7. Conservation Significance

7.1 Overview

This section summarise the results of the desktop assessment, targeted surveys and habitat assessments to identify the threatened biota and Matters of National Environmental Significance that are likely to occur within the Forest and be affected by the project. Threatened fish and aquatic ecosystems are discussed separately.

7.2 Flora

7.2.1 Threatened Flora Species

The desktop literature review indicates eleven threatened plant species which have previously been recorded (three recorded), or are predicted (eight predicted) to occur in the locality. DECCW (2009a) Wildlife Atlas threatened species records from the locality of the Forest are shown on Figure 14. None of these species were recorded during site surveys. The majority of these species are considered unlikely to occur as they have limited ranges and/or habitat requirements, which are not present in the Forest. These include species associated with Mallee or Saltbush vegetation communities which do not occur within the Forest or the adjoining floodplain of the Murray River.

There is suitable habitat for four threatened plant species in the Forest. These species are presented in Table 17 along with their conservation status, the nature of their previous occurrence in the study area, the vegetation communities and habitats in which they are likely to occur and the potential for impacts arising from the project.

Table 17 Threatened Flora Species and their Habitats Likely to Occur within the Forest

Scientific Name	Common Name	EPBC Act	TSC Act	Nature of Previous Records	Likelihood of Occurring in the Forest	Likelihood of Impacts
Amphibromus fluitans	Floating Swamp Wallaby-grass	V	V	Recorded within 10km of the Forest (Vennell and Nias, 2005).	Possible (permanent to semi-permanent swamps with fluctuating water levels)	Direct impacts unlikely due to the dryness of the Forest. Positive impacts likely through proposed flooding.
Austrostipa wakoolica	-	E	E	Predicted, based on habitat surrogates [4](DEWHA, 2009a).	Possible (floodplain of Murray River tributaries)	Potential for mortality of individuals and removal of habitat if occurs within surface disturbance areas*.

Scientific Name	Common Name	EPBC Act	TSC Act	Nature of Previous Records	Likelihood of Occurring in the Forest	Likelihood of Impacts
Lepidium monoplocoides		E	E	Predicted, based on habitat surrogates (DEWHA, 2009a).	Possible but unlikely due to dearth of recent records (seasonally moist to waterlogged Forests, including Black Box woodland)	Potential for mortality of individuals and removal of habitat if occurs within surface disturbance areas*.
Swainsona murrayana		V	V	Predicted, based on habitat surrogates (DEWHA, 2009a).	Possible (black box woodland, floodplains, depressions. Also known from moderately grazed or cultivated paddocks)	Potential for mortality of individuals and removal of habitat if occurs within surface disturbance areas*.

* During construction period only.

Vennell and Nias (2005) noted Floating Swamp Wallaby-grass (*Amphibromus fluitans*) in Pollack Swamp, within the Koondrook SF but outside the Forest, following the environmental watering of this wetland during spring 2004.

Although not detected during site surveys these species of threatened plants may colonise habitat within the Forest in the future or may exist in the soil seed bank or as dormant individuals. The full list of threatened plant species considered in this assessment, including their habitat requirements and conservation status is presented in Appendix B.

7.2.2 Endangered Flora Populations

No endangered flora populations are known to occur in the locality of the Forest or in the Murray Fans CMA sub-region (DECCW, 2009b).

7.2.3 Endangered Ecological Communities

The desktop literature review indicates five EECs listed under the TSC/EPBC Acts which are known or predicted to occur in the locality of the Forest. The full list of EECs known from the region, including their habitat requirements and conservation status, is presented in Appendix B.

Two of these, Grassy Box-gum Woodland and Weeping Myall Woodland, can be reliably excluded from occurring in the Forest based on known distributions and the absence of suitable habitat. There is potentially suitable habitat for Buloke Woodland within the Forest, and some isolated patches of representative species were noted during site surveys. Areas of Buloke Woodland habitat within the Forest are extensively degraded, remote from project construction footprints and above the proposed inundation area and so these isolated remnants were not mapped or assessed in detail. The remaining

two EECs were confirmed as occurring in the Forest and are described in detail below and mapped in Figure 12.

Inland Grey Box Woodland

Inland Grey Box Woodland in the South West Slopes bioregion is listed as an EEC under the TSC Act. All areas mapped as Riverine Inland Grey Box Woodland grassy woodland within the Forest qualify as this EEC due to the presence of Inland Grey Box (*Eucalyptus microcarpa*) as the dominant canopy species and a characteristic understorey of native grasses and herbs, consistent with the Scientific Committee Determination for the EEC (DECCW, 2009d).

Areas mapped as Derived Grassland or Herbland in the Forest are probably a result of historic removal of trees rather than natural environmental factors. Some of these areas would comprise Inland Grey Box Woodland habitat. The Scientific Committee Determination for Inland Grey Box Woodland states: "Some remnants of the community survive with trees partly or wholly removed". Further "Disturbed remnants are considered to form part of the community including remnants where the understorey, overstorey or both would, under appropriate management, respond to assisted natural regeneration from the soil seed bank" (DECCW, 2009d). Therefore treeless lands surrounded by, or in the immediate vicinity of Inland Grey Box Woodland were mapped as the community and are treated as the EEC for the purposes of this assessment.

Sandhill Pine Woodland

A stand of White Cypress Pine dominated vegetation in the former Toorangabby property was sampled in the site survey and would qualify as the EEC Sandhill Pine Woodland. The Forest contains a number of other sandhills which would have historically supported either of the EECs Sandhill Pine Woodland or Buloke Woodland and may currently qualify as degraded forms of the EECs or their habitat. These geomorphic settings are extensively degraded by historical clearing and grazing and many now contain Derived Grassland and Herbland with severely modified canopy, shrub layer and groundcover. This is typical of both EECs in the region as vegetation diversity and structure have been extensively modified by the history of timber harvesting, grazing and soil erosion (DECCW, 2009b; Benson et al., 2006).

There are no Sandhill Pine Woodlands, or sand dune habitats in the vicinity of the proposed construction footprint and they occur on higher ground that would not be affected by the proposed flooding of the Forest (refer Section 9).

7.3 Fauna

7.3.1 Threatened Fauna Species

A total of twelve threatened fauna species and a further three preliminary-listed species are known, or are highly likely to occur in the Forest based on the site surveys or other recent survey records, including:

- Four threatened species of birds (Gilberts Whistler, the Hooded Robin, Diamond Firetail and Australasian Bittern) and a further three species which have a preliminary listing as threatened species under the TSC Act (the Varied Sittella, Scarlet Robin and White-browed Woodswallow) recorded during site surveys;
- Recent DECCW (2009a) Wildlife Atlas records of the Koala and Barking Owl in the Forest;

- Recent Summer-Autumn records of the Black-chinned Honeyeater (MDBC, 2008);
- Late 2008 Anabat recordings of the Yellow-bellied Sheathtail Bat (GHD, 2009b);
- Observations of Bush-stone Curlews by land owners near the northwestern boundary of the Forest (Tyers, H, pers. comm.);
- 'Possible' Anabat recordings of the Large-footed Myotis and Little Pied Bat during site surveys; and
- Gliders (*Petaurus* sp.) recorded by spotlight in the site survey that may have been the threatened Squirrel Glider and a November 2008 record of this species, all within Box woodlands in the Perricoota SF (GHD, 2009b).

Threatened species recorded during the current site surveys are shown on Figure 12 and Figure 13. The desktop review indicates the potential presence of additional threatened fauna species which are known or predicted to occur in the locality of the Forest. DECCW (2009a) Wildlife Atlas threatened species records from the locality of the Forest are shown on Figure 14. The list of threatened fauna revealed database searches, including their conservation status, habitat requirements, the nature of previous records and likelihood of occurrence is presented in Table 24. A review of the nature of specific habitat requirements of these species, and the habitat present within the study area allowed a number of these species to be eliminated as having a low likelihood of occurrence in the Forest.

Threatened fauna species which are likely to occur in the Forest are presented in Table 18 along with their conservation status, the nature of their previous occurrence in the study area, the habitats in which they are likely to occur and the potential for impacts arising from the project.

Table 18 Threatened Fauna Species Recorded and Likely to Occur within the Forest

Scientific Name	Common Name	TSC Act	EPBC Act	Nature of Previous Records	Likelihood of Occurring in the Forest	Likelihood of Impacts
Artamus superciliosus	White-browed Woodswallow	PV		Recent Record (GHD, 2009a, Webster, 2008).	**Present**. Multiple records during site surveys.	Potential for displacement of individuals and removal of habitat within limited areas of suitable woodland habitat in surface disturbance areas.
Botaurus poiciloptilus	Australasian Bittern	V	-NE	Previous Record (DECCW, 2009a)	**Present** –recorded in the Gunbower SF immediately across the Murray River from the Forest. Would probably forage in the Forest, especially during flood events.	Potential for displacement of individuals and removal of habitat within small areas of floodplain marsh and drainage lines in surface disturbance areas.
Burhinus grallarius	Bush Stone-curlew	E	-	Observations by land owners adjoining the Forest (Tyers, H., pers. comm.)	**Likely** –historical records adjoining the Forest and suitable habitat throughout the Forest.	Potential for displacement of individuals and removal of habitat within forest and woodland in surface disturbance and inundation areas.
Chalinolobus picatus	Little Pied Bat	V	-	Previous Record (DECCW,	**Likely** – Possible Anabat recording in the current survey.	Potential for displacement and/or mortality of individuals and removal of habitat and important habitat resources (HBTs) within

Scientific Name	Common Name	TSC Act	EPBC Act	Nature of Previous Records	Likelihood of Occurring in the Forest	Likelihood of Impacts
				2009a)		forest and woodland in surface disturbance areas.
Daphoenositta chrysoptera	Varied Sittella	PV		Recent Record (GHD, 2009a, Webster, 2008).	**Present**. Multiple records during site surveys.	Potential for displacement of individuals and removal of habitat within limited areas of suitable woodland habitat in surface disturbance areas.
Melanodryas cucullata	Hooded Robin	V	-	Recent Record (GHD, 2009b)	**Present**. Multiple records during site surveys, mainly in box woodlands.	Potential for displacement of individuals and removal of habitat within forest and woodland in surface disturbance areas.
Melithreptus gularis gularis	Black-chinned honeyeater (eastern sub-species)	V	-	Recent Record (MDBC, 2008)	**Present** – not recorded during site surveys but occurs in the Forest on a seasonal, migratory basis (Webster, 2008; MDBC, 2008).	Potential for displacement of individuals and removal of habitat within forest and woodland in surface disturbance areas.

Scientific Name	Common Name	TSC Act	EPBC Act	Nature of Previous Records	Likelihood of Occurring in the Forest	Likelihood of Impacts
Myotis adversus	Large-footed Myotis	V	-	Previous Record (GHD, 2009b)	**Likely** – Possible Anabat recording in the current survey and known from similar River Red Gum forests in the region.	Potential for displacement and/or mortality of individuals and removal of habitat and important habitat resources (HBTs) within forest and woodland in surface disturbance areas.
Ninox connivens	Barking Owl	V	-	Previous Record (Parker, *et al*. 2007)	**Likely** – previous records within the Forest (Parker, *et al*. 2007) and extensive areas of suitable foraging and roosting resources.	Potential for displacement of individuals and removal of habitat and important habitat resources (HBTs) within forest and woodland in surface disturbance areas.
Pachycephala inornata	Gilbert's Whistler	V	-	Recent Record (GHD, 2009b)	**Present**. Multiple records during site surveys, exclusively in forest and woodland with dense understorey, mainly of Dwarf Cherry.	Potential for displacement of individuals and removal of habitat within limited areas of suitable woodland habitat in surface disturbance areas.

Scientific Name	Common Name	TSC Act	EPBC Act	Nature of Previous Records	Likelihood of Occurring in the Forest	Likelihood of Impacts
Petaurus norfolcensis	Squirrel Glider	V	-	Previous Record	**Likely** –recent record in the Forest, tentative observations during site surveys.	Potential for displacement and/or mortality of individuals and removal of habitat and important habitat resources (HBTs) within forest and woodland in surface disturbance areas.
Petroica multicolor	Scarlet Robin	PV		Recent Record (GHD, 2009a, Webster, 2008).	**Present**. Multiple records during site surveys, mainly in forest and woodland with dense understorey, mainly of Dwarf Cherry.	Potential for displacement of individuals and removal of habitat within limited areas of suitable woodland habitat in surface disturbance areas.
Phascolarctos cinereus	Koala	V	-	Previous Record (DECCW, 2009a)	**Likely** –historical records from the Forest. Fragmented, but expanding introduced population known from the Riverina.	Potential for displacement of individuals and removal of habitat within forest and woodland in surface disturbance areas.
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat	V	-	Recent record (GHD, 2009b).	**Likely** – recorded in the Forest in late 2008 (GHD, 2009b).	Potential for displacement and/or mortality of individuals and removal of habitat and important habitat resources (HBTs) within forest and woodland in surface disturbance areas.

Scientific Name	Common Name	TSC Act	EPBC Act	Nature of Previous Records	Likelihood of Occurring in the Forest	Likelihood of Impacts
Stagonopleura guttata	Diamond Firetail	V	-	Recent record (GHD, 2009b).	**Present** - Recorded during site surveys and in late 2008 (GHD, 2009b) in box woodlands.	Potential for displacement of individuals and removal of habitat within forest and woodland in surface disturbance areas.

Status Codes

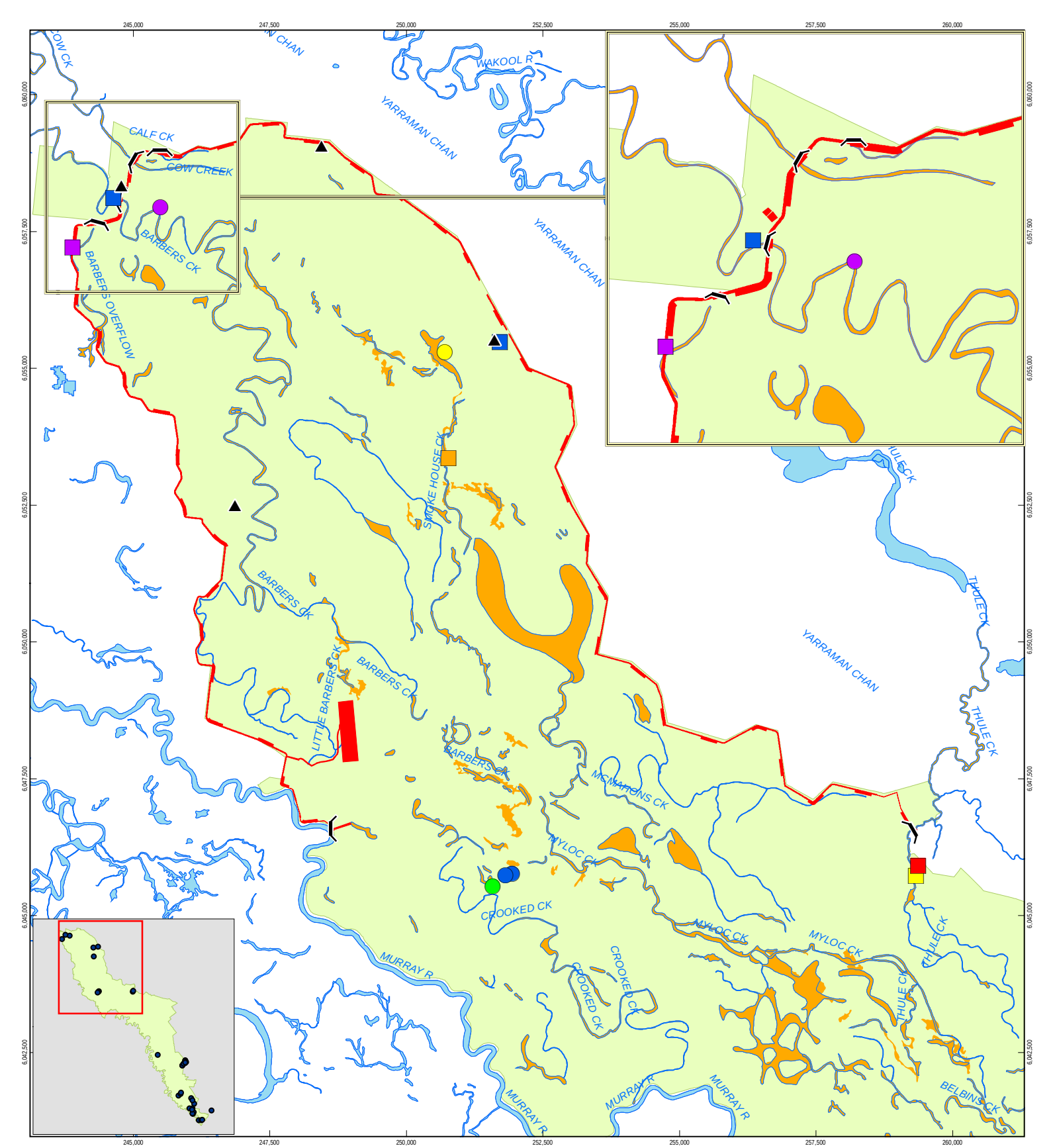
V - Vulnerable
PV- preliminary listing as vulnerable
NE - Nominated for listing as endangered

A further 21 threatened fauna species may possibly occur within the Forest based on the presence of suitable foraging and roosting habitat. There is no evidence, such as recent records within the Forest or specific important habitat resources that suggests the Forest regularly supports local populations of any of these species, either on a permanent or seasonal basis. However these fauna species may occur in habitat in the Forest on an occasional or opportunistic basis. Threatened fauna species that may potentially utilise habitat in the Forest are presented below:

- *Anseranas semipalmata* Magpie Goose;
- *Anthochaera phrygia* Regent Honeyeater;
- *Glossopsitta pusilla* Little Lorikeet;
- *Lathamus discolor* Swift Parrot;
- *Rostratula benghalensis* s. lat. Australian Painted Snipe;
- *Pyrrholaemus saggitatus* Speckled Warbler;
- *Pomatostomus temporalis temporalis* Grey-crowned Babbler (eastern subspecies);
- *Dasyurus maculatus* Spotted-tailed Quoll;
- *Phascogale tapoatafa* Brush-tailed Phascogale;
- *Polytelis swainsonii* Superb Parrot;
- *Oxyura australis* Blue-billed Duck;
- *Limosa limosa* Black-tailed Godwit;
- *Glossopsitta porphyrocepha* Purple-crowned Lorikeet;
- *Grantiella picta* Painted Honeyeater
- *Grus rubicunda* Brolga;
- *Stictonetta naevosa* Freckled Duck;
- *Cacatua leadbeaterii* Pink Cockatoo;
- *Grantiella picta* Painted Honeyeater;
- *Lophoictinia isura* Square-tailed Kite;
- *Neophema pulchella* Turquoise Parrot; and
- *Crinia sloaneii* Sloane's Froglet.

7.3.2 Endangered Fauna Populations

No endangered fauna populations are known to occur in the locality of the Forest or in the Murray Fans CMA sub-region (DECCW, 2009b).



Legend

- Turkey's nest dam
- Regulator
- Construction features
- Koondrook Perricoota Forest Site

Threatened species recorded at the site

- Bush Stone Curlew
- Diamond Firetail
- Gilbert's Whistler
- Hooded Robin
- Large-footed Myotis (possible)
- Little Pied Bat (possible)
- Scarlet Robin
- Varied Sittella
- White-browed Woodswallow

- Murray River EEC

1:65,000 (at A3)

0 0.5 1 2

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

GHD

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NSW Office of Water

Koondrook-Perricoota Flood Enhancement Works

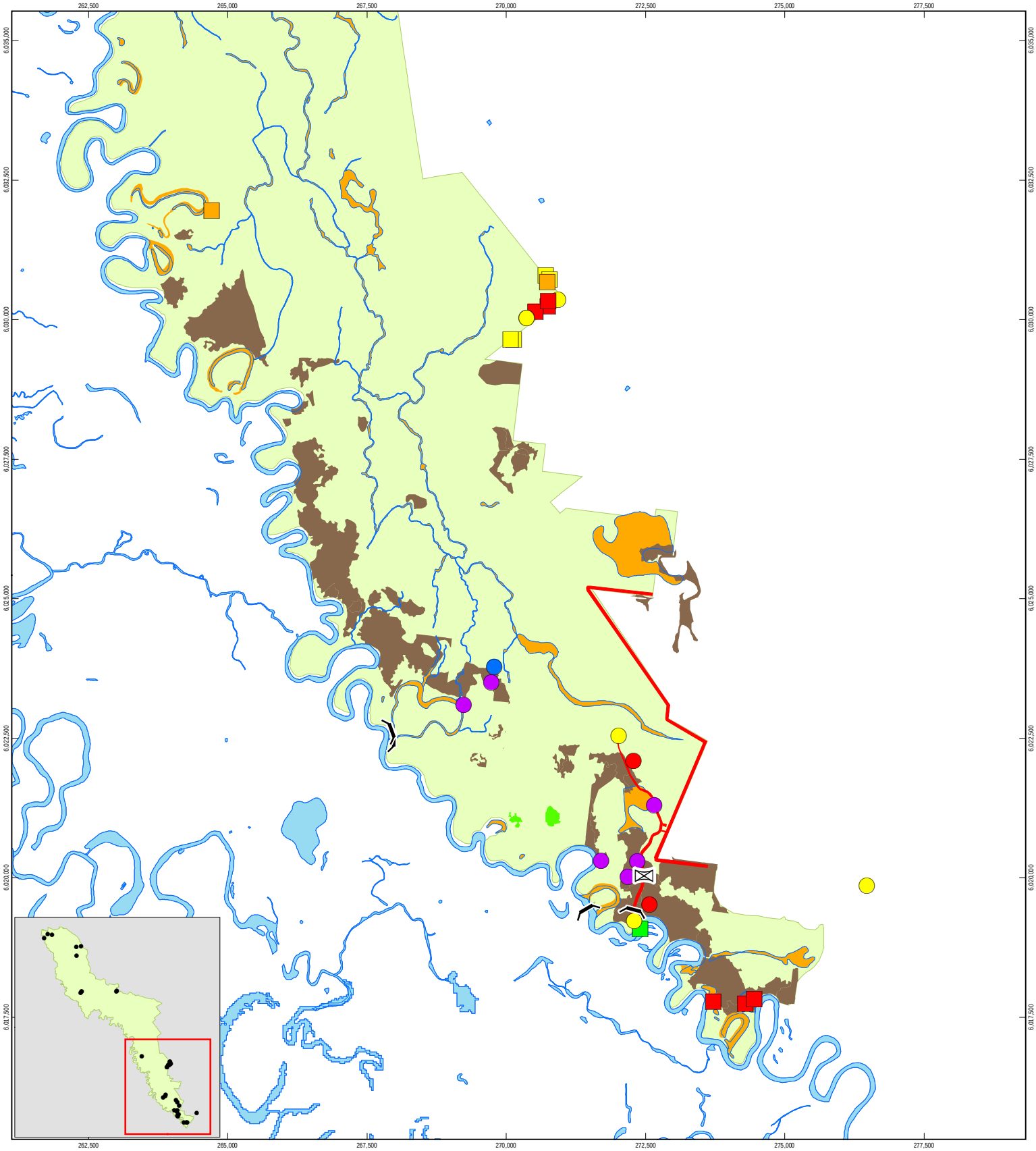
Figure 12 - Conservation significance - downstream section

Job Number	21-18573
Revision	B
Date	11 FEB 2010

G:\21\18573\GIS\Arcview\Map_Documents\21.18573.Z022_Conservation.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: StreetMap - Navegate, Drawn: Cwilson, cwilson



Legend

- River Road bridge
- Regulator
- Construction features
- Koondrook Perricoota Forest Site

Threatened species recorded at the site

- Australasian Bittern
- Bush Stone Curlew
- Diamond Firetail
- Gilbert's Whistler
- Hooded Robin
- Large-footed Myotis (possible)
- Little Pied Bat (possible)
- Scarlet Robin
- Squirrel Glider (possible)
- Varied Sittella
- White-browed Woodswallow

- Murray River EEC
- Inland Grey Box Woodland EEC
- Sandhill Pine Woodland EEC

1:65,000 (at A3)

0 0.5 1 2

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

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NSW Office of Water

Koondrook-Perricoota Flood Enhancement Works

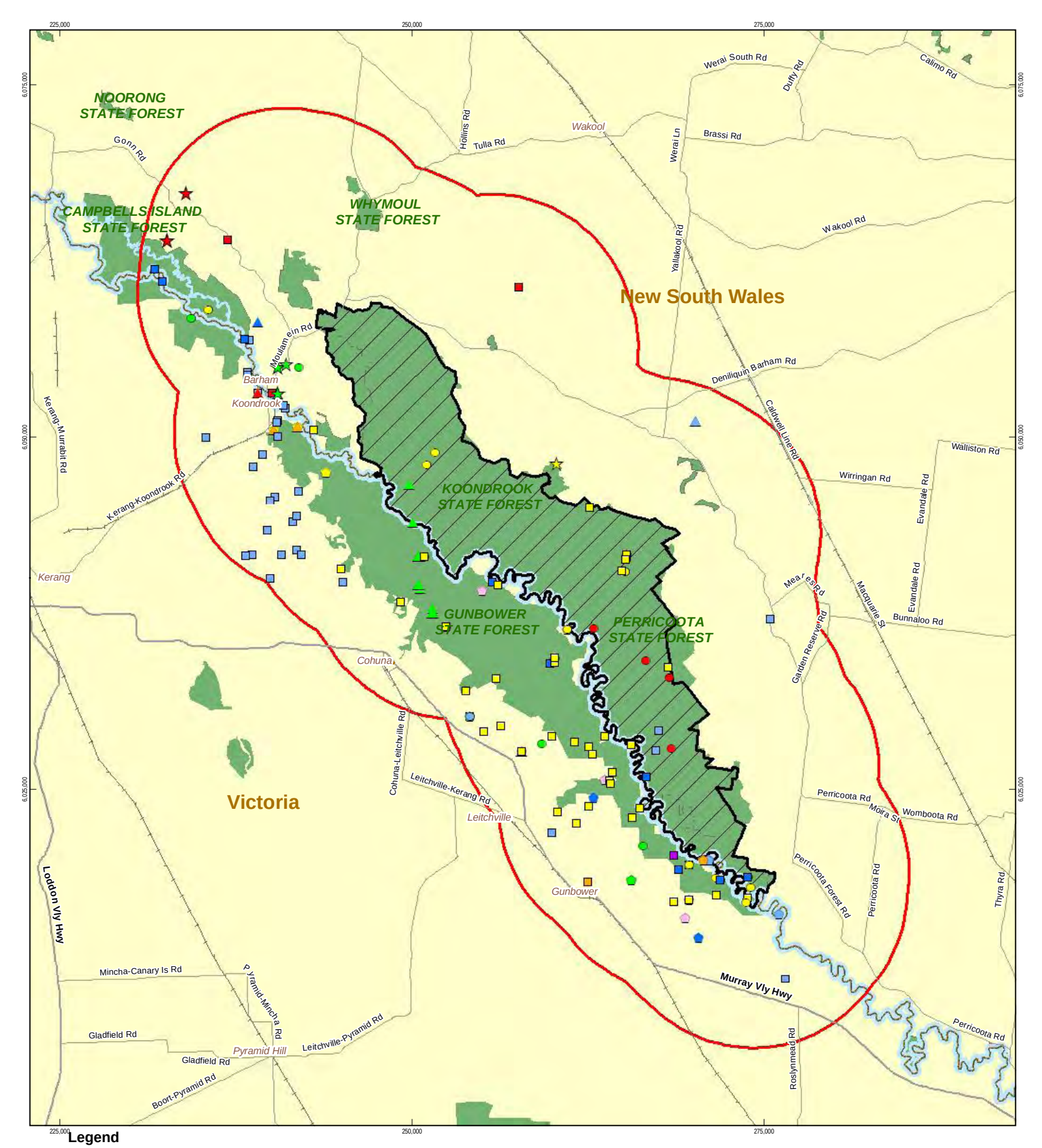
Job Number	21-18573
Revision	B
Date	11 FEB 2010

Figure 13 - Conservation significance - upstream section

G:\21\18573\GIS\Arcview\Map_Documents\21.18573.Z022_Conservation_1.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: StreetMap - Navegate, Drawn: Cwilson, cwilson



Legend

- 10km radius of site
- Koondrook Perricoota Forest Site
- State Border

Threatened Flora

- Eucalyptus leucoxylon subsp. pruinosa
- Maireana cheelii
- Wilsonia rotundifolia

Threatened Fauna

- Australasian Bittern
- Barking Owl
- Black-chinned Honeyeater
- Bridled Nailtail Wallaby
- Brown Treecreeper
- Brush-tailed Bettong
- Brush-tailed Phascogale
- Bush Stone-curlew
- Diamond Firetail
- Gilbert's Whistler
- Grey Falcon
- Grey-crowned Babbler (eastern subspecies)
- Hooded Robin
- Koala
- Large-footed Myotis
- Little Pied Bat
- Magpie Goose
- Murray Cod
- Pink Robin
- Plains-wanderer
- Regent Honeyeater
- Rufous Bettong
- Silver Perch
- Sloane's Froglet
- Speckled Warbler
- Squirrel Glider
- Superb Parrot
- White-browed Woodswallow

1:250,000 (at A3)

0 2.5 5 10
Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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NSW Department of Commerce
Koondrook-Perricoota Flood Enhancement Works EA

Job Number	21-18573
Revision	B
Date	09 DEC 2009

Figure 14: Threatened species records in the locality

G:\21\18573\GIS\Arcview\Map_Documents\21.18573.Z001_DECC_ThreatenedSpecies.mxd
Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: StreetMap - Navigate, DECC Wildlife Atlas, Cwilson

7.4 Aquatic Ecological Communities

The EEC 'Aquatic ecological community in the natural drainage system of the lower Murray River catchment' (Murray River EEC) Includes all natural creeks, rivers, and associated lagoons, billabongs and lakes of the regulated portions of the Murray River below the Hume Weir (DII, 2009). There is an extensive network of drainage lines and floodplain marshes in the Forest that all comprise part of this EEC (refer Figure 12 and Figure 13). The listing of the Murray River EEC has given all native fish and other aquatic animal life within its boundaries the protected status of endangered species. The community includes 23 native fish species and over 400 recorded native invertebrate species.

Two threatened aquatic fauna species are likely to occur in the Forest:

- The Murray Cod, which is listed as Vulnerable under the EPBC Act; and
- The Silver Perch, which is listed as Vulnerable under the FM Act.

Local populations of the Murray Cod and Silver Perch are known from the Murray River adjacent to the Forest. It is likely that some individuals, including adult fish, juveniles, larvae and/or spawn would enter the Forest during flood events (FPTF, 2009).

These species may potentially breed on the Forest, depending on the timing and duration of the managed flood. The project will remove or modify small amounts of aquatic habitat for these species at the locations of the proposed regulators and would remove habitat resources for the species associated with floodplain vegetation within the construction footprint.

The desktop review indicates the potential presence of an additional three threatened fish species which are known or predicted to occur in the locality of the Forest and are presented in Table 24 along with their conservation status, habitat requirements, the nature of previous records and likelihood of occurrence at the Forest. A review of their distribution and the nature of specific habitat requirements of these species, and the habitat present led to the conclusion that these three fish species have a low likelihood of occurrence in the Forest.

7.5 Matters of National Environmental Significance

7.5.1 Approach

The EPBC Act establishes a process for assessing the environmental impact of activities and developments where 'matters of national environmental significance' (MNES) may be affected. Under the EPBC Act any action, which "has, will have, or is likely to have a significant impact on a matter of national environmental significance" is defined as a "controlled action", and requires approval from the Minister for the Environment, Water, Heritage and the Arts.

A Protected Matters Search (DEWHA, 2009) was performed for the project and is presented as Appendix D. A number of EPBC Act listed threatened species have previously been recorded or are predicted to occur in the locality The NSW Wildlife Atlas (DECC, 2009b) also revealed records of EPBC Act listed threatened species previously recorded in the study area (refer Figure 14). MNES listed under the EPBC Act of potential relevance to the study area include:

- Threatened species (e.g. Murray Cod, *Amphibromus fluitans*, Superb Parrot, Greater Long-eared Bat);
- Endangered Ecological Communities (e.g. Buloke Woodland);
- Migratory species (e.g. Swift Parrot, waterfowl);
- The NSW Central Murray State Forests Ramsar Site; and
- Other Ramsar Sites within the same catchments as the study area.

EPBC Act listed biota known from the study area are presented in Table 27 along with an assessment of their habitat requirements, likelihood of occurring in the study area and potential for impacts arising from the project. A number of the EPBC Act listed biota may potentially occur in the Forest and be affected by the project. Potential impacts on these biota, or their habitats, comprise an impact on a MNES. Potentially affected MNES are discussed below.

7.5.2 Threatened Flora Species

There is suitable habitat for four EPBC Act listed plant species in the Forest: *Amphibromus fluitans*, *Austrostipa wakoolica*, *Lepidium monoplocoides*; and *Swainsona murrayana*. There is potential for mortality of individuals and removal of habitat for these plant species within surface disturbance areas. These four species are also listed under the TSC Act and are described in detail above.

7.5.3 Endangered Ecological Communities

The DEWHA (2009b) search engine predicts that four EECs listed under the EPBC Act may occur in the Forest (refer Appendix B). All four of these EECs are also listed under the TSC Act and their relevance to this assessment is described in Section 6.1.2 above. In summary:

- Two EECs, Grassy Box-gum Woodland and Weeping Myall Woodland, can be reliably excluded from occurring in the Forest based on known distributions and the absence of suitable habitat;
- There are patches of potentially suitable habitat for Buloke Woodland in the Forest, however these patches are extensively degraded, remote from project construction footprints and above the proposed inundation area and so were not mapped or assessed in detail; and
- There is a stand of Sandhill Pine Woodland in the former Toorangabby property as mapped in Figure 12 This stand is remote from project construction footprints and above the proposed inundation area.

There are areas of the TSC Act listed EEC Inland Grey Box Woodland in the Forest that would qualify as the threatened ecological community currently nominated to be listed as an EEC on the schedules of the EPBC Act (DEWHA, 2009c).

7.5.4 Threatened fauna Species

No EPBC Act listed fauna species were recorded during site surveys and there is no evidence such as recent records or important habitat resources to suggest that local populations occur within the Forest.

Based on desktop and habitat assessments five EPBC Act listed fauna species are likely to occur in the Forest on an occasional or opportunistic basis:

- *Anthochaera phrygia* Regent Honeyeater;
- *Lathamus discolor* Swift Parrot;

- *Rostratula benghalensis* s. lat. Australian Painted Snipe;
- *Dasyurus maculatus* Spotted-tailed Quoll; and
- *Polytelis swainsonii* Superb Parrot.

7.5.5 Migratory Species

The Forest provides habitat for a number of migratory bird species protected under the provisions of International treaties and/or the EPBC Act, including:

- 13 bird species listed under JAMBA or CAMBA;
- 7 migratory terrestrial bird species, including 2 species also listed as threatened species under the EPBC Act; and
- At least a further 29 species belonging to bird families recognised as migratory under the EPBC Act.

Migratory bird species known from the study area are presented in Table 19 along with their status and the nature of their dependency on habitats in the Forest.

Table 19 Migratory Bird Species Occurring within the Forest

Common Name	Scientific Name	EPBC Act	JAMBA / CAMBA	Habitat dependency
Forked-tailed Swift	*Apus pacificus*	M	J,C	Non-breeding migrant
Great Egret	*Ardea alba*	M	J,C	Regular seasonal breeding
Cattle Egret	*Ardea ibis*	M	J,C	Irregular breeding
Sharp-tailed Sandpiper	*Calidris acuminata*		J,C	Non-breeding migrant
Red-necked Stint	*Calidris ruficollis*		J,C	Non-breeding migrant
Latham's Snipe	*Gallinago hardwickii*	M	J,C	Non-breeding migrant
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	M	C	Breeding resident – juveniles dispersive, migratory
White-throated Needletail	*Hirundapus caudacutus*	M	J,C	Non-breeding migrant
Caspian Tern	*Hydropogne caspia*	M	C	Non-breeding migrant
Glossy Ibis	*Plegadis falcinellus*		C	Non-breeding migrant
Painted Snipe	*Rostralula benghalensis*	E, M	C	Non-breeding migrant
Greenshank	*Tringa nebularia*	M	J, C	Non-breeding migrant
Marsh Sandpiper	*Tringa stagnatilis*	M	C	Non-breeding migrant
Waterfowl	Anatidae	M	-	14 species known from study area including breeding migrants

Common Name	Scientific Name	EPBC Act	JAMBA / CAMBA	Habitat dependency
Cranes	*Grus* spp.	M		1 species known from study area, non-breeding migrant
Snipe	Scolopacidae	M		5 species known from study area including breeding migrants
Shorebirds	Recurvirostridae, Charadriidae	M		6 species known from study area including breeding migrants
Regent Honeyeater	*Xanthomyza phrygia*	E, M		Non-breeding migrant
Swift Parrot	*Lathamus discolor*	E, M		Non-breeding migrant
Migratory terrestrial species		M		4 species known from study area (in addition to threatened species)
Raptors	Accipitridae	M		3 species known from study area, breeding resident – juveniles dispersive, migratory

M, Migratory; E, endangered under EPBC Act; J: Japan - Australia Migratory Bird Agreement (JAMBA); C: China - Australia Migratory Bird Agreement (CAMBA)

The project would remove habitat for these migratory species within construction footprints. The proposed environmental watering of the Forest would potentially affect the timing and nature of usage of the habitats in the Forest by many of these species. Potential affects include triggering flood-induced migration, foraging or breeding activity.

7.5.6 Threatened Aquatic Species

One threatened aquatic fauna species is likely to occur in the Forest: the Murray Cod.

The desktop review indicates an additional three threatened fish species which are predicted to occur in the locality of the Forest (Trout Cod, Murray Hardyhead and Macquarie Perch) however a review of the distribution, specific habitat requirements of these species, and the habitat present led to the conclusion that these three fish species have a low likelihood of occurrence in the Forest (Table 24).

7.5.7 Wetlands of International Importance (Ramsar Wetlands)

The Forest includes part of the NSW Central Murray State Forests Ramsar Wetland and so this Ramsar Site would be directly affected by the proposed activity. Forests NSW have tenure over this land and administer the NSW Central Murray State Forests for timber production, biodiversity conservation, recreation and other purposes. The Forest comprises 83, 965.9 ha of riverine floodplain within the Ramsar Wetland composed of three geographically discrete but interrelated units: the Millewa Forests, the Werai Forests, and the Koondrook Forests (GHD, 2009a). The Millewa Forests and Werai Forests are both upstream and hydrologically separated from the Forest. The project would affect approximately

32,000 ha of the Ramsar Wetland within the Koondrook Forests through direct construction impacts and operational changes to the hydrology of the Forest and ecosystem processes.

The Forest is in the immediate vicinity of the Victorian Gunbower Forest Ramsar Wetland which lies immediately across the Murray River from the Koondrook and Perricoota State Forests. The Kerang Wetlands Ramsar Site is less than 30 km from the Forest, also on the Victorian side of the Murray River.

The Forest also falls within the catchments of a number of other Ramsar Sites which are downstream of the Forest along the Murray River, including:

- Hattah-Kulkyne Lakes;
- Riverland;
- Banrock Station Wetland Complex; and
- Coorong and Lakes Alexandrina and Albert.

The project is unlikely to result in any direct or indirect construction impacts on any Ramsar Wetlands other than the NSW Central Murray State Forests. The operational phase of the project has the potential to cause indirect impacts through changes to the hydrology of the Murray River and impacts on ecosystem components of these wetlands such as waterbirds and fish (refer Section 9).

8. Construction Impacts

This Section assesses the potential impacts of the proposal during construction on the flora and fauna of the study area.

8.1 Construction Footprints

This impact assessment is based on indicative infrastructure locations and construction footprints supplied by the proponent as presented in Figure 2 and Figure 3 and the current concept design and construction methods and sequence of works described in the MacMahon (2009) *Final Draft Constructability Report.*

Site preparation would involve activities such as removal of vegetation along the construction footprint and establishment of site compounds. The contractor would undertake clearing that is required to allow the project to be constructed and would implement strategies to minimise the area of vegetation cleared. A strategy would be developed to manage potential impacts on habitat trees and this would involve a pre-clearance survey for habitat trees prior to clearing in the affected locality.

All vegetation that is cleared would be removed from the site, apart from:

- Possible stockpiling of logs for a maximum of 3 months of timber beside construction areas;
- Stockpiling stumps on the former Toorangabby property for up to 12 months for reuse. Opportunities would be investigated to reuse stumps in restoration projects, such as re-snagging in the Murray River; and
- Relocating felled fauna-bearing trees in nearby forest.

Cleared vegetation would not be burnt within the Forest as this would present a substantial bushfire risk.

Some vegetation would be mulched and reused on site to stabilise selected areas disturbed by construction.

The Construction Environmental Management Plan (CEMP) would detail measures to be implemented to minimise impacts associated with clearing and manage the cleared vegetation.

This Environmental Assessment is based on indicative infrastructure locations presented in Figure 2 and Figure 3 and on the construction methods and sequence of works described in the Final Draft Constructability Report (MacMahon, 2009).

The magnitude and duration of impacts arising from the project would vary with the type of infrastructure as follows:

- Permanent impacts would be associated with:
  - Permanent removal of native vegetation and habitat at the locations of regulators;
  - Permanent modification of native vegetation habitat would occur along the downstream levee which would contain regenerating native understorey vegetation on the batter slopes, and the inlet channel, which would contain regenerating native understorey, including wetland herbs and grasses; and
- Temporary impacts. These would occur in locations where native vegetation and habitat would be removed to enable construction to proceed and would be allowed to regenerate naturally following

completion of construction. These areas include the construction laydown areas, floodway, spoil disposal area, and borrow pits.

The locations and detailed design of project infrastructure and construction methods would be defined by the construction contractor. Therefore, this impact assessment is based on indicative infrastructure Therefore this impact assessment is based on infrastructure footprints that have been located within an indicative construction corridor based on information provided by the project team (Clark, B., NSW Civil Works, pers. comm.). Indicative footprints for the infrastructure and corridor are summarised in Table 20.

While the contractor may refine the infrastructure, it is constrained to within metres of the indicative locations and would not extend beyond the construction footprint. Although the location of construction compounds and associated facilities are yet to be confirmed, these features would be located in the construction footprint outlined in Table 20. Access to construction sites along the alignment of the inlet channel and downstream levee, including associated infrastructure sites and construction compounds, would be provided from within the construction footprint. Turkey nest dams would also be located within the construction footprint and would be sited in existing cleared areas where practicable.

As the temporary construction footprint would be influenced by the construction method, the contractor would be required to ensure that due diligence is exercised during planning and execution to identify and implement reasonable and feasible opportunities to avoid or otherwise minimise adverse impacts.

The construction footprint represents an estimated maximum area of surface disturbance and the contractor would implement measures to minimise the disturbance footprint by confining activities to existing cleared or disturbed areas where practicable. The total area required for the temporary construction footprint and permanent infrastructure footprint is unlikely to differ substantially from the estimates in Table 20.

Based on these estimates the project is likely to result in:

- Disturbance of approximately 206 ha of native vegetation and habitats; including
- Permanent removal or modification of 90 ha of native vegetation and habitats.

Disturbance beyond the construction footprint would be limited to that associated with construction of access roads to those structures that are unable to be accessed either from the construction corridor or the existing forest road network. These sites include:

- Internal floodway –this is likely to be accessed from a track extending from the downstream levee alignment;
- Swan Lagoon regulators – this would be accessed from a track extending from the existing forest road network; and
- Spoil disposal site – this would be accessed from a track extending from the existing forest road network.

The location of these tracks is unable to be defined at present and would be determined by the contractor. Alignments for new tracks would be selected to minimise impacts and would traverse existing disturbed areas where practicable.

Table 20 Construction Footprints for Project Infrastructure and Evaluation of Impacts

Project Infrastructure	Vegetation community type	Area within disturbance footprint (ha)	Temporary disturbance footprint (ha)	Permanent disturbance footprint (ha)	Impact Evaluation
Borrow pits			**44.31**		Modification of native vegetation and habitat within footprint situated in disturbed areas as far as is practicable. Vegetation would be allowed to regenerate.
	Comm ID 10: River Red Gum - Black Box woodland	10.81			
	Comm ID 13: Blackbox - Lignum woodland	1.79			
	Comm ID 250: Derived tussock grasslands	1.92			
	Comm ID 2: River Red Gum-sedge tall open forest	0.40			
	Comm ID 7: River Red Gum - herbaceous tall open forest	4.72			
	Comm ID 9: River Red Gum - wallaby grass tall woodland	24.67			
Downstream levee			**69.55**	**69.55**	Permanent removal of vegetation and habitat along maintenance tracks. Modification of forest and woodland vegetation through conversion to grass and herbland along remainder of levee.
	Comm ID 10: River Red Gum - Black Box woodland	19.45			
	Comm ID 13: Blackbox - Lignum woodland	1.05			
	Comm ID 250: Derived tussock grasslands	3.21			
	Comm ID 2: River Red Gum-sedge tall open forest	0.58			
	Comm ID 7: River Red Gum - herbaceous tall open forest	7.06			
	Comm ID 9: River Red Gum - wallaby grass tall woodland	38.20			
Downstream stop log regulators			**2.60**	**2.60**	Permanent removal of vegetation and habitat within infrastructure footprint.
	Comm ID 10: River Red Gum - Black Box woodland	0.29			
	Comm ID 13: Blackbox - Lignum woodland	0.24			
	Comm ID 250: Derived tussock grasslands	0.08			
	Comm ID 7: River Red Gum - herbaceous tall open forest	0.74			
	Comm ID 9: River Red Gum - wallaby grass tall woodland	1.26			
Haul road			**2.70**	**2.70**	Permanent removal of vegetation and habitat within infrastructure footprint.
	Comm ID 10: River Red Gum - Black Box woodland	0.03			
	Comm ID 13: Blackbox - Lignum woodland	0.11			
	Comm ID 250: Derived tussock grasslands	0.17			
	Comm ID 7: River Red Gum - herbaceous tall open forest	0.99			
	Comm ID 9: River Red Gum - wallaby grass tall woodland	1.39			

Project Infrastructure	Vegetation community type	Area within disturbance footprint (ha)	Temporary disturbance footprint (ha)	Permanent disturbance footprint (ha)	Impact Evaluation
Offtake channel, and Offtake regulator and fishways			**14.39**	**14.39**	Permanent removal or modification of native vegetation, including Inland Grey Box Woodland EEC. Understorey vegetation would be allowed to regenerate within the channel.
	Comm ID 10: River Red Gum - Black Box woodland	2.30			
	Comm ID 13: Blackbox - Lignum woodland	1.68			
	Comm ID 237: Riverine Inland Grey Box grassy woodland	8.37			
	Comm ID 250: Derived tussock grasslands	0.40			
	Comm ID 7: River Red Gum - herbaceous tall open forest	1.46			
	Comm ID 9: River Red Gum - wallaby grass tall woodland	0.19			
Internal floodway			**29.94**		Modification of native vegetation and habitat within footprint. Vegetation would be allowed to regenerate.
Internal floodway	Comm ID 2: River Red Gum-sedge tall open forest	12.31			
Internal floodway	Comm ID 7: River Red Gum - herbaceous tall open forest	16.62			
Internal floodway	Comm ID 9: River Red Gum - wallaby grass tall woodland	1.02			
Return channel, return channel regulator and exit structure			**1.06**	**1.06**	Permanent removal of vegetation within footprint, the majority of which is exotic grassland.
	Comm ID 250: Derived tussock grasslands	0.69			
	Comm ID 7: River Red Gum - herbaceous tall open forest	0.07			
	Comm ID 9: River Red Gum - wallaby grass tall woodland	0.30			
Site facilities			**0.77**		Modification of native vegetation and habitat within footprint. Vegetation would be allowed to regenerate.
	Comm ID 10: River Red Gum - Black Box woodland	0.26			
	Comm ID 237: Riverine Inland Grey Box grassy woodland	0.26			
	Comm ID 9: River Red Gum - wallaby grass tall woodland	0.25			
Spoil disposal area			**38.97**		Modification of native vegetation and habitat through spreading of approximately 500mm of spoil material. Disturbance would be concentrated on the existing levee.
	Comm ID 10: River Red Gum - Black Box woodland	3.85			
	Comm ID 13: Blackbox - Lignum woodland	30.79			
	Comm ID 237: Riverine Inland Grey Box grassy woodland	4.06			
	Comm ID 9: River Red Gum - wallaby grass tall woodland	0.28			
Swan lagoon regulators			**0.15**	**0.15**	Permanent removal of tall, highly significant riparian River Red Gum Forest.
	Comm ID 2: River Red Gum-sedge tall open forest	0.02			
	Comm ID 7: River Red Gum - herbaceous tall open forest	0.13			
Turkey's Nest Dams			**1.47**		Modification of native vegetation and

Project Infrastructure	Vegetation community type	Area within disturbance footprint (ha)	Temporary disturbance footprint (ha)	Permanent disturbance footprint (ha)	Impact Evaluation
	Comm ID 13: Blackbox - Lignum woodland	0.17			habitat within footprint, situated in disturbed areas as far as is practicable. Vegetation would be allowed to regenerate.
	Comm ID 250: Derived tussock grasslands	0.18			
	Comm ID 7: River Red Gum - herbaceous tall open forest	0.03			
	Comm ID 9: River Red Gum - wallaby grass tall woodland	1.10			
Total			**205.92**	**90.45**	

8.2 Vegetation Clearing and Construction Impacts

Native vegetation within the Forest footprint is shown on Figure 10 and Figure 11and threatened fauna and important habitat resources on Figure 12 and Figure 13. The removal of these resources is 'likely' to have negative impacts on species, populations or ecological communities' within the Forest. The magnitude of these 'likely' impacts is assessed below.

8.2.1 Flora Species

Vegetation clearing for the project would remove large numbers of mature River Red Gum and Black Box and moderate numbers of Inland Grey Box. Mature trees have value within plant populations as sources of seed. There are extensive areas of these species in the Forest and the removal of a small proportion of mature individuals would not threaten the persistence of local populations. With respect to River Red Gum and Black Box: these species mainly rely on floodwaters to disperse seeds (GHD, 2009a) and so the removal of seed trees would be unlikely to result in any additional impacts. The project would not remove any threatened tree species though it will remove plant species that are a component of the EEC Inland Grey Box Woodland, as discussed below.

Construction for the project would damage or remove understorey plants that are within the surface disturbance area at the time of the operations, noting that many understorey species of floodplain communities are only present after flood events. The proposed development would have direct impacts within a maximum surface disturbance area of 206 ha. Any vegetation clearing required in these areas would remove non-threatened native plants and noxious and environmental weeds. A proportion of this area is disturbed, cleared, subject to severe weed infestation and/or or severely drought affected and contains very little native vegetation cover and has little habitat value for native plants.

It is likely that flora populations would persist in the soil seed bank and in alternative habitat outside the surface disturbance area. Reproduction at the population scale is unlikely to be disadvantaged by damage to individual plants. Populations of extremely rare plants, or those with restricted distributions would be more vulnerable to negative effects arising from direct removal. The proposed construction is highly unlikely to remove a significant proportion of any threatened plant populations and is unlikely to remove any adult/above-ground individuals based on the following considerations:

- Targeted surveys did not record any threatened plants or populations within construction footprint areas; and
- Threatened plants which are likely to occur in the Forest are flood or rainwater dependant (refer Section 7.2.1) and are unlikely to occur at present, nor through the construction period given prevailing Forest conditions

The proposed construction may remove habitat for the four threatened plant species likely to occur in the Forest and potentially dormant individuals or seeds (refer 7.5.2).

8.2.2 Vegetation Communities

Construction for the project would require the clearing or modification of native vegetation within the surface disturbance area, including:

- Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints;

- The long-term modification of approximately 116 ha of native vegetation within project construction footprints that would be allowed to regenerate, in additional to the permanent removal area described above;
- Indirect impacts from dust and other disturbance within the area surrounding the construction corridor of 206 ha described above. Construction activities in these areas would utilise existing tracks and clearings as far as is practicable.

The majority of the Forest contains native vegetation communities and so the majority of this disturbance area would involve the removal or modification of native vegetation.

The project will remove approximately 8 ha of the EEC Inland Grey Box Woodland. The significance of impacts on this EEC is assessed in Section 12 and Appendix C.

Disturbance and regeneration regimes are part of the ecology of many native forests. River Red Gum Forests are relatively resilient to disturbance since natural regeneration coincides with floods and seedling recruitment is greatest in clearings created by storms, wildfire or severe floods under natural conditions (Di Stefano, 2001) or in gaps created by timber harvesting in managed forests (GHD, 2009a). Floodplain Marshes and Black Box Woodlands also contain many native plant species with reproductive cycles geared to flood events (GHD, 2009a). Therefore the proposed flooding of the Forest is likely to facilitate the regeneration of native vegetation in areas that are not required to be permanently cleared or modified for project infrastructure.

8.2.3 Fauna

The project would cause displacement or mortality of fauna that are within the surface disturbance area at the time of the operations. The project may also interrupt or prevent breeding for one season if species are breeding within or near disturbance footprints during construction. Given the extent of native vegetation within the Forest it is likely that fauna populations would persist in alternative habitat outside the surface disturbance area and would reoccupy disturbed areas as the Forest regenerates. The magnitude of likely impacts would vary between types of fauna.

Birds are relatively mobile and so most individuals would be able to avoid vegetation clearing or construction operations. Most individuals directly affected by the project would be displaced rather than killed. There is approximately 31, 000 ha of similar habitat within the Forest that could provide refuge and/or alternative habitat for displaced fauna. Some mortality of less mobile individuals, such as nestlings, old or sick birds may occur. Birds breeding in, or in the vicinity of the surface disturbance area may have breeding disrupted for one season. These direct impacts would affect limited numbers of individuals and would be isolated in time and space and so would be unlikely to threaten the survival of any local populations of any bird species.

Macropods and other large terrestrial mammals are likely to readily avoid vegetation clearing or construction operations and so individuals directly affected by the project would be displaced rather than killed. There may be some mortality of mammals less able to avoid the disturbance. These would include smaller terrestrial mammals, nocturnal species and especially arboreal mammals and microbats which may be sheltering in felled trees. There may be mortality of individuals sheltering in woody debris, tree hollows, and crevices or under bark. Displaced individuals would be vulnerable to predation since they would be disturbed in daylight hours and would experience energy costs, increased risk of predation and increased competition for resources (especially for alternative hollows). This may result in impacts beyond the disturbance area by favouring aggressive or generalist species.

The persistence of diverse and abundant bat populations in operating State Forests throughout the study area (e.g. Forests NSW, 2006; Law and Anderson, 1999), which are periodically subject to the removal of a portion of the available habitat suggests that bat populations are successfully maintained in habitat outside surface disturbance areas. The mobility of microbats and low energy cost of flight would facilitate successful dispersal after disturbance and recolonisation of regenerating areas. Therefore, although individual bats would be susceptible to short term impacts from vegetation clearing and especially removal of HBTs, bat populations would probably be resilient to these effects.

Diaplacement or mortality due to construction impacts would affect limited numbers of individuals and would be unlikely to threaten the survival of any local populations of any fauna species.

More significant negative effects on fauna populations may arise from removal of habitat for permanent project infrastructure and changes to vegetation structure and the quality of habitat in regenerating vegetation. Impacts on habitats are discussed below.

There is likely to be moderate, ongoing impacts on fauna utilising adjacent areas of habitat during construction associated with noise and other disturbances. Disruptive human activities already occur in the Forest associated with FNSW timber harvesting operations and public use activities. These exisitng activities are widely dispersed in time and space. The project would increase the overall amount of human activity in the Forest but also impose a more concentrated and prolonged impact period. The surrounding locality is extensively disturbed by agricultural activities. Larger, more mobile fauna currently occupying the Forest are likely to be adapted to these disturbances. There is likely to be impacts upon smaller, less mobile fauna in the immediate vicinity of the proposed works.

8.2.4 Terrestrial Habitats

Removal of Habitat

The project will have a direct negative effect on habitat for native flora and fauna through vegetation clearing as described above. Impacts would include reduced shelter or roost Forests, foraging habitat and actual food abundance. This clearing will have additional negative effects on the quality of habitats in the broader locality through edge effects, fragmentation of habitat and the disruption of vegetated habitat corridors which are discussed below.

Construction of project infrastructure would permanently remove some foraging resources for native fauna. *Eucalyptus* species would provide nectar resources as well as foraging substrate for a diverse range of arboreal species. It is likely that foraging substrate and resources removed for temporary infrastructure would regenerate relatively quickly. Closed canopies and fibrous bark develop in as little as 10 years (Vesk *et*. *al*., 2008). Given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat in the Forest, retained vegetation outside of surface disturbance areas is likely to provide sufficient alternative foraging resources for local populations of native biota. This magnitude of removal of habitat is unlikely to threaten the persistence of any species within the Forest. There is no evidence that the project would remove a significant proportion of any critical foraging resources for any rare or threatened species or populations.

Habitat trees, including HBTs are an important resource for hollow-dependent native fauna. Obligate hollow users are amongst the most vulnerable species of fauna to the effects of vegetation clearing. The project will remove additional HBTs from habitats which have already undergone partial removal of these resources through historical timber harvesting and silvicultural treatment of the River Red Gum forests. The crucial factor with respect to impacts on the hollow-bearing tree resource is the amount of time it

takes for suitable hollows to form. Various studies cited by Gibbons and Lindenmayer (1997) noted minimum ages of 85 to 162 years for hollow-bearing trees suitable for arboreal mammals or cockatoos. Significant and/or long term impacts on hollow-dependant fauna may arise if the HBT resource retained outside of disturbance areas is not sufficient to maintain local populations.

Based on the site surveys proposed construction will result in the removal of 532 habitat trees within the footprints for fixed project infrastructure that were surveyed in detail, including the locations of the regulators and channels. The project would also result in the removal of habitat trees within the construction footprints for project infrastructure that had not been located at the time of the survey and/or were too large to survey in detail.

The density, type and likely conservation significance of habitat trees varies across the Forest with factors such as vegetation type, topographic position and disturbance history. The greatest intensity of habitat tree removal is associated with the locations of the regulators since drainage lines contain a greater density of large trees, including habitat trees. Accurate counts were obtained in these areas.

Densities of HBTs are lower along the downstream levee, which includes areas of shorter, less productive River Red Gum vegetation, Black Box Woodlands, immature regrowth and disturbed land at the margins of the forest with lower densities of habitat trees. Counts were not obtained for the majority of the downstream levee, spoil disposal area and un-located features such as the proposed borrow pits. The project may remove habitat trees within an additional area of approximately 100 ha that would be disturbed and contains habitat trees distributed at approximately 4.1 habitat trees per hectare.

The distribution of habitat trees is also important. Where habitat trees are clumped the number of hollows available for occupation is less than where such trees are retained in a more even, or random distribution because the social and territorial behaviour of a number of hollow-dependent fauna exclude individuals from hollows which would otherwise be available. In addition, the distance between hollow-bearing trees must not exceed typical home range movements (Gibbons and Lindenmayer, 1997). Thus, despite the presence of alternative hollows outside surface disturbance areas the removal of habitat trees has impacts on fauna populations at the time of disturbance and potentially over longer time scales.

Project infrastructure has relatively small and/or linear disturbance footprints. The proposed infrastructure would create temporary gaps in arboreal habitat of under 100 metres width and permanent gaps of under 50 metres width. These gaps would result in a relatively minor increase in energy costs and risks of travelling for hollow-dependant fauna. Gaps between habitat trees are also unlikely to exceed typical home range movements of any hollow-dependant fauna.

Project infrastructure will remove habitat trees in potentially significant positions in the landscape, notably large hollow-bearing River Red Gums at the locations of regulators. Habitat trees close to drainage lines or surface water are particularly significant for many hollow-dependant fauna (Gibbons and Lindenmayer, 1997), including threatened species known from the Forest such as the Barking Owl and Large-footed Myotis (DECCW, 2009b). The project is unlikely to remove a significant proportion of habitat trees close to water given the extensive network of intermittent water bodies in the Forest and approximately 50 km of Murray River riparian strip adjoining the Forest. Significant impacts may occur if a nesting hollow or maternity roost is removed however it is difficult to predict or effectively mitigate these potential impacts.

Precisely determining the significance of impacts associated with habitat tree removal is difficult since on the one hand a proportion of the habitat trees to be removed would not be suitable for fauna occupation whilst some individual habitat trees may have particular significance for local populations. The removal of approximately 1.8 percent of the potential habitat tree resource in the Forest is unlikely to comprise the

removal of a significant proportion of the total resource, such that any local populations of fauna would experience significant negative impacts.

Impacts associated with the removal of habitat trees by the proposed construction would be partially offset by the environmental watering of 17, 000 ha of the Forest. The proposed inundation may help to secure the supply of habitat trees in the Forest in the longer term by improving the health of River Red Gums and Black Box. The potential for positive impacts is increased by the known concentration of habitat trees along drainage lines and depressions due to high productivity and exclusion of timber harvesting from these areas in recent decades (GHD, 2009a) and the likely significance of habitat trees in these settings to threatened fauna (DECCW, 2009b) since these are also the areas most likely to experience benefits from environmental watering. Further, large mature and over-mature River Red Gums (which are most likely to be hollow-bearing) have proven most susceptible to the effects of drought in recent years (Jurskis, 2007). Therefore the removal of habitat trees through the construction phase of the project would be mitigated by improvements to the long term security of the habitat tree resource through the proposed environmental watering.

Modification of Habitat

Vegetation clearing for project infrastructure would fragment native vegetation and create new edges along areas of retained vegetation, which would be exposed to additional edge effects. Edge effects refer to the impact of clearing on neighbouring areas of remnant vegetation. Negative impacts may include an increase in incursion of weeds, sedimentation or access for predators.

Vegetation structure modifies microclimates through the degree of canopy closure, canopy height, vegetation density and structural stratification. Structural changes as a result of the project may fragment habitat and have a considerable effect on microclimate through edge effects. Following construction the intensity of light at the soil surface and on plants would be greater in the disturbance area than in undisturbed vegetation. These changes would occur in the disturbance area as well as adjacent edges of remnant vegetation and may alter the plant and animal communities which occur there. There would be both positive and negative effects on native biota, depending on the ecology of individual species. Examples would include:

- Prolific regrowth of Red Gum seedlings (provided ample soil moisture is provided by floodwaters) (CSIRO, 2008a);
- Dense growth of annual herbs both native and exotic, as noted in clearings in the site survey;
- Increased abundance of opportunistic and dry open forest reptile species;
- Adverse impacts on flight and foraging ability of smaller microbats and birds of closed woodland and forest habitats as a result of alterations to habitat structure and increases in wind speed (Law, 1996);
- Increased foraging habitat quality for edge-specialists, including open woodland birds and larger, ‘clutter-sensitive’ microbat species (Lloyd, 2004 cited in Law, 2004); and
- Decrease in habitat quality for species that require structurally diverse vegetation and/or a dense understorey such as Gilberts Whistler and White-browed Scrubwren.

