Freshwater Wetland Complex and Constructed Drainage Lines

Plate 4: Photograph of typical Freshwater Wetland Complex on the study area.

Corresponding Hunter, Central and Lower North Coast Vegetation Classification & Mapping Project Map Unit:

MU200 Typha rushland.

Vegetation Formation:

Freshwater wetlands.

Vegetation Class:

Coastal freshwater lagoons.

Equivalent Vegetation Type:

Phragmites australis and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin (DECC Biometric Type Database 2009).

Structure:

Reedland to approximately 2m tall (**Plate 4**).

General description:

Freshwater Wetland Complex is located across the site in low lying areas and along the drainage lines. This vegetation community is dominated by Broadleaf Cumbungi (*Typha orientalis*) and Common Reed (*Phragmites australis*). Other common native species included *Bolboschoenus caldwellii*, Slender Knotweed (*Persicaria decipiens*) and Water Ribbons (*Triglochin procera*). Common exotic species include Kikuyu (*Pennisetum clandestinum*) and *Hydrocotyle bonariensis*.

Conservation Status:

The Freshwater Wetland Complex on the study area forms part of the endangered *freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions* TEC.

The areas mapped on the site as Constructed Freshwater Wetland Complex (see **Figure 9**) were determined not to form part of this TEC, given that these areas represent artificial drainage lines which have been significantly modified for agricultural purposes.

Exotic Grasslands

Plate 5: Photograph of Exotic Grasslands on the study area.

Corresponding Hunter, Central and Lower North Coast Vegetation Classification & Mapping Project Map Unit:

No equivalent.

Vegetation Formation:

Freshwater wetlands.

Vegetation Class:

Coastal freshwater lagoons.

Equivalent Vegetation Type:

No Equivalent.

Structure:

Grassland (**Plate 5**).

General description:

Exotic Grasslands cover a large portion of the study area. This vegetation community is the result of past disturbance and agricultural uses of the site. It is dominated by a variety of exotic species, including Kikuyu (*Pennisetum clandestinum*), Paspalum (*Paspalum dilatatum*), Purpletop (*Verbena bonariensis*), Curled Dock (*Rumex crispus*) and Fireweed (*Senecio madagascariensis*). Several native plant species also occur in low abundance, including scattered Swamp Oak (*Casuarina glauca*), *Juncus usitatus* and Couch (*Cynodon dactylon*).

Conservation Status:

Not listed.

3.3.2. Vegetation community significance

Figure 10 shows the significance values for each of the vegetation communities on the study area. In terms of vegetation community significance, Swamp Mahogany – Paperbark Swamp Forest, Swamp Oak Rushland Forest, Swamp Oak Rushland Forest - Regeneration and Freshwater Wetland Complex all gained an automatic high value since they are listed as TECs. The Exotic Grasslands community gained a low value of significance due to its highly disturbed nature and the dominance of exotic species.

3.4. Fauna

3.4.1. Terrestrial fauna habitat values

Figure 10 also shows the significance values for each of the vegetation communities on the study area in terms of fauna habitat value. The Exotic Grasslands and Freshwater Wetland Complex gained a low value due to their disturbed nature, dominance of exotic species and lack of fauna refugia. The strips of Swamp Mahogany – Paperbark Swamp Forest and the Swamp Oak Forest gained a medium value due to their greater structural complexity, presence of fauna refugia and provision of nectar and fruiting resources.

3.4.1.1. Hollow-bearing trees

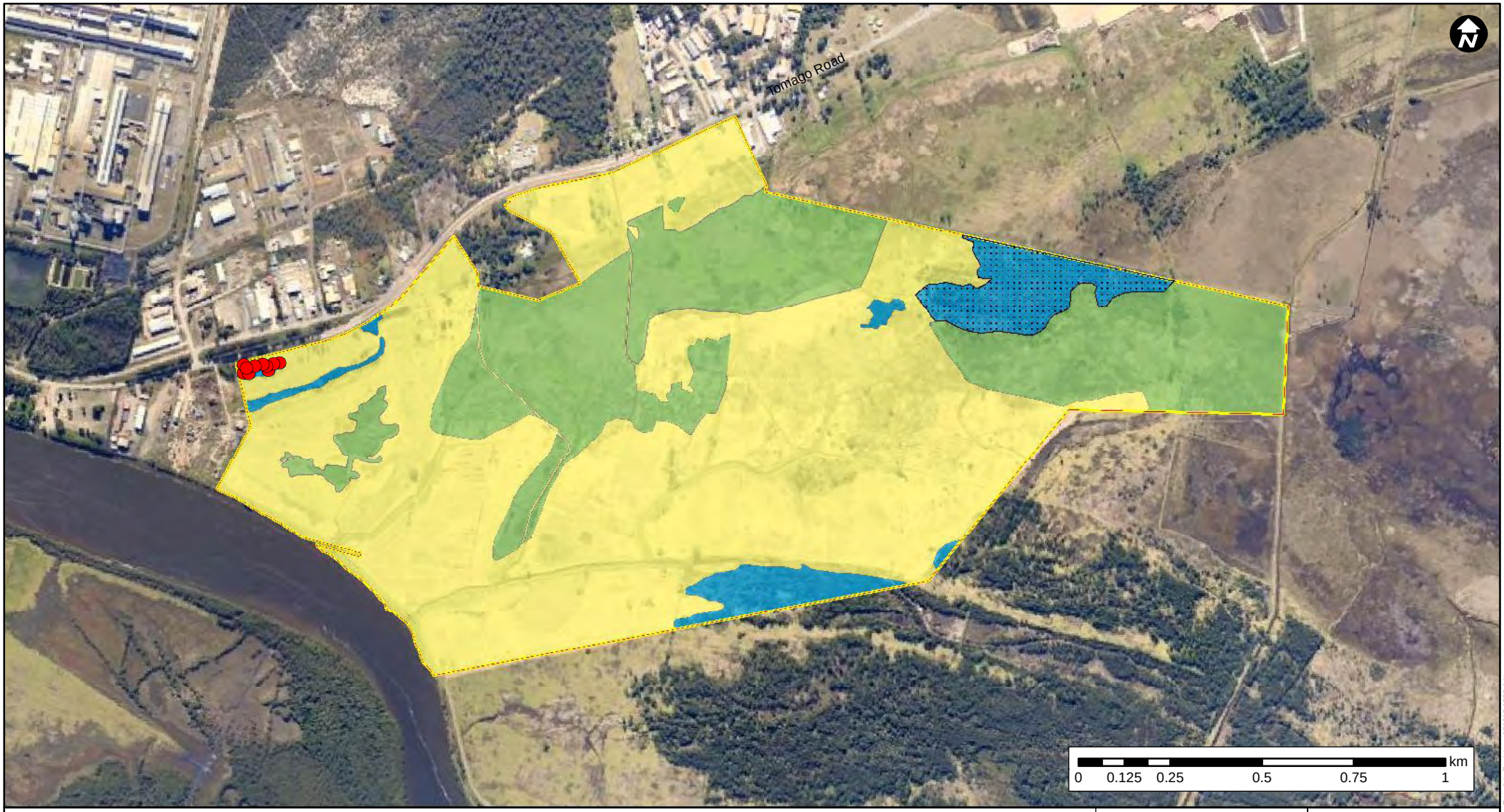
Hollows are an important resource utilised by a variety of forest fauna. Vertebrate and invertebrate species use hollows as diurnal or nocturnal shelter sites, for rearing young, feeding, thermoregulation and to facilitate ranging behaviour and dispersal (Gibbons & Lindenmayer 2002). Approximately 400 Australian species potentially use hollows either on a permanent or opportunistic basis. Many threatened species are obligate users, requiring the presence of hollows to survive in the landscape (Gibbons & Lindenmayer 2002).

A hollow survey was conducted across the study area to provide an assessment of the number of trees containing hollows. All of the trees containing hollows within the Swamp Mahogany – Paperbark Swamp Forest were mapped (**Figure 10**). Due to difficulties with access and waterlogging of the Swamp Oak Forest communities, the density of habitat hollows per hectare in these areas was calculated from data collected during the fauna habitat assessment plots (20 x 50m).

Ten trees (all Melaleucas) were found to contain between 1 – 3 small to medium-sized hollows within the Swamp Mahogany – Paperbark Swamp Forest. The majority of these hollows were small and may provide nesting and refuge habitat for insectivorous bats, amphibians, reptiles and parrot species.

An estimate of the number of hollow-bearing trees within the Swamp Oak Forest in the north of the study area was calculated by multiplying the average number of hollow-bearing trees counted in each 20 x 50 m fauna habitat assessment plot conducted in this community by the total area of the patch (i.e. mean = 4 hollow-bearing trees per hectare by 14.82 ha of Swamp Oak Forest). It is therefore estimated that this patch contains 59 trees containing hollow/s. The vast majority of hollows observed in this community were small. No hollows were observed within the Swamp Oak Forest Rehabilitation.

Figure 10 - Vegetation community and fauna habitat significance



Legend / Notes

- Study Area
- High Vegetation Significance, Medium Habitat Value
- High Vegetation Significance, Low Habitat Value
- Low Vegetation Significance, Low Habitat Value
- Hollow Bearing Trees
- ~4 Hollow-bearing Trees / Ha

ecobiological

Project Ref:	350-694
Plot Date:	09/12/2010 1155
Revision:	JRN 001

Map Projection:
NSW Lamberts Conformal Conic

Data Sources:
OpenStreetMap - 2010
ecobiological - 2010
DECCW - 2010
LPI - 2006

3.4.1.2. Amphibian fauna habitat values

The study area is dominated by extensive areas of swampy grassland, rush-filled drainage lines, with some areas of Swamp Oak-dominated forest which supports areas of surface water. All areas were found to have a watery groundstorey, particularly after heavy rains experienced during spring 2010. Areas of rush-filled "wetland" are derived largely from human-made channels across the floodplain. These areas tended to be choked with *Typha* rushes and a number of weed species, with very little open water. The channel wetlands had steep banks, an artefact of human construction.

There are a number of natural ephemeral streams which run through the study area, these riparian areas tend to support Swamp Oak dominated vegetation. These areas are most likely to develop acidic ponds which may be suitable habitat for the Vulnerable Wallum Froglet (*Crinia tinnula)*. One section on the northern boundary of the study area also supports a number of smaller open water bodies which may be potentially suitable, though ephemeral, habitat for the Green and Golden Bell Frog.

For the most part, ephemeral shallow ponding also occurs in the grassland areas, though would tend to dry out in drier weather. These ponds had not formed a distinctive water plant community around the edges, which tended to be grass with some rushes.

The water condition in the study area was freshwater, (from rainfall and storm water accumulation) with low levels of salinity or acidity. Some channels had noticeable levels of metal (ferrous) contaminants, likely as a result of either stormwater from adjacent industrial lands or from high metals in background groundwater (a regional trend from rutile sands).

The plant diversity in the wetland areas are generally moderate to low and dominated by *Typha* rushes and exotic water-philic plants. There was much regeneration occurring, and in some areas very thickly.

Invertebrate activity was found to be reasonably high with high levels of the exotic *Gambusia* fish present.

3.4.1.3. Migratory bird habitat values

Targeted surveys for migratory shorebirds and other threatened waterbird species such as the Magpie Goose, Australian Painted Snipe and Black-necked Stork were conducted in December 2010 (see bird survey quadrats and transect along the Hunter River in **Figure 7**).

The exotic grasslands which become inundated after prolonged periods of rainfall represent potential habitat for the Magpie Goose, Australian Painted Snipe, Latham's Snipe and Black-necked Stork however, there is no coastal saltmarsh or suitable open freshwater foraging habitat with muddy margins present on the study area for shorebirds. The western boundary of the study area adjoins the Hunter River. Historically, the study area river frontage has been highly modified, with the deposition of large rocks as retaining and revetment and extensive clearing of mangroves (Coast Ecology 2012). Some isolated mangroves remain among the rock wall retaining the foreshore, however, the mangrove forest characteristics of the foreshores opposite and to the east and west of the study area are largely absent from the study area (**Plate 6**). There is some clustering of mangroves around the two floodgates draining the Hunter River (**Plate 7**) however, these are isolated patches and were not considered to constitute Mangrove Forest. The margins of the river in this area are reinforced with rock and there is generally no more than 1 – 2 m of mud exposed at low tide. A number of constructed drainage lines occur on the study area (**Plate 8**). They are steep sided drains with no bank gradient and are largely dominated by *Typha orientalis* and *Phragmites australis*. These drainage lines partially drain the site through flapped outfalls (see floodgate in **Plate 7**) into the North Arm of the Hunter River.

Plate 6: Isolated small mangrove within the rocky revetment along the Hunter River frontage of the study area.

Plate 7: Clustered mangroves around one of the two floodgates entering the Hunter River.

Plate 8: Steep sided drainage channel on the study area dominated by *T. orientalis* and *P. australis*.

The majority of shorebirds feed on intertidal mudflats, the most extensive of which start on the eastern bank of the North Arm of the Hunter River at Fern Bay and extend into Fullerton Cove. Most of the remaining shoreline of the Hunter River is mangrove-fringed with narrow margins of mud exposed at low tide. These areas are avoided by the majority of waders (Straw 1999). This is the case on the study area where rock reinforcements line the river with a few scattered Mangrove trees present, with very little opportunity for shorebirds to forage. It is possible that some shorebirds that like to roost on rocky shorelines might do so in this area from time to time.

3.4.2. Fauna species composition

A total of 84 fauna species were recorded in the study area (**Appendix 2**). These species comprised 1 fish, 7 frogs, 3 reptiles, 5 terrestrial mammals, 15 bats and 53 birds. Of these, six are exotic species (Plague Minnow, European Rabbit, House Mouse, Red Fox, Common Myna and Black Rat).

3.4.2.1. Threatened fauna species

Nine threatened species listed as vulnerable under the NSW TSC Act (Grey-headed Flying-fox *Pteropus poliocephalus*, Eastern Grass Owl *Tyto longimembris*, Southern Myotis *Myotis macropus*, Eastern Bentwing-bat *Miniopterus oceanensis*, Little Bentwing-bat *Miniopterus australis*, Eastern Freetail-bat *Mormopterus norfolkensis,* Eastern False Pipistrelle *Falsistrellus tasmaniensis,* Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris* and Greater Broad-nosed Bat *Scoteanax rueppellii*) were recorded in the study area. The Grey-headed Flying-fox is also listed as vulnerable under the Commonwealth EPBC Act 1999.

Two migratory bird species listed on the EPBC Act were also recorded during field surveys of the study area (Cattle Egret and White-bellied Sea-Eagle). The detection locations of threatened species are shown in **Figure 11**. **Table 12** provides information on the survey method used, co-ordinates and number of individuals observed.

Table 12: Threatened fauna species recorded in the study area.

Location ID	Threatened fauna identified	Easting	Northing	Survey Method	No. of individuals
1	Greater Broad-nosed Bat Little Bentwing-bat Yellow-bellied Sheathtail Bat Eastern Bentwing-bat Eastern Freetail-bat	381955	6367184	Anabat analysis	Unknown
2	Eastern False Pipistrelle Eastern Freetail-bat	380860	6366592	Anabat analysis	Unknown
3	Eastern Bentwing-bat Eastern Freetail-bat Southern Myotis	381240	6366684	Anabat analysis	Unknown
4	Grey-headed Flying-fox	381215	6366246	Spotlighting	20 +
5	Eastern Grass Owl	381046	6366596	Owl call playback	1 over three nights

Figure 11 - Threatened fauna locations

Number	Threatened Fauna Identified
1	Greater Broad-nosed Bat
	Little Bentwing-bat
	Yellow-bellied Sheathtail-bat
	Eastern Bentwing-bat
	Eastern Freetail-bat
2	Eastern False Pipistrelle
	Eastern Freetail-bat
3	Eastern Bentwing-bat
	Eastern Freetail-bat
	Southern Myotis
4	Grey-headed Flying-fox
5	Eastern Grass Owl
6	Eastern Grass Owl

Legend

- Study Area
- Threatened Fauna Location

0 0.125 0.25 0.5 0.75 1 km

ecobiological

Project Ref:	350-694
Plot Date:	09/12/2010 1135
Revision:	JRN 001

Map Projection:
NSW Lamberts Conformal Conic

Data Sources:
OpenStreetMap - 2010
ecobiological - 2010
DECCW - 2010
LPI - 2006

3.4.3. Regional Eastern Grass Owl survey results

A total of 40 locations around the Newcastle region were surveyed initially between 2 August and 23 August 2011 for the Eastern Grass Owl. Overall, Grass Owls responded to call playback at a total of 11 sites (**Figure 12**).

A synchronised survey was then conducted at nine of the 11 sites over a three night period (12-15 September 2011) to estimate the minimum number of individuals in the region. The two sites that were left out of the synchronised survey were isolated from the other sites and were deemed far enough away to be considered separate records or groups of Grass Owls.

A total of eight Grass Owls was recorded simultaneously at seven sites as a result of the synchronised survey event (**Table 13**). **Figure 12** highlights these sites in relation to the confirmed sightings of the Grass Owl in the first round of surveys.

Table 13: Results of the simultaneous Grass Owl survey

Site	Location	Number of Owls	Times recorded during synchronised survey
2	Hexham Swamp Nature Reserve, Maryland	1	3
4	Hexham Swamp Nature Reserve, Fletcher	2	3
8	Hunter Wetlands National Park, Ash Island	1	3
10	Hexham Swamp, Hexham	1	2
20	Subject site, Tomago	1	2
23	Lavis Lane, Williamtown	1	1
31	Rooks Road, Salt Ash	1	2

A small sample of regurgitated pellets was also recovered from a survey site (site 10) and analysed by Luke Foster to determine the diet of the owls in that area. The pellets contained hair and bone fragments of the Black Rat (*Rattus rattus)* and House Mouse (*Mus domesticus)*.

3.4.3.1. Mapping of potential habitat

Mapping of potential Grass Owl habitat was undertaken to estimate the amount of potential habitat within the region. Selection of habitat was determined by habitat types where Grass Owls have been recorded, and by habitat deemed suitable in accordance with Debus *et al*. (2001). In total, 20,624.6 hectares within the Newcastle region is deemed potential habitat for the Eastern Grass Owl (**Figure 13**). It must be noted that this estimation of potential habitat cannot be taken as an absolute amount. To gain a more accurate estimate of habitat, extensive ground truthing and condition mapping of the estimated area must be undertaken.

Figure 12 - Grass Owl Confirmed Sightings

Legend / Notes

- Confirmed Grass Owl sightings
- Simultaneous Grass Owl sightings

SCALE 1: 150 000

0 1 2 4 6 8 Kilometers

ecobiological

Project Ref:	411-870
Plot Date:	10/08/2012 14:27
Revision:	001 (gayle.j)

Map Projection:
GDA 94
MGA Zone 56

Data Sources:
LPMA - 2011
OpenStreetMap - 2011
NearMap - 2011
ecobiological - 2011

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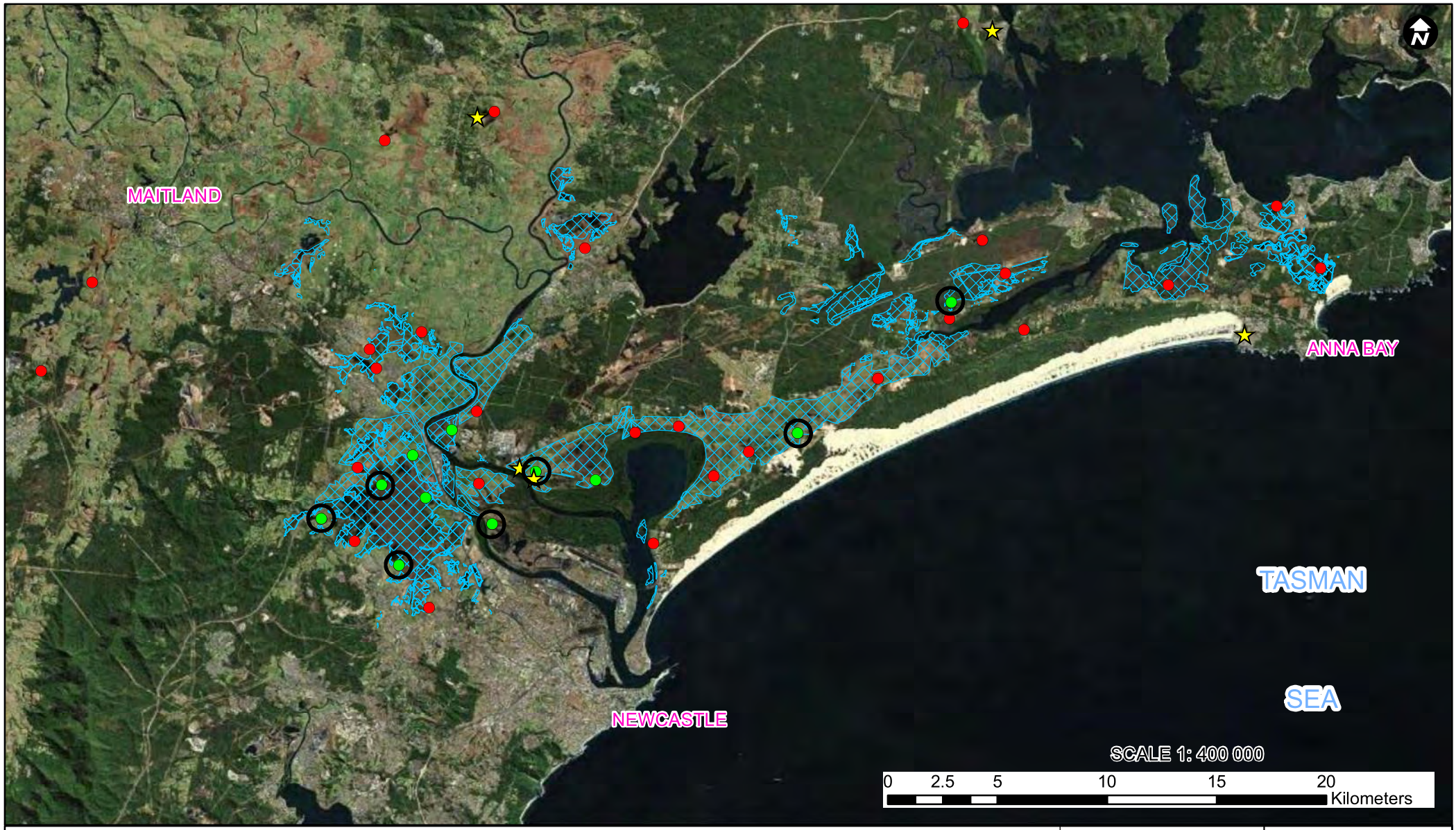


Figure 13 - Grass Owl Survey Locations

Legend / Notes

- OEH Atlas recorded Grass Owls
- Grass Owl sightings during survey
- Grass Owl survey locations
- Potential Grass Owl habitat - approximately 20624.6 ha
- Grass Owl recorded in synchronised survey

ecobiological
survey & assessment

Project Ref:	411-870
Plot Date:	28/09/2011 13:34
Revision:	001 (Luke)

Map Projection:
GDA 94
MGA Zone 56

Data Sources:
LPMA - 2011
OpenStreetMap - 2011
NearMap - 2011
ecobiological - 2011

L:\GIS FOLDER\00 CLIENT FILES\352 Mt Penny Coal\666\Maps\411-870 potential Grass Owl habitat within region.mxd

4. Impact evaluation

4.1. Direct and indirect impacts

Table 14 provides a list of direct, indirect, cumulative and facilitative impacts of the proposed development which have been considered when assessing the potential impact on threatened ecological communities, flora and fauna and migratory species. Proposed management strategies are also summarised in **Table 14** and expanded upon in section 5. A summary map of all identified ecological constraints both on and in the immediate vicinity of the study area is provided in **Figure 14**.

