17 October 2018

Ground Floor, Suite 01, 20 Chandos Street
St Leonards, NSW, 2065
PO Box 21
St Leonards, NSW, 1590

T +61 2 9493 9500
F +61 2 9493 9599
E info@emmconsulting.com.au

www.emmconsulting.com.au

Cameron Lay
A/Program Leader (Aquatic Habitat Rehabilitation)
NSW Department of Primary Industries (Fisheries)
PO Box 1138
Armidale, NSW 2350

Re: Snowy 2.0 Exploratory Works – Revised assessment of significance for Murray Crayfish

Dear Cameron,

This letter provides a revised assessment of significance (AoS) for Murray Crayfish (*Euastacus armatus*) for Snowy 2.0 Exploratory Works, and replaces the AoS for Murray Crayfish included as part of the Exploratory Works Aquatic Ecology Assessment (Cardno 2018) which accompanied the Exploratory Works Environmental Impact Statement (EMM 2018).

The revised AoS reflects the known population of Murray Crayfish in Talbingo Reservoir and findings of additional survey work completed by Cardno in October 2018, the results of which were presented to DPI Fisheries on 16 October 2018. It should be read in conjunction with the Exploratory Works Aquatic Ecology Assessment (Cardno 2018).

Please don't hesitate to contact me (0402 259 892) if you require further information.

Yours sincerely

Kate Cox
Associate Environmental Scientist
kcox@emmconsulting.com.au

Murray Crayfish (*Euastacus armatus*) – listed as vulnerable under the FM Act – Revised Assessment of Significance - Snowy 2.0 Exploratory Works

1.1 Introduction

This revised assessment of significance (AoS) for Murray Crayfish (*Euastacus armatus*) for Snowy 2.0 Exploratory Works replaces the AoS for Murray Crayfish included as part of the Exploratory Works Aquatic Ecology Assessment (Cardno 2018) which accompanied the Exploratory Works Environmental Impact Statement (EMM 2018).

This revised AoS reflects the known population of Murray Crayfish in Talbingo Reservoir and findings of additional survey work completed by Cardno in October 2018, the results of which were presented to DPI Fisheries on 16 October 2018. It should be read in conjunction with the Exploratory Works Aquatic Ecology Assessment (Cardno 2018).

1.2 Background on Ecology and Occurrence

Summary of Population, Lifecycle and Habitat Requirements

Murray crayfish are endemic to the southern tributaries of the Murray-Darling Basin (NSW DPI, 2018a). Prior to the 1950s the species was found in the Murray River for most of its length in New South Wales with the exception of the Darling River (Morgan, 1986). However, they have suffered considerable declines in range and distribution since the 1950s. NSW DPI conducted surveys to determine Murray crayfish stocks in 2012 and 2013. 53 sites were sampled each year throughout the species former range in the Murrumbidgee and Murray River systems (NSW DPI, 2014). Anecdotally, the species was historically abundant throughout this entire range. Murray crayfish was not detected in 42% of the sites including downstream sections of the Murrumbidgee and Murray Rivers.

Murray crayfish are the second largest freshwater crayfish in the world and are a slow-growing and long-lived species (NSW DPI, 2014). Growth occurs through a series of moults with moulting frequency dependent on size, but commonly occurring annually following the first year where an individual may enter up to 10 moulting cycles. Females become sexually mature between eight to 10 years' of age while males mature faster at around four years. Mating begins in May each year after moulting is complete and is thought to be triggered by a rapid decline in water temperature (O'Connor, 1986). Eggs are laid once a year and brood size can range between 150, at sexual maturity, to 2,000, at maximum size. The eggs are held under the mother's tail for up to six months and once hatched the offspring would remain within the mother's protection for another four weeks, allowing for two moults, before independence. Offspring survival is usually low (Clarke & Ascroft, 2003).

