Appendix D

Aquatic ecology impact assessment (Cardno Ecology Lab)

Shaping the Future

Marine and Freshwater Studies

Macquarie River to Orange **Pipeline Project**

Proposed Project Refinements – MR5a

Aquatic Ecology Assessment

Final Report

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Cover Image: MR5a Offtake site as seen from the northern bank of the Macquarie River, December 2012 (Source: Orange City Council).

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Executive Summary

Background and Scope of Works

This Aquatic Ecology Assessment part of the Environmental Assessment for the Macquarie River to Orange Pipeline Project focuses on an alternative offtake site situated adjacent to Cobbs Hut Hole on the Macquarie River and the pipeline corridor between that site and Chainage 4000 on Long Point Road (the MR5a Route).

The scope of works for the assessment included:

- Description of the existing aquatic environment of the study area/sites that could potentially be impacted by the project;
- Assessment of the impacts of the construction and operation of the offtake and the specified section of the pipeline on the aquatic environment and its biota, including any threatened species, populations and communities listed under NSW State and Federal legislation;
- Recommendations on practical, cost-effective mitigation/management measures that could be used to avoid or minimise the impacts of the proposed works;
- Assessment of differences in impacts and the quantum of impacts associated with the route outlined in the EA and the MR5a route.

Existing Environment

In October 2012, the aquatic habitat, aquatic plants, macroinvertebrates and fish that occur in the Macquarie River in the vicinity of Cobbs Hut Hole were surveyed and the aquatic habitat occurring at two potential pipeline crossings on unnamed watercourses was assessed.

A variety of aquatic habitats, including deep pools, silty and sandy substrata, cobbles, large boulders, bedrock and woody snags, were observed in the river, but instream aquatic vegetation was scarce. The riparian strip along the river was generally complete and consisted of exotic grasses and shrubs, River She-oak and Eucalypts. The pool edge habitat supported a diverse range of aquatic macroinvertebrates, with between 14 and 20 taxa represented per site. Five native fish species (Murray Cod, Golden Perch, Carp Gudgeon, Flathead Gudgeon and Australian Smelt) and one alien species (European Carp) were caught.

The road crossing at one site consisted of a corrugated iron/concrete culvert. The channel downstream of the culvert contained exotic grasses and shrubs and a few sedges and rushes but little water. Upstream of the culvert, there were shallow pools containing mostly boulders and cobbles and small numbers of a native fish species (Australian Smelt). The aquatic habitat in this watercourse was degraded and considered to be of minimal value as fish habitat.

The crossing at the other site consisted of a concrete ford over which the water was flowing. There were small, shallow pools with a silt/clay substratum and occasional boulders and cobble both upstream and downstream of this crossing. The aquatic habitat in this watercourse was also degraded and considered to be of unlikely value as fish habitat.

Potential Impacts and Mitigation Measures

Offtake Structure

The construction of the Offtake Structure adjacent to Cobbs Hut Hole would result in loss of a small area of aquatic habitat, degradation of adjacent riparian and aquatic habitats, reduction in water quality and exposure of aquatic biota to increases in sediment load and possibly greater levels of nutrients, organic matter and contaminants. The feeding excursions of platypus, movements of fish and downstream drift of aquatic macroinvertebrates could also be constrained when the coffer dam is installed. The loss of habitat would be permanent below the Offtake Structure but the other impacts would be localised and short-term in nature due to the small footprint and relatively short duration of the works, respectively.

These impacts would be minimised by:

- Limiting the disturbance of riparian zone and aquatic habitat;
- Rehabilitating disturbed areas;
- Implementing appropriate sediment and erosion control measures;
- Establishing a bunded area for storage of fuels, oils, refuelling and maintenance of construction vehicles and mechanical plant;
- Excluding biota from the construction area using coffer dams and translocating aquatic fauna trapped therein;
- Screening the pump inlet used to dewater coffer dams; and
- Avoiding instream construction work during the spawning and recruitment phases of the threatened fish species.

The construction of the Offtake Structure is unlikely to have a significant effect on instream ecology, given the above control measures.

Once the Offtake Structure is *in situ* and operational it would have the following impacts on aquatic ecology of the Macquarie River:

- Provision of a small area of artificial habitat;
- Disturbance of aquatic fauna resulting from noise and/or vibration
- Increased risk of predation due to stress and/or provision of novel habitat for fish and bird predators;
- Entrainment within the extracted water and/or impingement on screens of aquatic macroinvertebrates, invertebrate plankton, fish eggs and larvae and plant fragments;
- Injury and/or mortality of small organisms that pass through the screen and collide with impellors in the pump and wall of the pipeline or are exposed to changes in pressure;
- Exposure of water, sediments and biota to contaminants if lubricants are lost from the pump;
- Exposure of aquatic habitats and their biota to small decreases in the volume of low to moderate and moderate to high flows, reductions in and greater variability in hydraulic characteristics (i.e. stream depth, flow velocity, flow area and hydraulic radius);
- Reduced opportunity for passage of fish and platypus across riffle/cascade habitats downstream of the Offtake site due to decrease in water depth.

The potential for impacts associated with operation of the water transfer system would be avoided, minimised or mitigated by:

- Starting the pump up slowly and then ramping up its velocity to a level that reduces the chances of aquatic biota being drawn into the pump;
- Using a 2 mm mesh screen located in front of the suction manifold to minimise entrainment of fish eggs and larvae;
- Limiting the extraction period to 19 hours per day and to flows above 38 ML/d;
- Passing air through the screen at the end of each day's operation to dislodge organisms trapped on the mesh;
- Placing the pump within a wet sump and use of relatively small extraction rate would limit mobilisation of sediments;
- Using a sealed pump to minimise the risk of water and sediments becoming contaminated if lubricants were lost from the pump.

An additional mitigation measure that could be considered is the installation of devices that would deflect fish away from the Offtake Structure.

The provision of a small area of artificial habitat and localised impacts due to noise and vibration, increased risk of predation and loss of lubricants are unlikely to have significant effects on instream ecology. The use of a fine mesh exclusion screen and slow pumping rate would result in only a small proportion of the organisms passing the offtake site being entrained within or impinged on the Offtake Structure. These processes are consequently unlikely to have a significant effect on instream ecology.

Impacts on aquatic habitat and abundance and composition of biotic assemblages are likely to depend on the proportion of flows extracted, with effects being greater when moderate proportions (>20%) of low to moderate flows are extracted from the Macquarie River and greatest when 12 ML/d is extracted from a 38 ML/day flow. As the extraction operation will be intermittent and the water that is removed will be replenished by flows from upstream, the impacts on aquatic habitat during any one day are likely to be minor and transient. The reduction in stream depth would also be proportionally greater in riffle/cascade habitat than in pool habitat. There would be no impact on the availability of aquatic habitats during low and very low flow periods, because extraction would not occur under these conditions. The proportion of flows that could be removed before effects on abundance and composition of biotic assemblages and movements of aquatic fauna become detectable is not known. The scientific literature, however, indicates extraction of low to moderate volumes of water has little impact on aquatic macroinvertebrates.

The effect of extraction on the movements of fish, platypuses and turtles depends on the reduction in stream depth and their minimum depth requirements and swimming abilities, which will in turn vary with species, body size and shape. Approximations derived from Manning's equation indicate the movement of medium to large-bodied fish species and platypus across narrow riffles would be constrained during low to medium flows and that movement upstream across wide riffles may only be possible during some medium to high flows. Reductions in water depth due to extraction would further limit the movement of medium and large-bodied fish species and platypus. As extraction operations would be intermittent, the number of days that minimum depths would be exceeded would be only slightly smaller than under natural conditions and the water that is removed would be replenished by inflows from upstream, the impact on movement of fish and platypus would be transient. The numerous pools along the river would serve as temporary refugia when the water level drops to a level that hinders the movement of fish and platypus through shallow habitats.

Impacts on habitats and biota would be offset by rehabilitating other areas of habitat equivalent in size to those disturbed by the Project.

Pipeline Crossings

The construction of pipeline crossings over the waterways along the MR5a route would result in degradation of riparian and aquatic habitats, reduction in water quality and exposure of aquatic biota to increases in sediment load and possibly greater levels of nutrients, organic matter and contaminants.

The potential for impacts would be minimised by:

- Using existing cleared easements for the pipeline;
- Ensuring the alignment of the pipeline does not disturb locations containing significant aquatic or riparian habitat;
- Selecting construction methods that have a smaller construction footprint and result in less disturbance of the stream bed and banks and any associated vegetation;
- Using appropriate sediment and erosion control measures to protect aquatic habitats and biota immediately downstream of the construction area;

- Maintaining the existing hydraulic, hydrological, geomorphic and ecological function of the watercourses;
- Minimising the duration of in-stream activities;
- Limiting construction of crossings during times that are important for completion of life cycles (e.g. in spring and summer when threatened fish species spawn and recruit);
- Rehabilitating disturbed areas of stream bed and banks;

The construction of the pipeline crossings over the streams along the MR5a Route is unlikely to have a significant effect on instream ecology, given the above control measures.

Once the water transfer system is operating, instream ecology could potentially be impacted by leakage of water and sediment from the pipeline, discharge of water from scour valves and periodic cleaning of the pipeline.

These impacts would be avoided by:

- Undertaking routine inspections of the pipeline to ensure early detection of leaks;
- Prompt repair of leaks;
- Prohibiting direct discharge of water contained within the pipeline into watercourses via scour valves, except in emergencies and providing the quality of the water is acceptable.

Conservation Issues

Matters of National Environmental Significance

Three threatened fish species (Trout Cod, Murray Cod and Macquarie Perch) listed under the *EPBC Act* could occur in the vicinity of Cobbs Hut Hole. NSW DPI fish stocking records show that over the past decade Murray Cod fry have been released at a number of sites on the Macquarie River, with most being downstream of Cobbs Hut Hole. Trout Cod fry have also been released but mainly upstream of this site. During the October 2012 survey, an adult Murray Cod was caught approximately 300 m upstream of the proposed offtake site.

Assessments of the significance of impacts on EPBC-listed species indicate that local Murray Cod, Trout Cod and Macquarie Perch (if present) populations may be impacted during the construction and operation of the offtake. Adoption of the recommended mitigation and management measures would reduce the potential for impact on these species to minor levels.

Matters of State Environmental Significance

Three threatened fish species (Trout Cod, Silver Perch and Macquarie Perch) and one threatened fish population (Murray River Basin Population of Freshwater Catfish *Tandanus tandanus*), listed under the *FM Act* could occur in the vicinity of Cobbs Hut Hole, while two threatened fish species (Flathead Galaxias and Southern Purple-Spotted Gudgeon) could potentially occur in some of the unnamed streams. Assessments of the significance indicate that the Macquarie River to Orange Pipeline Project is unlikely to have a significant impact on the threatened species and population identified, provided the proposed avoidance, mitigation and management measures are adopted.

Comparison of the MR5a and EA Routes

Cobbs Hut Hole contains a greater variety of aquatic habitat and therefore probably supports a more diverse range of aquatic biota than Gardiners Hole. The total area of aquatic habitat that would be lost to construction would be greater at Cobbs Hut Hole than at Gardiners Hole. The erosion and depositional processes at Cobbs Hut Hole also appear to differ from those at Gardiners Hole, suggesting the potential for impacts on water quality, aquatic biota and threatened species during construction works may also differ. The construction of the

Offtake Structure, however, is unlikely to have a significant effect on instream ecology at either site, provided the proposed sediment and erosion control measures are adopted.

Impacts associated with the presence of the Offtake Structure, exposure to noise and vibrations and loss of lubricants during extraction operations are likely to affect a greater range of biota at Cobbs Hut Hole than at Gardiners Hole, but would not have a significant effect on instream ecology at either site. The risk of entrainment and impingement would be similar at the two sites, but effects could differ if the aquatic organisms vulnerable to these processes are more abundant at one site than the other. If the proposed control measures are adopted, losses due to entrainment and impingement would not be significant at either site. The impact of extraction on aquatic habitats would be greatest when 12 ML/day is extracted from a river flow of 38 ML/day. This would result in a 39 mm drop in the water level in Cobbs Hut Hole but only a 23 mm decline in Gardiners Hole. The proportional reduction in water depth over downstream riffle/cascade habitat would be greater than in the pool and also greater below Cobbs Hut Hole than Gardiners Hole. The potential for impact on passage of fish through such features is therefore likely to be greater at Cobbs Hut Hole. The reductions in depth, however, would be smaller than those that occur naturally during low and very low flows, so the impact of extraction on fish passage is unlikely to be significant.

The risk of construction and operation impacts at pipeline crossings of streams would be similar along the two routes provided appropriate mitigation measures were implemented.

Conclusion

There is a greater potential for impacts on aquatic ecology along the MR5a Route than the EA route, but the residual impact after control measures are implemented would be similar.

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1 Introduction

1.1 Purpose of this Report

Orange City Council (OCC) proposes to undertake the Macquarie River to Orange Pipeline Project ('The Project') to improve water security for Orange. An Environmental Assessment (EA) for The Project prepared by GHD (2012) in accordance with the requirements of Part 3A of the NSW Environmental Planning and Assessment Act 1979 (EP and A Act) was placed on public exhibition in August 2012. The EA included assessments prepared by a number of specialists, including an Aquatic Ecology Assessment that focused on a proposed offtake site adjacent to Gardiners Hole, the major waterways that would be crossed by a 37 km long pipeline extending from Gardiners Hole to Suma Park Dam and the receiving environment around the discharge structure (Cardno Ecology Lab 2012).

Orange City Council has now proposed the use of an alternative offtake site at Cobbs Hut Hole, approximately 4.6 river kilometres upstream of Gardiners Hole. This is one of the alternative offtake locations considered initially in the feasibility study for The Project (MWH 2010) and the Concept Investigation (MWH 2011). Cardno Ecology Lab, on behalf of Orange City Council, has prepared an additional aquatic ecology assessment for the alternative offtake site on the Macquarie River and a pipeline corridor extending between there and the original Chainage 4000 on Long Point Road (Figure 1). This assessment constitutes an addendum to the original Aquatic Ecology Assessment (Cardno Ecology Lab 2012). Further information on the location, including figures showing the overall route of the refined project, is provided in volume 1.

1.2 Scope and Structure of Assessment

1.2.1 Scope of Works

The scope of works for the Assessment included:

- Description of the existing aquatic environment at the alternative offtake site MR5a and potential stream crossings identified between Cobbs Hut Hole and Chainage 4000 on Long Point Road (referred to hereafter as the MR5a route);
- Assessment of the impacts of the construction and operation of the alternative offtake and pipeline section on the aquatic environment and its biota, including any threatened species, populations and communities listed under NSW State and Federal legislation;
- Provision of recommendations on practical, cost-effective mitigation/management measures that could be used to avoid or minimise the impacts of the proposed works;
- Assessment of differences in impacts associated with the route outlined in the EA and the MR5a route;
- Assessment of the quantum of impacts associated with the route outlined in the EA and the MR5a route.

This assessment also addresses the requirements of the Director-General of the NSW Department of Planning and Infrastructure (the Director-General's Requirements) dated 24 March 2011 and Supplementary DGRs issued by the Federal Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC) dated 27 February 2012.

1.2.2

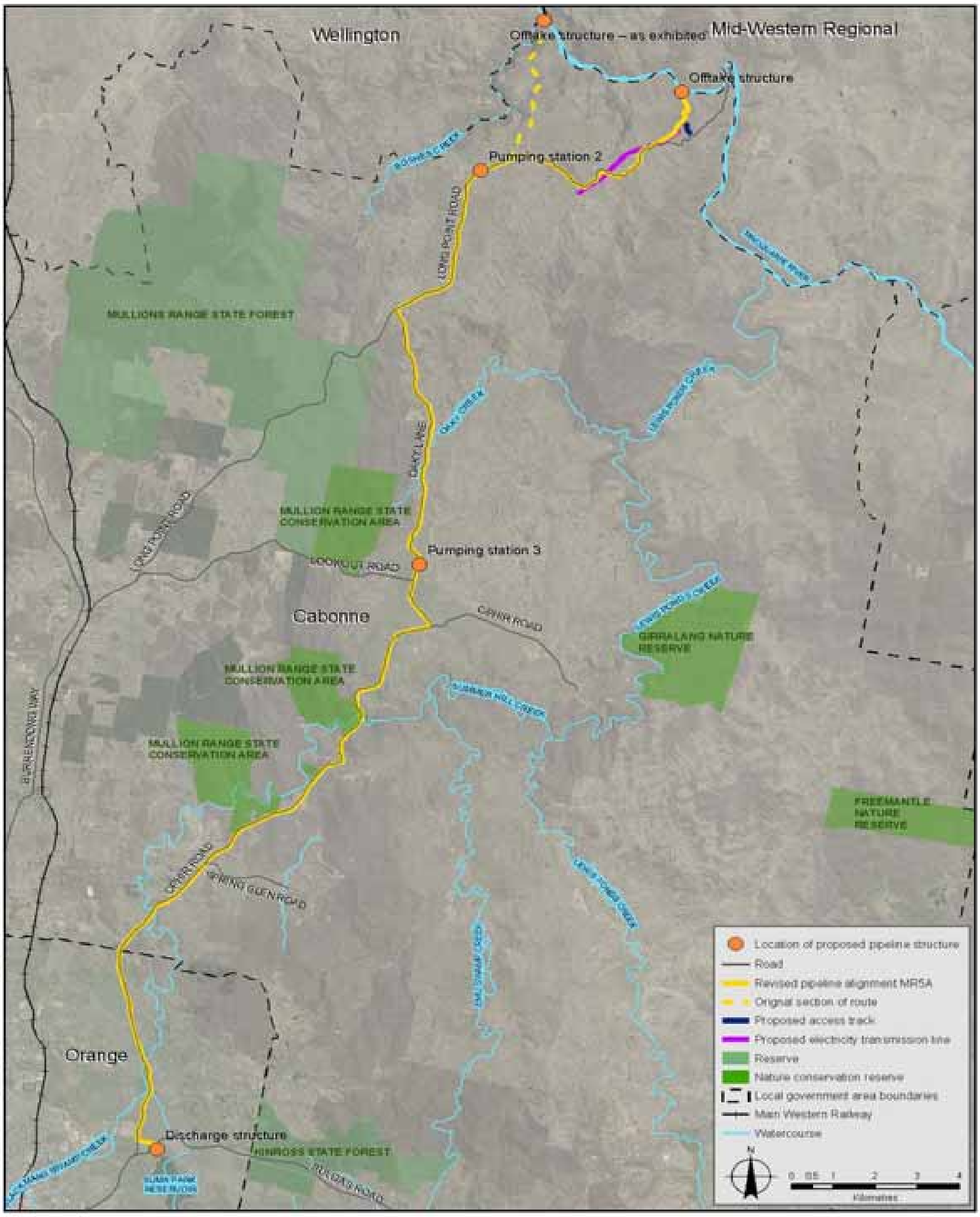

Figure 1
Location of the project

1.2.3 Sections where Director-General's requirements are addressed

The DGRs that are relevant to the Assessment are summarised in Table 1a, together with a reference to where they are addressed in the report.

Table 1a: Director General's (DoP) Requirements for the Aquatic Ecology Assessment

Assessment requirements	Section in report
Take into consideration impacts on any threatened species, populations, ecological communities, critical habitat	Section 5.
Riparian, instream ecology, water dependent ecosystems and groundwater dependent communities affected by the project, including consideration of the NSW Groundwater Dependent Ecosystems Policy	Sections 3 and 5.
Relevant recovery plans	Section 5
Riparian vegetation at watercourse crossings and downstream of the water offtake in the Macquarie River.	Section 3.2
Include a management framework outlining: measures to be implemented to avoid, mitigate, manage, monitor and/or offset aquatic impacts during construction and operation including but not limited to progressive rehabilitation works.	Sections 4 and 5.1.4.
Demonstrate the availability of viable and achievable options to offset the impacts of the project	Sections 4.1.1, 4.1.2 and 5.1.4
Where impacts are unavoidable, provide information on how impacts would be minimised, mitigated and offset consistent	Sections 4 and 5.1.4.
Identify impacts of construction of the off take pump on fish passage	Section 3.1.1.3
Identify how the pump would be designed to avoid entrainment or entrapment of fish eggs and larvae.	Section 4.1.2

The supplementary DGRs addressed in the Assessment are summarised in Table 1b, together with a reference to where they are addressed in the report.