Table 14: Direct and indirect impacts of the proposed development.

Type of Impact	Source and period of impact (pre-construction, construction and operation phases)	Threatened species / EEC's potentially affected	Proposed Management Strategies to avoid, mitigate and/or offset
Direct			
Clearing of native vegetation	Pre-construction Construction phase	All communities and species assessed in sections 4.2 and 4.3	Offset Package (includes on-site and off-site lands) being developed in consultation with OEH
Loss of hollow-bearing trees	Pre-construction Construction phase	• Tree-roosting microchiropteran bats	Pre-clearing survey protocol. Provision of nest boxes.
Removal of dead wood and dead trees	Pre-construction Construction phase	• Tree-roosting microchiropteran bats	Pre-clearing survey protocol. Provision of nest boxes.
Indirect			
Loss of individuals through: • Starvation • Exposure • Predation by domestic and/or feral animals • Loss of breeding opportunities • Loss of shade/shelter • Deleterious hydrological changes	Clearance of native vegetation and removal/ filling of waterbodies/drainage lines will occur during the pre-construction and construction phases of the project and consequently will result in a loss of individuals by various means. Hydrological impacts may occur across a much longer time scale if not mitigated.	All communities and species assessed in sections 4.2 and 4.3	Offset Package being developed in consultation with OEH Pre-clearing survey protocol. Drainage lines will be filled however constructed drainage lines will approximately follow the existing drainage lines, and discharge stormwater toward the Hunter River, avoiding freshwater input from the site entering the SEPP 14/Ramsar wetlands to the south and east. Constructed drainage lines as well as some landscaping and water retention ponds will preserve and /or create habitat for flora and fauna.

Table 14 cont: Direct and indirect impacts of the proposed development.

Type of Impact	Source and period of impact (pre-construction, construction and operation phases)	Threatened species / EEC's potentially affected	Proposed Management Strategies to avoid, mitigate and/or offset
Indirect			
Sedimentation / erosion	Significant quantities of fill will be required to raise the study area above the 1:100 year flood level.	• EECs mapped on site and in the surrounding area • Green and Golden Bell Frog (not recorded on site during surveys) • Threatened and migratory waders and waterbird species in adjoining Ramsar site (none recorded on site during surveys)	Best practice sediment and erosion control measures. Implementation of Flooding and Stormwater Management and Monitoring Plans. Wetland Management and Monitoring Plan to monitor indirect impacts on adjoining Ramsar wetland as well as retained and created habitat on site.
Acid Sulphate Soils and increased soil salinity	The period of impact is indefinite, however, the proposal will be to fill the site rather than excavate wherever possible.	All communities and species assessed in sections 4.2 and 4.3	An Acid Sulphate Soil Management Plan has been prepared in accordance with mitigation measures outlined by Douglas Partners.
Increased nutrients (waste water treatment, chemicals, herbicides, pesticides, fertilisers etc)	Caused by sediment and stormwater runoff pre, during and post clearing and construction. The period of impact is indefinite.	All communities and species assessed in sections 4.2 and 4.3	Diversion of stormwater away from the Ramsar site toward Hunter River. Intensive water quality treatment of stormwater runoff prior to entering the river. Limit pesticide use on the study area.
Increased human activity (from workers and associated traffic) directly adjacent to sensitive habitat areas	Construction and operation phases	All flora and fauna species assessed in sections 4.2 and 4.3	Increased presence of humans within the study area may cause disturbance to flora and fauna species in adjoining habitat. Human-induced impacts such as damage to vegetation from vehicles or trampling, increased rubbish and alteration to normal behaviour patterns are also possible.

Table 14 cont: Direct and indirect impacts of the proposed development.

Type of Impact	Source and period of impact (pre-construction, construction and operation phases)	Threatened species / EEC's potentially affected	Possible Management Strategies to avoid, mitigate and/or offset
Indirect			
Introduced species (animals and weeds)	Two of the main animal pests in the area are foxes and wild pigs. Foxes are a major threat in wetland areas where they feed on frogs and birds. A coordinated effort between agencies including NPWS, Hexham Swamp and Kooragang Wetland Rehabilitation Services is being undertaken to control foxes in the Hunter Estuary. In October each year, baits are laid in areas surrounding wetlands at Hexham, Kooragang Island, Tomago and Fullerton Cove (HCR CMA 2004). Clearing for the subdivision will not increase available habitat for pest animals. Weed species may be brought into the study area with imported materials, or encouraged by removal of native vegetation. Weed invasion could start occurring as soon as clearing and filling commences. The period of impact is indefinite.	All communities and species assessed in sections 4.2 and 4.3	Cooperate with the ongoing baiting program conducted by NSW NPWS. Wetland Management & Monitoring Plan to be implemented along the boundary of the study area and Ramsar site Use clean fill, cover all vehicles during the construction phase, and develop hygiene protocols for staff and vehicles.
Water management (stormwater management, wastewater treatment, flooding)	Potential long-term impacts on Tomago Wetlands Rehabilitation Project, Ramsar wetland, health of SEPP 14 wetlands and the Hunter River	All communities and species assessed in sections 4.2 and 4.3	Must be undertaken in cooperation with HCR CMA and OEH to ensure aims and objectives of the Tomago Wetlands Rehabilitation Project are not negatively affected. Implement a high quality, environmentally sensitive wastewater treatment system.

Table 14 cont: Direct and indirect impacts of the proposed development.

Type of Impact	Source and period of impact (pre-construction, construction and operation phases)	Threatened species / EEC's potentially affected	Possible Management Strategies to avoid, mitigate and/or offset
Facilitative			
Noise, Vibration, Lighting and Air Pollution NB: Ambient noise may be detrimental to birds through direct stress, masking of predator arrival or associated alarm calls, and by interference of acoustic signals in general. Two of the most important functions of avian acoustic signals are territory defence and mate attraction. Both of these functions are hampered when signal efficiency is reduced through rising noise levels, resulting in direct negative fitness consequences (Slabbekoorn and Ripmeester 2008). Impacts from operational activities, such as disturbance to an animal's normal behaviour patterns due to noise, vibration, lighting or dust may cause areas of previously suitable habitat to become sub-optimal, and may cause fauna species to vacate areas of previously suitable habitat.	It should be noted that this assessment is for the subdivision of the land only and therefore, these impacts will be negligible during the pre-construction phase (limited to detailed site surveys of the proposed subdivision layout). Future construction and operation phases will be subject to individual environmental impact assessments.	• Green and Golden Bell Frog • Migratory wading birds, as well threatened bird species such as Australasian Bittern, Black Bittern, Black-necked Stork, Magpie Goose, Australian Painted Snipe and Eastern Grass Owl • Megachiropteran and Microchiropteran bat species	Future development of the subdivision and of individual lots should be subject to separate environmental impact assessments. Assessment of future development should determine appropriate land uses and require acoustic assessment. Other possible future mitigation measures include raising a barrier between the noise source and bird breeding habitat which can lead to a significant reduction in detrimental noise levels. A solid barrier as close as possible to the noise source will be most effective (Maekawa 1977; Ishizuka & Fujiwara 2004). Vegetation screening, solid noise barriers, a lighting management plan and dust suppression techniques should all be considered.

Table 14 cont: Direct and indirect impacts of the proposed development.

Type of Impact	Source and period of impact (pre-construction, construction and operation phases)	Threatened species / EEC's potentially affected	Possible Management Strategies to avoid, mitigate and/or offset
Cumulative			
Contribution of direct and indirect impacts upon tidal, GDE, surface water and terrestrial habitats in the context of historic and ongoing impacts upon these ecosystems.	Construction and operation phases.	All fauna and flora species, ecosystems, GDEs, SEPP 14 wetlands, Ramsar wetlands and surface water systems.	While levels of coastal development have caused significant loss of some terrestrial ecosystems, the vegetation communities to be removed are considered to be well represented in the locality. Appropriate offsets will provide compensation for direct removal of habitat from the site. There is not anticipated to be any cumulative effect from indirect impacts upon GDEs, surface water or the nearby Ramsar areas provided appropriate mitigation measures are adhered to (see above).

4.1.1. Impact on adjoining Tomago Wetland Rehabilitation Project, National Parks estate and Ramsar wetland

The Kooragang Wetland Rehabilitation Project was formed in 1993 to rehabilitate the coastal wetlands of the Hunter estuary. Part of its aim is also to provide additional habitat for migratory shorebirds as much of this habitat has been lost since the draining of wetland areas in the 1970's. Prior to this time, the areas adjacent to the study area were known to be one of the most important nocturnal roost sites for migratory shorebirds in the lower Hunter estuary. As part of this project, tidal restoration works were proposed at Tomago Wetland. In August 2007, the main set of western floodgates was modified to permit tidal exchange via the installation of SmartGates.

Other on-ground works to support this strategy included the construction of a levee, the installation of floodgate flaps and culverts to direct the tidal water, the clearing of exotic and undesired species, and the installation of floating booms to minimise mangrove colonisation of the restored

floodplain. Approximately 248 hectares of the western section of Tomago Wetland was restored to saltmarsh habitat (cited from Rayner and Glamore, 2011). More recently, the rehabilitation of the eastern section of Tomago Wetland has commenced and aims to restore tidal exchange at the eastern floodgates of Tomago Wetland (Coast Ecology 2012). Additionally, it is possible that the project will be extended onto Lot 1002 (a proposed conservation offset for another local development).

It is noted that this project has been successful in encouraging migratory shorebirds such as the Black-tailed Godwit back into the recently flooded areas and that it is likely that increasing numbers of shorebirds will move into the adjoining Ramsar wetland and onto Lot 1002 in future (potentially within several hundred metres of the proposed development site).

The proposal has the potential for indirect impacts on the Tomago Wetland Rehabilitation Project (TWRP), adjoining Ramsar wetland and national park from noise/vibration and from changes to the local hydrology. There is potential for impacts on fauna from noise and vibration resulting from both the construction and on-going operations of the project. This may cause disruption to various fauna species roosting and nesting sites and mating or foraging activities. Refer to section 1.5 for the findings of the acoustics report prepared for the study area. A minimum 380 m buffer from the Ramsar boundary has been incorporated into the site layout design to further minimise potential indirect impacts on flora and fauna.

There is no direct connection of stormwater runoff from Lot 1001 to the TWRP/Ramsar site. This is because the outlet of runoff from Lot 1001 is via a floodgate discharging into the North South Drain. The floodgate is in the north east corner of Lot 1001 and discharges to the North South Drain, but only at low tides. At low tides, the floodgate discharge of the Lot 1001 runoff is too low elevation to enter TWRP, bypassing the TWRP entry point and discharging out through the Smart Gates. Following tidal inundation of flow from the river back up the North South Drain from the SmartGates, there is potential for residual freshwater left in the drain to reach the TWRP site.

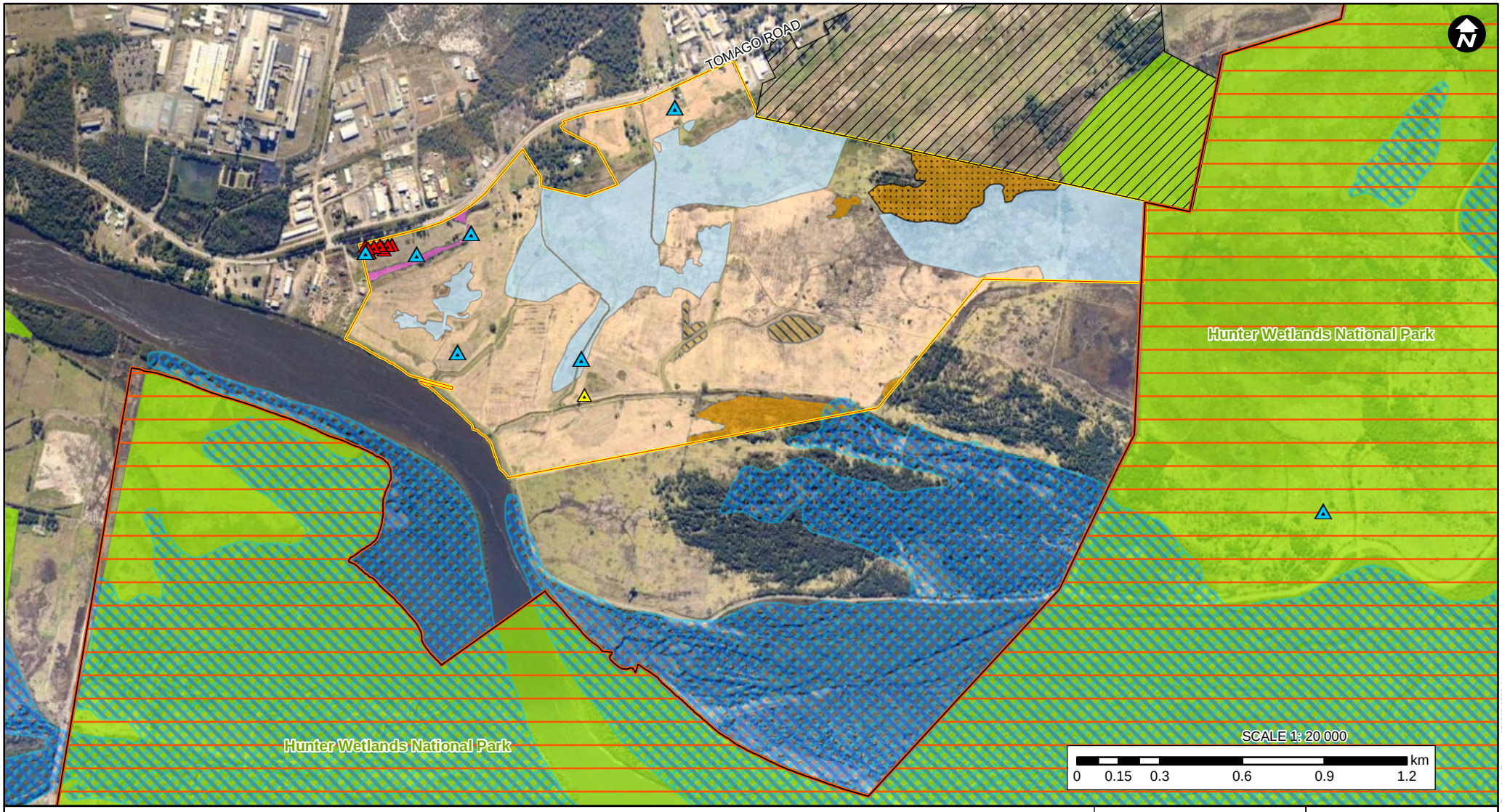
There is direct connection for stormwater runoff entering Lot 1002 at three discharge locations. Site design for stormwater runoff has targeted maintaining the same hydrological pathways and flow regime, mimicking post development to pre-existing conditions for discharge over the boundary. Any excess stormwater runoff is channelled to the Hunter

River, via a perimeter berm. Best practice management for water quality improvement of filtration and nutrient removal has been assessed and designed in place. Wetland interface strategy, management and monitoring plans are in place for control.

Groundwater modelling has been undertaken by Environ Australia. Environ Australia indicate that the groundwater flow toward the Lot 1002 and TWRP is low magnitude, approximately 5% of the wetland recharge. Post development potentiometric contours with the fill and perimeter berm in place, closely match pre development conditions at the boundary. The subsurface conditions of alluvial clays at the boundary convey only a small magnitude of groundwater. Again the North South Drain is an interception consideration of groundwater reaching TWRP.

Furthermore, pit controls at the discharge points from Lot 1001 for maintaining the same hydrology are adjustable for future adaptive management.

Figure 14 - Ecological constraints map



Legend

- Study Area
- MP07-0086 Approval
- Coastal Wetlands (SEPP 14)
- NPWS Estate
- Ramsar Wetlands
- ~4 Hollow-bearing Trees / Hectare

Vegetation Community

- Freshwater Wetland Complex (EEC)
- Swamp Oak Forest (EEC)
- Swamp Oak Forest - Regeneration (EEC)
- Swamp Mahogany - Paperbark Swamp Forest (EEC)

- Threatened Fauna Locations
- Secondary Grass Owl Roost Site
- Hollow-bearing Trees

KLEINFELDER Bright People. Right Solutions.
ecobiological

Project Ref:	350-694
Plot Date:	21/08/2012
Revision:	GJ 002

Map Projection:
NSW Lamberts Conformal Conic

Data Sources:
OpenStreetMap - 2010
ecobiological - 2010
DECCW - 2010
LPI - 2006

4.2. NSW TSC Act Assessments of Significance

4.2.1. Threatened ecological community assessment

Three Endangered Ecological Communities were mapped as occurring in the study area and have been accordingly assessed below.

Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions

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

Not applicable.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

The proposal is unlikely to put the local occurrence of this ecological community at risk of extinction, given that in the locality (within a 5km of the study area) there is an additional 512ha of Freshwater Wetland Complex mapped (NPWS, 2000). In addition, Freshwater Wetland Complex on the study area is a result of past disturbance. Formerly the majority of the study area contained Swamp Mahogany – Paperbark Swamp Forest, as mapped by the Lower Hunter Central Coast Estimated Pre-1750 Vegetation Map (HCCREMS, 2003).

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

The proposal will remove all of this ecological community from the study area.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Approximately 58.1 ha (or 82%) of this ecological community will be removed from the study area. The remaining 12.5 ha will be conserved within an Environmental Zone in the north-east corner of the study area. This area was noted during flora surveys to be within the highest quality section of this community present within the study area.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The removal of the majority of this ecological community as part of the proposal will not fragment or isolate other areas of this ecological community.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Given that the Freshwater Wetland Complex on the study area is a result of past disturbance and that there is an additional 512ha of Freshwater Wetland Complex mapped in the locality, the area to be removed is not considered important to the long-term survival of this ecological community in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
No critical habitat has been listed for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,
No recovery plan or threat abatement plans have been prepared for this ecological community.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The clearing associated with the proposed development will exacerbate two relevant Key Threatening Processes; Clearing of Native Vegetation and Alteration to the Natural Flow Regimes of Rivers, Streams, Floodplains and Wetlands.

Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,
Not applicable.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,
Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Approximately 13.6 ha (or 80%) of this ecological community will be removed for the proposed development. The remaining 3.4 ha will be conserved within an

Environmental Zone along the southern boundary of the study area. The proposal is unlikely to put the local occurrence of this ecological community at risk of extinction, since a relatively small portion of this ecological community in the locality will be removed. Within a 5km radius of the study area, there is an additional 505ha of this ecological community mapped (NPWS, 2000).

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

The proposal will remove all of this ecological community from the study area.

(d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Approximately 13.6 ha of this community will be removed from the study area as part of the proposal.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The removal of this ecological community as part of the proposal will not fragment or isolate other areas of this ecological community.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The highly fragmented and small size of the remnant patches of this ecological community on the study area are not considered important to its long-term survival in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
No critical habitat has been listed for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,
No recovery plan or threat abatement plans have been prepared for this ecological community.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The clearing associated with the proposed development will exacerbate two relevant Key Threatening Processes; Clearing of Native Vegetation and Alteration to the Natural Flow Regimes of Rivers, Streams, Floodplains and Wetlands.

Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions

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

Not applicable.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

The proposal is unlikely to put the local occurrence of this ecological community at risk of extinction, given that only a very small area is proposed to be cleared. In the locality (within a 5km of the study area), considerable areas of this community exist. A total 505ha of this ecological community is mapped around the study area (NPWS, 2000).

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

The proposal will remove all of this ecological community from the study area.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

All 1.5 ha of this community will be removed from the study area as part of the proposal.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The removal of this ecological community as part of the proposal will not fragment or isolate other areas of this ecological community.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The highly fragmented and small size of the remnant patches of this ecological community on the study area are not considered important to its long-term survival in the locality. The narrow nature of this ecological community exposes it to high levels of edges effects and reduces the vegetation condition through invasion by exotic species.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
No critical habitat has been listed for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

No recovery plan or threat abatement plans have been prepared for this ecological community.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The clearing associated with the proposed development will exacerbate two relevant Key Threatening Processes; Clearing of Native Vegetation and Alteration to the Natural Flow Regimes of Rivers, Streams, Floodplains and Wetlands.

4.2.2. Threatened flora assessment

No threatened flora species were detected in the study area. Threatened flora species with potential habitat occurring in the study area have been assessed below.

Trailing Woodruff (*Asperula asthenes*)
(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,
Asperula asthenes is a small herb with weak straggling stems, small leaves in whorls of four separated by internodes of 4-7 cm. The plant has small white flowers and grows in damp places often at the edge of streams or river banks and is recorded from Taree to Bulahdelah (Harden 1992). There are also known records for the species in the Booral region, and Port Stephens and Wallis Lakes area.

The main threats to this species are disturbance from grazing stock; invasion of habitat by introduced weeds, particularly near watercourses and use of herbicides.

Potential habitat for this species occurs within the Freshwater Wetland Complex and Swamp Sclerophyll Forest. Targeted searches within potential habitat were conducted within the known fruiting and flowering time for this species. This species was not identified as occurring in the study area; therefore, the proposed development is unlikely to place a local population at the risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,
Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed development would result in a loss of approximately 1.5 ha of Swamp Mahogany – Paperbark Swamp Forest and 58.1 ha of Freshwater Wetland Complex that could form potential habitat for *Asperula asthenes*.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed action is not likely to result in any fragmentation or isolation of habitat.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Targeted searches of both the Swamp Mahogany – Paperbark Forest and Freshwater Wetland Complex communities during the species known flowering and fruiting time did not detect this species. Therefore, the potential habitat on site is not considered important to the long-term survival of this species in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
No critical habitat has been listed for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,
There was no draft or final recovery plan in place at the time of survey for this species. No threat abatement plans are relevant.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The clearing associated with the proposed development will exacerbate two relevant Key Threatening Processes; Clearing of Native Vegetation and Alteration to the Natural Flow Regimes of Rivers, Streams, Floodplains and Wetlands.

Noah's False Chickweed (*Lindernia alsinoides*)

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

Lindernia alsinoides is a small herb that has blue flowers and opposite leaves. It usually grows to 15cm high, although it has been recorded up to 40cm high. Preferred habitat is swampy areas north from Bulahdelah (Harden, 1992). In NSW there are only several records, one at Coopernook, Bulahdelah and Shannon Creek near Grafton (DEC, 2005b). Of particular significance is that there are no known populations in NSW National Parks and Wildlife Service conservation reserves.

This species was not identified as occurring in the study area; therefore, the proposed development is unlikely to place a local population at the risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed development would result in a loss of approximately 1.5ha of Swamp Mahogany – Paperbark Swamp Forest that could form potential habitat for *Lindernia alsinoides*. This is considered a small amount of loss, given that an additional 505ha of this ecological community is mapped within 5km of the study area (NPWS, 2000).

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed action is not likely to result in any fragmentation or isolation of habitat.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Given the highly fragmented and small size of the remnant patches of Swamp Mahogany – Paperbark Swamp Forest and that this ecological community is well represented in the locality, the area of potential habitat for *Lindernia alsinoides* to be removed is not considered important to the long-term survival of this species in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been listed for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There was no draft or final recovery plan in place at the time of survey for this species. No threat abatement plans are relevant.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The clearing associated with the proposed development will exacerbate two relevant Key Threatening Processes; Clearing of Native Vegetation and Alteration to the Natural Flow Regimes of Rivers, Streams, Floodplains and Wetlands.

Maundia triglochinoides

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

Maundia triglochinoides grows in swamps, creeks or shallow freshwater 30 - 60 cm deep on heavy clay and low nutrients and it is often associated with wetland species e.g. *Triglochin procerum*. The flowering occurs during warmer months (November to January). The long distance dispersal is via seed and root tubers, which are probably dispersed by water. The plant spreads vegetatively, with tufts of leaves arising along the rhizomes (DEC, 2005c).