Murray crayfish prefer environments with high flow velocity and cool to cold water temperatures (NSW DPI, 2014) but are also known to occur in still water such as lakes and reservoirs. They are more active during the cooler months when cold, flowing water maximises the dissolved oxygen in the water column allowing the species to capitalise energy expenditure. They are tolerant of a variety of in-stream habitats and use burrows for shelter. Murray crayfish require clay banks for burrowing. Burrows are usually less than one metre long with up to six entrances. They appear to spend most of the warmer months in their burrows, emerging occasionally to feed, and become more active during the cooler months. Burrows can occur on the banks of small creeks as well as large rivers below altitudes of 700 m. In upland areas and tributaries, rocks, boulders and wood debris are used for shelter when the geomorphology of river banks is not favourable for burrowing. These are considered important habitat characteristics and may be particularly important in upland areas where riverbanks may not be conducive to burrowing (Gilligan *et al*. 2007 and references therein). During scuba diver observations at Khancoban Pondage, approximately 90 % of Murray crayfish were observed sheltered among snags along banks and juveniles (6 mm to 40 mm OCL) were only found under rocks. They were not found in open areas where adults were sampled. Habitat alteration is one of the main causes of the species decline (NSW DPI, 2013).

Surveys within the Study Area

Field surveys for Murray crayfish were included as part of the aquatic ecology assessment for Exploratory Works. These consisted of surveys in Yarrangobilly River and Wallaces Creek in January/February 2018 and in Talbingo Reservoir in October 2018. Five individuals were caught during electrofishing in Yarrangobilly River / Wallace's Creek and they are likely to inhabit the reaches of these watercourses within the Study

Area. During October 2018, a total of 130 hoop nets were deployed throughout Talbingo Reservoir over a three day period at depths between 5 m and 58 m. One Murray crayfish was caught; a berried female recorded close to the shore at Ravine Bay (mid to southern section of Talbingo Reservoir).

In Talbingo Reservoir, a total of 188 individuals were caught across three surveys in winter of 2008 to 2010 (Zukowski *et al*. 2013). Murray crayfish were caught to approximately 10 m depth in Talbingo Reservoir in August 2013 by NSW DPI (Fisheries) (sampling was not undertaken any deeper than this) and are reported to occur to 15 m depth in nearby Blowering Reservoir (Martin Asmus, NSW DPI (Fisheries) Pers. Comm.). They are reported to occur in Talbingo Reservoir deeper than 15 m, though at present there is no information available to indicate their abundance here or the maximum depth to which they may occur. The population within Talbingo Reservoir is relatively undisturbed by fishing pressure, with relatively even sex ratios and a size frequency distribution indicative of a non-fished and undisturbed population (Zukowski *et al*. 2013).

1.3 Components of the Exploratory Works Relevant to Murray Crayfish

Portal Construction Pad and Accommodation Camp

All waste water arising on-site during construction would be managed in accordance with the approach described in the updated Surface Water Assessment (EMM 2018) submitted as part of the Exploratory Works Response to Submissions. This includes measures to manage stormwater, avoid contamination, minimise, manage and clean up spillages of fuels, oils and greases and appropriate storage and refuelling areas have been identified.

The potential for impacts to the Yarrangobilly River and other watercourses due to stormwater discharges from Exploratory Works has been assessed. All practical controls to avoid or mitigate impacts are presented in the updated Surface Water Assessment (EMM 2018). Sediment and erosion controls will be implemented to minimise potential risks to water quality in Talbingo Reservoir, Yarrangobilly River and Wallaces Creek. These will aim to contain and prevent sediment laden water reaching waterways and associated sedimentation here. Standard controls would effectively remove all coarse sediment and no sedimentation is expected in these locations outside of extreme rainfall events.

Some coarse sediments many enter these watercourses during extreme rainfall events. Turbidity, and suspended solids and nutrients concentrations in discharged stormwater are expected to exceed default trigger levels for physical and chemical stressors on occasions and it is possible that metal concentrations may also exceed the relevant default trigger levels. The volume of stormwater run-off that would enter the Yarrangobilly River during rainfall events and the amount of coarse sediment that it would contain are expected to be a very small proportion of the natural levels that would occur in the river during flood events. The mixing zone within the river, outside of which there would be no impact to water quality due to stormwater run-off, is predicted to me on the scale of 10s of metres and no concentration impacts are predicted. The rapid dilution that would occur would also mean that there would be an increased pollutant load in the river of no more than 2.6 % (that for oxidised nitrogen).