Table 1b: Director General's (DSEWPAC) Requirements for the Aquatic Ecology Assessment

Assessment requirements	Where addressed in report
Assessment of relevant impacts on threatened ecological communities and threatened species listed under the *EPBC Act*	Sections 5.1.3 and 5.1.5
Description of proposed safeguards, mitigation and offset measures	Section 5.1.4, Table 3

1.2.4 Structure of the Assessment

This report contains the following sections:

- A description of the existing aquatic environment in the vicinity of the Cobbs Hut Hole offtake site and potential pipeline crossing sites on two unnamed creeks (Section 2);
- An assessment of the potential impacts on instream ecology at the above sites during the construction and operational phases of the project (Section 3);
- An overview of methods for avoiding, mitigating and offsetting potential impacts on instream ecology at the above sites during the construction and operational phases of the project (Section 4);

- Assessments of potential impacts of the project on aquatic biota of National and State conservation significance (Section 5);
- Assessment of differences in impacts and quantum of impacts associated with the route outlined in the EA and proposed MR5a route (Section 6);
- Conclusions (Section 7);
- Additional references cited (Section 8).

The Appendices referred to in the text are presented at the end of the report.

2 Existing Aquatic Environment

The following description of the existing aquatic environment adjacent to the preferred offtake site at Cobbs Hut Hole on the Macquarie River and waterways along the MR5a route is based on the results of a two day field survey of five study sites conducted on the 8th and 9th October 2012. The field studies were divided into two components: an initial investigation of all the stream crossings along the alternative pipeline route, followed by in-depth studies of aquatic ecology at sites containing sufficient and appropriate aquatic habitat.

2.1 Objectives

The primary objective of these investigations was to describe the existing aquatic environment at sites that may be impacted by The Project and identify issues that may arise from the proposed works.

The specific objectives of the studies at the stream crossings were to:

1. Assess the condition of the aquatic and riparian habitats and water quality at the proposed pipeline crossings over the major creeks (if applicable) and minor creeks/gullies, if water is present;
2. Identify potential issues associated with the installation of the proposed pipeline;
3. Identify study sites for more in-depth studies of aquatic ecology.

The objectives of the in-depth studies were to

1. Assess the condition of aquatic and riparian habitat features and water quality at the time of sampling;
2. Determine the species composition, structure and condition of native and non-native aquatic vegetation;
3. Determine the taxonomic composition and “health” of the aquatic macroinvertebrate fauna associated with riffle and pool edge habitats;
4. Identify and estimate the relative abundance of native and alien fish species and confirm the presence of any threatened fish species; and
5. Determine whether platypus is present.

The survey undertaken was not intended to serve as a baseline for impact assessment.

2.2 Study Sites

In-depth aquatic ecology studies were undertaken in the vicinity of the alternative offtake site adjacent to Cobbs Hut Hole on the Macquarie River (MR5a) and at sites 300 m upstream and 200 m downstream thereof (Figure 2). The aquatic habitats in two small un-named creeks/gullies situated to the south of the Macquarie River along the proposed MR5a route were also assessed, but the fish and macroinvertebrates occurring at these potential pipeline crossings were not sampled. The assessment of each study site was based on an approximately 100 m stretch of watercourse. For the smaller gullies, this included 50 m upstream and downstream from the proposed pipeline route.

The GPS co-ordinates of the study sites are listed in Appendix 1 and their position along the MR5a Route is shown in Figure 2.

2.3 Sampling Conditions

There was no significant rainfall in the week leading up to the field survey, so flows within the vicinity of the study area near the gauging station downstream of Long Point within the Macquarie River were fairly stable (400 - 500 ML/day). The conditions during this survey were very different from those that prevailed during the survey of sites undertaken for the Aquatic Ecology Assessment. Significant rainfall prior to the field survey undertaken in December 2011 resulted in very high water flows and levels within the Macquarie River and its associated tributaries.

Figure 2: Position of the aquatic ecology survey sites along the MR5a route.

2.4 Study Methodology

The condition of the aquatic and riparian habitat, measurements of water quality and occurrence of aquatic macroinvertebrates and fish at each study site were assessed using the methodology outlined in Section 3.4 of the Aquatic Ecology Assessment (Cardno Ecology Lab 2012).

2.5 Results

2.5.1 Macquarie River

2.5.1.1 Cobbs Hut Hole and MR5a Offtake Site

Cobbs Hut Hole is a natural pool situated immediately upstream of a large riffle/cascade sequence on the southern bank of a bend in the Macquarie River. At the time of sampling, the river ranged in width from 50 m to 60 m and had a maximum water depth of approximately 3 m. The flow through the main channel was considered moderate. The riverbed was composed mostly of silt and sand. There were also numerous bedrock outcrops at the downstream extremity of the pool and areas of sand/gravel interspersed with large boulders, cobble and bedrock along the northern shoreline. A number of large, woody snags (covering approximately 15% of the entire shoreline within the site) were also present, but mostly along the southern bank. The river banks are steep with a slope of 30-40%, reflecting the location of this reach of the river within a valley (Cardno 2013). Photographs of Cobbs Hut Hole and the proposed offtake site are presented in Plate 1.

(a)

(b)

(c)

Plate 1: **Macquarie River –** Views of (a) Cobbs Hut Hole from the northern bank and (b) shoreline along the northern bank at the time of sampling in October 2012 and (c) the proposed MR5a offtake site as seen in December 2012 from the northern bank.

Macrophytes were relatively scarce in this section of the river, with a total cover of approximately 5% and consisting mostly of rice sedge (*Cyperus difformis*) and rush (*Juncus* sp.). The riparian strip was generally complete and consisted mainly of exotic grasses and shrubs, although large river she-oak (*Casuarina cunninghamiana*) and a number of Eucalypts made up around 20% of the riparian vegetation along the shoreline. Two distinct breaks in the riparian tree line were evident on the southern bank, with one adjacent to the gauging station and the other opposite the riffle/cascade sequence. The cover of detritus within the offtake site was estimated to be around 10% and bank overhang was considered low/moderate (around 30%).
The surrounding land use consisted mostly of grazing land and native forest. The RCE score calculated for this section of the river was 40, which indicated a relatively undisturbed watercourse with low habitat degradation.

Water clarity at the time of sampling was considered fair/good, with turbidity levels averaging 8.00 NTU which was within ANZECC (2000) guidelines (Table 2). Other physico-chemical variables recorded during sampling were also within ANZECC (2000) guidelines, with the exception of pH (8.15) which was slightly higher than the recommended trigger value of 8.0 (Table 2).

Table 2: Mean (±S.E.) physico-chemical water quality measurements taken at sites along the MR5a route during site inspections in October 2012. The default trigger values taken from ANZECC/ARMCANZ (2000) guidelines for slightly disturbed river ecosystems in South-east Australian are also displayed. Grey shading indicates value outside of guidelines.

	ANZECC (2000) trigger values	Macquarie River						Un-named Creeks/Gullies			
		Offtake		Downstream		Upstream		WPT 339		WPT 340	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Temperature (°C)		18.01	0.05	17.67	0.02	18.21	0.09	20.81	0.04	22.05	0.01
Conductivity (mS/cm)		0.28	0.02	0.26	0.00	0.30	0.01	0.51	0.00	0.77	0.02
Conductivity (µS/cm)	30 - 350	317.00	0.00	312.00	0.00	312.00	0.00	554.50	1.50	844.50	4.50
Salinity (ppt)		0.15	0.00	0.13	0.00	0.14	0.01	0.25	0.00	0.39	0.01
pH	6.5 - 8.0	8.15	0.03	8.12	0.07	8.16	0.01	7.93	0.01	7.66	0.00
ORP (mV)		459.50	1.50	407.00	2.00	447.00	1.00	483.50	0.50	483.00	1.00
DO (% sat.)	90 - 110	103.70	0.50	108.00	0.60	107.25	1.15	120.95	1.05	110.20	1.30
DO (mg/l)		9.80	0.10	10.25	0.05	10.10	0.10	10.80	0.10	9.60	0.10
Turbidity (NTU)	2 - 25	8.00	0.33	15.13	0.15	11.42	0.19	1.35	0.10	4.78	0.49

The macroinvertebrate sample yielded 20 taxa and was dominated by leptoflebs (Leptophlebiidae), Caenidae and stick caddis (Leptoceridae) (Appendix 2). The sample was equivalent to the AUSRIVAS freshwater reference condition (Band A), with an excess of 9% of the families with a 50% probability of occurrence predicted to occur in pristine streams with similar characteristics. The SIGNAL2 score (3.95) for this site is indicative of “severe pollution” due to the paucity of sensitive macroinvertebrate taxa within the sample collected.

Cobbs Hut Hole appears to contain significant fish habitat. Carp gudgeon (*Hypseleotris* sp.), freshwater prawns (*Macrobrachium australiense*) and freshwater shrimp (Atyidae) were sampled using bait traps. The electrofishing also yielded freshwater prawns (*M. australiense*) and 2 specimens of golden perch (*Macquaria ambigua*), with fork lengths of 38 and 43 cm. The perch were caught in a hole that was approximately 1.6 m deep at the time of the survey situated to the north of the site of the proposed offtake and immediately west of the bed rock outcrop (Figure 2). Australian smelt (*Retropinna semoni*) were observed along the northern bank within the shallows. No fish were caught in the gill nets set at this site.

The proposed offtake would be constructed on the southern bank of the river at the eastern end of Cobbs Hut Hole immediately upstream of a high strength rock bar that extends approximately half-way across the river and opposite the large sand/gravel point bar on the northern bank (Plate 1b). This rock bar controls the level of ponding in the pool and is likely to deflect flow and dissipate fluvial energy during low flows but be overtopped during high flows (Cardno 2013). The southern river bank is steep and vegetated with river she-oak trees and grasses.

2.5.1.2 Downstream Site

This site was situated approximately 200 m downstream of the proposed offtake site. The site contained mostly pool habitat, bordered by two large riffle/rapid sections. The width of the river throughout the site ranged between 20 and 30 m, and the maximum water depth was estimated to be around 2 m at the time of sampling. The instream substratum consisted mostly of sand and silt (a total of 50% cover for both categories combined) with some areas of clay also present. Boulders and cobble were present along most of the northern shoreline. The two riffle sections at the extremities of the site contained mainly large boulders and cobble. The percentage cover of timber snags, and thus potential fish habitat, within this reach of the river (approximately 5%) was lower than that observed at the offtake site. Photographs of the river downstream of MR5a are presented in Plate 2.

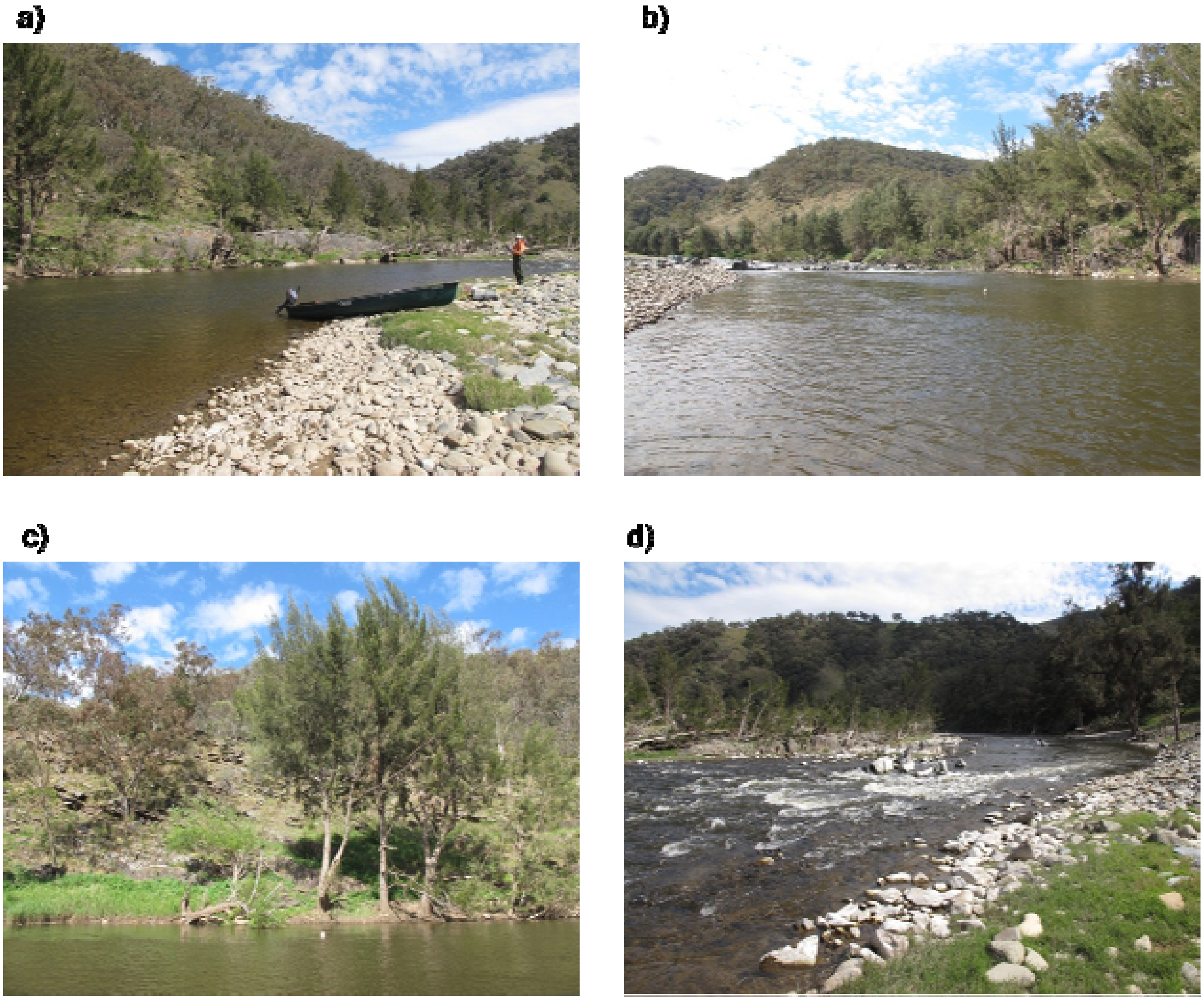

Plate 2: **Macquarie River – Downstream of MR5a** - a) Downstream view; b) Upstream view; c) Typical riparian vegetation along the south-western shoreline; (d) Riffle/rapid section immediately downstream of site.

Very few macrophytes were observed within this part of the river, with only small fragments of emergent rice sedge and rush (*C. difformis and Juncus* sp., respectively) scattered throughout the site. The riparian vegetation along the southern bank was mostly complete, consisting of exotic grasses and shrubs (30% cover) and large, scattered river she-oaks (*C. cunninghamiana*) (5% cover). The shoreline along the northern edge of the site was mostly devoid of riparian vegetation, but was stabilised by a large boulder/cobble accumulation that lead into both the downstream and upstream riffle/rapid sections of the site. The cover of detritus within this downstream reach (approx. 10%) was similar to that observed at the offtake site. Very little bank overhang on either shoreline was present during the survey. As for the proposed offtake site, the surrounding land use consisted mostly of grazing land and native forest. The RCE score calculated for this section of the river was 41, which indicated a relatively undisturbed watercourse with low habitat degradation.

A visual assessment of the water quality indicated little evidence of disturbance, with visibility considered good and no indication of foaming or odour present. With the exception of pH, none of the water quality variables measured during the survey was outside of the trigger values defined in the ANZECC (2000) guidelines. As at the proposed offtake site, the mean pH value was again slightly higher than the ANZECC (2000) trigger value of 8.00 for slightly disturbed ecosystems within south-east Australia (Table 2).

The macroinvertebrate sample yielded 19 taxa and was dominated by leptoflebs (Leptophlebiidae) and non-biting midges (Chironominae) (Appendix 2). The sample was significantly impaired relative to the AUSRIVAS reference condition (Band B), lacking 27% of the families with a 50% probability of occurrence predicted to occur in pristine streams with similar characteristics. The SIGNAL2 score (4.25) for this site indicated moderate degradation.

Significant fish habitat was present within this reach of the river. No fish were sampled within bait traps, although a number of freshwater shrimp and prawns were caught. Electrofishing yielded many shrimp and prawns, but only 2 fish were captured, both flathead gudgeon (*Philypnodon grandiceps*). No fish were sampled in gill nets set at this site.

2.5.1.3 Upstream Site

The upstream site was also set in a steep valley, with the prevailing land usage consisting mainly of rural grazing land and pockets of native forest. Minimal flow was apparent through this section of the river, and the site consisted entirely of pool habitat with no riffle sections observed. Maximum water depth was estimated to be between 2 and 3 m at the time of sampling. The substratum consisted mainly of a sand/silt matrix (85% cover), although some areas of exposed bedrock were also present. The amount of detritus cover on the river bed was again considered low (around 10% cover), as was the cover of large woody snags within this section of the river (~5% cover). The site on the river upstream of MR5a is shown in Plate 3a-d.

Instream aquatic vegetation was scarce, although the trailing bank vegetation covered approximately 70 % of the entire site. Riparian vegetation was present along much of both shorelines, and generally consisted of exotic grasses and large river she-oaks. Bank stabilisation along much of the site was considered stable, with some very minor bank undercutting in some areas. The RCE score calculated for this section of the river was 37, which indicated a slightly disturbed watercourse with generally low habitat degradation.

Little evidence of disturbance was observed in terms of water quality, with water clarity considered good and no evidence of foaming or odour. As for the other two sites on the Macquarie River, only pH was outside of the ANZECC (2000) trigger values, marginally higher than the upper limit for slightly disturbed ecosystems for south-east Australia (Table 2).

The macroinvertebrate sample yielded 14 taxa, with leptoflebs (Leptophlebiidae), water boatmen (Corixidae), stick caddis flies (Leptoceridae) and Caenidae being dominant

(Appendix 2). The sample was equivalent to the AUSRIVAS reference condition (Band A) and lacked only 9% of families with a 50% probability of occurrence predicted to occur in pristine streams with similar characteristics. The SIGNAL2 score (3.96) for this site indicates severe degradation due to the paucity of ecologically sensitive macroinvertebrate taxa present within the sample collected.

Plate 3: **Macquarie River – Upstream site** a) Downstream view; b) Upstream view; c) Woody snag habitat along southern bank; d) View of bank along southern shoreline; e) Murray Cod (*Maccullochella peelii peelii*); f) Carp (*Cyprinus carpio*).

This site also contained significant fish habitat. Bait traps set within the shallows yielded numerous freshwater shrimp and prawns, along with 7 individuals of carp gudgeon. In addition, a 58 cm long Murray Cod (*Maccullochella peelii peelii*) and a 47 cm Carp (*Cyprinus carpio*) were sampled in and around a large woody snag along the southern shoreline using electrofishing techniques (See Plates 3e-f). Native fish were returned to the river following identification and measurement.

2.5.2 Pipeline Stream Crossings

The alternative pipeline route between MR5a and Chainage 4000 would cross five watercourses, two of which are situated between the Offtake and Long Point Road with the remaining three on Long Point Road. Sampling was undertaken at two potential crossing sites that contained sufficient and appropriate aquatic habitat.

2.5.2.1 Un-named Creek/Gully (Way Point 339)

WPT 339 was situated within a broad valley setting and located approximately 2.9 km east of old chainage 4000 along Long Point Rd. The existing road crossing consisted of a large corrugated iron/concrete culvert, approximately 20 m in length. The surrounding land was primarily used for cattle grazing. The major features of this site are shown in Plate 4a-d.

Plate 4: **WPT 339:** a) Downstream view; b) Upstream view; c) Further upstream; d) Existing culvert.

At the time of the survey, there was very little water within the channel downstream of the culvert and it appeared that very little flow had been present for some time (Plate 4a). As a result, exotic grasses and shrubs had become established over the channel substratum with only small fragments of aquatic vegetation such as the sedges *C. difformis* and *Carex* sp., and the rush *Juncus* sp. observed. The riparian zone also consisted mostly of exotic grasses and shrubs, although there were also some large eucalypt trees present, mainly along the landward edge of the riparian strip.