The severity of edge effects arising from the project will vary significantly with the context of the environment to be disturbed. Some of the project infrastructure, most notably the downstream levee, would be constructed at the margins of patches of habitat. These areas are already substantially modified by edge effects associated with clearing for agriculture and FNSW tracks. These existing

disturbances have resulted in clearly visible edge effects in native vegetation such as reduced canopy tree foliage cover and average size and infestation of the understorey with exotic species. The proposed channels and regulators are located in areas of near-intact native vegetation and so this would create a novel impact which would increase the likely severity of edge effects on local populations.

The quality of small fauna habitat in the surface disturbance area would be altered through removal of trees and changes to the availability of woody debris, the structure and composition of understorey vegetation and microclimates. Changes in forest floor conditions can also result in short-term negative effects on invertebrate prey (Lemckert in prep.).

The project would impose these changes to vegetation structure and microclimate on limited portions of the Forest. Some portions of construction footprints (e.g. borrow bits, laydown areas) would be allowed to regenerate and so over time the native vegetation would regain its pre-disturbance characteristics. There are substantial areas of undisturbed woodland and forest habitats outside of the surface disturbance area, including areas completely excluded from timber harvesting (GHD, 2009a). These areas would provide refuges for flora and fauna that were negatively affected by the changes to vegetation structure and microclimate listed above. The Forest is extensive and features a variety of forest types at various successional stages due to ongoing forest management activities (GHD, 2009b) and a mix of microhabitat types. Local populations of native biota are likely to be tolerant of this disturbance regime. In this context, changes to vegetation structure and microclimate within the project construction footprint are unlikely to have a significant negative effect on any local flora or fauna populations.

Fragmentation of Habitat

The project will modify or remove a maximum of 206 ha of habitat. The modified construction footprint would constitute a partial barrier to regional movements of migratory fauna species by increasing the area of non-viable habitat that they need to traverse. Migratory species often rely on ‘stepping stones’ of suitable foraging and roosting habitat during migrations. By removing a maximum of 206 ha of habitat the project would increase the distance between suitable patches. All of the gaps created would be small (less than 100 m across) which would be minor in the context of the overall 32,000 ha of near-intact native vegetation in the Forest. The project would create relatively small gaps between areas of intact habitat. The magnitude of gap created would vary with the type of infrastructure according to three main types:

- Areas of temporary habitat disturbance, such as laydown areas and borrow pits - the topsoil and the soil seed bank would be retained and so disturbance areas would not comprise a gap in habitat with respect to plants or vegetation communities. Regenerating areas would contain habitat features such regenerating vegetation, leaf litter and woody debris that wood provide shelter for fauna traversing these areas.
- Permanently modified habitat, such as the proposed downstream levee would contain habitat features such as regenerating understorey vegetation, leaf litter and woody debris that wood provide shelter for fauna traversing these areas; and
- Permanently removed habitat, such as regulators.

Vegetation clearing increases the spacing between patches of fauna habitat, which is likely to increase the energy costs for fauna travelling and feeding and would also increase the risks of predation or accident (Bauer *et al*, n.d.). Negative effects of reduced habitat integrity would be localised and specific to different groups of fauna. Negative effects would be greatest on arboreal fauna. There would also be

impacts on smaller, terrestrial animals as these species would rely on trees for shelter. There would be relatively minor effects on mobile fauna such as birds, microbats and large terrestrial mammals. Conversely, creation of gaps and tracks may favour some species, such as larger microbats, which prefer open habitats for foraging or travelling (Law, 2004).

Intact native vegetation would be retained outside the surface disturbance area and would probably provide adequate connectivity for local fauna populations.

The project will not isolate any vegetation or wildlife corridors outside of immediate surface disturbance areas. The Murray River riparian corridor is an important wildlife corridor at the regional scale. The proposal will remove native vegetation directly adjoining this wildlife corridor, which would result in a minor modification by reducing the overall extent of habitat. The habitat removal is limited in extent relative to the overall width of the corridor and would not isolate or disconnect any vegetation patches. Viable alternative routes through the corridor would be maintained in native vegetation upslope of project infrastructure as well as within the Murray River and on the opposite bank. In this context, the project would be unlikely to significantly reduce the potential for fauna movement through the corridor.

8.2.5 Aquatic Biota and Habitats

There may be localised construction impacts on the aquatc biota and habitats where the proposed inlet and outlet channels adjoin the main channel of the Murray River. Sensitive construction techniques and mitigation measures would be used to minimise direct impacts (refer Section 11.3.1). Therefore construction would affect a very limited area of aquatic habitat within the boundary of sediment control devices in the immediate vicinity of the construction footprint. The affected area would not contain a significant proportion of individuals or habitat for the aquatic biota in the local area.

The proposed construction would directly disturb a number of intermittent water bodies at the locations of the proposed regulators and channels. This would remove habitat within the construction footprint and modify the form and flow characteristics of the water body. Negative effects would be very limited in extent in the context of the extensive network of intermittent water bodies at the site.

The remainder of the construction corridor contains ephemeral floodplain wetlands. These habitats would have limited value for the aquatic biota in their current dry state and are unlikely to be occupied during the construction period.

The proposed construction would not interrupt fish passage or otherwise affect migration and dispersal ability of the Silver Perch. Any silt fences, coffer dams or equivalent required for construction would be located in the immediate vicinity of the excavation area and would not completely cross any drainage lines or isolate any significant areas of aquatic habitat. Provision for fish passage has been incorporated into the design of the project infrastructure. The structures have been specifically designed to ensure that aquatic biota can enter and leave the floodplain (DSTA, 2009; FPTF, 2009). Movement of aquatic fauna is discussed further in Section 9.

8.3 Indirect Impacts

8.3.1 Contamination of surface waters

Potential sources of contaminated surface water include:

- Runoff from areas stripped of vegetation;

- Runoff from soil stockpiles;
- Runoff from hardstand areas, including roads, processing areas and Forest facilities;
- Leakage or spillage of hydrocarbon products from vehicles, wash down areas and workshops,
- Refuelling bays and fuel, oil and grease storages.

There are a number of sensitive aquatic habitats within close proximity of project infrastructure, including the Murray River, smaller drainage lines and floodplain marshes. These areas are all sensitive receptors for adverse impacts on water quality potentially arising from the project.

Potential water quality impacts of the project may be associated with runoff from disturbed areas, including harvesting/vegetation clearing areas, soil and timber stockpiles and access roads if risks are not effectively managed and appropriate mitigation measures implemented. Concentrated and/or altered water movement within the construction corridor could increase the potential for sediment mobilisation and transport. Negative effects on aquatic habitats may include increases in stream sediment load, changes in channel form, changes in stream hydrology and a variety of changes in stream faunal populations and communities. Infrastructure that impinge on the stream channel may also cause increases in sediment input and consequent declines in water quality and stream habitat integrity, leading to declines in abundance of invertebrates and fish (Davies and Nelson, 1994).

The overall risk of significant soil erosion and water pollution arising from the proposed construction is considered to be very low because of the following factors:

- The Forest is a depositional environment, with low rainfall and very low relief;
- Construction would occur in Spring, Summer and Autumn i.e. avoiding the wettest time of year;
- The broader Forest is maintained as a native forest environment and would have a substantially lower erosion hazard than, for example, cleared agricultural landscapes. Any localised increases in erosion hazard as a result of construction would be limited in extent and in most cases there would be buffers of intact vegetation between the disturbance footprint and aquatic habitats ;
- Within the Forest, the road network of primary and secondary roads is already established and any additional access roads would principally be short, temporary tracks; and
- Soil protection measures and techniques would be implemented during and following construction.

A more comprehensive discussion of activities and aspects of the project that have the potential to lead to sediment transport and adverse impacts on water quality in the absence of appropriate environmental management is provided in the Specialist Water Quality Assessment Report for the project (Water Quality in GHD, 2009c).

8.3.2 Sediments, dust and runoff

Floodplains of the Murray River are low contributors to the catchments of local drainage systems due to a combination of low rainfall and flat terrain. This, together with the low gradient of the Murray River, means that the Forest contains depositional rather than erosional landforms. Accordingly project activities such as road construction, vegetation clearing, excavation and construction, which may result in adverse erosion or sedimentation in steeper or higher rainfall environments, are not considered a significant threat in the study area (GHD, 2009a). GHD (2009b) field assessment of erosion hazard and evidence of negative effects within the Forest did not locate any appreciable instances of point source

erosion associated with roads and there were no differences in potential road erosion sources between recently harvested or unlogged areas of forest.

Potential indirect impacts to flora and fauna from construction activities would include dust and vehicle exhaust emissions generated from construction vehicles and equipment.

8.3.3 Roads and access

Collisions with wildlife (especially macropods, arboreal mammals, owls, corvids and raptors) within the Forest are possible, particularly during dusk and dawn when macropods are active. The Forest currently experiences light to moderate vehicle traffic depending on the location and extent of timber harvesting activities. Multiple road-kills were noted during the site survey, mainly Eastern Grey Kangaroos. The project will increase the risk of vehicle collisions with fauna in the Forest for the duration of the proposed construction activities.

8.4 Duration of Impacts

The proposed construction activities are estimated to take 8 ½ months (MacMahon, 2009).

Long-term impacts on native fauna will include the loss of ecological functions and habitat resources that take a long time to develop. These include:

- Mature hollow-bearing trees;
- Feed trees, since trees must reach full sexual maturity to produce large volumes of blossom and fruit;
- Structurally diverse vegetation, with a number of age classes and mature emergents; and
- A healthy soil seed bank, with sufficient number and diversity of propagules to allow the native vegetation to regenerate following disturbances such as bushfire.

Provided the mitigation measures outlined in Section 11 are adopted; in particular the remediation of portions of the Forest not containing permanent infrastructure, the project is unlikely to result in permanent or irreversible impacts on native biodiversity. This includes local populations of native flora and fauna, which are likely to persist in retained and remediated vegetation in the locality and recolonise the Forest after construction has finished.

The operational phase of the project will continue indefinitely, as discussed in Section 9.

8.5 Construction Impact Evaluation

The evaluation of impacts involves identifying the magnitude and extent of impacts, but also the significance of the impacts as related to the conservation importance of the native biota likely to be affected (DEC/DPI, 2005). The evaluation of construction impacts arising from the project is summarised in Table 21 below, with reference to the DEC/DPI (2005) guidelines for Part 3A Environmental Assessments.

Table 21 Evaluation of Construction Impacts Arising from the Project

Guideline (DEC/DPI, 2005)	Relevance to project
The magnitude and extent of impacts	Direct surface disturbance from the project would impact a maximum of 206 ha of the Forest. Most animals will readily escape harm from vegetation clearing and construction. Flora and fauna populations would persist in retained vegetation outside the disturbance area. Reproduction at population scale is unlikely to be disadvantaged by injury to individuals. Any disruption to reproduction would only be for the one season. Impacts on individual species would occur through removal of specific habitat resources. The project would remove habitat resources that take a long time to develop, such as hollow-bearing trees. There is the potential for negative impacts on fauna which rely on these resources. The project would remove a small proportion of the overall amounts of these resources available in the Forest.
Impacts will be more significant if…	
areas of high conservation value are affected;	The Forest contains a number of TSC/EPBC Act listed biota and their habitats. The Forest is part of the NSW Central Murray State Forests Ramsar Site, which is recognised internationally for its very high conservation significance. The Forest has high conservation value in the context of the extensively cleared native vegetation of western NSW. The Forest contains near-intact native vegetation communities, a moderate to high diversity of native plants and animals and valuable habitat resources.
individual animals and/or plants and/or subpopulations that are likely to be affected by the project play an important role in maintaining the long-term viability of the species, population or ecological community;	The study area contains a significant proportion of Australia's Red Gum dominated vegetation communities (approx. 32,000 ha). The study area also contains a significant proportion of Black Box dominated vegetation communities and floodplain forms of the Inland Grey Box Woodland EEC.
habitat features that are likely to be affected by the project play an important role in maintaining the long-term viability of the species, population or ecological community;	The project will remove intact native vegetation including an area of EEC. It will also remove important habitat resources that take a long time to develop, including tree-hollows, which play an important role in maintaining the long term viability of many fauna species (Gibbons and Lindenmayer, 1992). In terms of gross areas of habitat, the resources to be

Guideline (DEC/DPI, 2005)	Relevance to project
	directly removed or modified would play a relatively minor role in maintaining local populations of native biota. This is because the habitat affected would comprise a small portion of the habitat resources available in the Forest.
the duration of the impacts are long term;	Displacement and/or mortality of fauna populations within disturbance footprints is short term. Vegetation and habitat removal varies from short term to permanent, depending on project infrastructure proposed at particular locations. Removal of some habitat resources (e.g. HBTs) is long term.
the impacts are permanent and irreversible.	Impacts within immediate project infrastructure footprints are permanent and irreversible. Impacts within construction footprints are readily reversible through flood-induced regeneration of native vegetation.

9. Operational Impacts

This section describes the potential negative and positive impacts to floodplain ecology from the operational phase of the project i.e. the effect of managed inundation of the Forest on floodplain biota. The information here builds on the risk assessment conducted by Ecological Associates (2009). However, where the risk assessment focused on risks to achieving the objectives of the project, the primary aim of this EIA is to determine the potential impacts of the operational scenario provided. Further, the assessment included in this report includes the results of additional desktop research and field assessments, notably including the description and mapping of Inland Grey Box communities in the Forest. As such identified risks and impacts in the following sections may differ in significance from those determined by Ecological Associates (2009).

9.1 Operational Regime

This impact assessment is based on the operational regime described in the project team's (2009) *Preliminary Operating Plan Draft Version 1 - September 2009* (the Operating Plan). The Operating Plan does not prescribe particular flood events but provides a platform for operational decision making based on accumulated knowledge and the overall aims of the project. The structures have been designed to create a major flood event; however they can also deliver small or medium flows of variable volume and duration. This flexibility is required to attempt to mimic the highly variable natural flood regime and enable adaptive management principles to be implemented in response to:

- Differing water availability and river conditions;
- Risk management requirements; and
- The targeting of specific environment objectives.

The project would be conducted in accordance with the Annual Environmental Watering plan prepared to set the environmental watering priorities under The Living Murray program. The magnitude and duration of impacts arising from the project would vary with individual flood events. With reference to hydrologic conditions in the Murray River downstream of Torrumbarry Weir, the operation of the project will occur in one of three general ways:

- For flow events <18000 ML/d, water can be delivered to the forest via an entirely managed flood event through the inlet channel;
- For flow events >18000 ML/d, water can enter the forest through natural watercourses/effluents, potentially supplemented with water delivered through the inlet channel; and
- There may larger flood events >35000 ML/d when water enters the forest via overbank flow and the flood enhancement project infrastructure is not operated.

The exact nature of future unregulated and regulated river flows and the quantum of environmental water available are unknown. It will be important to be able to alter the operation of the structures, both during operations and from one operation to the next, in order to react to the ecological responses observed.

Given the project's high degree of operational flexibility, it is not considered feasible to assess all possible operational scenarios in this environmental assessment. As such, this environmental assessment focuses on one possible operating scenario which is described in the Preliminary Environmental Assessment (DoC, 2009). This operating scenario relates to an entirely managed flood

event, involving the maximum possible in-flows of 6000 ML/day via the inlet channel and maintaining a flood pool at 78.5m RL. This type of scenario would occur approximately every 3-4 years depending on water availability, river flow and whether any other managed or natural flood events had occurred. The indicative operating scenario would involve the following phases:

- Phase 1 - Commence diversion - The initial phase will include opening of the off-take regulator over a period of five days to achieve 6000ML/day diversion capacity. In this phase:
  - The return regulator will be fully open;
  - Swan Lagoon structures will be fully closed; and
  - Downstream stop-log regulator structures will be closed (stop-logs will be in place to deliver 50ML/day per structure or 200 to 250ML/day through one structure at Design Pool RL 78.5).
- Phase 2 - Rising flood - The off-take regulator will discharge at 6000ML/day, with the downstream section to be filled to the design operating level of RL 78.5. The maximum extent of inundation will be reached at the end of this period (approximately 17,800 ha). Theoretical modelling runs indicate that this process will take 45 days.
- Phase 3 - Steady flood - The gates of the off-take regulator will be raised to reduce flow to an appropriate level to maintain the design pool operating level of RL 78.5 (the proposed flood pool) – a rate of approximately 3400 ML/day. This diversion flow of 3400ML/day will be maintained for 55 days. Modelling has indicated that other surface flows may include:
  - Return channel out-flow at a rate of 1800ML/day or higher; and
  - Downstream stop-log structures out-flow at a rate of 250ML/day (combined flow).
- Phase 4 - Commence recession - The off-take regulator will be shut down, for example for a two week period, and flows ramped up and down (if required) to facilitate fish exit. Stop-logs will gradually be removed from one downstream structure bay, possibly Cow Creek, as the deepest structure, to maintain the 250ML/day flow.
- Phase 5 - Flood recession - Stop-logs will continue to be removed from the downstream structure bay to empty the pool. The emptying could theoretically take 130 days. A total of 542 stop-logs from all downstream structures will be stripped and stored. Stop-log removal will initially be slow; however this will gain momentum as the pool drops.

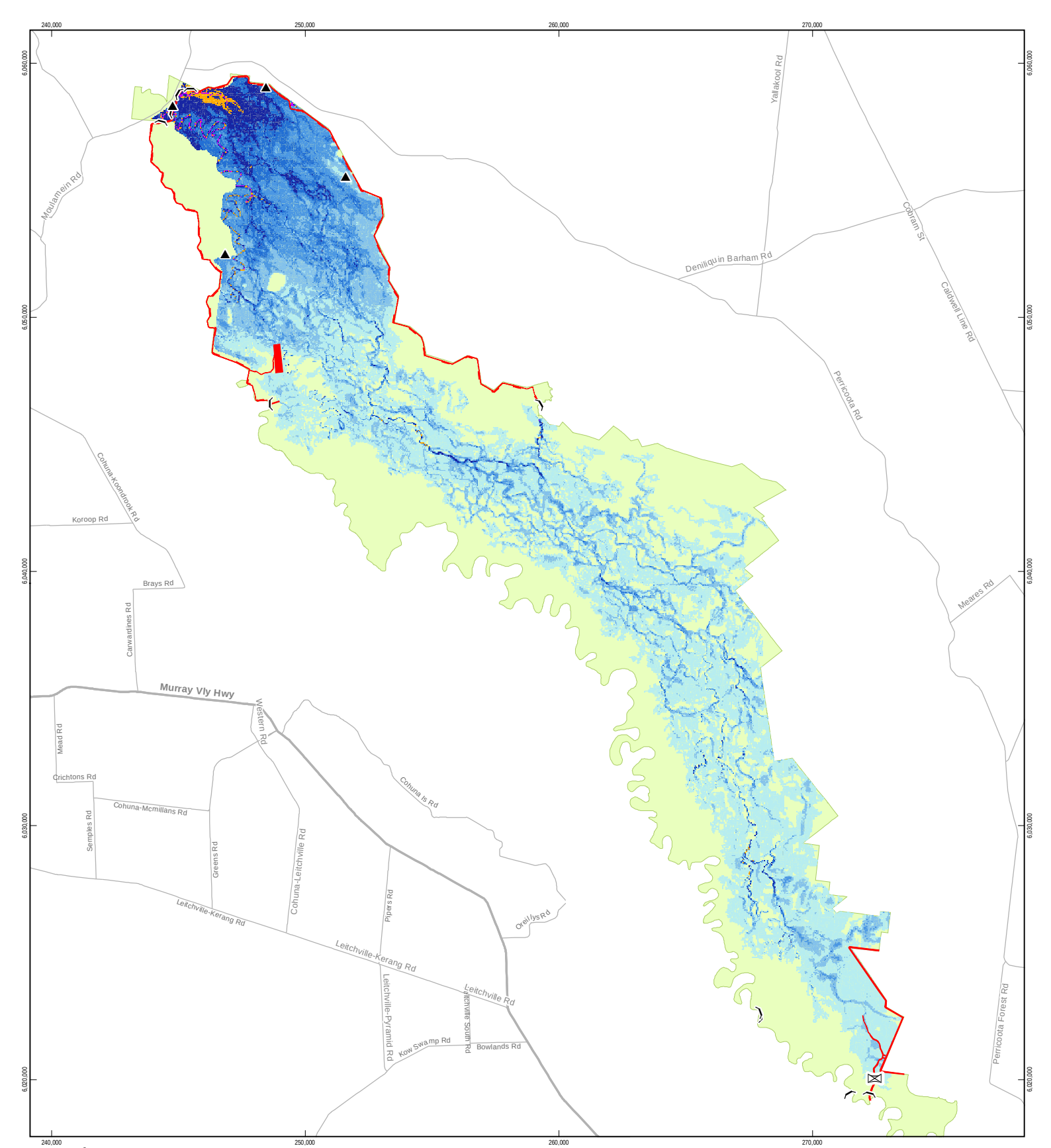
The extent and depth of inundation in the proposed flood pool (i.e. the flood level at RL 78.5 that would be maintained from approximately day 55 to day 110) based on DHI (2008) modelling is shown on Figure 15. Note that this modelled flood extent does not include the north-western portion of the Forest. This is because the downstream levee was re-aligned through this section after the hydrological model had been run. Therefore the hydrological modelling and interpretation of operational impacts presented in this report does not include empirical assessment of this area. The available modelling data covers the majority of the Forest and is considered to provide a suitable basis for this assessment. A qualitative assessment of likely impacts in the area not covered by the hydrological modelling is provided as Section 9.12.

The Operations Committee would base decisions to initiate watering events and management of watering events, on an established set of watering principles. The decision to initiate watering would be based on consideration of the constraints of the operating environment. This would involve consideration of:

- Water availability and water requirement which are the foundations for the decision to initiate a watering event;
- Clear ecological targets which will be defined before initiating a watering event;
- Watering events will aim to maximise net environmental benefits;
- Early watering during cooler months (winter and early spring) would be favoured over Summer watering. As discussed below, there is a greater risk of blackwater events during flood events over summer as water temperatures are higher. Watering during cooler months would reduce the risk of these events occurring. Depending on the water requirements at the Forest, water made available during summer may be rejected in favour of autumn watering;
- Large watering events would not commence beyond October to reduce the risk of blackwater events;
- Overbank flows would be favoured as a cue for initiating watering;
- Unregulated water would be used when beneficial; and
- Autumn watering would be considered if environmental water is not made available until late in the season.

The decision to water will also take into account a variety of relevant parameters including:

- Antecedent soil moisture – This will impact on infiltration rates and affect the rate of spread of flood waters, time to fill the pool, and required water volume;
- Landscape factors – Particularly relevant to waterbird needs, the presence or recent history of waterbird breeding in Gunbower Forest, Barmah-Millewa, and other locations in the Murray-Darling Basin may influence the targeted ecological objective;
- Season – Watering during cooler months is preferred as it would be more consistent with the natural flow regime;
- Climate – Watering during widespread drought would be avoided except for the maintenance of critical processes and drought refuges; and
- Modelled natural flow – Flow that would have occurred in the Forest if there were no river regulation provides a clue for appropriate timing of events.



Legend

- Turkey's nest dam
- River Road bridge
- Regulator
- Major roads
- Construction features
- Koondrook Perricoota Forest Site

Water depth at maximum maintained extent of flooding

- 0.1 to 0.5m
- 0.6 to 1.0m
- 1.1 to 1.5m
- 1.6 to 2.0m
- 2.1 to 3.0m
- 3.1 to 4.0m
- 4.1 and over

1:140,000 (at A3)

0 1 2 4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

CLIENTS | PEOPLE | PERFORMANCE

NSW Office of Water
Koondrook-Perricoota Flood Enhancement Works

Figure 15 Inundation extent and water depth in the proposed flood pool

Job Number	21-18573
Revision	B
Date	01 FEB 2010

G:\21\18573\GIS\Arcview\Map_Documents\21.18573.Z027_FloodDepth.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Dept of Commerce, Drawn: Cwilson, cwilson

9.2 Floodplain Ecosystem Responses

Cycles of wetting and drying affect the physical, chemical and biological processes and functions of floodplain ecosystems as described in Section 5.5. Of relevance to the operational impact assessment of the project are the general ecological processes that can be expected to occur during three distinct phases of the operation: filling; inundated state; and drying. The timing of these stages as they relate to the operation of the project is as follows:

- Filling
  - Day 001 - Start filling at 6000 ML/day
  - Day 045 – Maximum extent of inundation achieved. Inflow reduced to 3400 ML/day
- Inundated State
  - Day 055 – Flood pool height reaches 78.5m AHD. Inflows adjusted to maintain pool height. Flooded area constant to Day 100
  - Day 100 - Inflow ceased
- Drying
  - Day 110 - Dewatering of pool begins
  - Day 220 - Pool empty.

Biological processes expected throughout these phases are summarised below along with potential negative impacts.

Filling

The arrival of floodwaters waterlogs sediments and releases nutrients from sediments into floodwaters (Boon, 2006). The release of nutrients and subsequent “boom” in productivity act as cues for organisms to process nutrients and commence growth, breeding and dispersal (Boulton and Brock, 1999).

Identified potential negative impacts during this phase include (Ecological Associates, 2009):

- Rapid passage of water through channels and natural watercourses results in accelerated erosion of bed and banks and results in increased turbidity;
- Diversion of eggs, larvae and juvenile fish from the Murray River to the forest and depletion of native recruits in the Murray River;
- Reduction in flow pulses in the Murray River which act as a trigger for breeding of large-bodied native fish and a subsequent reduction in regional fish populations; and
- Diversion of introduced fish species (e.g. Carp, Eastern Gambusia) into the flooded forest and associated impacts on water quality and fish.

Inundated state

The productivity of a flood event is maintained through the inundation period (depending on conditions of light, temperature and nutrients released into the water column) and in response organisms continue to experience enhanced growth and feeding opportunities, breeding activity and development of young (Boulton and Brock, 1999).

Identified potential negative impacts during this phase include (Ecological Associates, 2009):

- Anaerobic nature of waterlogged soil negatively impacts on terrestrial plant species that are intolerant of inundation; including terrestrial grasses and forbs, shrubs and trees (e.g. Inland Grey Box) causing reduced productivity and death of individuals;
- If inundation persists beyond tolerances of "floodplain" species (e,g. River Red Gum, Black Box, Lignum) negative impacts such as reduced productivity and death of individuals can occur;
- Inundation acts as a shock to stressed River Red Gum and tree death ensues;
- Drought conditions result in reduced productivity in the inundated forest and resources are insufficient to sustain waterbird breeding;
- Calm, warm conditions can lead to algal blooms (which may not cause ecological effects on Forest; but be detrimental to river health if carried on return waters);
- Calm weather, warm conditions and high mobilisation of organic carbon stores can result in a "blackwater" event where dissolved oxygen concentrations are significantly reduced and can impair health or cause the death of aquatic fauna such as invertebrates, fish and tadpoles;
- Carp carried onto the floodplain in inflowing waters, breed. Adults feed acting as competition to native species and disturbing sediment beds and aquatic plants, increasing turbidity, which in turn negatively impacts on visual feeders such as turtles, tadpoles and native fish;
- Eastern Gambusia that entered with floodwaters prey upon native fish (juvenile and adult) and tadpoles resulting in decreased breeding success and recruitment; and
- Terrestrial animals (mammals, reptiles) become concentrated on "islands" on the floodplain, which are also occupied by predators such as foxes and cats; increasing the effects of predation.

Drying

The recession of floodwaters and subsequent drying of the soil results in concentration of nutrients and salts in depressional wetlands, storage of nutrients in the soil, completion of growth, foraging and breeding activities by wetland biota, germination of floodplain flora and dispersal or aestivation of wetland and aquatic fauna (Boulton and Brock, 1999).

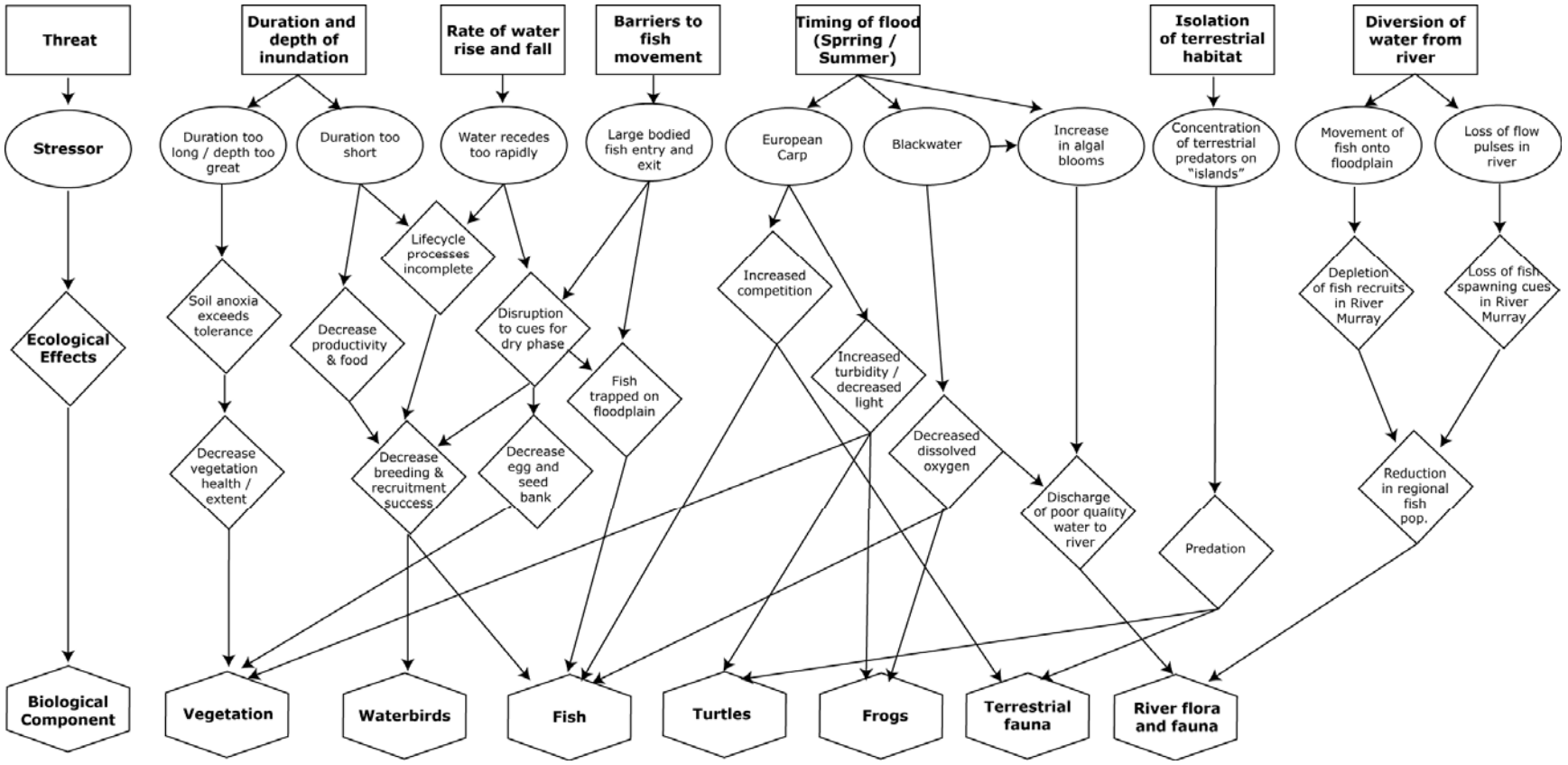
Identified potential negative impacts during this phase (Ecological Associates, 2009) include:

- A rapid rate of falling water can leave plants and animals with insufficient time to complete breeding cycles leading to reduced breeding success and recruitment; egg and seed bank depletion;
- A rapid fall and presence of barriers to lateral movement can leave fish stranded on the floodplain and unable to return to the river; and
- A rapid return to dry soil condition results in dramatically reduced eucalypt seedling success (Jensen, 2008).

9.3 Overview of Potential Impacts

A stressor conceptual model (after Gross, 2001) has been developed to illustrate the major impacts to the ecology of the system from the operational phase of the project (Figure 16). It should be noted that not all impacts identified by Ecological Associates (2009) have been included in the model, rather only those considered to have the greatest potential for negative impacts. Each of the identified threats is described below.

Figure 16 Stressor model of the major threats and impacts to floodplain ecology from the operation phase of the project.



9.4 Duration of Inundation

It is thought that wetland plants are more affected by flooding constraints and wetland animals by drying constraints (Mendelssohn and Batzer, 2006). This is reflected in the potential impacts of flood duration on the biota of the Koondrook-Perricoota Forest, where the greatest identified risk to vegetation is from inundation for too great a period and for waterbirds, fish and other fauna from inundation for too short a period of time (Ecological Associates, 2009).

9.4.1 Vegetation

Inundation of the floodplain changes the soil structure and creates anoxic conditions within the waterlogged sediment. Wetland and floodplain plants have varying degrees of tolerance to anoxic soil conditions and, in general, terrestrial plants are intolerant of prolonged inundation. The known inundation tolerances (and requirements) of key vegetation communities within the Forest are provided in Table 22. Exceedence of these tolerances can lead to decreased health; death of individuals and changes in community composition and extent; depending on the degree to which these tolerances are exceeded.

Table 22 Inundation requirements and tolerances of key species within vegetation communities in the study area

Community	Key species	Known inundation tolerance
Inland Grey Box woodland	Inland Grey Box (*Eucalyptus microcarpa*)	Inland Grey Box is intolerant of prolonged water-logging (Vesk *et al.* in press).
Derived tussock grasslands	Herbland - e.g. *Vittadinia cunneata, Vittadinia gracilis, Cotula bipinnata, Atriplex sp.*	Terrestrial species intolerant of flooding, but likely to survive in the seed bank and re-emerge after the flood recedes.
	Grassland – e.g. *Austrostipa* spp*., Austrodanthonia* sp	Terrestrial species intolerant of flooding, but likely to survive in the seed bank and re-emerge after the flood recedes.
	Sedgeland – e.g *Juncus* spp., and *Phragmites australis*	Emergent aquatic species tolerant of inundation. *Phragmites australis* is tolerant of permanent inundation up to a depth of 1 – 1.5 m (Roberts and Marston, 2000). Juncus species are tolerant of flooding for up to 8 months providing the plant is not totally submerged.
Black Box – Lignum woodland	Black Box (*E. largiflorens*)	Inundation for < 4 months (Roberts and Marston, 2000), with an ideal inundation in the region of 30 – 60 days, but tolerance for up to 180 days (Murray Flow Assessment Tool – MFAT; MDBC, 2009).
	Lignum (*Muehlenbeckia florulenta*)	Up to 12 months, permanent inundation eventually leads to death of plants (Roberts and Marston, 2000).

Community	Key species	Known inundation tolerance
River Red Gum forests	River Red Gum	Mature healthy trees can tolerate up to 24 months continuous flooding (Roberts and Marston, 2000). Optimum for the region is between 30 and 250 days (MFAT; MDBC, 2009).
Shallow Marsh	Aquatic herbs, sedges, forbs	Tolerant of continuous inundation (< 30 cm for some species). However, maximum floral diversity in fluctuating or seasonal water regimes (Roberts and Marston, 2000).

Vegetation communities within the proposed flood pool are shown on Figure 17. Approximately 57% of vegetation of the Forest would be inundated by the project. Note that the total area of 31,058 ha presented in this table is less than the total area of the Forest (approximately 32,000 ha). This is because the percentage extent of inundation was only calculated within the area covered by the DHI (2008) modelling. The relative extent of vegetation types in the Forest inundated by the project is presented in Table 23.

Table 23 Percentage Area of Vegetation Inundated in the Forest

Vegetation Type	Inundated area (ha)	Total area (ha)[1]	Extent of inundation (%)[1]
Comm ID 2: River Red Gum-sedge tall open forest	1136	1942	59
Comm ID 7: River Red Gum - herbaceous tall open forest	11104	17799	62
Comm ID 9: River Red Gum - wallaby grass tall woodland	2639	5280	50
Comm ID 10: River Red Gum - Black Box woodland	904	1357	67
Comm ID 13: Black Box - Lignum woodland	1549	3106	50
Comm ID 237: Riverine Inland Grey Box grassy woodland	189	951	20
Comm ID 250: Derived tussock grasslands	46	372	12
Comm ID 12: Shallow depressional marsh	140	240	58
Comm ID 19: Cypress Pine woodland of dunes	0	10	0
Floodplain Marshes[2]	1217	1622	75
Total	**17707**	**31058**	**57**

1 – The total and inundated areas do not include portions of the project Forest adjacent to the western levee alignment area as these were not covered by the available hydrological data.

2 - Floodplain Marshes are not included in the total area of vegetation because they were mapped separately and may overlap with other vegetation types.

Not all of these areas will experience prolonged inundation. Due to the flat topography of the Forest, the area of inundation decreases rapidly with a drop in water level. The duration of inundation across the floodplain for the modelled scenario is shown on Figure 18. The area of each vegetation community and floodplain marshes is plotted against inundation duration on Figure 19.

A comparison of the modelled duration of inundation against the tolerances provided in Table 22 resulted in the following assessment of potential impacts from inundation duration to vegetation communities:

Inland Grey Box woodland

Hydrological modelling indicates that approximately 190 hectares of Inland Grey Box Woodland will be inundated, out of approximately 951 ha in the Forest (i.e. approximately 20%), of which 180 hectares will be inundated for more than 30 days. Under natural conditions, large floods inundate this community but it is generally on higher, less frequently flooded levees and terraces (Benson et al., 2006) and may occur on more free draining, sandy soils. Inclusion of terrestrial vegetation in the inundation footprint was identified as a Very High project risk by Ecological Associates (2009) who anticipated it would result in the degradation of vegetation and habitat, including Inland Grey Box Woodland. Empirical studies on Inland Grey Box have concluded that lifecycle functions such as seed production are severely impacted by high soil water contents, which was used as an indicator of the poor inundation tolerance of this species (Vesk *et al*. in press). Duration of inundation sufficient to cause long term impacts to the health or death of individual Inland Grey Box trees is not known with certainty. There is no direct evidence of mortality of the species through inundation that could be used to determine a maximum frequency or duration that could be tolerated.

Inland Grey Box Woodland within the Forest generally co-occurs with River Red Gum and features flood tolerant species such as Lignum and Water Couch (*Paspalidum jubiflorum)* in the understorey, consistent with the Benson (2006) vegetation type 'Riverine Inland Grey Box grassy woodland of the semi-arid (warm) climate zone (Comm ID 237)'. This vegetation type is limited in extent and distinct from other Inland Grey Box grassy woodlands, which are typically located higher in the landscape and contain terrestrial species such as White Cypress Pine and Bimble Box (*Eucalyptus populnea*) for instance 'Inland Grey Box tall grassy woodland on alluvial loam and clay soils in the NSW South Western Slopes and Riverina Bioregions' and 'Inland Grey Box-White Cypress Pine - Buloke community' (ID80) in Benson (2006). GHD site surveys noted large areas of apparently intact Inland Grey Box Woodland, including mature trees of DBH >100cm within 50 metres of the banks of the Murray River, upstream of Torrumbarry Weir. This pattern, as well as the presence of flood tolerant species in the community, suggests that the natural distribution of Inland Grey Box Woodland includes at least some areas that would have been historically flooded relatively frequently and/or for prolonged periods.

Based on the GHD-mapped extent of the community, the 1993 flood of the Forest would have inundated extensive areas of Inland Grey Box Woodland. This flood event featured four successive months of Murray River flows at Torrumbarry Weir of greater than 30,000ML/day (MDBC, 2008), which would have resulted in overbank flow and extensive inundation of the forest. Therefore the estimated inundated area of Inland Grey Box Woodland is likely to have been flooded for a minimum of 30 days and potentially up to 120 days. Approximately eleven comparable flood events, with peak flows at Torrumbarry Weir of greater than 30,000ML/day occurred in the period 1973 to 2008 (MDBC, 2008 data presented in GHD, 2009a).

The project would produce an inundation area that is different to the natural flood extent due to the effect of project infrastructure. Notably the inlet channel will discharge upstream of the natural inflow for floods

at Swan Lagoon. This may inundate some areas of Inland Grey Box Woodland more frequently and/or for a greater duration than would have occurred naturally.

Ecological Associates related aerial photographs and mapped flood extents to vegetation mapping to infer patterns of flood tolerance in the Victorian Gunbower forests (Cooling, M., Ecological Associates, pers. comm.). The authors found that Inland Grey Box Woodland appeared to have a similar distribution relative to historical flood extents, and therefore similar tolerance of inundation, to Black Box Woodland (Cooling, M., Ecological Associates, pers. comm.). Based on comparisons with known tolerances of Black Box, it can be inferred that Inland Grey Box Woodland would tolerate inundation for < 4 months, i.e. 120 days (Roberts and Marston, 2000), with a maximum tolerance of up to 180 days (Murray Flow Assessment Tool – MFAT; MDBC, 2009). Based on DHI (2008) modelling of the indicative scenario, no Inland Grey Box Woodland in the Forest will be inundated for greater than 120 days. Therefore the proposed inundation is unlikely to result in significant or irreversible impacts on local populations of Inland Grey Box Woodland. Given the uncertainty about the inundation tolerance of this community, monitoring and adaptive management will be important in avoiding significant impacts over the operational life of the project. The proposed environmental monitoring program will include plots within Inland Grey Box Woodland in- and outside inundation areas. If significant negative effects in response to inundation are noted, then the project team will review the operation of the project to try and avoid these effects. Operational mitigation measures may include reducing the duration of flooding.

Derived tussock grasslands

Hydrological modelling indicates that 46 hectares of this community will be inundated for a sufficient period of time to result in the death of annual, terrestrial plants. However, the seed bank will survive and the community may benefit in terms of species diversity and productivity following the recession of the flood. In addition, impacts for sedge dominated communities are likely to be wholly positive (see section 9.11.

Black Box – Lignum woodland

Hydrological modelling indicates that a total of 1,550 hectares of this community will be inundated, for a maximum duration of 180 days. This is within the tolerance of this plant community (MFAT; MDBC, 2009) and as such the effects to this community are expected to be beneficial (see section 9.11) with no predicted negative impacts.

River Red Gum forests

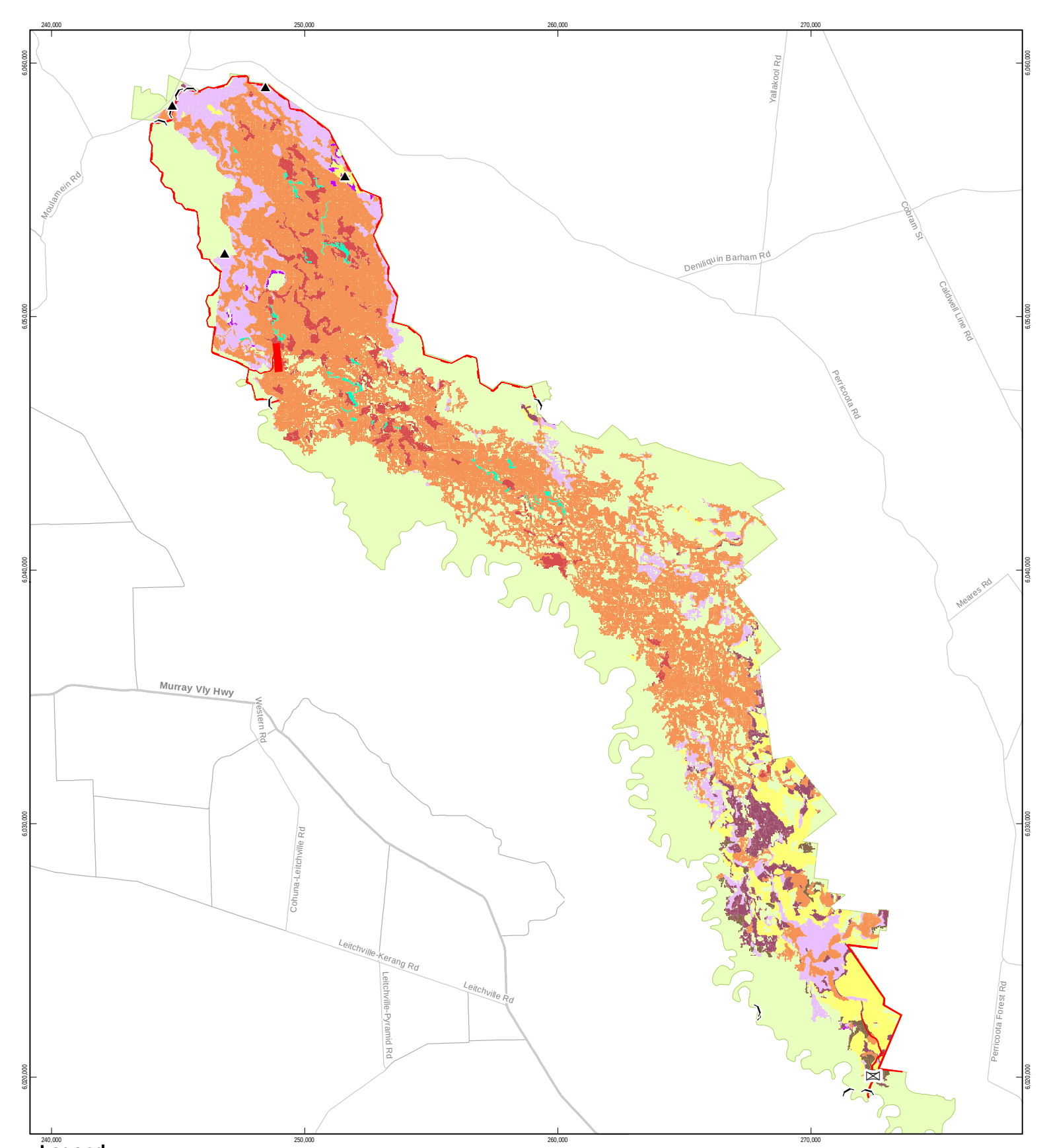
Hydrological modelling indicates that over 13,000 hectares of River Red Gum forest and woodland will be inundated. The duration of the flood will be between 30 and 200 days for the majority of the area, which is considered optimum for this species (MFAT; MDBC, 2009). Although Ecological Associates (2009) indicated a risk from inundation of stressed mature trees, evidence from elsewhere has indicated that even severely stressed trees with little canopy benefit from flooding. For example, environmental watering at Hattah Lakes in 2005 resulted in flooding of stressed River Red Gums that had been dry for nearly a decade. Mature, stressed River Red Gums that were nearly leafless responded with a flush of growth (Mallee CMA, 2009). Similarly, environmental watering of the Chowilla Floodplain in 2005 and 2006 resulted in improvements in tree health in even very stressed, leafless trees with inundation durations of 30 to > 200 days (Alderidge *et al*., 2006). The impacts to stressed River Red Gum individuals should also be considered in the context of expected responses to continued dry conditions. It could be expected that in the absence of inundation these trees will deteriorate in condition and eventually large numbers of tree deaths could occur.

Impacts to understorey communities have also been studied in similar systems. In Chowilla, environmental watering resulted in a change in community composition in floodplain understorey from terrestrial species to flood tolerant or wetland species (Nicol *et al*., 2009). While this may be seen as an impact to the terrestrial phase of these communities, under natural flooding conditions, it would be expected that during inundation wetland species would emerge; with species composition cycling with wet and dry water regimes. Any shift towards a more natural regime may be considered as generally positive.

It is predicted that the impacts to this community will be beneficial with little or no negative impacts compared with current conditions.

Floodplain marsh communities

Hydrological modelling indicates that over 1,200 hectares of floodplain marsh will be inundated for varying durations. As this community is dominated by wetland species, the only negative impacts that could be expected may be from areas that are not inundated for a sufficient period of time to allow for the completion of lifecycles of non-perennial species. Approximately 100 hectares will be inundated for < 60 days, which may be insufficient for all species within these areas to flower and set seed. However, the vast majority of these communities will be inundated for > 60 days and over 400 hectares will be inundated for more than 120 days. As such the majority of the effects to this community are expected to be beneficial (see section 9.11 below).



Legend

- ▲ Turkey's nest dam
- River Road bridge
- Regulator
- Major roads
- Construction features
- Koondrook Perricoota Forest Site

Vegetation Types Within the Maximum Inundated Area

- Comm ID 2: River Red Gum-sedge tall open forest
- Comm ID 7: River Red Gum - herbaceous tall open forest
- Comm ID 9: River Red Gum - wallaby grass tall woodland
- Comm ID 10: River Red Gum - Black Box woodland
- Comm ID 12: Shallow depressional marsh
- Comm ID 13: Blackbox - Lignum woodland
- Comm ID 237: Riverine Inland Grey Box grassy woodland
- Comm ID 250: Derived tussock grasslands

0 1.25 2.5 5
Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

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NSW Office of Water

Koondrook-Perricoota Flood Enhancement Works

Job Number	21-18573
Revision	B
Date	01 FEB 2010

Figure 18 - Vegetation types within the maximum inundated area

G:\21\18573\GIS\Arcview\Map_Documents\21.18573.Z028_vegetation_type_of_Max_Inundated_Area.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Dept of Commerce, Drawn: Cwilson, cwilson

Figure 19 Inundation Duration and Area of Vegetation Types

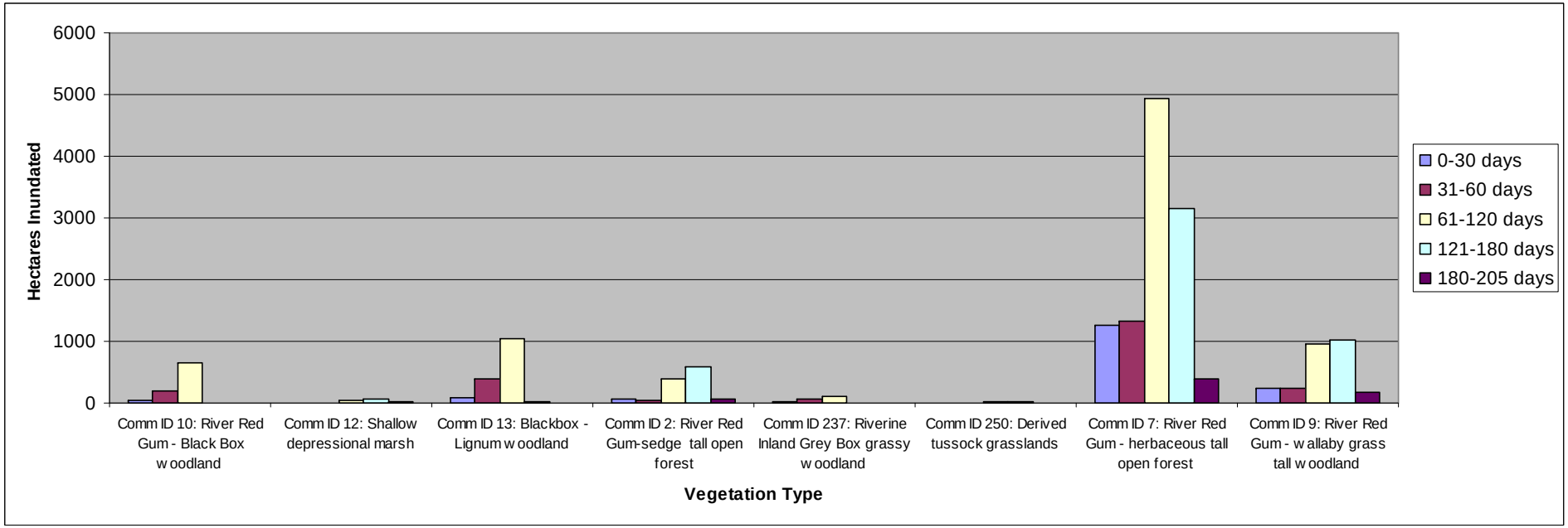
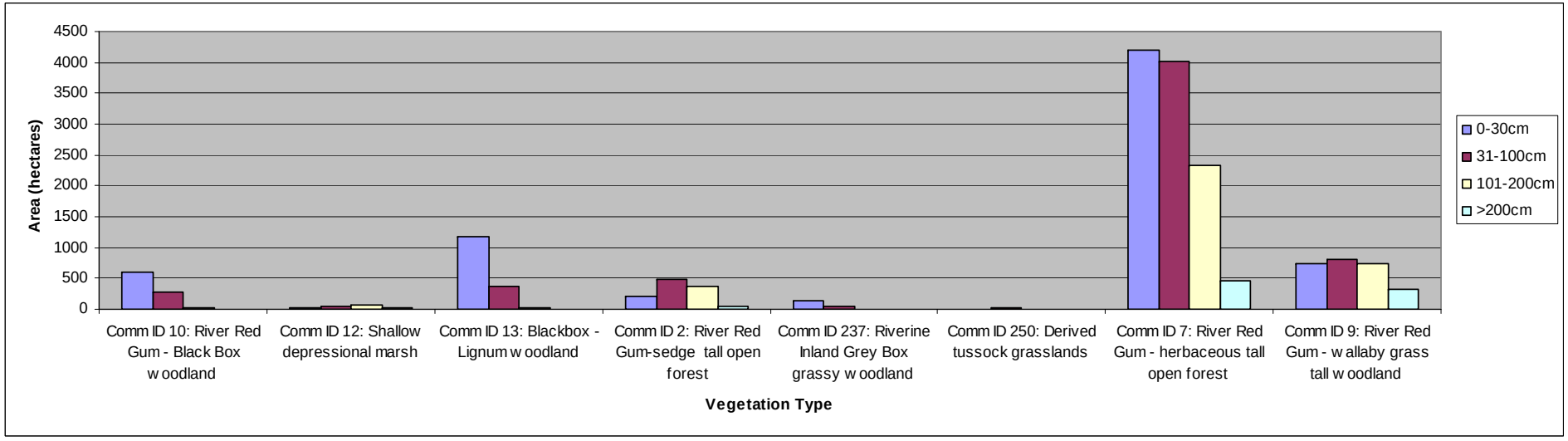


Figure 20 Inundation Depth and Area of Vegetation Types



9.4.2 Waterbirds

The major stressor to fauna arising from inundation duration is the risk that drying will occur prior to the completion of lifecycle stages such as breeding. In terms of the current project, the only identified risk by this pathway was to waterbirds (Ecological Associates, 2009).

Waterbirds breed in response to flooding in relation to nesting habitat as well as available food resources. There is evidence to suggest that waterbird breeding occurs when food resources are at a maximum (Kingsford and Norman, 2002), which depending on the season and diet of the species can lag behind the commencement of inundation for periods of 4 weeks to 7 months. Once breeding has commenced, many Australian waterbirds require surface water to remain in and around nesting sites until offspring are independent feeders (Jaensch, 2002). Drying prior to this can lead to abandonment of nests and young by parents or insufficient food resources for successful fledging. It is suggested that inundation for a minimum of four months would be required to allow for courting/mating, nest site selection and building, incubation and raising of young to independence (Jaensch, 2002).

There is little recent information regarding nesting waterbirds within the Koondrook Perricoota forest (Webster, 2008), but historical records provide an indication of the suite of species for which breeding could be supported in a flood event. Preferred nesting sites and required inundation requirements for waterbird species previously recorded breeding in the Forest are similar and the Forest predominantly supports birds that nest in trees or shrubs (Table 24). This is hardly surprising given that woodland and forest communities dominate the Forest.

Table 24 Nesting habitat and inundation requirements for waterbirds previously recorded breeding in Koondrook Perricoota Forest ([1]Webster, 2008; [2]Briggs, 1990; [3]Jaensch, 2002).

Species[1]	Stimuli for breeding[2]	Nesting Habitat[3]	Inundation requirements[3]
Great Crested Grebe	Flooding	Floating mound of aquatic vegetation is placed on floating weed mat or anchored to emergent vegetation; often under cover of trees or shrubs	Minimum depth of 30-50 cm for sufficient time to prevent nest sites becoming dry before nestlings leave nest and reach maturity. 4 weeks incubation; 1 week leave nest, independent some weeks later – approximately 3 months total.
Little Pied Cormorant	Flooding / seasonal	In forks and branches of trees (Eucalyptus) and tall shrubs in or over water; sometimes over dry land or on artificial structures.	Minimum depth of 30-50 cm for sufficient time to prevent nest sites becoming dry before nestlings leave nest and reach maturity – 3 to 4 months.
Little Black Cormorant	Seasonal / Flooding	In forks and branches of trees (Eucalyptus) and tall shrubs in or over water; sometimes over dry land or on artificial structures.	Minimum depth of 30-50 cm for sufficient time to prevent nest sites becoming dry before nestlings leave nest and reach maturity – 3 to 4 months.
White-necked Heron	Flooding / seasonal	Low near-horizontal branch of tree in or overhanging water Trees (e.g., River Red Gum) fringing river channels, waterholes, lakes and ponds; wooded swamps (e.g. Black Box).	Minimum depth of 30-50 cm for sufficient time to prevent nest sites becoming dry before nestlings leave nest and reach maturity – 3 months.
Great Egret	Flooding / seasonal	Wooded swamp (e.g. Eucalyptus); high in a tree or tall shrub standing in water, often at a higher Forest than associated species; on top of lignum shrub; sometimes high in trees on dry land.	Minimum depth of 30-50 cm for sufficient time to prevent nest sites becoming dry before nestlings leave nest and reach maturity – 3 to 4 months.
Intermediate Egret	Flooding / seasonal	Wooded swamp (e.g. Eucalyptus); high (e.g. Up to 15 m above water) in a tree or tall shrub standing in water.	Minimum depth of 30-50 cm for sufficient time to prevent nest sites becoming dry before nestlings leave nest and reach maturity – 3 to 4 months.

Species[1]	Stimuli for breeding[2]	Nesting Habitat[3]	Inundation requirements[3]
Nankeen Night Heron	Flooding	Wooded swamp (e.g. Eucalyptus); in a tree or tall shrub standing in water, at variable height; often in a discrete zone (e.g. encircling a group of breeding egrets); sometimes high in trees on dry land.	Minimum depth of 30-50 cm for sufficient time to prevent nest sites becoming dry before nestlings leave nest and reach maturity – 2 to 3 months.
Glossy Ibis	Flooding	Shrubby swamp (e.g. Lignum), wooded swamp (e.g. Eucalyptus), and reed/cumbungi beds. In a tree or tall shrub standing in water, usually low in the tree/shrub	Minimum depth of 30-50 cm for sufficient time to prevent nest sites becoming dry before nestlings leave nest and reach maturity – 2 to 3 months.
Australian White Ibis	Flooding / seasonal	Wide variety of habitats used for breeding: typically wooded swamp (e.g. Eucalyptus), shrub swamp (e.g. Lignum) and reed/cumbungi beds; also exotic wetland and dryland tree copses, bare islands and artificial structures.	Minimum depth of 30-50 cm for sufficient time to prevent nest site becoming dry before nestlings leave nest and reach maturity – 10 weeks to 3 months (not relevant to nests on dry land).
Royal Spoonbill	Seasonal / Flooding	Shrubby swamp (e.g. Lignum), wooded swamp (e.g. Eucalyptus), and reed/cumbungi beds; In a tree, tall shrub or reeds/rushes standing in water 0.5-1.5 m deep.	Minimum depth of 30-50 cm (often deeper) for sufficient time to prevent nest site becoming dry before nestlings leave nest and reach maturity - 3 months.
Yellow-billed Spoonbill	Seasonal / Flooding	Eucalyptus or other trees fringing (overhanging) waterholes and lakes or in wooded swamp, Lignum or reeds. Usually in a tree, on a horizontal or vertical branch, a few metres above water but sometimes higher.	Minimum depth of 30-50 cm (often deeper) for sufficient time to prevent nest site becoming dry before nestlings leave nest and reach maturity - 3 months.

Duration of inundation within vegetation types and floodplain marsh habitats is shown on Figure 19, which indicates that there are large areas of woodland and forest which will remain inundated for a sufficient time to allow for successful waterbird breeding. Over 10,000 hectares of River Red Gum forest and woodland will be inundated for more than 3 months of which over 4000 hectares will remain inundated for 4 months. Smaller areas (approximately 600 hectares) will remain inundated for approximately 6 months.

The other identified risk related to waterbird breeding and inundation was that there could be insufficient food resources to support waterbirds to successful recruitment, which was identified as a moderate risk by Ecological Associates (2009). This could result from inundation for too short a period as described above, or a deficit in primary and secondary productivity due to the prolonged drought.

Australian intermittent and temporary wetland systems are well adapted to cycles of wetting and drying and a persistent seed and egg bank is characteristic of these systems (Brock *et al*., 2003). Seed and egg banks have been shown to be resilient to extended periods of drought (> 10 years; Capon, 2007). However, reduced germination has been observed in wetlands and floodplains subjected to long intervals between floods (Daniels *et al*., 2009). Despite this risk of reduced germination, it should be noted that egg and seed banks within the floodplain would be augmented by propagules and biota arriving with the floodwaters.

There are numerous examples across Australia and within the Murray-Darling Basin of sufficient productivity to support breeding of waterbirds following inundation of wetlands that have been dry for prolonged periods. At Hattah Lakes, flooding in 2005 and 2006 followed a decade of drought and resulted in a boom in productivity and successful breeding of waterbirds, frogs and tortoises (MDBC, 2006). Similarly environmental water delivery to parts of the Chowilla Floodplain that had been dry for extended periods of time resulted in increased abundance and diversity of invertebrates, fish and waterbirds (Aldridge *et al*., 2007).

Given the multiple lines and levels of evidence (empirical studies, case studies and a suite of species) it is considered very unlikely that the operational phase of the project will result in a net negative impact to waterbirds compared to the current condition (see section 9.11.2 for discussion of positive impacts).

9.5 Rate of rise and fall of floodwaters

The effect of a rapid fall in water levels on waterbird breeding was identified as a low risk (Ecological Associates, 2009). Colonial nesting waterbirds only breed successfully if water remains around the nest site until young can independently feed. A rapid drop in water level can result in birds abandoning nests leaving chicks to die. This has been recorded in the past at a number of locations within the Murray-Darling Basin. For example in November 1996, water inflows in the Macquarie Marshes were reduced from 1800 ML/day to 400 ML/day. As a result a colony of Ibis (400 nests and 1000 chicks) abandoned their nests when water levels receded (Scott, 1997).

This is unlikely to occur under the operational 100 day fill – hold – empty scenario. The hydrograph (refer Table 23) indicates a slow recession of flood waters that mimics a natural flood event. Further, the proposed operational regime provides flexibility to prolong the inundation period in response to observed bird breeding behaviour. As such, this is not considered a significant risk to waterbirds at the Forest.

9.6 Timing of inundation

The maximum benefits from inundation are likely to be experienced from commencement of inundation in spring and inundation continuing to mid summer (see section 9.11 below). However, a spring / summer flood event increases the likelihood of three negative impacts of the operational phase of the project: creation of a 'blackwater' event; promotion of algal blooms; and recruitment of Carp.