Discharge of treated wastewater and treated process water into Talbingo Reservoir will occur. All practical controls to avoid or mitigate impacts are presented in the updated Surface Water Assessment (EMM 2018). Treatment of waste water will substantially reduce electrical conductivity (EC) (i.e. the levels of salinity and dissolved ions) and concentrations of potential contaminants and nutrients in discharge water. An assessment of residual impacts has concluded that discharges of treated waste water and process water may exceed default trigger levels for Talbingo Reservoir at the point of discharge. This includes EC and concentrations of nutrients at the point of discharge in Talbingo Reservoir that will be elevated above guidelines. However, modelling indicates that rapid dilution and mixing at the point of discharge would not result in any change in water quality 10 metres from the point of discharge.

Dredged and Excavated Material Management

Dredged sediment and excavated material from exploratory tunnel construction would potentially be placed within Talbingo Reservoir in three locations: Plain Creek Bay , Cascade Bay and Ravine Bay. It is anticipated that initially material would be placed in Plain Creek Bay, but other locations may also be used during Exploratory Works. Plain Creek Bay is located just downstream of the Yarrangobilly Arm within a small embayment with maximum depth approximately 35 m below Minimum Operating Level (MOL). Cascade Bay is on the western side of Talbingo Reservoir to the north of Plain Creek Bay, located approximately 7 to 8 km from the barge ramp in Middle Bay. Maximum water depths in Cascade Bay are approximately 45 m relative to MOL. Ravine Bay is situated near the confluence of the Yarrangobilly and Tumut Rivers, located 2 km to 3km from the barge ramp in Middle Bay. Maximum water depths in the bay are approximately 35 m relative to MOL. Rock would be tested to assess geochemical properties prior to placement and any rock assessed

as unsuitable for subaqueous placement based on the prior geochemical and leachability testing would be managed separately.

All placement would occur deeper than 3 m below MOL. A total 2D surface area of 84 ha of reservoir bed would be disturbed by placement between MOL and approximately 45 m below MOL (**Table 1-1**). This represents 9.3 % of the total 2D surface area of the reservoir bed present between 0 m and 45 m MOL or 5.2 % of the reservoir bed from MOL to the maximum depth.

Table 1-1 Disturbance footprint in the SERP locations (Plain Creek, Ravine and Cascade Bays combined) compared with total area within reservoir among depth bands. Areas are planer 2 dimensional area.

Location	2D Area (ha)	% of Reservoir 0-45 m below MOL	% of total Reservoir MOL to Max. Depth
Plain Creek Bay	9	1.0	0.6
Cascade Bay	41	4.5	2.5
Ravine Bay	31	3.4	1.9
Barge Ramps	1	0.1	0.1
Middle Bay Dredging	2	0.2	0.1
Total Works Area	**84**	**9.3**	**5.2**
Total reservoir area (0 m to 45 m below MOL)	902		
Total reservoir area at MOL (0 m to max depth)	1,616		

A proportion of excavated material is likely to comprise ‘fines’ (particles less than 63 microns) which could potentially be a source of turbidity and deposition of mobilised sediments. Unmitigated, there would be potential for sedimentation and smothering of habitat outside of the placement footprint. The following controls to minimise impacts outside the immediate placement area have been incorporated into the project design:

- The proportion of fines would be restricted to a maximum of 10% of the placed material;
- Fines would be wetted prior to placement to assist settling;
- Material would be discharged into the water column via a fall pipe below the disposal barge to reduce any surface turbidity (exit of fall pipe minimum 5 m below water surface);
- The disposal barge would be surrounded by a silt curtain and a second, exterior, silt curtain would be placed across the side bay used for the placement. The exterior silt curtain would not be removed until satisfactory water quality criteria within the placement area are met.

Barge Access and Other Infrastructure in Talbingo Reservoir

Barge access infrastructure will include construction of two dedicated barge ramps at Middle Bay and Talbingo Spillway. Dredging works would be required to achieve an appropriate operating depth for the barge ramps. Dredging of 35,000 m^3 fine textured, predominantly coarse silts will also be undertaken to establish a navigation channel (approximately 50 m x 500 m) to ensure safe access to the Yarrangobilly Arm of the reservoir. This material will be managed in accordance with the excavated material management program described above.