Upstream of the culvert, a series of shallow pools were present, with a maximum water depth of 0.5 m (Plate 4b). The substratum consisted mainly of boulder and cobble (60% combined cover), although silt, pebble and bedrock also contributed to the type of substratum in varying amounts. Aquatic vegetation was scarce upstream of the culvert (~ 5% cover), with the occasional tuft of rice sedge scattered along the shoreline. A mat of green filamentous algae was present in the pool closest to the culvert. Riparian vegetation was similar to that observed in the downstream section of the site, consisting mostly of exotic grasses and shrubs. Very little detrital cover was apparent within each of the pools, bank undercutting was very limited along this section of the site and no large woody debris was present. The RCE score for the site (27) indicated a moderately/highly disturbed watercourse with moderate/high habitat degradation. In terms of water quality, mean values of conductivity, dissolved oxygen and turbidity all fell outside of the trigger values set out in ANZECC (2000). Both conductivity and dissolved oxygen were above the upper trigger limits, whilst turbidity was below the lower limit set out in the guidelines. In addition to this, some foaming /scum was apparent in the upstream section of the site, although it was limited to a small area close to the culvert.

The site was classified as minimal fish habitat. Although no quantitative sampling of fish was undertaken at this site, a number of juvenile Australian smelt were opportunistically caught using a dip net in the pools upstream of the crossing.

2.5.2.2 Un-named Creek/Gully (WPT 340)

As for the previous site, WPT 340 was situated within a broad valley setting, located approximately 1.6 km east of chainage 4000 along Long Point Rd. The surrounding land was again classified as rural grazing land. The creek crossing consisted of an artificial ford (concrete), which allowed water to flow over it. The major features of this site are shown in Plate 5a-d.

A series of small pools were present upstream and downstream of the crossing with a maximum water depth of approximately 0.4 m. The substratum within the entire site consisted mainly of silt/clay with occasional boulders and cobble scattered throughout. Only small patches of aquatic sedges and rushes (*C. difformis* and *Carex* sp., *Juncus* sp.) were present along the shoreline of the gully. Riparian vegetation was made up solely of exotic grasses and weeds along this section of the site, although the banks appeared to be fairly stable. As for WPT 339, very little detritus was apparent within the sediment and no woody debris was observed within the watercourse. The RCE score for the site (25) indicated a highly disturbed watercourse with moderate/high habitat degradation.

Mean conductivity and dissolved oxygen measurements were both elevated compared to ANZECC (2000) guidelines for slightly disturbed ecosystems for south-east Australia. No foaming or odour was apparent within any of the pools present within the site.

The site was classified as unlikely fish habitat.

2.6 Conclusions

Data obtained during the survey provide an indication of the aquatic habitats and biota in the upper Macquarie River in the vicinity of Cobbs Hut Hole under moderate flow conditions that would prevail during operation of the pipeline. Data obtained from the unnamed streams were representative of conditions during low flow periods.

a) b)

c) d)

Plate 5: **WPT 340:** a) Downstream view; b) Upstream view; c) View of pool upstream of creek crossing; d) Pool immediately downstream of creek crossing.

3 Potential Impacts

In this section, the potential impacts on aquatic habitats, water quality and aquatic biota associated with of the construction and operation of the proposed Offtake Structure at Cobbs Hut Hole and the pipeline crossings over unnamed creeks situated along the MR5a route are described. Potential impacts on threatened species and populations and key threatening processes are described in Section 5. The measures that could be used to minimise potential impacts on the aquatic habitats, water quality and aquatic biota that occur in the waterways along the MR5a Route are described in Section 4 while those pertinent to minimising impacts on threatened species and populations and key threatening processes are described in Section 5.

3.1 Offtake Structure

The proposed position of the offtake structure, pumps, access road and associated infrastructure is shown in Figure 3. The offtake structure would consist of a concrete structure or trash rack enclosure surrounded by rock armouring and would be constructed by cutting into the bank of the river. The offtake structure would comprise an intake module, filter module and valve module. The filter module would incorporate trash screens to remove large floating objects from the intake water and fine screens (2 mm) to prevent uptake of and/or fouling by smaller objects, including identified threatened species.

3.1.1 Potential Construction Impacts

Construction activities that take place in the vicinity of the river bank and bed could have the following potential impacts on instream ecology:

- The disturbance of soils and sediments by construction equipment and runoff from the all-weather access road and areas where vegetation has been cleared and soils have been stockpiled could increase the sediment load in the river which, in turn, could have indirect impacts on water quality;
- The installation of the coffer dam would result in temporary loss of a small area of aquatic habitat, displacement of associated aquatic biota and changes in hydraulic conditions;
- The installation of the gabions and Offtake Structure would result in loss and/or degradation of riparian and aquatic habitats;
- Accidental release of lubricating oils, hydraulic fluids and fuel from construction equipment could result in the input of hydrocarbon and metal contaminants into the river;
- The modification of riparian and aquatic habitats and changes in water quality could have indirect impacts on abundance, distribution and health of aquatic and riparian biota.

Figure 3: Proposed position of the offtake structure, pumps and associated infrastructure at MR5a on the southern bank of the Macquarie River (Source: MWH).

3.1.1.1 Impacts on Aquatic and Riparian Habitat

The installation of the Offtake Structure would lead to permanent loss of approximately 27.2 m^2 (6.8 m of bank x 4 m into the river) of underlying benthic substratum and degradation of a small area of adjoining aquatic habitat (Caine Merten (MWH) 11 December 2012, email). The loss represents approximately 0.095% of the area within Cobbs Hut Hole (John Boyd (Orange City Council, 11 December 2012, email). As similar deep pool habitats are available nearby and at other locations in the upper Macquarie River, the loss of this habitat would not be significant. The temporary installation of a coffer dam would result in a short-term localised loss of 54 m^2 (9 m x 6 m) of aquatic habitat, but this would become available again once the dam is removed (Caine Merten (MWH) 11 December 2012, email).

The clearing of vegetation on the river banks and earthworks involved in the installation of the Offtake Structure could also degrade aquatic habitat. The deposition of sediments mobilised by runoff or through construction works could alter the nature of the benthic substratum and smother some aquatic habitats. Sections of the river bed and banks that are re-profiled may be more prone to erosion during flood events. As the concrete pit would be constructed in an area where there is bedrock just below the surface, such impacts would be minimal.

The cutting back of the embankment and installation of the gabions would result in permanent loss of a small area of riparian habitat and disturbance to adjoining areas of this habitat. The disturbance of the riparian zone would be addressed by rehabilitation works undertaken after the construction work is completed.

3.1.1.2 Impacts on Surface Water Quality

Runoff from cleared areas and stockpiles of soil, disturbance of the riverbed and banks by construction works within and adjacent to the watercourse, the installation, dewatering and dismantling of the coffer dam could lead to short-term increases in sediment loading and transfer of sequestered nutrients, organic matter and contaminants into the river. The clearing of vegetation and use of fertilisers during landscaping or rehabilitation works could lead to short-term increases in organic matter and nutrients, respectively.

Accidental spillage of fuels, hydraulic fluids and lubricating oils used in the operation of construction equipment could result in hydrocarbons and metals entering the river. The significance of the impact would depend on the type of fuel or oil used, the quantity spilt, the prevailing weather conditions and rate of flow of the river (i.e. dilution effect).

3.1.1.3 Impacts on Aquatic Fauna and Flora

The suspension of sediment particles in the water column would result in a short-term increase in the turbidity levels within the river, which if substantial or persistent, could in turn decrease the amount of light available for photosynthesis by aquatic plants, clog the gills and feeding apparatus of aquatic fauna and reduce the visual acuity of some predators. The sediment plumes that form would be dispersed downstream, with rate of dispersion depending on the prevailing river flow rate. As the aquatic flora and fauna that occur in the vicinity of MR5a would be exposed to moderate to large natural increases in sediment load during periodic rainfall events, temporary increases in sediment load are unlikely to have any significant effects on aquatic flora or fauna. Animals such as fish and shrimps that are capable of moving away from sediment plumes would be less susceptible to disturbance than sessile or sedentary species.

Sediment mobilised into waterways can release nutrients as they are carried downstream. The addition of excessive amounts of nutrients to rivers could result in the formation of algal and macrophyte blooms. The effects of additional nutrient inputs would depend on whether fertilisers are being used on the surrounding land, nutrient inputs from further upstream and the rate of flow within the river, with effects being greatest during protracted periods of low flows.

Impacts resulting from accidental inputs of fuel and oil would depend on their composition and properties, the quantities spilt, prevailing weather conditions and rate of flow of the river (i.e. dilution effect). Low concentrations of petroleum hydrocarbons are toxic to aquatic biota.

The input of organic matter in the form of leaves, wood, bark and detritus may be beneficial to small aquatic animals that feed on this resource or use it for shelter. The addition of large quantities of organic matter, however, can be problematic in pool environments, resulting in reductions in oxygen levels, changes in pH and increases in nutrient levels, which may in turn, have adverse effects on the biota living within the pool.

The installation of a coffer dam may hinder the localised movements and migration of fish species, downstream drift of aquatic macroinvertebrates and feeding excursions of platypus, if present. This effect would be restricted to a small area adjacent to the river bank and limited to the period of construction (expected to be about one month) and construction footprint of 54 m^2. It would not prevent downstream movements of fish and other organisms in the adjoining part of the river.

3.1.2 Potential Operational Impacts at the Offtake Site

Potential impacts on instream ecology that may occur during the operation of the Offtake and Pump Station include:

- Decreases in flow volume and velocity, stream depth and wetted perimeter which could lead to reductions in habitat availability, diversity and connectivity and affect movement of mobile fauna;
- Changes in habitat quality resulting from higher temperatures, reduced oxygenation and reduced dilution of effluents and contaminants;
- Entrainment and impingement of aquatic macroinvertebrates, invertebrate plankton, fish eggs and larvae and plant fragments by screens within the Offtake Structure;
- Physical injury or mortality of small aquatic organisms that pass through the screen and collide with impellors in the pump and wall of the pipeline or are exposed to changes in pressure;
- Disturbance of aquatic fauna resulting from noise and/or vibration;
- Increased risk of predation due to stress and/or provision of novel habitat for fish and bird predators (Blackley 2003).

The severity of impact on aquatic ecology depends on the magnitude, duration and timing of extraction operations and the availability of water (Miller *et al.* 2007). The proportion of the flows removed from the Macquarie River on any one day would range from small (<10%) to moderate (20-31.5%), so the severity of impacts will vary. As extraction operations will be intermittent, impacts will generally occur when water is being pumped out of the river and for a short time thereafter. Extraction that takes place over a number of consecutive days could potentially have cumulative impacts.

Previous studies on the effects of water extraction provide an insight into the nature and likely scale of impacts on aquatic ecology in the Upper Macquarie River and will be referred to where appropriate. Note that studies on the impacts of water extraction on aquatic habitats and biota in unregulated rivers, where a very large proportion or the entire flow is removed or where water is removed continuously are not relevant to The Project.

3.1.2.1 Impacts on Surface Water Flows

The impact of the project on surface water flows past Cobbs Hut Hole would be as described for Gardiners Hole (Geolyse 2012b).

The proportion of the annual flow past Cobbs Hut Hole extracted from the Macquarie River per year would be small, ranging from 0 to 6% (3,804 ML) and averaging 0.52% (1,616 ML)

(Geolyse 2012). The average annual extraction from the Macquarie River system would be reduced to around 325 ML/year (i.e. 0.11% of the average annual river flow at the proposed offtake point) as a result of the increases in volume of spills from Suma Park Dam and average annual flows from Summer Hill Creek into the river.

The proportion of flows removed on monthly and daily time scales is more relevant to aquatic biota and ecological processes. Extraction would occur throughout the year but would not be consistent across months, with 64% of the water transfer taking place on average between January and June and 36% between July and December. This is due to spring inflows into Suma Park Dam and the 90% trigger. There would be more pumping days on average per month from January to July (13.5 to 16) than between August and December (5-9.5). The proportion of flows removed on average per month would increase from 0.8% in January to 1.4% in May and then decline to 0.6% in June, remain around 0.2-0.3% from July to October before increasing to 0.6% again in December (Martin Haegh (Geolyse), 3 December 2012, email). The monthly flow duration curves indicate extraction would result in a small reduction in the volume of low to moderate and moderate to high flows between January and June but only a slight reduction in the volume of low to moderate flows from July to December.

The proportion of flows removed on any one day would vary from 0% to 31.5%, with an average of 1.6%. Pumping would occur on an average of 135 days per year, with <10%, 10-20%, 20-30% and >30% of flows being extracted on 84, 31, 18 and 2 of these days, respectively (Geolyse 2012). Pumping will cease during peak electricity demand, so there will be two brief periods (2-3 hours) each day, during which there will be no change to the prevailing flows at the extraction site.

Hydrological modelling indicates extraction would result in a 0-6 ML/d reduction in moderate to high flows and 5-8 ML/d decrease in low to moderate flows (Geolyse 2012). The proportion of moderate to high flows and low to moderate flows removed would be small (<5%) and small to moderate (6-13%), respectively. As changes of this magnitude occur naturally, impacts on surface water flows are likely to be limited. The rate of change during extraction operations, however, would be greater than natural changes. Extraction would have no effects on the amplitude or frequency of low flow events, as pumping would cease when flows drop below 38 ML/d.

3.1.2.2 Impacts on Surface Water Quality

The impact of extraction on the quality of water in the Macquarie River was not considered in the Water Quality and Geomorphology Assessment (Appendix E of the EA). A review of the literature on the effects of extraction indicates reductions in stream flow can lead to changes in water temperature and levels of dissolved oxygen, pH, electrical conductivity, sediments, nutrients, effluents and contaminants (Dewson *et al.* 2007). The magnitude of changes in these characteristics depends not only on the magnitude and duration of extraction operations but also the availability of water. Reductions in water quality are more likely to occur when moderate proportions (>10%) of low to moderate flows are extracted from the Macquarie River. The intermittent nature of the changes in flows during extraction combined with replenishment of water removed by upstream flows suggests there are unlikely to be significant changes in oxygen, conductivity, pH, effluent or contaminant levels in the Project Area or downstream thereof. Changes in water temperature, however, may occur, particularly in shallow habitats when moderate proportions of low to moderate flows are extracted during summer. In deep pools, changes in temperature would be buffered by the thermal capacity of the large volume of water contained therein.

The location of the pump within a wet sump and the relatively small extraction rate would limit mobilisation and dispersion of benthic sediments. The erosion of benthic sediments from the upstream side of the Offtake Structure, however, could result in an increase in sediment plume. The dispersal of this plume would depend on the prevailing river flows. The use of a sealed pump would prevent contamination of the water and sediments through loss of lubricants.

3.1.2.3 Impacts on Aquatic Habitat

Detailed assessment of impacts on physical and physico-chemical habitat characteristics based on hydraulic habitat modelling, remote sensing and/or stratification monitoring has not been undertaken for this project. It is, however, clear that extraction will reduce stream depth and in so doing may decrease habitat availability and diversity, and that the magnitude of these reductions will depend on the proportion of the flows abstracted and habitat (Dewson *et al.* 2007). The effects on aquatic habitat will be greater when moderate proportions (>10%) of low to moderate flows are extracted from the Macquarie River and greatest when 12 ML/d is extracted from a 38 ML/day flow. The availability of aquatic habitats will not be impacted during low and very low flow periods, because extraction would not occur under such conditions.

The water level in Cobbs Hut Hole would be reduced by 39 mm during maximum extraction but would be reduced by an average of 1-5 mm during moderate to high flows and by 11-14 mm during low to moderate flows (Geolyse 2012b). Changes in velocity would have less of an impact on pools, because these are naturally low velocity environments.

Reductions in flow due to extraction would have a proportionally greater effect on riffle habitat, because the depth of water in these habitats is considerably lower than in pools. In the absence of empirical data, Manning's equation for open channel flow was used to understand the likely changes in depth of water, hydraulic radius of the flow cross-section, flow area, top width and flow velocity of riffle habitat when different proportions of flows are extracted. The following parameters were used in these calculations:

- Trapezoidal channel shape;
- Side slopes of 1:2;
- Longitudinal slope of 1.1% which is similar to that between Gardiner's Hole and Cobb Hut Hole)
- Riffle width of 5 m;
- Manning's n = 0.04 (a roughness co-efficient representing a river bed consisting of gravel, cobbles and a few boulders).

It is important to note that riffles are highly variable structures, differing in width, side slope, longitudinal slope, substratum characteristics, presence of shallow and deep channels and that the estimates obtained from the equation are simply approximations intended to gauge the likely magnitude of changes in these habitats.

Figure 4b, d and e shows the reduction in stream depth, flow area and hydraulic radius of the flow cross-section in a generalised 5 m wide riffle would be relatively small (< 10%) until the proportion of flows removed exceeds 20%, but would be reduced by approximately 20% when 30% of flows are removed. The impact on flow velocity would be much smaller, ranging from 1.6% when 5% of flows are removed to 11.85% when 30% of flows are removed (Figure 4e). The impact of extraction on top width would be negligible, with the proportional reduction ranging from 0.15% when 5% of flows are removed to 1.96% when 30% are removed (Figure 4f). This suggests that impacts on habitat along the margins of riffles would be negligible. The reduction in depth of water over riffles, however, will have consequences for the pool and run/glide habitats below them, but the extent to which effects will propagate downstream is unknown.

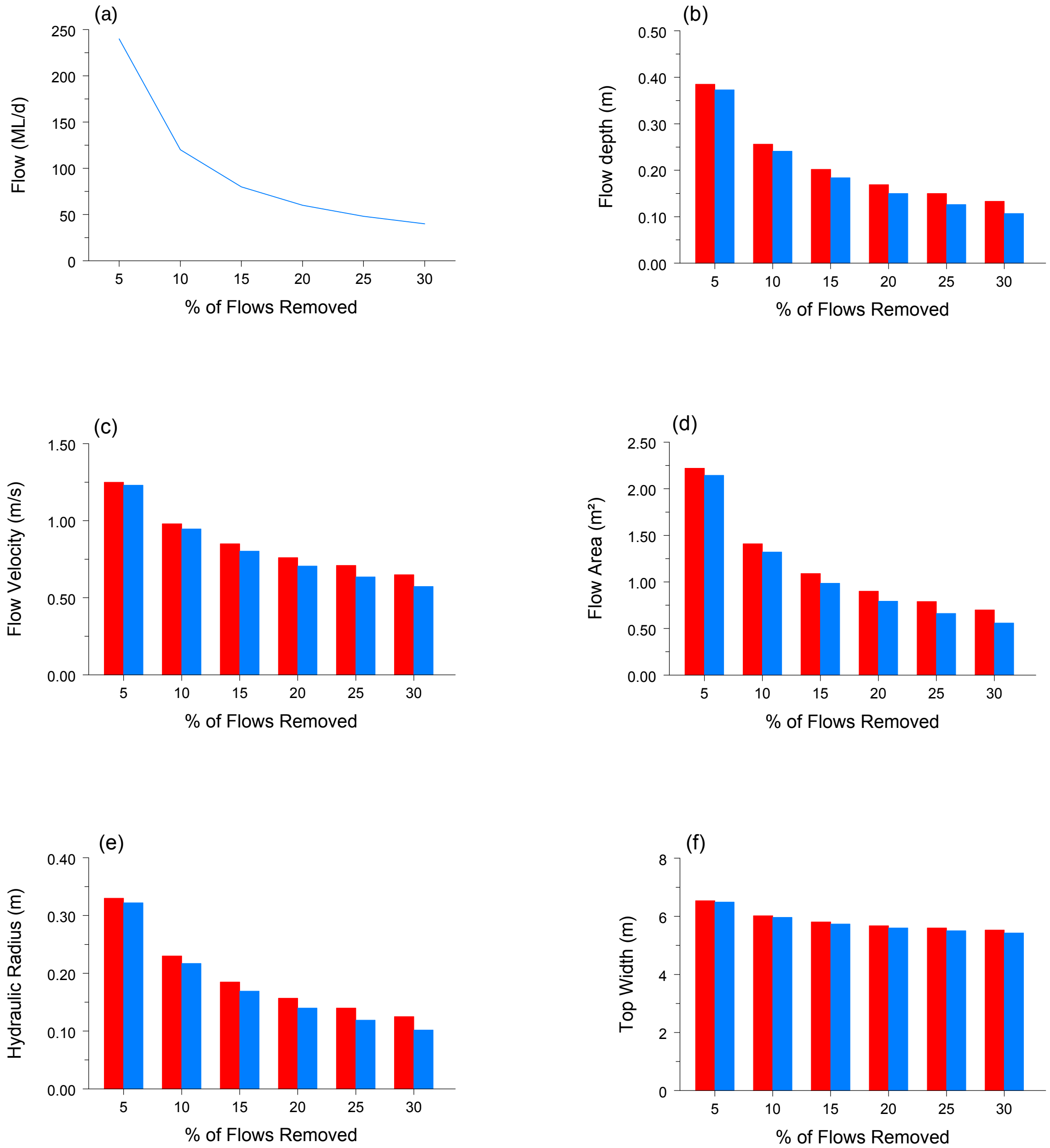

Figure 4: (a) Flows that would prevail when 5-30% of flows are extracted; Changes in (b) flow depth, (c) flow velocity, (d) flow area, (e) hydraulic radius and (f) top width of 5 m wide riffle that would occur when 5-30% of flows are extracted. These are approximations derived from Manning's Equation, red and blue bars indicate values without/with 12ML/d extraction and difference in height of bars represents magnitude of change due to extraction.

