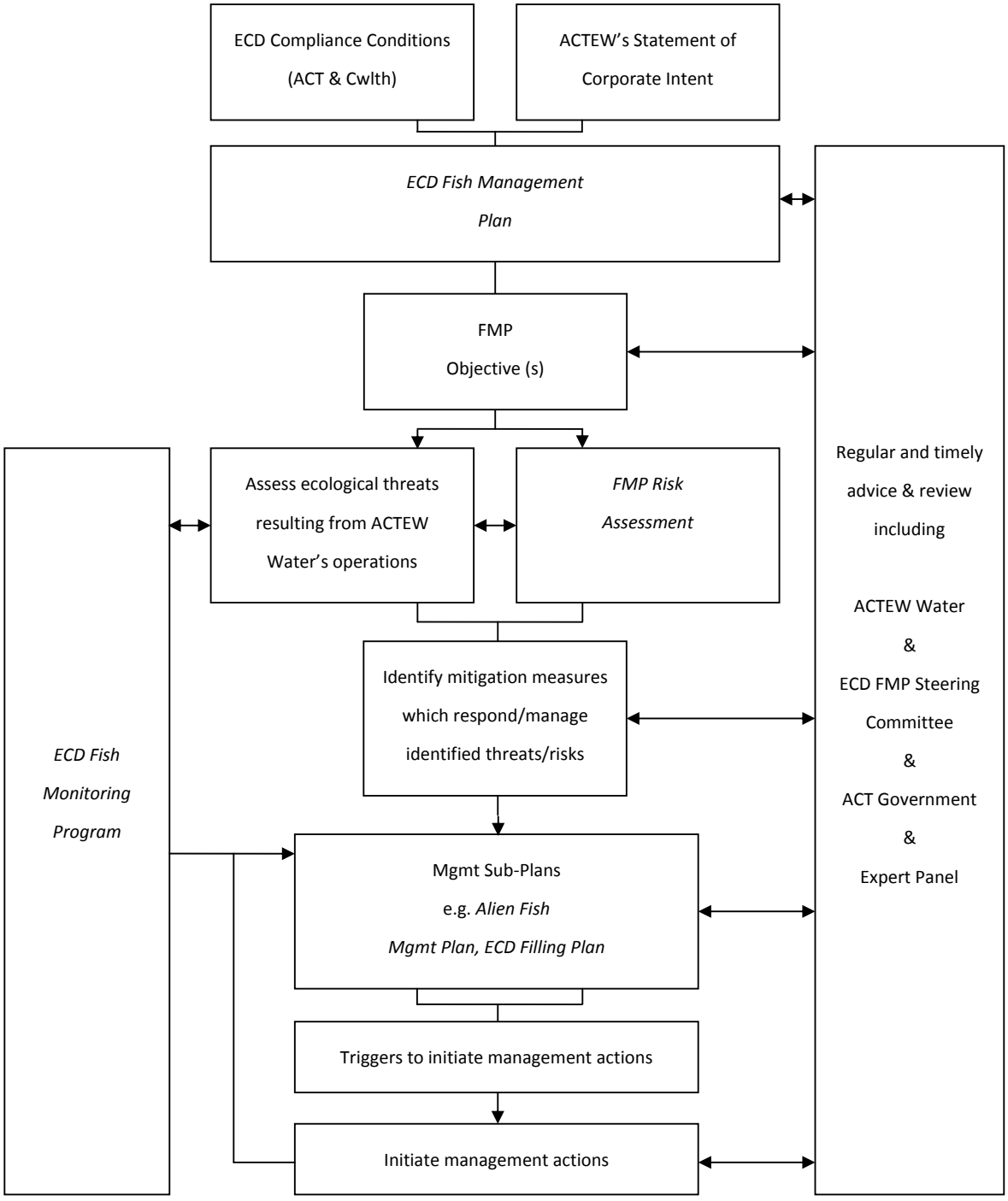


Figure 6 - ACTEW Water's fish management strategy for the Cotter Reservoir

In addition to monitoring already undertaken within the Cotter catchment (*ECD Fish Monitoring Program*) additional targeted monitoring will be undertaken to inform trigger levels for the initiation of management actions, for the protection of threatened fish, during filling and operation of the reservoir. The targeted monitoring criteria include:

- dissolved oxygen (DO) levels
- cormorant population numbers.