Geophysical surveys are required within Talbingo Reservoir to inform the design of Middle Bay barge ramp and navigation channel. A survey line with geo-hydrophones will be deployed from a boat onto the reservoir bed. An airgun will be used to acquire seismic readings following release of compressed nitrogen. The airgun would be fired at or just above the bed of watercourse, spaced at approximate 8 m intervals. The radius of physical disturbance from each shot would be approximately 1 to 1.5 m.

Roads and Access

Temporary and permanent crossings in Yarrangobilly River and Wallace’s Creek would be constructed as part of the Exploratory Works. During construction of the portal construction pad and accommodation camp and during the operation of the accommodation camp, there is potential for soil disturbance which may exacerbate the risk of sediment erosion and mobilisation into Yarrangobilly River and Wallace’s Creek if exposed to heavy rainfall.

1.4 Assessment of Significance

1. In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Portal Construction Pad and Accommodation Camp

The risk to Murray crayfish due to discharge of treated waste water to Talbingo Reservoir is expected to be very low. The mixing zone (assessed as 10 m from the point of discharge in the updated Surface Water Assessment (EMM 2018)) where changes in water quality would occur represents a very small area of effect when considering the amount of aquatic habitat present in the reservoir. Murray crayfish would be able to actively avoid areas of poor water quality in the vicinity of the discharge. In particular, Murray crayfish have been observed to leave the water in response to reduced dissolved oxygen during 'blackwater' events. Thus, it is likely they would be able to move to nearby sections of the reservoir unaffected by the discharge. Concentrations of metals in discharge water would not exceed guidelines, and, together with the predicted rate of mixing there is expected to be a very low risk of metal toxicity to Murray crayfish due to discharge of treated water.

Standard sediment and erosion controls that would be implemented to minimise stormwater discharges into Yarrangobilly River and Wallaces Creek and associated sedimentation as described in the updated Surface Water Assessment (EMM 2018). Alteration (e.g. filling of refuges) of Murray crayfish habitat is not expected to occur during normal operation (i.e. outside of high rainfall events). While the turbidity of stormwater run-off during high rainfall events would exceed guidelines for Yarrangobilly River, stormwater would only enter waterways when natural turbidity would also be expected to exceed these guidelines during high rainfall events. In particular, the volume of stormwater run-off that would enter the Yarrangobilly River during rainfall events and the amount of coarse sediment that it would contain are expected to be a very small proportion of the natural levels that would occur in the river during flood events. The mixing zone within the river, outside of which there would be no impact to water quality due to stormwater run-off, is also predicted to me on the scale of tens of metres. Thus, the likelihood of sedimentation of Murray crayfish habitat occurring in Yarrangobilly River due to sediment laden run-off entering the waterway during rainfall events is expected to be very low and below that expected to occur during natural flood events. Further characterisation of baseline water quality in Yarrangobilly River will be undertaken to further inform the assessment of risk of potentially elevated concentrations in stormwater runoff entering the river. Also, all reasonable and feasible controls will be applied to minimise impacts to water quality. Further characterisation of baseline conditions and ongoing monitoring of water quality would help minimise potential impacts as far as possible.

The risk of toxicity to aquatic biota, including Murray crayfish, due to use of water treatment chemicals (including coagulants / flocculants) is expected to be low. The identified chemicals have been selected based on their relatively low toxicity and their use will be carefully controlled to ensure the minimum amounts required to meet the water quality objectives are used. Although if released in sufficient quantities these chemicals do still have potential to be toxic, their use would substantially reduce the potential for coarse sediments to enter waterways. In particular, the risk of ferric chloride resulting in elevated EC would be managed by adherence to the identified discharge limits for EC. The risk associated with release of low concentrations of calcium carbonate are also expected to be low due to management of pH in the discharge water. Potential impacts associated with low concentrations of the anionic polymer flocculent entering waterways are likely also to be low due to the lower toxicity of anionic, compared with cationic, flocculants. The rapid mixing that would occur at the discharge point in Talbingo Reservoir would also further substantially reduce the risk of toxicity to aquatic biota present here.