Approximations derived from the Manning equation have also been used to assess the impact of maximal extraction (i.e. 12 ML/d removed from 38 ML/d flows) on riffles varying in width from 5 m to 20 m. These indicate the water depth over a generalised 5 m wide riffle would decrease from 13.3 to 9.8 cm, while that over a 20 m wide riffle would be reduced from 5.8 cm to 4.3 cm (Figure 5a). The hydraulic radius of the flow cross-section over a 5 m wide riffle would decrease from 0.125 m to 0.094 m, while that of 20 m wide riffle would be reduced from 0.058 m to 0.043 m (Figure 5b). The reductions in stream depth and hydraulic radius will consequently be greater in narrow riffles. Changes in flow area, in contrast, would be greater in wide riffles, increasing from 0.19 m^2 in 5 m wide structure to 0.31 m^2 in 20 m wide riffles (Figure 5c). Reductions in top width would be relatively small across all four widths, suggesting that habitat along the margins of riffles will not be adversely affected (Figure 5d). Reductions in flow velocity would also be greater in narrow riffles, decreasing from 0.63 to 0.52 m/s over a 5 m wide riffle and from 0.37 to 0.31 m/s over a 20 m wide riffle (Figure 5e). Although it is not shown here the effects would also vary with channel morphology, being proportionally greater in areas with small river slopes. It should be noted that maximal extraction would be a rare event, occurring on 0.11% of extraction days (Geolyse 2012).

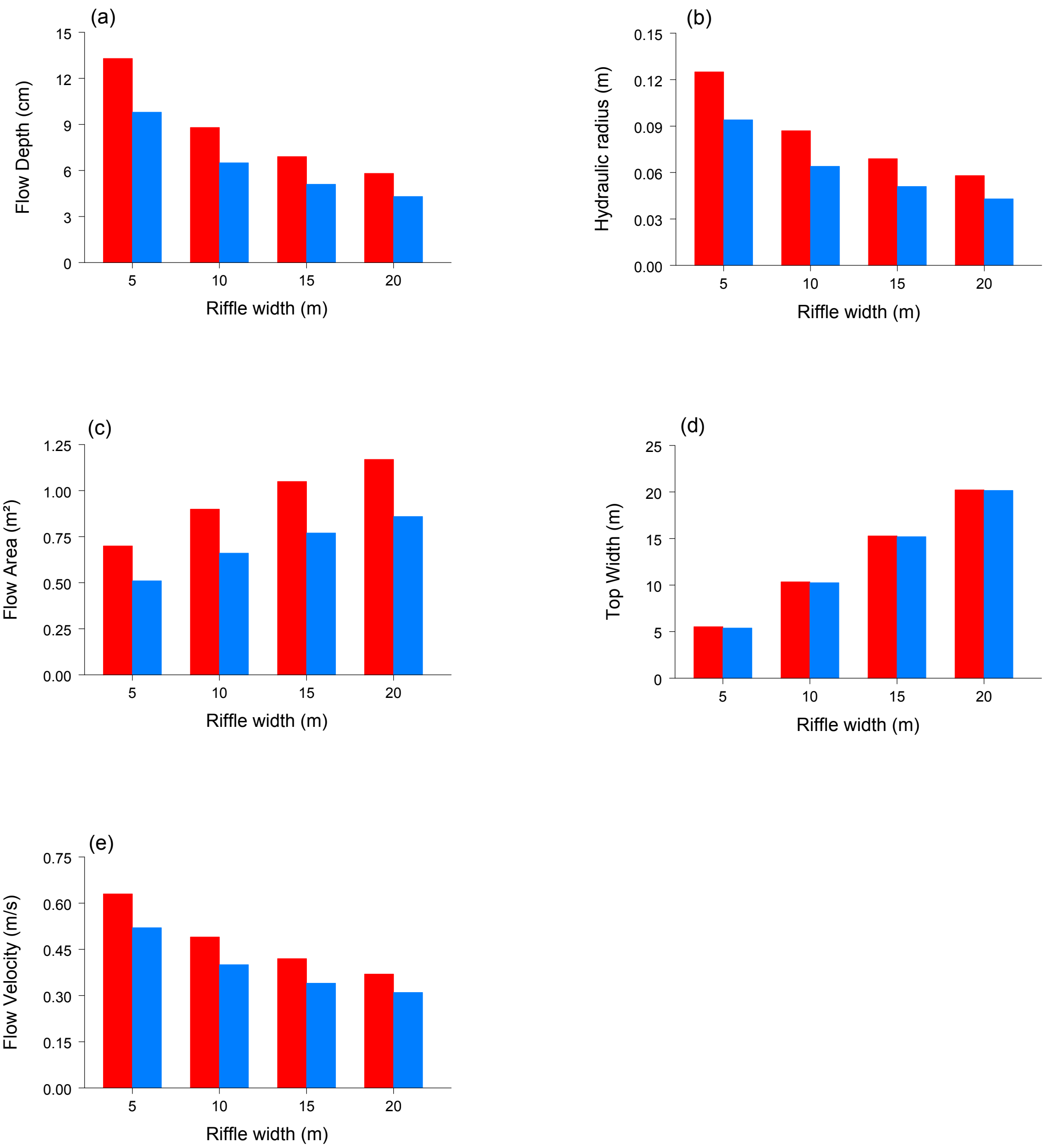

Figure 5: Estimates derived from Manning's equation of (a) flow depth, (b) hydraulic radius,(c) flow area (d) top width and (e) flow velocity of 5 – 20 m wide riffles under 38 ML/day flows (red bar) and after extraction has reduced flow to 22.8 ML/day (blue bar).

The water that is extracted would be replenished by flows from upstream, so the impact on the availability of habitat on any one day is likely to be minor and transient. Extraction will, however, result in greater and more rapid fluctuations in aquatic habitats than natural, because there will be two gradual declines in water depth each day interspersed by two brief (2-3 hour) periods during peak electricity demand when water levels will rise due to cessation of pumping and continued replenishment by water flowing from upstream. The effects of the "pulsing" of flow on habitats downstream of the offtake would be attenuated by pools and tributary inflows, so effects will diminish with distance downstream and become undetectable lower in the river system.

Extraction over a number of consecutive days could potentially have a cumulative effect. The magnitude of this is difficult to assess, because of the lack of detailed information on aquatic habitats in this section of the river and the uncertainty about when and for how long extraction would take place and the magnitude of flows likely to prevail at that time. The reduction in availability of aquatic habitat would be relatively small and would diminish with distance downstream. The duration of these changes would depend on the prevailing flow rate upstream of the offtake site and number of consecutive extraction days.

The Offtake Structure would provide an artificial substratum that could be colonised by aquatic flora and fauna, with some animals potentially using it as a spawning site. Woody debris that collects on the trash rack could provide a temporary habitat for aquatic flora and fauna, such as microscopic plants and aquatic macroinvertebrates, until it is dislodged by floods. As the Offtake Structure would cover only 0.095% of the area of the pool, it is unlikely to have a significant impact on the local availability of aquatic habitat. During prolonged periods of low flows the structure could serve as a roosting site for birds. If fish aggregate at the structure this could increase the risk of predation by birds. The structure would be designed to minimise its suitability as potential habitat, so the impact of predation, if any, on fish would be negligible.

The wet sump would pose an obstacle to the flow of water and could potentially result in erosion of the adjacent river bed and bank, which in turn could lead to changes in habitat quality. The impacts of this on habitat quality would be minimal.

3.1.2.4 Impacts on Abundance and Assemblages of Aquatic Biota

The reductions in flow volume and velocity, water depth and wetted area that occur during extraction could potentially alter the abundance of aquatic flora and fauna and the composition of their assemblages. A review of studies on the effects of natural, artificial and experimental flow reductions on macroinvertebrates indicates their abundance either increases or decreases, their taxonomic richness generally decreases, their community composition often changes and active drift often increases during periods of low flow (Dewson *et al.* 2007). The studies reviewed were mostly large-scale reductions, with many being ongoing extractions that had occurred for many years, so their impact on macroinvertebrates is likely to be more severe than the proposed extraction operation.

The impacts of the proposed extraction operation on abundance and assemblage composition are difficult to predict because studies on the effects on extraction undertaken in NSW have produced mixed outcomes (Chessman *et al.* 2008a and b, 2011; Brooks *et al.* 2011). These studies are also based on comparisons across multiple sites spanning large areas and are therefore not directly comparable with the proposed extraction. Studies undertaken in north-eastern NSW during a period of prolonged and recurring drought, when any biological impacts that occur should be easier to detect, found no evidence of any impacts on assemblages of aquatic and amphibious macrophytes (Chessman *et al.* 2008a) or aquatic macroinvertebrates (Chessman *et al.* 2011). There was, however, evidence that extraction might have impacted on fish assemblages in some cases (Chessman *et al.* 2008b), although the impact was not specified. In these studies, the aquatic biota at multiple sites on unregulated streams which had an average of 4% of their mean annual flow (MAF) licensed for upstream extraction (range 1–20%) were compared with biota at multiple reference sites where upstream entitlement for extraction was less than 1% of MAF. The lack of any detectable impact on macrophytes was attributed to the relatively small proportion of flow licensed for extraction, the continued presence of water within study sites, the resilience of these plants to drought and the high natural spatial variability in macrophyte assemblages (Chessman *et al.* 2008a). The lack of impact on aquatic macroinvertebrates was also attributed to the relatively small proportion of flows abstracted, although it was acknowledged that the rapid biological assessment method used in the study may not have been sensitive enough to detect impacts (Chessman *et al.* 2011).

A broader-scale comparison of macroinvertebrate assemblages associated with riffle and pool edge habitats at sites throughout NSW with licensed upstream extraction and reference sites where there is no extraction of water showed there was a high likelihood of effect of extraction on macroinvertebrates in 30% of riffles and 22% of pool edge habitat (Brooks *et al.* 2011). Information on the level of water use at the study sites was not available, so it is not known whether the results are representative of streams where low, medium or large proportions of water were extracted. The difference in results of the two studies may be due to the much-smaller geographic area and number of sites, apparently low level of extraction upstream of the sites considered by Chessman *et al.* (2011) and differences in the level of taxonomic resolution.

Studies elsewhere on the impact of extracting low to moderate volumes of water indicate there was little impact on aquatic macroinvertebrates (Corrarino & Brusven 1983; Rader & Belish 1999; Miller *et al.* 2007). These studies and those undertaken in NSW suggest that the intermittent removal of small proportions of flows may have little impact on the abundance and composition of aquatic macroinvertebrates in the Macquarie River.

3.1.2.5 Impacts on Movement of Aquatic Biota

Changes in depth and rate of flow over riffle/cascade habitats resulting from extraction could affect the ability of mobile organisms such as fish, turtles and platypus to move between habitats along the river, particularly during low flows. Mobile organisms that move through the very shallow water that covers riffle habitats run the risk of possible stranding, physical exhaustion and stress and increased exposure to terrestrial predators. The likelihood of this happening depends on their minimum depth requirements and swimming abilities, both of which vary with species, size and body shape and availability of water. Fish also require a minimum depth of flow to allow them to reach swimming potential (Dane 1978). Total submergence eliminates the risk of oxygen starvation, allows the fish to create maximum thrust, and lowers the risk of bodily injury through contact with the substratum. Fish with smaller, cylindrical or shallow body profiles are likely to be capable of negotiating shallower water than deep-bodied species. The suitability of pool and riffle habitat for the foraging activities of platypus also depends on flow velocity and depth of water, with low flows reducing the availability of their invertebrate food resources and the area of riffles, their most productive foraging habitat. Reductions in the depth of water could also hinder the movement of platypuses over riffles and between pools and increase their risk of predation if they have to come out of the water (Scott & Grant 1997).

The effects of extraction on the movements of fish, platypuses and turtles will depend on the proportion of flows removed and hence the extent of the reduction in stream depth. With intermittent extraction operations it is unclear what proportion of flows can be removed before effects on the movement of animals become detectable. This is likely to vary with stream size, duration and timing of the extraction and species, size and swimming abilities of the animal. Allibone (2000) suggested that intermittent extractions that remove only a small proportion of the instream flow are likely to have a limited impact on the movement of fish, because changes of this magnitude are within the normal range of instream fluctuations. The rate of change in flows during extraction operations, however, is likely to be greater than the gradual reduction in flows that occurs naturally.

A detailed assessment of the potential for impacts on fish and platypus passage would require the position of riffles and rapids downstream of the Offtake site to be identified, measurements to be taken of their morphological characteristics (e.g. flow depths, surface, middle and near-bed velocities in thalwegs) and two-dimensional hydraulic modelling of changes in velocity and depth across the riffles under different flow rates. These measurements would need to be combined with information on the depth and velocity requirements of platypus and individual fish species. As the morphological characteristics of the riffles, rapids and cascades downstream of the offtake site have not been measured and information on the depth requirements of fish and platypus is limited, Manning's equation for open channel flow was used to determine the likely magnitude of flows required to maintain minimum water depths of 20 cm and 30 cm above riffles ranging in width from 5 m to 20 m in an area with a river slope of 1% (see Section 3.1.2.1 for more details). The stream depths selected are the minimum water depths used respectively in previous studies of the flow requirements of adult Australian Bass and Eastern Freshwater Cod (Reinfelds *et al.* 2010; Butler 2008). Reduction in water depth to below 20 cm in riffle/runs is also thought to decrease the suitability of such habitat for platypus (Bacon *et al.* 2004). The flow velocity, passage gradient, nature and structure of the substratum are also known to influence movement of fish.

The approximations derived from Manning's equation indicate flows of 75 ML/d and 150 ML/d respectively would be needed to maintain depths of 20 cm and 30 cm above a 5 m wide section of riffle and that flows of 297 ML/d and 584 ML/d would be required respectively to maintain these depths over 20 m wide riffles (Figure 6a). This suggests that the movement of medium to large-bodied fish species and platypus across narrow riffles would be constrained during low to medium flows and that movement upstream across wide riffles may only be possible during some medium to high flows. Reductions in water depth due to extraction during such flow conditions would further limit the movement of medium and large-bodied fish species and platypus. It should be noted that the morphology of riffle habitats is highly variable and that some have several potential routes of passage that fish can utilise and areas of low velocity flow where they can rest prior to negotiating short, high-energy sections at the top of the riffle (Reinfelds *et al.* 2010). There are also numerous pools along the river where migrating fish and platypus could seek temporary refuge if the water level should drop to a level that hinders their passage through riffle and cascade habitat. The reduction in pool habitat would be much smaller than that in riffles, so they would still have sufficient volume to provide refugia when flows are reduced.

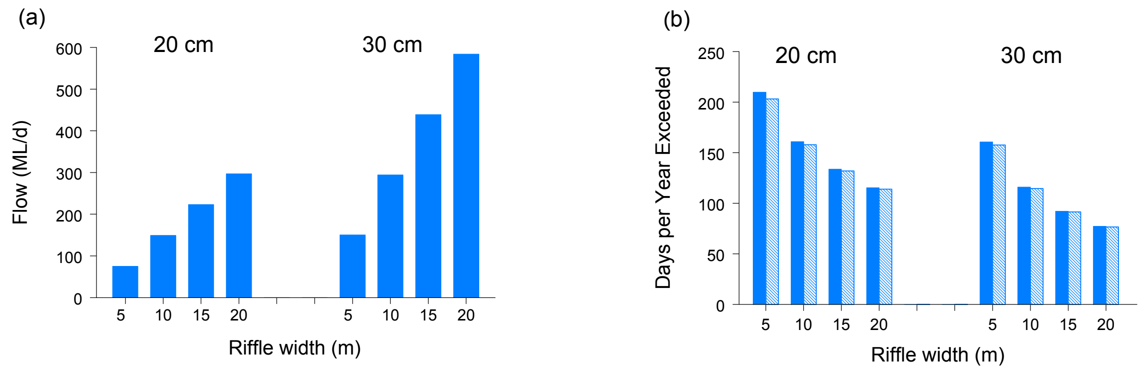

Figure 6: (a) Flows required to maintain minimum stream depths of 20 cm and 30 cm over riffles varying in width from 5 m to 20 m; (b) Number of days that minimum stream depths of 20 cm and 30 cm would occur naturally (solid bar) and during extraction (hatched bar) over riffles varying in width from 5 m to 20 m. Note: these are approximations derived from Manning's equation.

Estimates of the average number of days per year that stream depths of 20 cm and 30 cm would be exceeded naturally and after extraction derived from the river flow duration curve are presented in Figure 6b. Extraction would reduce the number of days that a minimum flow depth of 20 cm would be exceeded by 6.6, 2.9, 1.8 and 1.4 days in 5, 10, 15 and 20 m wide riffles, respectively and a minimum flow depth of 30 cm by 3.0, 1.4, 0.6 and 0.4 days in

5, 10, 15 and 20 m wide riffles, respectively. As the extraction operation would be intermittent, the number of days that minimum depths would be exceeded would be only slightly smaller than under natural conditions and the water that is removed would be replenished by inflows from upstream, the impact on movement of fish and platypus would be transient. On a medium to longer-term basis, the Project is not likely to have a significant impact on the movement of fish nor is it likely to prevent them from accessing critical habitats such as spawning, juvenile or feeding habitats.

The reductions in velocity of flow over riffles resulting from extraction of water (see Section 3.1.2.3) would be beneficial to upstream movement, as animals would need to expend less energy to swim against the flow.

The Offtake Structure would not impede the upstream or downstream passage of mobile organisms, as it will occupy only a small area (0. 0.095%) of Cobbs Hut Hole adjacent to the river bank.

3.1.2.6 Impacts due to Impingement and Entrainment

Extraction operations can result in direct removal, physical injury or mortality of riverine biota (Baumgartner *et al.* 2009). The extent of impacts depends on the amount of water extracted and effectiveness of any methods used to minimise impingement of aquatic macroinvertebrates, invertebrate plankton, fish eggs and larvae and plant fragments on screens and their entrainment within the extracted water. The risk of removal, injury or mortality of aquatic biota during extraction of water from the Macquarie River is likely to be very low given the small-to moderate proportions of flows that would be extracted, the proposed pumping rate is less than 12 ML/d, trash screens and a fine-mesh screen situated in front of the suction manifold would be used to minimise impingement and entrainment of large and small biota, respectively. Small organisms that pass through the screen may be injured or killed elsewhere in the pipeline as result of shear stress (i.e. collision with exclusion screens and the walls of the pipe and passage through pump stations) or exposure to sudden changes in pressure, if other control measures are not implemented. These organisms would effectively be lost from the population within the river. For mobile biota, small-bodied species and juveniles are likely to be more vulnerable to entrainment than those with larger bodies.