9.6.1 Blackwater

Blackwater conditions both in the forest and released to the river were assessed as high risks by Ecological Associates (2009). Blackwater is defined as flood waters with sufficient dissolved organic carbon to give the water a dark "tea" colour associated with reduced dissolved oxygen concentrations (Howitt *et al*., 2007). The phenomenon is natural and has been recorded on Australian floodplains from times prior to river regulation (Howitt *et al*., 2007). Upon inundation, organic carbon (and other nutrients) are leached from the sediments and leaf litter and rapidly mineralised into the water column. These are taken up and processed by microorganisms, which consume oxygen in the processe. If this cycle happens more quickly than oxygen can be replenished by diffusion from the air, dissolved oxygen concentrations can fall below that required to sustain aquatic biota and can result in fish kills. The impacts of blackwater can be felt both on the floodplain, but also in the river, if water depleted of oxygen and high in organic carbon is discharged by return flow in large volumes (Baldwin *et al*., 2001).

Production of a blackwater event is affected by a number of factors including the amount of leaf litter on the floodplain, type and age of leaf litter, period since last flood and temperature (Howitt *et al*., 2007). Modelling of the potential for blackwater has been undertaken for a number of operational scenarios (Water Quality in GHD, 2009c). Results indicated that in the first year of inundation there is likely to be a large release of dissolved organic carbon from the litter that has accumulated on the floodplain over the long inter-flood interval. This is expected to result in a decrease in dissolved oxygen to < 2mg/L under all operational scenarios assessed with the duration and severity of blackwater events varying with period since the last inundation event and especially the season of inundation (Water Quality in GHD, 2009c). On the basis of this modelling there is likely to be negative impacts on native fish and other aquatic fauna (e.g. tadpoles, Murray Crayfish and Yabbies) within the inundated portions of the Forest. Australian native fish are considered to require at least 2 mg/L of dissolved oxygen to survive and health may be impacted at concentrations above this (Gerkhe, 1988). Previous blackwater events resulting from the flooding of the Barmah Forest have resulted in deaths of fish in the receiving waterways as well as impacts on the floodplains themselves (Howitt *et al*., 2007). Environmental watering of the Barmah-Millewa Forest in 2000 resulted in a blackwater event that had severe short-term detrimental impacts on aquatic fauna within the Murray River (Gigney. *et al.,* 2006).

Despite the likely short term negative impacts to aquatic fauna, blackwater events are a part of the naturally occurring processes that are characteristic of floodplain inundation in Australia. The mobilisation of carbon from the floodplain to the river is an important process and may be a significant source of carbon for the river, maintaining productivity in the long term (Gawne *et al.,* 2007). Negative effects of blackwater production and positive effects of nutrient release would be experienced through the course of a flood event. The magnitude of these effects would vary with season, inundation duration; inter flood interval and other factors.

During the 2005/06 environmental watering of the Barmah Forest the abundance of planktonic microinvertebrates declined during the flood but increased rapidly during the falling limb of the hydrograph potentially due to bacterial productivity associated with the dissolved carbon and nutrient

pulse (Gigney. *et al.,* 2006). This flood event also resulted in positive effects on habitat resources, native fish spawning behaviour or the survival of young (King *et. al.,* 2007), including:

- Increases in Golden Perch and Silver Perch spawning activity compared to the two previous seasons;
- Murray Cod spawning activity appeared not to increase during the flood year compared to the previous two seasons; however, there was a significant increase in the number of young-of-year after the 2005–06 flood season, compared to the previous year;
- Habitat maintenance and improved connectivity of floodplain wetlands and drainage lines for a variety of fish residing and recruiting on the floodplain; and
- Indirectly it also probably provided a boost of nutrients and prey items in returning waters to permanent water bodies such as the main channel and wetlands.

There was no evidence of fish kills or other negative effects on Murray River aquatic ecosystems during this flood, which is consistent with minimum dissolved oxygen levels at sampling sites of not less than 4 ppm (King *et. al.,* 2007). Fish kills are likely if DO drops below about 2 mg/L. In modelled scenarios assessed by GHD (Water Quality Chapter, 2009) DO dropped below this level if flooding occurred in Summer, or where there had been no prior flood for 2 years, and higher amounts of accumulated organic material on the floodplain to leach dissolved organic carbon. This would result in negative effects within the flood pool. When the return channel is operating at maximum flow rates of 1,850ML/day, flows in the Murray River downstream of the Torrumbarry Weir are likely to be at least 5,000 - 6,000 ML/day. As a result, blackwater would be diluted by flows in the Murray River (Water Quality Chapter, 2009). If blackwater is released down Barbers Creek at the maximum rate of 250ML/day, it would flow approximately 58km downstream before being diluted by the Wakool River which is likely to have flows in the order of 500 – 600ML/day at this time. If flows from the Merran Creek system are entering Barbers Creek upstream of the confluence with the Wakool River, this would assist in diluting blackwater; however (Water Quality in GHD, 2009) negative effects on fish and other aquatic biota in the Barbers Creek system are likely.

Blackwater events would limit the productivity of the flood pool and in Barbers Creek under the indicative operating scenario by precluding fish and other species that require higher DO concentrations. However a positive ecological response to flooding is still likely since many aquatic species can persist in low DO environments, including many species of invertebrates and planktonic microninveratebres and anaerobic bacteria. These organisms are likely to support a boost in floodplain productivity via a trophic cascade. Based on results from Barmah forest this dissolved carbon and nutrient pulse is likely to benefit fish populations in the Murray River downstream of the Forest (King, *et al.,* 2007) and (Gigney. *et al.,* 2006). Further, shallow marginal portions of the flood pool are likely to have higher DO concentrations due to atmospheric exchange. These areas would not provide adequate shelter for fish, but would support invertebrates and potentially also tadpoles.

Potential negative effects on fish populations within the flood pool need to be balanced with likely positive effects through watering of the River Red Gum forests and contribution of carbon to downstream aquatic ecosystems (Howitt *et. al*., 2007). Likely positive effects of the proposed flooding, such as watering of River Red Gums, are described further in Section 9.11. Another consideration is that if the project did not proceed then organic matter would continue to accumulate on the flood plain between less-frequent flood events potentially resulting in more severe blackwater events when natural floods occur.

The proposed operational regime and monitoring and adaptive management framework will be used to minimise potential negative effects of blackwater as far as is practicable.

Potential mitigation measures (Water Quality in GHD, 2009) include:

- Avoiding retention of floodwater in the forest over the summer months, especially from January to March. The floodwater will need to be monitored for both dissolved organic carbon and dissolved oxygen, and the releases to the Murray managed by manipulating the Torrumbarry passing flows and the rate of release, to ensure adequate dilution within the river channel;
- Increasing the frequency of flooding so that there is less litter accumulation on the floodplain between floods (within water availability constraints); and/or
- Aerating the ponded water before release, either by mechanically aerating the area of the flooded forest immediately upstream of the release point or engineering discharge points to aerate the water as it is released. This could be done through some sort of drop structure (within fish passage constraints).

If monitoring detects a particularly severe blackwater event then the flood pool could be maintained in the Forest in order to avoided downstream impacts. Flood waters would be allowed to dissipate through evapotranspiration and infiltration. This approach would need to consider potential negative effects of extending the inundation of the Forest, such as excessive inundation of floodplain vegetation.

9.6.2 Pest fish species

Increases in Carp in the Forest and increases of Carp and other exotic fish in the river were assessed as very high risks by Ecological Associates (2009). Carp and Oriental Weatherloach are the main invasive species that may take advantage of the flooded forest with the extent of impacts strongly dependant on the season and frequency of inundation (DSTA, 2009).

Carp (*Cyprinus carpio*) are widespread around the Murray-Darling Basin. Carp have been implicated in decline of native fish populations and the degradation of river systems through damage to riverbanks, aquatic macrophytes, increasing turbidity and predation of native biota and competition with native fish for food and habitat (Stuart and Jones, 2000). The Barmah-Millewa River Red Gum forests have been noted for the abundance of Carp, which utilise the inundated floodplains for spawning and recruitment (Stuart and Jones, 2006). Carp have been implicated in the decline of native fish populations and the degradation of river systems.

Recent evidence from the Barmah-Millewa Forest (King *et. al*., 2009) and Ovens River Floodplain (King *et al*., 2003) have indicated that early spring inundation of floodplains can result in increased spawning and recruitment of Carp. King (2009) also found that Carp were able to spawn a second time on a late summer (February) flood, indicating a flexible spawning strategy. Oriental Weatherloach spawn in spring and summer, hence inundations in late autumn or winter would also provide little benefit for these species (DSTA, 2009). Increased spawning of pest fish species on the floodplain can result in increased Carp in the River Murray; with over 98% of Carp caught in Torrumbary Weir thought to have originated in the Barmah-Millewa Forest (Cook and Gillanders, 2006).

The mechanism for increased Carp larvae on inundated floodplains is complex and involves both movement of adults onto floodplain environments to spawn as well as passive movement of larvae from the river to the floodplain, where they take advantage of increased food resources to increase survival and recruitment (King *et al*., 2009). Trapping mechanisms such as Williams Cages on the inlet

structures, may reduce the movement of adult Carp onto the floodplain, they will not stop the movement of larvae. Young–of–year carp are too small to be caught in a carp trap and as carp are very fecund (300,000 to 500,000 eggs per fish) there is the potential for negative impacts as these fish are transported back to the river as the floodplain is drained (DSTA, 2009).

Shifts away from natural flood regimes have been implicated in the decline of native fish species in favour of exotic species, especially Carp. The highly regulated and modified Murray River system has created favourable conditions for pest fish species. Floodplains and especially frequently inundated marshes support large breeding populations of the Carp and may have a negative effect on the Murray River fish population through recruitment (Macdonald and Crook, 2006; Jones and Stuart, 2007). The creation of near-permanent wetlands through river regulation led to overabundance of Carp in the Moira State Forest and recruitment of large numbers of carp to the Murray River. Management of Moira Lake and other wetlands have attempted to maintain a hydrological regime less favourable for Carp populations (Stuart and Jones, 2002; Hess and Carter, 2007). Depending on natural flooding and forest health, the time between managed inundations arising from the project will vary between 1 and 5 years. The operational scenario assessed in this report would only be initiated every 3-5 years and smaller flood events would be managed to avoid prolonged or too-frequent inundation. The proposed operation is intended to achieve a more natural sequence of flooding frequency and duration, which may return the competitive advantage to the indigenous species which are well adapted to the opportunistic wetting and drying cycles associated with Australian river systems (DSTA, 2009).

The operational phase of the project has the potential to result in increased recruitment of Carp and other pest species. This negative impact must be considered in the context of net gains for native fish and other biota (see section 9.11).

9.6.3 Algal Blooms

Phytoplankton populations often exist in a “quasi equilibrium” where primary production is balanced by losses (Evans and Parslow, 1985) and phytoplankton populations are stable. A bloom can therefore be defined as a departure from this balance, when production exceeds losses and therefore leads to an increase in biomass. Algal blooms are a natural feature of aquatic ecosystems and occurred prior to river regulation. However, the frequency and intensity of algal blooms across many wetland types in Australia has increased in the last 100 years.

Algal biomass is regulated by a combination of factors including light, temperature and nutrient concentrations. The release of nutrients from the sediments and leaf litter following inundation is likely to stimulate algal growth. In late summer, when water will be still, shallow and warm on the floodplain, conditions may be optimum for an algal bloom. There are factors, however, that may inhibit algal growth and limit the potential for bloom development by reducing light availability.

Inundation of the floodplain is likely to result in the release of dissolved organic carbon from the leaf litter and stain the water with tannins (see section 9.6.1 above), which has an effect of reducing light within the water column. In open waterbodies, this may competitively advantage blue-green algae such as *Microcystis* and *Anabaena* that can regulate their buoyancy. However the Forest is predominantly covered by woodland and forest, which, even in conditions of tree stress, provides canopy and a reduction in light reaching the water’s surface, which reduces light for all algal species. This leaves only relatively small areas of open wetland, which may be susceptible to algal blooms.

An algal bloom within the floodplain ecosystem itself is unlikely to cause serious adverse effects. Temporary wetland systems such as floodplains are adapted to “boom and bust” cycles associated with wetting and drying (Boulton and Brock, 1999). An increase in algal growth adds to productivity and will ensure sufficient food resources to enable successful breeding of waterbirds, fish and other biota.

Although algal discharge to the river was identified as a high risk by Ecological Associates (2009); a more detailed assessment based on additional information has concluded that the risk of developing algal blooms following inundation of the forest is low (Water Quality in GHD, 2009c). As such the ecological implications from increased algal growth on both the floodplain and the Murray River are considered negligible.

9.7 Movement of Aquatic Fauna

9.7.1 Impacts on Fish Passage During Operations

Ecological Associates (2009) assessed the risk of trapping large big-bodied fish within the floodplain as a moderate risk. Species at risk include the threatened Murray Cod and Silver Perch which are present in the Murray River adjoining the Forest and may move onto the floodplain, and potentially breed during flood events.

A Fish Passage Task Force (FPTF) has been involved in the review of the Koondrook-Perricoota TLM project and provided recommendations on fish passage which have been incorporated into the present design. FPTF (2009) identifies the following likely stages in fish movement in response to the operation of the project and potential impacts:

- During the filling phase:
  - Large and small bodied native and exotic fish (including adults, juveniles and eggs/larvae) are likely to enter the upstream end of the Forest via the intake regulator and then Bullock Head Creek and the floodplain.
  - Fish may aggregate below the intake regulator during inundation.
  - Fish would not be attracted to the outlet regulators, either to move downstream from the forest or to move upstream from the Wakool River system. This is because the outlet regulators will generally be closed or in the case of the return channel regulator and the Barbers Creek regulator flows are expected to be too low to attract fish.
- During the flood pool maintenance stage:
  - Some of these fish may actively use the inundated forest habitats and shallow channels or they may remain in the deep excavated channel.
  - Fish may aggregate below the regulator whilst the forest is inundated.
- During the early-recession phase:
  - It is anticipated that large-bodied native fish will leave the floodplain and return to the main stem of the river when the flows start to recede, while small fish are expected to make these movements towards the end of receding flows. These fish would move upstream to the inlet regulator and Swan Lagoon or downstream to the outlet regulators.
- During the late recession phase:

- Small and large-bodied fish would very likely pass downstream out of the forest and fish may be attracted from the Wakool River system upstream to the regulators, depending on the rate of flow of discharged water.
- Fish may be stranded if water on the floodplain is dropped too quickly.
- Fish, crayfish, freshwater shrimp and freshwater turtles would aggregate below the regulator as water recedes. There is the risk that large fish may leave the forest floodplain and swim up the inlet channel at low flows and become trapped below the regulator.
- Fish may become trapped at the downstream stop log regulators.

Given these likely fish movements in response to the proposed flooding provision for fish passage has been incorporated into the design of the project. Potential impacts must be considered in the context of the proposed measures to provide for fish passage. The following section summarises advice provided by Mr Martin Mallen Cooper, who is on the FPTF, and presented in the NSW Department of Services Technology & Administration letter to DEWHA of 10 November 2009 (DSTA, 2009) and the FPTF (2009) summary report. The structures have been specifically designed to ensure that large-bodied native fish, including Murray Cod and Silver Perch, can enter and leave the floodplain by the following measures (DSTA, 2009; FPTF, 2009):

- At the inlet regulator:
  - Overshot gates have been used to ensure the safe passage into the floodplain, as undershot gates are known to cause mortalities in fish (Baumgartner *et al*., 2006);
  - Passage for large bodied fish to return to the river is provided by a Denil fishway specifically designed for large fish such as Murray Cod. The fishway is designed to operate for the upper half of the receding hydrograph (i.e. when flows at the inlet are starting to be reduced and levels in the floodplain starting to recede) which is when large fish are expected to move back into the river. The large fishway will not be operational in the lower half of the receding hydrograph and so a 'fish rescue plan' would be initiated for any Murray Cod downstream of the regulator during this period. This may include capture and transport of stranded fish, however details of a fish rescue plan are yet to be developed;
  - Passage for small-bodied fish to return to the river is provided by a separate fishway, specifically designed for small-bodied fish (e.g 20-100 mm long), including juvenile Murray Cod. The fishway is a vertical-slot fishway with small pools and low water velocities and turbulence, designed for the poor swimming ability of small fish. The fishway would operate during the lower half of the receding hydrograph;
  - A horizontal ramp allow fresh water turtles to escape from the main inlet channel and relocate to the Murray River. The ramp has been located downstream of the offtake regulator in a low turbulence and low velocity zone (Department of Commerce 2008).
  - Provision of high operational flexibility for effective ramping up and ramping down of the diversion discharge to maintain acceptable flow characteristics, structure profile and control for upstream fish passage (Department of Commerce 2008).
- At the return channel:
  - An upstream fish passage structure (to allow fish to move from the Murray River into the forest) is not required on the return regulator as discharges from the regulator, at up to 1,850 ML/d, are not sufficient to result in significant attraction of fish into the forest in the context of Murray River flows.

- Detailed design will ensure safe passage of fish in a downstream direction (i.e. fish moving from the forest to the Murray River). This includes avoidance of design features that could cause injury to fish, such as baffle blocks and sharp rocks. Operation of the regulator will control velocities of water released back to the Murray River so that the flow characteristics are suitable for downstream fish passage.

- At the outlet regulators:
  - The design flow rate release of 250 ML/d from the Barbers Creek regulator in a managed event will minimise the attraction of fish upstream into the Forest and so there is no provision of upstream fish passage. However the Barbers Creek regulator is being designed to allow provision for a fish lock to be readily retrofitted if it is found to be required in the future.
  - The Barbers Creek regulator is being designed to be suitable for downstream fish passage during the recession phase of the flood cycle. Flow through Barbers Creek would be via stoplogs or an overshot gate, providing safe passage of fish downstream to the Wakool River. A deep dissipating pool specifically designed for fish passage will be provided on the downstream side of the Barbers Creek Regulator.
  - The other downstream stop log regulators do not require fish passage structures, since it is not proposed to release flows via the other regulators during a managed event.

In Barbers Creek downstream of the Forest:

- Block banks on Barbers currently limit fish movement due to small pipes. By washes will be constructed which will improve fish passage downstream to the Wakool river system for fish exiting the Forest.

In addition to engineering design of the structures other key factors for fish passage include the timing of flood events and management of flows. Important timing issues for fish passage include (FPTF, 2009):

- Mimicking the timing of natural flow regimes (peak flows in October/November), variability and pulsing;
- Provision of a continuous and variable water supply to optimise water quality during a managed inundation event;
- Sufficient time during flooding recession phase to allow fish to move from the floodplain to the river; and
- Controlling summer Carp recruitment by ceasing flooding in late December/January.

Ecological Associates (2009) determined that the proposed inundation is likely to provide a highly productive small fish habitat on the floodplain and return small fish to the Murray River in significant numbers via the Return Channel and Barbers Creek. Based on the above considerations there is a residual risk that the project would trap large-bodied native fish, including threatened species. The main exit route is upstream and involves channels of a variety of depths over more than 30 km which must be negotiated between the time when flow-cues to exit the Forest are received and the time when the proposed Denil fishway ceases to operate effectively (FPTF, 2009, Ecological Associates, 2009). If a significant number of large-bodied native fish are found to be trapped by this process then a fish rescue plan may be required to avoid significant impacts on local populations of threatened fish. Monitoring and adaptive management will be important through this process as a number of other variables would combine to determine the risk to threatened fish populations. For instance, low DO concentrations in the

flood pool due to blackwater events may prove to be a more significant factor than fish passage out of the Forest (refer Section 9.7).

9.7.2 Impacts on Fish Passage During Natural Floods

Natural flood waters enter the Forest via Swan Lagoon and leaves the Forest via Thule, Barbers and Cow Creeks. The Swan Lagoon regulators and downstream stop log structures have been designed to allow for fish passage during a natural flood and will be fully open in a natural flood to allow the flood to operate with minimal change from the current situation (FPTF, 2009). The proposed structures are designed to provide appropriate velocities of water flow for upstream fish passage and specific measures are being designed to provide a low velocity/turbulence corridor at the abutments at each downstream stop log regulator structure to facilitate upstream fish passage (FPTF, 2009).

9.8 Isolation of terrestrial habitat

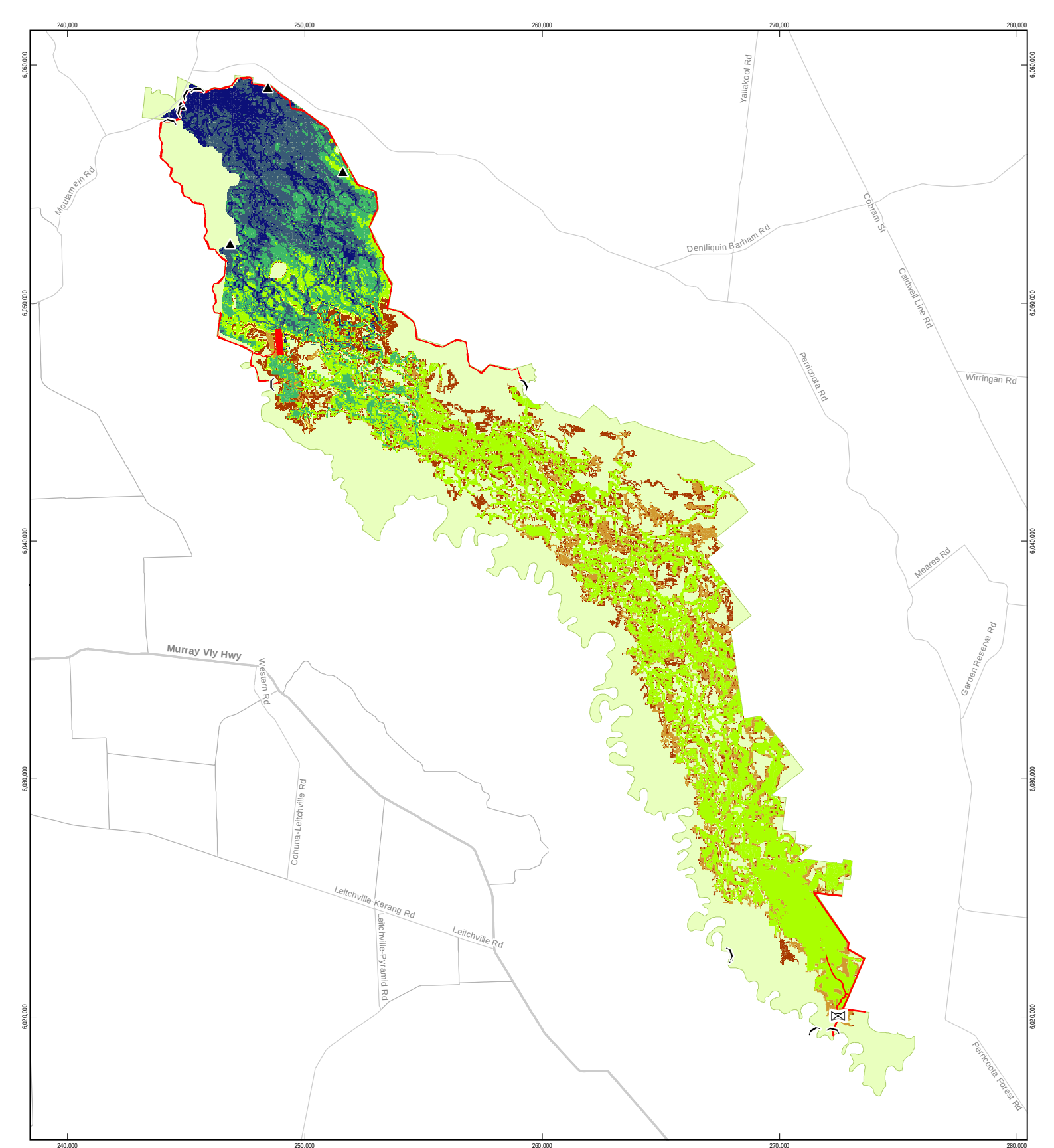
Inundation of the floodplain will reduce the area of accessible terrestrial habitat at the Forest and form a temporary network of “islands” on higher ground (refer Figure 15). The proposed flooding may drown or displace terrestrial fauna, increase the energy costs or risk of travelling and reduce the extent of available foraging resources. Impacts would depend upon the ecology of individual species.

Wetland specialists such as frogs, turtles and waterbirds would experience positive effects. Ecological Associates (2009) suggested that temporary islands created by the project these would provide good nesting habitat for freshwater tortoises; but that the concentration of predators in these areas (foxes and cats) would increase the risk of predation of eggs. There are three freshwater tortoise species likely to occur within the Koondrook-Perricoota Forest; Broad Shelled Tortoise (*Chelodina expansa*), Long-necked Tortoise (*Chelodina longicollis*) and Murray River Tortoise (*Emydura macquarii*), all of which lay eggs in sandy soils near water. Fox (and cat) predation is a significant threat to all three species. For example, monitoring of Murray River Tortoise nesting sites along the Murray River in South Australia showed that over 93% of eggs were taken by foxes (Thomson, 1983).

The concentration of predators on islands may represent an increased risk to all fauna that utilise the limited land available during the peak of the flood. This includes waterbirds that nest near the ground or in the soil, reptiles and small ground dwelling mammals as well as freshwater tortoises. However, the concentration effect on introduced predators will be limited, can be mitigated by a fox and cat control program prior to inundation and must be considered in the context of the benefits to fauna from the flood (see sections 9.10 and 9.11).

Arboreal and aerial foraging species, such as microbats, gliders and many bird species would experience minor inconvenience from flooding and benefit from a general boost in ecosystem productivity. Inundation would not affect foraging habitat for arboreal mammals but may increase energy costs and risks of movement between trees by forcing animals to swim. It may change foraging behaviour if a individuals restrict their foraging range to avoid flooded areas. These effects would be partially balanced by the increased health and productivity of River Red Gums by increasing energy ‘rewards’ of travelling and the productivity of accessible areas of habitat.

Terrestrial fauna would risk drowning, displacement and/or increase energy costs and risks of movement. The majority of the Forest contains trees, which would provide escape routes and alternative shelter and foraging substrate for many species.



Legend

- ▲ Turkey's nest dam
- River Road bridge
- Regulator
- Major roads
- Construction features
- Koondrook Perricoota Forest Site

TotalDays

- 0 - 29
- 30 - 58
- 59 - 87
- 88 - 116
- 117 - 145
- 146 - 174
- 175 - 203

1:150,000 (at A3)

0 1 2 4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

GHD

CLIENTS | PEOPLE | PERFORMANCE

NSW Office of Water

Koondrook-Perricoota Flood Enhancement Works

Job Number	21-18573
Revision	B
Date	01 FEB 2010

Figure 19 - Inundation duration within the maximum inundated area

G:\21\18573\GIS\Arcview\Map_Documents\21.18573.Z023_FloodingDuration.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Dept of Commerce, Drawn: Cwilson, cwilson

The proposed inundation of a portion of the Forest would limit some terrestrial species' access to preferred foraging habitat in the understorey and on the ground and so may change foraging behaviour of some individuals for the duration of the inundation period. Affected species are likely to include terrestrial mammals, reptiles and bird species that forage on the ground or in shrub layers. The likely increase in productivity of invertebrate and plant populations in response to flooding (Boulton and Brock, 1999) may compensate for the reduction in the area of dry land habitat. Regardless, there are extensive areas of alternative habitat that would not be inundated including approximately 15,000 ha of comparable woodland and forest within the Forest. Local populations of fauna have persisted in the context of natural flood regimes and are likely to be resilient to the risks of drowning and displacement. It is likely that an ecologically significant proportion of local populations would survive, utilise alternative habitat and reoccupy the inundation area after flood recession.

9.9 Diversion of Water

9.9.1 Reduced Murray River Flow

The project would divert water from the Murray River and change patterns of downstream flow into Barbers Creek and other effluents from the Forest. Potential sources of water used during the watering event will include water from TLM water account, Commonwealth acquired environmental water, water from Victoria Fauna and Flora, as well as unregulated flows in the Murray River system. Under the proposed operating scenario natural high flow events will be used to trigger a managed watering event, since under these circumstances there would be sufficient water in the TLM account to permit operation of the project. An Operations Committee would be established to provide advice to MDBA regarding event management and the day-to-day management of the structures. River Murray operations would make the operational decision required to implement the watering plan taking into consideration the other water requirements along the river system. It is intended that the operation of the works would be integrated with the needs of the River system as a whole, such that the downstream needs would not be adversely impacted on by the flooding within the Forest (DSTA, 2009).

A hydraulic model has been developed for the flood enhancement scheme to assist in identifying water use, predicting flood coverage and determining environmental benefit to be gained from the flooding (DHI, 2008). Based on DSTA, (2009) analysis of this model:

- The proposal requires initial inflows of 6000ML/day, which are then reduced to flows of 3400ML/day after 50 days;
- This results in the diversion of 466GL into the Forest; and
- An estimated 222GL will be returned directly to the Murray River, resulting in a total loss of approximately 244 GL of water from the Murray River to the floodplain.

The Murray River between Torrumbarry Weir and Swan Hill is the reach likely to be impacted by the diversions at Torrumbarry Weir, with the area between Torrumbarry Weir and the return flow channel the reach where water will mainly be lost from the Murray River. The reach between the return flow channel and Wakool River confluence will receive flows returning to the Murray River (via the return flow channel), while outflows from the Koondrook Forest down Barbers Creek and the Wakool River will flow back into the Murray River downstream of Swan Hill.

The water diverted into the Forest will largely be environmental water from the sources discussed above. The required volume of water would be 'called' and released from upstream storages specifically for the

purpose of achieving flows into the Forest. As such, water diverted at Torrumbarry weir will be flow that would not otherwise be in the system and, hence the diversions should have minimal or no impact on the Murray River flows downstream of Torrumbarry Weir (personal communication, D Green, MDBA, 2009).

9.9.2 Diverted Downstream Flow

Under the flood works scenario, flows from the Koondrook Perricoota Forest not spilling back to the Murray River will flow down Barbers Creek and into the Wakool River, returning to the Murray River downstream of Swan Hill. Under the proposed scenario, outflows will be limited to 250 ML/d during a managed event. Modelling of the proposed discharges suggests that the Barbers Creek and Wakool River system will benefit from the flood works, with increased outflows from the Koondrook Perricoota Forest flowing down the Barbers Creek and into the Wakool River. Barbers Creek has a natural in-bank capacity ranging from 1,270 ML to 2,300 ML, however is restricted by a number of block bank structures (NSW Water Solutions, 2008). The proposed discharges down Barbers Creek may result in erosion or washout of the block banks and/or localised flooding due to exceedance of the stream capacity of Barbers Creek (NSW Water Solutions, 2008). Works will be required to increase the hydraulic capacity currently limited by stop banks: by-washes will be constructed to allow 250 ML/d to flow around the banks without damaging them.

The regulators proposed on Barbers, Cow, Calf and Thule Creeks and will be sized to accommodate a discharge equivalent to the 1956 flood record, ranging between 5,100 ML/d (Barbers) to 17,100 ML/d (Cow Creek). This design allows natural flood waters to flow through the Forest. The project team has advised that natural flood waters would back up and inundate portions of the floodplain downstream of the proposed downstream levee. A levee system is already in place along the majority of the proposed levee alignment. The proposed works basically replicate the existing alignment therefore the changes to current drainage patterns is minimal (Erny, M., NSW DNR, *pers. comm.*).

9.9.3 Native fish movement onto the floodplain

Ecological Associates (2009) identified the movement of early life stage fish onto the floodplain (away from the river) as a high risk of reducing regional fish populations in the Murray River. They argued that a significant proportion of larvae and eggs would be diverted from the Murray River to the Forest during inundation. Once in the floodplain, these fish will be subject to a greater intensity of predation (from other fish, turtles, waterbirds) and that the survivors will then be subject to poor water quality in discharge waterways further reducing recruitment success.

While this may be a plausible outcome, there is little evidence from the literature to support this. Diverted water from the Murray River, as described above, represents only a fraction of the total flow and therefore only a fraction of the eggs and fish larvae of native fish that are passively carried within the river water. Whether native fish eggs and larvae that are carried into the floodplain will have a greater or lesser change of survival is considered in section 9.11.3 below. However, the proportion of eggs and larvae that remain in the Murray River channel will have the same opportunity for growth and successful recruitment as exists under current conditions. In addition, native fish in other tributaries, wetlands and waterbodies associated with the Murray-Darling Basin are unlikely to be impacted by this project. Further a comparable environmental watering event in the Barmah-Millewa Forest upstream of the Forest was correlated with increased spawning or recruitment of native fish in the Murray River (King *et. al.* 2006*).* Therefore, there is not considered to be a significant impact to native fish on a regional basis from this stressor.

9.9.4 Loss of flow pulse

Flow or flood pulses are thought to be important spawning cues for native fish such as Golden and Silver Perch (King *et al*. 2009). Ecological Associates (2009) considered that by diverting flow from the river to the forest, the operational phase of the project might reduce the magnitude of flow pulses downstream of Torrumbarry, which trigger spawning on many large-bodied native fish. This was considered to have the potential to impact negatively on regional native fish populations.

The operational scenario for the flood enhancement project involves the calling of water specifically for the project to be released from upstream water storages. Therefore, the project is not likely to alter current flow patterns in the river or change the frequency or magnitude of potential flood pulses in the Murray River. As a consequence, impacts to regional native fish populations via this mechanism are likely to be negligible.

9.10 Minor risks and impacts

There are a number of impacts that have been identified that are considered low or very low risk due to the design of the operation phase of the project (Ecological Associates, 2009). These are summarised briefly below.

9.10.1 Geomorphic processes

Scour of channels from high flow rates of inflow water and resulting turbidity in the water column and deposition on the flood plain has been identified as a very low risk (Ecological Associates, 2009; Water Quality in GHD, 2009c). Construction of structures and flow events will be managed to limit erosion of channels and the floodplain surface. In addition, any sediment suspended by the initial inflow of water is likely to be deposited on the floodplain as water moves slowly across the low relief topography, minimising any impacts to the Murray River via discharges (Water Quality in GHD, 2009c).

9.10.2 Groundwater

Increased salinity on the floodplain (and wetlands) or discharged to the Murray River is considered to be a very low risk (Ecological Associates, 2009; Groundwater in GHD, 2009c). There are a number of factors, which indicate that the risk of increasing salinity from groundwater interactions during and following inundation is negligible:

- Depth to groundwater –groundwater is too deep (6 to 12 m below the floodplain surface) to interact with surface flooding;
- Soil type – the clays and sandy clay soils that dominate the floodplain limit recharge potential.
- Groundwater flow – water flow within the Forest is from waterways (including the River Murray) to the groundwater, not vice versa; and
- The salinity of the areas of sandy soil (which have the greatest potential for interaction during a flood event, are very low.

As the risk of increased salinity is considered very low, it follows that the potential impact of salinity changes on the ecology of the system is also negligible.

9.10.3 Acid Sulphate Soils

Potential Acid Sulphate Soils (PASS) have been identified in the Koondrook-Perricoota Forest (Hall *et al*., 2007). It is possible that construction activities may disturb these sediments and the inundation of the floodplain may result in localised increased acidity and mobilisation of metals in the sediment (Soils in GHD, 2009c). In other wetland and floodplain systems this has resulted in deleterious impacts to aquatic fauna, especially fish and frogs (McCarthy *et al*., 2003).

The risk to the health of aquatic fauna within the Koondrook Forest is considered to be low, as the presence of acid sulphate soils within the construction zones has not been confirmed, and the footprint of construction is small in relation to the inundated area. Any acid and / or metals released into the water column are likely to be diluted in the large volumes of floodwater and any effects limited both spatially and temporally. Appropriate mitigation measures would be employed during the construction phase to further reduce the risk posed by PASS (refer (Soils in GHD, 2009c).

9.11 Potential beneficial impacts

The operation phase of the project will have a number of beneficial ecological impacts. These are described briefly below, together with conditions to optimise these.

9.11.1 Vegetation

There is significant evidence that the vast majority of vegetation communities within the Koondrook-Perricoota floodplain are in less than optimal condition as a result of reduced flood frequency and duration (GHD 2009a; FNSW, 2008a). The flood enhancement project has been designed to improve the ecological condition of the forest communities and as such there are numerous predicted benefits from the operational phase of the project.

The MFAT (MDBC, 2009) provides an indication of the optimal inundation durations and timing for the three dominant forest vegetation communities. A comparison of these with the predicted inundation regime for the operational scenario indicates that large areas of the project area will be provided with an almost optimal hydrological regime (Table 25) indicating that very large areas of forest will be provided with beneficial inundation durations.

Table 25 Areas of forest community predicted to be inundated for optimal and tolerance durations of inundation as predicted by the MFAT for the Koondrook-Perricoota zone of the Murray River.

Community	MFAT inundation preferences (MDBC, 2009)	Approximate area (ha) of community predicted to be inundated (DHI, 2008) to match preferences	Approximate percentage of area of community in the Forest (%)	Total area in the Forest
Black Box woodland (includes Black Box-Lignum woodland and River Red Gum – Black Box Woodland)	Optimal: 30 – 60 days	590	13	4463
	Tolerance: 60 – 180 days	1700	38	
River Red Gum Woodland	Optimal: 30 – 150 days	1800	34	5280
	Tolerance: 150 – 720 days	720	14	
River Red Gum Forest	Optimal: 30 – 250 days	10,000	51	19742
Floodplain Marshes*	Any inundation favourable.	1217	75	1622

* The 'optimal' and 'tolerance' range for Floodplain Marshes varies with plant species composition however any inundation is likely to be beneficial.

The MFAT (MDBC, 2009) also predicts the optimal timing of inundation for each of these communities as follows (noting that a flood at any time of the year is still likely to be beneficial):

- Black Box woodland – October to January;
- River Red Gum woodland – August to November; and
- River Red Gum forest – August to September.

Expected responses to inundation by forest vegetation communities include (Jenson, 2009; MDBC, 2009; Alderidge, 2006; Nicol, 2009; Roberts and Marston, 2000):

- Trees and Shrubs (Lignum, Black Box, River Red Gum):
  - Increase in leaf area and canopy condition (possibly flush of epicormic growth);
  - Increased root growth;
  - Flowering and seed production; and
  - Germination of seedlings of tree species (on wet soil following flood recession).
- Germination of wetland plants from the seed bank (during inundation);
- Replenishment of seed bank with wetland plant species (on recession of flood); and
- Increase in diversity and productivity of inundation tolerant and dependant plant species.

9.11.2 Waterbirds

The expected beneficial impacts to waterbirds are in terms of both breeding and foraging habitat. Waterbird nesting requirements for species previously recorded breeding within the Forest (Table 24) indicate that the vast majority of birds require inundated woody vegetation to a minimum depth of 30 cm for 3 to 4 months. The operational scenario indicates that over 9000 hectares of woody vegetation will be inundated to a depth of greater than 30 cm and some 4000 hectares will remain inundated for over four months. A spring / summer flood event not only would provide optimum timing for waterbird breeding within this inundated area, but due to increased temperatures and therefore productivity require les of a lag time for waterbird breeding events to commence (MDBC, 2009).

Foraging habitats for waterbirds are based on food preferences, bill shape and morphology and size of the waterbird (Kingsford and Norman, 2002). Wading species of birds generally require inundated foraging areas with a water depth of < 30 cm (Jaensch, 2002). At the peak of the flood event approximately 7000 hectares of the Forest will be inundated to a depth of < 30cm. This will include large areas under canopy as well as smaller, open areas, providing for feeding and foraging of a number of waterbird species (including international migratory wading species).

Deeper areas on the floodplain and in the channels provide foraging habitat for dabbling ducks and diving species of birds such as cormorants, gulls and terns. At peak inundation, over 5000 hectares will be inundated to a depth of > 1m, providing foraging habitat for a number of water bird species. Feeding and foraging will be enhanced by the pulse of productivity expected upon inundation.

9.11.3 Native Fish

Understanding of native fish use of flooded wetland habitats is in its infancy in Australia. However, evidence from some empirical studies and monitoring of environmental watering at Barmah-Milawa, Hattah Lakes and Chowilla Floodplain have indicated that a number of species benefit from floodplain inundation; either directly by using the inundated habitat on the floodplain or indirectly by increased productivity in the river channel following the release of carbon from the floodplain surface.

A number of native fish are known to use inundated floodplain habitats and it is likely that the increased productivity in the floodplain following inundation is beneficial to some native fish species. The role of the floodplain in providing spawning habitat is less certain and the results of research in comparable floodplain systems in Victoria has indicated that there is little difference in spawning and recruitment in native fish in years of flood as opposed to years when water remains within the river channels (King *et al*., 2003; King *et al*., 2009).

However, results from Barmah Forest indicate that the floodplain, channels and wetland habitats within the forest system are important for native fish and a diversity of habitats is the key to maintaining native fish diversity. The operational phase of the flood enhancement project will result in inundation of a number of habitats within the system, including channels and waterways, open waterbodies, floodplain wetlands and marshes and inundated forest areas as well as a significant amount of woody debris in localised areas. This will provide a diversity of habitat for both spawning and foraging of native fish.

9.11.4 Aquatic Ecosystems

Evidence from other environmental watering events at icon Forests on the Murray River such as Hattah, Chowilla and Barmah have indicated that reinstating a wetting and drying cycle can result in benefits for aquatic biota such as frogs and freshwater tortoises. Increased abundance and diversity of frogs,

tortoises, yabbies and crustaceans was recorded at Chowilla three months after inundation (Aldridge *et al*., 2006) and increased abundances of tortoises and frogs were observed in Hattah Lakes following environmental watering (Mallee CMA, 2009). Gigney *et. al*. (2006) noted that 2005/06 environmental flooding of the Barmah-Millewa Forest led to a significant exchange of material between the floodplain and main channel that appeared to stimulate microbial production and that this may, in turn, have stimulated microinvertebrate productivity.

Three species of freshwater tortoise likely to inhabit Koondrook-Perricoota, of these one (Long-necked Tortoise) is a habitat generalist and is capable of using a variety of wetland habitats as well as overland migration (Chessman, 1984). The remaining two (Broad Shell Tortoise and Murray River Tortoise) prefer deep, calm permanent waterways (Chessman, 1988). The main advantage to these species may be the increase in productivity upon inundation, which would allow for a build up of reserves prior to breeding. It is possible also that the inundation of floodplain depressions will provide suitable foraging and nesting habitat for these species.

A similar case could also be made for frogs within the system. Although there is limited data on the frog species that may be present in the system (or could potentially utilise the area during inundation) the operational phase is likely to result in suitable habitat. The majority of native, wetland frogs in south-eastern Australia prefer inundated vegetated habitat for breeding and foraging. Flooding of the Forest will result in approximately 1000 hectares of inundated shallow marsh, which should provide suitable habitat for frog breeding.

The flood enhancement project will result in increased productivity and watering of a large area (up to 17,800 ha) of the Koondrook-Perricoota floodplain. This will not only provide increased resources and habitat for aquatic and wetland dependant flora and fauna, but should result in flow on effects to terrestrial species. This has been demonstrated in other comparable areas, such as the increase in the diversity and abundance of bush birds in Barmah Forest following environmental watering (Barmah Millewa Forum, 2001). The increase in productivity with an increase in flower, fruit, seed and insect resources on the floodplain has the potential to benefit a wide range of species through the food web.

9.12 Gaps Within Modelled Data

This operational impact assessment does not include the north-western portion of the Forest because the downstream levee was re-aligned through this section after the hydrological model had been run. The model run also does not cover the upstream forest for the dewatering phase of the indicative operational scenario. The following qualitative assessment of likely impacts in the areas not covered by the hydrological modelling is provided (Clark, B. NSW Public Works, pers. comm.):

- During a managed event with pool levels of RL 78.5 m AHD, inundation will be complete over the western levee alignment area. Depths will vary from 1.3m at the upstream end to 2.4m at the downstream end. The general pattern of filling will occur through a backwater effect pooling water at the downstream end that slowly migrates upstream. It would be expected that the western levee alignment area will be inundated for most of the duration of a flooding event, especially at the downstream end; and
- The upstream forest is outside of the effects of the downstream pool and its de-watering phase is expected to be much faster. Depths at the end of the watering phase (i.e. day 110) in the Inland Grey Box Woodlands is likely to be around 0.2m. The inundation will shrink quickly and be confined to drainage lines and floodplain marshes as water is shed from higher ground.

10. Key Threatening Processes

10.1 Identification of KTPs

A 'key threatening process' is defined under the TSC Act as '*a threatening process specified in Schedule 3*' of the Act. A 'threatening process' is defined as *'a process that threatens, or may have the capability to threaten the survival or evolutionary development of species, populations or ecological communities*'. A number of TSC Act listed KTPS are also listed as a key threatening process under the NSW FM Act and/or the Federal EPBC Act.

The proposed activity will directly contribute to the operation of seven key threatening processes (KTPs):

- Clearing of native vegetation;
- Loss of hollow-bearing trees;
- Removal of dead wood and trees;
- The degradation of native riparian vegetation along New South Wales water courses;
- The introduction of fish to fresh waters within a river catchment outside their natural range
- In stream structures and other mechanisms that alter natural flow; and
- Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands.

A number of KTPs are currently operating within the Forest, given the modified landscapes and vegetation communities present in portions of the Forest and direct observation of feral species. The project may indirectly contribute to the following:

- Predation, competition and/or grazing by feral fauna including the KTPs:
  - Predation and competition by the European Red Fox;
  - Competition and grazing by the feral European Rabbit;
  - Predation by feral cats;
  - Predation by the European Red Fox;
  - Predation, habitat degradation, competition and disease transmission by Feral Pigs (*Sus scrofa*);
  - Herbivory and environmental degradation caused by feral deer; and
- Invasion of native plant communities by exotic perennial grasses.

Two additional, broad scale KTPs may be indirectly affected by the operation of the project:

- Ecological consequences of high frequency fires; and
- Human-caused climate change.

10.2 Assessment of Direct Contribution to KTPs

Clearing of native vegetation

Clearing, as defined in the KTP final determination, is the destruction of a sufficient proportion of one or more strata (layers) within a stand or stands of native vegetation so as to result in the loss, or long term modification, of the structure, composition and ecological function of a stand or stands. Long term modification of native vegetation is defined as the alteration of the composition, structure or ecological

function of an ecological community such that recovery by natural means will take periods of time from decades to centuries (depending on the plant community concerned) or will require substantial management intervention. Selective removal or alteration of one or more strata - for example removal and replacement of the understorey or removal of the canopy which can result in alteration of composition, structure and ecological function of the plant community may constitute long term modification (DEC, 2005).

The project would contribute to the operation of this KTP through the:

- Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints; and
- The long-term modification of approximately 116 ha of native vegetation within project construction footprints that would be allowed to regenerate at least partially.

These effects would contribute to the operation of the KTP; however negative impacts would be offset by the environmental watering of 17,000 ha of equivalent habitats within the inundation area.

The project would also partially remove or modify native vegetation within a construction corridor with a maximum area of 206 ha. Construction activities in these areas would utilise existing tracks and clearings as far as is practicable and would not affect a sufficient proportion of any vegetation strata to result in permanent loss or long-term modification of a stand. Therefore activities in the broader construction corridor would not contribute to the operation of the KTP.

Loss of Hollow-bearing trees

An estimated 15% of all terrestrial vertebrate fauna in Australia are dependent upon tree hollows and for many of these species the relationship is obligate i.e. no other habitat resource represents an adequate substitute (Gibbons and Lindenmayer, 2002). Hollow bearing trees (HBTs) have been systematically lost from the Australian environment over the past 200 years via clearing for agriculture, logging, changes in fire regimes, and timber salvage (Burgman and Lindenmayer, 1998).

HBTs are important as roosts for threatened species known from the Forest. Diurnal roost sites and maternity colony sites are a limiting resource for threatened microbats in many habitats (Law and Anderson 2000); are a critical resource for the Barking Owl (NPWS, 2003); and sufficient numbers of suitable HBTs close to suitable foraging habitat are a critical resource for the Squirrel Glider (DECCW, 2009b). HBTs are relatively plentiful at the Forest, particularly in River Red Gum Forests, and are likely to support local populations of these threatened species and other hollow-dependant fauna.

A detailed assessment of the impacts of the proposed activity on hollow-bearing trees is provided in Section 6.2.2. The project would remove a portion of the hollow bearing tree resource. This may increase the operation of this KTP and result in negative impacts on hollow-dependant fauna.

A quantitative survey of habitat trees was conducted at the Forest which included counts of hollow bearing trees, very large trees and stags. For the purposes of this assessment ‘habitat trees’ are considered synonymous with ‘HBTs’ since large trees and stags without hollows would still contain cracks, fissures and exfoliating bark with equivalent habitat value. Based on the survey of habitat trees at the Forest, the project is likely to result in the following impacts:

- Removal of 532 habitat trees that fall within the footprints for fixed project infrastructure that were surveyed in detail; and

- Removal of additional habitat trees that fall within the footprints for project infrastructure that have not been located and/or were too large to survey in detail. Removal would occur within a further 100 ha of construction footprints containing approximately 4.1 habitat trees per hectare.

The results of the habitat tree survey have been provided to the project team as a GIS shape file, which would be used to identify and avoid habitat trees within the broader construction corridor as far as is practicable.

Impacts associated with the removal of habitat trees would be partially offset by the environmental watering of 17, 000 ha of the Forest. The proposed inundation may help to secure the supply of HBTs at the Forest in the longer term by improving the health of River Red Gums and Black Box. The potential for positive impacts is increased by the known concentration of habitat trees along drainage lines and depressions due to high productivity and exclusion of timber harvesting from these areas in recent decades (GHD, 2009a), which are also the areas most likely to experience benefits from environmental watering. Further, large mature and over-mature River Red Gums (which are most likely to be hollow-bearing) have proven most susceptible to the effects of drought in recent years (Jurskis, 2007).

Therefore the removal of the HBT resource from an estimated 206 ha of native vegetation within construction footprints may be offset by potential benefits to the security of the HBT resource within 17,000 ha of the Forest through environmental watering. On this basis, the project would not comprise a significant contribution to the operation of this KTP.

Removal of dead wood and trees

Dead wood and dead trees provide important habitat for many native fauna and are a key resource feature in many ecosystems. Transfer of woody debris from floodplain to aquatic environments is an important source of carbon, nutrients and habitat for aquatic ecosystems. Coarse woody debris is a particularly important shelter and foraging resource for native fish, including the threatened Murray Cod (GHD, 2009a). The removal of dead wood can result in the loss of habitat, disruption of ecosystem processes and soil erosion (DEC, 2005).

The dead wood resource at the Forest is heavily influenced by timber harvesting and associated salvage activities governed by FNSW. Licence conditions that govern the operation of fire wood collection and salvage operations prohibit the removal of standing dead trees and aim to maintain ‘natural’ levels of woody debris through reference to photo standards (GHD, 2009b). Field observations as part of the present assessment noted that the majority of standing dead trees within harvest areas were retained and that there were large volumes of woody debris on the forest floor. GHD (2009b) quantitative assessments of woody debris in the Forest recorded volumes that were equivalent to DECCW benchmark levels for the relevant vegetation communities and in many cases considerably greater. Woody debris is not a depleted or limiting resource in the Forest.

The proposed construction would remove a number of standing dead trees. This impact is assessed with HBTs above. The proposed construction would also remove or modify fallen woody debris within infrastructure footprints. The EMP for the construction would include measures to mitigate impacts on debris-dependant fauna and conservation of the woody debris resource. This would include salvage of woody debris within construction footprints and replacement within areas of alternative habitat. Additional resources would be ‘created’ through the clearing of HBTs and stags that would also be replaced in adjacent areas of retained and regenerating vegetation. A portion of the woody debris generated by clearing would be placed in waterways to create ‘snag’ habitat in line with advice from DPI Fisheries.

Temporary access tracks and construction laydown areas would be constructed so as to avoid standing dead trees as far as is practicable. Where dead trees or large deposits of dead wood intersect with proposed access tracks they would be moved, however they replaced in adjacent areas of native vegetation and so their habitat value would be largely maintained.

Based on the above, the proposed construction and associated management and mitigation measures would not significantly increase the operation of this KTP.

Alteration to the natural flow regimes of rivers, streams, floodplains and wetlands

Alteration to natural flow regimes refers to reducing or increasing flows, altering seasonality of flows, changing the frequency, duration, magnitude, timing, predictability and variability of flow events, altering surface and subsurface water levels and changing the rate of rise or fall of water levels. Three human processes have predominantly altered flows in streams, rivers and their floodplains, and wetlands in NSW. These are: building of dams, diversion of flows by structures or extraction, and alteration of flows on floodplains with levees and structures.

The project will directly contribute to all three processes by:

- Building regulators across natural drainage lines;
- Diversion of flows through construction of the intake regulator and Torrumbarry cutting and extraction from the Murray River; and
- Alteration of flows across the floodplain through the downstream levee, floodway and the system of regulators.

Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands is recognised as a major factor contributing to loss of biological diversity and ecological function in aquatic ecosystems, including floodplains. These alterations have caused a large number of species, populations or ecological communities that rely on river flows for their survival to become threatened.

Three major factors mitigate the potential for negative impacts arising from alterations to hydrology due to the project:

- The hydrology of the Forest, the Murray River and associated catchments have been extensively modified by river regulation and the current situation is not characteristic of ‘natural flow regimes’;
- The hydraulics of the Forest (i.e. the geomorphology and upstream built structures that dictate hydrology) does not permit ‘natural flow regimes’ onto the floodplain under current and modelled future Murray River flow regimes; and
- The project infrastructure is designed to facilitate delivery of water in order to achieve a more natural flow regime and the proposed operation of the project would aim to simulate natural conditions as far as is practicable.

Potential impacts associated with alterations to hydrology arising from the proposed activity are assessed in detail in Section 9. The outcome of this assessment is that the project is not likely to have any significant negative impacts on aquatic and wetland habitats within the Forest or downstream. The operation of the project is likely to have a number of net positive impacts on aquatic and wetland habitats within the Forest. Therefore the proposed activity is unlikely to increase the operation of this KTP in a way that would threaten the survival of any native biota.

Instream structures and other mechanisms that alter natural flow

The project involves the construction of instream structures that modify natural flow including the proposed regulators, channels and downstream levee. Mechanisms that alter natural flow regimes include the operation of the above structures will include reducing or increasing flows; altering the seasonality of flows; changing the frequency, duration, magnitude, timing, predictability and variability of flow events; and changing the rate of rise or fall of water levels. The installation and operation of instream structures that alter natural flows may result in negative impacts on many threatened species, populations and ecological communities.

Provision for fish passage has been incorporated into the engineering design and Operating Plan for the project. Based on advice from fish passage specialists the structures have been specifically designed to ensure that native can enter and leave the floodplain (DSTA, 2009; FPTF, 2009). Other key factors for fish passage include the timing of flood events and management of flows. Purposeful management of the project would include mimicking the timing of natural flow regimes, variability and pulsing and providing sufficient time during the flooding recession phase to allow fish to move from the floodplain to the river (FPTF, 2009). Ecological Associates (2009) determined that the proposed inundation is likely to provide a highly productive small fish habitat on the floodplain and return small fish to the Murray River in significant numbers via the Return Channel and Barbers Creek. However, there is a residual risk that the project would trap some large-bodied native fish, including threatened species (refer Section 9.7).

The Swan Lagoon regulators and downstream stop log structures have been designed to allow for fish passage during a natural flood. All structures would be fully open in a natural flood to allow the flood to operate with minimal change from the current situation (FPTF, 2009). The proposed structures are designed to provide appropriate velocities of water flow for upstream fish passage and specific measures are being designed to provide a low velocity/turbulence corridor at the abutments at each downstream stop log regulator structure to facilitate upstream fish passage (FPTF, 2009).

Block banks on Barbers currently limit fish movement due to small pipes. By washes will be constructed to allow flood waters to pass without eroding the block banks, which will improve fish passage downstream to Wakool river system for fish exiting the forest.

Notwithstanding potential impacts on fish passage during managed floods, the overall intent of the project is to facilitate delivery of water in order to achieve a more natural flow regime. The proposed operation of the project would aim to simulate natural conditions as far as is practicable. The operation of the project is likely to have a number of net positive impacts on aquatic and wetland habitats within the Forest. Therefore the proposed activity is unlikely to increase the operation of this KTP in a way that would threaten the survival of any native biota.

The degradation of native riparian vegetation along New South Wales water courses

The proposed construction would involve impacts on native riparian and floodplain vegetation including:

- Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints; and
- The long-term modification of approximately 116 ha of native vegetation within project construction footprints that would be allowed to regenerate to their pre-disturbance state.

Additional construction activities in these areas would utilise existing tracks and clearings as far as is practicable.

The Forest contains approximately 32,000 ha of native riparian and floodplain vegetation that would not be removed or modified.

The proposed operation of the scheme would involve the inundation of up to 17,000 ha of the Forest via the diversion of water from the Murray River to the Forest. Adaptive management of the project would aim to avoid negative ecological impacts as far as is practicable. The Forest is dominated by flood-dependant biota and so the proposed inundation is expected to have net positive impacts. Negative impacts of vegetation and habitat removal would be offset by positive impacts from the environmental watering of 17,000 ha of equivalent habitats within the inundation area.

Therefore the project, when considered in its entirety, would not contribute to the operation of this KTP.

The introduction of fish to fresh waters within a river catchment outside their natural range

The operational phase of the project has the potential to result in increased recruitment of Carp and other pest species into the Forest. Exotic species, especially Carp, are a large component of fish populations in the Murray River. Carp are consistently more abundant in off stream habitats compared with the Murray River (Jones, 2006).The Barmah-Millewa forest upstream of the Forest, has previously been noted for the abundance of Carp, which utilise the inundated floodplains for spawning and recruitment (Stuart and Jones, 2006). Carp have been implicated in the decline of native fish populations and the degradation of river systems. Floodplains and especially frequently inundated marshes support large breeding populations of the Carp and may have a negative effect on the Murray River fish population through recruitment (Macdonald and Crook, 2006; Jones and Stuart, 2007). Increases in Carp in the Forest and increases of Carp and other exotic fish in the river were assessed as very high risks by Ecological Associates (2009). This negative impact must be considered in the context of net gains for native fish and other biota (see section 9.11). Further, Carp and other fish species outside of their natural range, are already well established and abundant in the Murray River and associated catchments. The project will not introduce any exotic fish species to 'virgin' catchments, beyond ephemeral aquatic habitats in the Forest which almost certainly would have supported these species during previous wet phases.

Therefore the project is likely to comprise a minor contribution to the operation of this KTP.

10.3 Assessment of Indirect Contribution to KTPs Operating within the Forest

Predation, competition and/or grazing by feral fauna

The assessment pertains to the following KTPs:

- Predation and competition by the European Red Fox;
- Competition and grazing by the feral European Rabbit;
- Predation by feral cats;
- Predation by the European Red Fox;
- Predation, habitat degradation, competition and disease transmission by Feral Pigs (*Sus scrofa*); and
- Herbivory and environmental degradation caused by feral deer.

European Rabbits were recorded across the Forest. Burrowing by the European Rabbit can result in erosion issues, reduce recruitment and survival of native plants, and attract introduced predators such as foxes. Rabbits may also threaten native animal species by altering habitat, reducing native food sources and displacing small animals from burrows (DEC, 2005e). Grazing by Rabbits reduces the survival and recruitment of species of threatened plants, which are known from the study area, and may have

negative effects on the structure and composition of the regenerating vegetation in the study area (DEC, 2005e).

Evidence of Red Foxes and Feral Cats was found across the Forest. These species have been implicated in the decrease a number of native animals through both predation and competition.

Grazing and trampling by large exotic herbivores such as deer, pigs and goats has the potential to adversely impact threatened plants and alter the composition and structure of vegetation, including endangered ecological communities and habitats for threatened fauna and flora.

Developments may affect the impact of feral fauna on natural environments through increased edge effects. Fragmentation of vegetation stands may exacerbate the impacts of these introduced predators on native fauna. Gaps in habitat facilitate the movement of large, exotic species into native vegetation and may increase the risk of predation for native fauna. The proposed construction would contribute to edge effects through direct disturbance and removal of habitat within disturbance footprints. This would affect limited areas and for limited periods. The proposed infrastructure would create temporary gaps in arboreal habitat of under 100 metres width and permanent gaps of under 50 metres width. In the context of the existing network of access tracks and harvest areas within the Forest and extensively cleared rural lands adjacent to the Forest, the gaps created by the proposed construction would have a minor effect.

Terrestrial vermin or feral species are not expected to increase and/or spread as a result of the project. The proposed activity will not significantly fragment or isolated any habitat nor result in any other changes that are likely to favour feral animals.

Feral animal control will form part of the Ecological Management Plan for the Forest and will be consistent with management plans already in place in the Forest and on adjoining lands.

The proposed activity is unlikely to increase the numbers of these pest species nor increase the susceptibility of native ecosystems to their effects. Therefore the proposed activity would not increase the operation of this KTP.

Invasion of native plant communities by exotic perennial grasses (TSC Act)

Invasive perennial grasses have adaptive characteristics that give them a competitive advantage over many native species. These include: tolerance of drought, heavy grazing and many herbicides; ability to produce a large, long-living seed bank; high survival of seedlings; and effective animal-borne and water-borne dispersal mechanisms for seeds. Perennial grasses produce large amounts of plant matter, which dries quickly and causes fuel loads to increase. This fuel results in fire regimes that favour the spread of these perennial grasses. Hotter and more frequent fires may lead to changes in the structure of the vegetation and in some cases to local extinctions of some plant and animal species.

The proposed activity may increase the operation of this KTP in the study area by disturbing the soil and understorey vegetation and potentially by transmitting grass seeds on vehicles or equipment.

Native vegetation within the study area featured moderate weed infestation in the central portions of vegetation patches, with moderate to severe infestations around the margins of the forest and near to drainage lines. Herbaceous environmental weeds and annual grasses are more prevalent in intact native vegetation in the Forest than the perennial grasses covered by this determination. Disturbed cleared areas in the Forest were severely infested with exotic perennial grasses and other environmental weeds.

The proposed activity would involve the clearing of native vegetation and replacement with areas of roads, stockpiles, and project infrastructure. Therefore it is likely that the area of environmental weed

infestation would increase within the project disturbance footprint. The majority of the disturbance footprint is associated with the downstream levee which is adjacent to disturbed cleared land. The remainder of the Forest is partially disturbed by FNSW access tracks and ongoing timber harvesting and grazing activities. In this context construction activities would have a relatively minor impact on the overall numbers and extent of weed species in the locality.

The proposed flooding would transmit weed propagules into the Forest and increase soil moisture and nutrient status. These changes are likely to increase the degree of weed infestation in the Forest. This effect would be balanced by positive effects to the health of native vegetation. Inundation is likely to have net positive impacts for these moisture-loving species of floodplain plants.

Factors mitigating the effect of this KTP include the moderate to good cover of native perennial grasses in the Forest and the ongoing management of weeds and tactical grazing systems as part of broader management activities undertaken by FNSW in the Forest (GHD, 2009b). Given these mitigating factors and the existing degree of weed infestation in the Forest, the proposed activity is likely to result in a relatively minor increase in the operation of this KTP.