Active management of the reservoir also occurs through a variety of mechanisms:

- environmental flow management
- Macquarie perch spawning risk assessment
- Filling Plan implementation
- EHN Virus Management and Response Plan implementation and training

These are individually discussed in more detail below.

5.1.1 Macquarie perch Filling Phase Plan

To manage the risk to Macquarie perch during filling and operational phase due to low DO conditions and associated cormorant predation, the Macquarie Perch Filling Phase Plan requires the following management and mitigation measures to be implemented:

- Monitoring of water quality in the reservoir to inform adaptive management responses in the event DO levels drop below established thresholds. Data collection is via three water quality buoys installed across the reservoir uploading DO and temperature information and the communication of this information ACTEW Water officers.
- Operation of mixers in the enlarged reservoir to assist in destratification and the remediation of low DO conditions.
- Slowing the rate of filling: If there is a threat of the enlarged Cotter Reservoir filling quickly and submerging large areas of vegetation quickly, water can be released from the Enlarged Cotter Dam to reduce the area of inundation. This provides some measure of control over the speed of reservoir filling; however, due to the probable high differential between inflows from significant rainfall and the ECD's outflow capacity, this response is unlikely to be particularly effective as a single mitigation response.
- Release of water from Bendora Reservoir to assist in remediating low DO conditions in the Cotter River/reservoir inlet area. These flows would be in addition to the required environmental flows. The FMP Sub Committee, would be convened to provide management and technical advice to ACTEW Water on the health of the Macquarie perch in the Cotter Reservoir and would need to determine whether the benefits to the Macquarie perch would outweigh any detrimental effects to Cotter River ecology.
- Emergency translocation of Macquarie perch from the Cotter Reservoir as a last resort mitigation option. Relocations could occur at natural sites such as the Cotter River upstream of inundation zone (between Vanity's Crossing and Pipeline Crossing); Bendora Reservoir; and Corin Reservoir and upstream.
- Cormorant management program: Noise will be used to scare cormorants from the reservoir during periods of potential low DO, to reduce the risk of Macquarie perch predation. Following a scare, cormorants tend to leave the area for approximately 7 days before returning, making noise an effective deterrent. If cormorant numbers exceed established management thresholds (based on monitoring undertaken as part of Project 9) lethal control may also be considered. Both of these actions would require prior approval for the ACT Government.

The following trigger levels will guide necessary actions (Table 12):

Table 12 - Established trigger levels and management response

Stage	Depth	Triggers		Response
		DO	Duration	
1	3m	Between 4.5 - 6mg/L at 3 or more locations	7 consecutive days	• Undertake Cotter Reservoir weekly field inspections. These inspections involve looking for signs of distressed fish and taking water quality spot measurements at specific habitat locations (habitat and edge locations). Continue to implement for minimum 1 week after DO level returns to above trigger level. • Consider implementation of cormorant control options as per the ECD Cormorant Management Program
2	3m	Between 3 – 4.5mg/L at 3 or more locations	4 consecutive days	• Undertake Cotter Reservoir thrice weekly field inspections. These inspections involve looking for signs of distressed fish and taking water quality spot measurements at specific habitat locations (habitat and edge locations). Continue to implement for minimum 1 week after DO level returns to above trigger level • Consider implementation of cormorant control options as per the ECD Cormorant Management Program • Consider release of additional water from Bendora Reservoir or release of water from Cotter Reservoir. • Prepare to initiate translocation as per the ECD Emergency Translocation Program
3	3m	Less than 3mg/L at 5 locations or more	3 consecutive days	• Undertake Cotter Reservoir daily field inspections. These inspections involve looking for signs of distressed fish and taking water quality grab samples at specific habitat locations (habitat and edge locations). Continue to implement for minimum 1 week after DO level return to above trigger level. • Consider implementation of cormorant control options as per the ECD Cormorant Management Program. • Consider implementation of translocation program as per the ECD Emergency Translocation Program

The actions described in Table 12 are described in further detail in the Macquarie Perch Filling Phase Plan (Appendix D).