If water extraction coincides with the spawning, hatching and larval development periods of species which exhibit downstream larval drift, large numbers of recruits could potentially be removed (Gilligan and Schiller 2003). Long-term extraction operations could lead to changes in the distribution and abundance of their populations within the river. The water that is pumped from the Macquarie River could contain fish eggs and larvae as well as the eggs and planktonic life cycle stages of other organisms that are reliant on passive dispersion. Such organisms would be a small proportion of the total number passing the offtake site, given the proposed pumping plan and fine screen (Section 4.1.1). As the fish species likely to occur in the vicinity of the offtake have a relatively large geographic range and only 0.2-0.6% of the average monthly flows would be extracted between June and December, the critical period for reproduction of many fish species, the impact of extraction on their populations is likely to be relatively small. As freshwater shrimp (Atyidae) and prawns (Palaemonidae) carry eggs below their abdomens, it is only their planktonic larval stages that would be susceptible to entrainment. The susceptibility of these organisms to this process depends on the number and size of egg batches produced per breeding cycle, length of larval phase and the preferred habitat of the larvae, all of which are unknown in the Macquarie River. It is unlikely that the proposed extraction operation would have a significant impact on shrimp and prawn populations within the river, because these animals are abundant and widely distributed.

3.1.2.7 Other Impacts

The operation of the pump is likely to disturb nearby aquatic fauna that are sensitive to noise and vibrations. The impact would be localised and more acute for sessile or sedentary species than for mobile organisms which would be able to move away from the disturbance.

The location of the pump within a wet sump and the relatively small extraction rate would limit mobilisation of sediments and reduce the impacts of this on aquatic biota to negligible levels.

3.1.3 Impacts on Groundwater-Dependent Ecosystems

The minor changes in river levels that are likely to occur downstream of the offtake site are not expected to alter the patterns of groundwater recharge from the river (Geolyse 2012). It is consequently unlikely that there would be any measurable impacts on GDEs adjacent to the river downstream of the offtake site.

3.2 Water Pipeline

3.2.1 Potential Construction Impacts

3.2.1.1 Impacts on Aquatic Habitats and their Biota

Instream construction activities would disturb the stream beds and banks and could alter hydrological characteristics, availability of aquatic habitat and water quality. These in turn could have an impact on the abundance, distribution and health of aquatic and riparian biota. Increases in suspended sediment concentrations and changes in stream bed substratum could also affect the behaviour and physiology of mobile fauna. These impacts would generally be localised and short-term in nature and are thus not considered to be significant at the scale of the watercourse. The impacts are also unlikely to be significant, because the species inhabiting the watercourses are periodically subject to high sediment loads during flood events.

3.2.1.2 Impacts on Groundwater-Dependent Ecosystems

The area does not appear to contain shallow aquifers that could be vulnerable to damage during construction works (Pells Consulting 2012 in Cardno 2012). The fractured rock aquifers in the Lachlan Fold Belt GMA are situated well below the depth level to which pipe trenching would extend, so it is highly unlikely that the construction of the pipeline crossings would have any impact on these groundwater resources. The linear nature and hence small total area covered by the pipeline suggest that it is unlikely to alter the recharge or water balance of existing aquifer systems. The groundwater vulnerability map for the Macquarie catchment indicates the risk of impacts due to spillages of contaminants is low to low-moderate for the Project Area (Piscopo 2001). Given the above, and that control measures would be used to contain spillages, the construction of the pipeline is expected to have no or only minor impacts on any nearby groundwater-dependent ecosystems.

3.2.2 Potential Operational Impacts

The major source of impact during operation of the pipeline would be potential leakage of water and sediment into the streams. The water released from the scour valves is unlikely to result in impacts to the aquatic environment, as it would be released in accordance with a scour management plan and would have to meet minimum water quality standards. The water removed during the periodic cleaning of the pipeline would be of poorer quality as it would contain material scoured form the wall of the pipe. This water would be treated prior to discharge. The impacts on aquatic ecology associated with operation of the pipeline would consequently not be significant.

3.2.3 Conclusions

The impacts on instream ecology along the MR5a Route associated with the construction works would generally be short-term and localised and therefore of minor significance. The impacts on aquatic ecology of the streams below pipeline crossings would be transient and localised and therefore not significant.

The operation of the Offtake Structure would affect the local aquatic environment by providing a small area of artificial substratum and lowering the water level in pools, riffle/cascade and margin habitats adjacent to and downstream of the offtake site and increasing the variability in this attribute. The level of water in these habitats during low and very low flow periods would not be impacted, because extraction would not occur under these conditions. Extraction would result in small decreases in the amplitude of low to moderate flows and moderate to high flows. The operation of the pump would disturb nearby aquatic fauna that are sensitive to noise and vibrations and could lead to entrainment or impingement of small organisms. The impact of extraction on populations of eggs and larvae is likely to be relatively small and not significant because only a small proportion of the total number passing the offtake site would be lost.

4 Avoidance, Mitigation and Offset Measures

The control measures that could be used to avoid, minimise and/or mitigate impacts on aquatic habitats, water quality and aquatic biota that may arise during construction of the Offtake Structure and the Water Pipeline were outlined in Tables 8 and 11 whilst those related to the operation of these components were presented in Table 9 of the Aquatic Ecology Assessment (Cardno Ecology Lab 2012). The specific measures that could be used to avoid, minimise and offset potential impacts on aquatic habitats and aquatic biota associated with the construction and operation of an Offtake Structure at MR5a and a Water Pipeline extending from there to Chainage 4000 are described below. The specific measures that could be used to avoid, minimise and offset potential impacts on threatened species and populations are described in Section 5.

4.1 Offtake Structure

4.1.1 Construction Phase

The loss of aquatic habitat at MR5a could be offset by rehabilitating other areas of habitat within the Project Area. This could be done by adding instream woody habitat in the form of snags to adjacent sections of the Macquarie River.

Loss of riparian habitat could be offset by removing weeds, replanting with appropriate native plants and installing fences to manage or exclude stock.

NSW I and I (2011) have indicated the following measures are required:

- A detailed management plan to be prepared outlining how the offtake pump station and infrastructure would be constructed to ensure free passage of fish is not blocked whilst work is conducted;
- A vegetation or revegetation management plan be implemented to ensure that riparian buffer zones at the offtake site are carefully managed.

Construction works are also to be done in accordance with the NSW DPI Policy and Guidelines for Aquatic Habitat Management and Fish Conservation (See Section 2.1.3) (NSW Fisheries 1999) (David Ward (NSW Fisheries), 13 March 2011email). This indicates that:

- free passage should be maintained for migratory fish species;
- mesh fences should not be deployed across waterways as they may obstruct fish passage;
- 50 m wide riparian buffer zones with natural features and vegetation preserved should be established and maintained and increased to a width of 100 m or more adjacent to ecologically sensitive areas.

A permit may also be required under s.219 of the *FM Act* for any works, which may result in the temporary or permanent blockage of fish passage within a waterway. This applies to blockages associated with the deployment of silt fencing across waterways for sediment, erosion control, bunding and dewatering works during construction of crossings (NSW DPI undated).

4.1.2 Operational Phase

Mortality and injury of juvenile, sub-adult and adult fish, turtles and platypus would be avoided by:

- Installing screens at the pump inlet;

- Starting the pump up slowly and then ramping up its velocity to a level that reduces the likelihood of aquatic biota in the vicinity of the Offtake Structure being drawn into the pump.

The advice on preliminary operating rules provided by GHD (2011c) indicates that:

- Initial start-up velocity needs to be below 0.05 m/sec or no greater than the passing flow velocity to avoid sudden entrainment
- Native fish less than 80 mm in length are unable to negotiate flows in excess of 0.15m/sec; and
- Flows in excess of 0.05 m/sec would be problematic for turtles.

Devices that induce the movement of fish away from the pump could also be installed.

The entrainment of fish eggs and larvae during operation of the offtake and pumping station would be minimised by:

- Screening the pump inlet;
- Limiting the extraction period to19 hours per day and by blasting air through the screen at the end of each day's extraction to dislodge any organisms trapped on the screen.

A 2 mm mesh screen would prevent the entrainment of eggs of the threatened fish species identified in Section 5.0 and limit uptake of larval fish (See Table 10 in the Aquatic Ecology Assessment). Note that the effects of this mesh size on entrainment of larvae can not be assessed at present, because of the lack of information on body depth of fish larvae. The letter from NSW Industry and Investment (2011) to DoP re: Orange Drought Relief Pipeline (10_0235) - Director General's Requirements dated 18 March 2011 indicates that fish exclusion screens should be designed, located and operated in such a way that pumping cannot occur unless adequate fish screen/filters are *in situ* surrounding the pump within the off-take well.

The risk of entrainment of eggs and fish larvae and impingement of larger individuals could potentially be reduced further by pumping at times of day when fish are less active and/or pumping at times of year when there is minimal spawning and recruitment activity. The seasonal adjustment of pumping regimes to achieve the same secure yield is not considered feasible, because larger pumps would be required to extract more water at certain times of the year. Unfortunately the use of larger pumps is not feasible due to power restrictions. It should, however be noted that the average number of pumping days per month would be lowest in spring/early summer, when movements related to spawning and recruitment are most likely to occur, because spring runoff would result in the storage level of Suma Park Dam exceeding the 90% trigger level more frequently.

Loss of aquatic organisms could be offset by improving the likelihood of native fish populations surviving elsewhere within the Project Area. This could be done by introducing additional instream woody habitat (i.e. snags). An additional control measure that could be considered is the installation of devices that deflect fish and other organisms away from the Offtake Structure.

The movement of aquatic biota during low and very low flows will not be affected as the operating rule precludes pumping under such conditions and will not result in the creation of low flows (i.e. those below 22 ML/d) (Geolyse 2012).

The location of the pump within a wet sump and the relatively small extraction rate would limit mobilisation of sediments and reduce potential flow-on effects on aquatic biota to negligible levels. The use of a sealed pump would minimise the risk of water and sediments becoming contaminated if lubricants were lost from the pump.

The option on an existing 640 ML/year irrigation licence on the upper Macquarie River that Orange City Council has secured for the Project would offset some of the water extracted.

4.2 Water Pipeline

4.2.1 Construction Phase

The design and construction of crossings within 40 m of watercourses, including temporary and permanent vehicle crossings, must be undertaken in accordance with the NSW Office of Waters guidelines on controlled activities (See letter from NSW Office of Water to DoP re: Orange Drought Relief Pipeline (10_0235) - Director General's requirements dated 23 March 2011). The relevant guidelines and control measures derived from them are outlined in Sections 2.1.2 and 4.2.1 of the Aquatic Ecology Assessment (Cardno Ecology Lab 2012).

Impacts on aquatic and/or riparian habitat would be avoided by:

- Using existing cleared easements for the pipeline;
- Ensuring the alignment of the pipeline does not disturb locations containing significant aquatic or riparian habitat;
- Using the measures specified in the Sediment and Erosion Control Plan to protect aquatic habitats and biota immediately downstream of the construction area.

Impacts would be minimised by

- Selecting construction methods that have a smaller construction footprint and result in less disturbance of the stream bed and banks and any associated vegetation;
- Maintaining the existing hydraulic, hydrological, geomorphic and ecological function of the watercourses;
- Using appropriate protection measures to minimise scour and impacts on water quality;
- Minimising the duration of in-stream activities;
- Limiting construction of crossings during times that are important for completion of life cycles (e.g. in spring and summer when threatened fish species spawn and recruit);
- Rehabilitating disturbed areas of stream bed and banks;
- Implementing a management plan to remove or lockdown equipment in the event that high flows are forecast during instream activities.

Stream crossings should also be constructed in accordance with NSW DPI's Policies and Guidelines on Fish-Friendly Waterway Crossings and Policy and Guidelines: Aquatic Habitat Management and Fish Conservation and be consistent with the Habitat Protection Plans gazetted under the *FM Act*, particularly HPP No. 1 which outlines requirements for the management of 'snags' (large woody debris or boulders) (David Ward, email communication 13 March 2012).

NSW DPI recommends that the following management strategies should be used to minimise impacts on native flora and fauna and enhance habitat quality and availability for fish:

- The health of existing native riparian vegetation should be maintained, recruitment of juvenile trees and shrubs should be encouraged and weeds should be controlled;
- Areas where little or no riparian vegetation remains should be rehabilitated by replanting or natural regeneration;
- The access of stock to riparian habitat should be controlled; and
- Exotic riparian vegetation should be replaced by native vegetation.

The amount of riparian vegetation that would need to be maintained will vary at the two crossing locations and an assessment will need to be undertaken at each once the crossing construction footprints and methodology are finalised.

A vegetation or revegetation management plan will also need to be implemented to ensure that riparian buffer zones along the pipeline corridor are carefully managed. A riparian buffer zone with natural features and vegetation preserved that is at least 50 m wide should be established and maintained. The width of this zone would need to be increased to 100 m or more adjacent to ecologically sensitive areas.

Impacts on aquatic habitat could be offset by rehabilitating disturbed areas and/ or similar habitats elsewhere within the streams of similar size. This could be done by adding instream woody habitat in the form of snags.

Loss of riparian habitat could be offset by removing weeds, replanting with appropriate native plants and installing fences to manage or exclude stock.

4.2.2 Operational Phase

Potential impacts on instream ecology due to leakage of water and residual sediment within the pipeline would be avoided by:

- Undertaking routine inspections of the pipeline to ensure early detection of leaks;
- Prompt repair of leaks;
- Prohibit direct discharge of water contained within the pipeline into watercourses via scour valves, except in emergencies and providing the quality of the water is acceptable.

4.3 Conclusions

The various measures that would be taken to avoid, minimise, mitigate and offset impacts associated with the Offtake Structure at MR5a and Water Pipeline between there are Chainage 4000 would reduce impacts on biodiversity values to negligible or minor levels. Nevertheless, Construction and Operational Environmental Management Plans, stipulating the various control measures that are to be used to minimise the potential for onsite and offsite impacts on aquatic habitats and associated aquatic biota, should be developed and implemented.

5 Conservation Issues

The threatened species and populations of fish of national and state significance that may occur in the Project Area were identified in Sections 6.1.2 and 6.2.1 respectively of the Aquatic Ecology Assessment (Cardno Ecology Lab 2012). The potential impacts on these assets associated with the proposed construction works and operation of the Offtake Structure and the Water Pipeline and the ways these impacts could be avoided, minimised and offset were outlined in Sections 6.13 and 6.1.4, respectively. The specific measures that could be used to avoid, minimise and offset potential impacts on threatened fish species and populations associated with the construction and operation of an Offtake Structure at MR5a and a Water Pipeline along the MR5a route are described below.

5.1 Matters of National Environmental Significance

5.1.1 MNES Identified

Section 6.1 of the Aquatic Ecology Assessment (Cardno Ecology Lab 2012) indicates three species of fish listed as threatened under the *EPBC Act* may occur or suitable habitat for them may occur within the Orange and Cabonne LGAs. These species are:

- Murray Cod (*Maccullochella peelii peelii*);
- Macquarie Perch (*Macquaria australasica*);
- Trout Cod (*Maccullochella macquariensis*).

The freshwater fish stocking records for the period 01/01/2001-31/10/2011 provided by NSW DPI show that Murray Cod fry have on several occasions been released at sites on the upper Macquarie River in close proximity to Cobbs Hut Hole (i.e. Dixons Long Point Crossing, Jumbo Hole and Noisy Hole) and that hatchery-bred Trout Cod were released at Dixons Hole in 2009 (See Table 5a in Cardno Ecology Lab 2012). It is therefore possible that local populations have become established at or in the vicinity of the MR5a offtake site. The capture of an adult Murray Cod at a site approximately 300 m upstream of MR5a during the survey undertaken in October 2012 supports this contention (see Section 2.5.1.3).

Macquarie Perch have been recorded in the Macquarie River (Trueman 2007), but are now presumed to be extinct, because none have been collected from there since the species original description, nor have any been reported ethnographically for many decades (Faulks *et al.* 2010). It should, however, be noted that the fish surveys that have been undertaken are limited in frequency, spatial extent, duration and intensity, so the possibility of the species still being present cannot be discounted

5.1.2 Proposed Construction and Operation Works

The proposed construction works and operation of the Offtake Structure in the vicinity of MR5a is expected to be similar to that presented in Section 4.1.1 of the Aquatic Ecology Assessment.

5.1.3 Potential Impacts on Threatened Species

5.1.3.1 Construction Phase

The potential impacts on the threatened fish species associated with the construction phase of the Project include:

- Loss and modification of habitat;
- Exposure to increased sediment load and/or turbidity;
- Reduction in water quality due to accidental release of contaminants;

- Disruption to movements and injury resulting from use of a coffer dam.

The construction of the Offtake Structure at MR5a would lead to permanent loss of a small area (approximately 27.2 m^2) of underlying benthic substratum within a deep pool (Cobbs Hut Hole). As this is only a small proportion (0.095%) of the area available within Cobbs Hut Hole and similar deep pool habitats are available immediately further upstream and downstream of MR5a and at other locations in the upper Macquarie River, the loss of habitat at MR5a would not be significant.

The deposition of sediments mobilised by runoff or during construction works could alter the nature of the benthic substratum and smother some aquatic habitats. Sections of the river bed and banks that are re-profiled during works could potentially be more prone to erosion during flood events. The impacts on potential habitat would be localised and thus of minor significance to the threatened fish species.

The construction works could also increase the sediment load and/or turbidity of the water. The sediment plumes that form would be dispersed downstream, with rate of dispersion depending on the prevailing flow within the river. The suspension of sediment particles in the water column load could clog the gills of the fish and reduce their ability to locate prey by eye. The fauna that occurs at MR5a is likely to be fairly tolerant of natural increases in sediment load that occur during periodic rainfall events. Mobile organisms such as fish would also be capable of moving away from any small sediment plumes created during construction works. The temporary increases in sediment load are consequently likely to have only minor effects on the threatened fish species.

Impacts resulting from accidental inputs of fuel and oil would depend on their composition and properties, the quantities spilt, prevailing weather conditions and rate of flow of the river (i.e. dilution effect). Low concentrations of petroleum hydrocarbons are toxic to aquatic biota, so there is a possibility of impacts on the threatened fish species. The likelihood of such events is low and would be reduced even further if appropriate control measures are implemented.

The installation of a coffer dam could hinder movements and/or migration of the fish species and injure fish retained within. Such structures would block fish passage in the streams, but not the river. The impact of this structure would be localised, limited to the period of construction and consequently of only minor significance to the three threatened fish species.

5.1.3.2 Operation Phase

The potential impacts on threatened fish species that may arise as a result of the presence and/or operation of the Offtake Structure and Pump Station include:

- Reductions in habitat availability, diversity and connectivity, with the latter affecting fish movements;
- Changes in habitat quality resulting from higher temperatures, reduced oxygenation and reduced dilution of effluents and contaminants;
- Entrainment and impingement of fish eggs and larvae by screens within the Offtake Structure;
- Physical injury or mortality of any eggs and larvae that pass through the screen and collide with impellors in the pump and wall of the pipeline or are exposed to changes in pressure;
- Disturbance from noise and/or vibration;
- Increased risk of predation due to stress and/or provision of novel habitat for fish and bird predators (Blackley 2003);
- Exposure to contaminants due to leakage of lubricants from the pump.

The severity of impact on threatened fish species will depend on the magnitude, duration and timing of extraction operations and the availability of water (Miller *et al.* 2007). The proportion of the flows removed from the Macquarie River on any one day would range from small (<10%) to moderate (20-31.5%), so the severity of impacts will vary. As extraction operations will be intermittent, impacts will generally occur when water is being pumped out of the river and for a short time thereafter. Extraction that takes place over a number of consecutive days could potentially have cumulative impacts.

Extraction would on average reduce the volume of low to moderate flows and moderate to high flows by 5-8 ML/d and 0-6 ML/d, respectively. The reduction in these flows would lead to decreases in wetted perimeter, depth of water and rate of flow in the section of the river between MR5a and Burrendong Dam. These, in turn, would reduce the availability of habitat for threatened fish species (See Section 3.1.2.3). The effects on aquatic habitat will be greater when moderate proportions (>10%) of low to moderate flows are extracted from the Macquarie River and greatest when 12 ML/d is extracted from a 38 ML/day flow. The availability of aquatic habitat during low and very low flows would not be compromised, because extraction would not occur under these conditions.