10.3.1 Assessment of Indirect Contribution to Broad-scale KTPs

Ecological consequences of high frequency fires (TSC Act)

Australian native plants and animals have a range of mechanisms to survive individual fires. The long-term survival of plants and animals over repeated fires is dependent upon two key features:

- The ability of species to maintain life cycle processes; and
- The maintenance of vegetation structure over time as habitat for animal species.

Where fires occur very close together in time (high frequency fire) both these key features can be disrupted. If high frequency fire is sustained it will consequently lead to a loss of sensitive plant species, changes to vegetation structure and a potentially a corresponding reduction in biodiversity. High frequency fire and inappropriate fire regimes have been identified as threats to a number of threatened species and communities.

The proposed activity would not involve any purposeful increases in the frequency, intensity or extent of fires. There may be minor increases in the risk of fires associated with increased vehicle traffic and human activity in the forests during the construction phase. The proposed inundation of the Forest would cause a dramatic reduction in the risk of wildfire for the duration of managed floods but may increase the risk in the medium term due to increased fuel loads arising from increased growth of floodplain vegetation.

These risks of increased fire frequency are minor and would be mitigated by the purposeful detection and control of wildfires as part of FNSW's general management of the study area.

Human-caused climate change

There is evidence that modification of the environment by humans may result in future climate change. Human induced activities as a result of energy use, industrial processes, solvent and other product use, agriculture, land use change and forestry, and waste cause greenhouse gas emissions. Human-caused climate change may occur at a faster rate than has previously occurred naturally and may involve both changes in average temperature conditions and changes to the frequency of occurrence of extreme

events (DEC, 2005). Under most modelled scenarios human induced climate change will significantly increase the impacts of drought and changed hydrology in the Murray-darling Basin (CSIRO, 2009b).

The distribution of many species, populations and communities is determined by climate and many species would be adversely affected unless populations were able to move across the landscape. Species at risk include those with long generations, poor mobility, narrow ranges, specific host relationships, isolated and specialised species and those with large home ranges (Hughes & Westoby 1994).

A project would have the potential to contribute to negative impacts of human-caused climate change if the proposed activity:

- Contributes to the causes of human-caused climate change including through land clearing or the production of greenhouse gases;
- Reduces the size or connectivity of important habitat, thereby reducing the ability of populations to cope with the effects of climate change through migration or dispersal;
- Results in direct impacts on populations which are significantly threatened by climate change;
- Results in direct impacts on environments which are significantly threatened by climate change (eg alpine or wetland habitats); and/or
- Contributes to the operation of negative effects of human-caused climate change, such as drought or adverse changes to hydrology.

The proposed activity is unlikely to contribute to the operation of this KTP, or increase the effect of resultant impacts on native populations or environments, because:

- The project would remove or modify a very small amount of vegetation (approximately 110 ha) relative to the amount that would experience increased productivity through environmental watering (approximately 17,000 ha). Nor would the proposed activity result in the significant production of greenhouse gases (refer Greenhouse in GHD 2009c);
- The proposed activity would have a minor effect on patch sizes and connectivity of habitat (refer Section 8.2.4; and
- The proposed activity would not result in significant cumulative impacts by increasing the operation of negative effects of human-caused climate change, including drought or adverse changes to hydrology. The project is likely to reinstate a more natural flood regime and result in net positive impacts on ecosystems which have been adversely affected by changes to hydrology (refer Section 9).

11. Mitigation

11.1 Overview

The mitigation of adverse effects arising from the project has been presented according to the hierarchy of avoidance; mitigation and offsetting of impacts, consistent with the approach outlined in the DEC/DPI (2005) guidelines.

Potential impacts of the project on native biota and their habitats will be greatest in the surface disturbance area. These impacts would be greatest during the construction phase due to direct habitat loss and modification. There is also the potential for impacts on habitat outside the disturbance area during the longer-term operational phase of the proposed works. Specific mitigation measures have been incorporated into the proposal design to minimise such impacts on the natural environment surrounding the project area, and in particular to reduce potential impacts on downstream aquatic environments and on threatened species and their habitats. The potential adverse impacts of the project on flora and fauna and their habitats on Forest and on surrounding lands will be further reduced through use of construction & environmental and operational management plans.

The project would result in some unavoidable residual adverse impacts imposed upon some elements of the natural environment, including the clearing of Inland Grey Box Woodland and removal of habitat for threatened fauna. Where residual impacts occur they need to be offset to satisfy the requirements of the DEC/DPI (2005) guidelines for assessments under Part 3A of the EP & A Act.

An offset package would be required to address these residual adverse impacts to achieve an overall 'maintain or improve' outcome for biodiversity conservation. This offsets package would be developed in consultation with DECCW and the DoP and would be included in the Statement of Commitments to accompany the project. The following sections detail the mitigation measures and offset package recommended for the project.

11.2 Avoidance of Impacts

11.2.1 Project Location & Scope

Where possible, the location of infrastructure has been selected to minimise environmental impacts, particularly through siting a substantial component of the downstream on the alignment of an existing levee. However, the majority of project infrastructure locations are constrained by Forest topography and hydrology and there is no feasible alternative. Notably it was not possible to avoid clearing of Inland Grey Box Woodland along the alignment of the proposed inlet channel as this structure needed to be sited at a topgographic low between the Torrumbarry weir pool and Barbers Creek. Construction areas that are not subject to engineering constraints, such as access roads and laydown areas, will be placed outside of the Inland Grey Box Woodland and outside intact native vegetation as far as is practicable.

As discussed in Section 10 the proposed inundation would be operated in accordance with a Operating Plan. One of the key functions of this plan is to ensure that watering events are managed to minimise the potential for adverse environmental impacts associated with factors such as:

- Potential blackwater events, by initiating floods in Winter-Spring; and

- Water bird breeding, by noting commencement of breeding as a potential cue for managed floods and by prolonging floods to facilitate completion of the breeding cycle.

11.2.2 Infrastructure Locations and Layout

The locations and detailed design of project infrastructure is being finalised by the detailed design consultant and the final construction details will be finalised by the construction contractor. Therefore, this environmental assessment is based on indicative infrastructure footprints that have been located within a construction corridor. While the contractor may refine the infrastructure, it is constrained to within metres of the indicative locations and would not extend beyond the construction corridor.

Although the locations of access roads, construction lay-down areas and turkey nest dams for the construction of the downstream levee alignment are yet to be confirmed, these features would be located in the construction corridor presented in Table 19. The construction corridor represents an estimated maximum area of surface disturbance and the contractor would implement measures to minimise the disturbance footprint by confining activities to existing cleared or disturbed areas where practicable.

It is assumed that construction Forests would be accessed from either within the construction corridors, for example the floodway could be accessed via downstream levee alignment, or from short tracks extending from the existing forest road network (for example the upstream spoil disposal site). As the extent and location of access tracks will be defined by the contractor, associated impacts have not been assessed. As with works within the construction corridors, access tracks would be sited within existing cleared and disturbed areas where practicable.

As the temporary construction footprint will be influenced construction method, the contractor will be required to ensure that due diligence is exercised during planning and execution to identify and implement reasonable and feasible opportunities to avoid or otherwise minimise adverse impacts.

11.3 Mitigation of Impacts

11.3.1 Construction Planning and Environmental Management

A Construction Environmental Management Plan (CEMP) would be developed for the project and include as a minimum the mitigation measures outlined below.

Tree Fauna Management

Mitigation measures for tree dwelling fauna are required as the proposed works involve the removal of mature trees, including hollow-bearing habitat trees. Further, roosting arboreal mammals and nesting birds were observed in the surface disturbance footprint during field surveys and would potentially occupy the Forest during construction. Due care during clearing is recommended to reduce direct impacts to any tree dwelling fauna species which may be utilising the area.

An appropriate sub plan within the CEMP would detail procedures for fauna management including the following points:

- Presence of a suitable qualified ecologist or Wires-accreditated fauna management officer (or equivalent) during the construction period;
- A pre-clearance survey of construction footprints focussed on locating individuals, and especially roosts of threatened species, and potentially including:

- Diurnal searches for birds, nests and roosts;
- Active searches for reptiles, including checking of woody debris within the construction footprint,
- Active searches for frogs, focussing on aquatic and wetland habitats;
- Active searches for micro bats, including checking under exfoliating bark; and
- Nocturnal surveys, including stag-watching of identified habitat trees, specifically focusing on observing use of hollows by micro bats.

- Monitoring of habitat trees fauna resident fauna during clearing operations and avoidance of impacts as far as practicable by postponing clearing through these areas;
- An appropriate methodology for felling habitat trees should be adopted using 'sensitive construction techniques'; and
- Hollow-bearing habitat trees should be replaced in a 'natural' context (i.e. not piled) in nearby revegetation areas.

The CEMP should include protocols for managing resident fauna within construction footprints. Project timing and construction constraints mean that it is not practical to postpone construction to avoid fauna. DECCW should be consulted to determine the most appropriate pre-clearing surveys, construction techniques and relocation methods.

Surface water management

The CEMP should include surface water management measures, including as a minimum the following principles:

- Ensure the fullest separation possible of 'clean' and 'dirty' water runoff;
- Minimise the area of disturbance, thus minimising the volume of 'dirty' water runoff;
- Runoff from disturbed areas to be intercepted with appropriate sediment control devices and allowed to settle, to avoid to discharge in to the natural system;
- Ensure water management systems do not adversely affect water quantity or quality in downstream water courses.

Construction would occur during dry months and so would avoid direct impacts on wetland and aquatic habitat in intermittent wetlands across the Forest. The Murray River would contain water and aquatic habitat during the construction period. Additional surface water management measures would be required for the proposed inlet and outlet channels as these will directly impact on the banks of the Murray River. Construction of these structure would be undertaken according to the following principals:

- Stage construction so as to minimise the period of direct disturbance of aquatic habitat and potential for indirect impacts. For instance, by excavating portions of the channel adjoining the Murray River last and pumping water into the excavation to minimise head loss and the potential for erosive scouring when the channel is connected;
- Use appropriate coffer dams, silt fences or equivalent to ensure that excavations do not affect water quality in the Murray River; and
- Ensure that installation of coffer dams, silt fences or equivalent does not interrupt fish passage beyond the immediate vicinity of the proposed works. Do not create a continuous barrier across the Murray River.

Soil management

Soil management should aim to ensure that topsoils are maintained in a form that will maintain their viability for regeneration of the Forest, minimise risks of erosion, sedimentation and the spread of environmental weeds. This would include measures such as:

- Minimise handling of soils through direct replacement onto progressive rehabilitation areas and careful selection of soil stockpile locations, where possible;
- Original topsoil should be retained and stockpiled to assist in future remediation of temporary disturbance areas such as coffer dams and laydown areas;
- Minimise handling of soils during periods of high soil moisture (i.e. during or immediately following wet climatic conditions);
- Restrict vehicle access on topsoil stockpiles once created, to minimise compaction, erosion and transfer of weeds;
- Topsoil stockpiles would be positioned away from direct surface water runoff; and
- Topsoil stockpiles should be sown with indigenous native grasses of local provenance as soon as is practicable to minimise the amount of bare earth available for the recruitment of weeds.

Dust

Appropriate construction measures must be incorporated to minimise the generation of dust and associated impacts on adjacent natural environments. These are likely to include:

- Setting appropriate speed limits for construction traffic to limit dust generation; and
- Applying water to internal haul roads during construction, where required.

Forest Management

The following mitigation measures are recommended in order to minimise construction impacts of the Forest:

- Setting appropriate speed limits for construction traffic to reduce the risk of fauna road fatalities; and
- Restrict access into adjacent remnant vegetation during construction by appropriate marking / fencing of surface disturbance footprint.

Weed and Pest Management

It is recommended that the following measures be adopted to manage environmental weeds during construction:

- Stockpiles of fill or vegetation should not be placed in areas of adjoining remnant vegetation but instead within existing cleared areas;
- To limit the spread of weeds into adjoining remnant vegetation the surface disturbance footprint should be temporarily fenced;
- Incorporate control measures in the design of the proposed works to limit the spread of weed propagules downstream of the Forest;
- Progressive rehabilitation of disturbed vegetation to limit the potential for colonisation by weeds;
- Monitor and control Noxious Weed species in line with legislative obligations; and

- Perform ongoing monitoring of weed infestation on and adjoining the Forest.

11.3.2 Revegetation and Habitat Enhancement

Revegetation of surface disturbance areas not required for project infrastructure is likely to occur naturally, given the proposed flooding of the Forest.

Habitat enhancement should include the placement of logs and tree trunks for ground fauna shelter sites. Hollow-bearing trees with evidence of occupation identified in the pre-clearing surveys and removed during construction should be relocated into adjoining revegetation areas to mitigate the loss of habitat resources.

11.3.3 Engineering and Operation

The design of project infrastructure has evolved to incorporate a range of engineering features to specifically reduce the environmental risk profile, including but not limited to:

- Ensuring that the regulators have sufficient capacity to enable passage of the 1956 flood, which is the largest flood on record, with minimum interference. This minimises the impact of the infrastructure on the function of the floodplain during large natural flood events;
- Having the flexibility to operate over a range of inflow conditions and deliver a range of different flood events according to the ecological objective. This flexibility also allows the project to be operated to reduce exposure to scenarios that have a higher risk of leading to adverse environmental impacts, such as blackwater events;
- Targeting of the indicative operating scenario (i.e. a fully managed event) to appropriate time of year to maximise ecological benefits (e.g. water bird breeding, native fish spawning) and minimise impacts (e.g. Carp spawning, Blackwater events). This would ideally involve initiation of flooding in September-October and commencement of recession no later than December-January to avoid water pooling in late Summer through Autumn;
- Including an internal floodway and return channel to ensure a significant proportion of water diverted into the forest during large events is returned directly to the Murray River from the flood pool. This minimises water losses;
- Providing erosion protection measures such as rock armouring and grout matts around structures such as regulators;
- Designing structures such that the resultant flow velocities are reduced to minimise environmental impacts;
- Incorporating fish passage through the inlet regulator and designing one of the downstream regulators to enable it to be retrofitted with a fishway in the future if required (refer to Section 9.7.1); and
- Where possible, the location of infrastructure has been selected to minimise environmental impacts, particularly through siting a substantial component of the downstream on the alignment of an existing levee.

The proposed operation of the project will incorporate purposeful operation of the structures to manage the following ecological risks as described in the Operating Plan:

- Damage to terrestrial communities from flood waters, especially Inland Grey Box Woodland (by managing the duration of inundation);
- Blackwater production or algal blooms in the forest and subsequent release into the Barber Creek and Wakool River (by managing the season of inundation and dilution of downstream flows);
- Depletion of fish populations in the Murray River due to diversion of flow pulses (by managing the timing of inundation and using 'called' water releases);
- Reduced fish recruitment in the Murray River due to diversion of eggs and larvae (by managing water quality and providing fish passage out of the forest); and
- Development of pest fish populations (including carp) in the forest and subsequent release into the Barber Creek and Murray and Wakool Rivers (by monitoring and incorporating engineering controls if required).

Adaptive management of the Forest by the project team would involve a number of additional activities that would further mitigate potential negative impacts, including but not limited to:

- An ongoing ecological monitoring program, specifically targeting ecosystem responses to flooding (see below);
- Potential provision of Carp control devices, such as fish traps at the proposed regulators; and
- Increased intensity of pest fauna control programs around managed flood events, targeting islands of higher ground isolated by floodwaters. This would be important for managing potential impacts of Cats and Foxes on nesting waterbirds and turtles.

The generation of blackwater, highly coloured water caused by the leaching of organic compounds from leaf litter, is the greatest water quality risk arising from the inundation of the Koondrook Perricoota Forest (Water Quality in GHD, 2009). Potential impacts arising from blackwater are discussed in Section 9.6.1. The key mitigation strategy to reduce potential blackwater impacts would be to time the release of the blackwater to periods when water temperatures are low, and if possible, when river flows are high.

Other operational measures may be to increase the frequency of flooding so that there is less litter accumulation on the floodplain between floods, although that option would be constrained by water availability.

It may also be possible to ameliorate the blackwater impact on the main river by aerating the ponded water before release. Aeration systems are widely used in reservoirs and aquaculture systems (e.g. Schladow 1993, Stephens and Imberger 1993) and may be applicable in the Forest. In particular, it may be possible to aerate the area of the flooded forest immediately upstream of the release point thus reducing the impact.

For managed floods, mitigation of effects caused by water discharged via the Murray return channel would be relatively straightforward. The water release could be controlled using the release structure or the volume of water flowing into the forest, or both. In addition the amount of dilution could be controlled by controlling the volume of water passed through Torrumbarry weir.

11.3.4 Monitoring and Adaptive Management

The following sections outline monitoring programs that would be implemented during operation of the project. This monitoring would be undertaken during flood events when the project is operated as well as

during flood events when the project is not operated. This would enable the impacts of operation of the project to be compared to those that occur during flood events when the project is not operated.

The Operating Plan describes the monitoring and adaptive management framework for the project. Environmental Manager (FNSW) will be responsible for environmental monitoring, reporting and advice to River Murray Operations. A fish expert will report to the Environmental Manager and will be responsible for providing advice on fish risks and opportunities. The Operations Manager (State Water) will manage operation and maintenance of all structures within the Scheme, utilising Goulburn Murray Water and Wakool Shire Council for day-to-day operation of the Scheme. Key factors identified in the Operating Plan that will require monitoring include:

- Changes in water availability that may enable the watering activity to be extended or varied to achieve additional or different environmental outcomes (e.g. a watering event initiated to provide a vegetation response may be extended to allow breeding of colonial nesting waterbirds);
- Monitoring of environmental outcomes (e.g. if a fish spawning event is observed then the event may be extended to allow this to complete);
- Monitoring of environmental risks (e.g. salinity, blue-green algae or blackwater); and
- Monitoring of impacts on third-parties (e.g. impacts on downstream landholders or other communities).

An Environmental Monitoring Plan would be developed for the project. A monitoring program would be developed that would include a baseline assessment and then monitoring of ecological indicators on an ongoing basis as well as in response to inundation events. Ecological components and response parameters that would be monitored include:

- Health and growth of floodplain vegetation, including detection of positive effects on River Red Gums and potential negative effects on Inland Grey Box woodland;
- Degree of weed infestation;
- Wetland response, including vegetation, macroinvertebrates and frogs;
- Native fish and turtle abundance, diversity and behaviour, particularly passage through structures and spawning/nesting;
- Pest fauna abundance and behaviour, including Carp spawning, or concentration of Cats and Foxes on islands or around waterbird colonies; and
- Bird abundance, diversity and behaviour, particularly mating, nesting and fledging of waterbirds;

The Operating Plan would include adaptive management principles and this would involve considering the results of the aquatic ecology monitoring programs to plan and implement flood events to minimise impacts on the aquatic ecosystem. Specific components of the proposed environmental monitoring are outlined below.

Water quality

There is the potential for blackwater events to occur during operation of the project if there are elevated concentrations of dissolved organic carbon and reduced levels of dissolved oxygen. Blackwater has the potential to have a significant impact upon threatened fish and aquatic invertebrate species, populations or the Lower Murray River endangered ecological community.

To ensure the functionality and effectiveness of adaptive management principles that form part of the Operating Plan, the resultant water quality outcomes (relevant to the key parameters of temperature, dissolved oxygen and dissolved organic carbon) would be regularly monitored to qualify and quantify the significance (if any) of the potential impact. The detection and management of such events would also inform the management and operational changes required to mitigate the impact to ensure no significant impact on threatened species.

Monitoring of water temperature, dissolved organic carbon and dissolved oxygen would commence several weeks prior to a flooding event to establish a robust baseline. The monitoring would continue throughout the event and conclude several weeks after the cessation of a flood event.

Monitoring locations would be selected in consultation with NSW Industry and Investment and would include points:

- Upstream of the forest within the Murray River channel;
- Within the inlet channel, downstream of the inlet regulator;
- Within the flooded areas of the forest (approximately 1 site per 1,000 ha flooded and/or key sites to be determined in consultation with NSW Industry and Investment); and
- Upstream and downstream of discharge points into the Murray River, Thule Creek, Barbers Creek and Cow Creek (whichever is discharging during a flood event).

Monitoring would be undertaken prior to, during, and following both managed flood events and possibly during uncontrolled flood events during which the project would not be operated. This would enable water quality impacts during operation of the project to be compared to water quality during flood events when the project is not operated.

Fish and aquatic invertebrates

The Lower Murray River EEC comprises dozens of species of fish and aquatic invertebrates that are characteristic of the Murray River channel, effluent streams, billabongs, lagoons and floodplains such as are found within and adjacent to the Forest. Many of these species have a passive, early larval lifecycle phase which drifts with the water flow. As a result, they are likely to enter the forest involuntarily with the diverted water. Many also undertake upstream and downstream migrations.

It is highly likely that the operation of the project would entrain quantities of these species and various lifecycle phases. The significance of the impact of entrainment into or out of the Forest would be qualified and quantified to inform the future management and operational changes required to mitigate the impact to ensure no significant adverse impact upon threatened species.

The fish and invertebrate monitoring program, the following program was developed in consultation with NSW Industry and Investment would be further refined with partner agencies prior to implementation and would involve:

- Monitoring within the inlet channel downstream of the inlet regulator during inflow periods to determine the species, numbers and size range of fish and aquatic invertebrates entering the Forest;
- Sampling within the Forest several times during each flood event (1 site per 1,000 ha flooded and/or key sites to be determined in consultation with NSW Industry and Investment) to determine changes to the community structure, survival and growth; and

- Sampling at each of the discharge points into the Murray River, Barbers Creek, Thule Creek and Cow Creek during the recession phase of flood events to determine the species, numbers and size range of fish exiting the Forest.

Stranding native fish

It is likely that native fish species would persist or reside within residual aquatic habitats (pools) and channels within the Forest during and post flood recession. These refuges are likely to have variable persistence and capacity to maintain threatened fish species and communities, dependant upon operations and flows. The impact of stranding and response of fish to the flood cessation needs to be quantified. The significance of this impact would inform the management and operational changes to mitigate the impact to ensure no significant impact on threatened species.

The monitoring outlined above for fish and aquatic invertebrates would allow the response of fish to flood operations to be monitored and would provide the basis for identification of opportunities to minimise impacts.

Pest Fish

Operation of the project may create or augment opportunities for spawning and dispersal of pest fish species (carp and Weatherloach in particular). The detection and management of such events would inform the management and operational changes required to mitigate the impact to ensure no significant impact on threatened species.

The quantification aspects required to address this issue are included within the monitoring program for fish and aquatic invertebrates.

11.4 Offsetting of Impacts

11.4.1 Approach

The DEC/DPI (2005) guidelines identify important heads of consideration or key thresholds that must be considered when assessing potential impacts on threatened species, populations, or ecological communities, or their habitats for development applications assessed under Part 3A. These guiding principles include the requirement that the proposed activity must 'improve or maintain' biodiversity values (i.e. there is no net impact on threatened biota or native vegetation). This ecological impact assessment describes the potential impacts of the proposed activity on native biota, including measures to avoid or mitigate those impacts described above. A detailed assessment of the 'improve or maintain' test is provided in Table 28 and Table 29 in the consideration of the Part 3A key thresholds presented in Section 13.1. The outcome of this assessment is as follows:

- Positive impacts, including environmental watering of approximately 17,000 ha of the Forest and associated ecological benefits for floodplain biota;
- Negative impacts, including removal or modification of native vegetation and habitat;
- Mitigation of impacts through environmental management systems during construction and purposeful operation of infrastructure and adaptive management during the proposed inundation; and

- Resultant residual negative impacts arising from the project on terrestrial vegetation that would not directly benefit from the environmental watering of the Forest, including the permanent removal of 8Ha of Inland Grey Box Woodland.

Therefore a biodiversity offset is required to accompany the project application in order to satisfy the requirements of the DEC/DPI (2005) guidelines and Part 3A of the EP&A Act, with regards to achieving an 'improve or maintain' outcome. A commitment to develop an appropriate offsets strategy forms part of the Draft Statement of Commitments for the proposed activity. The purpose of this offsets strategy is to address residual impacts on Inland Grey Box Woodland and associated terrestrial species that will not directly benefit from the proposed environmental watering of the Forest.

A biodiversity offset comprises one or more appropriate actions that are put in place to counterbalance specific impacts on biodiversity. Appropriate actions are considered to be long-term management activities that aim to improve biodiversity conservation. This can include legal protection of land (i.e. an offset site) to ensure security of management actions and remove threats (DECC, 2008). The biodiversity offset strategy outlined in this report was prepared with reference to the *Principles for the Use of Biodiversity Offsets in NSW* (DECC, 2008) and includes the identification of:

- An offset site;
- Appropriate management actions to improve the biodiversity value of the Forest; and
- Titling arrangements to ensure legal protection of the Forest.

A draft offset strategy was presented to DECCW for discussion during a teleconference on 17 November 2009. The offset strategy presented in this report incorporates recommendations arising from DECCW review and discussions with the Project Team.

11.4.2 Offset site

The Project Team have identified an offset site for the project within the former Toorangabby property in the Perricoota State Forest. The Toorangabby property was purchased and added to the State Forests Estate in the early planning stages of the project since it contains the proposed locations of the Swan Lagoon regulators. The titling and management of other portions of the former Toorangabby for biodiversity conservation is an additional use of the land. The proposed offset site is shown on Figure 21.

The offset site is 149 ha in area and contains appropriate 'like for like' vegetation communities including 94 ha of Inland Grey Box Woodland plus additional habitat for terrestrial fauna in other native vegetation communities. Benson (2006) vegetation types in the Forest include approximately:

- 94 ha of Comm ID 237: Riverine Inland Grey Box grassy woodland (EEC);
- 37 ha of Comm ID 7: River Red Gum - herbaceous tall open forest; and
- 17 ha Comm ID 250: Derived tussock grasslands.

The proposed site would offset the clearing of 8 ha of Inland Grey Box Woodland with the conservation and improvement of 94 ha of Inland Grey Box Woodland i.e. an offsets ratio of approximately 11.5 to 1.

The Tooranagabby property has been extensively cleared and degraded by historical timber harvesting and sheep grazing. The Inland Grey Box Woodland is in moderate condition, however River Red Gum dominated communities have been extensively cleared and degraded and converted to derived tussock grasslands in some areas. The project provides the opportunity to improve the condition of the Forest through a change in management regime.

11.4.3 Management

The DECC (2008) offsetting principals require the improvement of condition and biodiversity values at offset sites through management. This would be achieved at the offset site through the following measures:

- Maintenance of site boundaries and exclusion of potentially damaging activities;
- Conversion from sheep grazing to tactical cattle grazing;
- Management of weeds and pest fauna; and
- Facilitated regeneration of historically cleared and modified River Red Gum vegetation types through exclusion of timber harvesting and delivery of environmental water.

Grazing has been identified as the most extensive threatening process to riparian zones in Australia (Jansen *et al.,* 2007). Therefore exclusion or management of grazing from floodplain forests is likely to achieve improvements in the health and biodiversity value of these environments. Complete exclusion of grazing is not a practical option for the offset site due to logistical constraints (Broekman, L., FNSW pers. comm.) and because tactical grazing is considered the most practical bush fire hazard/fuel reduction method available in the Forest, since prescribed burns would be likely to have a negative effect on the River Red Gum Forests (Thompson, M., FNSW, pers. comm.).

Domestic stock grazing in the State Forests of the site is currently authorised by Occupation Permit within the strategic framework of the Riverina Grazing Strategy. The Riverina Grazing Strategy expands on FNSW objectives for ecologically sustainable grazing in the region, including the preparation of Grazing Management Plans, which accompany Occupation permits and describe management of grazing to achieve environmental objectives identified by FNSW (Childs, n.d.; *Grazing Management Plan Occupation Permit No. 2487 and No. 2519*, n.d.). Management of grazing, and especially setting stock limits, is effective in managing negative effects on the natural environment: Jansen and Robertson (2001) found that negative effects of grazing were substantially lower in lightly grazed State Forests than more intensely grazed privately owned land along the Murrumbidgee River. Use of tactical grazing systems may achieve positive environmental effects including high livestock grazing intensity during winter to reduce flowering and seed set of introduced annuals and then summer-autumn removal of stock as the annual pasture components begin to hay off in order to: allow native perennial grasses to flower and set seed in the absence of livestock grazing; and avoid drought reserve grazing on tree/shrub regeneration and mature plants (Leslie, 2000; Childs, n.d.).

Therefore the proposed tactical grazing of Cattle within the offset site is likely to achieve improvements in the condition of native vegetation and habitat when compared with previous land uses. Consultation with DECCW confirmed that the department would have preferred complete exclusion of grazing but the proposed shift to managed Cattle grazing, from intense Sheep grazing, is likely to achieve improvements in Forest condition (Ewin, P, DECCW, pers. comm.). The proposed, relatively high offset ratio of approximately 11.5 to 1 reflects this compromise position.

Weeds and pest fauna would be managed within the offset site in accordance with the Riverina Ecologically Sustainable Forest Management (ESFM) plan (FNSW, 2008a). Weed and pest animal control programs are carried out on an annual basis in conjunction with local and regional weed and pest animal management agencies to complement landscape wide control programs (GHD, 2009a).

Any improvement in condition of the offset site would be noted through an ongoing monitoring program. In the early stages of the operation of the project baseline monitoring plots would be set up to monitor

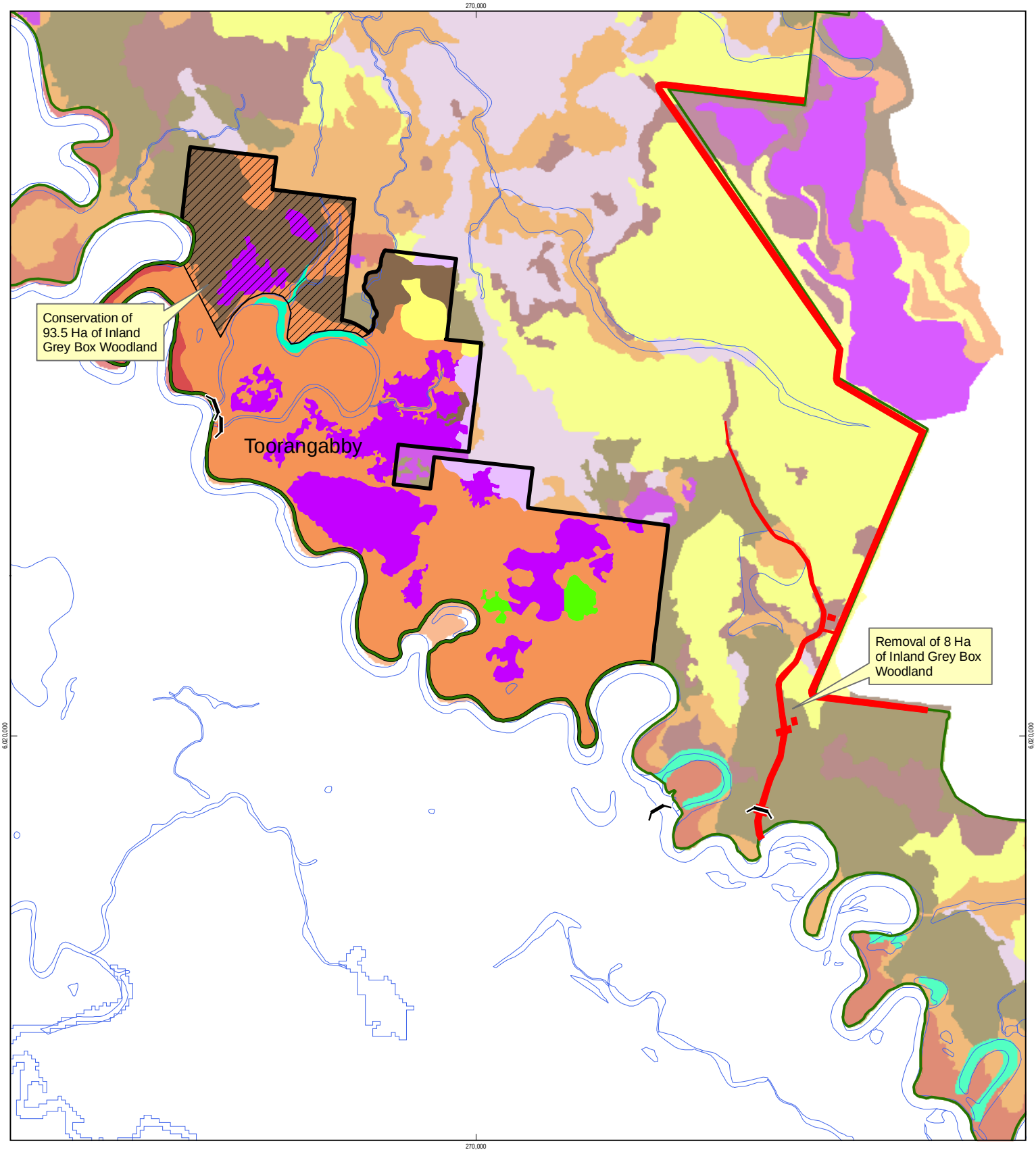
change in Forest condition after the proposed environmental watering and to inform adaptive management. This monitoring program would include plots within the offset site and would report separately on improvements in the condition of the offset site achieved through FNSW management actions.

11.4.4 Titling

The offset site would be managed within the Forests NSW Estate. Conservation of the offset site in perpetuity would be ensured by titling the Forest FMZ 3a within FNSW's Forest Management Zone (FMZ) system. FMZ is a land based classification system, which identifies and defines the primary management intent across the various components of the landscape. The FMZ system is based on nationally agreed reserve criteria and clearly differentiates between those areas of State Forests that are specifically set aside for conservation, and those areas that are available for other activities including timber harvesting (State Forests of NSW, 1999).

FMZ 3a – Special Prescription, allows only "Activities consistent with the area's nominated special value". Timber harvesting and removal of forest products is excluded. Activities consistent with the area's nominated special value are permitted, such as weed and pest management and tactical grazing. Additional activities may be performed where special conditions are needed to ensure consistency with the area's special value (e.g. road and fire trail construction) (State Forests of NSW, 1999).

The FMZ 3a zoning is consistent with other areas of Inland Grey Box Woodland in the State Forest which excludes timber harvesting from these areas (Broekman, L., FNSW, pers. comm.).



Legend

- River Road bridge
- Regulator
- Construction features
- Koondrook Perricoota Forest Site
- Proposed Offset Site
- Toorangabby Boundary

Vegetation Type Toorangabby

- Comm ID 19: Cypress Pine woodland of dunes
- Comm ID 2: River Red Gum-sedge tall open forest
- Comm ID 7: River Red Gum - herbaceous tall open forest
- Comm ID 9: River Red Gum - wallaby grass tall woodland
- Comm ID 10: River Red Gum - Black Box woodland
- Comm ID 12: Shallow depressional marsh
- Comm ID 13: Blackbox - Lignum woodland
- Comm ID 237: Riverine Inland Grey Box grassy woodland
- Comm ID 250: Derived tussock grasslands

1:29,018 (at A3)

0 0.25 0.5 1

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

GHD

CLIENTS | PEOPLE | PERFORMANCE

NSW Office of Water

Koondrook-Perricoota Flood Enhancement Works

Job Number 21-18573
Revision C
Date 01 FEB 2010

Figure 23 - Proposed offset site

G:\21\18573\GIS\Arcview\Map_Documents\21.18573.Z019_ToorangabbyVegetation_RevB.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Dept of Commerce, Drawn: Cwilson, cwilson

12. Assessments of Significance of Impacts

12.1 NSW TSC & FM Act Listed Threatened Biota

12.1.1 Threatened Flora Species

The proposed development will not directly impact any known populations of threatened flora species. It will remove potential habitat for four threatened flora species that are known or predicted to occur in the study area.

An evaluation of the magnitude, extent and significance of impacts of the proposal on these threatened flora species and their habitats following the assessment criteria identified in the Guidelines for Threatened Species Assessment under Part 3A of the EP & A Act (DEC and DPI 2005) – (a Part 3A Amos) has been undertaken and is provided in Appendix C.

The outcome of this assessment is that the project is not likely to have a significant negative effect on local populations of *Amphibromus fluitans, Austrostipa wakoolica, Lepidium monoplocoides* or *Swainsona murrayana* based on the following considerations:

- Habitat within the construction footprints would have limited value for these moisture-dependant threatened plants in their current drought-affected state and are unlikely to contain adult individuals during the construction period;
- Negative impacts arising from the project would be limited to indirect effects and would affect a very minor proportion of individuals and habitats; and
- The proposed inundation of a portion of the Forest would increase the area of potentially suitable habitat for the species and would be expected to have positive effects through a general increase in floodplain health and productivity as a result of flooding.

12.1.2 Endangered Ecological Communities

One endangered ecological community (EEC) listed under the TSC Act is present in the Forest and will be affected by the project: Inland Grey Box Woodland.

A Part 3A Amos has been undertaken for this EEC and is provided in Appendix C.

The outcome of this assessment is that the project is not likely to have a significant negative effect on local populations of Inland Grey Box Woodland based on the following considerations:

- The proposed construction would permanently remove approximately 8 ha of Inland Grey Box Woodland which is a minor proportion (0.84%) of the approximately 951 ha of Inland Grey Box Woodland in the Forest;
- The project will maintain approximately 32, 000 ha of near-continuous native vegetation around the disturbance footprint. Ecosystem functions necessary to the maintenance of the EEC, such as pollination, seed fall and germination of plants, are likely to continue around and/or across gaps in habitat created by the project infrastructure footprints; and
- The proposed operation of the project would modify approximately 189 ha of the community (i.e. approximately 20%) through inundations. Despite some evidence that inundation may have some negative effects on the health of Inland Grey Box trees (Vesk et. al., in prep) there is indirect

evidence that Inland Grey Box Woodland can tolerate inundation for up to 4 months (Cooling, M. pers. comm., Roberts and Marston, 2000) i.e. less than 120 days. Based on DHI (2008) modelling of the indicative scenario no Inland Grey Box Woodland in the Forest will be inundated for greater than 120 days. Therefore the proposed inundation is unlikely to result in significant or irreversible impacts on local populations of Inland Grey Box Woodland.

The proposed offset strategy described in Section 0 will further mitigate negative impacts on local populations of the EEC. The proposed conservation and management of 94 ha of Inland Grey Box Woodland within the offset site would compensate for the removal of approximately 8 ha of the community and produce a net gain in the viability of Inland Grey Box Woodland in the Forest in the long term.

12.1.3 Threatened Fauna Species

Affected threatened fauna and aquatic ecological communities

A total of 11 threatened terrestrial fauna species and a further three species that have a preliminary listing as threatened species under the TSC Act are known, or are highly likely to occur in the Forest based on the site surveys or other recent survey records. The project has the potential for negative effects on these species or their habitats. The project would involve direct or indirect impacts within maximum construction corridor of 206 ha and proposed inundation of 17,000 ha of potential habitat for threatened fauna.

Based on desktop assessments presented above, the project may result in modification of habitat and changes to the life cycle of one FM Act listed fish, the Silver Perch and direct impacts and modification of habitat for the FM Act listed EEC, Murray River Ecological Community.

Part 3A AoSs have been undertaken for these NSW TSC/FM Act listed threatened fauna and are provided in Appendix C. Where appropriate, multiple species of threatened fauna are grouped according to similar ecological characteristics and impacts on common habitat resources are presented together. The outcome of these assessments is as follows:

- The project is not likely to have a significant negative effect on local populations of the threatened woodland birds Hooded Robin, Gilbert's Whistler, Diamond Firetail or Black-chinned Honeyeater because:
  - Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats in the Forest (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha).
  - The proposed inundation of a portion of the Forest would reduce the area of available understorey foraging habitat but is unlikely to significantly constrain migration and dispersal ability of these highly mobile species.
  - These species of woodland birds do not rely on any specific habitat resources that would be removed by the project or significantly adversely affected by flooding.
  - Woodland birds are likely to benefit from a general increase in floodplain health and productivity as a result of flooding.
- The project is not likely to have a significant negative effect on local populations of the Large-footed Myotis, Yellow-bellied Sheathtail Bat and Little Pied Bat, because:

- Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats in the Forest (approximately 31,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha).
- Construction would remove key habitat resources in HBTs but would affect a minor proportion of resources available in the locality and may help to secure the HBT resource in the longer term through environmental watering of mature River Red Gums.
- These species of microbats do not rely on any specific habitat resources that are likely to be significantly adversely affected by flooding.
- The proposed construction and inundation are unlikely to significantly affect migration and dispersal ability of these highly mobile species.
- Microbats are likely to benefit from a general increase in floodplain health and productivity as a result of flooding.

- The project is not likely to have a significant negative effect on local populations of the Koala, because:
  - Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats in the Forest (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha).
  - The Koala is highly reliant on foraging resources provided by River Red Gums in the Forest, which will benefit from environmental watering. Positive effects of flooding on River Red Gum growth and productivity would more than offset the relatively small amount of foraging habitat that would be removed and increased energy costs and risk of travelling during flood events.
- The project is not likely to have a significant negative effect on local populations of the Squirrel Glider, because:
  - Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats in the Forest (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha).
  - Squirrel Gliders may experience slightly increased energy costs and risk of travelling due to gaps in habitat created by construction and/or during flood events. The proposed construction and inundation are unlikely to significantly affect migration and dispersal ability of the species as extensive areas of the species' preferred arboreal habitat would be maintained and individuals would readily glide over the majority of obstacles created by the project.
  - Construction would remove key habitat resources in HBTs but would affect a minor proportion of resources available in the locality and may help to secure the HBT resource in the longer term through environmental watering of mature River Red Gums.
  - The Squirrel Glider does not rely on any specific habitat resources that would be significantly adversely affected by flooding. Gliders are likely to benefit from a general increase in floodplain health and productivity as a result of flooding.
- The project is not likely to have a significant negative effect on local populations of the Australasian Bittern, because:

- Habitat within the construction footprint would have limited value for the Australasian Bittern in its current dry state and is unlikely to be occupied during the construction period.
- Negative impacts arising from the project would be limited to indirect effects and would affect a very minor proportion of individuals and habitats.
- The proposed inundation of a portion of the Forest would increase the area of potentially suitable habitat for the species and would be expected to have positive effects through a general increase in floodplain health and productivity as a result of flooding.

- The project is not likely to have a significant negative effect on the Barking Owl, because:
  - Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats in the Forest (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha).
  - The proposed construction and inundation are unlikely to significantly affect migration and dispersal ability of this highly mobile species.
  - Construction would remove valuable habitat resources including HBTs but would affect a minor proportion of resources available in the locality and may help to secure the HBT resource in the longer term through environmental watering of mature River Red Gums.
  - Barking Owls do not rely on any specific habitat resources that would be significantly adversely affected by flooding. Barking Owls are likely to benefit from a general increase in floodplain health and productivity as a result of flooding.
  - Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats in the Forest (approximately 32,000 ha).
- The project is not likely to have a significant negative effect on local populations of the Bush Stone-curlew, because:
  - Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats in the Forest (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha).
  - Bush Stone-curlews do not rely on any specific habitat resources that would be removed by the project. Notably the species preferred open understorey habitat would be allowed to regenerate across all of the disturbance footprint outside of immediate infrastructure footprints;
  - The proposed inundation of a portion of the Forest would reduce the area of available habitat and constrain migration and dispersal ability for the duration of the inundation period. The species' preferred open woodland habitat is at the upper edge of the floodplain and would be inundated for comparatively brief periods.
  - Bush Stone-curlews may experience some benefits from a general increase in floodplain health and productivity as a result of flooding.
- The project is not likely to have a significant negative effect on local populations of the preliminary-listed woodland birds the White-browed Woodswallow, Varied Sittella and Scarlet Robin because:
  - Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats in the Forest

(approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha).

  - The proposed inundation of a portion of the Forest would reduce the area of available understorey foraging habitat but is unlikely to significantly constrain migration and dispersal ability of these highly mobile species.
  - These species of woodland birds do not rely on any specific habitat resources that would be removed by the project or significantly adversely affected by flooding.
  - Woodland birds are likely to benefit from a general increase in floodplain health and productivity as a result of flooding.

- The project is not likely to have a significant negative effect on local populations of the Silver Perch because:
  - Negative impacts arising from the proposed construction would affect a very minor proportion of individuals and habitats.
  - Given the incorporation of fish passage considerations into the design of project infrastructure (FPTF, 2009) the project would not create any permanent barriers to fish passage and the proposed inundation would probably result in the trapping of a limited proportion of large bodied fish;
  - Blackwater events arising from the proposed inundation would only affect Silver Perch that are drawn into the Forest during flood events or are in Barbers Creek downstream.
  - Adaptive management of the timing, duration and other aspects of the proposed inundation provides scope to substantially mitigate negative effects of blackwater events and pest fish recruitment.
  - Residual negative effects of the project would be limited to the flood pool and are likely to be offset by the benefits of the project for populations and habitats of the Silver Perch outside the Forest including increased productivity and transfer of organic carbon and nutrients to the main channel of the Murray River (Gawne *et al.,* 2007). Comparable environmental watering events have resulted in increased spawning of the Silver Perch in the main channel of the Murray River (King *et. al.,* 2007).
- The project is not likely to have a significant negative effect on local populations of the Murray River EEC because:
  - The project would have minor negative impacts through a small reduction in the overall amount of available habitat and by limiting movement of large-bodied fish species.
  - Blackwater events would only affect sub-populations of the EEC that are drawn into the Forest during flood events or are in Barbers Creek downstream.
  - Adaptive management of the timing, duration and other aspects of the proposed inundation provides scope to substantially mitigate negative effects of blackwater events and pest fish recruitment.
  - Residual negative effects of the project would be limited to the flood pool and are likely to be offset by the benefits of the project including an increase in the area of available aquatic habitat for blackwater tolerant biota during flood events and increased productivity and transfer of organic carbon and nutrients to the main channel of the Murray River (Gawne *et al.,* 2007).

– Comparable environmental watering events have resulted in increased spawning or recruitment of native fish (King *et. al.,* 2007) and increased abundance of planktonic microinvertebrates (Gigney. *et al.,* 2006) following the flood. These effects are likely to be correlated with increases in abundances of other aquatic biota within the Murray River EEC outside the Forest.

Other Mobile Threatened Fauna

The project will remove potential habitat for additional threatened fauna species which may utilise habitat in the Forest, at least on occasion or on an opportunistic basis. An evaluation of the magnitude, extent and significance of impacts of the proposal on local populations of these species and their habitats following the assessment criteria identified in DEC (2005) and DPI (2005) guidelines has been undertaken, based on a general consideration of the likelihood of impacts on these species.

The project is not likely to have a significant negative affect on any mobile threatened fauna based on the following considerations:

- The proposed construction may displace or disturb some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of any fauna populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat in the Forest that could potentially be occupied by mobile fauna;
- The proposed inundation of a portion of the Forest may limit some species access to preferred habitat and so may displace some individuals for the duration of the inundation period. There are extensive areas of alternative habitat that would not be inundated both within and outside the Forest. Mobile fauna populations are likely to utilise alternative habitat and reoccupy the inundation area after flood recession;
- Construction would remove some valuable habitat resources, including habitat trees but would affect a minor proportion of resources available in the locality and may help to secure the habitat tree resource in the longer term through environmental watering of mature River Red Gums;
- There is no evidence that any specific habitat resources that would be removed by the project or significantly adversely affected by flooding are critical to the maintenance of any mobile threatened fauna populations. Many species are likely to benefit from a general increase in floodplain health and productivity as a result of flooding; and
- Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (within a maximum of 206 ha) compared to the overall area of similar habitats in the Forest (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). This magnitude of impacts is not likely to comprise a significant negative effect on any populations of mobile threatened fauna.

12.1.4 Critical habitat

There is no recommended or declared critical habitat on the DECCW NSW Critical habitat register (DECCW, 2009e) or the DPI critical habitat register (DPI, 2009b) in the locality or of relevance to the assessment of the project.

12.2 Matters of National Environmental Significance

12.2.1 Approach

The Commonwealth *Environment Protection & Biodiversity Conservation Act, 1999* (EPBC Act) establishes a process for assessing the environmental impact of activities and developments where 'matters of national environmental significance' may be affected. Under the Act any action, which "has, will have, or is likely to have a significant impact on a matter of national environmental significance" is defined as a "controlled action", and requires approval from the Minister for the Environment, Water, Heritage and the Arts.

The matters of national environmental significance (MNES) listed under the EPBC Act of potential relevance to the Forest are described in Section 7.5. An assessment of the significance of impacts on these MNES is provided below.

Based on the assessments presented above the project may result in impacts the following Matters of National Environmental significance (MNES) listed under the EPBC Act:

- The threatened plant species *Amphibromus fluitans, Austrostipa wakoolica, Lepidium monoplocoide;* and *Swainsona murrayana*;
- The preliminary listed Endangered Ecological Community Inland Grey Box Woodland;
- The Murray Cod;
- Mobile threatened fauna species that may occur in the Forest on an occasional or opportunistic basis;
- Migratory species;
- The NSW Central Murray State Forests Ramsar Site; and
- Other Ramsar Sites within the same catchments as the Forest.

The project will remove or modify habitat for EPBC Act listed biota occurring in the Forest and directly modify a Ramsar Site, which comprises impacts on matters of NES. A detailed assessment of the significance of these impacts on MNES is provided below prepared in accordance with the DEH (2006) *Significant Impact Guidelines*.

12.2.2 Potential Impacts on Nationally Listed Threatened Biota

Flora

The four EPBC Act listed flora potentially affected by the project are also listed under the NSW TSC Act. AoSs for these species using the NSW DEC/DPI (2005) guidelines have been performed and area and is included inAppendix C. The outcome of this assessments is that the project is not likely to have a significant impact on these threatened flora species or their habitats.

Endangered Ecological Communities

Inland Grey Box Woodland, which has a preliminary listing under the EPBC Act, is also listed under the NSW TSC Act. An AoSs for this EEC using the NSW DEC/DPI (2005) guidelines has been performed and is included in Appendix C. The outcome of this assessment is that the project is not likely to have a significant impact on Inland Grey Box Woodland in the Forest.

Murray Cod

One EPBC Act listed aquatic fauna species is likely to occur in the Forest: the Murray Cod. An Amos for the Murray Cod has been prepared in accordance with the DEH (2006) guidelines and is included as Appendix D.

The project would have negative effects on the Murray Cod including:

- isolation or removal of small areas of aquatic habitat within construction footprints;
- potential trapping of some individuals on the floodplain during flood events;
- likely mortality of some individuals within the flood pool during due to blackwater events; and
- likely increased abundance of Carp and other pest fish species.

These impacts would be mitigated and/or offset by the following:

- the project would affect a very small proportion of the aquatic habitat available for the species in the locality;
- the proposed fish passage measures are likely to facilitate the movement of the majority of individuals during flood events;
- monitoring of water quality and fish populations during flood events will be important to avoid negative effects of blackwater and pest species as far as is practicable;
- adaptive management of the timing, duration and other aspects of the proposed inundation provides scope to substantially mitigate negative effects;
- positive effects of environmental watering are likely to include an increase in the area of available aquatic habitat during flood events and increased productivity and transfer of organic carbon and nutrients to the main channel of the Murray River (Gawne *et al.,* 2007).
- comparable environmental watering events have resulted in increased recruitment of Murray Cod in the main channel of the Murray River (King *et. al.,* 2007).

Based on the above considerations, negative effects of the project are likely to affect a limited proportion of local populations of the Murray Cod and may be mitigated through purposeful operation and adaptive management. Residual negative effects of the project would be limited to the flood pool and are likely to be offset by the benefits of the project for populations and habitats of the Murray Cod outside the Forest.

Mobile Terrestrial Fauna

A number of other threatened fauna species listed under the EPBC Act are known or predicted to utilise habitat in the Forest on an occasional or opportunistic basis. The project will remove potential habitat for these species. An evaluation of the magnitude, extent and significance of impacts of the proposal on local populations of these species and their habitats following the assessment criteria identified in NSW DEC/DPI (2005) guidelines has been undertaken, based on a general consideration of the likelihood of impacts on these species. This assessment is included above in Section 12.1.3. The outcome of this assessment is that the project is not likely to have a significant negative affect on any mobile threatened fauna.

12.2.3 Potential Impacts on Migratory Species

Approach

An AoS for impacts on listed migratory species is provided below, including:

- A description of the importance of habitat in the Forest for listed migratory species; and
- Evaluation of the significant impact criteria for migratory species.

Importance of Habitat

The DEH (2006) guidelines identify 'important habitat' for a migratory species as:

- Habitat used by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species; and/or
- Habitat that is of critical importance to the species at particular life-cycle stages; and/or
- Habitat utilised by a migratory species which is at the limit of the specie's range; and/or
- Habitat within an area where the species is declining.

The Forest provides important habitat for a number of EPBC Act listed migratory species and is particularly valuable for wetland birds. Native vegetation and wetlands in the Forest are likely to be used by a range of these migratory species on a periodic basis. This would potentially include use of foraging resources by threatened migratory species including the Australian Painted Snipe, Swift Parrot, and Regent Honeyeater.

The Forest supports 13 migratory bird species listed under the international agreements JAMBA, CAMBA and ROKAMBA and listed on the schedules of the Federal EPBC Act. A further six migratory terrestrial species are known from the Forest, two of which are also listed as threatened under the EPBC Act. The Forest supports a further 29 species which are components of bird families recognised as Migratory under the EPBC Act (refer Table 19).The majority of wetland birds of the Forest are at least partially migratory, and so populations fluctuate with breeding and/or exploitation of floods.

The NSW Central Murray State Forests Ramsar Site contains particularly significant habitat for migratory birds including important breeding habitat. About 54 waterbird species have been recorded breeding in the NSW Central Murray State Forests including 25 colonial nesting species (Leslie, 2001). Other portions of the Ramsar Site are more significant for wetland birds than the project Forest, notably Moira and Gulpa State Forests (GHD, 2009a). Nonetheless the Forest is likely to support breeding aggregations of the majority of these species.

The key determinants of the numbers of breeding birds and reproductive success are:

- The extent and availability of suitable habitat, provided by the River Red Gum forests as well as treeless wetlands; and
- Flooding, which creates suitable nest sites and foraging areas and stimulates breeding events (Chesterfield *et al*., 1984; Maher, 1993 cited in Leslie, 2001).

Some species, such, as the Blue-billed Duck, are nomadic within Australia and travel to take advantage of suitable feeding and breeding opportunities. Others, such as Ibis, Spoonbill and Egret species, occur as permanent resident populations whose numbers are swelled by migratory individuals during breeding

events. Even resident, solitary nesting species such as Grey Teal, Coots and Moor Hens experience population eruptions as migratory populations take advantage of favourable conditions (Kingsford, 2007).

Nesting requirements vary between groups of species. The critical breeding habitat resources within the Forest include mature River Red Gums in the vicinity of open water and stands of Juncus or other emergent macrophytes in marshes (Briggs and Thornton, 1995; Barmah Millewa Forum, 2001).

The Forest would provide important shelter, foraging and roosting resources for terrestrial migratory species. Nectar, mistletoe fruits and other resources may be important to the threatened Swift Parrot and Regent Honeyeater on an occasional basis, however there is no critical habitat for these species recognised within the Forest.

The Forest would also continue to an important wildlife corridor for migratory species along with other River Red Gum forests along the Murray River.

Impact evaluation

An action is likely to have a significant impact on a migratory species, if there is a real chance or possibility that it will:

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for the migratory species;

Direct negative impacts arising from the project would affect a very minor proportion of native vegetation and habitats (within a maximum of 206 ha) compared to the overall area of similar habitats at the Forest (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). The proposed construction would remove 90 ha of habitat in native vegetation within infrastructure footprints. The gaps thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Migratory species would readily traverse these gaps in habitat and would easily traverse the physical structures of project infrastructure. This magnitude of impacts does not comprise a substantial modification to the area of important habitat in the Forest for migratory species.

Flood regimes are the critical determinant of migratory waterbird breeding success in the Riverina (Leslie, 2001). The project is intended to restore a more natural flood regime to the Forest and is likely to result in net positive impacts for migratory waterbird species.

The proposed inundation of the Forest may limit access of some migratory terrestrial species to foraging resources in the shrub and ground layers. These negative effects would be offset by the increased productivity of wetland and over storey vegetation throughout the flood and by increased productivity of all vegetation after recession.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat of the migratory species;

The suite of invasive species known to threaten these environments is established across the Forest. Clearing of habitat may increase the risk of predation of native animals by exotic predators through edge effects. The project would involve the clearing of native vegetation and replacement with areas of roads, stockpiles, and project infrastructure. There may also be transmission of weed propagules on vehicles and equipment. Therefore it is likely that the area of environmental weed infestation would increase within the project disturbance footprint. The majority of the disturbance footprint is associated with the

downstream levee which is adjacent to disturbed cleared land. The remainder of the Forest is partially disturbed by FNSW access tracks and ongoing timber harvesting and grazing activities. In this context construction activities would have a relatively minor impact on the overall numbers and extent of weed species in the locality.

The proposed flooding would transmit weed propagules into the Forest and increase soil moisture and nutrient status. These changes are likely to increase the degree of weed infestation in the Forest. This effect would be balanced by positive effects to the health of native vegetation. Inundation is likely to have net positive impacts for these moisture-loving species of floodplain plants.

Negative effects would be partially mitigated by the application of weed and pest control programs as part of broader Forests NSW activities undertaken at the Forest (Forests NSW, 2008a) and as detailed in the CEMP for the proposed construction.

Pest fauna, including Foxes and Cats which may prey on migratory species, are present within the Forest. Construction may, in general, facilitate the spread of terrestrial pest animals throughout edge effects. The impact from the proposed construction would be minor in the context of existing FNSW timber harvesting and road construction activities and public use activities within the Forest. The most extensive clearing proposed is associated with the downstream levee, which follows existing levees and clearings and adjoins agricultural land over the majority of its length. All other clearings would have a minor effect on the continuity of habitats within the Forest (refer Section 8.2).

The proposed inundation would reduce the accessibility of terrestrial predators to waterbirds and is likely to result in net positive impacts.

Overall the project is likely to have a minor effect on the current degree of weed and pest animal infestation. The project is highly unlikely to introduce any new weed or pest fauna species to the Forest or result in any new infestations in areas of important habitat.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

The project is not likely to have a significant negative affect on any mobile threatened fauna based on the following considerations:

- The ongoing drought reduces the likelihood of direct impacts on migratory fauna during the proposed construction period as feeding and breeding resources for many migratory species are only present in the Forest during flood events;
- The proposed construction may disrupt the breeding behaviour of some individuals if they are breeding within or near the disturbance area. This disturbance would be for one breeding season only and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within 32, 000 ha of similar habitat within the Forest. This disturbance is unlikely to affect an ecologically significant proportion of any populations;
- The proposed inundation of a portion of the Forest may limit some species access to preferred habitat and so may displace some individuals for the duration of the inundation period. There are extensive areas of alternative habitat that would not be inundated both within and outside the Forest. Potential travelling and resting habitat in the canopy would not be affected. The indicative operational scenario would only occur every three to five years. Given the maintenance of canopy habitats, extensive areas of understorey habitat outside the inundation area and likely flood intervals the effect

of flooding on migration and dispersal ability is likely to be minor. Flooding-intolerant migratory species are likely to utilise alternative habitat and reoccupy the inundation area after flood recession or in subsequent dry seasons;

- Approximately 90 ha of foraging habitat would be permanently removed or modified and there would be partial removal or modification of foraging habitat within a maximum construction corridor of approximately 206 ha. Migratory species would have to utilise alternative habitat to compensate for this loss of resources. In the context of the approximately 31,000 ha of alternative habitat at the Forest this would comprise a minor impact;
- The proposed construction would permanently remove 90 ha of habitat in native vegetation within and temporarily remove and/or modify 116 ha of habitat in native vegetation within infrastructure footprints. The gaps thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Migratory fauna would readily traverse these gaps in habitat with minimal change to their migration and resting behaviour;
- Construction would remove some valuable resting resources, including habitat trees but would affect a minor proportion of resources available in the locality and may help to secure the habitat tree resource in the longer term through environmental watering of mature River Red Gums; and
- The project is intended to restore a more natural flood regime to the Forest and is likely to result in net positive impacts for many migratory species, especially waterbirds. Negative effects on flooding-intolerant species would be at least partially offset by the increased productivity of wetland and over storey vegetation throughout the flood and by increased productivity of floodplain vegetation after recession.

Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (within a maximum of 206 ha) compared to the overall area of similar habitats within the Forest (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). This magnitude of impacts is not likely to disrupt life cycle process of an ecologically significant proportion of any populations of migratory fauna.

Conclusion

Based on the above considerations the project is unlikely to impose “a significant effect” on any of the listed migratory fauna species known from the Forest.

12.2.4 Potential Impacts on Ramsar Site

Approval is required under the EPBC Act for an action occurring within or outside a declared Ramsar wetland if the action has, will have, or is likely to have a significant impact on the ecological character of the Ramsar wetland.

NSW Central Murray State Forests

The Forest includes a portion of the NSW Central Murray State Forests Ramsar Site and so the Ramsar Site would be directly affected by the project. FNSW manages the tenure over this land and administers the NSW Central Murray State forests for multiple uses under an ecologically sustainable forest management framework. The Ramsar site is composed of three geographically discrete but interrelated units: the Millewa Forests, the Werai Forests, and the Koondrook Forests. The Forest occupies the majority of the Koondrook Forests unit and would result in direct or indirect impacts on approximately

32,000 ha out of the total Ramsar site area. The Ramsar Site had a total area of approximately 84, 000 ha at the time of the GHD (2009a) ECD. The project will add approximately 1,600 ha to the Ramsar Site via the addition of 800 ha in the former Toorangabby property and 800 ha of land purchased for the western levee alignment.

Potential effects associated with the project include:

- Removal or modification of habitat within a maximum construction corridor of 206 ha;
- Managed inundation of approximately 17,000 ha of the floodplain under the indicative operational scenario; and
- Changes to the hydraulics of the Forest through the construction of a channel to deliver environmental flows and associated regulators, outlet structures and levee which will modify hydrology within the approximately 32,000 ha area surrounding the proposed infrastructure.

Impact evaluation

Ramsar listing imposes national and international obligations on Forests NSW, as Forest manager, to ensure that the ecological character of the Forest is maintained. The EPBC Act prohibits FNSW, or any other party, from having a significant negative effect on the ecological character of a Ramsar site. The Ramsar Convention (Ramsar 2005) defines ecological character and possible changes in ecological character as follows:

- Ecological character is the combination of the ecosystem components, processes and benefits/services that characterise the wetlands; and
- Change in ecological character is the human–induced, adverse alteration of any ecosystem component, process and or ecosystem benefit/service.

Negative impacts on Australian Ramsar sites are measured in terms of a change in the ecological character, as defined in the ecological character description (ECD) for the Forest (DEWHA, 2008).