Excavated Material Management

Placement of excavated rock and dredged material within Talbingo Reservoir would disturb and permanently modify a portion of the reservoir bed. If present within the footprint of the placement area at the time of placement, then crayfish are likely to become buried and smothered beneath the rock. Burrows and soft-sediment habitats, would also be buried and lost beneath the material as it is placed on the reservoir bed. Wood debris would be relocated from the placement areas prior to placement and burial of this habitat would be minimal. Following placement, the reservoir bed within the placement footprints would be permanently altered. It would be shallower to varying degrees (depending on the final bedform) and the composition of substratum would be altered. Rather than consisting of primarily wood debris and riverine derived soft sediment, the substratum would be expected to consist of a much greater proportion of coarser sediment. There may also be opportunities to enhance the habitat quality of the finished surface at the conclusion of works. Following placement it is expected that Murray crayfish adults and juveniles would be able to utilise the modified habitat to some degree, whether this is for feeding or refuge. In any case, it is not expected that the habitat modification arising from placement would result in the complete or permanent exclusion of this

habitat from use by Murray crayfish. Accordingly, placement would not constitute a complete or permanent loss of Murray crayfish habitat.

Importantly, placement during Exploratory Works would not occur shallower than 3 m below MOL (i.e. no shallower than approximately 10 m below mean water level). This is the depth where Murray crayfish were caught by NSW DPI (Fisheries) in August 2013 and by Cardno in October 2018. This is expected to minimise loss of individuals and disturbance to shallower habitat (where crayfish may be relatively abundant, compared with greater depths). The area of habitat that would be modified by placement is also a small proportion (less than 10 %) of comparable habitat present throughout the reservoir. Although the duration of placement works would disturb the lifecycle of the component of the Murray crayfish population directly within the placement footprint, disturbance of the lifecycle of the entire population in the reservoir is not expected.

Some individuals may be lost due to placement, though this number is expected to be a small proportion of that in the entire reservoir, and would be minimised by implementation of a translocation program prior to commencement of works. Areas of habitat potentially disturbed by placement would be surveyed for Murray crayfish prior to disturbance and if captured, relocated to areas away from disturbance in consultation with DPI Fisheries. A management and monitoring plan will be developed Murray crayfish in consultation with DPI Fisheries

The reported presence of a relatively healthy population (in terms of sex ratio and length distribution) should also make it relatively resilient to a small reduction in size that may occur due to residual impacts associated with placement of excavated rock. The potential for impacts to Murray crayfish due to reduced water quality outside of the immediate disturbance areas is low given the proposed controls that would be implemented.

Barge Access and Other Infrastructure in Talbingo Reservoir

There would be a direct modification of potential Murray crayfish habitat within the dredging and barge ramp structure footprints. Any wood debris within these areas would also be displaced. However, the total area from which material would be disturbed and dredged is very small compared with the total area of reservoir (3 ha; less than 1 %). The loss / alteration of the small amount of potential habitat due to dredging of the barge ramp locations and Middle Arm navigation channel is expected to have very low to negligible effect on Murray crayfish. The implementation of controls including silt curtains and water quality monitoring during works is expected restrict indirect impacts, in particular potential sedimentation adjacent to works, to the areas directly affected by dredging, construction and placement of dredge material.

The risk of disturbance and/or harm to Murray crayfish due to release of compressed air during seismic surveys would depend on the level of noise generated and the duration of works. There is potential for harm and mortality of individuals in the immediate vicinity of the release of compressed air. The potential risk to this species would be minimised to an extent by the temporary nature of the surveys (approximately 100 shots over a few days) and the relatively localised position within an arm of the reservoir. Prior to commencement of seismic surveys, smaller releases of compressed air would also be undertaken just below the surface. This ‘soft start’ is expected to discourage crayfish away from the area before greater magnitude and potentially more harmful releases of compressed air take place. It is noted that harm or mortality of aquatic biota has not been observed during several previous comparable surveys undertaken by the operators (SMEC, Pers. Comm. 10 July 2018).

Roads and Access

Although this species is not known to migrate for breeding purposes and has a small home range, isolation of genetic material may occur if barriers are erected in watercourses such as the Yarrangobilly River. However, the temporary crossing would be designed and installed to provide fish passage hence would not obstruct movement of Murray crayfish. The permanent crossings in Yarrangobilly River and Wallace’s Creek would also be designed to allow free movement and no permanent or complete barriers to movement of Murray crayfish are expected.