The main threats to this species are further loss and fragmentation of habitat, changes in hydrology and water quality, and weed invasion (DECC, 2008a).

This species was not identified as occurring in the study area; therefore, the proposed development is unlikely to place a local population at the risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed development would result in a loss of approximately 58.1 ha of Freshwater Wetland Complex that could form potential habitat for *Maundia triglochinoides*. However, there is an additional 512ha of potentially suitable habitat mapped in the locality (NPWS, 2000).

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed action is not likely to result in any fragmentation or isolation of habitat.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Given that the Freshwater Wetland Complex on the study area is a result of past disturbance and considerable areas of this ecological community occur in the locality, the area of potential habitat for *Maundia triglochinoides* to be removed is not considered important to the long-term survival of this species in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
No critical habitat has been listed for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,
There was no draft or final recovery plan in place at the time of survey for this species. No threat abatement plans are relevant.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The clearing associated with the proposed development will exacerbate two relevant Key Threatening Processes; Clearing of Native Vegetation and Alteration to the Natural Flow Regimes of Rivers, Streams, Floodplains and Wetlands.

Tall Knotweed (*Persicaria elatior*)

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

This species has been recorded in south-eastern NSW (Mt Dromedary (an old record), Moruya State Forest near Turlinjah, the Upper Avon River catchment north of Robertson, Bermagui, and Picton Lakes. In northern NSW it is known from Raymond Terrace (near Newcastle) and the Grafton area (Cherry Tree and Gibberagee State Forests), and also occurs in Queensland. This species normally grows in damp places beside streams and lakes and occasionally in swamp forests or associated with disturbance. The listed threats for this species are inadvertent clearing from moist disturbed habitat; damage to road and track populations through maintenance activities and; clearing of or hydrological changes to wetland vegetation.

This species was not identified as occurring in the study area; therefore, the proposed development is unlikely to place a local population at the risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed development would result in a loss of approximately 58.1ha of Freshwater Wetland Complex and 1.5 ha of Swamp Mahogany – Paperbark Swamp Forest that could form potential habitat for *Persicaria elatior*.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed action is not likely to result in any fragmentation or isolation of habitat.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Given that the Freshwater Wetland Complex on the study area is a result of past disturbance, the Swamp Mahogany – Paperbark Swamp Forest is highly fragmented and that both of these ecological communities are well represented in the locality, the area of potential habitat for *Persicaria elatior* to be removed is not considered important to the long-term survival of this species in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been listed for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There was no draft or final recovery plan in place at the time of survey for this species. No threat abatement plans are relevant.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The clearing associated with the proposed development will exacerbate two relevant Key Threatening Processes; Clearing of Native Vegetation and Alteration to the Natural Flow Regimes of Rivers, Streams, Floodplains and Wetlands.

Zannichellia palustris

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

Zannichellia palustris is a small submerged aquatic plant with narrow opposite leaves less than 1mm wide and 2-7cm long (Harden 1993). This species is restricted to the Lower Hunter and Murray River Estuary of NSW, and is found in slow moving fresh or slightly saline environments (DECC 2008b).

This plant has separate male and female flowers which appear in the warmer months (Harden 1993). It is either a perennial or annual species, however it acts as an annual by dying off in summer in NSW (DEC 2005d). This species is threatened by changes to hydrological flows, conditions and water quality (DEC 2005d). It is currently not formerly protected as none of the known populations occur in any NSW National Parks and Wildlife Service conservation reserves (DECC 2008b).

This species was not identified as occurring in the study area; therefore, the proposed development is unlikely to place a local population at the risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed development would result in a loss of approximately 58.1ha of Freshwater Wetland Complex that could form potential habitat for *Zannichellia palustris*. However, there is an additional 512ha of potentially suitable habitat mapped in the locality (NPWS, 2000).

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed action is not likely to result in any fragmentation or isolation of habitat.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Given that the Freshwater Wetland Complex on the study area is a result of past disturbance and considerable areas of this ecological community occur in the locality, the area to be removed is not considered important to the long-term survival of this species in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
No critical habitat has been listed for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,
There was no draft or final recovery plan in place at the time of survey for this species. No threat abatement plans are relevant.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The clearing associated with the proposed development will exacerbate two relevant Key Threatening Processes; Clearing of Native Vegetation and Alteration to the Natural Flow Regimes of Rivers, Streams, Floodplains and Wetlands.

4.2.3. Threatened fauna assessment

Nine threatened fauna species listed as vulnerable under the NSW TSC Act (Grey-headed Flying-fox *Pteropus poliocephalus*, Eastern Grass Owl *Tyto longimembris*, Southern Myotis *Myotis macropus*, Eastern Bentwing-bat *Miniopterus oceanensis*, Little Bentwing-bat *Miniopterus australis*, Eastern Freetail-bat *Mormopterus norfolkensis*, Eastern False Pipistrelle *Falsistrellus tasmaniensis*, Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris* and Greater Broad-nosed Bat *Scoteanax rueppellii*) were recorded in the study area during field surveys. The potential impact of the proposed development is accordingly assessed for these species. Threatened fauna species that were considered as possibly occurring in the type of habitat represented in the study area have also been assessed below.

Green and Golden Bell Frog (Litoria aurea)

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

Once one of the most common frog species on the east coast of Australia the Green and Golden Bell Frog has undergone a widespread and unexplained range contraction since the mid 1970's. Its distribution today is restricted to isolated pockets along the coast at various scattered locations throughout its former range with only one known remaining highland population at Queanbeyan.

The species uses different habitat components throughout the various stages of its life cycle including different breeding, foraging and refuge habitats and has been known to disperse distances of up to several kilometres between these various habitats. Generally large, permanent water bodies containing high levels of emergent vegetation such as *Typha*, *Baumea* and the introduced *Juncus acutus* are favourable for the detection of the Green and Golden Bell Frog, however it has been observed utilising a wide range of natural and man-made water bodies including coastal swamps, marshes, dune swales, lagoons, lakes, estuary wetlands, riverine floodplain wetlands, billabongs, storm water retention basins, farm dams, bunded areas, storage tanks, water troughs, drains, ditches and other excavation areas capable of capturing water such as quarries and brick pits (DEC, 2005e). Terrestrial habitat attributes that appear to favour the species include large grassy areas associated with adjacent cover from logs, rocks or tussock forming vegetation that provide shelter. There also appears to be a preference shown to habitat containing a complexity of terrestrial and aquatic vegetation structure (Hamer *et al*., 2002). The introduced mosquito fish, *Gambusia holbrooki*, is believed to feed on small tadpoles and habitat free of these fish is preferred (White & Pike 1996).

A population of Green and Golden Bell Frogs exists on Kooragang Island to the south of the study area and is one of the largest remaining known populations in NSW. This population is less than 2.5km from the study area and is separated only by an arm of the Hunter River. Suitable connectivity in the form of drainage lines and wetlands connects the study area to this arm of the Hunter River, and from the other side of the river to the current site of the existing population.

Mostly marginal habitat for the Green and Golden Bell Frog exists across the study area. Apart from a small area of natural drainage line near the northern boundary, areas of wetland generally have no open water, presence of *Gambusia holbrooki*, steep banks, few logs or other ground shelter and thick weed cover, making most of the study area unsuitable as breeding, over-winter or foraging habitat. Some areas of ponding as a result of heavy rainfall generally have little aquatic vegetation. Much of the existing wetland is largely semi-permanent with areas that dry out completely and become inundated with water during and after heavy rain. However given the close proximity of a known Bell Frog population on Kooragang Island, it is possible that the study area may help the dispersal of this species and offer limited habitat after periods of heavy rainfall.

Surveys for the Green and Golden Bell Frog were undertaken during favourable conditions and no Green and Golden Bell Frogs were detected on, or adjacent to, the study area. It is therefore considered unlikely that the Green and Golden Bell Frog inhabits the study area on a permanent basis. The mapped wetland in the study area forms only a small fraction of the wetlands present in the surrounding area which consists in part of the adjoining Lot 1002, Hunter Wetlands National Park and SEPP 14 wetlands.

This species was not identified as occurring in the study area; therefore, the proposed development is unlikely to place a local population at the risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,
Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed development would result in a loss of approximately 211 ha of semi-permanent wetland, grassland and Riparian Oak/*Melaleuca* forest that could form potential dispersal and over-winter habitat for the Green and Golden Bell Frog.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed filling of the wetland on site would remove a small area of potential Green and Golden Bell Frog habitat in the locality and reduce the corridor width of this area as a dispersal corridor.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Given that the majority of the study area is considered to represent marginal habitat for this species and that considerable areas of more suitable habitat are present within the locality, the area to be removed is not considered important to the long-term survival of this species in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been listed for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

The draft Green and Golden Bell Frog Recovery Plan (DEC 2005e) outlines a number of key objectives to manage habitat for this species. While the proposal may reduce an area of potential habitat for this species, the associated protection of adjacent offset lands on Lot 1002 will "secure opportunities for increasing the protection of … habitat areas".

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Two key threatening processes that affect the Green and Golden Bell Frog will be triggered by the proposed activity including the 'clearing of native vegetation' and 'alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. However the alteration to hydrology caused by the proposal will not affect the population of Green and Golden Bell Frogs on Kooragang Island. Other threats specific to this species are listed in the Draft Recovery Plan. Of these, two may be enacted by the proposal. These include habitat eutrophication and pollution through soil (nutrient laden) and chemical run-off and the use of biocides in the control of weeds and mosquitoes that may cause deformities, hermaphroditism and death. However these threats will be significantly reduced or eliminated by the proposed ameliorative measures.

Wallum Froglet (Crinia tinnula)

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

The Wallum Froglet is one of a group of wallum-dependent frog species of coastal south-east Queensland and eastern New South Wales. All of the species in this group are wholly or largely restricted to Wallum or Wallum-equivalent habitat (Meyer *et al*, 2006). Dependence on this specific habitat type makes it difficult for the species to persist when it is removed. The fragmentation and destruction of this

habitat on which the Wallum Froglet depends as a result of urban land clearing has caused decline in the species and continues to be the main threat to its survival.

The Wallum is a system of silicious sand plains and dunes that support varying vegetation types including eucalypt forests and woodland, rainforest and heathland (Coaldrake, 1961). Tanin-stained water collects above organic hardpan layers forming swamps and lakes within the Wallum. Often these water bodies are acidic (pH <5.5) and oligotrophic (nutrient poor). While commonly occupying wallum habitat, the Wallum froglet may also be found in wallum-equivalent habitat (sub-coastal wet heath in areas of sandy soil) outside of the wallum (Stewart, 1995) and is more commonly associated with ephemeral swamps and soaks than lakes. The Wallum Froglet is most likely to be encountered in wet heath, Melaleuca swamps and sedge swamps in areas of sandy soil although it has been found to breed in disturbed wallum habitat including pine plantations and drainage ditches more readily than other species of Wallum-dependent frogs. The species has also been recorded in habitat well away from water during dry periods (Meyer *et al*, 2006). Its range extends along the coast from south-east Queensland to areas around Sydney. It has suffered significant habitat loss largely due to its distribution along the coast in mainland areas subject to exotic afforestation and urban development.

A number of records of this species have been recorded by **ecobiological** in the immediate locality within the past 5 years. An individual male Wallum Froglet was detected calling on lands adjacent to the study area (MP07-0086 site) in an area inundated with water considered to be highly disturbed wallum habitat (currently cleared paddock that receives water from an adjoining roadside drainage line that can become inundated with water to form a soak. The drainage line along the roadside easement (Tomago Road) that adjoins the study area is vegetated with regrowth shrubs and grasses. Several (<10) male Wallum Froglets were also detected calling along the northern edge of Tomago Road, between Tomago Road and Graham Drive, where a small patch of disturbed wallum habitat exists. A moderate population of Wallum Froglets (>50 calling males observed) was also detected approximately 80 metres north of Tomago Road in a naturally forested, ephemeral acid paperbark (*Melaleuca*) swamp. Acid paperbark swamp is commonly considered preferred *Crinia tinnula* habitat. Conditions were suitable for surveying for *C. tinnula* (based on heavy rainfall for the 3 weeks prior to the survey period and suitable seasonality).

In the study area, areas of Paperbark and Swamp Oak are present and promote the right conditions for this species for breeding, foraging and as refuge. It is considered likely that only a small number of individuals would occupy the habitat on the study area at any given time.

However, as none were detected during surveys of the study area, it is unlikely to support an important population for this species. As a result, the proposed development is unlikely to have a significant impact on the lifecycle of the species such that the local population would be placed at risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed action will reduce the area of suitable habitat for this species by 15.1 ha.

Land filling in the study area will result in this area no longer forming temporary soaks suitable for the species. The likelihood of Wallum Froglets moving into other areas of flooded paddock significantly decreases as these areas move away from the core population situated in the preferred acid paperbark swamp habitat to the north.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The loss of two small isolated patches of marginal habitat will not increase the overall level of fragmentation for this species in the locality. Suitable habitat for this species occurs extensively on the northern side of Tomago Road.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The habitat to be removed is considered marginal and poses no risk to the long-term survival of the species in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
No critical habitat has been listed for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,
The proposed development is not consistent with specific objectives 3 & 4 under Section 4 of the *National Recovery Plan for the Wallum Sedge-frog and Other Wallum-dependent Frog Species*. Specific objective 3 aims *"to rehabilitate degraded wallum frog habitat"* while specific objective 4 aims *"to determine population trends in areas of*

disturbed, undisturbed and rehabilitated habitat". The habitat present on the study area however is highly disturbed, marginal habitat on the outer fringe of an area of core habitat. It is not considered important habitat to the long-term survival of the population.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Two key threatening processes that affect the Wallum Froglet will be triggered by the proposed activity including the 'clearing of native vegetation' and the 'alteration to the natural flow regimes of rivers, streams, floodplains and wetlands'. However the alteration to hydrology caused by the proposal will not affect the population of Wallum Froglet to the north of Tomago Road.

Other threats specific to the Wallum Froglet are listed in the National Recovery Plan. Of these, two may be enacted by the proposal. These include habitat eutrophication and pollution through soil (nutrient laden) and chemical run-off and the use of biocides in the control of weeds and mosquitoes that may cause deformities, hermaphroditism and death. However these threats will be significantly reduced or eliminated by the proposed ameliorative measures.

Eastern Grass Owl (Tyto longimembris)

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

The Grass Owl generally prefers habitat of tussocky grasslands but can also be found in heaths, swamps, coastal dunes, tree-lined creeks and grassy areas in open forest (Brooker 1976; Schodde & Mason 1981; Higgins 1999, Debus *et al*. 1998, Debus *et al*. 2001, Schulz and Magarey 2010, Clulow *et al*. 2011). Grass Owls nest on the ground amongst dense clumps of tall grasses or sedges, particularly Bladey Grass (*Imperata cylindrica*) ranging from 50 – 100 cm tall and produce a clutch size of 3 – 8 chicks (Schodde & Mason 1981; Higgins 1999). Grass Owl roosts are cave-like pads, scrapes or shallow depressions, generally 30 – 60 cm in diameter or flimsy platforms of trampled stems of plants (Higgins 1999). Roosts are usually entered by narrow runways, tunnels or burrows up to several metres long through tall grasses or sedges (Higgins 1999). Little is known about the breeding habits of the Grass Owl but it is thought that in coastal parts of northern Australia, laying usually occurs between March and June (Hollands 1991). The Grass Owl is nocturnal but may occasionally hunt by day, preying mainly on terrestrial vertebrates in open treeless habitats; including marshy ground vegetated with tussocks of grass, low heath and recently harvested paddocks and canefields (Higgins 1999). Grass Owls feed predominately on small rodents but also take insects and birds when their preferred food is scarce (Schodde & Mason 1981, Hollands 2008, Schulz and Magarey 2010, Clulow *et al*. 2011).

The Grass Owl's distribution and range within Australia is not completely understood (Higgins 1999). The species' cryptic, nocturnal habits and occasional unpredictable long-distance movements make it something of an enigma, and it remains poorly studied (Olsen & Doran 2002). Confusion with the similar Barn Owl (*Tyto alba*) has also hampered scientists' understanding of its distribution and movements (Blakers *et al.* 1984). There were only 272 recorded sightings of this owl across Australia for the 135 years from 1866 – 2001 and all of these lie in the

northern and eastern half of the country from Victoria to the Kimberley (Olsen & Doran 2002). The majority of recorded sightings are from coastal north-east Queensland with a second population, usually widely scattered, occurring through the arid inland areas of Queensland and the Northern Territory (Hollands 1991). This inland population is usually very rare but may become locally and temporarily common during irruptions of Long-haired Rats (*Rattus villosissimus*) inland or Cane Rats (*Rattus sordidus*) in coastal regions (Hollands 1991). In NSW, most sightings are in a narrow coastal strip from around Nelson Bay up to the Queensland border (Garnet & Crowley 2000; Olsen & Doran 2002). The core population in NSW appears to be on the North Coast, extending regularly as far south as the Hunter Valley (Debus *et al.* 1998, Debus *et al*. 2001, Schulz and Magarey 2010, Clulow *et al*. 2011).

In Australia the Grass Owl is not listed as threatened under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* nor is it considered to be threatened nationally (Garnett, Szabo & Dutson 2010). However, it is listed as vulnerable in New South Wales on Schedule 2 of the *Threatened Species Conservation Act 1995*. The main reasons for this species listing were:

- Its distribution has been reduced
- Its population has been reduced to a critical level
- It is an ecological specialist (i.e. it depends on particular types of diet or habitats)

In January 2006 a population of Grass Owls was discovered at Tomago believed to be the southernmost resident population recorded in Australia (ecobiological 2007, Clulow *et al*. 2011). **ecobiological** undertook a targeted study of this population to determine aspects of the owl's ecology, diet, habitat usage and distribution through direct observation and collection of regurgitated pellets. A summary of findings from the 2006 targeted survey and the 2011 targeted survey is provided as background information below, however, for detailed methods and results refer to ecobiological (2007) and section 2.5 of this report:

1) Prey Species (Dietary Analysis)

Small terrestrial mammal trapping was undertaken on adjacent lands during May 2006 and October 2006. In May 2006 the Common House Mouse (*Mus domesticus*) was captured on 23 occasions across the subject site. The same trapping transects were repeated during October 2006 and only 1 Common House Mouse was caught. The discrepancy in *Mus domesticus* occurrence may be due to consistent rainfall prior to the October trapping which may have caused the Grass Owl's main prey species to move to higher ground. The second method used to identify Grass Owl prey species was regurgitated pellet hair and bone analysis. The most common prey item consumed by the Grass Owl was the House Mouse *Mus domesticus* (present in 77% of pellets; n=121) with substantial amounts of rat and bird also consumed (Clulow *et al*. 2011).

2) Movements and Home Range Size

Two Grass Owl roost sites were located within close proximity to the subject site during ecobiological's targeted survey. The main roost site was located to the east

of the subject site within the Ramsar wetlands and was used by the owls for a 7-month period. The secondary roost was located within the subject site and was used for a 2-month period when the Ramsar wetlands were temporarily inundated with water during heavy rainfall periods in late August 2006. Once the water had receded from the wetlands, the Grass Owls returned to the main roost.

Grass Owls presumed to be those resident to the Ramsar wetland roost site, were estimated to utilise a minimum area of 785 hectares of surrounding land for foraging (of which 97 ha adjacent to the subject site was subsequently cleared and developed), with a maximum of 6 individuals recorded using the main roost at one time (ecobiological 2007). The habitat for the Grass Owls in the area of the previous development has now been lost.

In 2010 - 2011, the National Parks and Wildlife Service began flooding portions of the Hunter Wetlands National Park to the east of the subject site. This inundation of the national park is aimed at promoting salt marsh species and to reduce the Swamp Oak and introduced grass lands from taking over the wetland system. This inundation has so far affected a large portion (exact portion unknown) of the home range of the known resident group at the subject site. The primary roost identified in 2006 is no longer in use due to salt water inundation and the secondary roost has not been recorded as having been used during 2010 or 2011. During the 2011 regional survey, Grass Owls were observed foraging on the subject site.

3) <u>Local Population Size</u>

Recordings of between two and three individual Grass Owls were the norm during ecobiological's surveys of the subject site and the two roost locations in 2006. However, a maximum of 6 individuals were recorded using the main roost site to the southeast of the subject site on one occasion.

The determination of local population size was hindered by the absence of Grass Owl records from the NSW Wildlife Atlas within a 5-kilometre radius of the subject site. One confirmed sighting to the southwest of the subject site within Hunter Wetlands National Park (L. Penman pers. comm.) was known prior to ecobiological's 2006 study. A roadkill specimen was also collected in 1997 from the Nelson Bay Road just north of Williamtown (HBOC Unusual Record Report #111).

As an alternative to determining local population size (which would require birds being trapped and marked), survey work focussed on finding other populations of Grass Owls in the wider region to provide an indication of the size of the regional population and its distribution. In 2006, the spread of Grass Owl populations in the surrounding region was determined through two (2) surveys at six (6) observation points, playing owl call play back simultaneously to recording the time and number of owls that responded. The six locations were chosen from anecdotal evidence of Grass Owl sightings, the confirmed record of a Grass Owl road kill near Williamtown, records from the NPWS Wildlife Atlas and the identification of potential habitat in the surrounding region.

The two regional surveys were conducted on 23.11.06 and 28.11.06, with 6 observation stations on each night:

On 23.11.06 four Grass Owls were sighted at three different locations:

- One individual on Ash Island to the south west of the main roost;
- One individual at the main roost; and
- Two individuals along Lavis Lane to the east of the main roost.

On 28.11.06 three Grass Owls were sighted, at two different locations:

- One individual on Ash Island to the south west of the main roost; and
- Two individuals along Lavis Lane to the east of the main roost.

The regional surveys conducted by **ecobiological** in 2006 identified an additional 5 Grass Owl locations with at least 12 individuals recorded between the 5 locations. Records from the Hunter Bird Observers Club in the local area since the 2006 surveys include sightings of individual birds on Ash Island and Broughton Island in 2007, a dead female bird at Stockton Sandspit in 2007, 1-3 birds on Ash Island in 2008, single birds on Ash Island in 2009, and a dead bird found near the Hunter Region Botanic Gardens in 2009. Grass Owls have also been confirmed at several other locations by **ecobiological** since the regional survey events in 2006, including Hexham Swamp Nature Reserve in November 2007 and Fletcher in April 2007.

In August and September 2011, a second more widespread regional Grass Owl survey was conducted by **ecobiological** (see methods, section 2.5 for details). Forty sites were chosen either by known records of the Grass Owl obtained through the OEH Atlas or through **ecobiological** records, and from site inspections of areas containing potential habitat. The area of potential habitat has been mapped (**Figure 13**) and is estimated to be approximately 20,624 hectares in area.

In total, 11 of the 40 sites had confirmed sightings of Grass Owls. A synchronised survey was carried out at the 11 sites to determine if owls were being counted multiple times. In total, seven sites had confirmed sightings simultaneously.

A map summarising the findings of the targeted Grass Owl study undertaken by **ecobiological** in 2011 is provided (**Figures 8 and 12**). **Figure 8** shows the 40 sites surveyed across the region, and **Figure 12** shows the 11 sites where Grass Owls were recorded, and the seven sites where Grass Owls were recorded simultaneously during the synchronized survey event.

4) <u>Residency</u>

The Grass Owls were recorded foraging on the subject site and surrounding grasslands in all seasons during 2006. Grass Owls were again recorded foraging to the east of the subject site in April 2011 and within the subject site in September 2011 on three out of five survey nights, thereby confirming a resident population using the subject site.

Grass Owls were observed in 2006 to be resident for a 12 month period but relocated from the main roost site (within Hunter Wetlands National Park) to nearby higher ground (on the subject site) for a 2 month period after their main

roost became inundated from prolonged rainfall. Grass Owls have been confirmed at Lavis Lane, Tomago and the Fletcher / Minmi area for the past 4 years.