Reductions in flow would have a proportionally greater effect on riffle habitat, because stream depth is considerably lower than in pools. Some appreciation of the maximum likely changes in depth of water, hydraulic radius of the flow cross-section, flow area and top width of flowing water that could occur in riffle habitat when flows are reduced from 38 ML/day and 22.8 ML/day was obtained by using Manning's equation for open channel flow (See Section 3.1.2.3 for more details). The calculations indicate the water depth over a generalised 5 m wide riffle would decrease from 13.3 to 9.8 cm, while that over a 20 m wide riffle would be reduced from 5.8 cm to 4.3 cm during maximal extraction (Figure 4a). The hydraulic radius over a 5 m wide riffle would decrease from 0.125 m to 0.094 m, while that of 20 m wide riffle would be reduced from 0.058 m to 0.043 m (Figure 4b). The reductions in stream depth and hydraulic radius will consequently be greater in narrow riffles. Changes in flow area, in contrast, would be greater in wide riffles, increasing from 0.19 m^2 in 5 m wide structure to 0.31 m^2 in 20 m wide riffles (Figure 4c). Reductions in top width of flowing water would be relatively small across all four widths, suggesting impacts on marginal habitat along the edges of riffles would be negligible (Figure 4d).

Maximal extraction would reduce the water level in Cobbs Hut Hole by 39 mm, but would be a rare event, occurring on 0.11% of extraction days (Geolyse 2012b). The water level would be reduced by an average of 1-5 mm during moderate to high flows and 11-14 mm during low to moderate flows (Geolyse 2012b). Changes in water quality due to biological activity that occur when the depth of the pool is lowered could potentially have adverse effects on threatened species, if present. These effects would be offset by the influx of water from upstream.

As the water extracted would be replenished by flows from upstream, the impact on the availability of habitat on any one day is likely to be minor and transient. Extraction will, however, result in greater and more rapid fluctuations in aquatic habitats than natural, because there will be two gradual declines in water depth each day interspersed by two brief (2-3 hour) periods during peak electricity demand when water levels will rise due to cessation of pumping and continued replenishment by water flowing from upstream. The effects of the "pulsing" of flow on habitats downstream of the offtake would be attenuated by pools and tributary inflows, so the changes will diminish with distance downstream and become undetectable lower in the river system.

Extraction over a number of consecutive days could potentially have a cumulative effect on the availability of habitat. The magnitude of this is difficult to assess, because of the lack of information on aquatic habitats in this section of the river and the uncertainty about when and for how long extraction would take place and the magnitude of flows likely to prevail at that time. The reduction in availability of aquatic habitat would be relatively small and would diminish with distance downstream. The duration of these changes would depend on the prevailing flow rate upstream of the offtake site and number of consecutive extraction days.

Reductions in depth and velocity of water over riffles and cascades could potentially impede the movement of threatened fish species, particularly in shallow areas of the river during low flows. Fish that move through such areas run the risk of possible stranding, physical exhaustion and stress and increased exposure to terrestrial predators. The effects, however, are difficult to predict because minimum depth requirements and swimming abilities vary with species, size and shape of fish and little is known about such attributes or the movement patterns of the threatened fish species. Species that have smaller, cylindrical or shallow body profiles are likely to be capable of negotiating shallower water than deep-bodied species. The morphology of riffle habitats also varies, with some having several potential routes of passage that fish can utilise and areas of low velocity flow where fish can rest prior to negotiating short, high-energy sections through the top of the riffle (Reinfelds *et al.* 2010).

An appreciation of the likely flows required for the maintenance of minimum depths of 20 cm and 30 cm above riffles ranging in width from 5 m to 20 m in an area with a river slope of 1% was obtained by using Manning's equation for open channel flows (see Section 3.1.2.3 for more details). The stream depths selected are the minimum water depths used in previous studies of the flow requirements of adult Australian bass and Eastern Freshwater Cod (Reinfelds *et al.* 2010; Butler 2008). The calculations indicate flows of 75 ML/d and 150 ML/d respectively would be needed to maintain depths of 20 cm and 30 cm above a 5 m wide section of riffle and that flows of 297 ML/d and 584 ML/d would be required respectively to maintain these depths over 20 m wide riffles (Figure 5a). This implies the upstream movement of large-bodied threatened fish species, such as Trout Cod and Murray Cod, across narrow riffles would be restricted during all low to medium flows and that movement upstream of wide riffles may only be possible during some medium to high flows. It is important to note that there are numerous pools along the river where migrating fish could seek temporary refuge if the water level should drop to a level that hinders their passage through riffle and cascade habitat.

Extraction operations would reduce the number of days that a minimum flow depth of 20 cm would be exceeded by 6.6, 2.9, 1.8 and 1.4 days in 5, 10, 15 and 20 m wide riffles, respectively while a minimum flow depth of 30 cm would be exceeded by 3.0, 1.4, 0.6 and 0.4 days in 5, 10, 15 and 20 m wide riffles, respectively (Figure 5b). As these changes are relatively small and the water that is removed on extraction days would be replenished by inflows from upstream, pumping is unlikely to have a significant impact on the movement of fish beyond that which they normally experience.

The temporal variability in the various components of the flow regime (i.e. floods, high, medium and low flows) is expected to be similar to that at present (Geolyse 2012). The proposed extraction is consequently unlikely to result in loss of cues for migration, spawning or recruitment of threatened fish species.

Water extraction that coincides with the spawning, hatching and larval development periods of threatened species which exhibit downstream larval drift could potentially remove large numbers of recruits and contribute to changes in the distribution and abundance of their populations within the river (Gilligan and Schiller 2003). The risk of injury or mortality of eggs is likely to be very low given all three species deposit adhesive eggs on hard substrata, a 2 mm mesh screen situated in front of the suction manifold would be used to prevent their entrainment and the proposed pumping rate would be less than 12 ML/d. The drifting larvae of Trout Cod, Murray Cod and Macquarie Perch could potentially be entrained in the water that is extracted from the Macquarie River. The control measures specified above would reduce the risk of entrainment of such larvae. Small larvae, however, may be able to pass through the screen. These are likely to be injured or killed elsewhere in the pipeline as result of shear stress and would be lost from the population within the river. As the threatened fish species likely to occur in the vicinity of the offtake have a relatively large geographic range and only 0.2-0.6% of the average monthly flows would be extracted between June and

December (See Section 3.1.2.1), the critical period for reproduction of many fish species, the impact of extraction on their populations is likely to be relatively small.

The use of a sealed pump would minimise the potential for contamination of water and sediments due to loss of lubricants and subsequent exposure of threatened fish species to toxicants. The location of the pump within a wet sump and the relatively small extraction rate suggest that mobilisation of sediments would be limited and that flow-on effects on threatened fish species would be negligible.

The reduction in volume of flows would result in less sediment, leaf litter, woody debris and plankton being transported downstream. The likelihood of threatened fish species being damaged as a result of contact with mobilised sediment, debris and rocks would also be reduced. The general reduction in flows would result in less exchange of oxygen with the atmosphere, so the amount of dissolved oxygen available to threatened fish species may decline. The changes in the aquatic environment associated with the decreased volumes of low to moderate and moderate to high flows, however, are expected to be within the range of natural variability and much smaller than those that would occur periodically during droughts. They are consequently unlikely to have a significant impact on the threatened fish species that frequent this section of the river.

5.1.4 Safeguards, Mitigation and Offset Measures for Threatened Species

The impacts of construction works at the proposed MR5a Offtake would be minimised by:

- Limiting the area of aquatic habitat disturbed;
- Screening the pump inlet used to dewater the coffer dam;
- Limiting construction work during critical life cycle stages of fish (i.e. spring and summer when the threatened fish species spawn and recruit);
- Implementing a Sediment and Erosion Control Plan to protect any individuals of the threatened fish species occurring immediately downstream of the construction area;
- Translocating threatened fish from the construction area to the river prior to dewatering;
- Establishing a bunded area for storage of fuels, oils, refuelling and appropriate maintenance of vehicles and mechanical plant..

The loss of a small area of potential aquatic habitat for Trout Cod and Murray Cod could be offset by adding more instream woody habitat (i.e. snags) to the Macquarie River, either adjacent to or within the vicinity of the Project Area. The quality of existing habitat could also be improved by removing weeds from the riparian zone, replanting with appropriate native plants and using fences to manage or exclude stock.

Operational impacts on the threatened fish species would be minimised by:

- Using a screen with a 2 mm mesh size at the pump inlet to prevent intake of fish eggs and minimise intake of larvae;
- Starting the pump up slowly and then ramping up its velocity to a level that reduces the likelihood of any fish in the vicinity of the Offtake Structure being drawn into the pump;
- Limiting the extraction period to 19 hours per day and flows above 38 ML/d when the storage volume in the Suma Park Reservoir is below 90%
- At the end of each day's extraction blasting air through the screen to dislodge any organisms trapped on the screen;

The ability of threatened fish species to move between habitats during low and very flows (i.e. those below 22 ML/d) would not be compromised as the operating rule precludes pumping during such flows and will not create low flows (Geolyse 2012).

An additional control measure that could be considered is the installation of a device that would return fish to the river or deflect them away from the Offtake Structure.

The adoption of these control measures would reduce the potential impact of the construction and operational phases of the Project on Murray Cod, Trout Cod and Macquarie Perch to minor levels.

5.1.5 Assessments of the Significance of Impacts on Threatened Species

Assessments of the significance of impacts of the Project on the threatened fish species listed under the *EPBC* Act that may occur in the vicinity of the proposed Gardiner's Hole offtake and in the section of the river between there and Burrendong Dam were presented in Table 14 and Section 6.1.5 of the Aquatic Ecology Assessment. Background information on the geographic distribution, habitat requirements and reproduction of these species presented in Table 14 of the Aquatic Ecology Assessment has not been included here, for the sake of brevity. As the issues associated with the proposed MR5a route are common to all three species one over-arching assessment has been prepared (See Table 2). This assessment indicates there is a possibility of local Murray Cod, Macquarie Perch and Trout Cod populations being impacted during the construction and operation of the Offtake Structure. The adoption of the mitigation and management measures recommended in Section 4.1.3.2, however, would reduce the potential for impact to minor levels.

Table 3: Assessments of the Potential for Significant Impact on EPBC-listed Fish

Assessment Criteria	Response
Long-term decrease in the size of local and regional populations	The Project would have an adverse effect on the size of local and regional populations if it resulted in the mortality of significant numbers of sexually-mature fish or affected reproductive success by reducing the survival of eggs and larvae. The current size of local and regional populations of Murray Cod, Trout Cod and Macquarie Perch is unknown. Murray Cod is still present throughout most of the Murray-Darling River system, and this study provided evidence of natural populations near one of the proposed offtake locations in the Macquarie River. There are historic reports of Trout Cod occurring naturally in the Macquarie River, but the only known extant natural population is restricted to a small section of the Murray River. Macquarie Perch have been recorded in the upper reaches of the Macquarie River system, but are now thought to be extinct. As only itinerant fish surveys have been conducted, the possibility of natural populations of these species existing near the proposed offtake site can not be discounted. In the last five years, hatchery-bred Murray Cod fry have been released at sites on the upper Macquarie River in close proximity to Cobbs Hut Hole (i.e. Dixons Long Point Crossing, Jumbo Hole and Noisy Hole) and Trout Cod fry have been released at the nearby Dixons Hole. It is not known whether any of the Murray Cod or Trout Cod fry have survived and, if so, whether local populations have been established at or in the vicinity of Cobbs Hut Hole. In October 2012, an adult Murray Cod was captured within 300 m of Cobbs Hut Hole. Macquarie Perch has been stocked at numerous sites within and outside its natural range, but there are no records of any recent stockings in the upper Macquarie River. The extraction of water from the river could potentially result in mortality of the eggs and larvae of the three fish species through impingement and entrainment within the Offtake Structure. The swimming abilities of juvenile, sub-adult and adult Murray Cod, Trout Cod and Macquarie Perch would make them less susceptible to impingement and entrainment. The loss of eggs and larvae would be minimised by screening the offtake with 2 mm mesh, slowly ramping up the pump velocity, restricting offtake to a maximum of 12 ML over a period of 19 hours per day when flows upstream of the offtake site are equal to or greater than 38 ML/day and the storage volume of Suma Park Dam is below 90%. After daily extraction operations, air would be passed through the screen to dislodge any eggs and larvae trapped in the screen. Devices that deflect fish away from the vicinity of the pump could also be installed. The proportion of the total number of the eggs and larvae passing the offtake that is likely to be lost each year would be small, given the proposed pumping plan, use of a fine-mesh exclusion screen and proportion of flows (0.2-0.6%) that would be removed each month during their spawning and recruitment periods. These species all have a relatively large geographic range and if they are breeding in the upper Macquarie River are likely to be doing so at several sites. Given the above, the loss of eggs and larvae is unlikely to have a significant impact on the extent of local or regional populations.
Reduced area of occupancy	The information that is available about the types of habitat utilised by Trout Cod, Murray Cod and Macquarie Perch suggest that suitable habitat for these species is present at and adjacent to Cobbs Hut Hole. The construction and operation of the Offtake Structure would disturb individuals of these species that occur in its immediate vicinity. Such fish are likely to respond to disturbance from noise, loss of habitat and increased sediment load by moving to suitable habitat elsewhere in the river. The installation of the Offtake Structure would lead to permanent loss of a small area (approximately 27.2 m²) of benthic substratum, equivalent to approximately 0.095% of the Cobbs Hut Hole pool habitat. Adjoining areas of habitat are likely to be disturbed by the works. Given the small footprint of the Offtake Structure and presence of alternative pool habitat upstream and

	downstream of Cobbs Hut Hole, the reduction in potential area of occupancy of the three fish species would be of minor significance. The extraction of water will reduce the size of aquatic habitats available for occupation. The magnitude of the reductions in habitat availability will depend on the proportion of flows abstracted and vary across habitats. The extraction of water would reduce the water level in Cobbs Hut Hole by an average of 1-5 mm during moderate to high flows and 11-14 mm during low to moderate flows. When 12 ML/day is extracted from a river flow of 38 ML/day the water level would drop by 39 mm, but this would be a rare event (occurring on 0.11% of extraction days) (Geolyse 2012b). Although the effects on pool depth would be relatively small and transient, the intermittent nature of the pumping will result in greater and more rapid fluctuations in the pool environment than occur naturally. The effect of this on the threatened fish species is not known. Extraction would have a proportionally greater effect on shallow habitats such as riffles and cascades. The impact of extraction on stream depth and flow velocity will vary with the width of these habitats and slope of the river and proportion of flows removed. Approximations derived from the Manning equation indicate the water depth over a 5 m wide riffle would decrease from 13.3 to 9.8 cm, while that over a 20 m wide riffle would be reduced from 5.8 cm to 4.3 cm during maximal extraction. Changes in flow area, in contrast, would be greater in wide riffles, increasing from 0.19 m^2 in 5 m wide structure to 0.31 m^2 in 20 m wide riffles. Reductions in top width of flowing water would be negligible, suggesting that habitat along the margins of riffles would not be adversely affected. Reductions in flow velocity would also be greater in narrow riffles, decreasing from 0.63 to 0.52 m/s over a 5 m wide riffle and from 0.37 to 0.31 m/s over a 20 m wide riffle. The reductions in flow depth, flow area and top width of flowing water would diminish as river slope increases. The effects of the ”pulsing” of flow on habitats downstream of Cobbs Hut Hole would be attenuated by pools and tributary inflows, so changes in water depth, velocity, flow area, hydraulic radius and top width of flowing water will decrease with distance downstream and become undetectable lower in the river system. The impacts on area of occupancy would be transient with duration of any changes depending on the prevailing flow rate upstream of the offtake site and number of consecutive extraction days.
Fragmentation of an existing population into two or more populations.	The small footprint of the Offtake Structure, intermittent nature of the extraction process and the removal of only small to moderate amounts of water combined with the availability of suitable habitat for Trout Cod, Murray Cod and Macquarie Perch elsewhere in the upper Macquarie River and the mobility of these species suggest that fragmentation of existing populations of these species into two or more populations is highly unlikely.
Adverse effects on habitat that is critical to the survival of the species	The Project would have an adverse effect on the survival of Trout Cod, Murray Cod and Macquarie Perch if it resulted in loss of critical spawning and feeding habitat or loss/reduction of habitat connectivity prevented these species from accessing such areas. The location of habitats that are critical to the survival of these species in the Macquarie River is not known. Similar habitats to those in the vicinity of Cobbs Hut Hole are present nearby and elsewhere in the upper Macquarie River, so it is unlikely that the small amount of habitat that will be lost would be critical to the survival of these species. The removal of moderate proportions of flows could reduce habitat connectivity and prevent fish from accessing habitats used for spawning and feeding. As extraction will be an intermittent process that removes moderate (>10%) proportions of flows on an average of 51 days per year and flows from upstream will replenish what is removed, the effects on access would be temporary. Extraction of water will not occur when flows drop below the 38 ML/d threshold. As this is in excess of the low flows that occur naturally within the Macquarie River, loss of habitat connectivity will not be greater than that which occurs naturally during low and very low flows.
Disrupt the breeding cycle of a	The breeding cycle of Trout Cod, Macquarie Perch and Murray Cod would be

population	adversely affected if the Project prevented large numbers of sexually-mature fish from finding suitable mates, caused loss of spawning cues, loss or degradation of spawning habitat, mortality of eggs, larvae and sexually mature fish or created barriers that impeded spawning migration and downstream movement of recruits. Note that it is not known whether self-sustaining populations of Trout Cod and Macquarie Perch are present in the upper Macquarie River. The greater swimming abilities of sexually-mature fish would make them less susceptible to entrainment and impingement, so extraction is unlikely to cause their mortality. The section above indicates extraction could result in temporary reduction in habitat connectivity. This could affect the ability of fish to find potential mates, but would be a temporary impact. Spawning of Trout Cod does not appear to be dependent on flow conditions, so the small reductions in amplitude of medium, and moderate to high flows resulting from extraction of water are unlikely to have any effects. The influence of flow on reproduction of the other species is not known. The temporal variability in floods, high, medium and low flows is expected to be similar to that at present, so loss of cues for migration, spawning or recruitment of threatened fish species is unlikely. All three species produce relatively large adhesive eggs which stick to hard substrata, so the likelihood of them being drawn into the Offtake structure during extraction is low. The inclusion of a screen at the pump intake with a 2 mm mesh would prevent their eggs being entrained. The small larvae that hatch from these eggs would be vulnerable to impingement and entrainment during their downstream dispersal. The risk of this would also be minimised by screening. The proportion of the total number of the eggs and larvae passing the offtake that is likely to be lost each year would be small, given the proposed pumping plan, use of a fine-mesh exclusion screen and proportion of flows (0.2-0.6%) that would be removed each month during their spawning and recruitment periods. These species all have a relatively large geographic range and if they are breeding in the upper Macquarie River are likely to be doing so at several sites. Given the above, the Project is unlikely to disrupt the breeding cycle of any self-sustaining Trout Cod, Murray Cod or Macquarie Perch populations occurring in the vicinity of the Offtake Structure.
Modify, destroy, remove, isolate or decrease the availability and or quality of habitat to the extent that the species is likely to decline.	Potential temporary impacts on the quality of habitat resulting from increased sediment loading during construction would be avoided or minimised by application of appropriate erosion and sediment control measures. The area of habitat that would be lost, modified or degraded as a result of the installation of the Offtake Structure is small. As there are numerous pools in the upper Macquarie River it is highly unlikely that the Project would change habitat availability and/or quality to such an extent that the species would decline. The impact of extraction on the availability of habitat is described above. The effects on availability of habitat would be relatively small and transient. The intermittent nature of the pumping will, however, result in greater and more rapid fluctuations in habitats than would occur naturally, but this is unlikely to result in a decline in these fish species.
Result in invasive species that are harmful becoming established in the threatened species habitat	Six invasive fish species, Brown Trout, Eastern Gambusia, European Carp, Goldfish, Rainbow Trout and Redfin Perch are known to occur in the upper Macquarie River and could potentially occur in the vicinity of Cobbs Hut Hole. European Carp have been recorded approximately 300 m upstream of this site. The construction and operation of the proposed pipeline does not include any mechanisms that would lead to establishment of additional invasive species.
Introduce disease that may cause the species to decline	The construction and operation of the proposed pipeline does not include any mechanisms that would introduce disease. The noise, vibrations, and increase in sediment loading during the construction work and operation of the Offtake Structure however, could stress the threatened fish species and increase their susceptibility to disease. The effects, however, would be localised and therefore unlikely to cause the species to decline.