Summary

Based on the relatively small area of habitat disturbance that would occur, the localised and temporary nature of the disturbance and the mitigation measures that would be undertaken, the residual impact to the Murray crayfish population in Talbingo Reservoir is not expected to place the population at risk of extinction. The reported presence of a relatively healthy population (in terms of sex ratio and length distribution) should also make it relatively resilient to a small reduction in size that could occur due to residual impacts associated with dredging, placement of excavated rock and geophysical survey. Changes to water quality are not considered to occur to the extent that it would lead to mortality of any individuals and would be much less than those changes naturally experienced during high rainfall events. Given the proposed crossings on Yarrangobilly River and Wallaces creek would not interfere with migration and the small home range size of Murray crayfish, impacts to this species associated with these crossings are not expected. Thus, Exploratory

Works is unlikely to have an adverse effect on the life cycle of Murray crayfish such that self-sustaining populations of the species (which are known to occur within the Study Area), would be placed at risk of extinction.

- **In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.**

Not applicable.

- **In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:**
    - i. **Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction; or**
    - ii. **Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.**

Not applicable.

In relation to the habitat of a threatened species, population or ecological community:

- i. **The extent to which habitat is likely to be removed or modified as a result of the action proposed; and**
- ii. **Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action; and**
- iii. **The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

Project activities with potential to alter Murray crayfish habitat include:

- Potential sedimentation in Talbingo Reservoir, Yarrangobilly River and Wallace's Creek due to release of sediment-laden water during Exploratory Works;
- Disturbance and modification to Murray crayfish habitat due to placement of excavated material, construction and dredging in Talbingo Reservoir; and
- Displacement of potential habitat beneath the temporary and permanent bridge structures in Yarrangobilly River.

<u>Potential sedimentation in Talbingo Reservoir, Yarrangobilly River and Wallace's Creek due to release of sediment-laden water during Exploratory Works;</u>

Control measures aimed at minimising mobilisation of sediment and associated deposition in Murray crayfish habitat include:

- Development and implementation of a Erosion and Sediment Control Management Plan;
- Treatment of water on site to remove coarse sediments from run-off; and
- Minimise release of coarse sediments to Yarrangobilly River and Wallaces Creek.

If coarse sediments do enter waterways during high rainfall events these are expected to contribute a negligible additional sediment load, indistinguishable from naturally occurring levels during wet weather events. Thus, impacts to Murray crayfish habitat in Yarrangobilly River and Wallaces Creek are not expected as a result of increased potential for erosion and sedimentation.

<u>Disturbance and modification to Murray crayfish habitat due to placement of dredged and excavated material, construction and dredging in Talbingo Reservoir</u>

Placement of excavated rock and dredged material would occur over approximately 84 ha of potential Murray crayfish habitat. This would result in a temporary loss of this habitat from the reservoir as they would be expected to return to the habitat once placement activities are completed. Opportunities to improve the habitat suitability of the final bedform of the placement areas will be investigated. This could include, for example, incorporation of larger rocks that would be expected to provide unique habitat and shelter for Murray crayfish and hence could enhance the value of this habitat to Murray crayfish. Wood debris within the placement areas would also be relocated to other areas of the reservoir prior to placement.

Further, wood debris is also abundant throughout the reservoir and is not likely to be a limiting factor for the growth of the Murray crayfish population. Overall, the area of habitat that would be modified represents a small proportion (less than 10 %) of the total habitat present within the reservoir. Placement in areas deeper

than 3 m below MOL would avoid shallower sections of the reservoir where the Murray crayfish have been caught previously and are expected to be more abundant.

The sections of reservoir where placement would occur are not unique in the context of the reservoir in terms of depth, presence of riparian vegetation, wood debris and bank profile. As indicated in historical aerial imagery of the reservoir area prior to inundation, large wooded debris is extensive throughout the reservoir, making up the majority of the reservoir bed. Placement activities would result in the modification of a relatively small area of potential Murray crayfish habitat and there is no indication that this habitat is more or less important than comparable habitat throughout the reservoir. There would not be any permanent habitat fragmentation or isolation due to placement activities.