The proposed subdivision and future development will remove or substantially modify the entire 239.7 ha of known Grass Owl habitat on the study area. It is likely that the cumulative loss of 43% (being the adjacent development, 97 ha and the proposed development 239.7ha) of this 'group's' estimated minimum foraging range and the wet weather roost site would place considerable pressure on the ability of this 'group' to successfully complete all stages of their lifecycle. The inundation of the Hunter Wetlands National Park with salt water has further added to the cumulative losses of this family group's home range. Taking into consideration the proposed development and existing cumulative losses, the estimated losses will be well over 50% of the group's mapped foraging range. The primary roost used in 2006 has been abandoned due to inundation and the secondary wet weather roost used in 2006 has not had confirmed usage for over 18 months. The cumulative loss of habitat over the last 12 months may have reduced the habitat for the resident group to such an extent that the area is now used only for foraging.

One Grass Owl was observed utilising the subject site during the August and September 2011 regional Grass Owl survey undertaken by **ecobiological**. Grass Owls were also observed at six other sites in the region. This indicates that there is suitable habitat for this species located throughout the region (estimated at 20,624 ha) which is able to support a number of different groups, although the structure of the observed 'groups' (i.e. whether they represent individuals, family groups or dispersing juveniles) is unknown.

The removal of a further 239.7 ha of habitat for this species within the study area will place the one family group using the site at risk of extinction. However, in a local context, the loss of 239.7 ha only represents an estimated 0.01% loss of suitable habitat (**Figure 13).** The local population of the Grass Owl, estimated to number no more than 5-10 family groups, will be placed under additional stress in the short to medium term. However this one event, being the loss of 239.7 ha of foraging habitat is unlikely to be the single event that will result in the local population being put at risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,
Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed subdivision and future development of the study area will result in the loss of approximately 239.7 ha of known foraging habitat and a wet weather roost site for the local Grass Owl population. This removal is in addition to the loss of 97 ha of foraging habitat for the adjacent development adjoining the north eastern boundary of the study area. The proposed clearing of habitat on the study area represents a cumulative loss of 43% of the minimum foraging range of one 'group' of owls forming part of the local Grass Owl population mapped by ecobiological (2007).

The cumulative effects of the already cleared adjacent development and the loss of habitat by the NPWS induced flooding, add up to a significant portion of known habitat for the resident 'group' of Grass Owls being lost over the last 12 months. The loss of the primary roost site, and the lack of recent usage of the wet weather roost suggest that the resident 'group' may have located another roosting area nearby, however, it is clear that the bird(s) still use the subject area as habitat for foraging.

It is acknowledged that similar areas of potentially suitable habitat likely to contain the Grass Owl's main prey species (House Mouse; ecobiological 2007) occur within the locality and region (estimated to be 20,624 ha). The regional survey conducted by **ecobiological** in August and September 2011 found seven potential groups of Grass Owls within the region, four of which were found to the south of the subject site (three in Hexham Swamp nature Reserve, and one on Ash Island), two to the north east, and one within the subject site. The proximity of the three sites at Hexham Swamp Nature Reserve does not preclude the possibility that these records represent only one family group of the owls.

The significance of removing the remaining 43% of the minimum foraging range of one 'group' of Grass Owls occurring on the subject site is unknown. However, it is likely that further loss of habitat will place this family group at risk and may result in either loss of this group entirely or relocation of this group to another area of suitable habitat. The loss of this group entirely may have adverse effects on the viability of the small population of Grass Owls in the Newcastle region in the long term, but only if combined with other events that may further reduce foraging and roosting habitat in the locality.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

From results obtained in the regional survey undertaken in August and September 2011 by **ecobiological**, there is known Grass Owl habitat to the south within Hexham Swamp Nature Reserve, within Ash Island, and also to the north towards Williamtown and Salt Ash. The proposed subdivision and future development

will remove a further 239.7 ha portion of the observed foraging range of the local population which consisted of seven groups, further fragmenting the western habitat on Ash Island from the eastern habitat along Tomago Road.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The discovery by NPWS staff and **ecobiological** of the Ash Island, Tomago, RAMSAR Wetland and Lavis Lane Grass Owls is considered to be of State significance, being the most southerly resident population on the NSW coast (pers. comm. R. Kavanagh).

The additional Grass Owl sightings recorded during the regional Grass Owl survey undertaken in 2011 by **ecobiological** confirms the State significance of this population.

The already noted observed loss of habitat for this species due to the NPWS flooding and the adjoining development represents a large portion of habitat that has been removed. The further loss of habitat within the study area is likely to place one group at risk of extinction, however as a stand-alone impact, it is unlikely to put the local population at risk of extinction. It is likely that habitat on the study area represents an important part of the foraging range of the local Grass Owl population. While the species has not been recorded roosting in the study area since 2006, it has been recorded foraging in the study area in September 2011.

Roosts are easily constructed and Grass Owls regularly move roosts due to inclement conditions, disturbance, prey availability and predators. Therefore, the long-term survival of the local population would be reliant on the preservation of roost sites and foraging habitat in the surrounding area. There is no reason why roost sites found on the study area would not be used again in the future.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been listed for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There was no draft or final recovery plan in place at the time of survey for this species. Predation by the Red Fox Threat Abatement Plan is of relevance to this species. While Grass Owls are not listed specifically as a priority species for fox control, several other ground-nesting birds are ranked as high priority due to observations of high mortality due to fox predation on eggs and juveniles. Objective 1 under section 5.3 of the Predation by the Red Fox Threat Abatement Plan (TAP) aims to reduce the impact of Foxes through Fox control programs. The proposed development will remove habitat suitable to the Red Fox across the study area, and it is recommended (section 4, Table 14) that the proponent cooperate with the relevant agencies to enable access to the Conservation Lands to the south as part of the annual baiting program.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The clearing associated with the proposed development constitutes one Key Threatening Process relevant to this species; Clearing of Native Vegetation. This would remove considerable areas of suitable vegetation used by the Grass Owl for foraging and potentially for roosting. One other key threatening process affecting the Grass Owl is already likely to be occurring in the study area and surrounding habitat - Predation by the Red Fox (*Vulpes vulpes*). However, the threat from this key threatening process will not further increase due to the proposed activity.

The following additional points have been suggested as possible threats to Grass Owl distribution and abundance (Schodde & Mason 1981):

- Loss of suitable habitat due to grazing, agriculture and development;
- Disturbance and habitat degradation by stock;
- Use of pesticides in agriculture to control rodent populations thereby reducing seasonal food sources for owls, and potentially poisoning owls; and
- Frequent burning, which reduces ground cover.

Conclusion

The results of the 2011 regional Grass Owl survey identified seven individuals, or 'groups' of Grass Owls located throughout the region, with one 'group' utilising the study area. This provides an indication of the population size and its sparse distribution within the low-lying and swampy areas around the Lower Hunter region near Newcastle. It is unknown whether the owls recorded represent individuals, family groups or dispersing juveniles.

The incremental loss of habitat over the last 12 months within the study area and immediate vicinity due to the flooding of the Hunter Wetlands National Park and the development to the northeast have significantly reduced the available home range area of the resident Grass Owls known to have occupied the site since 2006. Observations made by **ecobiological** in 2011 show that the primary roost used in 2006 (to the east of the site) has been destroyed and the secondary roost used in 2006 within the subject site is not currently being used by the owls. However, one or more owls is currently using the site as foraging habitat and new roosting sites could reasonably be expected to be established there in the future.

The study area and surrounds still represent ideal foraging habitat for the Grass Owl, as noted by sightings of Grass Owls within the study area during the 2011 regional survey. Suitable habitat and foraging resources, as well as the presence of other individuals or groups of Grass Owls, occur in close proximity to the study area within protected areas to the south on Ash Island, and further south within Hexham Swamp Nature Reserve which may enhance population viability of this species in the region. Five of the seven confirmed individuals or 'groups' of Grass Owls were recorded within protected lands, including the Hexham Swamp Nature Reserve, Hunter Wetlands National Park and Hunter Water owned land.

The small, resident population of Eastern Grass Owls in the Lower Hunter region is of State significance. The additional loss of a further 239.7 ha of known foraging and roosting habitat within the study area is likely to place the family group utilising this home range at risk of extinction. On a local scale, the loss of this foraging habitat is only minor, representing less than an estimated 1% of mapped suitable habitat. Therefore, the loss of this 239.7 ha of habitat is unlikely to be the catalyst for the entire local population being put at risk of extinction. However it must be noted that further habitat loss in the locality and any unforseen impacts upon conserved land may put the local population under extreme pressure for medium to long term survival. It is therefore recommended that any further land clearing be conditioned with regular regional surveys for a minimum 5 to 10 years on a yearly to 2 yearly basis.

White-fronted Chat (Epthianura albifrons)

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

The White-fronted Chat occurs across the southern third of Australia, inhabiting low vegetation in salty coastal and inland areas. It is also known from areas of open damp ground, grass clumps, fencelines, heath, samphire saltmarshes, mangroves, dunes and saltbush plains (Pizzey & Knight 2007).

Due to a long disturbance history for grazing and cropping, the study area's hydrology is now predominantly freshwater. Exotic grasslands, small patches of Swamp Oak forest and areas of freshwater wetland dominated by dense stands of phragmites occur across the study area and are considered to represent marginal habitat for this species. The White-fronted Chat was not observed on the study area during surveys, but has been recorded from nearby Ash Island, Kooragang Island and Hexham Swamp Nature Reserve.

It is considered that the proposed development is unlikely to have an adverse effect on the life cycle of this species such that a local population would be placed at the risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The majority of the study area is proposed to be filled for the creation of an industrial and business subdivision. The north-south drain leading into the conservation lands to the south will be retained, while other existing drainage lines will be filled or re-routed. The potential habitat present for the White-fronted Chat is considered to be marginal.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed action will remove a piece of an existing north-south corridor. Vegetation to the north does not represent suitable habitat for this species, therefore the proposed development is unlikely to fragment or isolate habitat for this species. Higher quality habitat for this species occurs within the conservation lands to the south (i.e. coastal saltmarsh adjoining mangroves) and within the adjoining Hunter Wetlands National Park to the south and east of the study area.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The habitat to be removed is not considered to be of high importance to the long-term survival of this species in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
No critical habitat has been listed for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,
There was no draft or final recovery plan in place at the time of survey for this species. No threat abatement plans are relevant.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The clearing associated with the proposed development constitutes one Key Threatening Process relevant to this species; Clearing of Native Vegetation. The development of the site is unlikely to have a significant impact on this species.

Red-backed Button-quail (Turnix maculosa)

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,
In Australia, this species has a largely coastal and sub-coastal range from the Kimberley region, Western Australia, through the Northern Territory, Queensland and NSW (Barrett *et al*. 2003, Blakers *et al*. 1984, Marchant & Higgins 1993). In NSW, the majority of Red-backed Button-quail records are from the North Coast Bioregion with a small number of records south as far as Sydney.

Red-backed Button-quail inhabit grasslands, woodlands and cropped lands of warm temperate areas that annually receive 400 mm or more of summer rain (Marchant & Higgins 1993). Observations of populations in other parts of its range suggest the species prefers sites near water, including grasslands and sedgelands near creeks, swamps and springs, and wetlands. Red-backed Button-quail usually breed in dense grass near water, and nests are made in a shallow depression sparsely lined with grass and ground litter.

The species is nocturnal and crepuscular and feeds on insects and seeds (Marchant & Higgins 1993). Birds normally hide and freeze rather than flushing, although individuals will fly for short distances before dropping back to cover. Red-backed Button-quail may be encountered individually, in pairs or in small family groups (NSW Scientific Committee 2005).

Due to a long disturbance history for grazing and cropping, the study area's hydrology is now predominantly freshwater. Exotic grasslands, small patches of Swamp Oak forest and areas of freshwater wetland dominated by dense stands of phragmites occur across the study area and are considered to represent marginal habitat for this species. The Red-backed Button-quail was not observed on the study area during surveys, but two birds have previously been recorded at Deep Pond on Ash Island in February 2006 and three birds at the same location in February 2007 (HBOC 2006, 2007).

It is considered that the proposed development is unlikely to have an adverse effect on the life cycle of this species such that a local population would be placed at the risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,
Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The majority of the study area is proposed to be filled for the creation of an industrial and business subdivision. The north-south drain leading into the conservation lands to the south will be retained, while other existing drainage lines will be filled or re-routed. The potential habitat present for the Red-backed Button-quail is considered to be marginal.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed action will remove a piece of an existing north-south corridor. Vegetation to the north does not represent suitable habitat for this species, therefore the proposed development is unlikely to fragment or isolate habitat for this species. Higher quality habitat for this species occurs on Lot 1002 (i.e. coastal saltmarsh adjoining mangroves) and within the adjoining Hunter Wetlands National Park to the south and east of the study area.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The habitat to be removed is not considered to be of high importance to the long-term survival of this species in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been listed for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There was no draft or final recovery plan in place at the time of survey for this species. No threat abatement plans are relevant.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The clearing associated with the proposed development constitutes one Key Threatening Process relevant to this species; Clearing of Native Vegetation. The development of the site is unlikely to have a significant impact on this species.

Threatened waterbirds

- Black-necked Stork (*Ephippiorhynchus asiaticus*)
- Australasian Bittern (*Botaurus poiciloptilus*)
- Black Bittern (*Ixobrychus flavicollis*)
- Magpie Goose (*Anseranas semipalmata*)
- Australian Painted Snipe (*Rostratula australis*)

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

The Black-necked Stork is an itinerant visitor to the region and as such a viable local population would not be present or placed at risk of extinction.

The Australasian Bittern occurs in reeds and marshes in terrestrial freshwater wetlands and, occasionally estuarine habitats, generally where there is permanent water. The Australasian Bittern is a cryptic bird, roosting during the day on the ground amongst dense reeds (Marchant & Higgins 1990). Foraging occurs mainly at night with typical prey consisting of small mammals, birds, amphibians, eels, crustaceans and insects. Little is known about this species' breeding ecology but the breeding season is considered to be between September through to February with nests being built in stands of Phragmites, Typha, and rushes (Juncus, Baumea spp.). The nest is usually comprised of a well-constructed flat platform of rushes or reeds. The species may occur singly, in pairs or in groups of up to 12 individuals (Marchant & Higgins 1990). The Australasian Bittern is generally sedentary but sometimes moves in response to flooding and drought (Smith *et al*. 1995).

The Tomago area (which includes the Hunter Wetlands National Park and Hunter Estuary Wetlands Ramsar site) are considered to represent vital habitat for the local Australasian Bittern population. In 2010, a single bird was at Tomago Wetlands in early January and two birds were there in late July (HBOC 2010). In 2009, 2 – 4 birds were regularly recorded at the Tomago Wetlands between April and September and single birds were observed at Hexham Swamp in January and Deep Pond on Kooragang Island in May (HBOC 2009). In 2008, 1-2 birds were often recorded at Tomago Wetlands over September – December and at Hexham Swamp in February, October and November (HBOC 2008). In 2007, single birds were seen / heard at Tomago Wetlands on the 5, 14 and 21 September and 18 and 19 October (HBOC 2008). Within the Hunter Region, the core breeding range is likely to be contained within the broader Hunter Estuary (i.e. Hexham Swamp, Kooragang Island, Tomago, Williamtown (Finegan *et al*. 2001). The majority of preferred habitat for this species occurs in areas with some level of protection e.g. National Parks, Council reserves and in SEPP 14 wetlands (Roderick & Stuart 2010). Some areas remain unprotected and may be at threat from inappropriate hydrological practices and indirect impacts of nearby development. It is also noted that it is unclear what the impact will be on this species' local habitat of the returning of brackish/saline waters to some of these areas via the opening of the floodgates in Hexham Swamp and the Tomago wetlands (Roderick & Stuart 2010).

The Black Bittern usually occurs singly or in pairs in thick vegetation in terrestrial wetlands, watercourses, swamps, billabongs, mudflats and mangroves, and also streamside vegetation in shrubland or low forest (Marchant & Higgins 1990). However, it is most often encountered in permanent wetlands fringed by dense vegetation and rarely in open habitats (McKilligan 2005). Foraging generally occurs at dusk and at night along the edges of still and running water. Typical prey items consist of reptiles, fish, crayfish, mussels and invertebrates (McKilligan 2005). During the day, the species roosts in trees or amongst dense reeds on the ground.

In most years there are a small number of records of Black Bittern from around creeks, rivers and freshwater lakes in the eastern parts of the Hunter Region. In 2005, a systematic study of some creeks around Lake Macquarie detected seven birds in a single day and several additional records in the following weeks. The Black Bittern has also been recorded at Scotts Point, Ash Island on 15/3/2009 (HBOC 2009) and more recently on 19 April 2011 in mature mangrove forest near the smart gates in the Tomago Wetlands (HBOC pers. comm.).

The Magpie Goose inhabits large seasonal wetlands and well-vegetated dams with rushes and sedges, wet grasslands and floodplains (Pizzey & Knight 2007). The study area supports marginal habitat for this species with little to no open water bodies present.

The Australian Painted Snipe inhabits well-vegetated shallows and margins of wetlands, dams, sewage ponds, wet pastures, marshy areas etc. (Pizzey & Knight 2007) and is rarely recorded in the Hunter Region.

Targeted surveys for these threatened waterbirds (i.e. meandering walks throughout the freshwater wetland community, Swamp Oak forest and exotic grasslands, call playback and spotlighting (for Bitterns)) for these species were conducted both during the breeding season and after significant rainfall throughout Spring and early Summer 2010 and Spring 2011. No individuals or evidence of nesting was recorded. It should also be noted that extensive traverses have been made throughout the study area both during bird surveys, spotlighting surveys, targeted threatened flora species meanders and vegetation mapping over several seasons and years. None of these species have been flushed or sighted during this time.

The Swamp Oak Rushland Forest and Freshwater Wetland Complex communities in the north and east of the study area may provide opportunistic foraging habitat for the two Bittern species during wet periods. However, as both the Australasian and Black Bittern prefer permanent water bodies with areas of open water for foraging it is considered that the study area does not represent optimal foraging habitat. Therefore, it is unlikely that the proposed action would have an adverse effect on the life cycle of these species such that any viable local populations would be placed at risk of extinction.

With regard to the Black-necked Stork, Magpie Goose and Australian Painted Snipe, these species have the potential to occur in the exotic grasslands during wet periods or around the edges of the dense reedbeds. However, the habitat present is not considered optimal for these species with higher quality habitat present in the adjoining Ramsar wetlands. It is unlikely that the proposed action would have an adverse effect on the life cycle of these species such that any viable local populations would be placed at risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,
Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The study area contains potential foraging habitat for these species following long periods of rain and runoff within the exotic grasslands (relevant mainly to the Black-necked Stork and Magpie Goose), Swamp Oak Rushland Forest, and Freshwater Wetland Complex. Approximately 200 ha of potential habitat will be removed or modified for the proposed development.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed action will remove a piece of an existing north-south corridor. Vegetation to the north does not represent suitable habitat for these species, therefore the proposed development is unlikely to fragment or isolate habitat for these species. Higher quality habitat for these species occurs within the adjoining Hunter Wetlands National Park to the east of the study area and within Lot 1002.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

While it is unlikely that the Northbank project will place these threatened waterbird species at risk of extinction in the locality, removal of approximately 200 ha of potential habitat will place pressure on the long-term survival of these species across their known range. Important habitat for the local Australasian Bittern population adjoins the study area (on Lot 1002 and within Hunter Wetlands National Park) and mitigation measures must be implemented to monitor any indirect impacts on the adjoining Hunter Wetlands National Park and Ramsar site.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
No critical habitat has been listed for these species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There was no draft or final recovery plan in place at the time of survey for these species. Predation by the Red Fox Threat Abatement Plan is relevant to these species, with foxes being observed on the study area during the survey period. The Australasian and Black Bittern are threatened by fox predation on eggs and juveniles. However, the proposed development would likely clear the majority of vegetation on the study area, therefore removing denning habitat for the Red Fox. A fox control program is undertaken within the adjoining Hunter Wetlands National Park using 1080 poison baiting.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The clearing associated with the proposed development will trigger two Key Threatening Processes relevant to these species; Clearing of Native Vegetation and Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands. This proposal will remove habitat potentially used by these species for opportunistic foraging and may have off-site impacts from a change in flow regimes to the grasslands and SEPP 14 wetlands to the south and Ramsar wetlands to the east if not properly mitigated.

Conclusion

While it is unlikely that the Northbank project will place these threatened waterbird species at risk of extinction in the locality, removal of approximately 200 ha of potential habitat will place pressure on the long-term survival of these species across their known range. Mitigation in the form of Surface and Groundwater Management Plans and a proposed Wetland Management and Monitoring Plan are required to ensure that the quality and quantity of water entering the adjoining SEPP 14 wetlands and Ramsar wetland will not compromise the health of these adjoining sensitive ecosystems.

Threatened shorebird species

- Black-tailed Godwit (*Limosa limosa*)
- Great Knot (*Calidris tenuirostris*)
- Lesser Sand-plover (*Charadrius mongolus*)
- Australian Pied Oystercatcher (*Haematopus longirostris*)
- Terek Sandpiper (*Xenus cinereus*)

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

Records of threatened migratory species such as the Great Knot, Terek Sandpiper, Black-tailed Godwit, Lesser Sand Plover and Australian Pied Oystercatcher are from nearby Kooragang Island, the Kooragang Dykes area and within Fullerton Cove. While the study area contains Freshwater Wetland Complex, this habitat is almost exclusively reedbeds dominated by *Typha orientalis* and *Phragmites australis*. There is no saltmarsh, permanent open water or sandy beach habitat within the study area. Potential habitat along the Hunter River foreshore is restricted to rocky revetment with the occasional Mangrove (or small clump of mangroves) present.

Targeted surveys in December 2010 within the study area and along the Hunter River foreshore did not detect any threatened or migratory shorebird species.

Provided appropriate mitigation measures are adopted to address potential indirect impacts on wetland habitat within the nearby SEPP 14 and Ramsar wetland, the proposed development is unlikely to significantly impact on the lifecycle of these species.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,
Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

There is no suitable shorebird habitat on the study area (i.e. coastal saltmarsh, open wetlands with muddy margins or sandy beaches). The Hunter River foreshore is considered to provide marginal foraging and roosting habitat for shorebirds. Potential indirect impacts on known habitat for these species within the adjoining SEPP 14 wetlands and Ramsar wetlands have been considered and mitigation measures are proposed in section 5.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

No habitat will be fragmented or isolated as a result of the proposed development.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
Habitat on the study area is not considered important to the long term survival of these species in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
No critical habitat has been listed for these species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,
There was no draft or final recovery plan in place at the time of survey for these species.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The clearing associated with the proposed development will trigger two Key Threatening Processes relevant to these species; 'Clearing of Native Vegetation' and minor 'Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands'.

Conclusion
The proposed project is unlikely to have a significant impact on these threatened species in the locality or the region.

Threatened Raptors

- **Spotted Harrier (*Circus assimilis*)**

- **Eastern Osprey (*Pandion cristatus*)**

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,
The Spotted Harrier occurs in grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe (e.g. chenopods) (Marchant and Higgins 1993; Aumann 2001). It is found most commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands. The species builds a stick nest in a tree and lays eggs in spring (or sometimes autumn), with young remaining in the nest for several months. Generation length is estimated as 10 years (Debus and Soderquist 2008).

The Eastern Osprey inhabits coasts, estuaries, bays, inlets, islands and surrounding waters, lagoons and rock cliffs. The species breeds between July to September in southern Australia and its large nest is constructed of sticks, seaweed, rope etc. high in a live or dead tree or on artificial structures and on islands, nest are sometimes built on the ground (Pizzey & Knight 2007).