The GHD (2009a) Draft ECD for the Forest contains ‘limits of acceptable change’ for the critical ecosystem components that make up the Ramsar site. The purpose of limits of acceptable change is to “help Forest managers determine limitations to activities, monitor the Forest, and take action to maintain ecological character” (DEWHA, 2008). Change in ecological character occurs when the critical parameters of the wetland ecosystem vary outside their normal range (Ramsar Convention 1996 Annex to Resolution VI.1).

An action is likely to have a significant impact on the ecological character of a declared Ramsar wetland if there is a real chance or possibility that it will result in:

Areas of the wetland being destroyed or substantially modified;

The proposed construction would involve destruction or modification of native vegetation and habitats within the wetland including:

- Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints;
- The long-term modification of approximately 116 ha of native vegetation within project construction footprints that would be allowed to regenerate to their pre-disturbance state;

- Removal or modification of native vegetation within a construction corridor of 206 ha. Construction activities in these areas would utilise existing tracks and clearings as far as is practicable.

Construction impacts are assessed in detail in Section 8. The Forest contains approximately 31,000 ha of native vegetation and habitats that would not be destroyed or modified.

The proposed operation of the scheme would involve the inundation of up to 17,000 ha of the Forest. The effect of changes to the hydrological regime of the wetland is assessed below. Adaptive management of the project would aim to avoid negative ecological impacts as far as is practicable, for instance appropriate flood levels would be maintained to facilitate waterbird breeding if it commences during a managed flood. The wetland is dominated by flood-dependant biota and the critical ecosystem components, processes, benefits and services that define the value of the Forest within the Ramsar framework are all flood dependant (GHD, 2009a). Therefore the proposed inundation is expected to have net positive impacts.

Negative impacts on up to 206 ha of the wetland would be offset by positive impacts from the environmental watering of 17,000 ha of equivalent habitats within the inundation area. Considered alongside the likely positive impacts of the project the proposed construction is not likely to comprise 'substantial' destruction or modification of the wetland.

Potential indirect impacts on the Ramsar site may arise if forest management changes in response to environmental watering. Approved forest management practices are part of the ecological character of the NSW Central Murray Forests as recognised in the Draft ECD (GHD, 2009a) for the Forest. The Ramsar Convention acknowledges 'wise use' of wetlands including development of wetlands through industries such as commercial fishery, timber and peat harvesting. Wise use is defined as 'the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development' (Ramsar Convention 2005a, Resolution IX.1 Annex A). These ecosystems were recognised as working forests at the time of designation as wetlands of international importance. The ecological character at the time of listing reflecting the continuing wise use of these forests as a sustainable timber resource. The Riverina ESFM Plan (Forests NSW, 2008a) is the management plan for the Ramsar site and provides the framework for sustainable use of timber resources. Potential negative effects of timber harvesting on the ecological character of the NSW Central Murray Forests Ramsar site are ameliorated by implementation of the Management Plan for the Murray Management Area, Forest Management Zoning in NSW State forests, the Harvest Planning Manual, licence conditions issued under the Threatened Species Conservation Act 1995 and the Native Forest Silviculture Manual (Forests NSW, 2008; MDBC 2006). It is assumed that the Forest would be sustainably managed by FNSW under the existing operational and legislative framework throughout the operational life of the project.

Based on the above considerations the project is unlikely to substantially modify or destroy any areas within the NSW Central Murray State Forests Ramsar site through the proposed construction, inundation or through any indirect effects.

A substantial and measurable change in the hydrological regime of the wetland, for example a substantial change to the volume, timing, duration and frequency of groundwater and surface water flows to and within the wetland;

The proposed construction may result in some localized changes in surface and groundwater flows. For instance, in the immediate vicinity of construction footprints runoff would increase and groundwater

tables may rise slightly with the removal of trees. These effects would be minor in magnitude and limited to the immediate vicinity of construction footprints.

The proposed infrastructure and operation of the project would directly affect the hydrology of the Ramsar site. The current hydrology of the Forest is primarily defined by regulatory structures upstream in the Murray River catchment and by the geomorphology of the Murray River adjoining the Forest. The current volume, timing, duration and frequency of surface water flows are substantially different to the likely pre-European regime due to constraints imposed by river regulation (GHD, 2009a). The most significant change is a reduction in the frequency and duration of large flows in the Murray River. The Murray River has high banks through the reaches adjoining the Forest and consequently the reduction in Murray River flows has resulted in a significant reduction in flood events within the Forest (GHD, 2009a). The majority of the floodplain, including drainage lines and depressional marshes is characterised by wetland commence to flow levels well above characteristic Murray River flows (Green and Alexander, 2006). Virtually all of these wetlands have experience a significant reduction in flood frequency and the majority have not been flooded since 2001 (GHD, 2009a). The proposed infrastructure allows for flooding of extensive areas of the Forest at relatively low Murray River flows by utilising the weir pool above Torrumbarry Weir. The project has the capability to deliver a substantial and measurable change in the hydrological regime of the wetland by increasing the frequency of flood events.

The proposed operation of the scheme would involve the inundation of up to 17,000 ha of the Forest via the diversion of up to 6000 ML/day of water from the Murray River. Under the indicative operating scenario presented in this assessment 6000 ML/day of water would be diverted to maintain a flood pool at RL 78.5m AHD, inundating approximately 14,000 ha of the Forest for a 55 day period. Inundation depth and duration would vary with position on the floodplain.

Purposeful management of the project is intended to restore a more natural flood regime to the Forest (Forests NSW, 2008a), avoid potential negative ecological effects as far as practicable (Operating Plan) and meet ecological objects outlined in the management plan for the Icon Forest (MDBC, 2007). Management includes operation of the off take channel and associated regulators to deliver environmental water allocations; prolong flooding to facilitate waterbird breeding events and to allow natural flood events to pass through the system. This management would be undertaken in consultation with MDBA, DII Fisheries and other authorities and is intended to maintain the ecological character of the Ramsar site (Operating Plan).

A key conclusion of the GHD (2009a) Draft ECD is that hydrological factors, especially the Forest's flood regime, are critical to the maintenance of ecological character. Adverse alterations to hydrology have caused a decline in the ecological condition of the Forest and are identified as the primary threat to its character in the future (GHD, 2009a).). These effects are the result of forces external to the Forest, mainly construction of storages and regulation of the Murray River (Thoms *et al*., 2001) exacerbated by the ongoing drought and probably by human-induced climate change in the longer term (CSIRO, 2008). The project is not likely to increase the likelihood or severity of potential negative effects arising from adverse alterations to hydrology. Rather the overriding intention of the project is to address these negative effects through restoration of a more natural hydrological regime.

The impacts of the project on the hydrology of the Forest are assessed in detail in the Hydrology Chapter in the EA for the project (GHD, 2009c). Resultant effects on floodplain and aquatic biota at the Forest are assessed in Chapter 7 of this report. The conclusion of these assessments is that the project is likely to result in net positive impacts on wetland ecosystems at the Forest through the restoration of a more natural flood regime.

Floodplain vegetation provides important regulatory services in riparian environments including lowering saline water tables, stabilising river banks, reducing overbank flow velocities and maintaining depositional environments. The removal of large tracts of vegetation in the Murray River corridor would have a major impact on the hydrology of the system (CSIRO, 2008). As described above, the project would not result in significant areas of the wetland being destroyed or substantially modified. The project would maintain the overall extent and integrity of floodplain vegetation and is unlikely to result in a significant reduction in the provision of these services.

The project would not extract, store, divert or otherwise directly interfere with groundwater flows.

Therefore the proposed operation of the project is likely to result in a substantial and measurable change in the hydrological regime of the Ramsar site; however the proposed changes are likely to be positive and beneficial to the ecological character of the wetland. The proposed construction would result in minor localized changes to flows which would have minor effects on the hydrology of the Forest.

The habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent upon the wetland being seriously affected;

The proposed construction and operation of the project would result in impacts on a variety of wetland dependant species. Species likely to occur within the Forest and be affected by the project are described in Sections 5 and 6 of this report. Construction impacts on floodplain biota are assessed in Chapter 6 of this report and operational impacts in Chapter 7. Assessments of significance under the TSC Act s.5a criteria have been conducted for aquatic ecosystems and threatened wetland flora and fauna species (Appendix C). Assessments of significance of impacts on Federally listed threatened aquatic species have been conducted according to the EPBC Act assessment criteria (Appendix D). The outcome of these assessments is that the project is considered unlikely to result in any significant adverse effects on any populations of native biota. Therefore the project is unlikely to have a serious effect on the habitat or life cycle of any native species within the Ramsar site.

A substantial and measurable change in the water quality of the wetland - for example a substantial change in the level of salinity, pollutants or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health; or

The ECD for the NSW Central Murray State forests did not identify any ongoing water quality issues within the Forest, or any threats to water quality from existing activities (GHD, 2009a).

There is a minimal risk of impacts on water quality arising from the proposed construction within the Ramsar site. The overall risk of significant soil erosion and water pollution arising from the project is considered to be very low because of the following factors:

- The Forest is a depositional environments, with low rainfall and very low relief;
- The broader Forest is maintained as a native forest environment and would have a substantially lower erosion hazard than, for example, cleared agricultural landscapes. Any localised increases in erosion hazard as a result of construction would be limited in extent and in most cases there would be buffers of intact vegetation between the disturbance footprint and aquatic habitats ;
- Within the Forest, the road network of primary and secondary roads is already established and any additional access roads would principally be short, temporary tracks; and
- Soil protection measures and techniques would be implemented during and following construction.

The proposed inundation of the Forest is likely to trigger a substantial and measurable change in the water quality of the wetland by triggering a blackwater event. Blackwater is defined as flood waters with sufficient dissolved organic carbon to give the water a dark “tea” colour associated with reduced dissolved oxygen concentrations (Howitt *et al*., 2007). Modelling of the potential for blackwater has been undertaken for the proposed operational scenario (Water Quality in GHD, 2009c). On the basis of this modelling there is likely to be significant impacts on native fish and other aquatic fauna (e.g. tadpoles, Murray Crayfish and Yabbies). Previous blackwater events resulting from the flooding of the Barmah Forest have resulted in deaths of fish in the receiving waterways as well as impacts on the floodplains themselves (Howitt *et al*., 2007).

Despite the likely short term negative impacts to aquatic fauna, blackwater events are a part of the naturally occurring processes that are characteristic of floodplain inundation in Australia. The mobilisation of carbon from the floodplain to the river is an important process and may be a significant source of carbon for the river, maintaining productivity in the long term (Gawne *et a*l., 2007).

The risk of developing algal blooms following inundation of the Forest is considered to be low and no other significant risks to water quality have been identified (Water Quality in GHD, 2009c).

Based on the above considerations, changes to water quality arising from the project would be restricted to short term consequences of blackwater events and are not likely to adversely impact on the biodiversity or ecological integrity of the Ramsar site in the longer term.

An invasive species that is harmful to the ecological character of the wetland being established (or existing invasive species being spread) in the wetland;

Invasive plants and fish are recognised as threats to the ecological character of the NSW Central Murray State forests. Existing invasive species include the exotic fish Common Carp and Plague Minnow, terrestrial pests including the European Fox and feral Pig and the invasive weeds Willow, Arrowhead, Salvinia and St. Johns Wort (GHD, 2009a).

The proposed construction would involve the clearing of native vegetation and replacement with areas of roads, stockpiles, and project infrastructure. The project may increase the spread and/or prevalence of exotic weeds in the Ramsar site through soil disturbance and transmission of propagules on vehicles and equipment. It is likely that areas environmental weed infestation would increase within the project disturbance footprint. The majority of the disturbance footprint is associated with the downstream levee which is adjacent to disturbed cleared land. The remainder of the Forest is partially disturbed by FNSW access tracks and ongoing timber harvesting and grazing activities. In this context, construction activities would have a relatively minor impact on the overall numbers and extent of weed species in the locality.

Removal of native vegetation may, in general, facilitate the spread of terrestrial pest animals and may increase the risk of predation of native animals by exotic predators. The Forest features an extensive network of access tracks and clearings associated with timber harvesting activities and is surrounded by extensively cleared agricultural land. Terrestrial vermin or feral species are not expected to significantly increase and/or spread as a result of the project. The proposed activity will not significantly fragment or isolated any habitat nor result in any other changes that are likely to favour feral animals.

The proposed flooding would transmit weed propagules into the Forest and increase soil moisture and nutrient status. These changes are likely to increase the degree of weed infestation within the Forest. These negative effects would be partially mitigated by measures within the CEMP for the proposed

construction and application of weed and pest control programs as part of broader Forests NSW activities undertaken at the Forest (Forests NSW, 2008a).

The proposed inundation may increase the spread and/or numbers of aquatic pest species in the Ramsar site. Increases in Carp in the forest and increases of Carp and other exotic fish in the river were assessed as very high risks by Ecological Associates (2009). Carp have been implicated in decline of native fish populations and the degradation of river systems through damage to riverbanks, aquatic macrophytes, increasing turbidity and predation of native biota and competition with native fish for food and habitat (Stuart and Jones, 2000). Negative effects may be partially mitigated by intended more natural sequence of flooding frequency and duration arising from the project, which may return the competitive advantage to the indigenous species which are well adapted to the opportunistic wetting and drying cycles associated with Australian river systems (DSTA, 2009). Regardless negative impacts associated with pest species must be considered in the context of net gains for native fish and other biota as a result of the proposed flooding (see Section 9.11).

Conclusion

Based on the above considerations:

- The destruction or modification of habitats within a maximum construction corridor of 206 ha within the Ramsar site is unlikely to result in negative effects on any local populations of wetland biota given the approximately 31,000 ha of equivalent habitats in the project Forest that would not be affected;
- The proposed operation of the scheme would involve the inundation of up to 17,000 ha which is likely to result in net positive impacts for the majority of species, habitats and ecosystem processes within this area; and
- Human-induced changes to hydrology are the single greatest threat to the Ramsar site (GHD, 2009a) and the intended restoration of a more natural flood regime is likely to result in a number of benefits to the ecological character of the Forest.

Further, preliminary stages of the project have involved the addition of 1600 ha of floodplain vegetation to the forest, which will be added to the Ramsar Site. This additional land was managed for agriculture under private tenure and has been transferred to the FNSW estate where it will be managed within an ecologically sustainable forestry framework. This transfer of tenure and management regime is likely to improve the security, condition and ecological health of this 1600 ha of floodplain vegetation.

Therefore it is concluded that the project is unlikely to impose a significant negative effect on the NSW Central Murray State Forests Ramsar site.

12.2.5 Other Ramsar Sites

Portions of the Forest are in the immediate vicinity of the Victorian Gunbower Forest Ramsar Site. This Forest lies immediately across the Murray River from the upstream end of the Forest, including approximately 50 km of the southern boundary of the Koondrook and Perricoota State forests. The Forest also falls within the catchments of a number of other Ramsar sites within the catchments of the Murray River.

Impact evaluation

An action is likely to have a significant impact on the ecological character of a declared Ramsar wetland if there is a real chance or possibility that it will result in:

Areas of the wetland being destroyed or substantially modified;

Direct negative effects of the project (such as clearing of native vegetation, mortality or displacement of native biota and erosion or compaction of soils) would be located entirely within the boundaries of the Forest. Therefore there would be no direct impacts on any Ramsar sites outside the Forest. Therefore no areas within these wetlands would be destroyed or substantially modified.

A substantial and measurable change in the hydrological regime of the wetland, for example a substantial change to the volume, timing, duration and frequency of groundwater and surface water flows to and within the wetland;

The project would divert water from the Murray River and change patterns of downstream flow into Barbers Creek and other effluents from the forest. Under the proposed operating scenario natural high flow events will be used to trigger a managed watering event, since under these circumstances there would be sufficient environmental water available to permit operation of the project. It is intended that the operation of the works would be integrated with the needs of the River system as a whole, such that the downstream needs would not be adversely impacted on by the flooding within the Forest (DSTA, 2009).

Based on DSTA, (2009) analysis of a DHI (2008) hydraulic model for the project:

- The proposal requires initial inflows of 6000ML/day, which are then reduced to flows of 3400ML/day after 50 days;
- This results in the diversion of 466GL into the Forest; and
- An estimated 222GL will be returned to the Murray River, resulting in a total loss of approximately 244 GL of water from the Murray River to the floodplain.

The Murray River between Torrumbarry Weir and Swan Hill is the reach likely to be impacted by the diversions at Torrumbarry Weir, with the area between Torrumbarry Weir and the return flow channel the reach where water will mainly be lost from the Murray River. This reach includes a number of inflows to the Victorian Gunbower Forest Ramsar Site. The water diverted into the Forest will largely be environmental water from the TLM water account, Commonwealth acquired environmental water, water from Victoria Fauna and Flora, as well as unregulated flows in the Murray River system. The required volume of water would be 'called' and released from upstream storages specifically for the purpose of achieving flows into the Forest. As such, water diverted at Torrumbarry weir will be flow that would not otherwise be in the system and, hence the diversions should have minimal or no impact on the Murray River flows downstream of Torrumbarry Weir (personal communication, D Green, MDBA, 2009).

Therefore the project would not result in a substantial and measurable change in the hydrological regime of the Victorian Gunbower Forest Ramsar Site nor any other Ramsar wetlands downstream of the Forest.

The habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent upon the wetland being seriously affected;

The project may affect native biota that are components of other Ramsar sites. The potential of the project to result in negative impacts on these biota has been assessed elsewhere in this Report. The outcome of these assessments is that the project is not likely to have significant adverse effects on either migratory fauna or mobile threatened species likely to comprise critical components of other Ramsar sites (refer Section 9), endangered ecological communities or threatened biota (Appendix C) nor EPBC Act listed aquatic biota (Appendix D). Further, the project would only be likely to affect local populations

of these species and would be unlikely to significantly affect their survival outside of the Forest. Therefore the project is unlikely to have a serious negative effect on the habitat or lifecycle of any native biota which are dependant on Ramsar wetlands.

A substantial and measurable change in the water quality of the wetland - for example a substantial change in the level of salinity, pollutants or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health; or

There is a minimal risk of impacts on water quality arising from the proposed construction because:

- The Forest is a depositional environments, with low rainfall and very low relief;
- Localised increases in erosion hazard as a result of construction would be limited in extent and in most cases there would be buffers of intact vegetation between the disturbance footprint and receiving waters ; and
- Soil protection measures and techniques would be implemented during and following construction.

Any localised water quality contamination through the construction phase is highly unlikely to be of a magnitude that would affect any environments outside the Forest

The proposed inundation of the Forest is likely to trigger a substantial and measurable change in the water quality of the wetland by triggering a blackwater event (Water Quality in GHD, 2009c). Previous blackwater events resulting from the flooding of the Barmah Forest have resulted in deaths of fish in the receiving waterways as well as impacts on the floodplains themselves (Howitt *et al*., 2007). Despite the likely short term negative impacts to aquatic fauna, blackwater events are a part of the naturally occurring processes that are characteristic of floodplain inundation in Australia. The mobilisation of carbon from the floodplain to the river is an important process and may be a significant source of carbon for the river, maintaining productivity in the long term (Gawne, *et. al.*, 2007).

The risk of developing algal blooms following inundation of the Forest is considered to be low and no other significant risks to water quality have been identified (Water Quality in GHD, 2009c).

Based on the above considerations, changes to water quality arising from the project would be restricted to short term consequences of blackwater events within the Forest and immediately adjacent waters. During the stage of the indicative operating scenario when blackwater events are likely, contaminated water would be discharged to the Murray River at the rate of approximately 1,800 ML/day and Murray River flows would be approximately 5-6,000 ML/day (Water Quality in GHD, 2009c). Given this dilution factor of approximately 1:3 significant negative effects on aquatic biota in the Murray River are considered unlikely. There is a low risk that residual adverse effects would be severe enough to have significant effect on the Victorian Gunbower Ramsar Site given further dilution of water quality effects in waters flowing from the Murray River into receiving waters within the Ramsar Site.

Similarly there are unlikely to be any discernible negative effects on the Riverland or Coorong and Lakes Alexandrina and Albert Ramsar sites, which are located hundreds of kilometres downstream of the Forest. Other Ramsar sites within the same catchment as the Forest are either upstream or separated by dry land. Therefore the project would not result in a substantial and measurable change in the water quality of any other Ramsar wetlands.

An invasive species that is harmful to the ecological character of the wetland being established (or existing invasive species being spread) in the wetland;

The project may increase the spread and prevalence of invasive weeds and terrestrial pest fauna within the Forest through soil disturbance, vehicle traffic and edge effects. These effects would be limited to surface disturbance areas within the Forest and so the project would not directly introduce any invasive species to other Ramsar sites.

The proposed flooding would transmit weed propagules into the Forest and increase soil moisture and nutrient status. These changes are likely to increase the degree of weed infestation within the Forest. These negative effects would be partially mitigated by measures within the CEMP for the proposed construction and application of weed and pest control programs as part of broader Forests NSW activities undertaken at the Forest (Forests NSW, 2008a).

Increased weed numbers within the Forest may increase the susceptibility of other Ramsar sites to invasion by providing a greater volume of weed material potentially transmitted by surface waters, birds or other vectors. The Forest would be maintained as a native forest environment, with predominantly native vegetation cover. In the context of other land uses in the catchment, such as extensive areas of agricultural lands, the project would make a minimal contribution to the threat posed by invasive species to other Ramsar sites.

Conclusion

On the basis of the above considerations, it is concluded that the project is unlikely to impose a significant effect on any other Ramsar sites.

13. Conclusion

13.1 Key Thresholds

Pursuant to DEC/DPI (2005) assessment guidelines development applications under Part 3A must contain a justification of the project based on the following key thresholds.

Whether or not the proposal, including actions to avoid or mitigate impacts or compensate to prevent unavoidable impacts will maintain or improve biodiversity values.

The application of the “improve or maintain” test to the project requires the consideration of positive and negative ecological impacts, proposed mitigation of negative impacts, and biodiversity offsets to compensate for residual negative impacts.

The proposed construction will directly and indirectly affect native biota and habitats within a maximum construction corridor of 206 ha. The proposed operation of the project will inundate 17,000 ha of the Forest and is likely to result in positive impacts on many floodplain and aquatic organisms within this area. Specific impact mitigation and environmental management measures have been recommended for implementation to increase the certainty of the long term maintenance of the biodiversity values of the Forest during construction and operation of the project. This would maintain some values of habitat within disturbance footprints and substantially avert indirect impacts on surface waters, native vegetation and fauna habitats. The project will not mitigate all impacts on native flora and fauna within the proposed surface disturbance area. Further, not all species and communities within the Forest will experience positive impacts from the proposed inundation. Therefore there are residual impacts on some native biota, including the EEC Inland Grey Box Woodland. These impacts will require commensurate biodiversity offsets to ensure the project will “improve or maintain biodiversity values”. The comparison of ecological impacts, mitigation and offsets associated with the application of the “improve or maintain” test to the project are summarised in Table 28 for terrestrial ecosystems and in Table 29 for aquatic ecosystems.

Table 26 Comparison of Ecological Impacts, Mitigation and Offsets on Terrestrial Ecosystems

Positive Impacts	Negative Impact	Mitigation	Offset
Environmental watering of approximately 17,000 ha of the Forest and associated ecological benefits for floodplain biota, including: ◗ improved health of River Red Gums, Black Box and associated understorey species; ◗ improved health of floodplain marshes and growth and reproduction opportunities for associated wetland biota; ◗ migration and breeding opportunities for waterbirds, frogs and other floodplain biota; and ◗ improved habitat resources for floodplain biota, including many terrestrial fauna, due to a general increase in floodplain health and productivity.	◗ Potential displacement or mortality of native biota within a construction corridor of 206 ha. ◗ Removal of native vegetation including: – Permanent removal of 8 ha of Inland Grey Box Woodland; – Temporary disturbance of approximately 206 ha of native vegetation. This includes 116 ha of project construction footprints that would be allowed to regenerate to their pre-disturbance state; – Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints; and ◗ Removal of 532 habitat trees for permanent project infrastructure and potential removal of additional habitat trees within the remaining 78 ha construction corridor. ◗ Isolation, displacement or degradation of flooding-intolerant flora, fauna and vegetation communities.	◗ Remediation and revegetation of construction laydown areas. ◗ Habitat enhancement in remediated areas through placement of hollow trees and fallen timber. ◗ Pre-clearing surveys for (and salvage of) resident native fauna. ◗ Soil and surface water management, and avoidance of off site impacts. ◗ Improved long-term security of the habitat tree resource, including HBTS, through watering of drought-stressed over-mature River Red Gums. ◗ Purposeful operation of infrastructure and adaptive management to avoid negative impacts during the proposed inundation.	Residual negative impacts arising from the project on terrestrial vegetation that would not benefit from the environmental watering of the Forest, including permanent removal of 8 ha of Inland Grey Box Woodland. Therefore an offsets strategy has been developed in consultation with DECCW that would include: ◗ A 149 ha offset site containing appropriate 'like for like' vegetation communities including 94 ha of Inland Grey Box Woodland plus additional habitat for terrestrial fauna in cleared and River Red Gum communities; ◗ Management for conservation, in perpetuity, under secure tenure as FMZ 3a within the FNSW Estate; and ◗ Improvement of condition through: – conversion from Sheep grazing to tactical Cattle grazing and management of weeds and pest fauna; and – facilitated regeneration of cleared and River Red Gum vegetation through exclusion of timber harvesting and delivery of environmental water.

Table 27 Comparison of Ecological Impacts, Mitigation and Offsets on Aquatic Ecosystems

Positive Impacts	Negative Impact	Mitigation	Offset
◗ Environmental watering of approximately 17,000 ha of the Forest and likely ecological benefits including: – increased productivity of wetlands and associated two-way transfer of organisms, carbon, nutrients and habitat resources between the Murray River and floodplain; – provision of additional floodplain aquatic habitat in flooded vegetation; – improved health of in stream habitats and floodplain marshes and growth and reproduction opportunities for associated aquatic biota; and – migration and breeding opportunities for native fish, crustaceans and invertebrates.	◗ Removal or modification of habitats including: – instream and riparian habitat within regulator footprints; and – loss or degradation of habitat resources within a construction corridor of 206 ha. ◗ Likely blackwater events and resultant mortality of aquatic fauna. ◗ Potentially reduced fish passage and risk of mortality associated with infrastructure. ◗ Likely increased numbers and distribution of pest aquatic fauna, especially Carp.	◗ Highly unlikely to cause injury, displacement or mortality of native biota within construction corridor due to prolonged dry conditions at the Forest. ◗ Remediation and revegetation of construction laydown areas. ◗ Retention of fallen timber and habitat enhancement through placement of snags in aquatic habitat. ◗ Surface water management, and avoidance of off site impacts. ◗ Soil management and avoidance of erosion and sedimentation impacts. ◗ Provision of fish passage according to FPTF recommendations. ◗ Purposeful operation of infrastructure and adaptive management to avoid negative impacts on off-site flows, water quality and/or fish passage during the proposed inundation.	The environmental watering of approximately 17,000 ha of the Forest and likely ecological benefits would offset the likely negative impacts arising from the project. Negative effects of the project are likely to affect a limited proportion of local populations of aquatic biota and may be mitigated through purposeful operation and adaptive management. Residual negative effects of the project would be limited to the flood pool and are likely to be offset by the benefits of the project for populations and habitats of aquatic biota outside the Forest. Therefore the project would 'improve or maintain' aquatic biodiversity values and an offsets strategy is not required for aquatic ecosystems.

Whether or not the proposal is likely to reduce the long-term viability of a local population of any threatened species, population or ecological community.

The project is not likely to reduce the viability of any local populations of threatened biota based on the following considerations:

- Direct negative impacts arising from the proposed construction would affect a very minor proportion of individuals and habitats (within a maximum of 206 ha) compared to the overall area of similar habitats within the Forest (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). This magnitude of impacts is not likely to comprise a significant negative effect on any populations of threatened biota;
- The proposed construction would disrupt habitat connectivity within a maximum temporary construction corridor of 206 ha and permanent infrastructure footprint of 90 ha. The modified gaps in habitat thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Ecosystem functions necessary to the maintenance of local populations such as migration, dispersal and pollination are likely to continue across these modified areas of habitat;
- Construction would remove some valuable habitat resources, including habitat trees but would affect a minor proportion of resources available in the locality and may help to secure the habitat tree resource in the longer term through environmental watering of mature River Red Gums;
- The proposed inundation of a portion of the Forest may displace some individuals for the duration of the inundation period and/or reduce the health or viability of local populations. There are extensive areas of native vegetation and alternative habitat that would not be inundated both within and outside the Forest. Local populations are likely to persist outside of the proposed inundation area and reoccupy the inundation area after flood recession; and
- There is no evidence that any specific habitat resources that are critical to the maintenance of any local populations would be significantly adversely affected by flooding. The Forest is a floodplain environment and local populations would have coexisted with periodic flooding and in many cases are dependant upon flooding. The project aims to restore a more natural flood regime and so the majority of species and populations within the Forest are likely to benefit from a general increase in floodplain health and productivity as a result of the proposed inundation.

Whether or not the proposal is likely to accelerate the extinction of any species, population or ecological community or place it at risk of extinction.

The project is not likely to accelerate the extinction of any threatened biota based on the following considerations:

- Direct negative impacts arising from the project would affect a relatively minor proportion of individuals and habitats compared to the overall area of similar habitats within the Forest (approximately 32,000 ha). There is no evidence that an ecologically significant proportion of any populations are concentrated within the disturbance footprint and so this would comprise a minor contribution to the rate of decline of any populations of threatened biota;
- The project is not likely to comprise a significant contribution to the operation of any KTPs. Notably the project will modify and natural hydrology and interrupt natural drainage systems but with the overall purpose of restoring a more natural flood regime. Potential negative effects of the proposed

hydrological changes would be mitigated by the proposed purposeful operation of the project, adaptive management and provision of appropriate fauna passages at project infrastructure;

- The proposed inundation of a portion of the Forest may limit some species access to preferred habitat and so may displace some individuals for the duration of the inundation period. There are extensive areas of alternative habitat that would not be inundated both within and outside the Forest. Mobile fauna populations are likely to utilise alternative habitat and reoccupy the inundation area after flood recession;
- There is no evidence that any specific habitat resources that would be removed by the project or adversely affected by flooding are critical to the maintenance of any populations of threatened biota;
- The environmental watering of approximately 17,000 ha of the Forest and likely ecological benefits would exceed the likely negative impacts arising from the project for the majority of aquatic, wetland and floodplain species occurring within the Forest; and
- Offsetting of residual negative impacts arising from the project on terrestrial vegetation that would not directly benefit from the environmental watering of the Forest. Residual impacts include the permanent removal of 8Ha of Inland Grey Box Woodland. These impacts would be offset through conservation, in perpetuity and under secure tenure, of an 149 ha offset site containing 94 ha of Inland Grey Box Woodland and management to improve its biodiversity value.

Whether or not the proposal will adversely affect critical habitat.

No listed critical habitat will be removed or adversely affected as a result of this project.

13.2 Federal EPBC Act Assessment

On the basis of the assessments undertaken, it is concluded that the proposed development is unlikely to impose a significant effect on any Matters of National Environmental Significance and hence is unlikely to constitute a controlled action as defined under the EPBC Act. The Project Team has submitted a referral for the project to DEWHA.

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Appendix A

Species Lists

Table 28 Flora Species Recorded within the Forest

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
NOTES																												
PTERIDOPHYTES																												
Marsileaceae																												
Marsilea drummondii	Common Nardoo										+		+								+		+				x	
GYMNOSPERMS																												
Cupressaceae																												
Callitris glaucophylla	White Cypress Pine																								+			
Pinaceae																												
**Pinus sp.*																												x
ANGIOSPERMS - MONOCOTYLEDONS																												
Anthericaceae																												

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
Arthropodium sp.	Vanilla Lily	+	1					1																				
Asparagaceae																												
**Asparagus asparagoides*	Bridal Creeper																											x
Asphodelaceae																												
Bulbine semibarbata	Leek Lily		+																									
Cyperaceae																												
Carex sp.	A sedge			+						1	+					+		1	+				+				x	
Cyperus sp.	A sedge																	+									x	
Hypoxidaceae																												
Hypoxis sp.							+																					
Juncaceae																												
Juncus sp.	A rush	+																+		+	+						x	
Juncaginaceae																												
Triglochin sp.	Water ribbons																					+						

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
Orchidaceae																												
Pterostylis mutica	Midget Greenhood																									1		
Poaceae																												
**Avena sp.*	Oats	+																										
Austrodanthonia sp.	Wallaby Grass	+	1	+	1	+	+	1	1		+		+			2			+	+	1	1	+	1	1	1	x	
**Bromus hordeaceus*	A soft brome									2																	x	
Chloris divericata	Slender Chloris																						+					
Chloris truncata	Windmill Grass								+																			
Cynodon dactylon	Couch Grass		+	+				+										+									x	
**Ehrharta longiflora*	Annual Veldtgrass												1	1	1		4	2	2						1			
**Hordeum marinum*	Sea Barley	+										1																
**Hordeum sp.*	Barley Grass				+		1	1	+	+			1	1	1	1	1	2	1	1					4	+		
**Lolium sp.*	Ryegrass	2	1	+	1	1	+		1	+		1	+	1	2	2	+	1	1	+	+						x	

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
Panicum sp.	Panic																									1		
**Pentaschistis airoides*	False Hairgrass			+																						+		
Phragmites australis	Common Reed																1										x	
Poaceae sp.	Unidentifiable grass		+	+	+	+		+		1		+	+	1	+	+		+	+	+	+	1						
**Polypogon monspeliensis*	Annual Beardgrass																										x	
**Schismus barbatus*	Arabian Grass										+																	
Austrostipa blackii	Speargrass															+								+				
Austrostipa nodosa	A speargrass		1										1											+				
Austrostipa sp.	Speargrass							+								+								+		1		
**Vulpia bromoides*	Squirrel-tail Fescue	1		2	2	2	1			2		2								1						2	x	
Whalleya proluta	Rigid Panic					+																+			1			

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
Typhaceae																												
Typha domingensis	Narrow-leaved Cumbungi																										x	
ANGIOSPERMS - DICOTYLEDONS																												
Aizoaceae																												
*Galenia pubescens					+																							
Glinus lotoides	Hairy Carpet-weed																	+										
Amaranthaceae																												
Alternanthera denticulata	Lesser Joyweed																									+		
Apiaceae																												
Daucus glochidiatus	Australian Carrot		+	+		+		+		1				+												+		
Asteraceae																												

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
Actinobole uliginosum	Flannel Cudweed																									4		
**Arctotheca calendula*	Capeweed	+		+	+	1	1	+		1		+	+				+	2	1	+					3	+	x	
**Asteraceae sp.*	Unidentifiable weed				+	+		+	1	+				+	+	+		+										
Brachyscome basaltica var. *gracilis*	Swamp Daisy		+					+								+				+		2						
Calotis hispidula	Bogan Flea				+		+	1																+				
Centipeda cunninghamii	Common Sneezeweed	+																+	+									
**Cirsium vulgare*	Spear Thistle									+				+	+		+	+	+								x	
**Conyza sp.*	Tall Fleabane																	+										
Cotula australis	Common Cotula	1						1		1	+		+								2							
**Cotula bipinnata*	Ferny Cotula	2	+	+	2	1	4	+	1	1	+		+						+	1	2			+			x	
Craspedia uniflora	Common Billy-buttons																				1							

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
Euchiton sphaericus	Japanese Cudweed	+	+	+	+																						x	
**Gazania rigens*	Treasure Flower	+																										
Gnaphalium sp.	Cudweed																				+							
**Helminthotheca echioides*	Ox-tongue		+			+			+																			
**Hypochaeris glabra*	Smooth Catsear			+																								
**Hypochaeris radicata*	Flatweed	1	+	+	1					+					+	+				+	+	+				+	x	
**Lactuca sp.*	Wild Lettuce								+		+		+	1	+	1	+		1		+	+				+		
Leptorhynchos panaetioides	Woolly Buttons							+																				
Pseudognaphalium luteo-album	Jersey Cudweed	+	+																									
Pycnosorus globosus	Drumsticks																	+										
Rhodanthe	Grey Sunray	+	+	+	+	2	1	1	+	+								+										

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
corymbiflora																												
Rhodanthe pygmaea	Pigmy Sunray		+																									
Senecio glossanthus	Slender Groundsel	1		+	+											+												
Senecio hispidulus var. *dissectus*	Hill Fireweed									+																		
Senecio quadridentatus	Cotton Fireweed	+		+		+			+	+			+			+		+		+	+						x	
**Sonchus asper* subsp. *glaucescens*	Prickly Sowthistle					+																						
**Sonchus oleraceus*	Common Sowthistle	+	+		+	+			+	1			+	+	+	+	+	+	1	+	+	+			+	+		
Vittadinia cuneata	Fuzzweed	1	1	+		1		+				+								1				+			x	
Vittadinia gracilis	Fuzzweed	1	1	2	1	1				+		+	+							+								
**Xanthium spinosum*	Bathurst Burr													+														
Xerochrysum	Sticky	2	1	+	1				1	2	+		+		1	1			+									

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
viscosum	Everlasting																											
Boraginaceae																												
**Amsinckia intermedia*	Common Fiddleneck											2	+	Sysimbrium											+			
**Echium plantagineum*	Patterson's Curse	+	+		1	1	1	+	+	1		2	2	2	1	+	+	2	2						+	+		
Plagiobothrys elachanthus	Hairy Forget-me-not					+	+												+									
**Phyla cunescens*	Lippia		+																									
Brassicaceae																												
*Cardamine hirsuta	Common Bittercress	+	+		1				+	+					1	+		+			+	1						
**Capsella bursa-pastoris*	Shepherd's Purse												1		1													
**Lepidium*	Peppercress				1						+		+	+														

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
africanum																												
Sisymbrium erysimoides	Smooth Mustard	+	+				+						1											1	1			
Sisymbrium irio	London Rocket														+													
**Sisymbrium sp.*													1															
Campanulaceae																												
Wahlenbergia fluminalis	River Bluebell		+	+											+	1												
Wahlenbergia gracilenta	Annual Bluebell		1															+				+						
Wahlenbergia sp.	A bluebell	+																									x	
Caryophyllaceae																												
**Cerastium glomeratum*	Mouse-ear Chickweed	+								2								+			+	1				+		
**Spergularia sp.*	Sandspurry		+	1					+							1				2	1							
**Stellaria media*	Common Chickweed								1	2					3		2				1				2			

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
Casuarinaceae																												
Allocasuarina luehamannii	Bulloak																											x
Chenopodaceae																												
Atriplex semibaccata	Creeping Saltbush	+		1	1	+			+						+	1								1				
Atriplex sp.	Saltbush	+	+				1	2	+											1	+						x	
**Chenopodium curvispicatuam*									+																			
**Chenopodium murale*	Nettle-leaf Goosefoot																								1			
Einadia nutans susp*. nutans*	Climbing Saltbush	1	1	1	1	1	+	1	+	+	1		1		+	1				1	+	1	1	2		1	x	
Enchylaena tomentosa	Ruby Saltbush	+		+	1	+	1	+	+				+	+		+				1	1		+	2		+	x	
Salsola kali	Buckbush			+			+					+							+									
Sclerolaena muricata	Black Roly-poly		+	+	1	1	+	+	+																			

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
Crassulaceae																												
Crassula colorata var. *acuminata*	Dense Stonecrop	1		2	1	1	1	1			1		2						+					1	+	1		
Crassula peduncularis	Purple Stonecrop	+		1		1	1		+			1	1					1	1	1	1				1		x	
Crassula sieberiana	Australian Stonecrop	1	1	1	2	1		1	+		1		1							2	2	1	1	1		1		
Euphorbiaceae																												
Euphoriba drummondii	Caustic Weed					+	+						+						1									
**Euphorbia peplus*	Petty Spurge													1														
Fabaceae - Faboideae																												
Eutaxia microphylla	Mallee Bush-pea																											x
**Medicago minima*	Small Woolly Burr-medic					1	+						1															
**Medicago polymorpha*	Burr Medic	+	+			2	1	+	+			+	1	2	+	1	+	+	1	+					1	2		

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
**Trifolium arvense*	Haresfoot Clover																		+							1		
**Trifolium dubium*	Yellow-suckling Clover	+																										
**Trifolium repens*	White Clover				+	+			+									+										
**Trifolium sp.*	Clover		2		1	2		+	+			1	1															
Fabaceae - Mimisoideae																												
Acacia acinacea	Gold-dust Wattle																											x
Acacia dealbata	Silver Wattle																										x	
Fumariaceae																												
**Fumaria muralis*	Wall Fumitory	1								+			+	2					1									
Geraniaceae																												
**Erodium cicutarium*	Common Crowfoot					+					+																	
Erodium crinitum	Blue Crowfoot					+	+												+						+			
**Erodium moschatum*	Musky Crowsfoot						+				1																	

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
Lamiaceae																												
**Marrubium vulgare*	Horehound	+			+	+						2	1	2	+		+		1									
Mentha australis	River Mint																		+									
Lobeliaceae																												
Pratia concolor	Poison Pratia		+						1				+						1	+								
Malvaceae																												
**Malva parviflora*	Small-flowered Mallow						1					2	+	+			+		+						+			
Sida sp.	Sida					+	+																	+				
Myrtaceae																												
Eucalyptus camaldulensis	River Red Gum	+	2	+	1	+			2	+	+	+	2	2	1	1	3	+	1	1	+	+					x	
Eucalyptus largiflorens	Black Box							2			2										+	+	1			+		
Eucalytpus microcarpa	Western Grey Box																			+	+			1				
Oxalidaceae																												

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
Oxalis perennans	Woodsorrel	+	+		+	+	+	+		+		+	+	+	+	+		+	1		+							
Pittosporaceae																												
Pittosporum phylliraeoides	Butterbush									+																		
Plantaginaceae																												
**Plantago sp.*	Buck's Horn Plantain																										x	
Polygonaceae																												
Muehlenbeckia florulenta	Lignum																											x
Persicaria lapathifolium	Pale Knotweed																											x
Persicaria prostrata	Creeping Knotweed																	1										
**Polygonum aviculare*	Wireweed													+	+				+						+			
Rumex crystallinus	Shiny Dock	+				+												+	+									

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
Rumex sp.	Dock	+			+				+	+				+		+		+			+						x	
Portulacaceae																												
Calandrinia eremaea	Small Purslane			+				1			1															1		
Ranunculaceae																												
Myosurus minimus var. *australis*	Mousetail		+		+				+													1						
Ranunculus lappaceus	Common Buttercup		1			1							1		+		+	+			1							
Ranunculus sessiliflorus var. *sessiliflorus*	Buttercup	1	1		1	1		+	1	1				1	1			+	+		1							
Rosaceae																												
Aphanes australiana	Australian Piert					+	+	+				+	+															
**Rosa rubiginosa*	Sweet Briar																										x	
**Rubus fruticosus*	Blackberry																											x

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
Rubiaceae																												
**Galium aparine*	Cleavers		+						+	+				+		4		1	1		+					+	x	
Santalaceae																												
Exocarpos strictus	Dwarf Cherry	+								2										2	2						x	
Scrophulariaceae																												
Stemodia glabella	Smooth Blue-rod					+																						
Solanaceae																												
**Lycium ferocissimum*	African Boxthorn												+															
**Solanum sp.*	Nightshade													1														
Stackhousiaceae																												
Stackhousia monogyna	Creamy Candles			+																								
Urticaceae																												
Parietaria debilis	Smooth Nettle									1	+																	
Urtica sp.	Nettle																											x

	Common Name	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	RM	Incid-entals
**Urtica urens*	Small Nettle												+												2			
Cover Abundance: + = infrequent, 1 = <5%; 2 = 5-25%; 3 = 25-50%; 4 = 50-75%; 5= 75-100%																												
*** = Exotic.**																												

Table 29 Biobanking Plot Data

Broad Vegetation Type	GHD Plot Name / Keith (2004) type	Native Over-storey Cover (%)	Native Mid-storey Cover (%)	Native Ground Cover - Grass (%)	Native Ground Cover - Shrub (%)	Native Ground Cover - Other (%)	Exotic Plant Cover (%)	Number Trees with Hollows	Native Over-storey Regeneration (%)	Total Length Fallen Logs (m)
Red Gum Forest (Benson Communities 2, 5, and 7) Red Gum Woodland (Benson Communities 8, 9, 10)										
River Red Gum Forest	Q1	0.1	0	0	0	44	30	2	100	232
River Red Gum Forest	Q2	7	0	8	0	32	46	5	100	82
River Red Gum Forest	Q3	5.1	0	4	0	62	6	4	100	40
River Red Gum Forest	Q4	0	0.5	0	0	40	62	1	100	106
River Red Gum Forest	Q5	3	2.5	0	0	42	54	0	100	0.5
River Red Gum Forest	Q8	11.5	0	0	0	10	22	6	100	182
River Red Gum Forest	Q9	0.5	27	0	8	16	64	7	100	113
River Red Gum Forest	Q12	8.5	0	0	0	24	34	0	100	96
River Red Gum Forest	Q13	23.5	0	0	0	6	58	0	100	36
River Red Gum Forest	Q14	6.2	0	0	0	0.5	66	0	100	296
River Red Gum Forest	Q15	15	0	12	0	2	14	2	100	37
River Red Gum Forest	Q16	62.6	2.8	0	0	0	72	13	100	111
River Red Gum Forest	Q17	10	12.5	4	0	14	38	1	100	56
River Red Gum Forest	Q18	12.5	15.4	0	0	6	52	1	100	93

Broad Vegetation Type	GHD Plot Name / Keith (2004) type	Native Over-storey Cover (%)	Native Mid-storey Cover (%)	Native Ground Cover - Grass (%)	Native Ground Cover - Shrub (%)	Native Ground Cover - Other (%)	Exotic Plant Cover (%)	Number Trees with Hollows	Native Over-storey Regeneration (%)	Total Length Fallen Logs (m)
Site Survey Average		12	4	2	1	21	44	3	100	106
Benchmark (DECCW, 2009f)	MU579	10-35	5-35	5-30	0-20	10-20		2		56
Black Box Woodland (Benson Communities 10, 13, 15, and 16)										
Black Box woodland	Q7	18.5	12.5	0	0	50	6	1	100	31
Black Box woodland	Q10	37	8.5	0	0	0	0	14	100	260
Black Box woodland	Q21	12.5	0	0	0	6	8	2	100	59
Black Box woodland	Q22	19.5	3	0	0	2	0	1	100	104
Site Survey Average		22	6	0	0	14.5	3.5	4.5	100	113.5
Benchmark (DECCW, 2009f)	MU513	10-30	8-30	9-13	5-10	9-40		0		30
(Inland Grey Box (Benson Community 237)										
Inland Grey Box woodland	Q19	15.5	7.5	0	8	14	6	1	100	0
Inland Grey Box woodland	Q20	23.5	4.7	4	6	4	10	1	100	24
Inland Grey Box woodland	Q23	20	7.5	4	0	10	0	1	100	27
Site Survey Average		20	7	3	5	9	5	1	100	17
Benchmark (DECCW, 2009f)	MU555	14-27	33-38	5-22	0-21	0.1-20		3		33
Sandhill Woodlands (Benson Community 19)										

Broad Vegetation Type	GHD Plot Name / Keith (2004) type	Native Over-storey Cover (%)	Native Mid-storey Cover (%)	Native Ground Cover - Grass (%)	Native Ground Cover - Shrub (%)	Native Ground Cover - Other (%)	Exotic Plant Cover (%)	Number Trees with Hollows	Native Over-storey Regeneration (%)	Total Length Fallen Logs (m)
Sandhill pine woodland	Q24	29.5	0	2	0	4	64	3	100	123
Sandhill pine woodland	Q25	3.5	8	8	12	26	30	1	100	122
Site Survey Average		16.5	4	5	6	15	47	2	100	122.5
Benchmark (DECCW, 2009f)	MU541	13-23	8-10	10-20	10-60	25-80		2		10
Derived Grassland and Herbland										
Derived Grassland or Herbland	Q6	0	0	0	0	6	88	0	0	0
Derived Grassland or Herbland	Q11	0	0	0	0	12	60	4	0	8
Site Survey Average		0	0	0	0	9	74	2	0	4

Table 30 Fauna Species Recorded within the Forest

Scientific Name	Common Name	Habitat	NSW Status	Federal Status	Observation Type
BIRDS					
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	W	P		Seen
Acanthiza lineata	Striated Thornbill	F	P		Seen
Acanthiza nana	Yellow Thornbill	W	P		Seen
Acanthiza pusilla	Brown Thornbill	F	P		Seen
Acanthiza reguloides	Buff-rumped Thornbill	W	P		Seen
Acanthiza uropygialis	Chestnut-rumped Thornbill	W	P, D		Seen
Accipiter cirrhocephalus	Collared Sparrowhawk	F	P		Seen
Accipiter fasciatus	Brown Goshawk	F	P		Seen
Accipiter novaehollandiae	Grey Goshawk	F	P		Seen
Acrocephalus australis	Australian Reed Warbler	M	P		Heard
Aegotheles cristatus	Australian Owlet-nightjar	F	P		Heard
Alcedo azurea	Azure Kingfisher	M	P		Seen
Anas gracilis	Australian Grey Teal	M, R	P		Seen
Anas superciliosa	Pacific Black Duck	M, R	P		Seen
Anhinga melanogaster	Australian Darter	R	P		Seen
Anthochaera carunculata	Red Wattlebird	F	P		Heard
Aquila audax	Wedge-tailed Eagle	W	P		Seen
Ardea novaehollandiae	White-faced Heron	M, R	P		Seen
Ardea pacifica	White-necked Heron	M, R	P		Seen
Artamus cyanopterus	Dusky Woodswallow	F	P		Seen
Artamus superciliosus	White-browed Woodswallow	W	PV		Seen
Botaurus poiciloptilus	Australasian Bittern	M, R	V	NE	Heard
Cacatua galerita	Sulphur-crested Cockatoo	F	P		Seen
Cacatua roseicapilla	Galah	F	P		Seen
Cacatua tenuirostris	Long-billed Corella	F	P		Seen
Cactua sanguinea	Little Corella	F	P		Seen
Chenonetta jubata	Wood Duck	M, R	P		Seen
Cheramoeca leucosternum	White-backed Swallow	W	P		Seen
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo	W	P		Heard
Cinclorhamphus mathewsi	Rufous Songlark	F	P		Seen
Circus approximans	Swamp Harrier	M	P		Seen
Climacteris picumnus picumnus	Brown Treecreeper (arid zone subspecies)	W, F	P		Seen
Cocomantis flabelliforms	Fan-tailed Cuckoo	W	P		Heard
Colluricincla harmonica	Grey Shrike-thrush	F	P		Seen
Coracina novaehollandiae	Black-faced Cuckoo-shrike	F	P		Seen
Coracina papuensis	White-bellied Cuckoo-shrike	W	P		Seen

Scientific Name	Common Name	Habitat	NSW Status	Federal Status	Observation Type
Corcorax melanorhamphos	White-winged Chough	W	P		Seen
Cormobates leucophaea	White-throated Treecreeper	F	P		Seen
Corvus coronoides	Australian Raven	W	P		Seen, heard
Corvus mellori	Little Raven	W	P		Seen, heard
Coturnix australis	Brown Quail	F, W	P		Seen
Cracticus nigrogularis	Pied Butcherbird	W	P		Seen
Cracticus torquatus	Grey Butcherbird	W	P		Seen
Cuculus pallidus	Pallid Cuckoo	W	P		Heard
Dacelo novaeguineae	Laughing Kookaburra	W	P		Seen
Daphoenositta chrysoptera	Varied Sittella	W	PV		Seen
Dromaius novaehollandiae	Emu	W	P, D		Seen
Falco berigora	Brown Falcon	W	P		Seen
Falco cenchroides	Australian Kestrel	W	P		Seen
Falco subniger	Black Falcon	W	P		Seen
Falco peregrinus	Peregrine Falcon	W	P		Seen
Falcunculus frontatus	Crested Shrike-tit	F	D		Seen
Fulica atra	Eurasian Coot	M	P		Seen
Gallinula tenebrosa	Dusky Moorhen	M	P		Seen
Geopelia striata	Peaceful Dove	W	P		Seen
Gerygone fusca	Western Gerygone	F	P		Seen
Grallina cyanoleuca	Australian Magpie-lark	W	P		Seen
Gymnorhina tibicen	Australian Magpie	W	P		Seen
Haliaeetus leucogaster	White-bellied Sea-Eagle	M	P		Seen
Hirundo neoxena	Welcome Swallow	F	P		Seen
Hirundo nigricans	Tree Martin	W	P		Seen
Lalage tricolor	White-winged Triller	W	P		Seen
Lichenostomus penicillatus	White-plumed Honeyeater	F	P		Seen
Malurus cyaneus	Superb Fairy-wren	W, F	P		Seen
Manorina melanocephala	Noisy Miner	W	P		Seen
Melanodryas cucullata cucullata	Hooded Robin (south eastern form)	W	V		Seen
Melithreptus brevirostris	Brown-headed Honeyeater	W, F	P		Seen
Microeca leucophaea	Jacky Winter	F	D		Seen
Milvus migrans	Black Kite	W	P		Seen
Milvus sphenurus	Whistling Kite	F, R	P		Seen
Myiagra inquieta	Restless Flycatcher	F	D		Seen
Neochima temporalis	Red-browed Finch	W	P		Seen
Ninox novaeseelandiae	Southern Boobook	W	P		Seen, heard
Nymphicus hollandicus	Cockatiel	W	P		Seen
Ocyphaps lophotes	Crested Pigeon	W	P		Seen
Oriolus sagittatus	Olive-backed Oriole	F	P		Heard
Pachycephala inornata	Gilbert's Whistler	W	V		Seen

Scientific Name	Common Name	Habitat	NSW Status	Federal Status	Observation Type
Pachycephala pectoralis	Golden Whistler	W	P		Seen
Pachycephala rufiventris	Rufous Whistler	F	P		Seen
Pardalotus striatus	Striated Pardalote	F	P		Seen, heard
Petroica goodenovii	Red-capped Robin	W	D		Seen
Petroica multicolor	Scarlet Robin	W	PV		Seen
Phalacrocorax carbo	Great Cormorant	M, R	P		Seen
Phalacrocorax melanoleucos	Little Pied Cormorant	M, R	P		Seen
Phalacrocorax sulcirostris	Little Black Cormorant	M, R	P		Seen
Phaps chalcoptera	Common Bronzewing	W	P		Seen
Philemon citreogularis	Little Friarbird	F	P		Heard
Philemon corniculatus	Noisy Friarbird	F	P		Seen, heard
Platalea flavipes	Yellow-billed Spoonbill	M, R	P		Seen
Platycercus elegans subsp. flaveolus	Crimson (Yellow) Rosella	F	P		Seen
Platycercus eximius	Eastern Rosella	F	P		Seen
Podargus strigoides	Tawny Frogmouth	F	P		Seen
Pomatostomus superciliosus	White-browed Babbler	W	P		Seen
Porphyrio porphyrio	Purple Swamphen	M, R	P		Seen
Psephotus haematonotus	Red-rumped Parrot	W	P		Seen
Rhipidura fuliginosa	Grey Fantail	F	P		Seen
Rhipidura leucophrys	Willy Wagtail	F, W	P		Seen
Sericornis frontalis	White-browed Scrubwren	F	P		Seen
Smicrornis brevirostris	Weebill	W	P		Seen
Stagonopleura guttatum	Diamond Firetail	W	V		Seen
Strepera graculina	Pied Currawong	W	P		Seen
Tachybaptus novaehollandiae	Australasian Grebe	M, R	P		Seen
Tadorna tadornoides	Australian Shelduck	M, R	P		Seen
Threskiornis Aethiopica	Australian White Ibis	M, R	P		Seen
Threskiornis spinicollis	Straw-necked Ibis	M, R	P		Seen
Todiramphus sanctus	Sacred Kingfisher	W, F	P		Heard
Vanellus miles	Masked Lapwing	M, R	P		Heard
Zosterops lateralis	Silvereye	W	P		Seen
MAMMALS					
Terrestrial mammals					
**Bos taurus*	Domestic Cow	F,W	U		Seen
**Canis vulpes*	Red Fox	F	U		Seen, Scat
Petarus norfolcensis	Squirrel Glider	F			Seen, heard (both tentative)
**Dama dama*	Fallow Deer	F	U		Seen
Antechinus flavipes	Yellow-footed Antechinus	F	P		Seen
**Lepus capensis*	Brown Hare	W	U		Seen
**Oryctolagus cuniculus*	European Rabbit	W	U		Seen
Macropus giganteus	Eastern Grey Kangaroo	F	P		Seen

Scientific Name	Common Name	Habitat	NSW Status	Federal Status	Observation Type
Wallabia bicolor	Swamp Wallaby	F	P		Seen
**Canis familiaris*	Domestic Dog	F	U		Scat
**Sus scrofa*	Feral Pig	F	U		Scat
Arboreal mammals					
Petaurus sp.	Unidentified Glider	F, W	P		Seen
Trichosurus vulpecula	Common Brushtail Possum	F, W	P		Seen
Pseudocheirus peregrinus	Common Ringtail Possum	W, F	P		Seen
Microbats					
Chalinolobus gouldi	Gould's Wattled Bat	W	P		Anabat, Definite
Chalinolobus morio	Chocolate Wattled Bat	W	P		Anabat, Definite
Chalinolobus picatus	Little Pied Bat	W	V		Anabat, Possible
Mormopterus species 2	Unidentified Mormopterus 2	W,F	P		Anabat, Possible
Mormopterus species 3	Unidentified Mormopterus 3	W,F	P		Anabat, Probable
Mormopterus species 4	Unidentified Mormopterus 4	W,F	P		Anabat, Definite
Myotis macropus	Southern Myotis	F	V		Anabat, Possible
Nyctophilus geoffroyi	Lesser Longeared Bat	W	P		Harp Trap
Nyctophilus gouldi	Gould's Longeared Bat	W	P		Harp Trap
Scoterepens greyii	Little Broad-nosed Bat	F, W	P		Anabat, Probable
Scotorepens balstoni	Inland Broad-nosed Bat	F	P		Harp Trap; Anabat, Definite
Tadarida australis	White-striped Freetail Bat	W	P		Anabat, Definite
Vespadelus darlingtoni	Large Forest Bat	W	P		Anabat, Definite
Vespadelus regulus	Southern Forest Bat	W	P		Anabat, Definite
Vespadelus vulturnus	Little Forest Bat	F, W	P		Harp Trap; Anabat, Definite
FROGS					
Crinia parinsignifera	Eastern Sign-bearing Froglet	M, R	P		Seen, heard
Limnodynastes tasmaniensis	Spotted Marsh Frog	M, R	P		Seen, heard
Crinia signifera	Common Eastern Froglet	M, A	P		Heard
REPTILES					
Varanus sp.	Unidentified Goanna	W	P		Seen (partial)
Pogona barbata	Bearded Dragon	W	P		Seen

Scientific Name	Common Name	Habitat	NSW Status	Federal Status	Observation Type
Cryptoblepharus carnabyi	Shinning Skink	F, W	P		Seen
Lampropholis guichenotti	Pale-flecked Garden Sun-skink	F, W	P		Seen
Morethia boulengeri	A Redthroat Skink	W	P		Seen
Chelodina longicollis	Eastern Long-necked Tortoise	M	P		Dead

Habitat types: M - Floodplain Depression Marshes; W plains woodland (River Red Gum Woodland, Box Woodland); F River Red Gum Forest; R – riparian.

Status Codes: V – Vulnerable; P- preliminary listing as vulnerable; NE - Nominated for listing as endangered

Appendix B

Threatened Biota Records

Table 31 Threatened Biota Known or Predicted to Occur within the Forest

Scientific Name	Common Name	TSC/FM Act Status	EPBC Act Status	Habitat Association (DECC, 2009b)	Record Type[1]	Likelihood of Occurrence[2]
Flora						
Amphibromus fluitans	Floating Swamp Wallaby-grass	V	V	Habitats in south-western NSW include swamp margins in mud, dam and tank beds in hard clay and in semi-dry mud of lagoons with *Potamogeton* and *Chamaeraphis* species. Disturbance regimes are not Known, although the species requires periodic flooding of its habitat to maintain wet conditions.	Previous Record	**Possible** in permanent to semi-permanent swamps with fluctuating water levels in the Forest.
Austrostipa metatoris	A Spear-grass	V	V	Grows in sandy areas of the Murray Valley; habitats include sandhills, sandridges, undulating plains and flat open mallee country, with red to red-brown clay-loam to sandy-loam soils. Associated species include *Eucalyptus populnea, E. intertexta, Callitris glaucophylla, Casuarina cristata, Santalum acuminatum and Dodonaea viscosa.*	Predicted	Unlikely – no suitable habitat in sandhills, sandridges, undulating plains and flat open mallee country within the Forest.
Austrostipa wakoolica	A Spear-grass	V	E	Grows on floodplains of the Murray River tributaries, in open woodland on grey, silty clay or sandy loam soils; habitats include the edges of a lignum swamp with box and mallee; creek banks in grey, silty clay; mallee and lignum sandy-loam flat; open Cypress Pine forest on low sandy range; and a low, rocky rise. Associated species include *Callitris glaucophylla, Eucalyptus microcarpa, E. populnea, Austrostipa eremophila, A. drummondii, Austrodanthonia eriantha and Einadia nutans.*	Predicted	**Possible** on the floodplain of the Murray River and smaller drainage lines.
Eucalyptus leucoxylon subsp. *pruinosa*	Yellow Gum	V		Occurs in sandhill pine and belah communities along the Murray River, particularly within Campbells Island and Euston SFs.	DGRs	Unlikely as it is restricted to several small areas between Barham and Euston in grassy woodland.

Scientific Name	Common Name	TSC/FM Act Status	EPBC Act Status	Habitat Association (DECC, 2009b)	Record Type[1]	Likelihood of Occurrence[2]
Lepidium monoplocoides	Winged Peppercress	E	E	Occurs on seasonally moist to waterlogged Forests, on heavy fertile soils, with a mean annual rainfall of around 300-500 mm. Predominant vegetation is usually an open woodland dominated by *Allocasuarina luehmannii* (Bulloak) and/or eucalypts, particularly *Eucalyptus largiflorens* (Black Box) or *E. populnea* (Poplar Box).	Predicted	**Possible** but unlikely due to dearth of recent records (seasonally moist to waterlogged Forests, including black box woodland)
Maireana cheelii	Chariot Wheels	V	V	The species has been collected from clay-based soils, ranging from grey, red and brown cracking clays to red-brown earths and loams. Grows in a variety of vegetation types including Bladder Saltbush, Black Box and grassland communities on level plains, floodplains and depressions and is often found with *Maireana* species. Plants have been found in remnant native grasslands or grassy woodlands that have been intermittently grazed or cultivated.	Previous Record Predicted	Unlikely - no suitable habitat (shallow depressions in chenopod shrublands) within the Forest.
Pimelea spinescens subsp. *spinescens*	Plains Rice-flower	-	CE	There are two known populations which occur on level ground with a loamy soil type. The Natimuk population occurs on a roadside reserve in a grassland dominated by spear grasses (*Austrostipa* sp.) and wallaby grasses (*Austrodanthonia* sp.), with scattered shrubs of *Bursaria spinosa* (Sweet Bursaria) and *Senna artemisioides* (Cassia), whereas the population at Minyip occurs on Crown Land within a Buloke grassland area (DEWHA, 2009b).	Predicted	Unlikely – no suitable habitat (grassland and grassy woodland, generally on the Victorian Volcanic Plain) within the Forest.
Swainson murrayana	Slender Darling Pea	V	-	The species has been collected from clay-based soils, ranging from grey, red and brown cracking clays to red-brown earths and loams. Grows in a variety of vegetation types, including Bladder Saltbush, Black Box and grassland communities on level plains, floodplains and depressions and is often found with *Maireana* species. Plants have been found in remnant native grasslands or grassy woodlands that have been intermittently grazed or cultivated.	Predicted	**Possible** in black box woodland, floodplains and depressions within the Forest. Also known from moderately grazed or cultivated paddocks.