Displacement of potential habitat beneath the barge ramps and navigation channel

The area of habitat that would be displaced under the barge ramp structures and modified within the dredging footprint in Middle Arm represents a very small area of total similar habitat available in the reservoir. The dredging footprint and area of disturbance for the barge ramps is approximately 3 ha representing less than 1 % of the area of reservoir bed (**Table 1-1**). There is no indication that this habitat is of particular importance when compared with habitat throughout the reservoir. Standard control measures, in particular silt curtains, will be used to minimise as far as practicable the potential for mobilisation of coarse sediments and the potential for smothering of habitat due to sedimentation outside the immediate works areas. The area of direct habitat disturbance due to release of compressed air is expected to be on the order of a few square metres per shot, equivalent to a few 100 square metres of temporary disturbance. This would have negligible consequences for Murray crayfish.

Roads and Access

The temporary crossings would be designed and installed to provide fish passage hence minimising potential obstruction of passage to Murray crayfish. The bridge crossings are not expected to result in a barrier to passage or the isolation or fragmentation of Murray crayfish habitat. Approximately four square metres of in-stream habitat would be displaced beneath the bridge pier in Yarrangobilly River. This would have negligible consequences for Murray crayfish.

Summary

With the above considered, the extent to which habitat is likely to be removed or modified as a result of the exploratory works would be minimal. The area of habitat that would be affected by placement, dredging and other works in Talbingo Reservoir represents less than 10 % of comparable habitat within the reservoir as a whole. This also represents habitat modification, rather than loss. The design considerations for fish passage would not result in barriers to movement of Murray crayfish or fragmentation/isolation of a population. With the design and control measures outlined above, the Exploratory Works are not expected to impact on the long-term survival of the population.

- **Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)**

Critical habitat refers to the register of critical habitat kept by the NSW DPI. No critical habitat is listed for Murray crayfish.

- **Whether the action proposed is consistent with the objective or actions of a recovery plan or threat abatement plan.**

No recovery plans have been developed for the Murray crayfish. However, a Priority Action Statement for Murray crayfish (NSW DPI, 2018b) does exist. This outlines the following recovery actions:

- Advice to consent and determining authorities;
- Collate and review existing information;
- Community and stakeholder liaison, awareness and education;
- Compliance / enforcement;
- Enhance, modify or implement Natural Resource Management planning processes to minimize adverse impacts on threatened species;
- Habitat rehabilitation;
- Pest eradication and control;
- Research / monitoring;
- Stocking / translocation; and

- Survey / mapping.

These recovery objectives and actions mostly surround conservation works, research and monitoring, agency consultation and community engagement. The proposed Exploratory Works are unlikely to interfere with these objectives.

- **Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.**

Key threatening processes are threatening processes that, in the opinion of the Fisheries Scientific Committee, adversely affect threatened species populations or ecological communities, or could cause species, populations or ecological communities that are not threatened to become threatened. There are currently eight key threatening processes listed under the FM Act of which two are applicable to the Exploratory Works:

i. Installation and operation of instream structure and other mechanisms that alter flow regimes of rivers and streams; and

ii. Removal of woody debris from New South Wales rivers and streams.

Large wood debris will need to be relocated within watercourses to facilitate bridge construction and within Talbingo Reservoir as part of placement, dredging works and construction of barge ramps. Wood debris within the placement areas would also be relocated within the reservoir prior to placement. If any wood is removed as part of bridge construction activities, it will be re-located within the River at another location and wood debris displaced during dredging works would be placed in other sections of the reservoir. Thus, no net loss of wood debris from the reservoir is expected and Exploratory Works are unlikely to trigger or exacerbate this KTP.

The Exploratory Works would involve the installation of temporary and some permanent instream structures over Class 1 watercourses and Type 1 key fish habitat. Crossing structures have been designed in consideration of the Fairfull and Witheridge (2003) guidelines for waterway crossings. As such, the installation of the proposed instream structures would have minimal impact on flow characteristics and would not constitute a barrier to passage. The identified threat abatement actions for this KTP include advice to consent authorities, community and stakeholder engagement, research and monitoring and habitat rehabilitation and protection. The Snowy 2.0 Exploratory Works Groundwater Assessment (EMM 2018b) assessed the reduction in baseflows in the Yarrangobilly River and other watercourses associated with groundwater seepage into the Exploratory Tunnel. The reduction in baseflows was predicted to be minor relative to the simulated baseflows in the Yarrangobilly River. Accordingly, the predicted reductions in baseflows are not expected to change the flow regimes in either the Yarrangobilly River or Wallaces Creek during normal and drought conditions. Thus, there would not be any reduction in the availability or connectivity of aquatic habitat and no associated impacts to this species are expected. The Exploratory Works are not expected to trigger or exacerbate this KTP.