The Spotted Harrier is generally uncommon close to the coast whereas the Eastern Osprey is regularly recorded throughout the Hunter Estuary. There are irregular records of the Spotted Harrier (generally 1-2 birds) in the Lower Hunter from Tomago Wetlands (HBOC 2009), Ash Island / Kooragang Island, Hexham Swamp, Pambalong Nature Reserve (HBOC 2008), Walka Water Works, Bolwarra and Thornton (HBOC 2007). Neither of these species was recorded in the study area during field surveys. No suitable habitat exists in the study area for the Eastern Osprey, however, the adjoining Hunter River and Ramsar wetlands provide foraging habitat and may be indirectly impacted by the proposed development. Approximately 141 ha of potential habitat (Exotic grasslands) for the Spotted

Harrier will require removal or modification, however, due to the availability of large patches of similar habitat in the locality it is considered that this clearing is unlikely to adversely affect the life cycle of this species to any significant degree.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable.

(c) in the case of an endangered ecological community, whether the action proposed:

i. (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

ii. (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:

iii. (i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The Spotted Harrier is a rare occurrence in the Lower Hunter region; however, it may forage over the exotic grasslands within the study area on occasion. Approximately 141 ha of foraging habitat will be removed and/or modified for the proposed development.

There is no suitable foraging habitat in the study area for the Eastern Osprey as the Freshwater Wetlands are largely vegetated with dense reed beds, however, the species may be observed flying over the study area to reach foraging habitat in the Hunter River or adjoining Ramsar wetlands. No nesting habitat is present.

iv. (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed action will remove a piece of an existing north-south corridor. Vegetation to the north does not represent suitable habitat for these species, therefore the proposed development is unlikely to fragment or isolate habitat for these species. The adjoining Hunter River (Osprey) and Lot 1002 and Ramsar wetlands (Spotted Harrier) will continue to provide habitat for these species in the immediate locality.

v. (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Due to the availability of large patches of similar habitat in the locality for the Spotted Harrier, it is considered that the habitat to be removed for this proposal is not of high importance to this species long-term survival.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
No critical habitat has been listed for either species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,
There was no draft or final recovery plan in place at the time of survey for these threatened raptors. None of the threat abatement plans are relevant for these species.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The clearing associated with the Northbank project constitutes one Key Threatening Process relevant to the Spotted Harrier; 'Clearing of Native Vegetation'.

Conclusion
It is unlikely that the Northbank project will place the Spotted Harrier at risk of extinction in the locality. Provided mitigation measures relating to water quality entering the Hunter River are implemented and appropriate monitoring of stormwater and groundwater is adhered to, adjoining foraging habitat for the Eastern Osprey will not be significantly impacted.

Koala (*Phascolarctos cinereus*)
(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,
The Koala generally occurs from the Townsville district in northern Queensland, south along the coast and ranges into Victoria and part of South Australia. Within New South Wales and Queensland, this distribution extends into the western slopes and plains. The Koala lives entirely on a diet of leaves of both eucalypt and non-eucalypt trees and it has been shown that within its range there are local and regional preferences for the tree species used for feeding. Examples of eucalypts used as feed trees are *E. camuldulensis*; *E. viminalis*; *E. ovata*; *E. teretecornis*; *E. microcorys*; *E. punctata*. Non-eucalypts recorded have been *Allocasuarina torulosa*; *Melaleuca quinquenervia*; and *Lophostemon confertus*. Throughout its range the Koala suffers from either a lack of numbers or severe over-population where problems such as eye disease and reproductive tract bacterial disease caused by *Chlamydia psittaci* become prevalent (Martin & Handasyde, 1995; Moore & Foley, 2000; Phillips & Callaghan, 2000; Phillips *et al.*, 2000).

This species was not detected during field surveys (spotlighting and scat searches as well as opportunistic diurnal observations). The NSW Wildlife Atlas does contain records of this species occurring within the study area however, all of the records are from between 1985 – 1992 and the accuracy is noted as within 1km. It is likely that the records are from mapped key koala habitat to the north of

Tomago Road. The two strips of mapped Swamp Sclerophyll Forest containing some juvenile *E. tereticornis* and *E. robusta* are highly isolated and disturbed. It is considered unlikely that Koalas would cross Tomago Road to forage on these trees. The habitat on the study area does not form part of a movement corridor for this species.

The removal of 1.5 ha of Swamp Sclerophyll Forest at this location and in this condition is considered unlikely to adversely affect the life cycle of this species such that a viable local population would be placed at risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

i. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

ii. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:

i. the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed development will result in a loss of 1.5 ha of Swamp Mahogany – Paperbark Swamp Forest which represents preferred foraging habitat for this species.

ii. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The habitat on site is already highly isolated and fragmented from more intact, extensive habitat to the north of Tomago Road.

iii. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The relatively small amount of potentially suitable habitat to be removed is not considered vital to the long-term survival of this species in the study area.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat is present in the study area.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

The Approved Recovery Plan for the Koala (*Phascolarctos cinereus*) (DECC 2008c) identifies mechanisms to conserve Koala habitat and increase our understanding of the biology and ecology of this species. The removal of habitat as proposed for this project is not consistent with the objectives of this plan albeit a relatively minor level of habitat removal.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

'Clearing of native vegetation' will occur as a result of the proposed development.

Conclusion:

Given the small area of isolated habitat for this species that will be removed compared to the extent of suitable habitat in the surrounding lands, the proposed project is unlikely to have a significant impact on this species in the locality or the region.

Grey-headed Flying-fox (Pteropus poliocephalus)

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

Grey-headed Flying Foxes exhibit a high site fidelity to their roosting locations and will travel up to 50 km from their roosting camp to forage. Roosting camps may be occupied by tens of thousands of individuals and generally occur within 20 km of a regular food source, in densely vegetated gullies close to permanent water (Hall & Richards, 2000).

There was no indication of a roosting camp occurring on the study area, but individual Grey-headed Flying Foxes were observed flying over the study area during surveys. A previous survey by ecobiological (2007) on the adjoining MP07-0086 land detected several Grey-headed Flying-foxes foraging in fig trees on the site. The study area has very little suitable habitat present for this species, with the exception of a single fig tree in the west of the study area and the two strips of Swamp Sclerophyll Forest containing *Eucalyptus robusta* and Paperbark feed trees.

Given their ability to traverse unsuitable habitat to reach foraging grounds is considerably greater than the size of the area to be removed under the proposed development, it is unlikely that the proposed development would affect the life cycle of this species such that any local viable population would be placed at risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The majority of vegetation on the study area consists predominately of improved pasture with small patches of Swamp Oak Forest that does not form foraging habitat for this species. Suitable habitat to be removed consists of a single fig tree and two narrow strips of Swamp Sclerophyll Forest in the northwest corner of the site.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed action will remove a piece of an existing north-south corridor. However, given that the majority of the study area does not represent suitable habitat and that this species is highly mobile, its removal is considered unlikely to affect this species' ability to reach other areas of suitable habitat in the locality.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The habitat to be removed is not considered to be important to the long-term survival of this species in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
No critical habitat has been listed for this species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,
A Draft National Recovery Plan (DECCW 2009) has been prepared for this species. The proposed removal of a small amount of foraging habitat is not consistent with 'Objective 2. To protect and increase the extent of key winter and spring foraging habitat of Grey-headed Flying-foxes'. However, the isolated and highly modified nature of these small strips of foraging habitat reduce their importance to the local population. No threat abatement plans are relevant.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The clearing associated with the proposed development constitutes one Key Threatening Process relevant to this species; Clearing of Native Vegetation. The proposed clearing of a small amount of foraging habitat is not considered likely to have a significant impact on this species.

Tree-roosting Insectivorous Bats

- Eastern Freetail-bat (*Mormopterus norfolkensis*)
- Greater Broad-nosed Bat (*Scoteanax rueppellii*)
- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)

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

The Eastern Freetail-bat occurs in a thin coastal band between the Sydney district and Brisbane. Little is known of the habits or the preferred habitat of this species, although it is apparent that it does inhabit dry sclerophyll forest and woodland, where it hunts for insects above the canopy or within clearings at forest edges. This species normally roosts in tree hollows or under loose bark on a variety of tree species (Churchill 1998; Allison & Hoye 1995).

The Greater Broad-nosed Bat occurs along the coast and ranges of eastern Australia, from northern Queensland to the NSW/Victorian border. This bat appears to be most frequent in the river systems draining the Great Dividing Range. Tree-lined creeks, and the junctions of woodland and cleared paddocks, are favoured hunting areas for the Greater Broad-nosed Bat, although it may also forage in rainforest environments, flying as low as one metre above the surface of a creek. The species normally roosts in tree hollows, but roosting records in the ceilings of old buildings also exist (Churchill 1998; Hoye & Richards 1995).

The Eastern False Pipistrelle occurs from coastal southeast Queensland to western Victoria and through Tasmania. Its ecology is not well known but its preferred habitat appears to be sclerophyll forests (Churchill 1998). It is a bat that hibernates in the colder winter period of the southern part of its range (Phillips 1995). Preferred roosting sites are large hollow trees and caves.

The Yellow-bellied Sheathtail-bat is found in a wide range throughout Australia only being absent from the southwest quarter of SA to southern WA and throughout this range it inhabits a similarly wide range of vegetative habitat. They are an adaptive roosting species and have been found under eaves of houses, in animal burrows in the ground and in tree hollows for example. Its reported rarity may be in part due to the fact that it flies high and fast and is not often captured (Churchill 1998, Richards 1995a).

The proposed action would remove areas of marginal foraging habitat from the home ranges of all of these species and small patches of potential roosting habitat. However, the area of clearing involved in the proposed development would not

likely have an adverse effect on the life cycle of these species such that any viable local populations would be placed at risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,
Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The majority of the study area is proposed to be filled for the creation of an industrial and business subdivision. The north-south drain leading into the conservation lands to the south will be retained, while other existing drainage lines will be filled or re-routed. The foraging and potential roosting habitat present for these species is considered to be marginal.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The study area and surrounding area to the south of Tomago Road is already heavily fragmented due to clearing for grazing and agricultural purposes with only small remnant patches of forest remaining. The proposed activity will remove two small patches of Swamp Oak Forest and two linear strips of Swamp Mahogany Paperbark Forest, further fragmenting habitat for these species.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The loss and further fragmentation of habitat by the proposal is likely to add long-term pressure for these species through ongoing incremental habitat loss. It is unlikely however that the removal of habitat on the study area will have a significant impact on these species such that they are at immediate risk of extinction in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
No critical habitat has been listed for these species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,
There was no draft or final recovery plan in place at the time of survey for these species. No threat abatement plans are relevant.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The clearing associated with the proposed development will trigger three Key Threatening Processes relevant to these species; Clearing of Native Vegetation, Loss of Hollow-bearing Trees and Removal of Dead Wood and Dead Trees. The Office of Environment & Heritage has also identified several further threats specific to these Microchiropteran bat species.

They are: 1) disturbance to roosting and summer breeding sites, 2) clearing of foraging habitats for residential and agricultural developments including clearing within rural subdivisions, 3) loss of hollow-bearing trees, and 4) pesticide and herbicide use for weed and insect control (affects insect availability and bioaccumulates in body fat of individuals). Points 2 and 3 will be enacted by the proposed development, while Point 4 can be mitigated as detailed in section 5.

Cave-roosting Insectivorous bats

- Little Bentwing-bat (*Miniopterus australis*)
- Eastern Bentwing-bat (*Miniopterus oceanensis*)
- Southern Myotis (*Myotis macropus*)

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,
All three species use caves for roosting, but *Miniopterus australis* will occasionally use tree hollows and *Myotis macropus* regularly uses them for roosting (pers. comm. G. Hoye). All three species also forage in forested habitats but their niches differ. Both *Miniopterus* spp. use the canopy for foraging, while *Myotis macropus* skims the surface of streams and ponds catching insects and small fish (Richards 1995b; Dwyer 1995a, 1995b).

Research on the home ranges of these species is limited but suggests that *M. australis* exhibits a high fidelity to a particular foraging area that may change seasonally, and that *Myotis macropus* is capable of travelling long linear distances along riparian zones to exploit hunting areas (pers. comm. G. Hoye).

The proposed action would remove foraging habitat from the home ranges of all three of these species and small patches of potential roosting habitat for *Miniopterus australis* and *Myotis macropus*. However, the area of clearing involved

in the proposed development would not likely have an adverse effect on the life cycle of the species such that a viable local population would be placed at risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,
Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:
(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:
(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The majority of the study area is proposed to be filled for the creation of an industrial and business subdivision. The north-south drain leading into the conservation lands to the south will be retained, while other existing drainage lines will be filled or re-routed. The foraging and potential roosting habitat present for these species is considered to be marginal.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The study area and surrounding area to the south of Tomago Road is already heavily fragmented due to clearing for grazing and agricultural purposes with only small remnant patches of forest remaining. The proposed activity will remove two small patches of Swamp Oak Forest and two linear strips of Swamp Mahogany Paperbark Forest, further fragmenting habitat for these species.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The loss and further fragmentation of habitat by the proposal is likely to add long-term pressure for these species through ongoing incremental habitat loss. It is unlikely however that the removal of habitat on the study area will have a significant impact on these species such that they are at immediate risk of extinction in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),
No critical habitat has been listed for these species.

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,
There was no draft or final recovery plan in place at the time of survey for these species. No threat abatement plans are relevant.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.
The clearing associated with the proposed development will trigger three Key Threatening Processes relevant to these species; Clearing of Native Vegetation, Loss of Hollow-bearing Trees and Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands. This proposal will remove habitat potentially used by these species for opportunistic foraging and potential roosting (Little Bentwing-bat and Southern Myotis only) and may have off-site impacts from a change in flow regimes to the grasslands and SEPP 14 wetlands to the south if not properly mitigated.

The Department of Environment and Conservation has also identified several further threats specific to these Microchiropteran species. They are: 1) loss or disturbance of roosting caves; 2) changes to habitat especially surrounding maternity caves; 3) loss of foraging habitat; 4) clearing adjacent to foraging areas; 5) reduction in stream water quality, and 6) predation by foxes and cats. Of these specific threats, the loss or modification of foraging habitat would occur as a consequence of the proposed development.

4.3. Commonwealth EPBC Act assessments

No threatened ecological communities, threatened species or migratory shorebirds listed under the EPBC Act were recorded to occur in the study area. Two threatened flora and five threatened fauna species listed under the EPBC Act were considered to have suitable habitat present on the study area and are accordingly assessed below. A migratory and/or marine species assessment is provided in section 4.3.3.

4.3.1. Threatened flora assessment

- ***Trailing Woodruff (Asperula asthenes)***
- ***Tall Knotweed (Persicaria elatior)***

Trailing Woodruff and Tall Knotweed are listed as Vulnerable species under the EPBC Act. The 7-part test for both species concluded that the proposal is unlikely to have a significant impact on either species.

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

No populations of these species were recorded.

Will the action reduce the area of occupancy of an important population of the species?

No. These species were not recorded during extensive surveys on the study area within their known flowering and fruiting times

Will the action fragment an existing population into two or more populations?

No populations of either species were recorded.

Will the action adversely affect habitat critical to the survival of a species?

The proposed development would result in a loss of approximately 58.1 ha of Freshwater Wetland Complex and 1.5 ha of Swamp Mahogany – Paperbark Swamp Forest which represents potential habitat for these species. The loss of this potential habitat is not considered critical to the survival of these species.

Will the action disrupt the breeding cycle of an important population?

The action will not have an impact on the breeding cycle of any local populations.

Will the action modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The removal of this potential habitat will not lead to any significant decline in these species.

Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?

Provided mitigation measures within a Vegetation Management Plan are adhered to, the action will not result in the establishment of invasive species into surrounding habitat.

Will the action interfere substantially with the recovery of the species?

The action will not interfere with the recovery of these species.

Conclusion

Based on the above assessment it is unlikely that Trailing Woodruff or Tall Knotweed will be significantly impacted by the proposal.

4.3.2. Threatened fauna assessment

Green and Golden Bell Frog

The Green and Golden Bell Frog is listed as a Vulnerable species under the EPBC Act. The 7-Part Test for this species concluded that the proposal is unlikely to have a significant impact on the species.

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

No population has been identified from the study area and so the proposed actions are unlikely to reduce the size of any population.

Will the action reduce the area of occupancy of an important population of the species?

The proposal will remove a small area of ephemeral habitat suitable for this species (approximately <5 ha) and a large area of potential dispersal habitat (approximately 211 ha). The extent of occupancy reduction however, is considered minor as no important population was recorded.

Will the action fragment an existing population into two or more populations?

No.

Will the action adversely affect habitat critical to the survival of a species?

No.

Will the action disrupt the breeding cycle of an important population?

No.

Will the action modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The removal of approximately 211 ha of marginal habitat for this species is not likely to result in any decline in any population of this species.

Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?

No. Provided mitigation measures within a Vegetation Management Plan are adhered to, the action will not result in the establishment of invasive species into surrounding habitat.

Will the action interfere substantially with the recovery of the species?

No.

Conclusion

Based on the above assessment it is unlikely that the Green and Golden Bell Frog will be significantly impacted by the proposal.

Grey-headed Flying-fox

The Grey-headed Flying Fox is listed as a Vulnerable species under the EPBC Act. The 7-Part Test for the Grey-headed Flying Fox concluded that the proposal is not likely to have a significant impact on the species.

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

No, habitat removal is minimal and not considered to represent critical foraging habitat.

Will the action reduce the area of occupancy of an important population of the species?

Due to the small number of potential feed trees to be removed and the abundance of other potential feed trees in the area it is considered unlikely that the area of occupancy will be reduced for the species.

Will the action fragment an existing population into two or more populations?

No.

Will the action adversely affect habitat critical to the survival of a species?

No, the two narrow strips of Swamp Sclerophyll Forest would not be considered habitat critical to this species survival.

Will the action disrupt the breeding cycle of a population?

No.

Will the action modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

No.

Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?

No. Provided mitigation measures within a Vegetation Management Plan are adhered to, the action will not result in the establishment of invasive species into surrounding habitat.

Will the action interfere substantially with the recovery of the species?

No.

Conclusion

Based on the above assessment it is unlikely that the Grey-headed Flying Fox will be significantly impacted by the proposal.

Australian Painted Snipe

The Australian Painted Snipe is listed as a Vulnerable species under the EPBC Act. The 7-Part Test for the Australian Painted Snipe concluded that the proposal is not likely to have a significant impact on the species.

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

No, an important population of the species has not been identified on the site and the site does not contain critical foraging habitat.

Will the action reduce the area of occupancy of an important population of the species?

Due to the marginal nature of the habitat present on site for this species and the abundance of higher quality habitat in surrounding areas, it is considered unlikely that the area of occupancy will be reduced for the species.

Will the action fragment an existing population into two or more populations?

No.

Will the action adversely affect habitat critical to the survival of a species?

No.

Will the action disrupt the breeding cycle of a population?

No.

Will the action modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

No.

Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?

No. Provided mitigation measures within a Vegetation Management Plan are adhered to, the action will not result in the establishment of invasive species into surrounding habitat.

Will the action interfere substantially with the recovery of the species?

No.

Conclusion

Based on the above assessment it is unlikely that the Australian Painted Snipe will be significantly impacted by the proposal.

Australasian Bittern

The Australasian Bittern is listed as a Vulnerable species under the EPBC Act. The 7-Part Test for the Australasian Bittern concluded that the proposal is not likely to have a significant impact on the species.

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

Targeted surveys using call playback (as well as extensive traverses throughout the study area during bird surveys, spotlighting, targeted flora searches and vegetation mapping) did not detect the presence of this species in the study area; however, an important population is known to exist in the adjoining Hunter Wetlands National Park and individuals have been recorded from the area known as the 'Rice Paddy' within Lot 1002. The Phragmites and Typha reedbeds present in the northeastern portion of the study area may offer roosting and nesting habitat for this species, and will be preserved as part of an Environmental Zone.

Will the action reduce the area of occupancy of an important population of the species?

While no presence of the species in the study area was detected, it is possible that the species could use the Phragmites and Typha dominated reedbeds in the northeast of the site for roosting and nesting. There is little to no open water foraging habitat present.

The removal of approximately 58.1 ha of Freshwater Wetland Complex may reduce the potential area of occupancy for the important population known from the adjoining Hunter Wetlands National Park and from Lot 1002.

Will the action fragment an existing population into two or more populations?

No.

Will the action adversely affect habitat critical to the survival of a species?

No.

Will the action disrupt the breeding cycle of a population?

This is unlikely given that the species was not detected within the study area.

Will the action modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

This is unlikely given that the species was not detected within the study area.

Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?

No. Provided mitigation measures within a Vegetation Management Plan are adhered to, the action will not result in the establishment of invasive species into surrounding habitat.

Will the action interfere substantially with the recovery of the species?

No.

Conclusion

Based on the above assessment it is unlikely that the Australasian Bittern will be significantly impacted by the proposal.

Koala

The Koala is listed as a Vulnerable species under the EPBC Act. The 7-Part Test for the Koala concluded that the proposal is not likely to have a significant impact on the species.

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

Spotlighting searches, general observations and scat searches did not detect this species within the study area. Due to the highly fragmented and isolated nature of the Preferred Koala Habitat present in the northwest corner of the study area, it is considered highly unlikely that Koalas would move across Tomago Road to forage in this habitat. Therefore, the action of removing 1.5 ha of Preferred Koala habitat is unlikely to lead to a long-term decrease in the size of the Port Stephens Koala population.

Will the action reduce the area of occupancy of an important population of the species?

No. It is considered highly unlikely that the study area is used by the local Koala population.

Will the action fragment an existing population into two or more populations?

No.

Will the action adversely affect habitat critical to the survival of a species?

Yes. According to the Interim Koala Referral Advice, habitat critical to the survival of the Koala includes "areas of forest or woodland where:

- primary koala food tree species comprise at least 30% of the overstorey trees".

The 1.5 ha of Swamp Sclerophyll Forest proposed to be removed contains *Eucalyptus robusta* and *E. tereticornis.* Individuals of these species exceed 30% of the overstorey trees present. The other dominant canopy species is *Melaleuca quinquenervia* which is considered to be a secondary browse tree for the species on the Mid North Coast. However, these small, linear patches of potential habitat are completely severed from extensive areas of mapped Preferred and Supplementary Koala Habitat on the northern side of Tomago Road. It would be undesirable for Koalas to move across Tomago Road due to the high chance of fatalities.

Will the action disrupt the breeding cycle of a population?

No.

Will the action modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

This is unlikely given that the species was not detected within the study area and is considered unlikely to occur.

Will the action result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?

No. Provided mitigation measures within a Vegetation Management Plan are adhered to, the action will not result in the establishment of invasive species into surrounding habitat.

Will the action interfere substantially with the recovery of the species?

No.

Conclusion

Based on the above assessment it is unlikely that the Koala will be significantly impacted by the proposal.

4.3.3. Migratory and/or marine species assessment

Six migratory and/or marine species were considered to have potentially suitable habitat on the study area (Common Sandpiper, Pacific Golden Plover, Latham's Snipe, White-throated Needletail, Fork-tailed Swift and Rainbow Bee-eater). Two migratory species were recorded during surveys (Cattle Egret and White-bellied Sea-Eagle). A migratory species assessment using the Matters of National Environmental Significance Guidelines has been undertaken below. The study area does not contain 'important habitat' for shorebirds as defined by the EPBC Act Policy Statement 3.21, however, the site adjoins a Ramsar wetland in the northeast.

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 a migratory species;*

A discussion of habitat removal / modification of migratory species whose habitat is likely to be impacted is provided below.