<table>
<tr><td>Interfere with the recovery of the species</td><td>There are National and NSW Recovery Plans for Trout Cod and a National Recovery Plan for Murray Cod but no Recovery Plans for Macquarie Perch. The activities associated with the Project that could pose a threat to the recovery of this species include:
• Removal of habitat including large woody debris from the vicinity of the Offtake Structure
• Reduction in water quality and increased sediment load associated with construction works;
• Construction of barriers to movement (e.g. coffer dams);
• Extraction of water

The threats posed by most of the above activities would be localised and transient and therefore unlikely to interfere with the recovery of the species. Extraction, however, could potentially have a cumulative effect on local populations, particularly if it results in periodic impingement and entrainment of eggs and larval fish. The likelihood of this depends on whether self-sustaining populations occur in the vicinity of Cobbs Hut Hole and the efficacy of the mitigation measures (i.e. low pump velocities, screening, limited extraction periods and purging of the screen) that would be used to minimise impingement and entrainment.

Cobbs Hut Hole is situated near sites in the Macquarie River where large numbers of hatchery-bred Trout Cod have been released as part of the NSW Recovery Plan and where Murray Cod fry have been released. The stocking that has been undertaken to date is unlikely to be compromised by the proposed Project if the proposed mitigation measures are implemented.</td></tr>
<tr><td>Conclusion</td><td>There is a possibility of local Trout Cod, Murray Cod and Macquarie Perch populations, if they exist, being impacted during the construction and operation of the offtake. The adoption of the mitigation and management measures recommended in Section 4.1.3.2, however, would reduce impacts to minor levels.</td></tr>
</table>

5.2 Matters of State Environmental Significance

5.2.1.1 Threatened Species and Populations

The following threatened fish species listed under the Fisheries Management Act 1994 are predicted or known to occur in the upland zone of the Macquarie River (Trueman 2007; Davies *et al.* 2008; FSC 2008a) and could potentially occur in the vicinity of MR5a:

- Flathead Galaxias (*Galaxias rostratus*) – listed as critically endangered;
- Macquarie Perch (*Macquaria australasica*) - endangered;
- Trout Cod (*Maccullochella macquariensis*) - endangered;
- Southern Purple-spotted Gudgeon (*Mogurnda adspersa*) – endangered; and
- Silver perch (*Bidyanus bidyanus*) – vulnerable.

The habitat requirements of these species indicate that Trout Cod, Macquarie Perch and Silver Perch could potentially occur in the Macquarie River but are unlikely to occur in the unnamed creeks along the MR5a route. Flathead Galaxias and Southern Purple-Spotted Gudgeon, in contrast, could potentially occur in the unnamed creeks, but are unlikely to occur in the river.

None of these species have been recorded during recent surveys undertaken in the Upper Macquarie River (Davies *et al.* (2008), GHD (2011a), Cardno Ecology Lab (2012a and this study) or by DPI NSW. Trout Cod fry, however, are known to have been released at various sites in the upland zone of the Macquarie River, including several deep pools holes in the vicinity of MR5a and Silver Perch has been stocked into Lake Burrendong. Flathead galaxias are now considered to be locally extinct in the Macquarie River.

One endangered fish population listed under the *FM Act* legislation, the Murray River Basin Population of Freshwater Catfish (*Tandanus tandanus*), could potentially occur in the vicinity of the offtake site. Juvenile Freshwater Catfish have recently been caught near Gardiners Hole (GHD 2011a; Cardno 2012). The DPI NSW records indicate this species has also been caught at Bruinbun, which is upstream of MR5a.

As intensive targeted sampling of these species has not been undertaken, an assessment of significance for each prepared in accordance with the Guidelines for Threatened Species Assessment applicable to Part 3A Projects was included in the Aquatic Ecology Assessment, as a precautionary measure.

The potential impact of the MR5a route on these conservation assets is considered in the next section.

5.2.2 Assessments of the Significance of Impacts on Threatened Species

In view of the difference in habitat requirements of these species and consequent exposure to different elements of The Project separate assessments of significance have been prepared for the threatened species likely to occur in river (i.e. Trout Cod, Macquarie Perch and Silver Perch) and unnamed creek (i.e. Flathead Galaxias and Southern Purple-Spotted Gudgeon). Note that background information on the life cycle, habitat and known distribution of these species presented in Table 15 of the Aquatic Ecology Assessment has not been included here, for the sake of brevity. The assessments presented are based on the Project Description (GHD 2011b) and our understanding of the likely impacts of the Project on the hydrological regime and instream ecology.

Table 4: NSW Threatened Species Assessments

(a) Flathead Galaxias (*Galaxias rostratus*) and Southern Purple-Spotted Gudgeon (*Mogurnda adspersa*)

Assessment Criteria	Response
How is the proposal likely to affect the life cycle of the threatened species?	The lifecycle of Flathead Galaxias and Southern Purple-Spotted Gudgeon would be adversely affected if the construction of the pipeline crossings prevented sexually-mature fish finding suitable mates, caused loss of spawning cues, loss or degradation of spawning habitat, mortality of eggs, larvae and sexually mature fish or created barriers that impeded their movements (e.g. spawning migration or downstream movement of recruits). The movement of both species and hence their ability to find mates could be impeded when coffer dams are temporarily installed at the proposed stream crossings. The impact of this could be minimised by transferring any Flathead Galaxias and Southern Purple-Spotted Gudgeon fish trapped within the coffer dam to adjacent sections of the creek, limiting the period for which the dam is installed and avoiding their use during critical fish migration and spawning periods. The pump could also be screened to minimise entrainment of fish when the water within the dam is pumped out. The construction of the pipeline crossings could potentially result in direct loss and degradation of spawning habitat (e.g. smothering with silt and changes in water quality due to increased sediment load and accidental releases of drilling fluids, fuels or lubricants). These impacts would be localised and short-term in nature. Such impacts would be minimised by limiting the construction footprint, using construction methods that limit disturbance of the stream bed and bank and using appropriate sediment and erosion control measures. The limited spatial extent of the pipeline crossings, availability of potential spawning habitat for this species elsewhere in the waterways and suggested mitigation measures indicates the Project would have minor effects on the life cycle of any Flathead Galaxias or Southern Purple-Spotted Gudgeon present in the waterways along the MR5a route.
How is the proposal likely to affect the habitat of the threatened species?	The construction of the pipeline crossings could affect the availability and quality of habitat. The potential impacts include loss or modification of physical habitat and changes in water quality due to increased sediment load and accidental releases of drilling fluids, fuels or lubricants. The loss of habitat would be permanent, but restricted to a small area at each crossing. The other impacts would be localised and generally short-term in nature. The potential for such impacts would be minimised by limiting the construction footprint, using construction methods that limit disturbance of the stream bed and bank, using appropriate sediment and erosion control measures and translocating fish, if necessary. The limited spatial extent of the pipeline crossings and availability of suitable habitat for these species elsewhere in the creeks indicate the Project is unlikely to have a significant effect on the availability of Flathead Galaxias or Southern Purple-Spotted Gudgeon habitat.
Does the proposal affect threatened species at the limits of their known distribution	The waterways along the MR5a Route are a considerable distance from the downstream and upstream limits of the upper Macquarie River, so the Project is unlikely to affect the distribution limits of Flathead Galaxias, if a population persists. Purple-Spotted Gudgeon are predicted to have been present in the upper Macquarie River prior to human intervention (Davies *et al.*2008). A new population has recently been discovered in the Macquarie catchment near Wellington (NSW DPI 2008). If a population is present in the waterways along the MR5a Route it would not therefore be at or close to the limit of its distribution range.
How is the proposal likely to affect current disturbance regimes?	The major disturbances that would affect Flathead Galaxias and Southern Purple-Spotted Gudgeon are runoff during rainfall events, flooding and fire. The construction of the pipeline crossings could potentially expose these

	fish species to greater runoff, particularly if the removal of vegetation coincides with a rainfall event. The impacts of this would be minimised by implementing appropriate sediment and erosion control measures (e.g. restricting vegetation clearing and construction works to no rainfall periods, deploying erosion control matting in the riparian zone and silt curtains along the river bank, revegetating disturbed areas immediately after construction works. The construction of the pipeline crossings would have no effect on flooding or fire. The operation of the pipeline crossings would not affect current disturbance regimes.
How is the proposal likely to affect habitat connectivity?	Habitat connectivity could be reduced if the construction of pipeline crossings decreased the depth of water and its rate of flow over riffle and cascade habitat to such an extent that it impeded the movement of Flathead Galaxias and Southern Purple-Spotted Gudgeon along the creeks. Habitat connectivity would be lost if the construction works lead to isolation of pools and exposure of sections of the river bed. The only time that construction works along the MR5a pipeline route are likely to affect habitat connectivity is when a coffer dam is temporarily installed at stream crossings. The impact of this could be minimised by transferring any Flathead Galaxias and Southern Purple-Spotted Gudgeon fish trapped within the coffer dam to adjacent sections of the creek, limiting the period for which the dam is installed and avoiding their use during critical fish migration and spawning periods. The pump could also be screened to minimise entrainment of fish when the water within the dam is pumped out.
How is the proposal likely to affect critical habitat?	There are no critical habitats for Flathead Galaxias or Southern Purple-Spotted Gudgeon listed under the *FM Act*. The recommended and declared critical habitats listed on the NSW Critical Habitat Register (OEH, 2012) and DSEWPAC Register of Critical Habitat (2009) do not occur within the Project area or its surrounds.

(b) Trout Cod (*Maccullochella macquariensis*), Silver Perch (*Bidyanus bidyanus*) and Macquarie Perch (*Macquaria australasica*)

Assessment Criteria	Response
How is the proposal likely to affect the life cycle of the threatened species?	The lifecycle of Trout Cod, Macquarie Perch and Silver Perch would be adversely affected if the construction and operation of the Offtake structure prevented sexually-mature fish finding suitable mates, caused loss of spawning cues, loss or degradation of spawning habitat, mortality of eggs, larvae and sexually mature fish or created barriers that impeded movement of fish (e.g. spawning migration or downstream movement of recruits). The temporal variability in floods, high, medium and low flows is expected to be similar to that at present, so loss of cues for migration, spawning or recruitment of threatened fish species is unlikely. The construction of the Offtake Structure would lead to permanent loss of approximately 27.2 m² of underlying benthic substratum and disturbance of adjoining habitat. The footprint of the development is small relative to the channel of the river at Cobbs Hut Hole, so the Offtake structure will not impede the movement of fish. As there is potential spawning habitat for Trout Cod, Silver Perch and Macquarie Perch nearby and elsewhere in the Upper Macquarie River, the impact of construction work on spawning habitat is likely to be negligible. The extraction of water could potentially result in mortality of the eggs and larvae of these fish species through impingement and entrainment. These eggs and larvae would effectively be lost from the population within the river, but would represent only a small proportion of the total number passing the offtake. Their loss would be minimised by screening the offtake, slowly ramping up the pump velocity, restricting offtake to a maximum of 12 ML/d over a maximum of 19 hours when river flows are ≥ 38 ML/day and purging the screen at the end of the extraction period. Impacts could be minimised further by installing devices that deflect fish away from the pump. The greater swimming abilities of sexually-mature fish would make them less susceptible to entrainment and impingement, so extraction is unlikely to cause their mortality. Extraction will not have a significant effect on habitat connectivity so it will not prevent individuals from finding mates or spawning migrations (see below).
How is the proposal likely to affect the habitat of the threatened species?	The Project could affect the threatened fish species if it resulted in loss or modification of physical habitat and changes in water quality due to increased sediment load and accidental releases of drilling fluids, fuels or lubricants. The availability of aquatic habitat during low and very low flows would not be compromised, because extraction would not occur under these conditions. The construction of the Offtake Structure would lead to permanent loss of approximately 27.2 m² of underlying benthic substratum which is equivalent to approximately 0.095% of the Cobbs Hut Hole pool habitat. Adjoining areas of habitat are also likely to be disturbed by the works, but these effects would be localised and short-term. As the footprint of the development is relatively small and there is suitable habitat for Trout Cod, Silver Perch and Macquarie Perch nearby, construction work is likely to have only a minor impact. The potential for impacts would be minimised by limiting the construction footprint, using construction methods that limit disturbance of the stream bed and bank, using appropriate sediment and erosion control measures and translocating animals, if necessary. The extraction of water will reduce the size of aquatic habitats. The magnitude of the reductions in habitat availability will depend on the proportion of flows abstracted and vary across habitats. The extraction of water would reduce the water level in Cobbs Hut Hole by an average of 1-5 mm during moderate to high flows and 11-14 mm during low to moderate flows. When 12 ML/day is extracted from a river flow of 38 ML/day the water level would drop by 39 mm, but this would be a rare event (occurring on 0.11% of extraction days) (Geolyse 2012b). Although the effects on pool depth would be relatively small and transient, the intermittent nature of the pumping will result in greater and more rapid fluctuations in the pool

	environment than occur naturally. Extraction would have a proportionally greater effect on shallow habitats such as riffles and cascades. The impact of extraction on stream depth and flow velocity will vary with the width of these habitats and slope of the river. Approximations derived from the Manning equation indicate the water depth over a 5 m wide riffle would decrease from 13.3 to 9.8 cm, while that over a 20 m wide riffle would be reduced from 5.8 cm to 4.3 cm during maximal extraction. Changes in flow area, in contrast, would be greater in wide riffles, increasing from 0.19 m^2 in 5 m wide structure to 0.31 m^2 in 20 m wide riffles. Reductions in top width of flowing water would be relatively small, suggesting that habitat along the margins of riffles would not be adversely affected. Reductions in flow velocity would also be greater in narrow riffles, decreasing from 0.63 to 0.52 m/s over a 5 m wide riffle and from 0.37 to 0.31 m/s over a 20 m wide riffle. The reductions in flow depth, flow area and top width of flowing water would diminish as river slope increases. The effects of the "pulsing" of flow on habitats downstream of Cobbs Hut Hole would be attenuated by pools and tributary inflows, so changes in water depth, velocity, flow area, hydraulic radius and top width of flowing water will decrease with distance downstream and become undetectable lower in the river system. The duration of these changes would depend on the prevailing flow rate upstream of the offtake site and number of consecutive extraction days.
Does the proposal affect threatened species at the limit of their known distribution	There are two reports of Trout Cod occurring naturally in the Macquarie River, but one of these is unconfirmed. This species has undergone a dramatic decline in its distributional range and abundance over the past century. The only known natural population occurs in the Murray River between Yarrawonga Weir and Strathmerton. Hatchery-bred Trout Cod have been released at a number of sites on the upper Macquarie River between 1991 and 2011, three of which are close to Cobbs Hut Hole (i.e. Boat Hole, Gardiners Hole and Dixons Hole). It is not known whether any of these fish have survived and if so whether they have established local populations in Cobbs Hut Hole. The preferred offtake location is situated towards the downstream end of the stocking sites on the upper Macquarie River and is therefore likely to be well within the distribution range of any populations that have become established. Macquarie Perch have been recorded in the upper Macquarie River, but are now presumed to be extinct (Faulks *et al.* 2010). As the fish surveys that have been undertaken are limited in frequency, spatial extent, duration and intensity, the possibility of the species still being present cannot be discounted. There are reports of self-sustaining Silver Perch populations in the Macquarie River. This species has also been released into several reservoirs and dams in the Upper Macquarie catchment, including Lake Burrendong. As there are no barriers to the upstream movement of fish above this lake, Silver Perch may be resident in or periodically migrate through Cobbs Hut Hole. The Project Area is a considerable distance from the downstream and upstream limits of the upper Macquarie River and will not prevent movement of Trout Cod, Macquarie Perch or Silver Perch. It is therefore unlikely to have any effects on their distribution limits.
How is the proposal likely to affect current disturbance regimes?	The major disturbances that are likely to affect Trout Cod, Silver Perch and Macquarie Perch are runoff during rainfall events, flooding and fire. The construction of the Offtake Structure could expose these fish species to runoff, particularly if the removal of vegetation coincides with a rainfall event. The impact would be short-term and greater in the immediate vicinity of the construction works than further downstream. The exposure of the fish to such runoff could be minimised by implementing appropriate sediment and erosion control measures (e.g. restricting vegetation clearing and construction works to no rainfall periods, deploying erosion control matting in the riparian zone and silt curtains along the river bank,

	revegetating disturbed areas immediately after construction works. Extraction of water would not occur during floods or if water quality was not acceptable, as may occur if significant rainfall events lead to runoff. The operation of the Offtake Structure would not result in fire.
How is the proposal likely to affect habitat connectivity?	The connectivity of the habitats along the river depends on stream water level and varies naturally, being greatest during large flows and poorest during low and very low flows. Habitat connectivity would be reduced if the Project decreased the depth of water and its rate of flow over riffle and cascade habitat to such an extent that it impeded the movement of Trout Cod, Macquarie Perch and Silver Perch along the river. Habitat connectivity would be lost if the Project resulted in isolation of pools and exposure of sections of the river bed or blocked the passage of fish along the river. During construction works, habitat connectivity will be reduced when a coffer dam is temporarily installed in the river. The impact of this would be minor as the dam would encompass only a small section of Cobbs Hut Hole adjacent to the river bank. Fish would be able to bypass the coffer dam by moving into the channel. The potential for impact could be minimised by transferring any Trout Cod, Macquarie Perch and Silver Perch trapped within the coffer dam to adjacent sections of the river, limiting the period for which the dam is installed and avoiding their use during critical fish migration and spawning periods. The pump could also be screened to minimise entrainment of fish when the water within the dam is pumped out. The ability of the threatened fish species to move over riffle/cascade habitats depends on their minimum depth and velocity requirements and swimming abilities, all of which vary with species, size and shape of fish. The passage gradient and nature and structure of the substratum, including presence of resting areas, also influence fish passage. As only small to moderate proportions of flows would be extracted, fish passage may still be possible but it could be constrained by velocity or gradient barriers. Estimates of the likely flows required to maintain minimum water depths of 20 cm and 30 cm above riffles ranging in width from 5 m to 20 m in an area with a river slope of 1% were obtained from Manning's equation for open channel flows (see Section 3.1.2.1 for more details and note that these are approximations). The stream depths selected are the minimum water depths used in previous studies of the flow requirements of adult Australian bass and Eastern Freshwater Cod (Reinfelds *et al.* 2010; Butler 2008). The estimates indicate flows of 75 ML/d and 150 ML/d respectively would be needed to maintain depths of 20 cm and 30 cm above a 5 m wide section of riffle and that flows of 297 ML/d and 584 ML/d would be required respectively to maintain these depths over 20 m wide riffles. This implies the upstream movement of large-bodied threatened fish species, such as Trout Cod and Murray Cod, across narrow riffles would be restricted during all low to medium flows and that movement upstream of wide riffles may only be possible during some medium to high flows. Reductions in water depth due to extraction during these flow conditions would further limit the movement of medium and large-bodied fish species. The average number of days per year that stream depths of 20 cm and 30 cm would be exceeded in an area of river with 1% slope would decrease by 6.6, 2.9, 1.8 and 1.4 days and by 3.0, 1.4, 0.6 and 0.4 days in 5, 10, 15 and 20 m wide riffles, respectively. As the extraction operation would be intermittent, the number of days that minimum depths would be exceeded would be only slightly smaller than under natural conditions and the water that is removed would be replenished by inflows from upstream, the Project is unlikely to have a significant impact on habitat connectivity. There are also numerous pools along the river and resting sites within riffles where fish could seek temporary refuge if the water level drops to a level that hinders their passage through riffle and cascade habitat. Habitat connectivity will not be affected during low and very low flows because the operating rule preclude extraction of water when flows drop below a threshold of 38 ML/d, which is in excess of the low flows that occur naturally within the river.