5.1.2 DO levels

As vegetation becomes inundated during filling and begins to decompose there may be associated decreases of DO in the water column of the enlarged Cotter Reservoir. This may be exacerbated by warmer temperatures.

While many native aquatic species can survive for short periods of time in water containing low DO levels, extended low DO conditions can be fatal to fish. Low DO levels may also force fish closer to the water surface where they are more susceptible to predation by cormorants.

The most significant DO drop events are likely to occur after significant rainfall events, particularly in summer (November to March) when warmer water temperatures lead to a rapid increase in bacteria numbers.

The Macquarie perch population in the Cotter Reservoir have previously survived very low DO events as a result of the Canberra bushfires when DO dropped well below 4mg/L.

ACTEW Water have installed three water quality monitoring buoys in the Cotter Reservoir that collect DO and temperature information across the reservoir. This information informs the management actions and trigger levels identified in the Macquarie Perch Filling Phase Plan. Management actions triggered by DO levels include:

- reservoir inspections
- cormorant control (see below)
- management of inflows/outflows
- translocation.

ACTEW Water will consult a Sub-Committee of the Fish Management Program Steering Committee prior to implementing any management actions.

5.1.3 Alien Fish Management Plan

The ECD Alien Fish Management Plan (Appendix G) will use the monitoring data gathered from the ECD Fish Monitoring Program to identify appropriate trigger levels for mitigation responses. While the dataset builds, ACTEW Water is undertaking detailed investigations into mitigation options which focus on mitigating alien fish impacts on threatened fish.