Scientific Name	Common Name	TSC/FM Act Status	EPBC Act Status	Habitat Association (DECC, 2009b)	Record Type[1]	Likelihood of Occurrence[2]
Thesium australe	Austral Toadflax, Toadflax	V	-	Damp Forests in grassland or grassy woodland, often in association with *Themeda australis* (DECC, 2009b).	Predicted	Unlikely – lack of suitable habitat (grassland and grassy woodland, often growing with *Themeda*; mainly occurs east of Cobram-Barooga)
Tylophora linearis		V	E	Found in the Barraba, Mendooran, Temora and West Wyalong districts in the northern and central western slopes of NSW. Grows in dry scrub and open forest. Recorded from low-altitude sedimentary flats in dry woodlands of *Eucalyptus fibrosa, E. sideroxylon, E. albens, Callitris endlicheri, Callitris glaucophylla* and *Allocasuarina luehmannii*	Predicted	Unlikely – lack of suitable habitat (northern and western slopes of NSW, dry scrub and open forest)
Wilsonia rotundifolia	Round-leafed Wilsonia	E	-	Grows in mud in coastal salt marsh and inland saline lakes. In undisturbed habitat, it can be a good coloniser as the creeping stems root from the nodes.	Previous Record	Unlikely – lack of suitable habitat (coastal saltmarsh and inland saline lakes)
EECs						
Aquatic ecological community in the natural drainage system of the lower Murray River catchment	Murray River EEC	EEC		Includes all natural creeks, rivers, and associated lagoons, billabongs and lakes of the regulated portions of the Murray River below the Hume Weir.	Predicted	**Present** – drainage lines, lagoons and marshes within the Forest are part of this EEC.

Scientific Name	Common Name	TSC/FM Act Status	EPBC Act Status	Habitat Association (DECC, 2009b)	Record Type[1]	Likelihood of Occurrence[2]
Allocasuarina luehmannii Woodland in the Riverina and Murray-Darling Depression bioregions / Buloke Woodlands of the Riverina and Murray-Darling Depression Regions	Buloke Woodland	EEC	EEC	*Allocasuarina luehmannii* Woodland typically occupies patches of red-brown loamy sands with alkaline sub-soils on the alluvial plain of the Murray River and its tributaries in south-western NSW.	Predicted	**Possible –** small, remnant patches may occur on sand hills in the study area, but outside the Forest.
Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions	Grey Box Woodland	EEC	-	Inland Grey Box Woodland occurs on fertile soils of the western slopes and plains of NSW. The community generally occurs where average rainfall is 375- 800 mm pa and the mean maximum annual temperature is 22- 26°C	Predicted	**Present** in the southeast of the Forest, including along the Torrumbarry cutting alignment.
Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling	Weeping Myall Woodland	EEC	EEC	This ecological community is scattered across the eastern parts of the alluvial plains of the Murray-Darling river system. Typically, it occurs on red-brown earths and heavy textured grey and brown alluvial soils within a climatic belt receiving between 375 and 500 mm mean annual rainfall (DECC 2009b).	Predicted	Unlikely – no previous areas mapped within the Forest and not generally known from floodplains.

Scientific Name	Common Name	TSC/FM Act Status	EPBC Act Status	Habitat Association (DECC, 2009b)	Record Type[1]	Likelihood of Occurrence[2]
Depression, Riverina and NSW South western Slopes bioregions / Weeping Myall Woodlands						
Sandhill Pine Woodland in the Riverina, Murray-Darling Depression and NSW South Western Slopes bioregions	Sandhill Pine Woodland	EEC	EEC	Found on red-brown loamy sands with alkaline sub-soils, and is typically associated with prior streams and aeolian source-bordering dunes	Predicted	**Present** as small isolated patches on sandhills, including in the former Toorangabby property. Patches are remote from the construction footprints and inundation area.
White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Box Gum Woodland	EEC	CEEC	Tablelands and western slopes of NSW, typically on fertile substrates in lower parts of the landscape (DECC, 2009b).	Predicted	Unlikely – no previous areas mapped within the Forest and not generally known from floodplains
Fish						

Scientific Name	Common Name	TSC/FM Act Status	EPBC Act Status	Habitat Association (DECC, 2009b)	Record Type[1]	Likelihood of Occurrence[2]
Maccullochella peelii peelii	Murray Cod	-	V	The Murray Cod is sedentary and territorial rather than free ranging, and has a distinct preference for woody debris (snags), debris piles and bank side vegetation that provides shelter from high water velocities (Bishop, 1996).	Previous Record	**Likely** – would occur in the Murray River adjacent to Forest and may occupy flood runners within the Forest during flood events.
Maccullochella macquariensis	Trout Cod	E	E	Found close to cover and in relatively fast currents, especially in fairly deep water close to the bank, and often congregate around large woody debris (snags). They tend to remain at the one Forest and to have small home ranges. They are carnivores, preying mainly on other fishes as well as crustaceans and aquatic insects.	DGRs	**Unlikley –** suitable habitat in the Murray River adjacent to the Forest, however the species is regionally restricted to the area between Yarrawonga Weir and the Barmah Choke (ASFB, 2001) approximately 200 km upstream of the Forest.
Bidyanus bidyanus	Silver Perch	V		Prefer fast-flowing, open waters, especially where there are rapids and races, however they will also inhabit warm, sluggish water with cover provided by large woody debris and reeds.The most abundant remaining natural population occurs in the central Murray River downstream of Yarrawonga Weir as well as several of its anabranches and tributaries (DPI, 2009).	Previous Record	**Likely** – would occur in the Murray River adjacent to Forest and may occupy flood runners within the Forest during flood events.
Craterocephalus fluviatilis	Murray Hardyhead	CE	V	Edges of slow-flowing lowland rivers and in lakes, billabongs and backwaters. They are often found amongst aquatic weeds, in both fresh and quite saline waters. They probably feed on aquatic insects, crustaceans and some plant material. Further research is needed to confirm this. Spawning occurs in the warmer months from about October to February. The eggs are randomly dispersed amongst aquatic vegetation	Predicted	**Unlikley –**regionally found in slightly to highly saline waters, mostly in ephemeral deflation basins associated with near-permanent lakes near Kerang and Mildura. It has not been recorded within the Forest and is very unlikely to occur in the future as the Forest contains only ephemeral wetland habitats, which have been

Scientific Name	Common Name	TSC/FM Act Status	EPBC Act Status	Habitat Association (DECC, 2009b)	Record Type[1]	Likelihood of Occurrence[2]
						dry for many years, that would not form saline lakes (DSTA, 2009).
Macquaria australasica	Macquarie Perch	E	E	Found in both river and lake habitats, especially the upper reaches of rivers and their tributaries. They are quiet, furtive fish that feed on aquatic insects, crustaceans and molluscs. Macquarie perch spawn in spring or summer in shallow upland streams or flowing parts of rivers.	Predicted	**Unlikely -** has not been recorded in the Murray River downstream of Yarrawonga Weir (i.e. well upstream of the Forest) in recent years and are now restricted to upland habitats (DSTA, 2009).
Birds						
Anseranas semipalmata	Magpie Goose	V	-	Shallow wetlands (less than 1 m deep) with dense growth of rushes or sedges. Breeding can occur in both summer and winter dominated rainfall areas and is strongly influenced by water level; most breeding now occurs in monsoonal areas; nests are formed in trees over deep water; breeding is unlikely in south-eastern NSW.	Previous Record	**Possible –** may forage in the Forest on a seasonal, migratory basis, more likely during flood events.
Anthochaera phrygia	Regent Honeyeater	E	V	This species is a semi-nomadic species that inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of River She-oak where there are significantly large numbers of mature trees, high canopy cover and abundance of mistletoes. (DECC, 2009b).	Previous Record	**Possible –** may forage in the Forest on a seasonal, migratory basis. Unlikely to breed in the Forest due to absence of large floodplain marshes.
Botaurus poiciloptilus	Australasian Bittern	V	-	Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (*Typha* spp.) and spikerushes (*Elaeocharis* spp.). Hides during the day amongst dense reeds or rushes and feed mainly at night on frogs, fish, yabbies, spiders, insects and snails.	Previous Record	**Present** –recorded in the Gunbower SF immediately across the Murray River from the Forest. Would probably forage in the Forest, especially during flood

Scientific Name	Common Name	TSC/FM Act Status	EPBC Act Status	Habitat Association (DECC, 2009b)	Record Type[1]	Likelihood of Occurrence[2]
						events.
Burhinus grallarius	Bush Stone-curlew	E	-	Inhabits open forests and woodlands with a sparse grassy ground layer and fallen timber. Largely nocturnal, being especially active on moonlit nights (DECC, 2009b).	Previous Record	**Likely –** recent records near the Forest, suitable habitat in the Forest, but may be limited by presence of feral predators.
Climacteris picumnus victoriae	Brown Treecreeper (South- eastern subspecies)	V	-	Found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species (DECC, 2009b).	Previous Record	Absent – Forest is outside the range of this threatened subspecies. Previous records were of the nominate (non-threatened) subspecies *picumnus.*
Glossopsitta pusilla	Little Lorikeet	V	-	Occur in dry, open eucalypt forests and woodlands. Recorded from both old-growth and logged forests in the eastern part of their range, and in remnant woodland patches and roadside vegetation on the western slopes. Feed primarily on nectar and pollen in the tree canopy, particularly on profusely-flowering eucalypts, but also on a variety of other species including melaleucas and mistletoes ;and fruits, particularly those of mistletoes (DECC, 2009b).	Predicted	**Possible** - may occur in the Forest on a seasonal, migratory basis based on previous records in the study area.
Lathamus discolor	Swift Parrot	E	V	The Swift Parrot breeds in Tasmania during spring and summer, migrating in the autumn and winter months to south-eastern Australia from Victoria and the eastern parts of South Australia to south-east Queensland. In NSW, mostly occurs on the coast and south west slopes. Favoured feed trees include winter flowering species such as Swamp Mahogany (*Eucalyptus robusta*), Spotted Gum (*Corymbia maculata*), Red Bloodwood (*C*. *gummifera*), Mugga Ironbark (*E*. *sideroxylon*), and White Box (*E*. *albens*). Commonly used lerp infested trees	Predicted	**Possible –** may occur in the Forest on a seasonal, migratory basis.

Scientific Name	Common Name	TSC/FM Act Status	EPBC Act Status	Habitat Association (DECC, 2009b)	Record Type[1]	Likelihood of Occurrence[2]
				include Grey Box (*E*. *macrocarpa*), Grey Box (*E*. *moluccana*) and Blackbutt (*E*. *pilularis*) and Swift Parrots will return to some foraging Forests on a cyclic basis depending on food availability. Following winter they return to Tasmania where they breed from September to January, nesting in old trees with hollows and feeding in forests dominated by Tasmanian Blue Gum (*E*. *globulus*) (DECC, 2009b).		
Melanodryas cucullata	Hooded Robin	V	-	It is considered a sedentary species, but local seasonal movements are possible. Prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. Requires structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses (DECC, 2009b).	Recent Record	**Present.** Multiple records during site surveys, mainly in box woodlands.
Melithreptus gularis gularis	Black-chinned honeyeater (eastern sub-species)	V	-	Occupies mostly upper levels of drier open forest or woodlands dominated by Box and Ironbark eucalypts, as well as open forests of smooth-barked gums, stringybarks, ironbarks and tea-trees. This species usually occurs in pairs or is nomadic. It forages along twigs, branches, and trunks probing for insects. Nectar is taken from flowers and honeydew is gleaned from foliage. The Black-chinned Honeyeater nests high in the crown of a tree in the uppermost lateral branches (DECC, 2009b).	Previous Record	**Present** – not recorded during site surveys but occurs in the Forest on a seasonal, migratory basis (Webster, 2008; MDBC, 2008).
Ninox connivens	Barking Owl	V	-	Inhabits eucalypt woodlands, open forest, swamp woodlands, and, especially in inland areas, timber along watercourses. During the day they roost along creek lines, usually in tall understorey trees with dense foliage such as Acacia and Casuarina species, or in dense clumps of canopy leaves in large eucalypts. Territories range from 30 to 200 hectares. Nests are built in hollows of large, old eucalypts, including River Red Gum (*Eucalyptus camandulensis*), White Box	Previous Record	**Likely –** previous records within the Forest (Parker, *et al*. 2007) and extensive areas of suitable foraging and roosting resources.

Scientific Name	Common Name	TSC/FM Act Status	EPBC Act Status	Habitat Association (DECC, 2009b)	Record Type[1]	Likelihood of Occurrence[2]
				(*Eucalyptus albens*), Red Box (*Eucalyptus polyanthemos*), and Blakely's Red Gum (*Eucalyptus blakelyi*) (DECC, 2009b).		
Pachycephala inornata	Gilbert's Whistler	V	-	Ranges, plains and foothills in arid and semi-arid timbered habitats. In NSW, it occurs mostly in mallee shrubland, but also in box-ironbark woodlands, Cypress Pine and Belah woodlands and River Red Gum forests. Within the mallee the species is often found in association with an understorey of spinifex and low shrubs, including acacias, hakeas, sennas and grevilleas. In woodland habitats, the understorey comprises dense patches of shrubs.	Recent Record	**Present.** Multiple records during site surveys, exclusively in forest and woodland with dense understorey, mainly of Dwarf Cherry. .
Pedionomus torquatus	Plains-wanderer	E	V	Semi-arid, lowland native grasslands that typically occur on hard red-brown soils. These grasslands support a high diversity of plant species, including a number of state and nationally threatened species. Grassland habitat structure is more important than species composition. Preferred habitat typically has 50% bare ground, 10% fallen litter, and the remaining 40% comprised of herbs, forbs and grasses. Most of the vegetation is <5 cm high but some vegetation up to a maximum of 30 cm is important for concealment, grass tussocks are spaced 10-20 cm apart.	Previous Record	**Unlikley –**limited areas of grassland in the Forest and no natural native grasslands.
Polytelis swainsonii	Superb Parrot	V	V	Generally inhabits Box-Gum, Box-Cypress-pine and Boree Woodlands and River Red Gum Forest. It nests in hollows in small colonies, often with more than one nest in a single tree. It forages up to 10 km from nesting Forests, primarily in grassy box woodland, feeding mainly on grass seed and herbaceous plants, fruits, berries, nectar, buds, flowers, insects and grain (DECC, 2009b).	Predicted	**Possible –**The closest known breeding population is approximately 100 km upstream and to the east of the Forest in and around the Millewa and Gulpa Island State Forests (GHD, 2009b; Webster, 1988; DECCW, 2009b). May forage in the Forest on an occasional or opportunistic basis.

Scientific Name	Common Name	TSC/FM Act Status	EPBC Act Status	Habitat Association (DECC, 2009b)	Record Type[1]	Likelihood of Occurrence[2]
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	-	Open Box-Gum Woodlands on the slopes and Box-Cypress-pine and open Box Woodlands on alluvial plains. It lives in family groups that consist of up to fifteen individuals. All members of the family group remain close to each other when foraging, feeding on invertebrates, either on the trunks and branches of eucalypts and other woodland trees, or on the ground digging and probing amongst litter and tussock grasses. Territories range from 1 to 50 hectares (usually around 10 hectares), and are defended all year round (DECC, 2009b).	Previous Record, DGRs	**Possible –** suitable habitats in box woodlands, but an obvious, easily detected species not recorded in multiple surveys (GHD, 2009b; Webster, 2008). More likely in dry land habitats upslope of the Forest.
Pyrrholaemus saggitatus	Speckled Warbler	V	-	The Speckled Warbler lives in a wide range of *Eucalyptus* dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Large, relatively undisturbed remnants are required for the species to persist in an area (DECC, 2009b).	Previous Record	**Possible –** Forest is remote from core grassy woodland habitat on Western Slopes. Previous records are likely to be vagrants (Webster, 2008).
Rostratula benghalensis s. lat.	Painted Snipe	E	E, M	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds.	Predicted	**Possible –** may occur in limited areas of permanent wetlands in the Forest, or broader areas during flood events.
Stagonopleura guttata	Diamond Firetail	V	-	Open woodland with understorey of native grasses and intact fallen timber and leaf litter (DECC, 2009b).	Previous Record	**Present -** Recorded during site surveys and in late 2008 (GHD, 2009b) in box woodlands.
Mammals						

Scientific Name	Common Name	TSC/FM Act Status	EPBC Act Status	Habitat Association (DECC, 2009b)	Record Type[1]	Likelihood of Occurrence[2]
Chalinolobus picatus	Little Pied Bat	V	-	This species is found in caves, rock outcrops, mine shafts, tunnels, tree hollows and buildings in dry open forest and woodland, mulga woodlands, chenopod shrublands, cypress-pine forest, mallee, and Bimble box communities (DEC 2009b).	Previous Record	**Likely** – Possible Anabat recording in the current survey.
Dasyurus maculatus	Spotted-tailed Quoll	V	E	Large home ranges in variety of woodland and forest types. May have preference for moister types, including tall wet sclerophyll forest. Sub-alpine to coastal (DECC, 2009b).	Predicted	**Possible –** widespread but uncommon and difficult to survey species that may occur in many native woodlands and forests.
Myotis adversus	Large-footed Myotis	V	-	River Red Gum forest, semi-arid woodlands and savannahs. Also occurs in box/ironbark/Callitris open forests and Buloke woodland. Requires large, still water bodies for feeding. Generally roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage.	Previous Record	**Likely** – Possible Anabat recording in the current survey and known from similar River Red Gum forests in the region.
Nyctophilus timoriensis (South-eastern form)	Eastern Long-eared Bat	V	V	Inhabits a variety of vegetation types, including mallee, bulloke *Allocasuarina leuhmannii* and box eucalypt dominated communities, but it is distinctly more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland. Roosts in tree hollows, crevices, and under loose bark. (DECC, 2009b).	Predicted	**Unlikely –** based on FNSW site surveys and specialist opinion is not considered to occur in the River Red Gum Forests of the Riverina.
Petaurus norfolcensis	Squirrel Glider	V		Inhabits dry sclerophyll forest and woodland. Potential habitat includes Box-Ironbark woodland and River Red Gum forests. Requires abundant hollow bearing trees and a mix of eucalypts, banksias and acacias (DECC, 2009b).	Previous Record	**Likely** –recent record in the Forest, tentative observations during site surveys.

Scientific Name	Common Name	TSC/FM Act Status	EPBC Act Status	Habitat Association (DECC, 2009b)	Record Type[1]	Likelihood of Occurrence[2]
Phascogale tapoatafa	Brush-tailed Phascogale	V	-	Prefer dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter. Also inhabit heath, swamps, rainforest and wet sclerophyll forest. Nest and shelter in tree hollows with entrances 2.5 - 4 cm wide and use many different hollows over a short time span.	Previous Record	**Possible –** widespread but uncommon and difficult to survey species that may occur in many native woodlands and forests.
Phascolarctos cinereus	Koala	V	-	The Koala has a fragmented distribution throughout eastern Australia. It is limited to areas of preferred feed trees in eucalypt woodlands and forests. Size of home range varies depending on the quality of habitat, ranging from less than 2 ha to several hundred hectares in size. Females breed at two years of age and produce one young per year (DEC, 2009).	Previous Record	**Likely** –historical records in the Forest. Fragmented, but expanding introduced population known from the Riverina.
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat	V	-	Distribution encompasses study area. Known to forage and roost in a wide variety of habitats. Roosts singly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows. Forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory. Forages high and fast over the forest canopy or lower in more open country.	Recent record.	**Likely** – recorded in the Forest in late 2008 (GHD, 2009b).
Frogs						
Litoria raniformis	Southern Bell Frog	E	V	Usually found in or around permanent or ephemeral Black Box/Lignum/Nitre Goosefoot swamps, Lignum/Typha swamps and River Red Gum swamps or billabongs along floodplains and river valleys. They are also found in irrigated rice crops, particularly where there is no available natural habitat. Requires still or very slow flowing water.	Predicted	**Unlikely** – despite broadly suitable habitat, no previous records in the locality, nor in well-surveyed River Red Gum forests in the Central Murray (Ward, 2006).
Reptiles						

Scientific Name	Common Name	TSC/FM Act Status	EPBC Act Status	Habitat Association (DECC, 2009b)	Record Type[1]	Likelihood of Occurrence[2]
Delma impar	Striped Legless Lizard	V	V	Found mainly in Natural Temperate Grassland, secondary grassland near Natural Temperate Grassland and occasionally in open Box-Gum Woodland. Habitat is where grassland is dominated by perennial, tussock-forming grasses such as Kangaroo Grass (*Themeda australis*), spear-grasses (*Austrostipa* spp.) and poa tussocks (*Poa* spp.), and occasionally wallaby grasses (*Austrodanthonia* spp.) Sometimes present in modified grasslands with a significant content of exotic grasses.	Predicted	**Unlikely** –no suitable grassy box-gum woodlands with stone fragments in the Forest.

***Record type: the nature of the entities previous or predicted occurrence in the study area:**

- Recent Record – previous record on Wildlife Atlas (DECC, 2009a) within 10km of the Forest; Bionet (2009) record or recent (post 2000) literature review record.
- Present– Known to occur within the Forest based on GHD (2009a) and GHD (2009b) records.
- Predicted – predicted to occur within study area by DEWHA (2009a) Protected Matters Search Tool or by DPI (2009) listings for Murray CMA and associated distribution descriptions..
- DGRs – listed in DECC DGRs for the project

Appendix C

Part 3a Assessments of Significance

C.1 Approach

Based on the assessments presented above the project may result in the following impacts on threatened biota listed under the NSW TSC or FM Acts:

- Removal of habitat and potentially direct disturbance of four threatened plant species *Amphibromus fluitans, Austrostipa wakoolica, Lepidium monoplocoide;* and *Swainsona murrayana;*
- Direct clearing and removal of habitat of one EEC, Inland Grey Box Grassy Woodland; and
- Removal of habitat and potential mortality, disturbance or displacement of 11 species of terrestrial fauna, including:
  - the woodland birds - Gilberts Whistler, the Hooded Robin, Diamond Firetail and the Black-chinned Honeyeater;
  - the microbats Yellow-bellied Sheathtail Bat, Large-footed Myotis and Little Pied Bat;
  - the arboreal mammals – the Squirrel Glider and the Koala;
  - the wetland bird Australasian Bittern;
  - the ground-dwelling woodland bird Bush Stone-curlew; and
  - the preliminary-listed woodland birds , the White-browed Woodswallow, Varied Sittella and Scarlet Robin;
- Modification of habitat and changes to the life cycle of one threatened fish, the Silver Perch; and
- Direct impacts and modification of habitat for the FM Act listed EEC, Murray River Ecological Community.

An evaluation of the magnitude, extent and significance of impacts of the proposal on these threatened biota and their habitats following the assessment criteria identified in the Guidelines for Threatened Species Assessment under Part 3A of the EP & A Act (DEC 2005 and DPI 2005) has been undertaken and is included below.

C.2 Impacts Summary

The proposed construction would involve impacts on native vegetation and habitats including:

- Temporary removal or modification of approximately 206 ha of native vegetation within project construction footprints that would be allowed to regenerate to their pre-disturbance state.
- Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints;
- Removal of approximately 532 habitat trees counted within confirmed infrastructure footprints and potential removal of habitat trees within a further 78 ha of construction footprints that had not been located at the time of the survey.

The site contains approximately 31,000 ha of native vegetation and habitats that would not be removed or modified.

The proposed operation of the scheme would involve the inundation of up to 17,700 ha of the site via the diversion of up to 6000 ML/day of water from the Murray River to the site. A flood pool would be maintained at RL 78.5m AHD, inundating approximately 14,000 ha of the site for a 55 day period.

Inundation depth and duration would vary with position on the floodplain. Adaptive management of the project would aim to avoid negative ecological impacts as far as is practicable, for instance appropriate flood levels would be maintained to facilitate waterbird breeding if it commences during a managed flood. The site is dominated by flood-dependant biota and so the proposed inundation is expected to have net positive impacts. Negative impacts would include inundation of terrestrial vegetation and flooding or isolation of areas of terrestrial fauna habitat.

Negative impacts on aquatic fauna would include creation of a blackwater event in the flood pool, increased recruitment of pest fish and partial restrictions to fish passage.

Negative impacts of vegetation and habitat removal would be offset by positive impacts from the environmental watering of 17,700 ha of equivalent habitats within the inundation area. Negative impacts of blackwater events and pest fish recruitment would be offset by transfer of organic carbon and other nutrients between river and floodplain and the likely boost to health and productivity of aquatic ecosystems.

C.3 Assessments of Significance

C.3.1 Threatened Flora Species

The desktop literature review indicates eleven threatened plant species which have previously been recorded, or are predicted to occur in the locality. None of these species were recorded during site surveys. There is suitable habitat for four threatened plant species at the site:

- *Amphibromus fluitans* (Floating Swamp Wallaby-grass)
- *Austrostipa wakoolica;*
- *Lepidium monoplocoides;* and
- *Swainsona murrayana.*

Direct impacts on adult individuals of these moisture-loving plants (DECCW, 2009b) are unlikely due to the dryness of the site. There is the potential for mortality of dormant individuals and removal of habitat if suitable habitat occurs within surface disturbance areas. An AoSs prepared according to the DEC/DPI (2005) guidelines is presented below. For the purposes of this AoS these three species of threatened plants are grouped since they have similar ecological characteristics. Impacts on common habitat resources are presented together. Impacts on specific aspects of their life cycle are assessed separately.

Table 1 Assessment of Significance for Threatened plants

Criteria	*Amphibromus fluitans*	*Austrostipa wakoolica*	*Lepidium monoplocoides*	*Swainsona murrayana*
i) How is the project likely to affect the lifecycle of a threatened species and/or population?				
a) displaces or disturbs threatened species and/or populations;	There is suitable habitat for the species in permanent or semi-permanent swamps with fluctuating water levels within the site. Direct impacts on the species are highly unlikely because the construction corridor is remote from permanent wetlands and the remainder of the site is dry.	No individuals of these threatened plants were recorded during site surveys. There are extensive areas of habitat for these species at the site including seasonally moist to waterlogged sites across the floodplain (DECCW, 2009b). Adult individuals of these moisture-loving plants (DECCW, 2009b) are unlikely to occur during the construction period, given the prolonged drying of the site. They may occur within the construction corridor as dormant individuals or in the soil seed bank. The proposed construction may disturb or displace these dormant individuals if they occur within surface disturbance areas. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This magnitude of disturbance is unlikely to threaten the persistence of these species at the site.		
	The proposed inundation of a portion of the site would increase the area of potentially suitable habitat for the species and would be expected to have positive effects.	The proposed inundation of a portion of the site would increase soil moisture and thus the area of potentially suitable habitat for the species and would be expected to have positive effects.		
b) disrupts breeding cycle;	Not relevant to the assessment of these threatened flora species. Refer to Sections f), g) and h) for assessment relevant to plants.			
c) disturbs the dormancy period; d) disrupts roosting behaviour; or e) changes foraging behaviour.	Not relevant to the assessment of these threatened flora species.			

f) disrupts pollination cycle;	As grasses, *Austrostipa wakoolica* and *Amphibromus fluitans* would rely on the wind to disperse their pollen. The proposed construction is unlikely to remove any adult individuals, isolate any areas of habitat from the wind or otherwise disrupt the pollination cycle of these species or any other native grasses.	Information on pollinators for *Lepidium monoplocoides* and *Swainsona murrayana* was not available. As members of the Families Brassicaceae and Fabaceae subf. Faboides respectively their flower morphology suggests they would rely on insect pollinators. The project will result in the loss of only a small percentage of their potential habitat as well as habitat for potential pollinators from the surrounding region and would have a minor effect on their overall populations, should they occur locally. Considering the limited width of disturbance footprints (less than 50 metres) and the extent of intact native vegetation to be retained the project is unlikely to create significant barriers within the landscape for any pollinators. As such the project is unlikely to disrupt the pollination cycle of either of these species, should they occur in the locality.
g) disturbs seedbanks;	The proposed construction will disturb the soil seedbank within a maximum of 206 ha of habitat for these plant species. The soil seedbank would remain at least partially intact within the majority of this area and would only be permanently removed within the immediate infrastructure footprints.	
h) disrupts recruitment (i.e. germination and establishment of plants);	None of these species have been recorded within the disturbance footprint and so there is no direct evidence that the habitat to be removed or modified is important for connecting local populations or allowing for germination or recruitment. The project is unlikely to disturb pollinators nor comprise an obstacle to wind-aided pollination (see section g). The proposed construction would have a minor impact by reducing the overall area of potential habitat that these species could potentially colonise in the future. The proposed inundation would have positive effects on germination and establishment of these threatened plants.	
i) affects the interaction between threatened species and other species in the community (e.g. Pollinators, host species, microrrhizal associations).	The project is unlikely to disrupt any known pollinators (see section g above). Only a small percentage of potential habitat will be removed for these species. None of these species have been recorded within the disturbance footprint and alternative habitat exists within the site and locality. Environmental management measures should ensure that negative effects from the proposed activity would be confined to the surface disturbance area, and thus the project is unlikely to affect interactions with other species in the community in habitat outside the site.	

ii) How is the project likely to affect the habitat of a threatened species, population or ecological community?	
a) disturbs any permanent, semi permanent or ephemeral water bodies;	The proposed construction would directly disturb a number of intermittent water bodies at the locations of the proposed regulators and channels. This would remove habitat within the construction footprint and modify the form and flow characteristics of the water body. Negative effects would be very limited in extent in the context of the extensive network of intermittent water bodies at the site. The majority of the remainder of the site, including the entire construction disturbance footprint, is an ephemeral floodplain wetland. These habitats would have limited value for these moisture-loving threatened plants in their current dry state and are unlikely to contain any adult plants during the construction period. The proposed operation of the project would affect: the Murray River; approximately 1200 ha of mapped floodplain marshes and drainage lines; a multitude of smaller flood runners; and ephemeral forest-wetlands on the floodplain itself. The project is expected to have net-positive effects on these habitats through restoration of a more natural flood regime. These threatened plants would also be expected to experience positive effects such as an increase in flooded wetland area and a general increase in floodplain health and productivity as a result of flooding. The project would divert water away from the Murray River potentially reducing flows into habitat for the species outside the site. The water diverted into the forest will largely be environmental water that would be 'called' and released from upstream storages specifically for the purpose of achieving flows into the site. As such, water diverted at Torrumbarry weir will be flow that would not otherwise be in the system and, hence the diversions should have minimal or no impact on the Murray River flows (personal communication, D Green, MDBA, 2009).
b) degrades soil quality;	The project would degrade soil quality within the construction disturbance footprint through direct removal, earthworks or compaction. Negative impacts would affect a very minor proportion of the site: a maximum of 206 ha out of an area of approximately 32,000 ha. Measures to contain impacts from construction, including sediment control and the retention and re-spreading of topsoil will be implemented, and thus soil quality is unlikely to be affected outside of the immediate surface disturbance area. This magnitude of degradation is unlikely to result in significant negative effects on any habitat or resources for these species.
c) clears or modifies native vegetation;	Construction for the project would require the clearing or modification of native vegetation within the surface disturbance area, including: ◗ Temporary disturbance of approximately 206 ha of native vegetation. This includes 116 ha of project construction footprints that would be allowed to regenerate to their pre-disturbance state; and ◗ Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints.

	The site contains approximately 31,000 Ha of native vegetation and habitats that would not be removed or modified. The removal of this vegetation would reduce the area of available habitat for these species and potentially affect pollination, dispersal ability or other components of the life cycles of plants. These effects are described in the relevant Criteria within this assessment. The outcome of these assessments is that the proposed clearing or modification of native vegetation is unlikely to have a significant negative effect.
d) introduces weeds, vermin or feral species or provides conditions for them to increase and/or spread;	Native vegetation within the study area featured moderate weed infestation in the central portions of vegetation patches, with moderate to severe infestations around the margins of the forest and near to drainage lines. The proposed construction would involve the clearing of native vegetation and replacement with areas of roads, stockpiles, and project infrastructure. The project may increase the spread and/or prevalence of exotic weeds in the site through soil disturbance and transmission of propagules on vehicles and equipment. It is likely that areas environmental weed infestation would increase within the project disturbance footprint. The majority of the disturbance footprint is associated with the downstream levee which is adjacent to disturbed cleared land. The remainder of the site is partially disturbed by FNSW access tracks and ongoing timber harvesting and grazing activities. In this context, construction activities would have a relatively minor impact on the overall numbers and extent of weed species in the locality. The proposed flooding would transmit weed propagules into the site and increase soil moisture and nutrient status. These changes are likely to increase the degree of weed infestation at the site. This effect would be balanced by positive effects to the health of native vegetation. Inundation is likely to have net positive impacts for these moisture-loving species of floodplain plants. Terrestrial vermin or feral species are not expected to increase and/or spread as a result of the project. The proposed activity will not significantly fragment or isolated any habitat nor result in any other changes that are likely to favour feral animals.
e) removes or disturbs key habitat features such as trees with hollows, caves and rock crevices, foraging habitat;	Not relevant to the assessment of these threatened plants.
f) affects natural revegetation and recolonisation of existing species following	The proposed construction would have a minor negative impact on the ability of these plant species to recolonise following disturbance by reducing the overall amount of available habitat and the overall amount of potential propagules in the soil seed bank. The proposed inundation will have a positive effect on natural revegetation and recolonisation of plant species following

disturbance.	disturbance by increasing soil moisture and potentially also by transmitting propagules. Inundation is highly likely to benefit the semi aquatic grass *Amphibromus fluitans* but is also likely to benefit the other three species which are known to grow or reproduce on floodplains in response to inundation (DECCW, 2009b).
iii) Does the project affect any threatened species or populations that are at the limit of its known distribution?	These threatened flora species have broad, patchy distributions (DECCW, 2009b). None of these species are at the limit of their geographical range at the site.
iv) How is the project likely to affect current disturbance regimes?	
a) modifies the intensity and frequency of fires;	The project would not directly affect the intensity and frequency of fires.
b) modifies flooding flows;	The project would have a positive effect on the flooding flows by restoring a more natural flood regime to the site. This would be expected to have net positive effects on these threatened plants by improving the extent of inundated wetland habitats for *Amphibromus fluitans* and improving the health and productivity of floodplain habitats for the other three species.
v) How is the project likely to effect habitat connectivity?	
a) creates a barrier to fauna movement;	Not relevant to the assessment of these threatened plants.
b) removes remnant vegetation or wildlife corridors; and	The proposed construction would disturb or modify 206 ha of habitat in native vegetation within infrastructure footprints. The gaps thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. The soil seed bank would remain at least partially intact in these areas. These four understorey species would be able to regenerate in all but the immediate infrastructure footprints.
c) modifies remnant vegetation or wildlife corridors.	The proposed construction would temporarily remove and/or modify 116 ha of habitat in native vegetation within the construction corridor. These areas would contain regenerating understorey vegetation after construction. The modified areas thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation.
iv) How is the project likely to affect critical habitat?	There is no listed critical habitat at the site or of relevance to this AoS.

Conclusion	habitat within the construction footprints would have limited value for these threatened plants in their current drought-affected state and are unlikely to contain adult individuals during the construction period. Negative impacts arising from the project would be limited to indirect effects and would affect a very minor proportion of individuals and habitats. The proposed inundation of a portion of the site would increase the area of potentially suitable habitat for the species and would be expected to have positive effects through a general increase in floodplain health and productivity as a result of flooding. Therefore the project is not likely to have a significant negative effect on local populations of *Amphibromus fluitans, Austrostipa wakoolica, Lepidium monoplocoides* or *Swainsona murrayana.*

C.3.2 Endangered Ecological Communities

Table 2 Assessment of Significance for Inland Grey Box Woodland

Criteria	Inland Grey Box Woodland
i) How is the project likely to affect the lifecycle of a threatened species and/or population?	Not applicable to the assessment of this EEC.
ii) How is the project likely to affect the habitat of a threatened species, population or ecological community?	
a) disturbs any permanent, semi permanent or ephemeral water bodies;	The proposed construction would directly disturb a number of intermittent and ephemeral floodplain wetlands. These areas do not comprise habitat for Inland Grey Box Woodland. The proposed operation of the project would affect: the Murray River; approximately 1200 ha of mapped floodplain marshes and drainage lines; a multitude of smaller flood runners; and ephemeral forest-wetlands on the floodplain itself. The project is expected to have net-positive effects on these habitats through restoration of a more natural flood regime. These areas do not comprise habitat for Inland Grey Box Woodland. Potential adverse effects on the EEC through the proposed inundation are addressed below.
b) degrades soil quality;	The project would degrade soil quality within the construction disturbance footprint through direct removal, earthworks or compaction. Negative impacts would affect a very minor proportion of the site: a maximum of 206 ha out of an area of

Criteria	Inland Grey Box Woodland
	approximately 32,000 ha. Measures to contain impacts from construction including sediment control and the retention and re-spreading of topsoil will be implemented, and thus soil quality is unlikely to be affected outside of the immediate surface disturbance area. This magnitude of degradation is unlikely to result in a significant negative effect on the EEC.
c) clears or modifies native vegetation;	The proposed construction would permanently remove approximately 8 ha of Inland Grey Box Woodland within the footprints of the proposed inlet regulator, inlet channel and associated maintenance tracks. The project may temporarily modify additional areas of Inland Grey Box Woodland where the community falls within the construction corridor. The removal of 8 ha of the community is a minor proportion (0.84%) of the approximately 951 ha of Inland Grey Box Woodland at the site. The proposed operation of the project would modify approximately 189 ha of the community through inundation (i.e. approximately 20% of the community at the site). There is some evidence that inundation may have negative effects on the health of Inland Grey Box trees (Vesk et. al., in prep.). The effects of prolonged inundation on this community have not been studied in detail, however there is indirect evidence that Inland Grey Box Woodland has similar tolerances as Black Box Woodland (Cooling, M. pers. comm.). Black Box can tolerate inundation for < 4 months (Roberts and Marston, 2000) i.e. less than 120 days. Based on DHI (2008) modelling of the indicative scenario no Inland Grey Box Woodland at the site will be inundated for greater than 120 days. Therefore the proposed inundation is unlikely to result in significant or irreversible impacts on local populations of Inland Grey Box Woodland.
d) introduces weeds, vermin or feral species or provides conditions for them to increase and/or spread;	Native vegetation within the study area featured moderate weed infestation in the central portions of vegetation patches, with moderate to severe infestations around the margins of the forest and near to drainage lines. The proposed construction would involve the clearing of native vegetation and replacement with areas of roads, stockpiles, and project infrastructure. The project may increase the spread and/or prevalence of exotic weeds in the site through soil disturbance and transmission of propagules on vehicles and equipment. It is likely that areas environmental weed infestation would increase within the project disturbance footprint. The majority of the disturbance footprint is associated with the downstream levee which is adjacent to disturbed cleared land. The remainder of the site is partially disturbed by FNSW access tracks and ongoing timber harvesting and grazing activities. In this context, construction activities would have a relatively minor impact on the overall numbers and extent of weed species in the locality. The proposed flooding would transmit weed propagules into the site and increase soil moisture and nutrient status. These changes are likely to increase the degree of weed infestation at the site. This effect would be partially balanced by positive effects to the health of native vegetation. Inundation is likely to have net positive impacts for flood-dependant species within the Inland Grey Box Woodland, including River Red Gums and macrophytes in the understorey. Understorey grasses and annual herbs are also likely to experience a flush of growth after flooding.

Criteria	Inland Grey Box Woodland
	Terrestrial vermin or feral species are not expected to increase and/or spread as a result of the project. The proposed activity will not significantly fragment or isolated any habitat nor result in any other changes that are likely to favour exotic animals.
e) removes or disturbs key habitat features such as trees with hollows, caves and rock crevices, foraging habitat;	Not relevant to the assessment of this EEC.
f) affects natural revegetation and recolonisation of existing species following disturbance.	The proposed construction would have a minor negative impact on the ability of the EEC to recolonise following disturbance by reducing the overall amount of available habitat and the overall amount of potential propagules in the soil seed bank. The proposed inundation may suppress seed production or otherwise reduce the health of Inland Grey Box (Vesk *et al*., in prep) which may limit regeneration ability. The proposed inundation will have a positive effect on natural revegetation and recolonisation of some native plant species following disturbance by increasing soil moisture and potentially also by transmitting propagules. Notably, River Red Gum, which occurs in the canopy of the EEC at the site, would experience increased regeneration through the proposed flooding. Many understorey species within the EEC are also likely to experience improved regeneration through flooding. Given the location of the EEC on the floodplain previous flood events do not appear to have significantly affected the persistence of local populations of the EEC.
iii) Does the project affect any threatened species or populations that are at the limit of its known distribution?	The site is near the south-western limit of the EECs distribution in NSW. Inland Grey Box Woodland continues to the south, through Victoria and into South Australia, but does not occur in far western NSW or central Australia (DECCW, 2009b). The form of the EEC at the site (i.e. a floodplain community, co-occurring with River Red Gum) has a very restricted distribution on the floodplain of the central Murray valley (Benson, 2006). The site is near the centre of this sub-distribution and includes some of the most extensive and significant areas of the community in NSW (Benson, 2006). The removal of 8 ha of the community would have a minor effect on its overall distribution.
iv) How is the project likely to affect current disturbance regimes?	
a) modifies the intensity and frequency of fires;	The project would not directly affect the intensity and frequency of fires.
b) modifies flooding flows;	The project would alter flooding flows by restoring a more natural flood regime to the site. This will involve an overall increase in the average frequency, extent and duration of floods and under the indicative scenario would involve the

Criteria	Inland Grey Box Woodland
	simulation of a large flood event. The pattern of inundation (in terms of extent, depth and duration) will differ from a natural flood of an equivalent magnitude due to the influence of project infrastructure. The most pronounced differences will occur in the downstream section, where the flood pool would be maintained above the downstream levee. Changes in the upstream section would be restricted to the vicinity of the inlet channel and would only be for the duration of the filling phase (i.e. less than 55 days). Flood depths would be comparatively shallow in the upstream section and would recede relatively rapidly. No Inland Grey Box Woodland at the site would be inundated for in excess of 120 days (DHI, 2008).
v) How is the project likely to effect habitat connectivity?	
a).creates a barrier to fauna movement;	Not relevant to the assessment of this EEC.
b) removes remnant vegetation or wildlife corridors; and	The proposed construction would remove approximately 8 ha of inland Grey Box Woodland. The disturbance would occur as a single linear strip, less than 50m wide through the centre of a patch of near continuous native vegetation of approximately 32, 000 ha. Continuity of native vegetation, including of Inland Grey Box Woodland, would be maintained around the disturbance footprint. The proposed construction would remove a further 49 ha of habitat in other native vegetation within infrastructure footprints across the site, which would affect the maintenance and recruitment of native plants common to the EEC. The gaps thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. The soil seed bank would remain at least partially intact in these areas. Understorey species, including some species representative of the EEC would be allowed to regenerate in all but the immediate infrastructure footprints. This limited area of clearing would not comprise the 'removal' of a patch of native vegetation nor isolate any areas of habitat. Ecosystem functions, such as pollination, seed fall and regeneration are likely to continue across these modified areas of habitat.
c) modifies remnant vegetation or wildlife corridors.	The proposed construction would temporarily remove and/or modify 116 ha of habitat in native vegetation within the construction corridor. These areas would contain regenerating understorey vegetation after construction. The modified areas thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Ecosystem functions necessary to the maintenance of the EEC, such as pollination, seed fall and germination of plants, are likely to continue across these modified areas of habitat.
iv) How is the project likely to affect critical habitat?	There is no listed critical habitat at the site or of relevance to this AoS.

Criteria	Inland Grey Box Woodland
Conclusion	The proposed construction would permanently remove approximately 8 ha of Inland Grey Box Woodland which is a minor proportion (0.84%) of the approximately 951 ha of Inland Grey Box Woodland at the site. The proposed operation of the project would modify approximately 189 ha of the community (i.e. approximately 20%) through inundations. Despite some evidence that inundation may have some negative effects on the health of Inland Grey Box trees (Vesk et. al., in prep) there is indirect evidence that Inland Grey Box Woodland can tolerate inundation for up to 4 months (Cooling, M. pers. comm., Roberts and Marston, 2000) i.e. less than 120 days. Based on DHI (2008) modelling of the indicative scenario no Inland Grey Box Woodland at the site will be inundated for greater than 120 days. Therefore the proposed inundation is unlikely to result in significant or irreversible impacts on local populations of Inland Grey Box Woodland. Based on the above considerations the project is not likely to have a significant negative effect on local populations of Inland Grey Box Woodland. Further the proposed offset strategy for the project will compensate for negative impacts on local populations of the EEC. The proposed conservation and management of 94 ha of Inland Grey Box Woodland within the offset site would compensate for the removal of approximately 8 ha of the community and produce a net gain in the viability of Inland Grey Box Woodland at the site in the long term.

C.3.3 Threatened Terrestrial Fauna Species

A total of 11 threatened fauna species and a further three species that have a preliminary listing as threatened species under the TSC Act are known, or are highly likely to occur at the site based on the site surveys or other recent survey records. The project has the potential for negative effects on these species or their habitats. Where appropriate, multiple species of threatened fauna are grouped according to similar ecological characteristics and impacts on common habitat resources are presented together. The following AoSs are presented below:

- Four threatened species of woodland birds - Gilberts Whistler, the Hooded Robin, Diamond Firetail and the Black-chinned Honeyeater;
- Three species of microbats - Yellow-bellied Sheathtail Bat, Large-footed Myotis and Little Pied Bat all of which are flexible in their selection of roost sites and may roost in tree hollows at the site (DECCW, 2009b);
- Two species of arboreal mammal – the Squirrel Glider and the Koala;
- The wetland bird Australasian Bittern;
- The hollow-dependant forest owl Barking Owl;
- The ground-dwelling woodland bird Bush Stone-curlew; and
- Three species of preliminary-listed Woodland birds, the White-browed Woodswallow, Varied Sittella and Scarlet Robin.

Table 3 Assessment of Significance for Threatened Woodland Birds

Criteria	Hooded Robin	Gilbert's Whistler	Diamond Firetail	Black-chinned honeyeater
i) How is the project likely to affect the lifecycle of a threatened species and/or population?				
a) displaces or disturbs threatened species and/or populations;	The Hooded Robin was recorded in low numbers in all habitats at the site. The proposed construction may displace or disturb some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within 32, 000 ha of similar habitat at the site. This magnitude of disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would limit the species' access to preferred habitat in the understorey and on the ground and so may displace	Gilbert's Whistler was only recorded in suitable habitat with a dense shrub layer of Dwarf Cherry at the site. The proposed construction may displace or disturb some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This magnitude of disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would limit the species' access to preferred habitat in the shrub and small tree layer and so	The Diamond Firetail was recorded in grassy River Red Gum woodland near the boundary of the site in the current site surveys and by GHD (2009b). The proposed construction may displace or disturb some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of local populations given the maximum construction corridor of 206 ha within 32, 000 ha of similar habitat at the site. This disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would limit the species' access to	There are recent Summer-Autumn records of the Black-chinned Honeyeater at the site (MDBC, 2008). It is likely that the species exploits seasonal nectar resource in flowering Eucalypts at the site. The proposed construction may displace or disturb some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within 32, 000 ha of similar habitat at the site. This disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would not affect the

Criteria	Hooded Robin	Gilbert's Whistler	Diamond Firetail	Black-chinned honeyeater
	some individuals for the duration of the inundation period. There are extensive areas of alternative habitat that would not be inundated including approximately 15,000 ha of comparable woodland and forest within the project site. Local populations of the species have persisted in the context of natural flood regimes and are likely to utilise alternative habitat and reoccupy the inundation area after flood recession.	may displace some individuals for the duration of the inundation period. There are extensive areas of alternative habitat that would not be inundated within the project site. Local populations of the species have persisted in the context of natural flood regimes and are likely to utilise alternative habitat and reoccupy the inundation area after flood recession.	preferred habitat on the ground and so may displace some individuals for the duration of the inundation period. The species preferred grassy habitat is at the upslope edge of the floodplain. These higher areas would be inundated less frequently and for relatively brief periods. There are extensive areas of alternative habitat that would not be inundated both within and outside the project site. Local populations would readily utilise alternative habitat and reoccupy the inundation area after flood recession.	species' access to preferred habitat in the canopy and so is unlikely to displace any individuals.
b) disrupts breeding cycle;	The Hooded Robin, Gilbert's Whistler and Diamond Firetail are sedentary species (DECCW, 2009b). The Black-chinned Honeyeater is locally migratory (MDBC, 2008) but records at the site overlap with the species June to December breeding period. Therefore the site is likely to support local breeding populations of these four species of threatened Woodland birds. The proposed construction may disrupt the breeding behaviour of some individuals if they are nesting within or near the disturbance area. This disturbance would be for one breeding season only, is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within 32, 000 ha of similar habitat at the site. This disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site may disrupt the breeding cycle of the species by flooding potential nest sites and/or increasing the distance that must be traversed to reach suitable, dry foraging habitat. The site contains substantial areas of alternative breeding habitat and so serious impacts are only likely for individuals that have commenced breeding and subsequently have their nest site inundated. These effects may be balanced by positive, impacts such as increased			

Criteria	Hooded Robin	Gilbert's Whistler	Diamond Firetail	Black-chinned honeyeater
	productivity of the floodplain, which would benefit other breeding individuals.			
c) disturbs the dormancy period;	None of these threatened woodland birds are known to have a dormancy period that could potentially be affected by the project.			
d) disrupts roosting behaviour;	None of these threatened woodland birds are known to exhibit long term or ecologically important roosting behaviour that could potentially be affected by the project. These species would roost daily in appropriate areas of native vegetation. The proposed construction may affect some roosting individuals if they are roosting within or near the disturbance area. This disturbance would be short-term, is likely to affect a small proportion of local populations and is unlikely to threaten the persistence of the species at the site. Floodwaters would be well below the level of the canopy and so inundation would not affect canopy-roosting species. There would be a reduction in the area of suitable habitat for shrub-roosting species for the duration of inundation. The majority of the inundation area would be less than one metre deep. There are extensive areas of alternative habitat that would not be inundated. A proportion of local species and individuals may also alter their behaviour to roost in the canopy. Local populations of these species have persisted in the context of natural flood regimes and are likely to utilise alternative roosting habitat and reoccupy the inundation area after flood recession.			
e) changes foraging behaviour;	The Hooded Robin was recorded in low numbers in all habitats at the site. The species uses low perches to target prey on the ground and so may favour areas with a small tree/shrub layer and intact groundcover. The proposed construction may displace or disturb some individuals if they are foraging within or near the disturbance area. This disturbance would be short-term and is likely to affect a	Gilbert's Whistler was only recorded in suitable habitat with a dense shrub layer of Dwarf Cherry at the site. The proposed construction may change foraging behaviour of some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the	The Diamond Firetail was recorded in grassy River Red Gum woodland near the boundary of the site in the current site surveys and by GHD (2009b). The proposed construction may change foraging behaviour of some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction	There are recent Summer-Autumn records of the Black-chinned Honeyeater at the site (MDBC, 2008). It is likely that the species exploits seasonal nectar resource in flowering Eucalypts at the site. The proposed construction may change foraging behaviour of some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of

Criteria	Hooded Robin	Gilbert's Whistler	Diamond Firetail	Black-chinned honeyeater
	small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This disturbance is unlikely to threaten the persistence of the species at the site. Some foraging habitat would be permanently removed (refer *Criteria ii*). The species would have to utilise alternative habitat to compensate for this loss of resources. In the context of the approximately 31,000 ha of alternative habitat at the site this would comprise a minor impact. The proposed inundation of a portion of the site would limit the species' access to preferred foraging habitat in the understorey and on the ground and so may change foraging behaviour of some individuals for the duration of the inundation period. The likely increase in productivity of invertebrate and plant populations in response to	32, 000 ha of similar habitat at the site. This disturbance is unlikely to threaten the persistence of the species at the site. Some foraging habitat would be permanently removed (refer *Criteria ii*). These species would have to utilise alternative habitat to compensate for this loss of resources. In the context of the approximately 31,000 ha of alternative habitat at the site this would comprise a minor impact. The proposed inundation of a portion of the site would limit the species' access to preferred habitat in the shrub and small tree layer and so may displace some individuals for the duration of the inundation period. The likely increase in productivity of invertebrate and plant populations in response to flooding (Boulton and Brock, 1999) may compensate for the reduction in the area of dry land habitat. Regardless, there are extensive areas of	corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This disturbance is unlikely to threaten the persistence of the species at the site. Some foraging habitat would be permanently removed (refer *Criteria ii*). The species would have to utilise alternative habitat to compensate for this loss of resources. In the context of the approximately 31,000 ha of alternative habitat at the site this would comprise a minor impact. The proposed inundation of a portion of the site would limit the species' access to preferred habitat on the ground and so may displace some individuals for the duration of the inundation period. The species preferred grassy habitat is at the upslope edge of the floodplain. These higher areas would be inundated less frequently and for relatively brief periods. There are extensive areas of	local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This disturbance is unlikely to threaten the persistence of the species at the site. Some foraging habitat would be permanently removed (refer *Criteria ii*). The species would have to utilise alternative habitat to compensate for this loss of resources. In the context of the approximately 31,000 ha of alternative habitat at the site this would comprise a minor impact. The proposed inundation of a portion of the site would not affect the species' access to preferred foraging habitat in the canopy and so is unlikely to displace any individuals. The species may experience positive impacts through increased growth and nectar production of flowering Eucalyptus in response to flooding.

Criteria	Hooded Robin	Gilbert's Whistler	Diamond Firetail	Black-chinned honeyeater
	flooding (Boulton and Brock, 1999) may compensate for the reduction in the area of dry land habitat. Regardless, there are extensive areas of alternative habitat that would not be inundated including approximately 15,000 ha of comparable woodland and forest within the project site. Local populations of the species have persisted in the context of natural flood regimes and are likely to utilise alternative habitat and reoccupy the inundation area after flood recession.	alternative habitat that would not be inundated within the project site. Local populations of the species have persisted in the context of natural flood regimes and are likely to utilise alternative habitat and reoccupy the inundation area after flood recession.	alternative habitat that would not be inundated both within and outside the project site. Local populations would readily utilise alternative habitat and reoccupy the inundation area after flood recession. The increase in grass productivity after inundation may result in net-positive impacts on the species.	
f) disrupts pollination cycle; g) disturbs seedbanks; or h) disrupts recruitment (i.e. germination and establishment of plants);	Not relevant to these threatened woodland bird species.			
i) affects the interaction between threatened species and other species in the community (eg. Pollinators, host species, microrrhizal associations).	Not relevant to these threatened woodland bird species.			
j) affects migration and	The proposed construction may affect migration and dispersal ability through direct disturbance and removal of habitat			

Criteria	Hooded Robin	Gilbert's Whistler	Diamond Firetail	Black-chinned honeyeater
dispersal ability;	within disturbance footprints. This would affect limited areas for limited periods. Birds would readily traverse obstacles and gaps in habitat created by permanent project infrastructure. The proposed inundation of a portion of the site would flood habitats in the understorey and on the ground and so may limit the migration and dispersal ability of some individuals for the duration of the inundation period. Potential travelling and resting habitat in the canopy would not be affected. Given the maintenance of canopy habitats and extensive areas of understorey habitat outside the inundation area the effect of flooding on migration and dispersal ability is likely to be minor.			
ii) How is the project likely to affect the habitat of a threatened species, population or ecological community?				
a) disturbs any permanent, semi permanent or ephemeral water bodies;	The proposed construction and operation would directly disturb a number of water bodies across the site. Negative impacts would affect a very minor proportion of wetland habitats (a maximum of 206 ha) compared to the overall area of wetland habitat at the site (over 30,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). These species of Woodland birds do not rely on any specific wetland habitat resources that would be removed by the project. Woodland birds are likely to benefit from a general increase in floodplain health and productivity as a result of flooding. This has been demonstrated in other comparable areas, such as the increase in the diversity and abundance of bush birds in Barmah Forest following environmental watering (Barmah Millewa Forum, 2001)			
b) degrades soil quality;	The project would degrade soil quality within the construction disturbance footprint through direct removal, earthworks or compaction. Negative impacts would affect a very minor proportion of the site: a maximum of 206 ha out of an area of approximately 32,000 ha. Measures to contain impacts from construction, including sediment control and the retention and re-spreading of topsoil will be implemented, and thus soil quality is unlikely to be affected outside of the immediate surface disturbance area. This magnitude of degradation is unlikely to result in significant negative effects on any habitat or resources for these species.			
c) clears or modifies native vegetation;	Construction for the project would require the clearing or modification of native vegetation within the surface disturbance area, including: ◗ Temporary disturbance of approximately 206 ha of native vegetation. This includes 116 ha of project construction footprints that would be allowed to regenerate to their pre-disturbance state; and ◗ Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints. The removal of this vegetation would affect fauna life cycles, remove foraging resources and affect migration and dispersal			

Criteria	Hooded Robin	Gilbert's Whistler	Diamond Firetail	Black-chinned honeyeater
	ability by reducing the area of available habitat. These effects are described in the relevant Criteria within this assessment. The outcome of these assessments is that the proposed clearing or modification of native vegetation is unlikely to have a significant negative effect.			
d) introduces weeds, vermin or feral species or provides conditions for them to increase and/or spread;	Woodland birds are dependant on native understorey species for foraging substrate and resources and so may be disadvantaged by weed infestation. Native vegetation within the study area featured moderate weed infestation in the central portions of vegetation patches, with moderate to severe infestations around the margins of the forest and near to drainage lines. The proposed construction would involve the clearing of native vegetation and replacement with areas of roads, stockpiles, and project infrastructure. The project may increase the spread and/or prevalence of exotic weeds in the site through soil disturbance and transmission of propagules on vehicles and equipment. It is likely that areas environmental weed infestation would increase within the project disturbance footprint. The majority of the disturbance footprint is associated with the downstream levee which is adjacent to disturbed cleared land. The remainder of the site is partially disturbed by FNSW access tracks and ongoing timber harvesting and grazing activities. In this context, construction activities would have a relatively minor impact on the overall numbers and extent of weed species in the locality. The proposed flooding would transmit weed propagules into the site and increase soil moisture and nutrient status. These changes are likely to increase the degree of weed infestation at the site. This effect would be balanced by positive effects to the health of native vegetation and would not significantly reduce the value of habitat at the site for Woodland birds. Terrestrial vermin or feral species are not expected to increase and/or spread as a result of the project. The proposed activity will not significantly fragment or isolated any habitat nor result in any other changes that are likely to favour feral animals.			
e) removes or disturbs key habitat features such as trees with hollows, caves and rock crevices, foraging habitat;	The project will remove a maximum of 206 ha of foraging, shelter and breeding habitat for Woodland birds in native vegetation to be disturbed. Negative impacts would affect a very minor proportion of available habitats compared to the overall area of wetland habitat at the site (over 30,000 ha). Woodland birds are likely to benefit from a general increase in floodplain health and productivity within the area likely to experience beneficial effects of flooding (17,700 ha).These species of Woodland birds do not rely on any other specific habitat resources that would be removed by the project.			
f) affects natural revegetation and recolonisation of existing species following	The proposed activity may affect the ability of threatened Woodland birds to recolonise following disturbance by reducing the overall amount of available habitat. The magnitude of this effect on the local populations is likely to be minor as these species are mobile and will travel large distances to exploit seasonal foraging resources. The propose inundation will, in general, have a positive effect on natural revegetation and recolonisation of existing species			

Criteria	Hooded Robin	Gilbert's Whistler	Diamond Firetail	Black-chinned honeyeater
disturbance.	following disturbance.			
iii) Does the project affect any threatened species or populations that are at the limit of its known distribution?	None of these species of threatened Woodland birds are at, or near the limit of their known distribution within the site. Regardless, the project will have a minor effect on the extent of available habitat and area of occupation of these species.			
iv) How is the project likely to affect current disturbance regimes?				
a) modifies the intensity and frequency of fires;	The project would not directly affect the intensity and frequency of fires.			
b) modifies flooding flows;	The project would have a positive effect on the flooding flows by restoring a more natural flood regime to the site. This would be expected to have net positive effects on Woodland birds by improving the health and productivity of floodplain ecosystems.			
v) How is the project likely to effect habitat connectivity?				
a) creates a barrier to fauna movement;	The proposed construction may create a partial barrier to fauna movement removal of habitat within disturbance footprints. This would affect limited areas and for limited periods. Birds would readily traverse obstacles and gaps in habitat created by permanent project infrastructure. The proposed inundation of a portion of the site would flood habitats in the understorey and on the ground and so may create a partial barrier to some individuals for the duration of the inundation period. habitat connectivity in the canopy would not be affected and extensive areas of understorey habitat would be maintained outside the inundation area. Therefore inundation is unlikely to comprise a significant barrier to the movement of birds.			
b) removes remnant vegetation or wildlife	The proposed construction would remove 90 ha of habitat in native vegetation within infrastructure footprints. The gaps thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Birds			

Criteria	Hooded Robin	Gilbert's Whistler	Diamond Firetail	Black-chinned honeyeater
corridors; and	would readily traverse these gaps in habitat created by permanent project infrastructure.			
c) modifies remnant vegetation or wildlife corridors.	The proposed construction would temporarily remove and/or modify 116 ha of habitat in native vegetation within the construction corridor. These areas would contain regenerating understorey vegetation after construction. The modified areas thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Birds would readily traverse these areas of modified habitat.			
iv) How is the project likely to affect critical habitat?	There is no listed critical habitat at the site or of relevance to this AoS.			
Conclusion	Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats at the site (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). These species of woodland birds do not rely on any specific habitat resources that would be removed by the project or significantly adversely affected by flooding. Woodland birds are likely to benefit from a general increase in floodplain health and productivity as a result of flooding. This has been demonstrated in other comparable areas, such as the increase in the diversity and abundance of bush birds in Barmah Forest following environmental watering (Barmah Millewa Forum, 2001). Therefore the project is not likely to have a significant negative effect on local populations of the Hooded Robin, Gilbert's Whistler, Diamond Firetail or Black-chinned Honeyeater.			