The Common Sandpiper is considered uncommon in the Hunter Estuary. They are usually observed as single birds, and rarely in pairs, mostly in saltwater habitats. The species is a non-breeding migrant, arriving in the Hunter Estuary during October and departing during April (Herbert, 2007). The species has been recorded on Ash Island, roosting at Fern Bay, Kooragang Dykes, and in the Stockton Channel (both roosting and foraging) (Herbert, 2007). The species is rarely recorded on intertidal mudflats, preferring rocky creeks, channels, dams, mangrove-lined inlets and occasionally piers and jetties (Geering *et al*. 2007) however; the species has not been recorded along the upper sections of the Hunter River North Arm (i.e. in the vicinity of Tomago) before. It is possible that a small number of birds might roost on the rocky shore of the river foreshore of the study area but the habitat is considered marginal. This habitat will not be directly impacted by the proposed development. Indirect impacts will be managed to avoid impacts on the Hunter River estuary and downstream wetlands.

Pacific Golden Plovers are known to mainly frequent the North Arm of the Hunter River and Ash Island. The species is a non-breeding migrant, arriving in the Hunter Estuary during September and departing during April to early May (Herbert, 2007). Most birds regularly roost at high tide at the Kooragang Dykes and lesser numbers in Stockton Channel. The species is known to forage on the North Arm sandflats, Fullerton Cove and Kooragang Dyke ponds with small numbers of plovers foraging in Stockton Channel and on Ash Island ponds (Herbert, 2007). The species forages on intertidal sand and mudflats, coastal saltmarsh and rocky shores (Geering *et al*. 2007) however; the species has not been recorded foraging along the upper sections of the Hunter River North Arm (i.e. in the vicinity of Tomago) before. It is possible that a small number of birds might roost on the rocky shore of the river foreshore of the study area but the habitat is considered marginal. This habitat will not be directly impacted by the proposed development. Indirect impacts will be managed to avoid impacts on the Hunter River estuary and downstream wetlands.

The Latham's Snipe is a non-breeding migrant to the south east of Australia including Tasmania, passing through the north and New Guinea on passage. This species breeds in Japan and on the east Asian mainland. Latham's Snipe are seen in small groups or singly in freshwater wetlands

on or near the coast, generally among dense cover. They are found in any vegetation around wetlands, in sedges, grasses, lignum, reeds and rushes and also in saltmarsh and creek edges on migration. They also use crops and pasture (Higgins & Davies 1996). This species was not observed in the study area despite several meandering surveys covering patches of potentially suitable habitat containing small shallow pools fringed by reeds and grasses. It is considered that habitat present within the study area is marginal for this species, due to the lack of any permanent dams or water bodies with muddy margins and the dominance of the exotic grasslands by dense Kikuya to 50 cm in height. More suitable habitat for this species is present in the locality within the adjoining Hunter Wetlands National Park, Hexham Swamp Nature Reserve and on Kooragang Island. Future proposed development is unlikely to have any significant effect on this species in the locality.

The White-throated Needletail and Fork-tailed Swift are aerial foragers, mostly over open country, farmland, and woodland and sometimes over urban areas. They are likely to be seen aerially foraging over the study area on occasion, however, future proposed development is unlikely to have any significant effect on these species in the locality.

The Rainbow Bee-eater is recorded in a variety of habitats including woodland, open forest and in various cleared or semi-cleared habitats, including farmland and areas of human habitation (Higgins 1999). The nest is located in an enlarged chamber at the end of long burrow or tunnel that is excavated, by both sexes, in flat or sloping ground, in the banks of rivers, creeks or dams, in roadside cuttings, in the walls of gravel pits or quarries, in mounds of gravel, or in cliff-faces (Higgins 1999). Suitable habitat exists across the study area for this species, particularly within the Swamp Oak and Swamp Mahogany – Paperbark patches and surrounding the isolated patches of Swamp Oak throughout the paddocks. Considering the large amount of similar habitat in the locality, future development of the study area is unlikely to significantly impact on migrant populations of this species occurring in the locality over spring/summer.

Suitable habitat is present across the pasturelands on the study area for the Cattle Egret, however, very few (<5) birds were observed at any one time during surveys. No nests were observed within the Swamp Oak forest patches. Considering the large amount of similar habitat in the locality,

future development of the study area is unlikely to significantly impact on local populations of this species.

The White-bellied Sea-Eagle was also observed flying over the Hunter River to the east of the study area; however, no suitable foraging or nesting habitat is present on site. Future development of the study area is unlikely to significantly impact on local populations of this species.

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

A Vegetation Management Plan and Wetland Management and Monitoring Plan has been recommended in section 5 of this report to reduce the likelihood of any invasive weed species becoming established in adjoining important habitat for these species.

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

It is considered that the proposed development will not seriously disrupt the lifecycle of any ecologically significant proportion of the population of a migratory species.

Conclusion: Provided sufficient offsets are protected in perpetuity and mitigation measures as outlined in section 5 are adhered to, there is unlikely to be any significant impact on migratory species.

4.4. Port Stephens CKPoM assessment

The Port Stephens CKPoM maps the Swamp Sclerophyll Forest strips in the northwest of the study area as Preferred Koala Habitat with a 50 m buffer over cleared land. The remainder of the study area is mapped as cleared land (**Figure 15**). Ground truthing by **ecobiological** found the CKPoM mapping to be fairly accurate however, the Freshwater Wetland Complex and Swamp Oak Forest have been remapped as Other Vegetation (**Figure 16**).

One Koala SAT test was undertaken within the Swamp Mahogany – Paperbark Swamp Forest community in the northwest of the study area. The minimum recommended 20 trees were surveyed and no signs of Koala presence (i.e. scats or claw marks) were observed. It is noted that the

NPWS Wildlife Atlas contains records of this species from the study area from as recently as 1992. Due to the highly fragmented and disturbed nature of the remaining narrow strips of Preferred Koala Habitat (see Plates 9 – 11), the large expanse of surrounding cleared areas, and the barrier of Tomago Road between adjacent habitats, it is considered highly unlikely that Koalas would move across the study area.

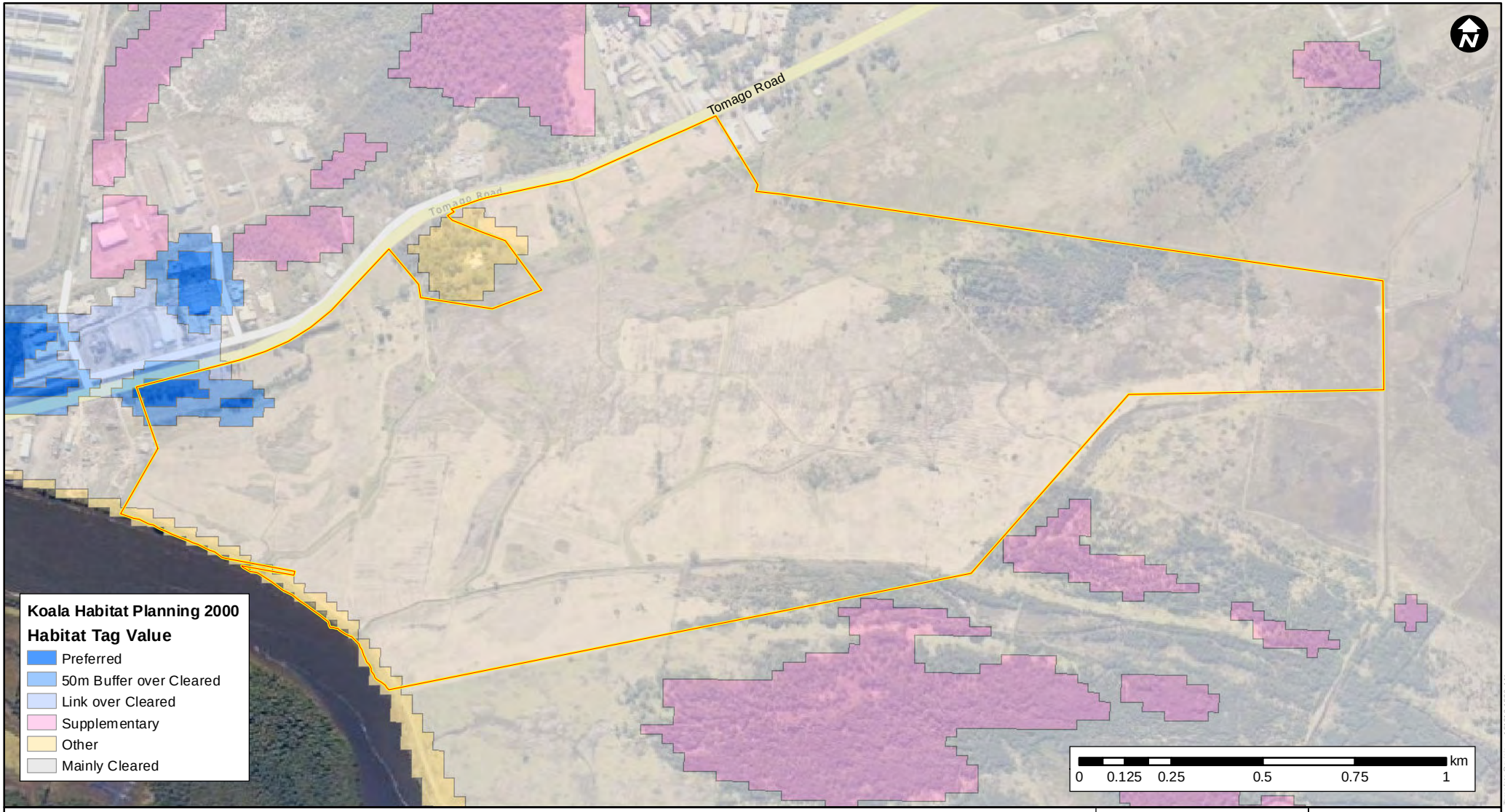
The exact locations of the Koala records are uncertain due to NPWS's policy of denaturing sensitive threatened species location coordinates (i.e. rounded, for example to 1km or 10km, in order to generalise the spatial locality). A more intact corridor containing continuous areas of preferred and supplementary Koala habitat occurs to the north of Tomago Road and it considered more likely to be used as a movement corridor by the local Koala population.

Plate 9: Regrowth *E. tereticornis* and *E. robusta* strips along the north eastern edge of the study area (adjoining Tomago Road).

Plate 10: Regrowth *E. tereticornis* and *E. robusta* strips and isolated trees along the north eastern edge of the study area (adjoining Tomago Road).

Plate 11: Old growth *Melaleuca quinquenervia* clump in the north-eastern corner of the study area.

Figure 15 - Port Stephens CKPoM Mapping



Legend / Notes

Study Area

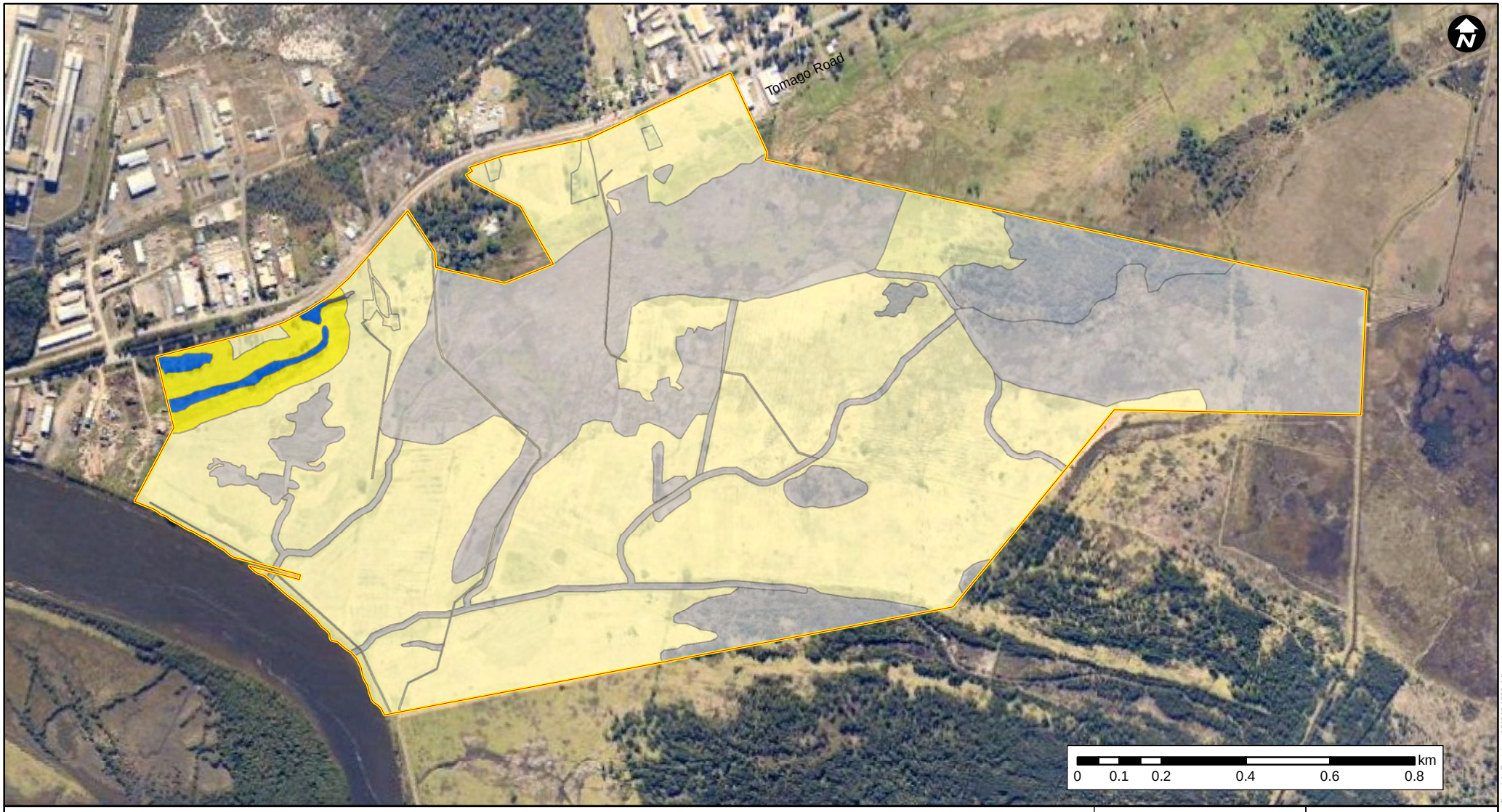
ecobiological survey & assessment

Project Ref:	350-694
Plot Date:	09/12/2010 1205
Revision:	JRN 001

Map Projection:
NSW Lamberts Conformal Conic

Data Sources:
OpenStreetMap - 2010
ecobiological - 2010
NearMap - 2010
Port Stephens Council - 2000

Figure 16 - Revised Koala Mapping



Legend / Notes

- Study Area
- Preferred
- 50m Buffer Over Cleared
- Other
- 50m Buffer Over Other
- Mainly Cleared

ecobiological

Project Ref:	350-694
Plot Date:	06/12/2010 1123
Revision:	JRN 001

Map Projection:
NSW Lamberts Conformal Conic

Data Sources:
OpenStreetMap - 2010
ecobiological - 2010
DECCW - 2010
LPI - 2006

4.5. SEPP 14 assessment

Assessment of SEPP 14 is not required under SEPP 2005 (Major Projects). However, due to the sensitive nature of the surrounding environment, mitigation measures are provided in section 5 to reduce the potential for any indirect impacts on the large expanse of mapped SEPP 14 wetland occurring to the south and east of the study area. Mitigation measures have been proposed (BMT WBM, 2012a, 2012b, 2012c) to minimise potential flooding and stormwater impacts of the proposal on the broader aquatic and terrestrial environment. The hydrologic pathways and flow regime to Lot 1002 will remain the same post development.

Mitigation measures include the use of a perimeter berm for any excess freshwater along a portion of the eastern and southern boundary with connections to the adjoining Lot 1002. Adjustable pit discharge controls are part of the site design for any change in strategy preferred by NPWS (i.e. adaptive management).

4.6. SEPP 44 assessment

SEPP 44 requires that any development proposals affecting one hectare or more of a property must be evaluated for potential and core Koala habitat. Adherence to **Appendix 4** of the Port Stephens Council Comprehensive Koala Plan of Management (PSC, 2002) fulfills the statutory obligations contained under the SEPP 44. Refer to CKPoM assessment in section 4.4 above.

4.7. SEPP 71 assessment

Clause 8 of the SEPP 71 outlines several environmental considerations, particularly:

(g) measures to conserve animals (within the meaning of the Threatened Species Conservation Act 1995) and plants (within the meaning of that Part) and their habitats,

An Offset Package comprising on-site and off-site offset lands is being determined in consultation with OEH. Appropriate conservation mechanisms will be determined to protect these areas in perpetuity. A Wetland Management & Monitoring Plan is also proposed to mitigate any potential impacts on adjoining Ramsar wetland / NPWS estate.

(i) existing wildlife corridors and the impact of development of these corridors,

The development of the 239.7 ha site along with the surrounding developments along Tomago Road would likely pose some impediment to flora and fauna dispersal. In particular, aquatic plants, amphibians, reptiles, terrestrial mammals, fish, sedentary bird species with small home ranges such as Fairy-wrens, Scrub-wrens, Thornbills, Grassbirds and Emu-wrens; and, the Eastern Grass Owl population. The significance of the study area as part of a wildlife corridor is difficult to quantify. Dispersal to the west is impeded for the majority of species by the Hunter River, to the north by Tomago Road and other existing industrial development and to the east by the existing approved MP07-0086 lands. The conservation lands to the south and southeast will continue to provide an east-west corridor however, the proposed development of Lot 1001 will sever a portion of the north-south corridor.

(m) likely impacts of development on the water quality of coastal waster bodies,

Provided mitigation measures and recommendations outlined in Section 5 are adopted, adjoining Ramsar and SEPP 14 wetland will not be adversely affected by the development.

4.8. Ramsar wetland assessment

Internationally important numbers of migratory shorebirds using Kooragang Nature Reserve (now Hunter Wetlands National Park) led to its listing as a Ramsar site (a wetland of international importance) in 1984. The Hunter Estuary Wetlands Ramsar site (ID 24) comprises Kooragang Nature Reserve (designated to the Ramsar list in 1984) and Shortland Wetlands, now called the Wetlands Centre Australia. The two areas are about 2.5 km apart and are connected by a wildlife corridor consisting of Ironbark Creek, the Hunter River and Ash Island (DECCW, 2008d).

The Hunter Estuary Wetlands Ramsar site is widely recognised for its importance in the conservation of migratory birds. At least 38 species of migratory birds recorded at Kooragang NR and 21 species of migratory birds at Shortland Wetlands are presently listed under international treaties including the Japan-Australia and China-Australia Migratory Bird Agreements (JAMBA and CAMBA) (DECCW, 2008d).

Important habitat for these species in the wider area includes *Sarcocornia* saltmarsh found within the Tomago wetlands and on the northern edge of

Kooragang (Ash) Island and intertidal mudflats found around Fullerton Cove, the north east end of Kooragang (Ash) Island and the east bank of the North Arm of the Hunter River upstream of Stockton Bridge. The Hunter Estuary Wetlands and adjoining lands are also important habitat for the Green and Golden Bell Frog *Litoria aurea*, particularly in the south west corner of Kooragang Island and Juncus Swamp.

The Hunter Estuary Wetlands adjoin the study area to the east along 300 m of common boundary. These wetlands and the important habitats identified above will not be directly affected by the proposal (BMT WBM 2012a, 2012b, 2012c). With respect to impacts from indirect, cumulative and facilitative impacts, including any changes to hydrology and the activation of acid sulphate soils, please refer to the discussion points below, Section 4.1, Section 4.9 (impacts on GDEs) and Section 4.10.

Impacts on Sarcornia saltmarsh

There was no saltmarsh mapped within the study area. Targeted surveys for migratory shorebirds in the study area in December 2010 did not record any usage of the site. A review of the literature on migratory shorebird habitat use in the Hunter Estuary (Geering 1995; Straw 1999; Herbert 2007) did not identify the habitat in the study area as important for these species. A search of relevant databases also found that there have been no previous records of migratory shorebirds in the study area. It is acknowledged that important habitat containing *Sarcocornia* saltmarsh exists in the wider area surrounding the project site and is found adjacent on Lot 1002 and within the Tomago Wetlands and on Kooragang Island.

While no direct impacts will occur on saltmarsh habitat, there is potential for indirect impacts from sedimentation and erosion, acid sulphate soil disturbance, increased nutrients, contaminates and pollutants, spread of introduced species and air pollution. These indirect impacts will be mitigated by the provision of a minimum 380 m setback from the adjoining Ramsar wetlands to the development footprint. A range of management strategies and Environmental Management Plans (Groundwater and Surface Water, Vegetation, Wetland, Weed and Acid Sulphate Soil) have been recommended to mitigate these potential impacts and will be prepared prior to construction.

Conclusion: Provided the 380 m setback and other appropriate mitigation measures relating to these identified potential indirect impacts are enforced

and monitored, there is unlikely to be any significant impact on this important habitat in the nearby Ramsar wetlands and National Park.

Impacts on Intertidal Mudflats

The majority of migratory waders visiting the Hunter Estuary feed on intertidal mudflats, the most extensive of which are found around Fullerton Cove, the north east end of Kooragang Island and the east bank of the North Arm of the Hunter River upstream of Stockton Bridge. Most of the remaining shoreline of the Hunter River is mangrove-fringed with narrow margins of mud exposed at low tide. These areas are avoided by the majority of waders (Straw 1999). As stated above, targeted surveys for migratory shorebirds in the study area in December 2010 did not record any usage of the site.

Conclusion: Provided the 380 m setback and other appropriate mitigation measures relating to the identified potential indirect impacts are enforced and monitored, there is unlikely to be any significant impact on this important habitat in the nearby Ramsar wetlands and National Park.

Impacts from changes to hydrology, including freshwater inflows and the tidal regime

There are a number of potential impacts upon the quality of Groundwater Dependent Ecosystems (such as Saltmarsh, Freshwater Wetlands and Swamp Oak Forest), both during the construction and production phases, from the proposed development (see section 4.9 Groundwater Dependent Ecosystem Assessment). Changes to water quality include the potential for contamination from petrochemical spills and from polluted stormwater runoff. However, it is anticipated that there will be no significant changes to groundwater levels due to the close proximity of the Hunter River and surrounding vegetation. Therefore, there is unlikely to be any change to freshwater inflows and the existing tidal regime.

Conclusion: Provided the 380 m setback and other appropriate mitigation measures relating to the identified potential indirect impacts are enforced and monitored, there is unlikely to be any significant impact on hydrology of the adjoining Ramsar wetlands.

Impacts from the activation of acid sulfate soils

Douglas Partners has completed laboratory testing on material samples and identified potential acid sulphate soils on site. An Acid Sulphate Soils (ASS) Management Plan has been prepared as part of the EA. Groundwater Monitoring and Management has been outlined to mitigate potential impacts on flora and fauna and the nearby Ramsar wetlands.

Conclusion: It is considered that the risk of activation of ASS can be reduced to an acceptable level, provided the 380 m set-back for the adjoin Ramsar Wetlands and management strategies prepared as part of the ASS Management Plan are adopted and enforced during construction.

A management and monitoring plan for the boundary between the study area and the adjacent Ramsar wetland (Hunter Wetlands National Park) is recommended in section 5 to address potential impacts on this sensitive environment. A thorough and intensive program is recommended to protect the adjoining wetland against weed invasion, significant alterations to hydrology, and surface and underground run-off that may occur from land filling both during and after the construction phase of the proposed development. Further detail of a preliminary methodology, reporting and impact threshold criteria is provided in section 5.