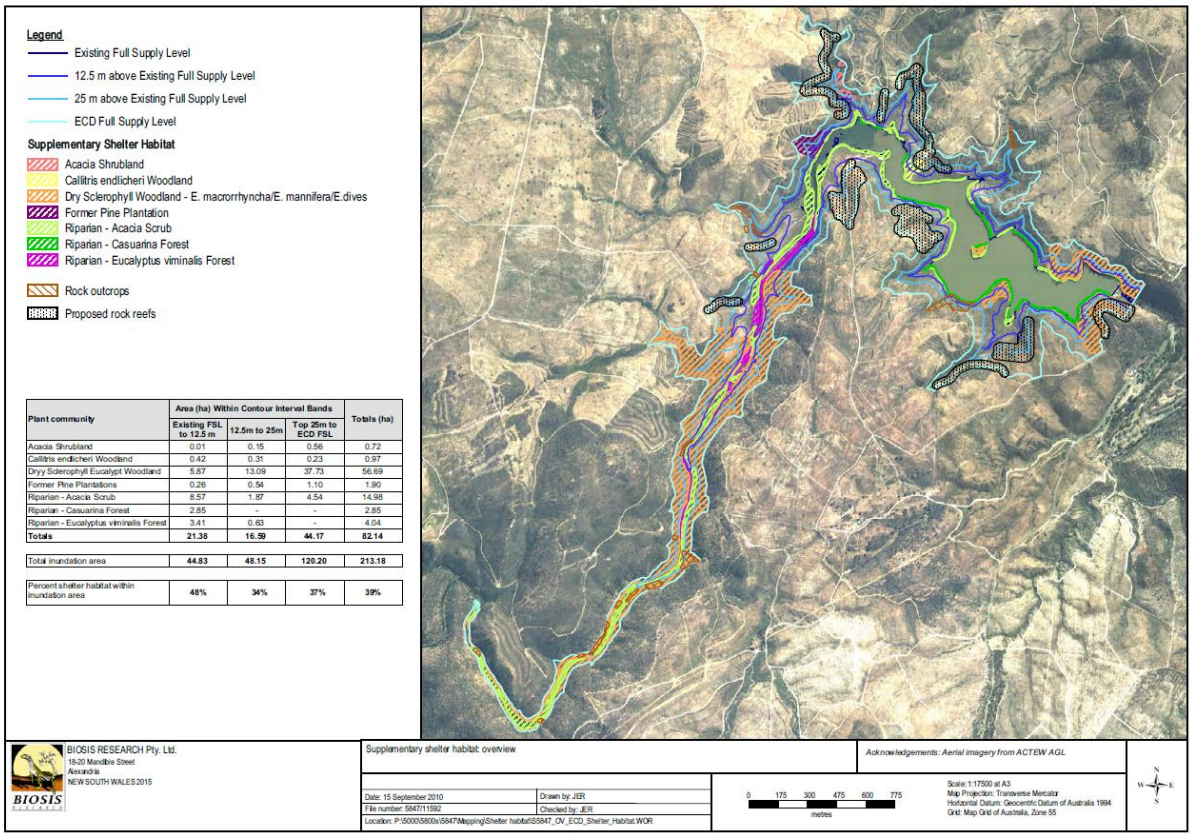
5.1.4 Cormorant population numbers

A shortage of suitable shelter habitat during the filling phase, or low DO causing fish to rise to the surface, would make Macquarie perch more susceptible to avian predators, especially cormorants. Due to this potential risk, significant work has gone into:

- assessing the availability of Macquarie perch habitat once filling of the Enlarged Cotter Reservoir commences
- assessing the impacts of critical numbers of cormorants associated with predation of Macquarie perch.

Habitat availability work has determined that vegetation between the current FSL of Cotter Dam and RL 520m (the level at which constructed rock reef habitat commences) will provide Macquarie perch with suitable shelter habitat during the filling phase (see Figure 7).

Cormorant management involves monitoring cormorant numbers and if required, scaring cormorants away from the reservoir during periods of Macquarie perch DO stress (particularly during the spawning season). This can be as simple as firing a gun nearby or disturbance by driving a boat around the reservoir. Lethal take of cormorants may also be considered. The management of cormorants on the Cotter Reservoir requires support from the ACT Government.



Plant community	Area (ha) Within Contour Interval Bands			Totals (ha)
	Existing FSL to 12.5 m	12.5m to 25m	Top 25m to ECD FSL	
Acacia Shrubland	0.01	0.15	0.56	0.72
Callitris endlicheri Woodland	0.42	0.31	0.23	0.97
Dryy Sclerophyll Eucalypt Woodland	5.87	13.09	37.73	56.69
Former Pine Plantations	0.26	0.54	1.10	1.90
Riparian - Acacia Scrub	8.57	1.87	4.54	14.98
Riparian - Casuarina Forest	2.85	-	-	2.85
Riparian - Eucalyptus viminalis Forest	3.41	0.83	-	4.04
Totals	**21.38**	**16.59**	**44.17**	**82.14**
Total inundation area	**44.83**	**48.15**	**120.20**	**213.18**
Percent shelter habitat within inundation area	**48%**	**34%**	**37%**	**39%**

Figure 7 - Vegetation within the enlarged Cotter reservoir inundation zone

5.1.5 Spawning Risk Assessment

ACTEW Water is required to provide a Macquarie Perch Spawning Risk Assessment to the ACT EPA every year prior to spawning season. This assessment looks at the previous spawning success of the reservoir population, and based on ACTEW Water's proposed operations of ECD (i.e. reservoir level and inflows); assess the likelihood and criticality of spawning success. This assessment is based on two key factors:

- The presence or absence of natural riverine barriers immediately upstream of the reservoir (determined by reservoir level and inflows).
- The recent history of spawning success as indicated by the monitoring data provided through the Fish Monitoring Program. ACTEW Water's broad aim is to achieve successful spawning conditions two years in every five.

5.1.6 Environmental flows

ACTEW Water's release of environmental flows into the Cotter Reservoir (from Bendora Reservoir) has key linkages to riverine and Cotter Reservoir ecosystem health. ACTEW Water is strictly regulated by the ACT

Environment Protection Authority with regard to these environmental flow releases, via ACTEW's *Licence To Take Water* and the *ACT Water Resources Act 2007*.

The releases from Bendora Dam into the Cotter River and ultimately the enlarged Cotter Reservoir include base flows, riffle flows and pool flushing flows: each of which perform various ecosystem functions. Furthermore, the temperatures of releases are also regulated, with ACTEW Water required to match downstream water quality conditions as much as is practicable. More information on this can be found in the *ACT Environmental Flow Guidelines* on the ACT EPA and ESDD web pages.