Table 4 Assessment of Significance for Threatened Microbats

Criteria	Large-footed Myotis	Yellow-bellied Sheathtail Bat	Little Pied Bat
i) How is the project likely to affect the lifecycle of a threatened species and/or population?			
a) displaces or disturbs threatened species and/or populations;	The Large-footed Myotis roosts close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage (DECCW, 2009b). The proposed construction may displace or disturb some individuals if they are within or near the disturbance area, particularly roosting individuals. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This magnitude of disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would increase the extent of the species' preferred aquatic foraging habitat and is likely to result in positive impacts on the species.	The Yellow-bellied Sheathtail Bat is flexible in its selection of roost sites, including tree hollows and buildings and mammal burrows in treeless areas (DECCW, 2009b). The proposed construction may displace or disturb some individuals if they are within or near the disturbance area, particularly roosting individuals. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This magnitude of disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would not have a negative effect on aerial and arboreal habitat for the species. Flooding may suppress populations of some prey species, but would increase populations of other species, notably	The Little Pied Bat roosts in caves, rock outcrops, mine shafts, tunnels, tree hollows and buildings (DECCW, 2009b). The proposed construction may displace or disturb some individuals if they are within or near the disturbance area, particularly roosting individuals. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This magnitude of disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would not have a negative effect on aerial and arboreal habitat for the species. Flooding may suppress populations of some prey species, but would increase populations of other species, notably insects with amphibious stages of

Criteria	Large-footed Myotis	Yellow-bellied Sheathtail Bat	Little Pied Bat
		insects with amphibious stages of their life cycle. The proposed inundation is highly unlikely to displace the species from flooded areas.	their life cycle. The proposed inundation is highly unlikely to displace the species from flooded areas.
b) disrupts breeding cycle;	The status of local populations of these microbat species at the site is not clearly understood. However, none of these species are obligate cave-roosters (DECCW, 2009b) and so for the purposes of this AoS it is assumed that hollow-bearing trees at the site may support local breeding populations of these threatened microbats. Factors likely to disrupt the life cycle of microbats are loss of roost trees and loss of significant areas of foraging habitat. The proposed construction may affect breeding behaviour of some individuals if they are nesting within or near the disturbance area. This disturbance would be for one breeding season only, and is likely to affect a small proportion of local populations. Longer term disruption may occur through removal of roost sites. The proposed activity will remove at least 532 habitat trees, which comprise potential maternity roost sites for the species. This is a relatively minor proportion of the estimated 132, 300 habitat trees within the project site and is unlikely to threaten the persistence of local populations of these species. The proposed inundation of a portion of the site would not have a negative effect on aerial and arboreal habitat and is unlikely to affect the breeding cycle of microbats.		
c) disturbs the dormancy period;	These microbat species utilise tree hollows and other shelter during an annual cool-season dormancy period. The proposed activity would remove potential dormancy roosts in the 206 ha of native vegetation to be removed or disturbed, including at least 532 habitat trees. This would disturb the dormancy period of any individuals of this species potentially roosting within the construction corridor during the construction period. The project is unlikely to disturb any other microbat species outside the proposed construction corridor and so is only likely to affect a small proportion of individuals within local populations. Impacts would be for one season only. The proposed inundation is unlikely to affect the dormancy period of these species as they are likely to utilise tree hollows and other roost sites above the depth of inundation.		

Criteria	Large-footed Myotis	Yellow-bellied Sheathtail Bat	Little Pied Bat
d) disrupts roosting behaviour;	The proposed activity would remove potential roost sites within a maximum of total area of native vegetation to be affected, including at least 532 habitat trees. These hollow bearing trees would provide diurnal roost sites and potential maternity colony sites for the microbats. The proposed activity may disrupt potential roosting activity in areas of remnant vegetation within the construction corridor through noise and other disturbance. The proposed inundation is unlikely to affect the roosting behaviour of these species as they are likely to utilise tree hollows and other roost sites above the depth of inundation.		
e) changes foraging behaviour;	The proposed construction may change foraging behaviour of some individuals if they are within or near the disturbance area. This disturbance would be short-term, is likely to affect a small proportion of local populations and is unlikely to threaten the persistence of these species at the site. Some foraging habitat would be permanently removed (refer *Criteria ii*). These species would have to utilise alternative habitat to compensate for this loss of resources. In the context of the approximately 31,000 ha of alternative habitat at the site this would comprise a minor impact. The proposed inundation of a portion of the site would not have a negative effect on aerial and arboreal habitat for these species. The large-footed Myotis would experience positive effects through increases in the extent of its preferred aquatic foraging habitat. With respect to the Yellow-bellied Sheath tail bat and Little Pied Bat, flooding may suppress populations of some prey species, but would increase populations of other species, notably insects with amphibious stages of their life cycle. The likely overall increase in productivity of invertebrate and plant populations in response to flooding (Boulton and Brock, 1999) may compensate for the reduction in the area of dry land habitat. Regardless, there are extensive areas of alternative foraging habitat that would not be inundated within the project site. Local populations of the species have persisted in the context of natural flood regimes.		
f) disrupts pollination cycle; g) disturbs seedbanks; or h) disrupts recruitment (i.e. germination and establishment of plants);	Not relevant to these threatened microbat species.		
i) affects the interaction between threatened species and other	The proposed activity is unlikely to have any significant effects on interactions between threatened microbats and other organisms in the community.		

Criteria	Large-footed Myotis	Yellow-bellied Sheathtail Bat	Little Pied Bat
species in the community (eg. Pollinators, host species, microrrhizal associations).			
j) affects migration and dispersal ability;	The proposed construction may affect migration and dispersal ability through direct disturbance and removal of habitat within disturbance footprints. This would affect limited areas and for limited periods. Microbats would readily traverse obstacles and gaps in habitat created by permanent project infrastructure. The proposed inundation would not affect arboreal and aerial habitats for threatened microbats.		
ii) How is the project likely to affect the habitat of a threatened species, population or ecological community?			
a) disturbs any permanent, semi permanent or ephemeral water bodies;	The proposed construction would directly disturb a number of intermittent water bodies at the locations of the proposed regulators and channels. This would remove habitat within the construction footprint and modify the form and flow characteristics of the water body. Negative effects would be very limited in extent in the context of the extensive network of intermittent water bodies at the site. The majority of the remainder of the site, including the entire construction disturbance footprint, is an ephemeral floodplain wetland. These water bodies would have value to microbats as water sources and as foraging habitat, especially for the Large-footed Myotis but also for insectivorous species since prey insects are often concentrated above water bodies. The proposed operation of the project would affect: the Murray River; approximately 1200 ha of mapped floodplain marshes and drainage lines; a multitude of smaller flood runners; and ephemeral forest-wetlands on the floodplain itself. Negative impacts would affect a very minor proportion of wetland habitats (a maximum of 206 ha) compared to the overall area of wetland habitat at the site (over 30,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). These species of microbats are unlikely to rely on any specific wetland habitat resources that would be removed by the project. Microbats are likely to benefit from increases in the area of aquatic habitat and the general increase in floodplain health and productivity as a result of flooding.		
b) degrades soil quality;	The project would degrade soil quality within the construction disturbance footprint through direct removal, earthworks or compaction. Negative impacts would affect a very minor proportion of the site: a maximum of 206 ha		

Criteria	Large-footed Myotis Yellow-bellied Sheathtail Bat Little Pied Bat
	out of an area of approximately 32,000 ha. Measures to contain impacts from construction, including sediment control and the retention and re-spreading of topsoil will be implemented, and thus soil quality is unlikely to be affected outside of the immediate surface disturbance area. This magnitude of degradation is unlikely to result in significant negative effects on any habitat or resources for these species.
c) clears or modifies native vegetation;	Construction for the project would require the clearing or modification of native vegetation within the surface disturbance area, including: ◗ Temporary disturbance of approximately 206 ha of native vegetation. This includes 116 ha of project construction footprints that would be allowed to regenerate to their pre-disturbance state; and ◗ Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints. The removal of this vegetation would affect fauna life cycles, remove foraging resources and affect migration and dispersal ability by reducing the area of available habitat. These effects are described in the relevant Criteria within this assessment. The outcome of these assessments is that the proposed clearing or modification of native vegetation is unlikely to have a significant negative effect.
d) introduces weeds, vermin or feral species or provides conditions for them to increase and/or spread;	It is likely that the areas and/or severity of environmental weed infestation would increase within the project disturbance footprint. The degree of exotic weed species in the understorey is unlikely to have a significant effect on the ecology of microbats at the site. Terrestrial vermin or feral species are not expected to increase and/or spread as a result of the project. The proposed activity will not significantly fragment or isolated any habitat nor result in any other changes that are likely to favour feral animals.
e) removes or disturbs key habitat features such as trees with hollows, caves and rock crevices, foraging habitat;	The project will remove a maximum of 206 ha of foraging habitat for these threatened micorbats in native vegetation to be cleared. It will also remove at least 532 trees which comprise diurnal roost sites and potentially maternity colony sites. Mature trees throughout native vegetation within the construction corridor would provide further roost sites in smaller cracks and fissures and beneath flaking bark. The loss of hollow bearing tress is significant because of the time it takes for these resources to develop in regenerating vegetation. Negative impacts would affect a relatively minor proportion of available habitats compared to the overall area of retained native vegetation at the site

Criteria	Large-footed Myotis	Yellow-bellied Sheathtail Bat	Little Pied Bat
	(over 31,000 ha) which would contain a comparable density of habitat trees. Microbats are likely to experience benefits from a general increase in floodplain health and productivity within the area likely to experience beneficial effects of flooding (17,700 ha) including improved health and survival of habitat trees. The project may improve the long term supply of habitat trees at the site since large, mature trees have proven to be most susceptible to drought over the last decade (Jurskis, 2007).		
f) affects natural revegetation and recolonisation of existing species following disturbance.	The proposed activity may affect the ability of threatened microbats to recolonise following disturbance by reducing the overall amount of available habitat. The magnitude of this effect on the local populations is likely to be minor as these species are mobile and will travel to exploit seasonal foraging resources. The propose inundation will, in general, have a positive effect on natural revegetation and recolonisation of existing species following disturbance.		
iii) Does the project affect any threatened species or populations that are at the limit of its known distribution?	The Large-footed Myotis has a relatively limited distribution in the Riverina (Churchill, 1998) but is not at, or near the limit of its known distribution within the site. Regardless, the project will have a minor effect on the extent of available habitat and area of occupation of these species.	Populations of the Yellow-bellied Sheathtail Bat at the site are not near the limit of their known, broad distribution in Western NSW (Churchill, 1998). Regardless, the project will have a minor effect on the extent of available habitat and area of occupation of these species.	Populations of the Little Pied Bat are near the extreme southeastern limits of the species' known distribution, which is Central Australia (Churchill, 1998). Regardless, the project will have a minor effect on the extent of available habitat and area of occupation of these species.
iv) How is the project likely to affect current disturbance regimes?			
a) modifies the intensity and frequency of fires;	The project would not directly affect the intensity and frequency of fires.		
b) modifies flooding flows;	The project would have a positive effect on the flooding flows by restoring a more natural flood regime to the site. This would be expected to have net positive effects on microbats by improving the health and productivity of floodplain ecosystems.		

Criteria	Large-footed Myotis	Yellow-bellied Sheathtail Bat	Little Pied Bat
v) How is the project likely to effect habitat connectivity?			
a) creates a barrier to fauna movement;	The proposed construction may create a partial barrier to microbat movement through removal of arboreal habitat within disturbance footprints. This would affect limited areas and for limited periods. Aerial habitat would not be affected and so microbats would readily traverse obstacles and gaps in habitat created by permanent project infrastructure. The proposed inundation of a portion of the site would not affect arboreal and aerial habitats and is unlikely to comprise a significant barrier to the movement of microbats.		
b) removes remnant vegetation or wildlife corridors; and	The proposed construction would remove 90 ha of habitat in native vegetation within infrastructure footprints. The gaps thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Microbats would readily traverse these gaps in habitat created by permanent project infrastructure.		
c) modifies remnant vegetation or wildlife corridors.	The proposed construction would temporarily remove and/or modify 116 ha of habitat in native vegetation within the construction corridor. These areas would contain regenerating understorey vegetation after construction. The modified areas thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Aerial habitat would not be affected and so microbats would readily traverse these areas of modified habitat.		
iv) How is the project likely to affect critical habitat?	There is no listed critical habitat at the site or of relevance to this AoS.		
Conclusion	Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats at the site (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). Construction would remove key habitat resources in habitat trees but would affect a minor proportion of resources available in the locality and may help to secure the HBT resource in the longer term through environmental watering of mature River Red Gums. These species of microbats do not rely on any specific habitat resources that are likely to be significantly adversely affected by flooding. Microbats are likely to benefit from a general increase in floodplain health and productivity as a result of flooding. Therefore the project is not likely to have a significant negative effect on local populations of the Large-footed Myotis, Yellow-bellied Sheathtail Bat and Little Pied Bat.		

Table 5 Assessment of Significance for Threatened Arboreal Mammals

Criteria	Koala	Squirrel Glider
i) How is the project likely to affect the lifecycle of a threatened species and/or population?		
a) displaces or disturbs threatened species and/or populations;	The Koala is known from historical records at the site as part of a fragmented, but expanding introduced population known from the Riverina (GHD, 2009b). The site contains extensive areas of River Red Gum, which is a preferred feed tree for the species (DECCW, 2009b). The proposed construction may displace or disturb some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This magnitude of disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would not have a negative effect on arboreal habitat for the species. The proposed inundation is unlikely to permanently displace the species from flooded areas. Flooding would increase energy costs and risks of movement between trees by forcing Koalas to swim. This would be partially balanced by the increased health and productivity of River Red Gums.	The Squirrel Glider is known from a recent (GHD, 2008b) record at the site and from tentative records during the current survey. The species is thought to have a preference for areas of the site with superior foraging resources, including those with flowering box-type Eucalyptus and/or dense understoreys of Acacia (Miller, G., FNSW, pers. comm.). The proposed construction may displace or disturb some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This magnitude of disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation is unlikely to permanently displace the species from flooded areas. Flooding would not increase energy costs and risks of movement between trees as the Squirrel Glider would readily glide above flood waters. The proposed inundation of a portion of the site would limit the species' access to some foraging habitat in the shrub and small tree layer. This would be partially balanced by the increased health and productivity of River Red Gums and Black Box. Local populations of the species have persisted in the context of natural flood regimes and are likely to utilise alternative foraging resources and/or habitat and resume their previous life cycle functions in the inundation area after flood recession.

Criteria	Koala	Squirrel Glider
b) disrupts breeding cycle;	The status of local populations of the Koala is not clearly understood. For the purposes of this AoS it is assumed that the site may support local breeding populations of the Koala at present or in the future. Factors likely to disrupt the breeding cycle of the Koala are isolation of habitat, fragmentation of populations and loss of significant areas of foraging habitat. The proposed construction may affect breeding behaviour of some individuals if they are within or near the disturbance area. This disturbance would be for one breeding season only and is likely to affect a small proportion of local populations. Longer term disruption may occur through removal or fragmentation of habitat. The removal and fragmentation of habitat is addressed below. The project would have a minor affect on habitat connectivity and is unlikely to threaten the persistence of local populations of the Koala. The proposed inundation of a portion of the site would not affect arboreal habitat. Flooding would increase energy costs and risks of breeding movements between trees by forcing Koalas to swim. This would be partially balanced by the increased health and productivity of River Red Gums by increasing energy availability for travelling males and females with dependant young.	The proposed construction may disrupt breeding behaviour of some individuals if they are sheltering within or near the disturbance area. This disturbance would be for one breeding season only, is likely to affect a small proportion of local populations and is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site is unlikely to directly disrupt the breeding cycle of the species since breeding hollows are likely to be above floodwaters (maximum depth of 2 metres outside of drainage lines and floodplain marshes). Flooding would not increase energy costs and risks of movement between trees as the Squirrel Glider would readily glide above flood waters. The proposed inundation of a portion of the site would limit the species' access to some foraging resources in the shrub and small tree layer. This would be partially balanced by the increased health and productivity of River Red Gums and Black Box and is unlikely to significantly disrupt the species breeding cycle.
c) disturbs the dormancy period;	These arboreal fauna species are not known to have a dormancy period that could potentially be affected by the project.	
d) disrupts roosting behaviour;	For the purposes of this AoS the Koala's practice of resting in the canopy is considered synonymous with	For the purposes of this AoS the Squirrel Glider's use of diurnal shelter and breeding hollows is considered synonymous with

Criteria	Koala	Squirrel Glider
	roosting. The Koala would rest daily in appropriate areas of canopy vegetation. The proposed construction may affect some individuals if they are resting within or near the disturbance area. This disturbance would be short-term, is likely to affect a small proportion of local populations and is unlikely to threaten the persistence of the species at the site. Floodwaters would be well below the level of the canopy and so inundation would not disrupt the resting behaviour of the Koala.	roosting. The proposed activity would remove potential diurnal shelter and breeding hollows within a maximum of total area of native vegetation to be affected, including approximately at least 532 habitat trees. The proposed activity may disrupt potential sheltering individuals in areas of remnant vegetation adjoining the construction corridor through noise and other disturbance. The proposed inundation is unlikely to affect sheltering behaviour as the Squirrel Glider is likely to utilise hollows above the depth of inundation.
e) changes foraging behaviour;	The proposed construction may change foraging behaviour of some individuals if they are within or near the disturbance area. This disturbance would be short-term, is likely to affect a small proportion of local populations and is unlikely to threaten the persistence of these species at the site. Some foraging habitat would be permanently removed (refer *Criteria ii*). The Koala would have to utilise alternative habitat to compensate for this loss of resources. In the context of the approximately 31,000 ha of alternative habitat at the site this would comprise a minor impact. The proposed inundation of a portion of the site would not have a negative effect on arboreal foraging habitat for the Koala. Flooding would increase energy costs and risks of movement between trees by forcing Koalas to swim. It may change foraging behaviour if a Koala restricts its foraging range to avoid flooded areas. These effects would be partially balanced by the increased health and productivity of River Red Gums by increasing energy	The proposed construction may change foraging behaviour of some individuals if they are within or near the disturbance area. This disturbance would be short-term, is likely to affect a small proportion of local populations and is unlikely to threaten the persistence of the species at the site. Some foraging habitat would be permanently removed (refer *Criteria ii*). The Squirrel Glider would have to utilise alternative habitat to compensate for this loss of resources. In the context of the approximately 31,000 ha of alternative habitat at the site this would comprise a minor impact. The proposed inundation is unlikely to permanently displace the species from flooded foraging habitat. Flooding would not increase energy costs and risks of movement between trees as the Squirrel Glider is likely to glide above flood waters. The proposed inundation of a portion of the site would limit the species' access to some foraging habitat in the shrub and small tree layer. This would be partially balanced by the increased health and productivity of River Red Gums, Black Box and invertebrates. Local populations of the species have persisted in the context of natural flood regimes and are likely to utilise alternative foraging resources

Criteria	Koala	Squirrel Glider
	'rewards' of travelling and the productivity of accessible areas of habitat.	and/or habitat and resume their previous life cycle functions in the inundation area after flood recession.
f) disrupts pollination cycle; g) disturbs seedbanks; or h) disrupts recruitment (i.e. germination and establishment of plants);	Not relevant to these threatened arboreal mammal species.	
i) affects the interaction between threatened species and other species in the community (eg. Pollinators, host species, microrrhizal associations).	The proposed activity is unlikely to have any significant effects on interactions between threatened arboreal mammal and other organisms in the community.	
j) affects migration and dispersal ability;	The proposed construction may affect migration and dispersal ability through direct disturbance and removal of habitat within disturbance footprints. This would affect limited areas and for limited periods. The proposed infrastructure would create temporary gaps in arboreal habitat of under 100 metres width and permanent gaps of under 50 metres width. This would result in a minor increase in energy costs and risks of travelling for Koalas. The proposed inundation would increase energy costs and risks of movement between trees by forcing Koalas to swim, which would limit migration and dispersal ability.	The proposed construction may affect migration and dispersal ability through direct disturbance and removal of habitat within disturbance footprints. This would affect limited areas and for limited periods. The proposed infrastructure would create temporary gaps in arboreal habitat of under 100 metres width and permanent gaps of under 50 metres width. Depending on the height and position of retained trees Gliders are likely to readily traverse obstacles and gaps in habitat created by permanent project infrastructure with minor modification of their movement. This would result in a very minor increase in energy costs and risks of travelling for Gliders. The proposed inundation is unlikely to affect migration and dispersal ability of the Squirrel Glider. Flooding would not increase energy costs and risks of movement between trees as the Squirrel Glider is likely to glide above flood waters.

Criteria	Koala	Squirrel Glider
ii) How is the project likely to affect the habitat of a threatened species, population or ecological community?		
a) disturbs any permanent, semi permanent or ephemeral water bodies;	The proposed construction and operation of the project would affect: the Murray River; approximately 1200 ha of mapped floodplain marshes and drainage lines; a multitude of smaller flood runners; and ephemeral forest-wetlands on the floodplain itself. Negative impacts would affect a very minor proportion of wetland habitats (a maximum of 206 ha) compared to the overall area of wetland habitat at the site (over 30,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). These species of arboreal mammals are unlikely to rely on any specific wetland habitat resources that would be removed by the project. These species are likely to benefit from the general increase in floodplain health and productivity as a result of flooding.	
b) degrades soil quality;	The project would degrade soil quality within the construction disturbance footprint through direct removal, earthworks or compaction. Negative impacts would affect a very minor proportion of the site: a maximum of 206 ha out of an area of approximately 32,000 ha. Measures to contain impacts from construction, including sediment control and the retention and re-spreading of topsoil will be implemented, and thus soil quality is unlikely to be affected outside of the immediate surface disturbance area. This magnitude of degradation is unlikely to result in significant negative effects on any habitat or resources for these species.	
c) clears or modifies native vegetation;	Construction for the project would require the clearing or modification of native vegetation within the surface disturbance area, including: ◗ Temporary disturbance of approximately 206 ha of native vegetation. This includes 116 ha of project construction footprints that would be allowed to regenerate to their pre-disturbance state; and ◗ Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints. The removal of this vegetation would affect fauna life cycles, remove foraging resources and affect migration and dispersal ability by reducing the area of available habitat. These effects are described in the relevant Criteria within this assessment. The outcome of these assessments is that the proposed clearing or modification of native vegetation is unlikely to have a significant negative effect.	
d) introduces weeds, vermin or feral species or provides	It is likely that the areas and/or severity of environmental weed infestation would increase within the understorey of the project disturbance footprint. The degree of exotic weed species in the understorey is unlikely to have a significant effect on the	

Criteria	Koala	Squirrel Glider
conditions for them to increase and/or spread;	ecology of arboreal mammals at the site. River Red Gum and Black Box dominate the canopy within the site forming extensive monoculture communities. These canopy species are highly resilient to weed invasion. Therefore the proposed construction would not affect the species' canopy habitat beyond the direct removal of trees addressed in point c) above. The proposed inundation is unlikely to facilitate the invasion of any canopy species that would have a competitive advantage over River Red Gum and Black Box. Terrestrial vermin or feral species are not expected to increase and/or spread as a result of the project. The proposed activity will not significantly fragment or isolated any habitat nor result in any other changes that are likely to favour feral animals.	
e) removes or disturbs key habitat features such as trees with hollows, caves and rock crevices, foraging habitat;	The project will remove a maximum of 206 ha of important foraging habitat for the Koala in River Red Gum forest to be cleared. Negative impacts would affect a relatively minor proportion of available habitats compared to the overall area of retained River Red Gum Forest at the site (over 31,000 ha) which would contain a comparable density of foraging resources. Koalas are likely to experience benefits from a general increase in River Red Gum health and productivity within the area likely to experience beneficial effects of flooding (17,700 ha).	The project will remove a maximum of 206 ha of habitat for the Squirrel Glider in native vegetation to be cleared, including at least 532 habitat trees. Negative impacts would affect a relatively minor proportion of available habitats compared to the overall area of retained vegetation at the site (over 31,000 ha) which would contain a comparable density of habitat trees. Squirrel Gliders are likely to experience benefits from a general increase in River Red Gum health and productivity within the area likely to experience beneficial effects of flooding (17,700 ha), including improved health and survival of habitat trees. The project may improve the long term supply of habitat trees at the site since large, mature trees have proven to be most susceptible to drought over the last decade (Jurskis, 2007).
f) affects natural revegetation and recolonisation of existing species following disturbance.	The proposed activity may affect the ability of threatened arboreal mammals to recolonise following disturbance by reducing the overall amount of available habitat. The magnitude of this effect on the local populations is likely to be minor as these species are mobile and will travel to exploit seasonal foraging resources. The proposed inundation will, in general, have a positive effect on natural revegetation and recolonisation of existing species following disturbance.	
iii) Does the project affect any threatened species or	Local populations of the Koala are apparently near the northwestern limit of the species limited distribution in the	Local populations of the Squirrel Glider are near the northwestern limit of the species narrow distribution along the Murray River

Criteria	Koala	Squirrel Glider
populations that are at the limit of its known distribution?	Riverina (DECCW, 2009b), however expanding, translocated populations are known (GHD, 2009b). Regardless, the project will have a minor effect on the extent of available habitat and area of occupation of the species.	riparian corridor (DECCW, 2009b). Regardless, the project will have a minor effect on the extent of available habitat and area of occupation of the species.
iv) How is the project likely to affect current disturbance regimes?		
a) modifies the intensity and frequency of fires;	The project would not directly affect the intensity and frequency of fires.	
b) modifies flooding flows;	The project would have a positive effect on the flooding flows by restoring a more natural flood regime to the site. Aside from short term, direct effects of inundation on fauna movement described above, this would be expected to have net positive effects on arboreal mammals by improving the health and productivity of floodplain ecosystems.	
v) How is the project likely to effect habitat connectivity?		
a) creates a barrier to fauna movement;	The proposed construction may create a partial barrier to Koala movement through removal of habitat within disturbance footprints. This would affect limited areas and for limited periods. The proposed infrastructure would create temporary gaps in arboreal habitat of under 100 metres width and permanent gaps of under 50 metres width. This would result in a minor increase in energy costs and risks of travelling for Koalas. The proposed inundation would comprise a partial barrier to Koalas and increase energy costs and risks of movement between trees by forcing Koalas to swim.	The proposed construction may create a partial barrier to fauna movement removal of habitat within disturbance footprints. This would affect limited areas and for limited periods. Gliders would readily traverse obstacles and gaps in habitat created by permanent project infrastructure. The proposed inundation of a portion of the site would flood foraging habitats in the small tree layer and understorey and so may create a partial barrier to some individuals for the duration of the inundation period. habitat connectivity in the canopy would not be affected and extensive areas of understorey foraging habitat would be maintained outside the inundation area. Therefore inundation is unlikely to comprise a significant barrier to the movement of gliders.
b) removes remnant vegetation or wildlife	The proposed construction would remove 90 ha of habitat in native vegetation within infrastructure footprints. The	The proposed construction would remove 90 ha of habitat in native vegetation within infrastructure footprints. The gaps thus created

Criteria	Koala	Squirrel Glider
corridors; and	gaps thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Koalas are likely to traverse these areas with a minimal increase in energy costs or risk. Continuity of arboreal habitat would be maintained around permanent structures and so Koalas would also be able to move along alternative corridors with lesser gaps between trees.	would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Depending on the height and position of retained trees Gliders may traverse these gaps. Regardless, continuity of arboreal habitat would be maintained around permanent structures and so Gliders would be able to move along alternative corridors. Gliders are likely to traverse these gaps in habitat created by permanent project infrastructure with minimal additional energy costs or risk.
c) modifies remnant vegetation or wildlife corridors.	The proposed construction would temporarily remove and/or modify 116 ha of habitat in native vegetation within the construction corridor. These areas would contain regenerating understorey vegetation after construction. The modified areas thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. The modified areas thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Arboreal mammals are likely to traverse these areas with a minimal increase in energy costs or risk.	
iv) How is the project likely to affect critical habitat?	No critical habitat listed under legislation occurred in the project area or within adjacent areas of vegetation.	There is no listed critical habitat at the site or of relevance to this AoS.
Conclusion	Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats at the site (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). The Koala is highly reliant on foraging resources provided by River Red Gums at the site which will benefit from environmental watering. Positive effects of flooding on River Red Gum growth and productivity would more than offset the relatively small amount of foraging habitat that would be removed and increased energy costs and risk of travelling during flood events. Therefore the project is not likely to have a significant negative effect on local populations of the Koala.	Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats at the site (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). Construction would remove key habitat resources in habitat trees but would affect a minor proportion of resources available in the locality and may help to secure the HBT resource in the longer term through environmental watering of mature River Red Gums. The Squirrel Glider does not rely on any specific habitat resources that would be significantly adversely affected by flooding. Gliders are likely to benefit from a general increase in floodplain health and productivity as a result of flooding. Therefore the project is not likely to have a significant negative effect on local populations of the Squirrel Glider.

Table 6 Assessment of Significance for Australasian Bittern

Criteria	Australasian Bittern
i) How is the project likely to affect the lifecycle of a threatened species and/or population?	
a) displaces or disturbs threatened species and/or populations;	The Australasian Bittern was only recorded in suitable habitat in a permanent closed wetland in the vicinity of the site. There are some areas of similar wetland habitats within the site, but none within the proposed construction corridor. The construction corridor contains intermittent water bodies and ephemeral floodplain wetlands. These habitats would have limited value for the Australasian Bittern in their current dry state and are unlikely to be occupied during the construction period. The proposed construction may displace or disturb some individuals in flooded wetlands near the disturbance area. Notably the individual recorded during site surveys was within 100 metres of the proposed inlet regulator and upstream end of the Torrumbarry cutting. Any disturbance would be short-term, is likely to affect a small proportion of local populations given the presence of similar habitats along greater than 50 km of Murray River riparian corridor adjoining to the site. This magnitude of disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would increase the area of potentially suitable habitat for the species and would be expected to have positive effects.
b) disrupts breeding cycle;	Permanent and near-permanent wetlands fringing the Murray River are likely to support local breeding populations of the Australasian Bittern. The proposed construction may disrupt breeding behaviour of some individuals if they are nesting near the disturbance area. This disturbance would be for one breeding season only, is likely to affect a small proportion of local populations and is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would increase the area of potentially suitable habitat for the species, increase wetland productivity and potentially stimulate breeding behaviour. The proposed flooding would be expected to have positive effects on the breeding cycle of the species. The proposed operational regime would aim to maintain flood conditions in floodplain marshes at appropriate seasons, and for appropriate durations to facilitate waterbird breeding. This purposeful operation would minimise the potential for adverse affects through rapid recession of flood waters or other impacts on breeding events.
c) disturbs the dormancy period;	The Australasian Bittern is not known to have a dormancy period that could potentially be affected by the project.
d) disrupts roosting behaviour;	The Australasian Bittern is not known to exhibit long term or ecologically important roosting behaviour that could potentially be affected by the project. The species would roost daily in appropriate areas of dense semi aquatic

	vegetation in floodplain marshes. The proposed construction may affect some roosting individuals if they are roosting within or near the disturbance area. This disturbance would be short-term, is likely to affect a small proportion of local populations and is unlikely to threaten the persistence of the species at the site. The proposed inundation would increase the area of suitable habitat for the species for the duration of inundation. Over longer periods the project is likely to have further positive effects by improving the health and extent of flood-dependant plants across the site.
e) changes foraging behaviour;	The Australasian Bittern was only recorded in suitable habitat within dense beds of semi-aquatic plants at the site. The proposed construction may change foraging behaviour of some individuals if they are near the disturbance area. This disturbance would be short-term, is likely to affect a small proportion of local populations and is unlikely to threaten the persistence of the species at the site. There are no currently wet marshes containing semi-aquatic plants within the infrastructure footprint and so no foraging habitat would be removed (refer *Criteria ii*). The proposed inundation would increase the area of suitable habitat for the species for the duration of inundation. Over longer periods the project is likely to have further positive effects by improving the health and extent of flood-dependant plants across the site. Any changes to foraging behaviour would be positive through a potential increase in foraging ranges.
f) disrupts pollination cycle; g) disturbs seedbanks; or h) disrupts recruitment (i.e. germination and establishment of plants);	Not relevant to the Australasian Bittern.
i) affects the interaction between threatened species and other species in the community (eg. Pollinators, host species, microrrhizal associations).	Not relevant to the Australasian Bittern.
j) affects migration and dispersal ability;	The proposed construction may affect migration and dispersal ability through direct disturbance and removal of habitat within disturbance footprints. This would affect limited areas, for limited periods. Further, the disturbance footprint does not contain any core closed-wetland habitat for the species and is unlikely to comprise an important movement corridor. Individuals would readily traverse obstacles and gaps in habitat created by permanent project infrastructure if required. The proposed inundation would have positive effects (if any) on the movement ability of this wetland bird.
ii) How is the project likely to affect the habitat of a threatened species, population or ecological community?	

a) disturbs any permanent, semi permanent or ephemeral water bodies;	The proposed construction would directly disturb a number of intermittent water bodies at the locations of the proposed regulators and channels. This would remove habitat within the construction footprint and modify the form and flow characteristics of the water body. Negative effects would be very limited in extent in the context of the extensive network of intermittent water bodies at the site. The majority of the remainder of the site, including the entire construction disturbance footprint, is an ephemeral floodplain wetland. These habitats would have limited value for the Australasian Bittern in their current dry state and are unlikely to be occupied during the construction period. The proposed operation of the project would affect: the Murray River; approximately 1200 ha of mapped floodplain marshes and drainage lines; a multitude of smaller flood runners; and ephemeral forest-wetlands on the floodplain itself. The project is expected to have net-positive effects on these habitats through restoration of a more natural flood regime. The Australasian Bittern would also be expected to experience positive effects such as an increase in flooded wetland area and a general increase in floodplain health and productivity as a result of flooding. The project would divert water away from the Murray River potentially reducing flows into habitat for the species outside the site. The water diverted into the forest will largely be environmental water from the sources discussed above. The required volume of water would be 'called' and released from upstream storages specifically for the purpose of achieving flows into the site. As such, water diverted at Torrumbarry weir will be flow that would not otherwise be in the system and, hence the diversions should have minimal or no impact on the Murray River flows (personal communication, D Green, MDBA, 2009). The disturbance footprint does not contain any core closed-wetland habitat for the species.
b) degrades soil quality;	The project would degrade soil quality within the construction disturbance footprint through direct removal, earthworks or compaction. Negative impacts would affect a very minor proportion of the site: a maximum of 206 ha out of an area of approximately 32,000 ha. The disturbance footprint does not contain any core closed-wetland habitat for the species. Measures to contain impacts from construction, including sediment control and the retention and re-spreading of topsoil will be implemented, and thus soil quality is unlikely to be affected outside of the immediate surface disturbance area. This magnitude of degradation is unlikely to result in significant negative effects on any habitat or resources for the species.
c) clears or modifies native vegetation;	Construction for the project would require the clearing or modification of native vegetation within the surface disturbance area, including: ◗ Temporary disturbance of approximately 206 ha of native vegetation. This includes 116 ha of project construction footprints that would be allowed to regenerate to their pre-disturbance state; and ◗ Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints. The disturbance footprint does not contain any core closed-wetland habitat for the species. The removal of this vegetation would potentially affect fauna life cycles, remove supplementary foraging resources and affect migration and dispersal ability by reducing the area of available

	habitat. These effects are described in the relevant Criteria within this assessment. The outcome of these assessments is that the proposed clearing or modification of native vegetation is unlikely to have a significant negative effect.
d) introduces weeds, vermin or feral species or provides conditions for them to increase and/or spread;	Australasian Bitterns are dependant on native wetland species for foraging substrate. The species prefers dense beds of Cumbungi and Common Reed. These vigorous native species are relatively resilient to weed infestation provided appropriate hydrological conditions. The project is intended to restore a more natural flooding regime and would be expected to favour native wetland plants at the expense of terrestrial species or environmental weeds. The proposed flooding would transmit weed propagules into the site and increase soil moisture and nutrient status. These changes are likely to increase the degree of weed infestation at the site. This effect would be balanced by positive effects to the health of native vegetation and would not significantly reduce the value of habitat at the site for Australasian Bittern. Terrestrial vermin or feral species are not expected to increase and/or spread as a result of the project. The proposed activity will not significantly fragment or isolated any habitat nor result in any other changes that are likely to favour feral animals.
e) removes or disturbs key habitat features such as trees with hollows, caves and rock crevices, foraging habitat;	The Australasian Bittern does not rely on any specific habitat resources that would be removed by the project. There are some areas of important wetland habitats within the site, but none within the proposed construction corridor. The construction corridor contains intermittent water bodies and ephemeral floodplain wetlands. The project will remove a maximum of 206 ha of potential supplementary foraging or travelling habitat for Australasian Bittern in the habitat to be disturbed. Negative impacts would affect a very minor proportion of available habitats compared to the overall area of wetland habitat at the site (over 30,000 ha). Australasian Bittern are likely to benefit from a general increase in floodplain health and productivity within the area likely to experience beneficial effects of flooding (17,700 ha).
f) affects natural revegetation and recolonisation of existing species following disturbance.	The proposed construction may affect the ability of native biota in general to recolonise following disturbance by reducing the overall amount of available habitat. The Australasian Bittern does not rely on any specific habitat resources that would be affected by construction. The proposed inundation will, in general, have a positive effect on natural revegetation and recolonisation of existing species following disturbance.
iii) Does the project affect any threatened species or populations that are at the limit of its known distribution?	The site is not at, or near the limit of the Australasian Bitterns' known distribution. Regardless, the project would not have a negative effect on the extent of available habitat and area of occupation of the species.
iv) How is the project likely to affect current disturbance regimes?	

a) modifies the intensity and frequency of fires;	The project would not directly affect the intensity and frequency of fires.
b) modifies flooding flows;	The project would have a positive effect on the flooding flows by restoring a more natural flood regime to the site. This would be expected to have net positive effects on Australasian Bittern by improving the extent of inundated wetland habitats and improving the health and productivity of floodplain ecosystems. The intended restoration of a more natural flooding regime is likely to increase the area of habitat for species by improving the health and extent of flood-dependant understorey plants.
v) How is the project likely to effect habitat connectivity?	
a) creates a barrier to fauna movement;	The proposed construction may create a partial barrier to fauna movement through removal of habitat within disturbance footprints. This would affect limited areas and for limited periods. Birds would readily traverse obstacles and gaps in habitat created by permanent project infrastructure. The proposed inundation of the site is likely to have positive effects on the movement of this wetland bird.
b) removes remnant vegetation or wildlife corridors; and	The proposed construction would remove 90 ha of habitat in native vegetation within infrastructure footprints. The gaps thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Birds would readily traverse these gaps in habitat created by permanent project infrastructure.
c) modifies remnant vegetation or wildlife corridors.	The proposed construction would temporarily remove and/or modify 116 ha of habitat in native vegetation within the construction corridor. These areas would contain regenerating understorey vegetation after construction. The modified areas thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Birds would readily traverse these areas of modified habitat.
iv) How is the project likely to affect critical habitat?	There is no listed critical habitat at the site or of relevance to this AoS.
Conclusion	habitat within the construction footprint would have limited value for the Australasian Bittern in its current dry state and is unlikely to be occupied during the construction period. Negative impacts arising from the project would be limited to indirect effects and would affect a very minor proportion of individuals and habitats. The proposed inundation of a portion of the site would increase the area of potentially suitable habitat for the species and would be expected to have positive effects through a general increase in floodplain health and productivity as a result of flooding. Therefore the project is not likely to have a significant negative effect on local populations of the Australasian Bittern.

Table 7 Assessment of Significance for Barking Owl

Criteria	Barking Owl
i) How is the project likely to affect the lifecycle of a threatened species and/or population?	
a) displaces or disturbs threatened species and/or populations;	There are three records of the Barking Owl in Perricoota SF in the last five years (DECCW, 2009a). The species was not recorded in the current surveys, however the site contains suitable habitat resources for the species and is likely to support a local population, probably at low densities. The proposed construction may displace or disturb some individuals if they are within or near the disturbance area, particularly roosting individuals. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This magnitude of disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would not have a negative effect on aerial and arboreal habitat for the species. The proposed inundation is highly unlikely to displace the species from flooded areas.
b) disrupts breeding cycle;	Local populations of the Barking Owl are likely to breed in large habitat trees at the site. Factors likely to disrupt the life cycle of Barking Owls are direct disturbance, loss of roost trees and loss of significant areas of foraging habitat. The proposed construction may affect breeding behaviour of some individuals if they are nesting within or near the disturbance area. This disturbance would be for one breeding season only, and is likely to affect a small proportion of local populations given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. Longer term disruption may occur through removal of roost sites. The proposed activity will remove approximately at least 532 hollow-bearing trees, which comprise potential nest sites for the species. This is a relatively minor proportion of the estimated 132, 300 habitat trees within the project site and is unlikely to threaten the persistence of local populations of these species. The proposed inundation of a portion of the site would not have a negative effect on aerial and arboreal habitat and is unlikely to directly affect the breeding cycle of Barking Owls. Flooding may suppress populations of some prey species in some areas for the duration of inundation, but may have positive effects including easier access to prey species seeking arboreal refuge and the predicted general increase in floodplain health and productivity.
c) disturbs the dormancy period;	The Barking Owl is not known to have a dormancy period that could potentially be affected by the project.
d) disrupts roosting	The proposed activity would remove potential roost sites within a

behaviour;	maximum of total area of native vegetation to be affected, including at least 532 habitat trees. These hollow-bearing trees would provide diurnal roost sites and potential nest sites for the Barking Owl. The proposed activity may disrupt potential roosting activity in areas of remnant vegetation within the construction corridor through noise and other disturbance. The proposed inundation is unlikely to affect the roosting behaviour of the Barking Owl as they are likely to utilise tree hollows and other roost sites above the depth of inundation.
e) changes foraging behaviour;	The proposed construction may change foraging behaviour of some individuals if they are within or near the disturbance area. This disturbance would be short-term, is likely to affect a small proportion of local populations and is unlikely to threaten the persistence of these species at the site. Some foraging habitat would be permanently removed (refer *Criteria ii*). These species would have to utilise alternative habitat to compensate for this loss of resources. In the context of the approximately 31,000 ha of alternative habitat at the site this would comprise a minor impact. The proposed inundation of a portion of the site would not have a negative effect on aerial and arboreal habitat for these species. Flooding may suppress populations of some prey species in some areas for the duration of inundation. Flooding is likely to increase populations in the longer term due to the predicted general increase in floodplain health and productivity. The likely overall increase in productivity of invertebrate and plant populations in response to flooding (Boulton and Brock, 1999) may compensate for the reduction in the area of dry land habitat. Foraging efficiency may potentially increase due to prey species seeking arboreal refuge. Local populations are likely to be resilient to the effects of flooding, particularly given the species known preference for treed habitats close to drainage lines (DECCW, 2009b). Regardless, there are extensive areas of alternative foraging habitat that would not be inundated within the project site. Short term increases in foraging distances and associated energy costs are unlikely to significantly disadvantage this highly mobile species.
f) disrupts pollination cycle; g) disturbs seedbanks; or h) disrupts recruitment (i.e. germination and establishment of plants);	Not relevant to the Barking Owl.
i) affects the interaction between threatened species and other species in the community (eg. Pollinators, host species, microrrhizal associations).	The proposed activity is unlikely to have any significant effects on interactions between Barking Owls and other organisms in the community.
j) affects migration and dispersal ability;	The proposed construction may affect migration and dispersal ability through direct disturbance and removal of habitat within disturbance footprints. This would affect limited areas and for limited periods. Barking Owls would readily traverse obstacles and gaps in habitat created by permanent project infrastructure.

	The proposed inundation would not affect arboreal and aerial habitats for the Barking Owl.
ii) How is the project likely to affect the habitat of a threatened species, population or ecological community?	
a) disturbs any permanent, semi permanent or ephemeral water bodies;	The proposed construction would disturb extensive areas of intermittent and ephemeral floodplain wetlands. The Barking Owl does not rely on any specific wetland habitat resources that would be removed or modified by the project. The species may benefit from a general increase in floodplain health and productivity as a result of flooding.
b) degrades soil quality;	The project would degrade soil quality within the construction disturbance footprint through direct removal, earthworks or compaction. Negative impacts would affect a very minor proportion of the site: a maximum of 206 ha out of an area of approximately 32,000 ha. This magnitude of degradation is unlikely to result in significant negative effects on any habitat or resources for the species.
c) clears or modifies native vegetation;	Construction for the project would require the clearing or modification of native vegetation within the surface disturbance area, including: ◗ Temporary disturbance of approximately 206 ha of native vegetation. This includes 116 ha of project construction footprints that would be allowed to regenerate to their pre-disturbance state; and ◗ Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints. The removal of this vegetation would affect fauna life cycles, remove foraging resources and affect migration and dispersal ability by reducing the area of available habitat. These effects are described in the relevant Criteria within this assessment. The outcome of these assessments is that the proposed clearing or modification of native vegetation is unlikely to have a significant negative effect.
d) introduces weeds, vermin or feral species or provides conditions for them to increase and/or spread;	It is likely that the areas and/or severity of environmental weed infestation would increase within the project disturbance footprint. The degree of exotic weed species in the understorey is unlikely to have a significant effect on the ecology of Barking Owls at the site. Terrestrial vermin or feral species are not expected to increase and/or spread as a result of the project. The proposed activity will not significantly fragment or isolated any habitat nor result in any other changes that are likely to favour feral animals.
e) removes or disturbs key habitat features such as trees with hollows, caves and rock crevices, foraging habitat;	The project will remove or modify a maximum of 206 ha of foraging habitat for the Barking Owl in native vegetation to be cleared. It will also remove at least 532 habitat trees which comprise diurnal roost sites and potentially nest sites. Mature trees throughout native vegetation within the construction corridor would provide further roost sites on large boughs and in dense foliage. The removal of habitat trees is significant because of the time it takes for these resources to develop in regenerating vegetation. The proposed regulators would remove habitat trees in the species' preferred habitat of tall productive forests close to drainage lines. Negative impacts would affect a relatively minor

	proportion of available habitats compared to the overall area of retained native vegetation at the site (over 31,000 ha) and extensive network of drainage lines which would contain a comparable density of habitat trees. Barking Owls are likely to experience benefits from a general increase in floodplain health and productivity within the area likely to experience beneficial effects of flooding (17,700 ha) including improved health and survival of habitat trees. The project may improve the long term supply of habitat trees at the site since large, mature trees have proven to be most susceptible to drought over the last decade (Jurskis, 2007).
f) affects natural revegetation and recolonisation of existing species following disturbance.	The proposed activity may affect the ability of threatened Barking Owls to recolonise following disturbance by reducing the overall amount of available habitat. The magnitude of this effect on the local populations is likely to be minor as the species is mobile and forages within extensive home ranges. The propose inundation will, in general, have a positive effect on natural revegetation and recolonisation of existing species following disturbance.
iii) Does the project affect any threatened species or populations that are at the limit of its known distribution?	Populations of the Barking Owl at the site are not near the limit of their known, broad distribution. Regardless, the project will have a minor effect on the extent of available habitat and area of occupation of these species.
iv) How is the project likely to affect current disturbance regimes?	
a) modifies the intensity and frequency of fires;	The project would not directly affect the intensity and frequency of fires.
b) modifies flooding flows;	The project would have a positive effect on the flooding flows by restoring a more natural flood regime to the site. This would be expected to have net positive effects on Barking Owls by improving the health and productivity of floodplain ecosystems.
v) How is the project likely to effect habitat connectivity?	
a) creates a barrier to fauna movement;	The proposed construction may create a partial barrier to Barking Owl movement through removal of arboreal habitat within disturbance footprints. This would affect limited areas and for limited periods. Aerial habitat would not be affected and so Barking Owls would readily traverse obstacles and gaps in habitat created by permanent project infrastructure. The proposed inundation of a portion of the site would not affect arboreal and aerial habitats and is unlikely to comprise a significant barrier to the movement of Barking Owls.
b) removes remnant vegetation or wildlife corridors; and	The proposed construction would remove 90 ha of habitat in native vegetation within infrastructure footprints. The gaps thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Barking Owls would readily traverse these gaps in habitat created by permanent project infrastructure.

c) modifies remnant vegetation or wildlife corridors.	The proposed construction would temporarily remove and/or modify 116 ha of habitat in native vegetation within the construction corridor. These areas would contain regenerating understorey vegetation after construction. The modified areas thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Aerial habitat would not be affected and so Barking Owls would readily traverse these areas of modified habitat.
iv) How is the project likely to affect critical habitat?	No critical habitat listed under legislation occurred in the project area or within adjacent areas of vegetation.
Conclusion	Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats at the site (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). Construction would remove valuable habitat resources including habitat trees but would affect a minor proportion of resources available in the locality and may help to secure the HBT resource in the longer term through environmental watering of mature River Red Gums. Barking Owls do not rely on any specific habitat resources that would be significantly adversely affected by flooding. Barking Owls are likely to benefit from a general increase in floodplain health and productivity as a result of flooding. Therefore the project is not likely to have a significant negative effect on the Barking Owl.

Table 8 Assessment of Significance for Bush Stone-curlew

Criteria	**Bush Stone-curlew**
i) How is the project likely to affect the lifecycle of a threatened species and/or population?	
a) displaces or disturbs threatened species and/or populations;	The Bush Stone-curlew is known from Black Box Woodland in the north western corner of the site. The majority of the site contains suitable habitat for the species, including all woodland and forest areas outside of limited areas of closed wetlands and dense shrubby understoreys. The proposed construction may displace or disturb some individuals if they are within or near the disturbance area. This disturbance would be short-term, is likely to affect a small proportion of local populations given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site and is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would limit the species' access to preferred habitat and so would displace some individuals for the duration of the inundation period. There are extensive areas of alternative habitat that would not be inundated within the project site (approximately 14, 000 ha). The significance of impacts will depend on the relative importance of the habitat to be flooded to the life cycle of local populations. The distribution and home ranges of local populations of the species at the site is not known. Home range characteristics of the species are likely to vary depending on the availability and proximity of roosting, foraging and breeding habitat (DEC, 2006). Studies have noted considerable variation in home range size and fidelity; ranging from permanent occupation of ranges under 50 ha to seasonal movements

	within ranges of over 300 ha. Home ranges typically contract during the breeding season (DEC, 2006). More serious impacts would occur if the species core breeding habitat was inundated. Previous records of the species are in the vicinity of the downstream levee near the margins of Black Box Woodland in the site and adjoining areas of cleared farmland. Overall, the species is more likely to occur in drier, more open habitats at higher elevations. These areas would be inundated at lesser depths and for shorter durations under the indicative operating scenario and less frequently overall. Local populations of the species have persisted in the context of natural flood regimes and are likely to utilise alternative habitat and reoccupy the inundation area after flood recession.
b) disrupts breeding cycle;	The proposed construction may disrupt breeding behaviour of some individuals if they are nesting within or near the disturbance area. This disturbance would be for one breeding season only, is likely to affect a small proportion of local populations and is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site may disrupt the breeding cycle of the species by flooding potential nest sites and/or increasing the distance that must be traversed to reach suitable, dry foraging habitat. The site contains substantial areas of alternative breeding habitat and so serious impacts are only likely for individuals that have commenced breeding and subsequently have their nest site or proximal foraging habitat inundated.
c) disturbs the dormancy period;	The Bush Stone-curlew is not known to have a dormancy period that could potentially be affected by the project.
d) disrupts roosting behaviour;	The Bush Stone-curlew does not roost *per se* but does occupy diurnal shelter sites on the ground, generally amongst suitable substrate in fallen timber (DEC, 2006). These species would shelter daily in appropriate areas of native vegetation. The proposed construction may affect some sheltering individuals if they are within or near the disturbance area. This disturbance would be short-term, is likely to affect a small proportion of local populations and is unlikely to threaten the persistence of the species at the site. The proposed inundation would reduce the area of suitable shelter for the species. There are extensive areas of alternative habitat that would not be inundated within the project site (approximately 14, 000 ha). This species is more likely to occur in drier, more open habitats at higher elevations. These areas would be inundated at lesser depths and for shorter durations under the indicative operating scenario and less frequently overall.
e) changes foraging behaviour;	The Bush-stone Curlew forages in open woodland with a sparse grassy understorey, plentiful fallen timber and areas of bare earth (DEC, 2006). There are extensive areas of these habitats at the site, with the most suitable areas likely to be Box woodlands around the margins of the site. The proposed downstream levee coincides with these areas of likely preferred habitat. The proposed construction may change foraging behaviour of some individuals if they are within or near the disturbance area. This disturbance would be short-term, is likely to affect a small proportion of local populations and is unlikely to threaten the persistence of the species at the site. The risk of direct disturbance is further reduced

	by the fact that the species is nocturnal and so would not be foraging during active construction. Some foraging habitat would be permanently removed or modified (refer *Criteria ii*). The species would have to utilise alternative habitat to compensate for this loss of resources. In the context of the approximately 31,000 ha of potential alternative habitat at the site this would comprise a minor impact. The proposed inundation of a portion of the site would limit the species' access to preferred habitat in the shrub and small tree layer and so may displace some individuals for the duration of the inundation period. The likely increase in productivity of invertebrate and plant populations in response to flooding (Boulton and Brock, 1999) may compensate for the reduction in the area of dry land habitat. Regardless, there are extensive areas of alternative habitat that would not be inundated within the project site. Local populations of the species have persisted in the context of natural flood regimes and are likely to utilise alternative habitat and reoccupy the inundation area after flood recession.
f) disrupts pollination cycle; g) disturbs seedbanks; or h) disrupts recruitment (i.e. germination and establishment of plants);	Not relevant to the Bush Stone-curlew.
i) affects the interaction between threatened species and other species in the community (eg. Pollinators, host species, microrrhizal associations).	Not relevant to the Bush Stone-curlew.
j) affects migration and dispersal ability;	The proposed construction may affect migration and dispersal ability through direct disturbance and removal of habitat within disturbance footprints. This would affect limited areas and for limited periods. Birds would readily traverse obstacles and gaps in habitat created by permanent project infrastructure. The proposed inundation of a portion of the site would flood habitats in the understorey and on the ground and so may limit the migration and dispersal ability of some individuals for the duration of the inundation period. The significance of impacts will depend on the relative importance of the habitat to be removed to the life cycle of local populations. As described above, the distribution and home ranges of local populations of the species at the site is not know and home range characteristics of the species, in general, are highly variable (DEC, 2006). More serious impacts would occur if the species' core breeding habitat was inundated. The species is more likely to occur in drier, more open habitats at higher elevations. These areas would be inundated at lesser depths and for shorter durations under the indicative operating scenario and less frequently overall.
ii) How is the project likely to affect the habitat of a threatened species, population or ecological community?	
a) disturbs any permanent, semi permanent or	The proposed construction would disturb extensive areas of intermittent and ephemeral floodplain wetlands. The Bush Stone-curlew does not rely

ephemeral water bodies;	on any specific wetland habitat resources that would be removed or modified by the project. The species may benefit from a general increase in floodplain health and productivity as a result of flooding.
b) degrades soil quality;	The project would degrade soil quality within the construction disturbance footprint through direct removal, earthworks or compaction. Negative impacts would affect a very minor proportion of the site: a maximum of 206 ha out of an area of approximately 32,000 ha. This magnitude of degradation is unlikely to result in significant negative effects on any habitat or resources for the species.
c) clears or modifies native vegetation;	Construction for the project would require the clearing or modification of native vegetation within the surface disturbance area, including: ◗ Temporary disturbance of approximately 206 ha of native vegetation. This includes 116 ha of project construction footprints that would be allowed to regenerate to their pre-disturbance state; and ◗ Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints. The removal of this vegetation would affect fauna life cycles, remove foraging resources and affect migration and dispersal ability by reducing the area of available habitat. These effects are described in the relevant Criteria within this assessment. The outcome of these assessments is that the proposed clearing or modification of native vegetation is unlikely to have a significant negative effect.
d) introduces weeds, vermin or feral species or provides conditions for them to increase and/or spread;	Bush Stone-curlews are dependant on native understorey species for foraging substrate and resources and so may be disadvantaged by weed infestation. The species relies on open ground strata for foraging and to allow for detection of predators (DEC, 2006) and so would experience negative impacts where weed infestation leads to a dense understorey. Native vegetation within the study area featured moderate weed infestation in the central portions of vegetation patches, with moderate to severe infestations around the margins of the forest and near to drainage lines. The proposed construction would involve the clearing of native vegetation and replacement with areas of roads, stockpiles, and project infrastructure. The project may increase the spread and/or prevalence of exotic weeds in the site through soil disturbance and transmission of propagules on vehicles and equipment. It is likely that areas environmental weed infestation would increase within the project disturbance footprint. The majority of the disturbance footprint is associated with the downstream levee which is adjacent to disturbed cleared land. The remainder of the site is partially disturbed by FNSW access tracks and ongoing timber harvesting and grazing activities. In this context, construction activities would have a relatively minor impact on the overall numbers and extent of weed species in the locality. The proposed flooding would transmit weed propagules into the site and increase soil moisture and nutrient status. These changes are likely to increase the degree of weed infestation at the site. This effect would be partially balanced by positive effects to the health of native vegetation but may reduce the value of habitat at the site for the Bush Stone-curlew through dense understorey regrowth. The effects of inundation would be most pronounced in wetter River Red Gum Forests in lower lying portions

	of the site. Impacts would be less pronounced in the species' preferred dry woodland habitats at the margins of the site. Terrestrial vermin or feral species are not expected to increase and/or spread as a result of the project. The proposed activity will not significantly fragment or isolated any habitat nor result in any other changes that are likely to favour feral animals.
e) removes or disturbs key habitat features such as trees with hollows, caves and rock crevices, foraging habitat;	The project will remove a maximum of 206 ha of foraging, shelter and breeding habitat for Bush Stone-curlews in native vegetation to be disturbed. Negative impacts would affect a very minor proportion of available habitats compared to the overall area of wetland habitat at the site (over 30,000 ha). Bush Stone-curlews are likely to benefit from a general increase in floodplain health and productivity within the area likely to experience beneficial effects of flooding (17,700 ha).These species do not rely on any other specific habitat resources that would be removed by the project.
f) affects natural revegetation and recolonisation of existing species following disturbance.	The proposed activity may affect the ability of threatened Bush Stone-curlews to recolonise following disturbance by reducing the overall amount of available habitat. The magnitude of this effect on the local populations is likely to be minor as permanent removal of all native vegetation would affect very small areas and is concentrated in drainage lines and wetter River Red Gum Forests, which are less suitable habitat for the species. The proposed downstream levee will permanently modify relatively extensive areas of core habitat for the species around the margins of the site. However, the modified footprint would be suitable habitat for the species, as it would feature regrowth of native grasses and herbs. Removal of trees from a linear strip, less than 20m wide, would not disadvantage the species, since it prefers open woodland habitats (DEC, 2006). The propose inundation will, in general, have a positive effect on natural revegetation and recolonisation of other floodplain species following disturbance.
iii) Does the project affect any threatened species or populations that are at the limit of its known distribution?	The Bush Stone-curlew is not at, or near the limit of its known distribution within the site. The species has a very broad distribution in inland and northern Australia, albeit as fragmented populations within this range (DEC, 2006). Regardless, the project will have a minor effect on the extent of available habitat and area of occupation of the species.
iv) How is the project likely to affect current disturbance regimes?	
a) modifies the intensity and frequency of fires;	The project would not directly affect the intensity and frequency of fires.
b) modifies flooding flows;	The project would have a positive effect on flooding flows by restoring a more natural flood regime to the site. This may have short term negative effects on Bush Stone-curlews by temporarily reducing the area of dry-land foraging habitat. This would be partially offset by positive impacts on the general health and productivity of floodplain ecosystems.
v) How is the project likely to effect habitat connectivity?	
a) creates a barrier to fauna movement;	The proposed construction may create a partial barrier to fauna movement through removal of habitat within disturbance footprints. This would affect limited areas and for limited periods. Birds would readily traverse

	obstacles and gaps in habitat created by permanent project infrastructure. The proposed inundation of a portion of the site would flood habitats for the Bush-stone Curlew and may create a partial barrier to some individuals for the duration of the inundation period. The significance of impacts will depend on the relative importance of the habitat to be flooded to the life cycle of local populations. As described above, the distribution and home ranges of local populations of the species at the site is not known and home range characteristics of the species, in general, are highly variable (DEC, 2006). More serious impacts would occur if the species' core breeding or foraging habitat was inundated. The species is more likely to occur in drier, more open habitats at higher elevations. These areas would be inundated at lesser depths and for shorter durations under the indicative operating scenario and less frequently overall.
b) removes remnant vegetation or wildlife corridors; and	The proposed construction would remove or permanently modify 90 ha of habitat in native vegetation within infrastructure footprints. The gaps thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Birds would readily traverse these gaps in habitat created by permanent project infrastructure.
c) modifies remnant vegetation or wildlife corridors.	The proposed construction would temporarily remove and/or modify 116 ha of habitat in native vegetation within the construction corridor. These areas would contain regenerating understorey vegetation after construction. The modified areas thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. The Bush-stone Curlew prefers open woodland habitats and open understorey and so modified and regenerating native vegetation, with less trees and shrubs, would still comprise habitat for the species. Birds would readily traverse these areas of modified habitat and are likely to use these areas as foraging habitat with minor overall loss of their value.
iv) How is the project likely to affect critical habitat?	There is no listed critical habitat at the site or of relevance to this AoS.
Conclusion	Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats at the site (approximately 32,000 ha). Bush Stone-curlews do not rely on any specific habitat resources that would be removed by the project. The proposed inundation of a portion of the site would reduce the area of available habitat for the Bush-stone Curlew for the duration of the inundation period. Bush Stone-curlews may experience some benefits from a general increase in floodplain health and productivity as a result of flooding. Therefore the project is not likely to have a significant negative effect on local populations of the Bush Stone-curlew.

Table 9 Assessment of Significance for Preliminary-listed Woodland Birds

Criteria	Varied Sittella	Scarlet Robin	White-browed Woodswallow
i) How is the project likely to affect the lifecycle of a threatened species and/or population?			
a) displaces or disturbs threatened species and/or populations;	The Varied Sittella was recorded in all habitats at the site in small foraging parties. The species appears to be relatively widespread and abundant at the site. The proposed construction may displace or disturb some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This magnitude of disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would not affect the species' access to preferred habitat in upper trunks and branches and so is unlikely to displace any individuals.	The Scarlet Robin was recorded in all habitats at the site with a possible preference for grassy Box woodlands. It appeared to be relatively widespread across the site but in small numbers. The proposed construction may displace or disturb some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This magnitude of disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would limit the species' access to preferred habitat in the shrub and small tree layer and on the ground and so may displace some individuals for the duration of the inundation period. There are extensive areas of alternative habitat that would not be inundated within the project site. Local populations of the	The White-browed Woodswallow was recorded in all habitats at the site and appears to be relatively widespread and abundant at the site. The proposed construction may displace or disturb some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site would not affect the species' access to preferred aerial foraging habitat and roost sites in the canopy and so is unlikely to displace any individuals.