Mitigation measures have been proposed (BMT WBM, 2012a, 2012b, 2012c) and within the Wetland Interface Strategy to minimise potential flooding and stormwater impacts of the proposal on the broader aquatic and terrestrial environment. Surface water connections between Lot 1001 and Lot 1002 will be maintained at the same discharge points as existing conditions. This is to maintain the same hydrological pathways and flow regime post development. The pits at the discharge points give opportunity to regulate freshwater flows into the wetlands at a later date if deemed necessary.

4.9. Groundwater Dependent Ecosystems assessment

Using the rapid assessment methodology for identifying and attributing a value to Groundwater Dependent Ecosystems (DLWC 2002), the following assessment steps are given below:

- *Identify geographical area*. The study area is identified in **Figure 2** as an area of lowland sands, adjoining the estuarine foreshores of the Hunter River.

- *List GDEs present.* Given in **Table 15**.

Table 15. GDEs present on study area

Location	Ecosystem Type	Groundwater system
Swamp Mahogany – Paperbark Forest	Terrestrial Vegetation	Coastal Sand Bed
Swamp Oak Forest	Terrestrial Vegetation	Underlying sands (however, down to 15m is predominantly deep clays which result in groundwater pooling on the surface)
Freshwater Wetland Complex	Wetlands	Underlying sands (however, down to 15m is predominantly deep clays which result in groundwater pooling on the surface)

Swamp Oak Forest also extends into Lot 1002 along the site's southern boundary. Provided the measures to avoid hydrological change are put in place as detailed in the wetland interface strategy and BMT WBM reporting, there will be no significant hydrological impacts on this adjoining Groundwater Dependent Ecosystem.

- *Assess the vulnerability of GDEs*. Given in **Table 16**.

Table 16. Vulnerability of GDEs on study area

Ecosystem Type	Groundwater depletion	Quality impacts
Terrestrial Vegetation	None	The majority is to be removed from site
Wetlands	None	The majority will be removed or modified

It is not expected that activities will undermine groundwater levels at the study area. No extraction of groundwater is anticipated for any function of the development.

- *Assess the value of the ecosystems.*

The Terrestrial Vegetation remaining in the study area has medium ecological value primarily due to structural diversity, species diversity and fauna refugia. The wetland ecosystem has low ecological value due to low species diversity, historical disturbance and substantial modification for farming practices (refer to **Figure 10**).

- *List management tools to be used.*

Management tools proposed for the study area are designed to reduce the potential for any impact on adjoining GDE's (i.e. hydrological and edge effects):

(a) Maintain a 100m buffer from the Ramsar wetland as recommended in the Coastal Design Guidelines for NSW (a minimum 380 m buffer is part of the site design layout);

(b) Control sediment and nutrient runoff; and,

(c) Implement a Wetland Management & Monitoring Program.

- *Prioritise management actions.*

It is anticipated that all above actions will be implemented as part of the ongoing operation management of the site.

- *Implement management actions*

The following documents are recommended to be produced:

- Pre-clearing survey protocol – to minimise harm to native fauna;
- Wetland Management & Monitoring Plan – this document will set out the monitoring methodology for the boundary interfaces with the Ramsar wetland and national park, retained Freshwater Wetland Complex and Swamp Oak Forest habitat, the Overflow Wetland Rehabilitation Area and proposed landscaped watercourses and rehabilitation areas;
- A Vegetation Management Plan will be prepared to rehabilitate the environmental and landscaped watercourses, the Overflow Wetland Rehabilitation Area and surrounding areas within the Environmental Zone. It will contain the practical, on-ground detail for site delineation and signage, primary and follow-up weed control, stockpile management, proposed plantings, plant maintenance, progress reporting and remediation actions;

- Soil and Water Management Plan to manage runoff, pollution and sedimentation of adjoining natural waterbodies.

- *Review process and outcomes.*

Details for monitoring of management actions will be contained within the above management plans.

4.10.NSW Wetlands Policy assessment

An assessment of compliance with the **NSW Wetland Policy** is given below:

- *Appropriate water regimes and water quality needed to maintain or restore the ecological sustainability of wetlands will be provided through the implementation of water management plans;*

  Freshwater wetlands will be removed or modified across the study area. A Wetland Management & Monitoring Plan is proposed to mitigate any potential indirect impacts on the adjoining Ramsar and SEPP 14 wetlands. An operational soils and water management plan is intended to ensure that adjoining water bodies are not contaminated by any runoff or sediment.

- *Wetlands of international, national, state and regional significance will be identified and conserved;*

  A 300 m common boundary with Ramsar wetland (ID 24) occurs adjoining the northeastern boundary of the study area. The study area is separated from the Ramsar wetland by the North South drain and a minimum 380 m buffer from future development. A small area of SEPP 14 wetland occurs along the southern boundary. This area will be conserved within 3.4 ha of retained Swamp Oak Forest. Mitigation measures are proposed in section 5 to address this point.

- *Land use and management practices will maintain or rehabilitate wetland habitats, processes and cultural values;*

  A 12.5 ha portion of Freshwater Wetland Complex will be retained and monitored in the northeast of the study area. This will enable the provision of a minimum 380 m buffer from the adjoining

Ramsar wetland. In addition, it is proposed to create an approximately 11 ha Overflow Wetland Rehabilitation Area (includes an area of open water and surrounding freshwater reedbeds) to both manage excess water and provide habitat for local fauna. An Offset Package is also being prepared in consultation with OEH to compensate for the loss of approximately 58.1 ha of Freshwater Wetland Complex in the northern half of the study area.

- *Degraded wetlands and their habitats will be rehabilitated and their ecological processes restored as far as is practicable;*

  Not applicable.

- *The potential impacts of climate change will be considered in long term strategies for water resources and land use;*

  Not applicable at the subdivision stage.

- *Natural wetlands should not be destroyed or degraded. When social or economic imperatives in the public interest result in a wetland being degraded or destroyed, the rehabilitation or construction of a compensatory wetland that supports similar biodiversity and ecological functions will be required;*

  An Offset Package is being prepared in consultation with OEH to compensate for the loss of approximately 58.1 ha of Freshwater Wetland Complex in the northern half of the study area.

- *Purpose-built wetlands will not be constructed on the site of viable natural wetlands;*

  Not applicable. The proposed Overflow Wetland Rehabilitation Area will be constructed on land mapped as exotic grasslands.

4.11. Corridor assessment

The LHRCP does not identify the study area as occurring within the Green Corridor. An important wildlife corridor flows through Hexham Swamp Nature Reserve, Hunter Wetlands National Park (adjoining Lot 1002 to the east) and Fullerton Cove. Lot 1002 is proposed to be protected in perpetuity by Port Waratah Coal Services (as part of an offset for another local development) adding to the width of the existing mapped corridor

which includes the adjacent Hunter Wetlands National Park and important shorebird habitat of Fullerton Cove.

With regard to mapping undertaken by Scotts (2003), the study area lies near a north-south corridor (Richardson Road) which also runs in an east-west direction to the north of the proposal (refer to **Figure 5)**. This corridor links the Tomago sand beds / Tilligerry area with the Hunter Wetlands National Park, however, no key habitat has been mapped as occurring on the study area itself. Key habitat has been mapped as occurring north of Tomago Road and contains an extensive area of Coastal Sand Apple – Blackbutt Forest (Supplementary Koala Habitat) and smaller patches of Swamp Mahogany – Paperbark Forest (Primary Koala Habitat) (NPWS, 2000).

The development of the 239.7 ha site along with the surrounding developments along Tomago Road would likely pose some impediment to flora and fauna dispersal. In particular, aquatic plants, amphibians, reptiles, terrestrial mammals, fish, sedentary bird species with small home ranges such as Fairy-wrens, Scrub-wrens, Thornbills, Grassbirds and Emu-wrens; and, the Eastern Grass Owl population. The significance of the study area as part of a wildlife corridor is difficult to quantify. Dispersal to the west is impeded for the majority of species by the Hunter River, to the north by Tomago Road and other existing industrial development and to the east by the approved MP07-0086 development. The proposed conservation lands on Lot 1002 to the south and southeast will continue to provide an east-west corridor however, the proposed development of Lot 1001 will sever a portion of the north-south corridor.

5. Mitigation

The ameliorative measures for this proposal fall into the following categories:

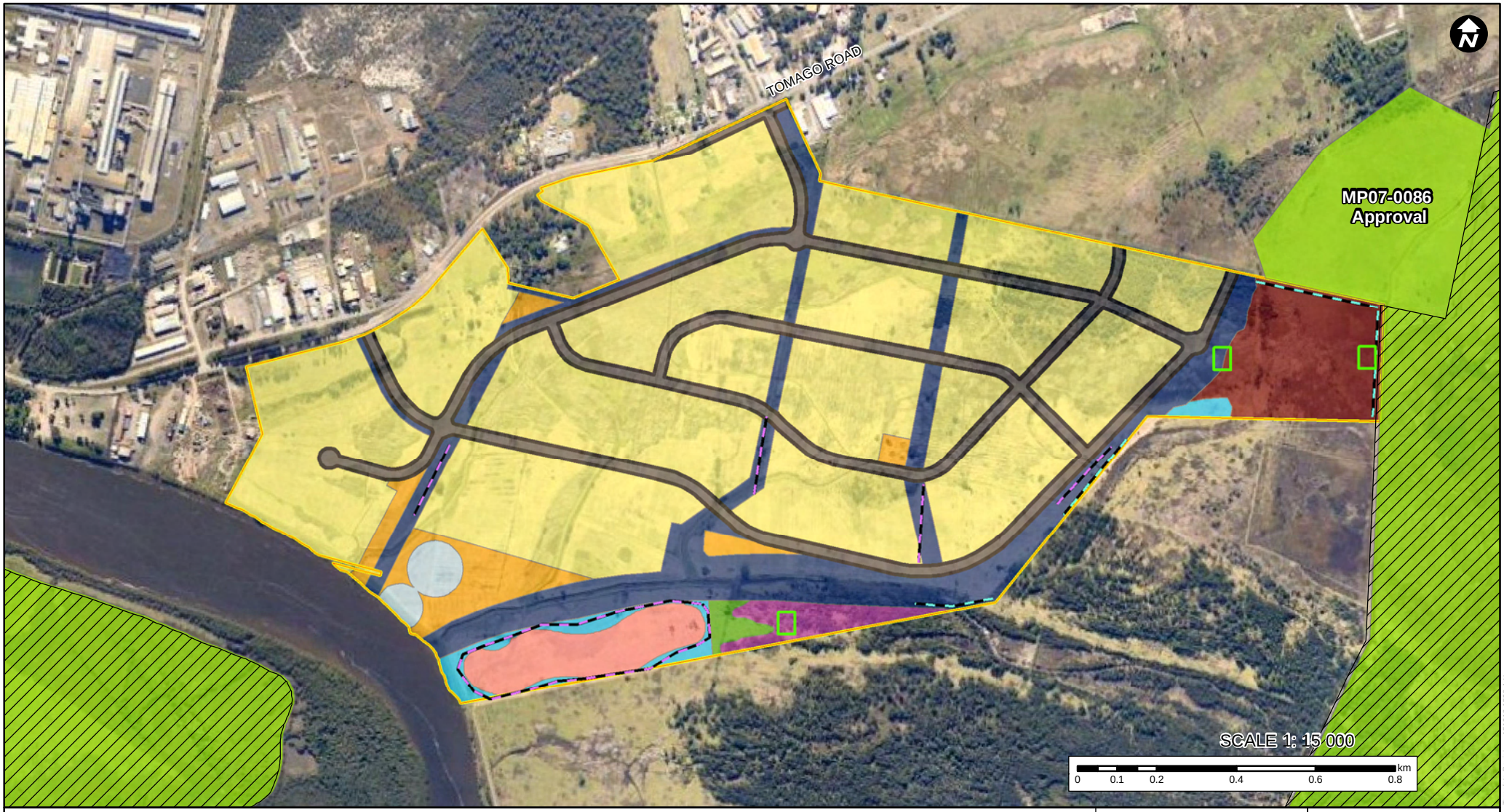
- Compensatory Strategies (Environmental Offsets)
- Long-term management strategies;
- Recommendations for future development.

5.1. Compensatory (environmental offset) strategies

An Offset Package (containing both on-site and off-site offsets) is currently being developed in consultation with OEH. Appropriate conservation mechanisms and management plans for these areas will be determined in due course.

The proponent has incorporated into the site design layout retention of a 12.5 ha portion of Freshwater Wetland Complex and a 3.4 ha portion of Swamp Oak Forest (**Figure 17**). The retained Freshwater Wetland Complex provides a minimum 380 m buffer to the adjoining Ramsar wetland. The western section of the proposed perimeter berm will be located north of the existing drainage channel. This will enable preservation of mapped SEPP 14 wetland within the retained Swamp Oak Forest patch. Management plans to protect and monitor these retained habitats are detailed in section 5.2.3. Preliminary flora, vegetation and weed monitoring locations are indicated in **Figure 17**.

Figure 17 - On-site offsets and mitigation measures



Legend / Notes

- Study Area
- Hunter Wetlands National Park
- Ramsar Wetlands
- Flora Monitoring Transects
- Vegetation/Weed Monitoring Transects
- Flora Monitoring Quadrats
- Retained Freshwater Wetland Complex EEC
- Retained Swamp Oak Forest EEC
- Proposed Freshwater Wetland Complex Rehab
- Proposed Swamp Oak Forest Rehab
- Overflow Wetland Rehabilitation Area
- Constructed Drainage Lines - Riparian Zone
- Roads
- Building Sites
- Landscaped Areas
- Environmental & Landscaped Watercourses

KLEINFELDER Bright People. Right Solutions.
ecobiological

Project Ref:	350-694
Plot Date:	21/08/2012
Revision:	GJ 002

Map Projection:
NSW Lamberts Conformal Conic

Data Sources:
OpenStreetMap - 2010
Suters - 2012
ecobiological - 2010
DECCW - 2010
LPI - 2006

5.2. Long-term management strategies

5.2.1. Minimising impact on SEPP 14 and Ramsar listed wetlands

BMT WBM (2012a, 2012b, 2012c) and the Wetland Interface Strategy outline a number of mitigation efforts in order to reduce the impact of the proposed development on the neighbouring SEPP 14 and Ramsar listed wetlands (within Hunter Wetlands National Park). These measures include: a continuous, impermeable perimeter berm which is proposed to run along the majority of the common boundary between the development lot and the adjoining wetlands. This berm will prevent excess freshwater surface flows from the development site from entering the SEPP 14 wetlands. Surface water connections between Lot 1001 and Lot 1002 will be maintained at the same discharge points as existing conditions. This is to maintain the same hydrological pathways and flow regime post development. The pits at the discharge points would give opportunity to regulate freshwater flows into the wetlands at a later stage if deemed necessary.

A 380 m buffer to the Ramsar wetlands has been incorporated into the site design. Discharge from Lot 1001 to the Tomago Wetland Rehabilitation Project is indirect via the North South Drain and would only occur at low tides. Any runoff from the site will be diverted into constructed drains within the study area that will be retained in various holding ponds and filtered via aquatic vegetation that will be planted along the proposed drainage channels before being discharged into the Hunter River. Mitigation measures addressing the impact of the proposal on water quality entering the Hunter River are addressed in BMT WBM (2012c).

5.2.2. Retaining integrity of habitat and minimising harm

The use of insecticides and herbicides in the study area should be avoided where possible to retain the integrity of the remaining habitat for insectivorous Microchiropteran bats utilising the surrounding area for foraging and to prevent deformities or death to Wallum Froglets in the area. The use of pesticides affects insect availability and is known to bioaccumulate in the body fat of individuals of various Microchiropteran bat species. The use of biocides in the control of weeds and mosquitoes has been shown to be toxic to frogs causing deformities, hermaphroditism and death and has been listed as a potential threat to the Wallum Froglet in the

National Recovery Plan for the Wallum Sedgefrog and Other Wallum Dependant Frog Species.

It is recommended that 15 suitably sized nest boxes for insectivorous bats be attached to trees within the retained Swamp Oak Forest along the southern boundary. These boxes should be installed and certified by an appropriately qualified fauna ecologist. A copy of the certification must be submitted to the Principle Certifying Authority prior to issue of the Construction Certificate.

5.2.3. Flora and fauna management and monitoring plans

It is envisaged that the proposed management and monitoring plans be incorporated into conditions of consent and that these plans be approved by OEH prior to construction.

5.2.3.1. Pre-clearing surveys

Approximately 1 week prior to any vegetation clearing a survey of habitat trees should be conducted in the planned clearing area. These trees should be watched at dusk to determine whether any of the hollows are in use by fauna. The actual felling of any habitat trees should be attended by a suitably experienced fauna ecologist in order to ensure the safety of any fauna found to be in the hollows. On all occasions, trees having potential habitat hollows should be 'soft felled' by an experienced machine operator.

5.2.3.2. Management plans

Prior to the commencement of construction detailed management plans should be prepared to cover the following:

- Pre-clearing survey protocols including measures to be taken where fauna are found to be occupying habitat hollows, are captured during felling or where fauna are injured;
- A Vegetation Management Plan is recommended for the study area based on the proposed Landscape Plan. The VMP should be prepared by a bush regeneration company with expertise in environmental restoration. The VMP should be divided into stages: Stage 1 would focus on initial weed control, soil stockpiling and site clearing protocols; Stage 2 would involve planting of the Landscaped Watercourses, Pocket Parks, Riverside Park and the Floodplain/Ponding Zone with endemic native species (where

available and suitable); and, Stage 3 would involve ongoing monitoring of the plantings and follow-up weed control;

- A Soil and Water Management Plan to manage runoff, pollution and sedimentation of adjoining natural waterbodies;

- A lighting management plan should be prepared for the subdivision to ensure no direct light impacts on the adjacent wetlands. This may be achieved by ensuring any lighting to be installed on the study area either faces away from the wetland area or has a shade attached to prevent an excess of light entering the wetland area of a night time. These measures will insure that minimal impact occurs as a result of light pollution;

- A Wetland Management and Monitoring Plan management and monitoring plan. This document will set out the monitoring methodology for the boundary interfaces with the Ramsar wetland and national park, retained Freshwater Wetland Complex and Swamp Oak Forest habitat, the Overflow Wetland Rehabilitation Area and proposed landscaped watercourses and rehabilitation areas for the adjacent Ramsar wetland (Hunter Wetlands National Park). A thorough and intensive monitoring program will be put in place to protect the adjoining wetlands against weed invasion, alterations to hydrology, and surface and underground run-off that may occur from land filling both during and after the construction phase of the proposed development.

The proposed WMMP will focus on four key areas (refer to **Figure 17** for proposed retained habitat and rehabilitation areas and monitoring locations):

1. **Hunter Wetlands National Park and Ramsar wetland boundaries and discharge points to Lot 1002**

Retention of 12.5 ha of Freshwater Wetland Complex and rehabilitation of a 0.7 ha area of Exotic Grasslands in the northeast of the study area provides a 380 m buffer from the adjoining Ramsar wetlands. The northern edge of this retained habitat adjoins the compensatory habitat area dedicated to NPWS as part of the MP07-0086 approval. It is proposed that the boundaries of both of these interfaces be monitored as well as two flora transects at discharge points entering into Lot 1002) and two flora quadrats (one on the boundary with the Ramsar site and the other on the development/retained habitat interface) using the same methodology as

the ongoing annual monitoring along the interface of the existing MP07-0086 development and the Hunter Wetlands National Park boundary (ecobiological 2009). The aim of the boundary monitoring is to assess whether the development is causing any edge effects or variation in native vegetation community extent at the interface with the adjoining conservation estate. The aim of the quadrat monitoring is to assess whether there is any change over time in species richness, composition and abundance. Proposed timing and frequency of monitoring and remediation/response actions are discussed below.

The following methodology is proposed for this component of the WMMP:

- *Phase 1: An assessment of the existing vegetation status*

Part of Phase 1 has already been completed by **ecobiological** as part of the ecological surveys of the study area in 2009. This phase established the existing vegetation status for all vegetation community types directly adjacent to the disturbance area within the study area. Vegetation mapping from the adjoining MP07-0086 conservation area and Hunter Wetlands National Park has also been conducted by **ecobiological** in 2011. The following steps will be taken to complete this phase:

1. Identification of the ecotones and extent of the vegetation community types by walking the boundary of each vegetation community, tracking the boundary using a Global Positioning System (GPS). The boundary tracks will be entered into a GIS program and shown over aerial photography during each annual survey;

2. A weed infestation assessment will be performed at the development area interface by walking the interface and marking weed infestation with a hand-held GPS;

3. Two permanent survey plots (20m x 20m) and (20m x 50m) for BioBanking data collection within the retained Freshwater Wetland Complex will be established (see **Figure 17**). Data will be collected in accordance with Appendix 2 of the BioBanking Assessment Methodology Operation Manual (field methodology for measuring condition attributes in site value), a method prepared by the Department of Environment and Climate Change (Seidel & Briggs, 2008).

These steps will need to be completed prior to construction, during construction and then repeated annually for a period of five years post construction of the final stage of development.

- *Phase 2: The establishment of baseline benchmark data*

Phase 2 was completed by **ecobiological** in April 2010 (as part of the adjoining MP07-0086 conservation area monitoring). This phase established the baseline vegetation benchmark data to compare the data within the proposed vegetation plots in Lot 1001 against data attained from 20m x 20m (0.04ha) and 50m x 20m survey plots surveyed in similar vegetation community types from the surrounding locality.

Sample sites were referenced from the locality including Pambalong Nature Reserve, Ash Island and Tomago. To encompass variation in benchmark data, a minimum of three plots for each community type were chosen. Four plots were surveyed both in Forested Wetland, and Saline Wetlands, and three plots were sampled in Freshwater Wetland communities.

Data was collected as per Appendix 2 of the BioBanking Operational manual. **ecobiological** has also accessed the Ecological Character Description for the Hunter Estuary Wetlands Ramsar site from 1984 as further background on the site's condition.

- *Phase 3: Monitoring*

Annual monitoring will commence in the spring/summer post construction commencing on Stage 1. Phase 3 will involve annual monitoring events which will collect data relating to vegetation condition and extent. The extent of the vegetation community types mapped by walking the boundary of each vegetation community will be conducted on an annual basis using the same method detailed in Phase 1.

Weed infestations at the development/conservation interface will be measured annually using the methods detailed in Phase 1. Weed infestations will be measured using a qualitative approach, by walking the interface and identifying any infestations.

The two permanent survey plots in the retained Freshwater Wetland Complex area will be monitored on an annual basis. The preferred period for annual monitoring is between late spring/summer. This period has

been selected to allow annual weed growth and infestation identification, and is considered a suitable seasonal period to identify the majority of plant species inside the 0.04ha plots.

Impact Threshold Criteria – Vegetation Mapping

The annual mapping of vegetation community boundaries will be compared against the baseline maps and any significant vegetation community boundary changes and the dominance of another vegetation type will be highlighted. Minor boundary variations are to be expected as the vegetation community areas are dynamic, and would react to environmental pressures. Any significant boundary change over time will be highlighted through map comparison and the likely causes will be investigated through consultation with the stormwater consultants. If the monitoring data collected in annual surveys from permanent quadrats is within the established benchmark measurements, no action is required. If data for any benchmark attribute is outside benchmark parameters, likely causes will be investigated and actions recommended to mitigate the potential causes. This may require further surveys to determine the cause, and specific action plans prepared to mitigate the issues.

Impact Threshold Criteria – Weed Mapping

Weed infestation along the whole development-conservation area interface will be compared to baseline data, where a ranking system will be used to trigger whether or not preparation of a Weed Management Plan is required. The provision of exotic plant cover measurements within two proposed survey plots will give a quantitative measurement of weed infestation. Any significant increase in weed cover within the survey plots would highlight the requirement for appropriate actions. If and when weed management is required, the weed management actions for control of weed and weed infestations at the development and conservation area interface will be detailed in a Weed Management Plan (WMP) prepared specific for the subject site.