5.1.7 EHN Management and Response Plan and training

ACTEW Water's EHN Virus Management and Response Plan (Appendix F) outlines management actions to ensure that ACTEW water staff and contractors do not bring EHN Virus into the Cotter catchment. This includes training for all ACTEW Water staff and contractors working in the catchment; as well as a reporting process should illegal fishing activities be sighted by staff.

5.2 Cooperation and coordination with government agencies

It is critical to ensure that ACTEW Water's regulators are satisfied with all aspects of the ECD Fish Management Program. To provide a forum to ensure that ACTPLA and DoE are satisfied with how ECD approval conditions (relating to the protection of threatened fish species) are being met a Fish Management Program Steering Committee was established.

The following is an excerpt from the Terms of Reference for the FMP Steering Committee:

The Steering Committee responsibilities are to:

- Oversee the activities being undertaken to meet EIS and PER approval conditions and EIS commitments.
- Work with ACTEW Water and BWA to ensure approval conditions and commitments are met.
- Provide strategic direction and inform the implementation of the broader project.
- Represent the interests and needs of the organisations represented by the Steering Committee and the broader stakeholder group.
- Provide advice and assist in the communication of Fish Management Plan outcomes.

During the construction phase the FMP Steering Committee had representation from:

- DoE (formerly SEWPAC)
- ACT Government – TAMS
- ACT Government – EPA/ESDD
- University of Canberra Fish Biologist (ACTEW's Fish Advisor)
- Bulk Water Alliance
- ACTEW

Expert opinion on issues was sought when required. Although the FMP Steering Committee met regularly during the construction phase of the ECD project it now meets on a needs basis.

6 References

ACT Government 2006, *Environmental Flow Guidelines,* Environment and Sustainable Development Directorate, Canberra.

ACT Government 2007, *ACT Aquatic Species and Riparian Zone Conservation Strategy,* Department of Territory and Municipal Services, Canberra.

ACTEW Corporation [ACTEW] 2010, *Enlarged Cotter Dam Fish Management Plan Version 2*, Canberra.

Allen, G. R., S. H. Midgley, and M. Allen. 2002, *Field guide to the freshwater fishes of Australia*, Western Australian Museum, Perth.

Astles, K, Winstanley, R, Harris, J and Gehrke, P 2003, *Regulated rivers and fisheries restoration project - Experimental study of the effects of cold water pollution on native fish,* Sydney, NSW Fisheries Office of Conservation.

Bernays, E. A., K. L. Bright, N. Gonzalez, and J. Angel. 1994, *Dietary mixing in a generalist herbivore: tests of two hypotheses,* Ecology 75:1997-2006.

Cadwallader, P. L. and J. D. Douglas. 1986, *Changing food habits of Macquarie perch Macquaria australasica Cuvier (Pisces: Percichthyidae). during the initial filling phase of Lake Dartmouth, Victoria*, Australian Journal of Marine and Freshwater Research 37:647-657.

Cadwallader, P. L. and A. K. Eden. 1979, *Observations on the food of Macquarie perch, Macquaria australasica (Pisces: Percicthyidae) in Victoria*, Australian Journal of Marine and Freshwater Research 30:401-409.

Cadwallader, P. L. and P. L. Rogan. 1977, *The Macquarie perch, Macquaria australasica (Pisces: Percicthyidae), of Lake Eildon, Victoria*, Australian Journal of Ecology 2:409-418.

Douglas, J., A. Giles, and R. Strongman. 2002, *Lake Dartmouth Multi-species Fishery Assessment. Marine and Freshwater Resources Institute Freshwater Fisheries Report No. 02/2*, Marine and Freshwater Resources Institute, Department of Natural Resources and Environment, Victoria.

Fishway Consulting Services 2011, Pipeline Crossing Rock-Ramp Fishway: Commissioning Report, St Ives.

Fulton, C, Starrs, D and Ruibal, M 2010, *Distribution, abundance and habitat-use of upland river populations of Murray River crayfish (Euastacus armatus),* final report to the ActewAGL Future Water Planning Group, Research School of Biology, College of Medicine, Biology and Environment, Australian National University, Canberra.