Conclusion

Overall, there is not expected to be a significant impact to the populations of Murray crayfish within the Study Area due to Exploratory Works. There would not be an impact to the lifecycle of the species or changes to its habitat that would place it at risk of extinction. This is due to the following aspects of the project design:

- No complete or ongoing loss of Murray crayfish habitat due to placement of excavated rock and dredging activities – placement and dredging activities would result in habitat modification, rather than habitat loss
- Area of habitat modified by placement and other activities is a small proportion (approx. 5-10%) of the total amount of comparable habitat present throughout the reservoir
- No indication that the habitat that would be impacted represents habitat of particular importance, and there would not be any fragmentation or isolation of Murray crayfish habitat. The effect on a small proportion of the available habitat does not represent a significant risk to the local population of crayfish
- Implementation of targeted mitigation (translocation from placement areas to other locations in Talbingo prior to works) aimed at minimising as far as practicable loss of individuals during disturbance
- Changes in water quality in Talbingo Reservoir and watercourses are expected to be localised and/or negligible compared with natural variability. Best practice controls would be adopted during placement, construction and dredging in the reservoir to minimise as much the potential for indirect impacts on water quality, particularly any sedimentation, outside the immediate works areas.
- Placement of excavated material no shallower than 3 m below MOL.

Thus, considering these project elements and the targeted translocation mitigation, it is considered unlikely that the Exploratory Works will have a significant impact to this species and further assessment in a species impact statement is not recommended.

References

Clarke, G. & Ascroft, F., 2003. *A Review of the Conservation Status of Selected Australian Non-marine Invertebrates,* s.l.: s.n.

EMM Consulting Pty Ltd, 2018. Updated Surface Water Assessment. Appendix E of the Exploratory Works Response to Submissions, 3 October 2018.

Fairfull, S. and Witheridge, G. (2003) Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings. NSW Fisheries, Cronulla, 16 pp.

Gilligan, D, R. Rolls, J. Merrick, M. Lintermans, P. Duncan and J. Kohen (2007) Scoping the knowledge requirements for Murray crayfish (*Euastacus armatus*). MDBC Project No. 05/1066.

Morgan, G., 1986. Freshwater crayfish of the genus Euastacus Clark (Decapoda: Parastacidae) from Victoria. *Memoirs of the Museum Victoria,* Volume 47, pp. 1-57.

NSW DPI, 2013. Primefact. Murray Crayfish - *Euastacus armatus.* June 2013 Primefact 1300 first edition. https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0010/635662/Primefact-1300-Murray-Crayfish.pdf

NSW DPI, 2014. *Recreational fishing for Murray Crayfish (Euastacus armatus),* s.l.: NSW DPI.

NSW DPI, 2018a. *Murray Crayfish.* [Online]
Available at: https://www.dpi.nsw.gov.au/fishing/threatened-species/conservation/what-current/vulnerable-species/murray-crayfish
[Accessed 2018].

NSW DPI, 2018b. *Priorities Action Statement - Actions for Murray Crayfish.* [Online]
Available at: https://www.dpi.nsw.gov.au/fishing/threatened-species/conservation/what-current/vulnerable-species/murray-crayfish/priorities-action-statement-actions-for-murray-crayfish
[Accessed 2018].

O'Connor, P., 1986. *The biology of the Murray crayfish, Euastacus armatus (Decapoda: Parastacidae) and recommendations for the future management of the Fishery,* s.l.: s.n.

Zukowski, S., Whiterod N., and Watts, R.J. (2013). Comparing Murray Crayfish (*Euastacus armatus*) Population Parameters Between Recreationally Fished and Non-fished Areas. Freshwater Crayfish. 19(2): 153-160.