How is the proposal likely to affect critical habitat?	There are no critical habitats for Trout Cod, Macquarie Perch or Silver Perch listed under the *FM Act*. The recommended and declared critical habitats listed on the NSW Critical Habitat Register (OEH, 2012) and DSEWPAC Register of Critical Habitat (2009) do not occur within the Project area or its surrounds.

Table 5: NSW Threatened Population Assessment

**Murray River Basin Population of the Freshwater Catfish (*Tandanus tandanus*)
(Source: Lintermans 2009; Fisheries Scientific Committee 2008d)**

Assessment Criteria	Response
How is the proposal likely to affect the life cycle of the threatened species and/or population?	The lifecycle of the Freshwater Catfish population would be adversely affected if the construction and operation of the Offtake structure prevented sexually-mature fish finding suitable mates, caused loss or degradation of spawning habitat, mortality of eggs, larvae and sexually mature fish or created barriers that impeded movement of recruits. Note this is a sedentary species that does not undertake migration. The construction of the Offtake Structure would lead to permanent loss of approximately 27.2 m² of underlying benthic substratum and disturbance of adjoining habitat. The footprint of the development is small relative to the channel of the river at Cobbs Hut Hole, so the Offtake structure will not impede the movement of fish. As there is potential spawning habitat for Freshwater Catfish nearby and elsewhere in the Upper Macquarie River, the impact of construction work on spawning habitat is likely to be negligible. Freshwater catfish lay their eggs in nests constructed of pebbles or gravel. Exposure of the nest by a drop in water level or fluctuating water levels would lead to abandonment of the nest or lack of spawning. The extraction operation is unlikely to expose nests. The extraction of water could potentially result in mortality of the Freshwater Catfish eggs and larvae of these fish species through impingement and entrainment. These eggs and larvae would effectively be lost from the population within the river, but would represent only a small proportion of the total number passing the offtake. Their loss would be minimised by screening the offtake, slowly ramping up the pump velocity, restricting offtake to a maximum of 12 ML/d over a maximum of 19 hours when river flows are ≥ 38 ML/day and purging the screen at the end of the extraction period. Impacts could be minimised further by installing devices that deflect fish away from the pump. The greater swimming abilities of sexually-mature fish would make them less susceptible to entrainment and impingement, so extraction is unlikely to cause their mortality. The section below indicates extraction will not have a significant effect on habitat connectivity so it will prevent individuals finding suitable mates or prevent spawning migration.
How is the proposal likely to affect the habitat of this threatened population?	The Project could affect the Freshwater Catfish population if it resulted in loss or modification of physical habitat and changes in water quality due to increased sediment load and accidental releases of drilling fluids, fuels or lubricants. The construction of the Offtake Structure would lead to permanent loss of approximately 27.2 m² of underlying benthic substratum which is equivalent to approximately 0.095% of the pool habitat. Adjoining areas of habitat are also likely to be disturbed by the works, but these effects would be localised and short-term. As the footprint of the development is relatively small and there is suitable habitat for this species nearby, the impact of construction work is likely to be of minor significance. The potential for such impacts would be minimised by limiting the construction footprint, using construction methods that limit disturbance of the stream bed and bank, using appropriate sediment and erosion control measures and translocating animals, if necessary. The extraction of water would reduce the water level in Cobbs Hut Hole by an average of 1-5 mm during moderate to high flows and 11-14 mm during low to moderate flows. The greatest impact on habitat would occur when 12 ML/day is extracted from a river flow of 38 ML/day. This would reduce the water level of Cobbs Hut Hole by 39 mm, but would be a rare event, occurring on 0.11% of extraction days (Geolyse 2012b). The changes in water depth in Cobbs Hut Hole during extraction would be phased, with a

	small gradual change occurring when the pump starts up being followed by a more rapid change as the velocity of the pump is ramped up. During these two phases the water that is removed would be replenished to some extent by water flowing in from upstream. When pumping ceases after 19 hours, the water would be replenished at a greater extent. Although the effects on pool depth would be relatively small and transient, extraction will lead to a more variable pool environment. The effects of the resultant "pulsing" of flow on depth of habitats downstream of MR5a would be attenuated by pools and tributary inflows, so such impacts will decline with distance downstream and become undetectable lower in the river system. The availability of aquatic habitat during low and very low flows would not be compromised, because extraction would not occur under these conditions
Does the proposal affect a threatened populations at the limit of its known distribution	A moderate remnant population is present in the Macquarie catchment upstream of Warren. Recent surveys indicate this species is present both downstream and upstream of MR5a (GHD 2011; Cardno 2012; NSW DPI 2006). The Project is consequently unlikely to have any effects on the species distribution limits.
How is the proposal likely to affect current disturbance regimes?	The major disturbances that are likely to affect the Freshwater catfish population are runoff during rainfall events, flooding and fire. The construction of the Offtake Structure could expose these fish to runoff, particularly if the removal of vegetation coincides with a rainfall event. The impact would be short-term and greater in the immediate vicinity of the construction works than further downstream. The exposure of the fish to such runoff could be minimised by implementing appropriate sediment and erosion control measures (e.g. restricting vegetation clearing and construction works to no rainfall periods, deploying erosion control matting in the riparian zone and silt curtains along the river bank, revegetating disturbed areas immediately after construction works. Extraction of water would not occur during floods or if water quality was not acceptable, as may occur if significant rainfall events lead to runoff. The operation of the Offtake Structure would not result in fire.
How is the proposal likely to affect habitat connectivity?	The connectivity of the habitats along the river depends on stream water level and varies naturally being greatest during large flows and poorest during low and very low flows. This connectivity would be reduced if the Project decreased the depth of water in pools and its rate of flow over riffle and cascade habitat to such an extent that it impeded the movement of Freshwater Catfish along the river. Habitat connectivity would be lost if the Project resulted in isolation of pools and exposure of sections of the river bed or blocked the passage of fish along the river. During the construction works at MR5a, habitat connectivity would be reduced when a coffer dam is temporarily installed in the river. The impact of this would be minor as the dam would encompass only a small section of Cobbs Hut Hole adjacent to the river bank. Freshwater Catfish would be able to bypass the coffer dam by moving into the channel. The potential for impact could be minimised by transferring fish trapped within the coffer dam to adjacent sections of the river, limiting the period for which the dam is installed and avoiding their use during critical fish migration and spawning periods. The pump could also be screened to minimise entrainment of fish when the water within the dam is pumped out. The small size of the Offtake Structure relative to available instream habitat indicates it is unlikely to affect habitat connectivity. The extraction of water would reduce the water level in Cobbs Hut Hole by an average of 1-5 mm during moderate to high flows and 11-14 mm during low to moderate flows but not cause drainage of the pool. The greatest impact on habitat connectivity would occur when 12 ML/day is extracted from a river flow of 38 ML/day. This would reduce the water level of Cobbs Hut Hole by 39 mm, but would be a rare event, occurring on 0.11% of extraction days (Geolyse 2012b). The impact on riffle and cascade habitat downstream of Cobbs Hut Hole would be considerably smaller than in the pool, because the flow of water through these habitats is faster than within

	pools. The change in depth of flow over riffles depends on their width and flow velocity, with changes declining as width of riffle and flow velocity increases. Calculations based on the continuity equation Q = VA (flow = velocity x flow area) indicate the depth change in riffles during low velocity flows (1.5 m/s) would vary from 24 mm in narrow (5 m wide) riffles to 6 mm in wide riffles (15- 20 m) when the river flow is 38 ML/day. As the water that is removed would be replenished by flows from upstream and there will be no change in flows past the Offtake Structure during the 5 hour period each day that extraction ceases each day, the effect of the reductions in water depth on habitat connectivity would be relatively small and transient. The effects of the resultant "pulsing" of flow on depth of habitats downstream of MR5a would be attenuated by pools and tributary inflows, so impacts would decline with distance downstream and become undetectable lower in the river system. As extraction would cease when flows drop below 38 ML/d, it is unlikely that it would result in loss of habitat connectivity beyond that which occurs naturally during low to very low flows.
How is the proposal likely to affect critical habitat?	No critical habitats for Murray River Basin population of Freshwater Catfish are listed under the FM Act. The recommended and declared critical habitats listed on the NSW Critical Habitat Register (OEH, 2012) and DSEWPAC Register of Critical Habitat (2009) do not occur within the Project area or its surrounds.

5.2.3 Assessment of Impacts on Key Threatening Processes

5.2.3.1 Offtake Structure

The proposed clearing of vegetation and earthworks on the river banks would result in loss of and degradation of some of the native riparian vegetation along the river. As indicated in Section 4.1.2.1, the disturbance of the riparian zone would be localised, temporary and addressed by rehabilitation works undertaken after the construction work is completed. The effects of the loss and degradation of riparian vegetation on native fish and aquatic macroinvertebrates that utilise the wood debris, leaf fall or detritus produced by this vegetation would be minimal, as inputs of these would continue from upstream of the construction works.

The installation of the Offtake Structure and rock armouring may require large woody debris, such as tree trunks, branches or root masses, to be removed from a small area of the river bed. Snags are present at the offtake site, but cover only 5% of the area surveyed (Section 3.5.1.1). Impacts on this potential aquatic habitat, if present within the construction footprint, could be avoided by relocation elsewhere within Cobbs Hut Hole.

The installation of a coffer dam around the construction site would result in a temporary modification to the natural flows within a small area (54 m^2) of Cobbs Hut Hole.

The operation of the offtake would alter the natural flows within the upper Macquarie River and Summer Hill Creek. It would lead to a slight reduction in low to moderate and moderate to high flows (i.e. those across the 10^{th} to 80^{th} percentile flow range) in the river, but would have no effect on low flows, nor would it create the latter (Geolyse 2012b). The proposed transfer of water from the Macquarie River would increase the average annual volume of spills from Suma Park Dam, which in turn would increase the average annual flows in Summer Hill Creek. As the flow regime in NSW rivers and streams is naturally highly variable and the aquatic biota within these systems are adapted to such variability it is highly unlikely that the small modification in flows resulting from extraction would have any measurable adverse effects on the aquatic biota within the two watercourses.

The operation of the Offtake Structure would not result in the removal of large woody debris or lead to degradation of native riparian vegetation in either watercourse.

5.2.3.2 Water Pipeline

The clearing of vegetation and earthworks on the unnamed creek banks would result in loss of and degradation of some of the native riparian vegetation. As indicated above, these impacts would be localised, temporary and addressed by rehabilitation works undertaken after the construction work is completed. The effects of the loss and degradation of riparian vegetation on native fish and aquatic macroinvertebrates that utilise the wood debris, leaf fall or detritus produced by this vegetation would be minimal, as inputs of these would continue from upstream of the construction works.

The construction of the pipeline crossings may require large woody debris, such as tree trunks, branches or root masses, to be removed from small areas of the creek bed. Impacts on potential aquatic habitat at the crossings could be avoided by relocating the woody debris outside the construction footprint.

The installation of coffer dams around the crossing sites would result in a temporary modification to the natural flows within small sections of the creek.

The operation of the pipeline would have no effects on the three Key Threatening Processes identified in Section 6.2.1.5 or on Groundwater Dependent Ecosystems.

5.3 Conclusions

The various measures that would be taken to avoid, minimise, mitigate and offset impacts associated with the MR5a Route indicate the Project is likely to have only minor effects on the long-term viability of local populations of threatened fish species in the Macquarie River and it is therefore unlikely to accelerate their extinction or place them at risk of extinction.

6 Impacts associated with the EA vs. MR5a Route

This section focuses on the similarities and differences in impacts associated with the construction and operation of the section of the original pipeline route extending from the proposed offtake site at Gardiners Hole to Chainage 4000 described in the Environmental Assessment (GHD 2012) (referred to hereafter as the EA route) and the MR5a route between Cobbs Hut Hole and Chainage 4000 (See Figure 1). The two components of these routes (i.e. Offtake Structure and Pipeline crossings over streams) that may impact on aquatic ecology are considered separately.

6.1 Offtake Structure

The general topography and physical setting of the Gardiners Hole and Cobbs Hut Hole are similar in that both are set in a valley with steep walls. The river channel adjacent to Gardiners Hole, however, is relatively straight whereas Cobbs Hut Hole is situated on a bend. Gardiners Hole is situated just upstream of the confluence with Boshes Creek, whereas Cobbs Hut Hole is downstream of the confluence with an unnamed creek. The river channel immediately downstream of both sites is constricted, but to a greater extent at Gardiners Hole. There is a substantial difference in the aquatic habitat present within the immediate vicinity of the two sites, with the Gardiners Hole site being situated entirely within a pool habitat, but that at Cobbs Hut Hole being situated immediately upstream of a large riffle/rapid sequence consisting of bedrock outcrops, large boulders and cobbles and opposite an extensive sand/gravel point bar. Cobbs Hut Hole is consequently likely to contain a greater variety of aquatic habitats than Gardiners Hole and support a more diverse range of aquatic biota, including threatened fish species. Note that it is not possible to compare the proportional representation of aquatic habitats at the two sites because of differences in flow rates and water level during the two surveys. The presence of scattered rock outcrops amongst the vegetation on the relatively steep southern river bank and sand/gravel point bar along the northern bank suggest that platypus are unlikely to have constructed resting or breeding burrows at the MR5a site.

The similarities and differences in impacts on instream ecology of Offtake Structures constructed at Gardiners Hole and Cobbs Hut Hole are summarised in Table 6. The total area and proportion of aquatic habitat lost to construction would be greater and the type of habitat lost at Cobbs Hut Hole would most likely be different from that at Gardiners Hole. The amount of aquatic habitat lost, however, would still be small (<1% of the total area). The presence of an accretion zone on the bank and small hole in the river immediately downstream of the bedrock outcrop at MR5a and point bar on the opposite bank suggest that erosion and depositional processes in Cobbs Hut Hole probably differ from those at Gardiners Hole. The riverbank at both sites is steep and consists of bedrock covered by a thin layer of topsoil which supports some riparian vegetation. The potential for impacts on water quality, aquatic biota and threatened species arising from erosion and sediment mobilisation during construction works could therefore be different at the two sites. If the proposed sediment and erosion control measures are adopted, the construction of the Offtake Structure is unlikely to have a significant effect on instream ecology at either site.

Impacts associated with the presence of the Offtake Structure (i.e. provision of artificial habitat and increased risk of predation), exposure to noise and vibrations and loss of lubricants during extraction operations are likely to affect a greater range of biota at Cobbs Hut Hole than at Gardiners Hole (see above), but would not have a significant effect on instream ecology at either site. The risk of entrainment and impingement would be similar at the two sites, although effects may differ if aquatic organisms that are vulnerable to these processes are more abundant at one site than the other. The difference in availability of potential habitats, for example, suggests that the risk of entrainment and impingement of eggs and larvae produced by the threatened fish species may be greater at Cobbs Hut Hole than at Gardiners Hole. It should, however, be noted that Cobbs Hut Hole is not a stocking site for Trout Cod. If the proposed control measures are adopted, losses due to entrainment and impingement would not be significant at either site.

The greatest impact of extraction on aquatic habitats would occur when 12 ML/day is extracted from a river flow of 38 ML/day. The maximum reduction in water level would be greater in Cobbs Hut Hole (39 mm) than at Gardiners Hole (23 mm) due to differences in the geometry of river at the two holes. The river level changes across the flow deciles would also be slightly higher (by a maximum of 5 mm) at Cobbs Hut Hole. The effects of this decline on stream depth and velocity of flow over riffle/cascade habitat downstream are difficult to assess without knowledge of differences in stream width and gradient. If these are similar in the two areas, the effects on riffles/cascade habitats would be more marked at the Cobbs Hut Hole site.

Table 6: Similarity/Differences in Impacts on Aquatic Ecology of Offtake Structures located at Gardiners Hole (EA route) and Cobbs Hut Hole (MR5a Route)

Phase	Attribute	Similarity/Differences in Impacts on Aquatic Ecology between the EA and MR5a Routes
Construction	Aquatic Habitat	Total area of aquatic habitat lost to construction and type of habitat lost would differ.
	Water Quality	The potential for sediment movement and associated effects on water quality may differ at the two sites (note, an accretion zone has been observed downstream of the proposed MR5a offtake). This could be resolved by using appropriate sediment and erosion control measures.
	Aquatic Biota	Impacts on biota resulting from sediment load and turbidity may be potentially greater at MR5a but could be managed by appropriate sediment and erosion control measures.
	Threatened Species	Impacts on threatened species associated with sediment load and turbidity may be potentially greater at MR5a, but could be managed by appropriate sediment and erosion control measures
Operation	Aquatic Habitat	Provision of artificial habitat would be similar at the two sites. Decrease in depth of pool habitat would be greater at Cobbs Hut Hole.
	Water Quality	Changes due to mobilisation and dispersion of benthic sediments would be similar at the two sites
	Aquatic Biota	Exposure of biota to noise and vibrations would be similar at the two sites. Risk of entrainment would be similar, but effects on biota would depend on whether abundance of aquatic biota is similar at the two sites.
	Threatened Species	Aquatic habitats suitable for threatened species appear to be more common at MR5a, so there is a potential for greater impact, assuming similar numbers of fish are present at the two sites. Trout Cod have not been released at Cobbs Hut Hole.

6.2 Pipeline Crossings

The terminal ends of the EA route and MR5a route cross a total of one and four waterways, respectively, so the potential for cumulative impacts on aquatic ecology during construction works is greater along the MR5a route. The stream along the EA route was not surveyed during the December 2011 survey, so it is not possible to comment on differences in the level of potential impacts. The streams along both routes are narrow and ephemeral, so would be of minimal or unlikely value as fish habitat. The waterways along the MR5a route differed from those along the EA route in that they were generally more confined within the narrow valleys and had little connection with a floodplain (Cardno 2012). The geomorphology assessment indicated the two crossings closest to the Macquarie River are stable due to the presence of highly resistant channel materials and lack of in-channel disturbance, respectively. At the other crossings there is evidence of past erosion, with a small, shallow scour pool being present on the downstream side of the causeways. Threatened fish species are unlikely to be present due to the poor quality of the aquatic habitats in these creeks.

The methods that would be used to mitigate impacts on aquatic ecology at stream crossings along the two routes are likely to be similar and would reduce the potential for impact to non-significant levels.

The major source of impact during operation of the pipeline would be potential leakage of water and sediment into the streams. As the MR5a route requires more stream crossings the potential for cumulative impacts on aquatic ecology during the operation phase is also greater than along the EA route. The risk of such impacts, however, would be similar along the two routes provided appropriate mitigation measures were implemented.

6.3 Overall Conclusion

There is a greater potential for impacts on aquatic ecology along the MR5a Route than the EA route, but the residual impact after control measures are implemented would be similar.

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Appendix 1. GPS coordinates of the study sites surveyed within The Project area during October 2012 (WGS84, Zone 55H).

Site	Description	Easting	Northing
1	Downstream Macquarie River	711736	6344893
2	Upstream Macquarie River	712132	6344732
3	Intake Macquarie River	711859	6344720
4	WPT 339	710355	6342468
5	WPT 340	709355	6342342

Appendix 2: Numbers of each macroinvertebrate taxon picked from the AUSRIVAS samples collected from the edge habitat at each study site in the vicinity of MR5A in the Upper Macquarie River in October 2012.

Taxon		Macquarie River	
	Downstream	Upstream	Intake
Physidae			2
Oligochaeta	3	2	2
Cladocera	2		1
Copepoda	1	1	1
Ostracoda	1		
Atyidae		3	6
Lycosidae	1		
Tetragnathidae	1		1
Hydracarina	3		2
Hypogastruridae	2		
Caenidae	5	10	10
Baetidae		1	
Leptophlebiidae	10	10	10
Gripopterygiidae	1		6
Veliidae			2
Saldidae	1		
Corixidae	1	10	7
Notonectidae			5
Dytiscidae	8	1	2
Hydrophilidae	1	1	2
Chironomidae/Chironominae	10	5	2
Chironomidae/Orthocladiinae			2
Chironomidae/Tanypodinae	5	1	
Tipulidae		1	1
Ecnomidae	1	1	1
Leptoceridae	8	10	10