Gooderham, J. and E. Tsyrlin. 2002, *The waterbug book: a guide to the freshwater macroinvertebrates of temperate Australia,* CSIRO Publishing, Collingwood, Victoria.

Gray, S. C., S. S. De Silva, B. A. Ingram, and G. J. Gooley. 2000, *Effects of river impoundment on body condition and reproductive performance of the Australian native fish, Macquarie perch (Macquaria australasica),* Lakes & Reservoirs: Research and Management 5:281-291.

Howell, T., L. J. Laurenson, J. H. Myers, and P. L. Jones. 2004*, Spatial, temporal and size-class variation in the diet of estuary perch (Macquaria colonorum) in the Hopkins River, Victoria, Australia*, Hydrobiologia 515:29-37.

Lammers, J. H., K. Warburton, and B. W. Cribb. 2009, *Anti-predator strategies in relation to diurnal refuge usage and exploration in the Australian freshwater prawn, Machrobrachium australiense,* Journal of Crustacean Biology 29:175-182.

Lintermans, M. 2006, *The re-establishment of endangered Macquarie perch Macquaria australasica in the Queanbeyan River, New South Wales, with an examination of dietary overlap with alien trout,* Cooperative Research Centre for Freshwater Ecology, Canberra.

Lintermans, M, Broadhurst, B, Thiem, J, Ebner, B, Wright, D, Clear, R and Norris, R 2010, *Constructed homes for threatened fishes in the Cotter River catchment: Phase 2 Final Report*, Report to ACTEW Corporation, Institute for Applied Ecology, University of Canberra, Canberra.

Lintermans, M 2010, *Research into the establishment of new populations of Macquarie Perch, Trout Cod and Two-spined Blackfish through translocation: Progress report for Milestone 3*, prepared for ACTEW April 2010, Institute for Applied Ecology, University of Canberra, Canberra.

Lintermans, M 2013, *Research into the establishment of new populations of Macquarie perch, Trout cod and Two-spined blackfish through translocation: Final Draft Report*, prepared for ACTEW August 2011, Institute for Applied Ecology, University of Canberra, Canberra.

Lobel, P. S. and J. C. Ogden. 1981, *Foraging by the herbivorous parrotfish Sparisoma radians,* Marine Biology 64:173-183.

Mallen-Cooper, M 2011, Design of a Rock-Ramp Fishway for Pipeline Crossing, Cotter River, ACT, prepared for ACTEW Corporation, Fishway Consulting Services, St Ives.

Norris, R., Wright, D., Lintermans, M., Bourke, D. and Harrison, E 2012, *Food resources for Macquarie perch in Cotter Reservoir – Final report*, Institute for Applied Ecology , University of Canberra.

Schmude, K. L., M. J. Jennings, K. J. Otis, and R. R. Piette. 1998, *Effects of habitat complexity on macroinvertebrate colonization of artificial substrates in north temperate lakes,* Journal of the North American Benthological Society 17:73-80.

Schoener, T. W. 1971, *Theory of feeding strategies,* Annual Review of Ecology and Systematics 2:369-404.

Smith, J. A., L. J. Baumgartner, I. M. Suthers, and M. D. Taylor. 2011, *Generalist niche, specialist strategy: the diet of an Australian percichthyid,* Journal of Fish Biology 78:1183-1199.

Starrs, D, Fulton, C and Starrs, T 2009, *Predicted passage of native and alien freshwater fish in the Cotter River, ACT using measures of swimming speed performance,* Report to ActewAGL Future Water Planning Program, Research School of Biology, College of Medicine, Biology and Environment, Australian National University, Canberra.

Sternberg, D., S. Balcombe, J. Marshall, and J. Lobegeiger. 2008, *Food resource variability in an Australian dryland river: evidence from the diet of two generalist native fish species,* Marine and Freshwater Research 59:137-144.

Vantage Environmental Management 2013, *Enlarged Cotter Dam Audit of Requirements of Conditions of Approval.*

Wharton, J. C. F. 1968, *Spawning areas of the Macquarie perch Macquaria australasica above the Eildon Lake (Victoria),* Australian Society for Limnology Newsletter 6:11-13.