Criteria	Varied Sittella	Scarlet Robin	White-browed Woodswallow
		species have persisted in the context of natural flood regimes and are likely to utilise alternative habitat and reoccupy the inundation area after flood recession.	
b) disrupts breeding cycle;	The Scarlet Robin is locally migratory and dispersive; the Varied Sittella is nomadic within arid environments; and the White-browed Woodswallow is highly nomadic. The site is likely to support local breeding populations of these species of woodland birds in at least some seasons. The proposed construction may disrupt breeding behaviour of some individuals if they are nesting within or near the disturbance area. This disturbance would be for one breeding season only and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This disturbance is unlikely to threaten the persistence of the species at the site. The proposed inundation of a portion of the site may disrupt the breeding cycle of these species by flooding potential nest sites and/or increasing the distance that must be traversed to reach suitable, dry foraging habitat. The site contains substantial areas of alternative breeding habitat and so serious impacts are only likely for individuals that have commenced breeding and subsequently have their nest site inundated. These effects may be balanced by positive, impacts such as increased productivity of the floodplain, which would benefit other breeding individuals.		
c) disturbs the dormancy period;	None of these woodland birds are known to have a dormancy period that could potentially be affected by the project.		
d) disrupts roosting behaviour;	None of these woodland birds are known to exhibit long term or ecologically important roosting behaviour that could potentially be affected by the project. These species would roost nightly in appropriate areas of native vegetation. The proposed construction may affect some roosting individuals if they are roosting within or near the disturbance area. This disturbance would be short-term, is likely to affect a small proportion of local populations and is unlikely to threaten the persistence of these species at the site. Floodwaters would be well below the level of the canopy and so inundation would not affect canopy-roosting species. There would be a reduction in the area of suitable habitat for shrub-roosting individuals for the duration of inundation. The majority of the inundation area would be less than one metre deep. There are extensive areas of alternative habitat		

Criteria	Varied Sittella	Scarlet Robin	White-browed Woodswallow
	that would not be inundated. A proportion of local species and individuals may also alter their behaviour to roost in the canopy. Local populations of these species have persisted in the context of natural flood regimes and are likely to utilise alternative roosting habitat and reoccupy the inundation area after flood recession.		
e) changes foraging behaviour;	The proposed construction may change foraging behaviour of some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This disturbance is unlikely to threaten the persistence of the species at the site. Some foraging habitat would be permanently removed (refer *Criteria ii*). The species would have to utilise alternative habitat to compensate for this loss of resources. In the context of the approximately 31,000 ha of alternative habitat at the site this would comprise a minor impact.	The proposed construction may displace or disturb some individuals if they foraging within or near the disturbance area. This disturbance would be short-term, is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This disturbance is unlikely to threaten the persistence of the species at the site. Some foraging habitat would be permanently removed (refer *Criteria ii*). The species would have to utilise alternative habitat to compensate for this loss of resources. In the context of the approximately 31,000 ha of alternative habitat at the site this would comprise a minor impact.	The proposed construction may change foraging behaviour of some individuals if they are within or near the disturbance area. This disturbance would be short-term and is likely to affect a small proportion of local populations, given the maximum construction corridor of 206 ha within the 32, 000 ha of similar habitat at the site. This disturbance is unlikely to threaten the persistence of the species at the site. Some foraging habitat would be permanently removed (refer *Criteria ii*). The species would have to utilise alternative habitat to compensate for this loss of resources. In the context of the approximately 31,000 ha of alternative habitat at the site this would comprise a minor impact.
	The proposed inundation of a portion of the site would not affect the species' access to preferred foraging habitat in the upper branches and trunk of trees and so is unlikely to displace any individuals. The species may experience positive impacts through increased growth and	The proposed inundation of a portion of the site would limit the species' access to preferred foraging habitat in the understorey and on the ground and so may change foraging behaviour of some individuals for the duration of the inundation period. The likely increase in productivity of	The proposed inundation of a portion of the site would not affect the species' access to preferred aerial foraging habitat and so is unlikely to displace any individuals. The species may experience positive impacts through increased productivity of floodplain ecosystems in response to

Criteria	Varied Sittella	Scarlet Robin	White-browed Woodswallow
	productivity of Eucalyptus in response to flooding, which is likely to result in a increase in the abundance of the species' invertebrate prey.	invertebrate and plant populations in response to flooding (Boulton and Brock, 1999) may compensate for the reduction in the area of dry land habitat. Regardless, there are extensive areas of alternative habitat that would not be inundated including approximately 15,000 ha of comparable woodland and forest within the project site. Local populations of the species have persisted in the context of natural flood regimes and are likely to utilise alternative habitat and reoccupy the inundation area after flood recession.	flooding, which is likely to result in a increase in the abundance of the species' invertebrate prey. Notably mosquitos, midges, mayflys and other insects with an amphibious life cycle are likely to increase in abundance.
f) disrupts pollination cycle; g) disturbs seedbanks; or h) disrupts recruitment (i.e. germination and establishment of plants);	Not relevant to these woodland bird species.		
i) affects the interaction between threatened species and other species in the community (eg. Pollinators, host species, microrrhizal associations).	Not relevant to these woodland bird species.		
j) affects migration and dispersal ability;	The proposed construction may affect migration and dispersal ability through direct disturbance and removal of habitat within disturbance footprints. This would affect limited areas and for limited periods. Birds would readily traverse		

Criteria	Varied Sittella	Scarlet Robin	White-browed Woodswallow
	obstacles and gaps in habitat created by permanent project infrastructure. The proposed inundation of a portion of the site would flood habitats in the understorey and on the ground and so may limit the migration and dispersal ability of some individuals for the duration of the inundation period. Potential travelling and resting habitat in the canopy would not be affected. Given the maintenance of canopy habitats and extensive areas of understorey habitat outside the inundation area the effect of flooding on migration and dispersal ability is likely to be minor.		
ii) How is the project likely to affect the habitat of a threatened species, population or ecological community?			
a) disturbs any permanent, semi permanent or ephemeral water bodies;	The proposed construction would directly disturb a number of intermittent water bodies at the locations of the proposed regulators and channels. This would remove habitat within the construction footprint and modify the form and flow characteristics of the water body. Negative effects would be very limited in extent in the context of the extensive network of intermittent water bodies at the site. The majority of the remainder of the site, including the entire construction disturbance footprint, is an ephemeral floodplain wetland. The proposed operation of the project would affect: the Murray River; approximately 1200 ha of mapped floodplain marshes and drainage lines; a multitude of smaller flood runners; and ephemeral forest-wetlands on the floodplain itself. Negative impacts would affect a very minor proportion of wetland habitats (a maximum of 206 ha) compared to the overall area of wetland habitat at the site (over 30,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). These species of woodland birds do not rely on any specific wetland habitat resources that would be removed by the project. Woodland birds are likely to benefit from a general increase in floodplain health and productivity as a result of flooding. This has been demonstrated in other comparable areas, such as the increase in the diversity and abundance of bush birds in Barmah Forest following environmental watering (Barmah Millewa Forum, 2001).		
b) degrades soil quality;	The project would degrade soil quality within the construction disturbance footprint through direct removal, earthworks or compaction. Negative impacts would affect a very minor proportion of the site: a maximum of 206 ha out of an area of approximately 32,000 ha. This magnitude of degradation is unlikely to result in significant negative effects on any habitat or resources for these species.		
c) clears or modifies native vegetation;	Construction for the project would require the clearing or modification of native vegetation within the surface disturbance area, including: ◗ Temporary disturbance of approximately 206 ha of native vegetation. This includes 116 ha of project construction		

Criteria	Varied Sittella	Scarlet Robin	White-browed Woodswallow
	footprints that would be allowed to regenerate to their pre-disturbance state; and ◗ Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints. The removal of this vegetation would affect fauna life cycles, remove foraging resources and affect migration and dispersal ability by reducing the area of available habitat. These effects are described in the relevant Criteria within this assessment. The outcome of these assessments is that the proposed clearing or modification of native vegetation is unlikely to have a significant negative effect.		
d) introduces weeds, vermin or feral species or provides conditions for them to increase and/or spread;	The Varied Sittella's preferred trunk and upper branch habitat is composed almost entirely of native species at the site. River Red Gum and Black Box dominate the site forming extensive monoculture communities. These canopy species are highly resilient to weed invasion. Therefore the proposed construction would not affect the species' canopy habitat beyond the direct removal of trees addressed in point c) above. The proposed inundation is unlikely to facilitate the invasion of any canopy species that would have a competitive advantage over River Red Gum and Black Box. Terrestrial vermin or feral species are not expected to increase and/or spread as a result of the project. The proposed activity will not significantly	The Scarlet Robin is dependant on native understorey species for foraging substrate and resources and so may be disadvantaged by weed infestation. Native vegetation within the study area featured moderate weed infestation in the central portions of vegetation patches, with moderate to severe infestations around the margins of the forest and near to drainage lines. The proposed construction would involve the clearing of native vegetation and replacement with areas of roads, stockpiles, and project infrastructure. The project may increase the spread and/or prevalence of exotic weeds in the site through soil disturbance and transmission of propagules on vehicles and equipment. It is likely that areas environmental weed infestation would increase within the project	The White-browed Woodswallow is an aerial forager and so weed invasion would have little impact on its life cycle. Roosting habitat is composed almost entirely of native species at the site. River Red Gum and Black Box dominate the site forming extensive monoculture communities. These canopy species are highly resilient to weed invasion. Therefore the proposed construction would not affect the species' roosting habitat beyond the direct removal of trees addressed in point c) above. The proposed inundation is unlikely to facilitate the invasion of any canopy species that would have a competitive advantage over River Red Gum and Black Box. Terrestrial vermin or feral species are not expected to increase and/or

Criteria	Varied Sittella	Scarlet Robin	White-browed Woodswallow
	fragment or isolated any habitat nor result in any other changes that are likely to favour feral animals.	disturbance footprint. The majority of the disturbance footprint is associated with the downstream levee which is adjacent to disturbed cleared land. The remainder of the site is partially disturbed by FNSW access tracks and ongoing timber harvesting and grazing activities. In this context, construction activities would have a relatively minor impact on the overall numbers and extent of weed species in the locality. The proposed flooding would transmit weed propagules into the site and increase soil moisture and nutrient status. These changes are likely to increase the degree of weed infestation at the site. This effect would be balanced by positive effects to the health of native vegetation and would not significantly reduce the value of habitat at the site for the Scarlet Robin. Terrestrial vermin or feral species are not expected to increase and/or spread as a result of the project. The proposed activity will not significantly fragment or isolated any habitat nor result in any other changes that are likely to favour feral animals.	spread as a result of the project. The proposed activity will not significantly fragment or isolated any habitat nor result in any other changes that are likely to favour feral animals.
e) removes or disturbs key habitat features such	The project will remove a maximum of 206 ha of foraging, shelter and breeding habitat for Woodland birds in native vegetation to be disturbed. Negative impacts would affect a very minor proportion of available habitats compared to the		

Criteria	Varied Sittella	Scarlet Robin	White-browed Woodswallow
as trees with hollows, caves and rock crevices, foraging habitat;	overall area of wetland habitat at the site (over 30,000 ha). Woodland birds are likely to benefit from a general increase in floodplain health and productivity within the area likely to experience beneficial effects of flooding (17,700 ha).These species of Woodland birds do not rely on any other specific habitat resources that would be removed by the project.		
f) affects natural revegetation and recolonisation of existing species following disturbance.	The proposed activity may affect the ability of woodland birds to recolonise following disturbance by reducing the overall amount of available habitat. The magnitude of this effect on the local populations is likely to be minor as these species are mobile and will travel large distances to exploit seasonal foraging resources. The propose inundation will, in general, have a positive effect on natural revegetation and recolonisation of existing species following disturbance.		
iii) Does the project affect any threatened species or populations that are at the limit of its known distribution?	None of these species of woodland birds are at, or near the limit of their known distribution within the site. Regardless, the project will have a minor effect on the extent of available habitat and area of occupation of these species.		
iv) How is the project likely to affect current disturbance regimes?			
a) modifies the intensity and frequency of fires;	The project would not directly affect the intensity and frequency of fires.		
b) modifies flooding flows;	The project would have a positive effect on flooding flows by restoring a more natural flood regime to the site. This would be expected to have net positive effects on woodland birds by improving the health and productivity of floodplain ecosystems.		
v) How is the project likely to effect habitat connectivity?			
a) creates a barrier to fauna movement;	The proposed construction may create a partial barrier to fauna movement removal of habitat within disturbance footprints. This would affect limited areas and for limited periods. Birds would readily traverse obstacles and gaps in habitat created by permanent project infrastructure. The proposed inundation of a portion of the site would flood habitats in the understorey and on the ground and so may create a partial barrier to some individuals for the duration of the inundation period. habitat connectivity in the canopy would not be affected and extensive areas of understorey habitat would be maintained outside the inundation area.		

Criteria	Varied Sittella	Scarlet Robin	White-browed Woodswallow
	Therefore inundation is unlikely to comprise a significant barrier to the movement of birds.		
b) removes remnant vegetation or wildlife corridors; and	The proposed construction would remove 90 ha of habitat in native vegetation within infrastructure footprints. The gaps thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Birds would readily traverse these gaps in habitat created by permanent project infrastructure.		
c) modifies remnant vegetation or wildlife corridors.	The proposed construction would temporarily remove and/or modify 116 ha of habitat in native vegetation within the construction corridor. These areas would contain regenerating understorey vegetation after construction. The modified areas thus created would be less than 100 metres across and would be adjacent to extensive areas of intact native vegetation. Birds would readily traverse these areas of modified habitat.		
iv) How is the project likely to affect critical habitat?	There is no listed critical habitat at the site or of relevance to this AoS.		
Conclusion	Direct negative impacts arising from the project would affect a very minor proportion of individuals and habitats (a maximum of 206 ha) compared to the overall area of similar habitats at the site (approximately 32,000 ha) and the area likely to experience beneficial effects of flooding (17,700 ha). These species of woodland birds do not rely on any specific habitat resources that would be removed by the project or significantly adversely affected by flooding. Woodland birds are likely to benefit from a general increase in floodplain health and productivity as a result of flooding. This has been demonstrated in other comparable areas, such as the increase in the diversity and abundance of bush birds in Barmah Forest following environmental watering (Barmah Millewa Forum, 2001). Therefore the project is not likely to have a significant negative effect on local populations of the Varied Sittella, Hooded Robin or White-browed Woodswallow.		

C.3.4 Threatened Aquatic Biota

Based on the assessments presented above the project may result in:

- Modification of habitat and changes to the life cycle of one threatened fish, the Silver Perch; and
- Direct impacts and modification of habitat for the FM Act listed EEC, Murray River Ecological Community.

An evaluation of the magnitude, extent and significance of impacts of the proposal on these threatened biota and their habitats following the assessment criteria identified in the Guidelines for Threatened Species Assessment under Part 3A of the EP & A Act (DEC 2005 and DPI 2005) has been undertaken and is included below.

C.4 Assessments of Significance

Table 10 Assessment of Significance for the Silver Perch

Criteria	Silver Perch
i) How is the project likely to affect the lifecycle of a threatened species and/or population?	
a) displaces or disturbs threatened species and/or populations;	There may be localised construction impacts on the species and its habitat where the proposed inlet and outlet channels adjoin the main channel of the Murray River. Sensitive construction techniques and mitigation measures would be used to minimise direct impacts (refer Section 11.3.1). Therefore construction would affect a very limited area of aquatic habitat within the boundary of sediment control devices in the immediate vicinity of the construction footprint. The affected area would not contain a significant proportion of individuals or habitat for the species in the local area. The remainder of the construction corridor contains intermittent water bodies and ephemeral floodplain wetlands. These habitats would have limited value for the Silver Perch in their current dry state and are unlikely to be occupied during the construction period. The proposed inundation of the site would displace or disturb some individuals if they are drawn into the site in floodwaters. This would increase the area of potentially suitable habitat for the species and would be expected to have many positive effects. There may be short term negative effects as a result of blackwater events. Modelling of the potential for blackwater has been undertaken for the project (Water Quality in GHD, 2009c). Results indicated that there is likely to be release of dissolved organic carbon from the litter that has accumulated on the floodplain. This is expected to result in a decrease in dissolved oxygen to < 2mg/L for periods during managed floods which would have negative impacts on Silver Perch within the flood pool. If the indicative operating scenario occurred after a period of prolonged litter accumulation (which is likely) it would kill a proportion of local populations of the species. The proposed operational regime and monitoring and adaptive management framework will be used to minimise potential negative effects of blackwater as far as is practicable, such as through avoiding flooding over Summer.

Criteria	Silver Perch
	Under the indicative operational scenario the project would discharge water into Barbers Creek when it is experiencing low flows. Therefore blackwater impacts on downstream Barbers Creek are likely. When the proposed return channel is operating at maximum flow rates of 1,850ML/day, flows in the Murray River downstream of the Torrumbarry Weir are likely to be at least 5,000 - 6,000 ML/day. As a result, blackwater would be diluted by flows in the Murray River (Water Quality Chapter, 2009) and is unlikely to result in significant impacts on Silver Perch populations within the Murray River. Therefore potential blackwater events are only likely to affect individuals that are drawn into the site during flood events or are in Barbers Creek. Given the extent of aquatic habitat in the Murray River and in other floodplain wetlands and drainage lines in the locality this is unlikely to affect an ecologically significant proportion of any local populations of Silver Perch. Analysis of natural and managed floods and associated blackwater events in comparable environments in the Barmah-Millewa forest suggest that local populations of aquatic biota are resilient to these effects over longer time scales (Howitt *et al*., 2007; King *et. al.,* 2007) and that populations of Silver Perch in the Murray River may increase spawning activity following a managed flood (King *et. al.,* 2007). Downstream Silver Perch habitats may benefit from increased carbon and nutrient transfer as a result of flooding (Gawne *et al.,* 2007). Monitoring of water quality and fish populations during flood events will be important to avoid negative effects as far as is practicable. Overall, short term negative effects of the project within the flood pool are likely to be offset by the benefits of the project for local populations of Silver Perch and their habitats outside the site.
b) disrupts breeding cycle;	Silver Perch are a schooling fish with distinct migratory movements before and after spawning. Adults move upstream in spring and summer, to areas behind the peaks of floods, in order to spawn. Little is known of the species' movements during the rest of the year, although juvenile fish are also known to move upstream, apparently in response to rises in water temperature and river level (NSW DPI 2006). The proposed inundation of a portion of the site would increase the area of potentially suitable habitat for the species, increase wetland productivity and potentially stimulate breeding behaviour. The proposed operational regime would aim to maintain flood conditions in floodplain marshes at appropriate seasons, and for appropriate durations to facilitate fish breeding. This purposeful operation would minimise the potential for adverse affects through rapid recession of flood waters or other impacts on breeding events. Populations of Silver Perch in the Murray River increased spawning activity following a comparable flood in the Barmah-Millewa forest (King *et. al.,* 2007). Importantly dissolved oxygen levels did not decline sufficiently to affect fish during this event (King *et. al.,* 2007) whereas blackwater is likely to have negative effects within the flood pool under the scenarios assessed in this report (Water Quality in GHD, 2009). The proposed operational regime and monitoring and adaptive management framework will be used to minimise potential negative effects of blackwater as far as is practicable, such as through avoiding flooding over Summer. Nonetheless, the proposed flooding would be expected to have positive effects on the breeding cycle of the species downstream of the site and

Criteria	Silver Perch
	over subsequent seasons.
c) disturbs the dormancy period;	The Silver Perch is not known to have a dormancy period that could potentially be affected by the project.
d) disrupts roosting behaviour;	The Silver Perch is not known to exhibit long term or ecologically important roosting behaviour that could potentially be affected by the project.
e) changes foraging behaviour;	The proposed construction would affect limited areas of aquatic habitat in the immediate vicinity of excavations for the inlet and outlet channels. A small area of foraging habitat would be isolated by sediment control devices. this would have a negligible effect on local populations of the Silver Perch. The proposed operation would affect foraging behaviour by creating an area of aquatic habitat on the floodplain. During the filling phase of the proposed inundation event, Silver Perch (including adults, juveniles and eggs/larvae) are likely to enter the upstream end of the site via the intake regulator and then Bullock Head Creek and the floodplain. Fish may also aggregate below the intake regulator during inundation. Fish would not be attracted to the outlet regulators as they would either be closed or discharge flows would be too low to attract fish (FPTF, 2009). Low DO concentrations in the flood pool due to blackwater events may threaten Silver Perch within the flood pool; refer *Criteria i), a).* Monitoring and adaptive management will be important through this process as a number of other variables would combine to determine the risk to threatened fish populations. Portions of the local population of Silver Perch outside the site may experience beneficial effects through the transfer of organic carbon and other nutrients in flood waters (refer Section 9.11).
f) disrupts pollination cycle; g) disturbs seedbanks; or h) disrupts recruitment (i.e. germination and establishment of plants);	Not relevant to the Silver Perch .
i) affects the interaction between threatened species and other species in the community (eg. Pollinators, host species, microrrhizal associations).	Not relevant to the Silver Perch .
j) affects migration and dispersal ability;	Adult Silver Perch move upstream in spring and summer to spawn and juvenile fish are also known to move upstream, apparently in response to rises in water temperature and river level (NSW DPI 2006). The proposed construction would not interrupt fish passage or otherwise affect migration and dispersal ability of the Silver Perch. Any silt fences, coffer dams or equivalent required for construction would be

Criteria	Silver Perch
	located in the immediate vicinity of the excavation area and would not completely cross any drainage lines or isolate any significant areas of aquatic habitat. Provision for fish passage has been incorporated into the design of the project infrastructure. The structures have been specifically designed to ensure that large-bodied native fish, including Silver Perch, can enter and leave the floodplain (DSTA, 2009; FPTF, 2009). During the filling phase of the proposed inundation event, Silver Perch (including adults, juveniles and eggs/larvae) are likely to enter the upstream end of the site via the intake regulator and then Bullock Head Creek and the floodplain. Fish may also aggregate below the intake regulator during inundation. Fish would not be attracted to the outlet regulators as they would either be closed or discharge flows would be too low to attract fish (FPTF, 2009). There is a residual risk that the project would trap large-bodied native fish, including Silver Perch since the main exit route is upstream and involves channels of a variety of depths over more than 30 km which must be negotiated between the time when flow-cues to exit the forest are received and the time when the proposed Denil fishway ceases to operate effectively (FPTF, 2009, Ecological Associates, 2009). If a significant number of large-bodied native fish are found to be trapped by this process then a fish rescue plan may be required to avoid significant impacts on local populations of the Silver Perch. Monitoring and adaptive management will be important through this process as a number of other variables would combine to determine the risk to threatened fish populations. For instance, low DO concentrations in the flood pool due to blackwater events may prove to be a more significant factor than fish passage out of the forest; refer *Criteria i), a).*
ii) How is the project likely to affect the habitat of a threatened species, population or ecological community?	
a) disturbs any permanent, semi permanent or ephemeral water bodies;	The proposed construction would directly disturb a number of intermittent water bodies at the locations of the proposed regulators and channels. This would remove habitat within the construction footprint and modify the form and flow characteristics of the water body. Negative effects would be very limited in extent in the context of the extensive network of intermittent water bodies at the site. The majority of the remainder of the site, including the entire construction disturbance footprint, is an ephemeral floodplain wetland. These habitats would have limited value for the Silver Perch in their current dry state and are unlikely to be occupied during the construction period. The proposed operation of the project would affect: the Murray River; approximately 1200 ha of mapped floodplain marshes and drainage lines; a multitude of smaller flood runners; and ephemeral forest-wetlands on the floodplain itself. The project is expected to have net-positive effects on these habitats through restoration of a more natural flood regime. The Silver Perch would also be expected to experience positive effects such as an increase in flooded wetland area and a general increase in floodplain health and productivity as a result of flooding. Black water events are likely to have localised negative effects on Silver Perch within the flood pool and Barbers Creek and may kill a

Criteria	Silver Perch
	portion of local populations of the species; *refer Criteria i), a).* The project would divert water away from the Murray River potentially reducing flows into Silver Perch habitats outside the site. The water diverted into the forest will largely be environmental water that would be 'called' and released from upstream storages specifically for the purpose of achieving flows into the site. As such, water diverted at Torrumbarry weir will be flow that would not otherwise be in the system and, hence the diversions should have minimal or no impact on the Murray River flows (personal communication, D Green, MDBA, 2009).
b) degrades soil quality;	The project would degrade soil quality within the construction disturbance footprint through direct removal, earthworks or compaction. Negative impacts would affect a very minor proportion of the site: a maximum of 206 ha out of an area of approximately 32,000 ha. Measures to contain impacts from construction, including sediment control and the retention and re-spreading of topsoil will be implemented, and thus soil quality is unlikely to be affected outside of the immediate surface disturbance area. This magnitude of degradation is unlikely to result in significant negative effects on any habitat or resources for the species.
c) clears or modifies native vegetation;	The proposed construction would permanently remove or modify aquatic vegetation and habitat within the footprints of the proposed regulators and downstream portions of the inlet channel that coincide with Bullock Head Creek. Construction for the project would require the clearing or modification of terrestrial native vegetation within the surface disturbance area, including: ◗ Temporary disturbance of approximately 206 ha of native vegetation. This includes 116 ha of project construction footprints that would be allowed to regenerate to their pre-disturbance state; and ◗ Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints. The removal of this terrestrial vegetation would remove some habitat resources for the species, such as supplementary foraging resources during flood events and coarse woody debris. These effects are described in the relevant Criteria within this assessment. The outcome of these assessments is that the proposed clearing or modification of native vegetation is unlikely to have a significant negative effect on the Silver Perch.
d) introduces weeds, vermin or feral species or provides conditions for them to increase and/or spread;	Silver Perch are dependant on native wetland species for foraging substrate and to support aquatic prey species. The project is intended to restore a more natural flooding regime and would be expected to favour native wetland plants at the expense of terrestrial species or environmental weeds. The proposed flooding would transmit weed propagules into the site and increase soil moisture and nutrient status. These changes are likely to increase the degree of weed infestation at the site. This effect would be balanced by positive effects to the health of native vegetation and would

Criteria	Silver Perch
	not significantly reduce the value of habitat at the site for Silver Perch . Based on the results of environmental watering events in the Barmah-Millewa Forest (King *et. al*., 2009) the proposed inundation is likely to increase the abundance and/or spread of exotic fish. Notably Carp are known to breed on floodplains through movement of adults onto floodplain environments to spawn as well as passive movement of larvae from the river to the floodplain, where they take advantage of increased food resources to increase survival and recruitment (King *et al*., 2009). There is the potential for negative impacts as these fish are transported back to the river as the floodplain is drained (DSTA, 2009).
e) removes or disturbs key habitat features such as trees with hollows, caves and rock crevices, foraging habitat;	The Silver Perch does not rely on any specific habitat resources that would be removed or significantly disturbed by the project. There are extensive areas of important aquatic and wetland habitats within the site, but only limited areas within the proposed construction corridor. The proposed construction would permanently remove or modify aquatic vegetation and habitat within the footprints of the proposed regulators and downstream portions of the inlet channel that coincide with Bullock Head Creek. The broader construction corridor contains intermittent water bodies and ephemeral floodplain wetlands. The project will remove a maximum of 168 ha of potential provisioning habitat for Silver Perch in the floodplain vegetation to be disturbed. Negative impacts would affect a very minor proportion of available habitats compared to the overall area of wetland habitat at the site (over 30,000 ha). Silver Perch are likely to benefit from a general increase in floodplain health and productivity within the area likely to experience beneficial effects of flooding (17,700 ha).
f) affects natural revegetation and recolonisation of existing species following disturbance.	The proposed construction would have a minor negative impact on the ability of Silver Perch to recolonise following disturbance through a minor reduction in the overall amount of available habitat and by limiting movement of some individuals that may be trapped within the flood pool. These effects would be offset by positive effects of environmental watering including an increase in the area of available aquatic habitat during flood events and increased productivity and transfer of organic carbon and nutrients to the main channel of the Murray River (Gawne *et al.,* 2007). Comparable environmental watering events have resulted in increased spawning of Silver Perch in the Murray River (King *et. al.,* 2007).
iii) Does the project affect any threatened species or populations that are at the limit of its known distribution?	Many recent surveys within the Murray-Darling Basin, including the NSW Rivers Survey, have recorded extremely low numbers of Silver Perch. In NSW, only one remaining secure and self-sustaining natural population has been confirmed in the central Murray River downstream of Yarrawonga Weir, as well as several anabranches and tributaries including the Edward River, Wakool anabranch, Colligen Creek, Yallakool Creek and the Neimur River (Fisheries Ecosystems 2007). The site is within distribution of this natural population. The direct removal of a portion of the habitat for the community within project infrastructure footprints would have a minor effect on its overall distribution within this range.
iv) How is the project likely to affect current disturbance regimes?	

Criteria	Silver Perch
a) modifies the intensity and frequency of fires;	The project would not directly affect the intensity and frequency of fires.
b) modifies flooding flows;	The project would modify flooding flows through the construction of hydraulic infrastructure with the aim of restoring a more natural flood regime to the site. Alteration to natural flow regimes refers to reducing or increasing flows, altering seasonality of flows, changing the frequency, duration, magnitude, timing, predictability and variability of flow events, altering surface and subsurface water levels and changing the rate of rise or fall of water levels. Three human processes have predominantly altered flows in streams, rivers and their floodplains, and wetlands in NSW. These are: building of dams, diversion of flows by structures or extraction, and alteration of flows on floodplains with levees and structures. The project will directly contribute to all three processes by: ◗ Building regulators across natural drainage lines; ◗ Diversion of flows through construction of the intake regulator and Torrumbarry cutting and extraction from the Murray River; and ◗ Alteration of flows across the floodplain through the downstream levee, floodway and the system of regulators. Alteration to flooding flows is recognised as a major factor contributing to loss of biological diversity and ecological function in aquatic ecosystems and as a direct threat to the Silver Perch (DPI, 2009). Three major factors mitigate the potential for negative impacts arising from alterations to hydrology due to the project: ◗ The hydrology of the site, the Murray River and associated catchments have been extensively modified by river regulation and the current situation is not characteristic of 'natural flow regimes'; ◗ The hydraulics of the site (i.e. the geomorphology and upstream built structures that dictate hydrology) does not permit 'natural flow regimes' onto the floodplain under current and modelled future Murray River flow regimes; and ◗ The project infrastructure is designed to facilitate delivery of water in order to achieve a more natural flow regime and the proposed operation of the project would aim to simulate natural conditions as far as is practicable. Potential impacts associated with alterations to hydrology arising from the proposed activity are assessed in detail in Section 9. The outcome of this assessment is that the project is not likely to have any significant negative impacts on aquatic and wetland habitats within the site or downstream. The operation of the project is likely to have a number of net positive impacts on aquatic and wetland habitats within the site. Therefore the proposed activity is unlikely to modify flows in a way that would have a significant negative effect on the Silver Perch.
v) How is the project likely to effect habitat connectivity?	

Criteria	Silver Perch
a).creates a barrier to fauna movement;	The project involves the construction of a number of regulators and levees which, in general, would comprise potential barriers to movement of aquatic fauna. Provision for aquatic biota passage has been incorporated into the engineering design and Operating Plan for the project. Based on advice from fish passage specialists the structures have been specifically designed to ensure that native fish can enter and leave the floodplain (DSTA, 2009; FPTF, 2009). Other key factors for fish passage include the timing of flood events and management of flows. Purposeful management of the project would include mimicking the timing of natural flow regimes, variability and pulsing and providing sufficient time during the flooding recession phase to allow fish to move from the floodplain to the river (FPTF, 2009). Due to the layout of the site there is a residual risk that the project would trap some Silver Perch within the flood pool during managed events (refer Section **Error! Reference source not found.**). The Swan Lagoon regulators and downstream stop log structures have been designed to allow for fish passage during a natural flood and will be fully open in a natural flood to allow the flood to operate with minimal change from the current situation (FPTF, 2009). The proposed structures are designed to provide appropriate velocities of water flow for upstream fish passage and specific measures are being designed to provide a low velocity/turbulence corridor at the abutments at each downstream stop log regulator structure to facilitate upstream fish passage (FPTF, 2009). The overall intent of the project is to facilitate delivery of water in order to achieve a more natural flow regime. The proposed operation of the project would aim to simulate natural conditions as far as is practicable. The operation of the project is likely to have a number of positive impacts on connectivity of aquatic and floodplain habitats within the site through the proposed flooding. Notwithstanding potential impacts on fish passage at project infrastructure, flooding would improve connectivity between the main stem Murray River and floodplain habitats when compared with the prolonged drying of the site.
b) removes remnant vegetation or wildlife corridors; and	The proposed construction would not permanently remove any habitat corridors for the Silver Perch. Continuity of aquatic habitat would be maintained around the disturbance footprint. The effect of project infrastructure on fauna movement is addressed in point *v), a)* above.
c) modifies remnant vegetation or wildlife corridors.	The proposed construction would modify habitat corridors for the Silver Perch at the locations of the proposed regulators and downstream portions of the inlet channel that coincide with Bullock Head Creek.. Continuity of aquatic habitat would be maintained around the disturbance footprint. The modified areas thus created would be less than 50 metres across and would be adjacent to extensive areas of aquatic and floodplain habitat and intact native vegetation. The effect of project infrastructure on fauna movement is addressed in point *v), a)* above.
iv) How is the project likely to affect critical	There is no listed critical habitat at the site or of relevance to this AoS.

Criteria	Silver Perch
habitat?	
Conclusion	habitat within the majority of the construction footprint would have limited value for the Silver Perch in its current dry state and is unlikely to be occupied during the construction period. Negative impacts arising from the proposed construction would affect a very minor proportion of individuals and habitats. Given the incorporation of fish passage considerations into the design of project infrastructure (FPTF, 2009) the project would not create any permanent barriers to fish passage and the proposed inundation would probably result in the trapping of a limited proportion of large bodied fish. There is the potential for blackwater events to have locally severe negative effects on Silver Perch that are drawn into the site during flood events or are in Barbers Creek downstream. The project may also result in increased spawning and recruitment of Carp and other pest fish and transfer back to the Murray River. Monitoring of water quality and fish populations during flood events will be important to avoid negative effects of blackwater and pest species as far as is practicable. Adaptive management of the timing, duration and other aspects of the proposed inundation provides scope to substantially mitigate negative effects. These effects would be offset by positive effects of environmental watering including an increase in the area of available aquatic habitat during flood events and increased productivity and transfer of organic carbon and nutrients to the main channel of the Murray River (Gawne *et al.,* 2007). Comparable environmental watering events have resulted in increased spawning of the Silver Perch in the main channel of the Murray River (King *et. al.,* 2007). Overall, negative effects of the project are likely to affect a limited proportion of local populations of the Silver Perch and may be mitigated through purposeful operation and adaptive management. Residual negative effects of the project would be limited to the flood pool and are likely to be offset by the benefits of the project for populations and habitats of the Silver Perch outside the site.

Table 11 Assessment of Significance for Murray River EEC

Criteria	Murray River EEC
i) How is the project likely to affect the lifecycle of a threatened species and/or population?	Not applicable to the assessment of this EEC.
ii) How is the project likely to affect the habitat of a threatened species, population or ecological community?	
a) disturbs any	The proposed construction would directly disturb a number of intermittent water

Criteria	Murray River EEC
permanent, semi permanent or ephemeral water bodies;	bodies at the locations of the proposed regulators and channels. This would remove habitat within the construction footprint and modify the form and flow characteristics of the water body. Negative effects would be very limited in extent in the context of the extensive network of intermittent water bodies at the site. The majority of the remainder of the site, including the entire construction disturbance footprint, is an ephemeral floodplain wetland. These habitats would have limited value for the Murray River EEC in their current dry state and are unlikely to contain any aquatic biota during the construction period. The proposed operation of the project would affect: the Murray River; approximately 1200 ha of mapped floodplain marshes and drainage lines; a multitude of smaller flood runners; and ephemeral forest-wetlands on the floodplain itself. Over the operational life of the project the proposed inundation is expected to have net-positive effects on these habitats through restoration of a more natural flood regime. Aquatic biota would be expected to experience positive effects such as an increase in flooded aquatic habitat and a general increase in floodplain health and productivity as a result of flooding. There may be short term negative effects as a result of blackwater events. Modelling of the potential for blackwater has been undertaken for the project (Water Quality in GHD, 2009c). Results indicated that there is likely to be release of dissolved organic carbon from the litter that has accumulated on the floodplain over the long inter-flood interval. This is expected to result in a decrease in dissolved oxygen to < 2mg/L for periods during managed floods which would have negative impacts on native fish and other aquatic biota within the flood pool. If the indicative operating scenario occurred after a period of prolonged litter accumulation (which is likely) it would kill a proportion of local populations of the species. The proposed operational regime and monitoring and adaptive management framework will be used to minimise potential negative effects of blackwater as far as is practicable, such as through avoiding flooding over Summer. Under the indicative operational scenario the project would discharge water into Barbers Creek when it is experiencing low flows. Therefore blackwater impacts on downstream Barbers Creek are likely. When the proposed return channel is operating at maximum flow rates of 1,850ML/day, flows in the Murray River downstream of the Torrumbarry Weir are likely to be at least 5,000 - 6,000 ML/day. As a result, blackwater would be diluted by flows in the Murray River (Water Quality Chapter, 2009) and is unlikely to result in significant impacts on sub-populations of the EEC within the Murray River. Therefore potential blackwater events are only likely to affect sub-populations of the EEC that are drawn into the site during flood events or are in Barbers Creek. Given the extent of aquatic habitat in the Murray River and in other floodplain wetlands and drainage lines in the locality this is unlikely to affect an ecologically significant proportion of any local populations of aquatic biota. Analysis of natural and managed floods and associated blackwater events in comparable environments in the Barmah-Millewa forest suggest that local populations of aquatic biota are resilient to these effects over longer time scales (Howitt *et al*., 2007; King *et. al.,* 2007). Further, downstream aquatic ecosystems may experience beneficial effects such as increased carbon and nutrient transfer (Gawne *et al.,* 2007) which may be correlated with increased spawning or recruitment of native fish (King *et. al.,* 2007). Monitoring of water quality and fish populations during flood events will be important to avoid negative effects as far as is practicable. The project would divert water away from the Murray River potentially reducing flows into areas of the EEC outside the site. The water diverted into the forest will

Criteria	Murray River EEC
	largely be environmental water that would be 'called' and released from upstream storages specifically for the purpose of achieving flows into the site. As such, water diverted at Torrumbarry weir will be flow that would not otherwise be in the system and, hence the diversions should have minimal or no impact on the Murray River flows (personal communication, D Green, MDBA, 2009).
b) degrades soil quality;	The project would degrade soil quality within the construction disturbance footprint through direct removal, earthworks or compaction. Negative impacts would affect a very minor proportion of the site: a maximum of 206 ha out of an area of approximately 32,000 ha. Measures to contain impacts from construction including sediment control and the retention and re-spreading of topsoil will be implemented, and thus soil quality is unlikely to be affected outside of the immediate surface disturbance area. This magnitude of degradation is unlikely to result in a significant negative effect on the EEC.
c) clears or modifies native vegetation;	The proposed construction would permanently remove or modify native vegetation within the Murray River EEC within the footprints of the proposed regulators and downstream portions of the inlet channel that coincide with Bullock Head Creek. Construction for the project would require the clearing or modification of native floodplain vegetation within the surface disturbance area, including: ◗ Temporary disturbance of approximately 206 ha of native vegetation. This includes 116 ha of project construction footprints that would be allowed to regenerate to their pre-disturbance state; and ◗ Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints. The removal and modification of this vegetation would remove habitat resources for the aquatic biota that make up the Murray River EEC, such as supplementary foraging resources during flood events and coarse woody debris. The proposed operation of the project is expected to have net-positive effects on native vegetation and habitats through restoration of a more natural flood regime.
d) introduces weeds, vermin or feral species or provides conditions for them to increase and/or spread;	The proposed construction would involve the clearing of native vegetation and replacement with areas of roads, stockpiles, and project infrastructure. The project may increase the spread and/or prevalence of exotic weeds in the site through soil disturbance and transmission of propagules on vehicles and equipment. It is likely that areas environmental weed infestation would increase within the project disturbance footprint. The majority of the disturbance footprint is associated with higher ground along the downstream levee which would have little value for aquatic biota. The remainder of the site is partially disturbed by FNSW access tracks and ongoing timber harvesting, grazing activities and public use. In this context, construction activities would have a relatively minor impact on the overall numbers and extent of weed species in the locality. The proposed flooding would transmit weed propagules into the site and increase soil moisture and nutrient status. These changes are likely to increase the degree of weed infestation in terrestrial portions of the site after recession of floodwaters. This effect would be partially balanced by positive effects to the health of native vegetation and would not significantly reduce the value of habitat at the site for aquatic biota. Inundation is likely to have net positive impacts for flood-dependant species and would be expected to favour native wetland plants at the expense of terrestrial species or environmental weeds.

Criteria	Murray River EEC
	Based on the results of environmental watering events in the Barmah-Millewa Forest (King *et. al*., 2009) the proposed inundation is likely to increase the abundance and/or spread of exotic fish. Notably Carp are known to breed on floodplains through movement of adults onto floodplain environments to spawn as well as passive movement of larvae from the river to the floodplain, where they take advantage of increased food resources to increase survival and recruitment (King *et al*., 2009). There is the potential for negative impacts as these fish are transported back to the river as the floodplain is drained (DSTA, 2009).
e) removes or disturbs key habitat features such as trees with hollows, caves and rock crevices, foraging habitat;	Not relevant to the assessment of this EEC.
f) affects natural revegetation and recolonisation of existing species following disturbance.	The proposed construction would have a minor negative impact on the ability of the aquatic biota which comprise the Murray River EEC to recolonise following disturbance through a minor reduction in the overall amount of available habitat and by limiting movement of some species. These effects would be offset by positive effects of environmental watering including an increase in the area of available aquatic habitat during flood events and increased productivity and transfer of organic carbon and nutrients to the main channel of the Murray River (Gawne *et al.,* 2007). Comparable environmental watering events have resulted in increased spawning or recruitment of native fish (King *et. al.,* 2007) and increased abundance of planktonic microinvertebrates (Gigney. *et al.,* 2006) following the flood. These effects are likely to be correlated with increases in abundances of other aquatic biota within the Murray River EEC.
iii) Does the project affect any threatened species or populations that are at the limit of its known distribution?	The distribution of the Murray River EEC continues downstream to the south and west, through Victoria and into South Australia, and upstream to Hume Dam in the east (DPI, 2009b). The site is near the centre of this distribution and includes some of the most extensive and significant floodplain portions of the community in NSW. The direct removal of a portion of the habitat for the community within project infrastructure footprints would have a minor effect on its overall distribution.
iv) How is the project likely to affect current disturbance regimes?	
a) modifies the intensity and frequency of fires;	The project would not directly affect the intensity and frequency of fires.
b) modifies flooding flows;	The project would alter flooding flows by restoring a more natural flood regime to the site. Alteration to natural flow regimes refers to reducing or increasing flows, altering seasonality of flows, changing the frequency, duration, magnitude, timing, predictability and variability of flow events, altering surface and subsurface water levels and changing the rate of rise or fall of water levels. Three human processes have predominantly altered flows in streams, rivers and their floodplains, and wetlands in NSW. These are: building of dams, diversion of flows by structures or extraction, and alteration of flows on floodplains with levees and structures.

Criteria	Murray River EEC
	The project will directly contribute to all three processes by: ◗ Building regulators across natural drainage lines; ◗ Diversion of flows through construction of the intake regulator and Torrumbarry cutting and extraction from the Murray River; and ◗ Alteration of flows across the floodplain through the downstream levee, floodway and the system of regulators. Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands is recognised as a major factor contributing to loss of biological diversity and ecological function in aquatic ecosystems, including floodplains. These alterations have caused a large number of species, populations or ecological communities that rely on river flows for their survival to become threatened. Three major factors mitigate the potential for negative impacts arising from alterations to hydrology due to the project: ◗ The hydrology of the site, the Murray River and associated catchments have been extensively modified by river regulation and the current situation is not characteristic of 'natural flow regimes'; ◗ The hydraulics of the site (i.e. the geomorphology and upstream built structures that dictate hydrology) does not permit 'natural flow regimes' onto the floodplain under current and modelled future Murray River flow regimes; and ◗ The project infrastructure is designed to facilitate delivery of water in order to achieve a more natural flow regime and the proposed operation of the project would aim to simulate natural conditions as far as is practicable. Potential impacts associated with alterations to hydrology arising from the proposed activity are assessed in detail in Section 9. The outcome of this assessment is that the project is not likely to have any significant negative impacts on aquatic and wetland habitats within the site or downstream. The operation of the project is likely to have a number of net positive impacts on aquatic and wetland habitats within the site. Therefore the proposed activity is unlikely to increase the operation of this KTP in a way that would threaten the survival of any native biota.
v) How is the project likely to effect habitat connectivity?	
a).creates a barrier to fauna movement;	The project involves the construction of a number of regulators and levees which, in general, would comprise potential barriers to movement of aquatic fauna. Provision for aquatic biota passage has been incorporated into the engineering design and Operating Plan for the project. Based on advice from fish passage specialists the structures have been specifically designed to ensure that native fish can enter and leave the floodplain (DSTA, 2009; FPTF, 2009). Other key factors for fish passage include the timing of flood events and management of flows. Purposeful management of the project would include mimicking the timing of natural flow regimes, variability and pulsing and providing sufficient time during the flooding recession phase to allow fish to move from the floodplain to the river (FPTF, 2009). Ecological Associates (2009) determined that the proposed inundation is likely to provide a highly productive small fish habitat on the

Criteria	Murray River EEC
	floodplain and return small fish to the Murray River in significant numbers via the Return Channel and Barbers Creek. However, there is a residual risk that the project would trap large-bodied native fish, including threatened species (refer Section **Error! Reference source not found.**). The Swan Lagoon regulators and downstream stop log structures have been designed to allow for fish passage during a natural flood and will be fully open in a natural flood to allow the flood to operate with minimal change from the current situation (FPTF, 2009). The proposed structures are designed to provide appropriate velocities of water flow for upstream fish passage and specific measures are being designed to provide a low velocity/turbulence corridor at the abutments at each downstream stop log regulator structure to facilitate upstream fish passage (FPTF, 2009). The overall intent of the project is to facilitate delivery of water in order to achieve a more natural flow regime. The proposed operation of the project would aim to simulate natural conditions as far as is practicable. The operation of the project is likely to have a number of positive impacts on connectivity of aquatic and floodplain habitats within the site through the proposed flooding. Notwithstanding potential impacts on fish passage at project infrastructure flooding would improve connectivity between the main stem Murray River and floodplain habitats when compared with the prolonged drying of the site.
b) removes remnant vegetation or wildlife corridors; and	The proposed construction would not permanently remove any habitat corridors for aquatic biota. Continuity of habitat, including of Murray River EEC, would be maintained around the disturbance footprint. The effect of project infrastructure on fauna movement is addressed in point *v), a)* above.
c) modifies remnant vegetation or wildlife corridors.	The proposed construction would modify habitat corridors for aquatic biota at the locations of the proposed regulators and downstream portions of the inlet channel that coincide with Bullock Head Creek.. Continuity of habitat, including of Murray River EEC, would be maintained around the disturbance footprint. The modified areas thus created would be less than 50 metres across and would be adjacent to extensive areas of aquatic habitat and intact native vegetation. Ecosystem functions necessary to the maintenance of the EEC are likely to continue across these modified areas of habitat. The effect of project infrastructure on fauna movement is addressed in point *v), a)* above.
iv) How is the project likely to affect critical habitat?	There is no listed critical habitat at the site or of relevance to this AoS.
Conclusion	The project would have a minor negative impact on the Murray River EEC through a minor reduction in the overall amount of available habitat and by limiting movement of large-bodied fish species. These effects would be offset by positive effects of environmental watering including an increase in the area of available aquatic habitat during flood events and increased productivity and transfer of organic carbon and nutrients to the main channel of the Murray River (Gawne *et al.,* 2007). Comparable environmental watering events have resulted in increased spawning or recruitment of native fish (King *et. al.,* 2007) and increased abundance of planktonic microinvertebrates (Gigney. *et al.,* 2006) following the flood. These effects are likely to be correlated with increases in

Criteria	Murray River EEC
	abundances of other aquatic biota within the Murray River EEC. There is the potential for blackwater events to have locally severe negative effects on sub-populations of the EEC that are drawn into the site during flood events or are in Barbers Creek downstream. The project may also result in increased spawning and recruitment of Carp and other pest fish and transfer back to the Murray River. Monitoring of water quality and fish populations during flood events will be important to avoid negative effects of blackwater and pest species as far as is practicable. Adaptive management of the timing, duration and other aspects of the proposed inundation provides scope to substantially mitigate negative effects. Overall, negative effects of the project are likely to affect a limited proportion of the Murray River EEC and may be mitigated through purposeful operation and adaptive management. Therefore negative effects of the project are likely to be offset by the benefits of the project for aquatic biota and their habitats.

Appendix D

EPBC Act Assessments of Significance

D.1 Approach

The Murray Cod is listed as vulnerable under the EPBC Act. Based on the assessments presented above the project may result in modification of habitat and changes to the life cycle the Murray Cod. A detailed assessment of the significance of these impacts on the Murray Cod is provided below prepared in accordance with the DEH (2006) *Significant Impact Guidelines*.

D.2 Assessments of Significance

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of an important population of a species;

The Central Murray region supports a relatively stable and abundant breeding population of Murray Cod (GHD, 2009a) and so local populations near the site are 'important' to the overall survival of the species.

There may be localised construction impacts on local populations of the Murray Cod where the proposed inlet and outlet channels adjoin the main channel of the Murray River. Sensitive construction techniques and mitigation measures would be used to minimise direct impacts (refer Section 11.3.1). Therefore construction would affect a very limited area of aquatic habitat within the boundary of sediment control devices in the immediate vicinity of the construction footprint. The affected area would not contain a significant proportion of individuals or habitat for the species in the local area.

The remainder of the construction corridor contains intermittent water bodies and ephemeral floodplain wetlands. These habitats would have limited value for the Murray Cod in their current dry state and are unlikely to be occupied during the construction period.

The proposed inundation of the site would displace or disturb some individuals if they are drawn into the site in floodwaters. This would increase the area of potentially suitable habitat for the species and would be expected to have many positive effects. There may be short term negative effects as a result of black water events.

Modelling of the potential for black water has been undertaken for the project (Water Quality in GHD, 2009c). Results indicated that there is likely to be release of dissolved organic carbon from the litter that has accumulated on the floodplain over the long inter-flood interval. This is expected to result in a decrease in dissolved oxygen to < 2mg/L for periods during managed floods which would have negative impacts on Murray Cod within the flood pool. If the indicative operating scenario occurred after a period of prolonged litter accumulation (which is likely) it would kill a proportion of local populations of the species. The proposed operational regime and monitoring and adaptive management framework will be used to minimise potential negative effects of black water as far as is practicable, such as through avoiding flooding over Summer.

Under the indicative operational scenario the project would discharge water into Barbers Creek when it is experiencing low flows. Therefore black water impacts on downstream Barbers Creek are likely. When the proposed return channel is operating at maximum flow rates of 1,850ML/day, flows in the Murray River downstream of the Torrumbarry Weir are likely to be at least 5,000 - 6,000 ML/day. As a result, black water would be diluted by flows in the Murray River (Water Quality Chapter, 2009) and is unlikely to result in significant impacts on Murray Cod populations within the Murray River. Therefore potential black water events are only likely to individuals that are drawn into the site during flood events or are in Barbers Creek. Given the extent of aquatic habitat in the Murray River and in other floodplain wetlands and drainage lines in the locality this is unlikely to affect an ecologically significant proportion of any local populations of Murray Cod. Analysis

of natural and managed floods and associated black water events in comparable environments in the Barmah-Millewa forest suggest that local populations of aquatic biota are resilient to these effects over longer time scales (Howitt et al., 2007; King et. al., 2007) and that populations of Murray Cod in the Murray River may experience increased abundance of young-of-year and hence recruitement following a flood (King et. al., 2007). Downstream Murray Cod habitats may benefit from increased carbon and nutrient transfer as a result of flooding (Gawne et al., 2007). Monitoring of water quality and fish populations during flood events will be important to avoid negative effects as far as is practicable. Overall, short term negative effects of the project within the flood pool are likely to be offset by the benefits of the project for local populations of Murray Cod and their habitats outside the site. Therefore the project is unlikely to lead to a long-term decrease in the size of an important population of the Murray Cod.

2. reduce the area of occupancy of an important population;

The proposed construction would isolate a very limited area of aquatic habitat within the boundary of sediment control devices in the immediate vicinity of the construction footprint. The affected area would not contain a significant proportion of habitat for the Murray Cod in the local area.

The Murray Cod does not rely on any specific habitat resources that would be removed or significantly disturbed by the project. There are extensive areas of important aquatic and wetland habitats within the site, but only limited areas within the proposed construction corridor. The proposed construction would permanently remove or modify aquatic vegetation and habitat within the footprints of the proposed regulators and downstream portions of the inlet channel that coincide with Bullock Head Creek (less than 10 ha in total). The broader construction corridor contains intermittent water bodies and ephemeral floodplain wetlands. The project will disturb a maximum of 206 ha of potential provisioning habitat for Murray Cod in the floodplain vegetation to be disturbed. Negative impacts would affect a very minor proportion of available habitats compared to the overall area of wetland habitat at the site (over 30,000 ha). Further, under a ‘do nothing’ scenario the habitat to be affected would have very little value for the species as the site has not flooded for over 15 years and hydrological modelling suggests that the site would flood very infrequently if the project were not to proceed. Murray Cod are likely to benefit from a general increase in floodplain health and productivity within the area likely to experience beneficial effects of flooding (17,700 ha).

Provision for fish passage has been incorporated into the design of the project infrastructure. The structures have been specifically designed to ensure that large-bodied native fish, including Murray Cod, can enter and leave the floodplain (DSTA, 2009; FPTF, 2009). There is a residual risk that the project would trap some large-bodied native fish, including Murray Cod (FPTF, 2009, Ecological Associates, 2009) however this would affect a limited number of individuals and for limited periods. Notwithstanding the effect of the proposed infrastructure on fish passage the project would increase the extent of available habitat for the species in many years by increasing the frequency and duration that floodplain habitats would be inundated.

3. fragment an existing important population into two or more populations;

The proposed construction would not interrupt fish passage or otherwise affect migration and dispersal ability of the Murray Cod. Any silt fences, coffer dams or equivalent required for construction would be located in the immediate vicinity of the excavation area and would not completely cross any drainage lines or isolate any significant areas of aquatic habitat.

During the filling phase of the proposed inundation event, Murray Cod (including adults, juveniles and eggs/larvae) are likely to enter the upstream end of the site via the intake regulator and then Bullock Head Creek and the floodplain. Fish may also aggregate below the intake regulator during inundation. Fish would not be attracted to the outlet regulators as they would either be closed or discharge flows would be too low to

attract fish (FPTF, 2009). Provision for fish passage has been incorporated into the design of the project infrastructure. The structures have been specifically designed to ensure that large-bodied native fish, including Murray Cod, can enter and leave the floodplain (DSTA, 2009; FPTF, 2009).

Block banks on Barbers currently limit fish movement due to small pipes. By washes will be constructed to allow flood waters to pass without eroding the block banks, which will improve fish passage downstream to the the Wakool river system for fish exiting the forest.

There is a residual risk that the project would trap some large-bodied native fish, including Murray Cod since the main exit route is upstream and involves channels of a variety of depths over more than 30 km which must be negotiated between the time when flow-cues to exit the forest are received and the time when the proposed Denil fishway ceases to operate effectively (FPTF, 2009, Ecological Associates, 2009). If a significant number of large-bodied native fish are found to be trapped by this process then a fish rescue plan may be required to avoid significant impacts on local populations of the Murray Cod. This isolation of fish is likely to affect a small proportion of individuals and would only apply for a short period during the recession phase of certain managed flood events. Connectivity of local populations would be maintained via the Murray River around the site. Therefore the project would not fragment the local population of the Murray Cod.

4. adversely affect habitat critical to the survival of a species;

There may be localised construction impacts on critical habitat for the Murray Cod where the proposed inlet and outlet channels adjoin the main channel of the Murray River. Sensitive construction techniques and mitigation measures would be used to minimise direct impacts (refer Section 11.3.1). Therefore construction would affect a very limited area of aquatic habitat within the boundary of sediment control devices in the immediate vicinity of the construction footprint. Impacts would only be for the duration of the construction activities. This would not comprise an adverse affect on aquatic habitat in the local area.

The proposed construction would directly disturb a number of intermittent water bodies at the locations of the proposed regulators. This would remove habitat within the construction footprint and modify the form and flow characteristics of the water body. Negative effects would be very limited in extent in the context of the extensive network of intermittent water bodies at the site. The majority of the remainder of the site, including the entire construction disturbance footprint, is an ephemeral floodplain wetland. These habitats would have limited value for the Murray Cod in their current dry state and are unlikely to be occupied during the construction period.

The proposed operation of the project would affect important habitat including: the Murray River; approximately 1200 ha of mapped floodplain marshes and drainage lines; a multitude of smaller flood runners; and ephemeral forest-wetlands on the floodplain itself. The project is expected to have net-positive effects on these habitats through restoration of a more natural flood regime. The Murray Cod would also be expected to experience positive effects such as an increase in flooded wetland area and a general increase in floodplain health and productivity as a result of flooding. Black water events are likely to have temporary, localised negative effects on Murray Cod habitat within the flood pool and Barbers Creek.

The project would divert water away from the Murray River potentially reducing flows into Murray Cod habitats outside the site. The water diverted into the forest will largely be environmental water that would be ‘called’ and released from upstream storages specifically for the purpose of achieving flows into the site. As such, water diverted at Torrumbarry weir will be flow that would not otherwise be in the system and, hence the diversions should have minimal or no impact on the Murray River flows (personal communication, D Green, MDBA, 2009).

5. disrupt the breeding cycle of an important population;

The proposed inundation of a portion of the site would increase the area of potentially suitable habitat for the species, increase wetland productivity and potentially stimulate breeding behaviour. The proposed operational regime would aim to maintain flood conditions in floodplain marshes at appropriate seasons, and for appropriate durations to facilitate fish breeding. This purposeful operation would minimise the potential for adverse affects through rapid recession of flood waters or other impacts on breeding events. Populations of Murray Cod in the Murray River featured a greater abundance of young-of-year following a comparable flood in the Barmah-Millewa forest (King *et. al.,* 2007) suggesting increased recruitment. Importantly dissolved oxygen levels did not decline sufficiently to affect fish during this event (King *et. al.,* 2007) whereas black water is likely to have negative effects within the flood pool (Water Quality in GHD, 2009). The proposed operational regime and monitoring and adaptive management framework will be used to minimise potential negative effects of black water as far as is practicable, such as through avoiding flooding over Summer. Nonetheless, the proposed flooding would be expected to have positive effects on the breeding cycle of the species downstream of the site and over subsequent seasons.

6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;

The proposed construction would permanently remove or modify aquatic vegetation and habitat within the footprints of the proposed regulators and portions of the inlet channel that coincide with Bullock Head Creek and the banks of the Murray River. These impacts on critical habitat are addressed in factor 4) above, and would not comprise a significant adverse affect on aquatic habitat for the Murray Cod.

Construction for the project would require the clearing or modification of terrestrial native vegetation within the surface disturbance area, including:

- Permanent removal or modification of approximately 90 ha of native vegetation within project infrastructure footprints; and
- Temporary removal or modification of approximately 206 ha of native vegetation within project construction footprints that would be allowed to regenerate to their pre-disturbance state.

The site contains approximately 31,000 ha of native vegetation and habitats that would not be removed or modified.

The removal of this terrestrial vegetation would remove some habitat resources for the species, such as supplementary foraging resources during flood events and coarse woody debris. These impacts would be minor in the context of over 32,000 ha of equivalent habitat at the site and 17,000 ha that is likely to experience positive effects due to environmental watering. The project is likely to improve the abundance and transfer of habitat resources from the floodplain to aquatic habitats for the Murray Cod (refer Section 9).

The proposed inundation may temporarily decrease the quality of floodplain habitat for the species through black water events. Floodplain habitat at the site would have no value for the species during the current protracted dry phase and would experience comparable or worse black water events during natural floods as leaf litter accumulation would be greater than under the proposed operating regime. Black water events caused by the operation of the project are unlikely to degrade habitat in the Murray River as flows would be sufficient to dilute water quality impacts (Water Quality, in GHD, 2009).

7. result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;

Based on the results of environmental watering events in the Barmah-Millewa Forest (King *et. al*., 2009) the proposed inundation is likely to increase the abundance and/or spread of exotic fish. Notably Carp are known to breed on floodplains through movement of adults onto floodplain environments to spawn as well as passive movement of larvae from the river to the floodplain, where they take advantage of increased food resources to increase survival and recruitment (King *et al*., 2009). There is the potential for negative impacts as these fish are transported back to the river as the floodplain is drained (DSTA, 2009). The project may increase the abundance of Carp but is highly unlikely to introduce pest species into any areas of Murray Cod habitat that are not already infested. In the context of the existing degree of Carp infestation in the Murray River the project is likely to have a minor effect.

8. introduce disease that may cause the species to decline; or

The project would not connect any permanently disconnected waterways or catchments, introduce foreign plant or animal material or otherwise act as a vector for any diseases. The project would connect areas of habitat and transfer portions of local fish populations however these effects would only occur at a within-catchment scale.

9. interfere substantially with the recovery of the species.

The project would have negative effects on the Murray Cod including:

- isolation or removal of small areas of aquatic habitat within construction footprints;
- potential trapping of some individuals on the floodplain during flood events;
- likely mortality of some individuals within the flood pool during due to black water events; and
- likely increased abundance of Carp and other pest fish species.

These impacts would be mitigated and/or offset by the following:

- the project would affect a very small proportion of the aquatic habitat available for the species in the locality;
- the proposed fish passage measures are likely to facilitate the movement of the majority of individuals during flood events;
- monitoring of water quality and fish populations during flood events will be important to avoid negative effects of black water and pest species as far as is practicable;
- adaptive management of the timing, duration and other aspects of the proposed inundation provides scope to substantially mitigate negative effects;
- positive effects of environmental watering are likely to include an increase in the area of available aquatic habitat during flood events and increased productivity and transfer of organic carbon and nutrients to the main channel of the Murray River (Gawne *et al.,* 2007).
- comparable environmental watering events have resulted in increased recruitment of Murray Cod in the main channel of the Murray River (King *et. al.,* 2007).

Based on the above considerations, negative effects of the project are likely to affect a limited proportion of local populations of the Murray Cod and may be mitigated through purposeful operation and adaptive management. Residual negative effects of the project would be limited to the flood pool and are likely to be offset by the benefits of the project for populations and habitats of the Murray Cod outside the site.

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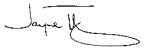
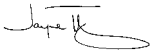
1	Ben Harrington	J Tipping		J Tipping		21/10/09
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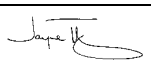
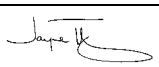
3	Ben Harrington and Jenny Hale	J Tipping		J Tipping		30/11/09
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