Whitington, R 2008, *Testing for EHNV Cotter Dam*, Report to ACTEW Corporation, Faculty of Veterinary Science, University of Sydney, Sydney.

7 Glossary and abbreviations

Term	Definition
ACT	Australian Capital Territory.
ACT EPA	ACT Environment Protection Authority.
ACTEW	ACTEW Corporation.
ACTPLA	ACT Planning and Land Authority.
Biosis	Biosis Research Pty Ltd.
BRUV	Baited Remote Underwater Video.
BWA	Bulk Water Alliance. A partnership between ACTEW and ActewAGL, GHD, Abigroup and John Holland Group, formed for the delivery of water security projects.
CEMP	Construction Environmental Management Plan.
Chironomidae	Taxomonic family informally referred to as non-biting midges.
cm	Centimetre.
Coleoptera	Taxonomic order of the beetle.
CPUE	Catch per unit effort; the number of target individuals caught for each sampling period.
d^{-1}	Per day.
DA	Development Application.
Decapoda	Taxonomic order of crustaceans including freshwater shrimp *Paratya australiensis* and freshwater prawns *Macrobrachium australiens.*
DEWHA	The Commonwealth Department of the Environment, Water, Heritage and the Arts.
Diel	24 hour period.
Diel range	Length of shoreline used by an individual in a complete diel period.
Diel mobility	Sum of all movements of an individual in a complete diel period.
Diel activity	Mean percentage of distance covered by an individual for each interval between tracks for each diel period.
Diptera	Taxonomic order of flies and midges.
DO	Dissolved oxygen.
EHN virus	Epizootic Haematopoietic Necrosis virus.
EIS	Environmental Impact Statement.
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

Term	Definition
Ephemeroptera	Taxonomic order of the mayfly.
ESDD	Environment & Sustainable Development Directorate
FSL	Full Supply Level.
GIS	Geographic Information System.
GL	Gigalitres.
GPS	Global Positioning System. A system which enables a mobile receiver to determine its precise location based on signals received from satellites orbiting the Earth.
ha	Hectares.
Home range (daily only)	The total length of shoreline used by an individual based on daily tracks only.
Home range (total)	The total length of shoreline used by an individual for all tracks.
IRI	Index of Relative Importance.
km	Kilometres.
m	Metres.
mm	Millimetres.
Mesohabitat	Medium scale patches of habitat in which an organism can live. Measured over a 10-100 m scale.
Microhabitat	A small, specific habitat type within a mesohabitat patch where an organism resides, for example under and between boulders in a river. Measured at a 1-10 m scale.
ML	Megalitre.
NSW	New South Wales.
OCL	Occipital carapace length. The length of the hard shell which forms the exoskeleton of the crayfish. Does not include the tail segments.
PCL	Parks, Conservation and Lands, a branch within the ACT Government Department of Territory and Municipal Services.
PER	Public Environment Report.
pH	A measure of the acidity or basicity of a solution.
Piscivorous	Feeds on fish.
PIT	Passive Integrated Transponder.
Quadrat	A quadrat is a measured and marked rectangle used in ecology to isolate a sample.
s^{-1}	Per second.

Term	Definition
DoE	The Commonwealth Department of the Environment (formerly Sustainability, Environment, Water, Population and Communities).
Snags	Large structural woody debris (including fallen trees, branches and root balls) in a waterway which is partly or wholly submerged in water.
TAMS	Territory and Municipal Services, a department within the ACT Government.
Tricoptera	Taxonomic order of the caddisfly.
Ucrit	Critical swimming speed, measured as the final velocity reached prior to fatigue during prolonged swimming trials.
Usprint	Sprint swimming speed, measured as the final velocity reached prior to fatigue during sprint swimming trials.

8 Appendices

Appendix A **Review by Independent Auditor**

Appendix B **ECD Fish Monitoring Baseline Data Report**

Appendix C **ECD Fish Monitoring Program (Summary)**

Appendix D **ECD Macquarie Perch Filling Phase Plan**

Appendix E **EHN Virus Disinfection Report**

Appendix F **EHN Virus Management & Response Plan**

Appendix G **ECD Alien Fish Management Plan**

Appendix H **ECD Native Fish Risk Assessment**