Impact Threshold Criteria – Flora Quadrat and Transect Monitoring

Data from ongoing annual surveys within the permanent survey plots and transects will be analysed and a comparison made against the established baseline benchmark data. Impact on the vegetation communities adjacent to the development area will be considered significant if the measured variance for any benchmark attribute is less than 25% of the lower

benchmark or greater than 25% of the upper benchmark. Measurements outside benchmark would initiate the requirement for the proponent to mitigate any disturbance impacting the vegetation community within the adjoining wetland.

Reporting

Future findings and recommendations will be presented in an annual report to be incorporated into the Annual Environmental Management Reports (AEMR) required for the development.

2. **Retained native vegetation (Freshwater Wetland Complex and Swamp Oak Forest)**

Two areas of native vegetation within the study area will be retained as on-site offsets: 1) 12.5 ha of Freshwater Wetland Complex in the northeast corner of the site; and, 3.4 ha of Swamp Oak Forest along the southern boundary of the study area. It is also proposed to rehabilitate an additional 1.1 ha of Swamp Oak Forest adjoining the existing retained community (see **Figure 17**). Methods for rehabilitation of this area will be detailed in the proposed Vegetation Management Plan.

Three nested 20 x 20m and 20 x 50m flora monitoring plots will be permanently established (two within the Freshwater Wetland Complex and one within the Swamp Oak Forest) and monitored annually prior to construction, during construction and then annually for a period of five years post construction of the final stage of development. The Freshwater Wetland Complex area is considered to be in good health and at this point in time is not considered to require rehabilitation. Rehabilitation of the Swamp Oak Forest is proposed (due to the presence of several weed species and dominance of the groundcover by Kikuyu) which will be detailed in the Vegetation Management Plan.

Data to be collected within these monitoring plots will include species diversity and abundance, percentage cover of each structural layer and other general habitat attributes such as hollow-bearing trees, fallen timber and a visual assessment (including photo monitoring) of community health. The provision of exotic plant cover measurements within the three proposed survey plots will give a quantitative measurement of weed infestation. Any significant increase in weed cover within the survey plots would highlight the requirement for appropriate actions. If and when weed management is required, the weed management actions for control of

weed and weed infestations in these areas will be detailed in a Weed Management Plan (WMP) prepared specific for the subject site.

3. **Overflow Wetland Rehabilitation Area**

This 9.4 ha overflow wetland area will be created by scraping back a shallow basin within exotic grassland in the southwest of the study area. It will have the dual purpose of providing overflow stormwater storage as well as creating a predominantly open water habitat. It is also proposed to rehabilitate the surrounding 1.6 ha of Exotic Grasslands to Freshwater Wetland Complex. The proposed Vegetation Management Plan will recommend appropriate edge plantings of rushes, sedges and grasses to provide cover for amphibian, reptile and bird species. Flora monitoring of this area would involve a transect survey around the wetland perimeter, establishment of photo monitoring points and a weed survey. This should be conducted annually in late spring/summer for a 5 year period post construction to ensure that rehabilitation objectives for this area are being achieved. Water quality monitoring has been proposed by Coast Ecology (2012). An annual survey for terrestrial fauna (targeting waterbirds and amphibian species) during Spring/Summer will also be incorporated to assess the value of this rehabilitated habitat over time.

4. **Landscaped watercourses**

The study area contains 7,345 m of highly modified, artificial drainage lines. A portion of these will be removed by the proposal, however following the construction of 6,074m of vegetated channels, there will be a net increase of 1,083 m of potential aquatic habitat. Vegetated channels will be monitored to ensure they continue to develop into a healthy aquatic habitat system (refer also to Coast Ecology 2012 recommendations). Flora transects to monitor species diversity, cover abundance and weed invasion are recommended at several locations along the major watercourse lengths (see **Figure 17** for proposed locations).

The above recommendations are preliminary and will be further developed as part of preparation of a site Vegetation Management Plan and WMMP. The ultimate aim of these plans is to avoid any direct or indirect impacts of the development on the adjoining Ramsar wetlands and National Parks estate. Adaptive management of stormwater flow from the site can be achieved in consultation with OEH in future, should this be required, in accordance with the objectives of the Tomago Wetland Rehabilitation Project.

5.3. Recommendations for future development

It is recommended that any future development proposed for the business and industrial subdivision is subject to a noise, vibration, lighting and air quality impact assessment to ensure that levels adhere to relevant guidelines and will not impact on the nearby wetlands.

5.4. Statement of Commitments

The following is a list of commitments the proponent will continue to work toward in negotiation with OEH for later submission:

- The proponent is committed to conservation of suitable offset lands in perpetuity, consistent with OEH's offsetting principles. An appropriate mechanism will be discussed with OEH in due course.
- A Vegetation Management Plan will be prepared by a suitably qualified and experienced bush regeneration company prior to clearing.
- A Plan of Management for the control of noxious weeds will be submitted to Council prior to the commencement of work.
- The proponent recognises that the vegetation to be removed represents significant habitat for the inhabiting fauna and, as such, will provide a detailed pre-clearing survey protocol before any clearing at the site takes place. Pre-clearing surveys and supervision of habitat tree felling will be undertaken by an appropriately qualified and experienced Ecologist.

6. Conclusion

Field surveys of the study area were conducted between October 2009 and November 2011. The key findings are summarised below.

Vegetation Community Mapping

A total of three defined natural vegetation communities, one regenerating natural vegetation community and one highly disturbed exotic grassland community were recorded on the study area.

Of the communities identified on the study area, four are listed as Threatened Ecological Communities (TEC). The Swamp Mahogany - Paperbark Swamp Forest forms part of the endangered Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions. The Swamp Oak Rushland Forest and Swamp Oak Rushland Forest – Regeneration both form part of the endangered Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions. The Freshwater Wetland Complex constitutes part of the endangered Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions.

Flora

Data collected during the field surveys revealed that the study area supported 111 plant species, 51 of which are exotic species. Ten of these exotic species are also listed as noxious; including Crofton Weed (*Ageratina adenophora*), Lacy Ragweed (*Ambrosia tenuifolia*), Groundsel Bush (*Baccharis halimifolia*), Bitou Bush (*Chrysanthemoides monilifera* subsp. *rotundata*), Fireweed (*Senecio madagascariensis*), Castor Oil Plant (*Ricinus communis*), Camphor Laurel (*Cinnamomum camphora*), Pampas Grass (*Cortaderia selloana*), Blackberry (*Rubus fruticosus*) and Lantana (*Lantana camara*).

No threatened flora species or ROTAP-listed species were recorded within the study area.

Fauna

A total of 84 fauna species were recorded in the study area, six of which are exotic species. These species comprised 1 fish, 7 frogs, 3 reptiles, 5 terrestrial mammals, 15 bats and 53 birds. Nine threatened species listed as

vulnerable under the NSW TSC Act (Grey-headed Flying-fox *Pteropus poliocephalus*, Eastern Grass Owl *Tyto longimembris*, Southern Myotis *Myotis macropus*, Eastern Bentwing-bat *Miniopterus oceanensis*, Little Bentwing-bat *Miniopterus australis*, Eastern Freetail-bat *Mormopterus norfolkensis,* Eastern False Pipistrelle *Falsistrellus tasmaniensis,* Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris* and Greater Broad-nosed Bat *Scoteanax rueppellii*) were recorded in the study area. Two migratory bird species listed on the EPBC Act were also recorded during surveys of the study area (White-bellied Sea-Eagle and Cattle Egret).

Ramsar Wetlands

It has been determined that no adverse impacts on the Ramsar Wetland adjoining the study area will occur provided that ameliorative measures outlined in BMT WBM (2012a, 2012b, 2012c) and section 5 of this report are put in place.

Management and Monitoring Plans

Management plans for the clearing of vegetation, proposed landscaping of the site and for the protection of the adjoining Ramsar, SEPP 14 wetlands, Tomago Wetland Rehabilitation Project and national parks estate against weed invasion, significant alterations to hydrology, disturbance of acid sulphate soils, surface run-off and groundwater are proposed. A Wetland Management and Monitoring Plan will form part of the site Construction Environmental Management Plan (CEMP) and will also detail processes for management and monitoring of on-site retained vegetation, the proposed Overflow Wetland Rehabilitation Area and landscaped watercourses.

Key Thresholds

An assessment of key thresholds found that the proposal could adequately address each threshold. With regard to the Eastern Grass Owl, a regional survey was undertaken by **ecobiological** in 2011 and identified seven 'groups' within the region including one utilising the study area. While the proposal is likely to result in the loss of one 'group' from the study area, it is unlikely to reduce the long-term viability of the local population of Eastern Grass Owls. However, further habitat loss in the locality and any unforseen impacts upon conserved land may put the local population under extreme pressure for medium to long term survival.

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Appendix 1: Flora species recorded in the study area

SORF = Swamp Oak Rushland Forest; EG = Exotic Grasslands; FWC = Freshwater Wetland Complex; SMPSF = Swamp Mahogany – Paperbark – Swamp Forest; MT = Meandering transect; * denotes an exotic species			SORF Regen	EG	FWC	SORF				EG	FWC				EG			SORF			SMPSF		FWC	SORF	
Family	**Scientific Name**	**Common Name**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	MT
Alismataceae	*Alisma plantago - aquatica*	Water Plantain																					+
Alliaceae	*Nothoscordum borbonicum**	Onion Weed																					+
Amaranthaceae	*Alternanthera denticulata*	Lesser Joy Weed					2																
Apiaceae	*Centella asiatica*	Indian Pennywort																					+
Apiaceae	*Foeniculum vulgare**	Fennel																					+
Apiaceae	*Hydrocotyle bonariensis**	Pennywort									2												+
Apiaceae	*Hydrocotyle peduncularis*																						+
Apocynaceae	*Gomphocarpus fruticosus**	Narrow-leaved Cotton Bush															1						
Apocynaceae	*Parsonsia straminea*	Monkey Rope							2														
Asteraceae	*Ageratina adenophora**	Crofton Weed																					+
Asteraceae	*Ambrosia tenuifolia**	Lacy Ragweed											2				1						+
Asteraceae	*Aster subulatus**	Wild Aster																			2	2	+
Asteraceae	*Baccharis halimifolia**	Groundsel Bush																				1	+
Asteraceae	*Chrysanthemoides monulifera subsp. rotundata**	Bitou Bush																					+
Asteraceae	*Cirsium vulgare**	Black Thistle												1	1		1						+
Asteraceae	*Conyza sumatrensis**	Tall Fleabane												2									+
Asteraceae	*Cotula coronopifolia**	Water Buttons																2					+
Asteraceae	*Crassocephalum crepidioides**	Thickhead																					+
Asteraceae	*Hypochaeris radicata**	Catsear																					+
Asteraceae	*Senecio madagascariensis**	Fireweed	2	2						2					2	2	2					2	+
Asteraceae	*Sonchus oleraceus**	Common Sowthistle		1																	1		
Azollaceae	*Azolla pinnata*	Ferny Azolla																					+
Cactaceae	*Opuntia stricta**	Prickly Pear																					+

SORF = Swamp Oak Rushland Forest; EG = Exotic Grasslands; FWC = Freshwater Wetland Complex; SMPSF = Swamp Mahogany – Paperbark – Swamp Forest; MT = Meandering transect; * denotes an exotic species			SORF Regen	EG	FWC	SORF				EG	FWC				EG			SORF	SMPSF		FWC	SORF	
Family	**Scientific Name**	**Common Name**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	MT
Campanulaceae	*Wahlenbergia gracilis*	Australian Bluebell																					+
Caryophyllaceae	*Spergularia marina**	Lesser Sea-spurrey																					+
Casuarinaceae	*Casuarina glauca*	Swamp Oak	4		1	4	4	4														3	
Chenopodiaceae	*Sarcocornia quinqueflora*	Samphire																3					
Commelinaceae	*Commelina cyanea*	Scurvy Weed																		2			+
Convolvulaceae	*Calystegia sepium*																						+
Cyperaceae	*Baumea articulata*	Jointed Twig-rush																	2				
Cyperaceae	*Bolboschoenus caldwellii*		1		2	3	4	3										3					+
Cyperaceae	*Carex appressa*	Tall Sedge							3											2			+
Cyperaceae	*Cyperus brevifolius**																			1			
Cyperaceae	*Cyperus sp.*																			1			
Cyperaceae	*Eleocharis acuta*			3	3		2												2		2		+
Cyperaceae	*Gahnia clarkei*	Tall Saw-sedge																	1				
Cyperaceae	*Isolepsis prolifera**																		2				
Cyperaceae	*Schoenoplectus subulatus*																						+
Dennstaedtiaceae	*Hypolepis muelleri*	Harsh Ground Fern							2					2						1			+
Dennstaedtiaceae	*Pteridium esculentum*	Bracken Fern																					+
Euphorbiaceae	*Homalanthus populifolius*	Bleeding Heart																					+
Euphorbiaceae	*Ricinus communis**	Castor Oil Plant																					+
Fabaceae - Faboideae	*Jacksonia scoparia*	Dogwood																					+
Fabaceae - Faboideae	*Kennedia rubicunda*	Dusky Coral Pea																		2			+
Fabaceae - Faboideae	*Trifolium repens**	White Clover	1							2			2			2	2					1	+
Fabaceae - Faboideae	*Vicia sativa**	Common Vetch	2	2											2		2						+

SORF = Swamp Oak Rushland Forest; EG = Exotic Grasslands; FWC = Freshwater Wetland Complex; SMPSF = Swamp Mahogany – Paperbark – Swamp Forest; MT = Meandering transect; * denotes an exotic species			SORF Regen	EG	FWC	SORF				EG	FWC				EG			SORF	SMPSF		FWC	SORF	
Family	**Scientific Name**	**Common Name**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	MT
Fabaceae - Mimosoideae	*Acacia decurrens*	Black Wattle																					+
Fabaceae - Mimosoideae	*Acacia longifolia subsp. longifolia*	Sydney Golden Wattle				1		1							1					3		1	+
Fabaceae - Mimosoideae	*Acacia saligna**	Golden Wreath Wattle																					+
Geraniaceae	*Geranium solanderi var. solanderi*	Native geranium												1									
Juncaceae	*Juncus cognatus**																					1	+
Juncaceae	*Juncus continuus*														2								+
Juncaceae	*Juncus kraussii subsp. australiensis*	Sea Rush					1	1	2									1				2	
Juncaceae	*Juncus planifolius*																						+
Juncaceae	*Juncus usitatus*	Common Rush	2	2	2					2						2				1	1	2	+
Juncaginaceae	*Triglochin procera*	Water Ribbons			1				1														
Juncaginaceae	*Triglochin striata*	Streaked Arrowgrass						3										1				2	
Lauraceae	*Cinnamomum camphora**	Camphor Laurel																					+
Lobeliaceae	*Lobelia alata*																						+
Malvaceae	*Sida rhombifolia**	Paddy's Lucerne													2					1			+
Moraceae	*Ficus rubiginosa*	Port Jackson Fig																					+
Myrsinaceae	*Anangallis arvensis**	Scarlet Pimpernel																					+
Myrtaceae	*Eucalyptus amplifolia subsp. amplifolia*	Cabbage Gum																					+
Myrtaceae	*Eucalyptus botryoides*	Bangalay																					+
Myrtaceae	*Eucalyptus grandis*	Flooded Gum																					+
Myrtaceae	*Eucalyptus robusta*	Swamp Mahogany																	3				+
Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum																					+
Myrtaceae	*Leptospermum juniperinum*	Prickly Teatree																	2				+

SORF = Swamp Oak Rushland Forest; EG = Exotic Grasslands; FWC = Freshwater Wetland Complex; SMPSF = Swamp Mahogany – Paperbark – Swamp Forest; MT = Meandering transect; * denotes an exotic species			SORF Regen	EG	FWC	SORF				EG	FWC				EG			SORF	SMPSF		FWC	SORF	
Family	**Scientific Name**	**Common Name**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	MT
Myrtaceae	*Melaleuca ericifolia*	Swamp Paperbark							5														
Myrtaceae	*Melaleuca linariifolia*	Flax-leaved Paperbark																					+
Myrtaceae	*Melaleuca quinquinervia*	Broad-leaf Paperbark																	3	3			
Myrtaceae	*Melaleuca styphelioides*	Prickly-leaved Tea Tree																					+
Myrtaceae	*Tristaniopsis laurina*	Water Gum																					+
Onagraceae	*Ludwigia peploides subsp. montevidensis*	Water Primrose						2															
Onagraceae	*Oenothera mollissima**																						+
Phormiaceae	*Dianella caerulea var. assera*	Blue Flax-lily																		1			
Phyllanthaceae	*Glochidion ferdinandi var. ferdinandi*	Cheese Tree																		1			+
Plantaginaceae	*Plantago lanceolata**	Lambs Tongue	2													2	2					1	+
Poaceae	*Andropogon virginicus**	Whisky Grass																					+
Poaceae	*Avena fatua**	Wild Oats																					+
Poaceae	*Briza maxima**	Quaking Grass																					+
Poaceae	*Briza minor**	Shivery Grass																					+
Poaceae	*Bromus cathaticus**	Prairie Grass	1	2																			+
Poaceae	*Cortaderia selloana**	Pampas Grass																					+
Poaceae	*Cynodon dactylon*	Couch	2	3	2	2			2							2		2	2	2	1	4	+
Poaceae	*Dichelachne micrantha*	Shorthair Plumegrass																					+
Poaceae	*Hemarthria uncinata*	Matgrass																		3			+
Poaceae	*Lachnagrostis filiformis*		2	2				2							2	2		2					
Poaceae	*Lolium perenne**	Perennial Ryegrass	2	2				2															+
Poaceae	*Melinis repens**	Red Natal Grass																					+
Poaceae	*Paspalum dilatatum**	Paspalum	2	2		2	3	2		2					2					2	1	3	+
Poaceae	*Pennisetum clandestinum**	Kikuyu	6	3		2		2		5	2	2	3	2	6	5	5			5	4		+

SORF = Swamp Oak Rushland Forest; EG = Exotic Grasslands; FWC = Freshwater Wetland Complex; SMPSF = Swamp Mahogany – Paperbark – Swamp Forest; MT = Meandering transect; * denotes an exotic species			SORF Regen	EG	FWC	SORF				EG	FWC				EG			SORF	SMPSF		FWC	SORF	
Family	**Scientific Name**	**Common Name**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	MT
Poaceae	*Phragmites australis*	Common Reed			3							6		4			2						
Poaceae	*Polypogon monspeliensis* *	Annual Beardgrass																1					
Poaceae	*Setaria sphacelata**	South African Pigeon Grass																		1			
Poaceae	*Sporobolus africanus**	Parramatta Grass																					+
Poaceae	*Sporobolus virginicus var. minor*	Marine Couch																4					
Poaceae	*Stenotaphrum secundatum**	Buffalo Grass																				3	+
Polygonaceae	*Persicaria decipiens*	Slender Knotweed		2	2	2				2	2									2	2		+
Polygonaceae	*Persicaria strigosa*								4					2					2				
Polygonaceae	*Rumex crispus**	Dock		2	2	1	2			2	2					2					1	2	+
Ranunculaceae	*Ranunculus inundatus*	Water Buttercup																				1	+
Rosaceae	*Rubus fruticosus**	Blackberry	1	2					1	2				2								1	+
Salicaceae	*Salix babylonica**	Weeping willow																					+
Scrophulariaceae	*Mimulus repens*	Creeping Monkey Flower																1					+
Solanaceae	*Solanum mauritianum**	Wild Tobacco																					+
Solanaceae	*Solanum nigrum**	Black-berry Nightshade						1															
Thymelaeaceae	*Pimelea linifolia subsp. linifolia*	Slender Rice Flower																					+
Typhaceae	*Typha orientalis*	Broadleaf Cumbungi			4						5		6	4		1		2			5		
Verbenaceae	*Lantana camara**	Lantana																					+
Verbenaceae	*Verbena bonariensis**	Purple Top	2	2						2			2	2	2	3	3				2		+
		Total no. of species	**15**	**15**	**10**	**8**	**7**	**11**	**9**	**9**	**5**	**2**	**5**	**10**	**10**	**10**	**10**	**11**	**9**	**18**	**11**	**17**	

Appendix 2: Fauna species recorded in the study area

Key to symbols

E	Endangered on EPBC Act & TSC Act	I	Introduced species
V	Vulnerable on TSC Act	M	Migratory species
SMPSF	Swamp Mahogany – Paperbark Swamp Forest	EG	Exotic Grasslands
SORF	Swamp Oak Rushland Forest	FWC	Freshwater Wetland Complex

Status	Scientific Name	Common Name	Method	Area recorded			
Fish				SMPSF	SORF	EG	FWC
I	*Gambusia holbrooki*	Plague Minnow	Opportunistic, amphibian searches		+	+	+
Amphibians							
	Crinia signifera	Common Eastern Froglet	Herpetofauna search, spotlighting	+	+	+	
	Limnodynastes peronii	Striped Marsh Frog	Trapping, herpetofauna search, spotlighting	+	+	+	+
	Limnodynastes tasmaniensis	Spotted Grass Frog	Herpetofauna search, spotlighting			+	
	Litoria dentata	Bleating Tree Frog	Spotlighting	+	+		
	Litoria fallax	Dwarf Sedge Frog	Herpetofauna search	+	+	+	+
	Litoria peroni	Peron's Tree Frog	Herpetofauna search	+	+		+
	Litoria verreauxii	Verreaux's Tree Frog	Spotlighting		+		
Reptiles							
	Pseudonaja textilis	Eastern Brown Snake	Opportunistic sighting			+	
	Lampropholis guichenoti	Grass Sunskink	Herpetofauna search			+	
	Demansia psammophis	Yellow-Faced Whip Snake	Opportunistic sighting			+	
Terrestrial Mammals							
	Macropus giganteus	Eastern Grey Kangaroo	Opportunistic sighting		+	+	
I	*Mus domesticus*	House Mouse	Trapping		+	+	+
I	*Oryctolagus cuniculus*	European Rabbit	Spotlighting			+	
I	*Rattus rattus*	Black Rat	Trapping		+	+	+
I	*Vulpes vulpes*	Red Fox	Spotlighting			+	
Bats							
	Nyctophilus sp.	Unidentified Long-eared Bat	Anabat analysis		+	+	
V	*Scoteanax rueppellii*	Greater Broad-nosed Bat	Anabat analysis			+	
V	*Miniopterus australis*	Little Bentwing-bat	Anabat analysis			+	
	Tadarida australis	White-striped Freetail-bat	Anabat analysis			+	
V	*Miniopterus oceanensis*	Eastern Bentwing-bat	Anabat analysis	+		+	
	Vespadelus vulturnus	Little Forest Bat	Anabat analysis	+		+	

Status	Scientific Name	Common Name	Method	Area recorded			
Bats cont.				SMPSF	SORF	EG	FWC
	Mormopterus sp. 2		Anabat analysis			+	
V	*Mormopterus norfolkensis*	Eastern Freetail-bat	Anabat analysis	+		+	
V	*Myotis macropus*	Southern Myotis	Anabat analysis	+			+
	Chalinolobus morio	Chocolate Wattled Bat	Anabat analysis	+			
	Chalinolobus gouldii	Gould's Wattled Bat	Anabat analysis	+		+	
V	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail-bat	Anabat analysis			+	
V	*Falsistrellus tasmaniensis*	Eastern False Pipistrelle	Anabat analysis	+			
	Vespadelus regulus	Southern Forest Bat	Anabat analysis			+	
V	*Pteropus poliocephalus*	Grey-headed Flying-fox	Spotlighting (flying overhead)	+			
Nocturnal birds							
V	*Tyto longimembris*	Eastern Grass Owl	Spotlighting, Owl call playback			+	
	Ninox novaeseelandiae	Southern Boobook	Opportunistic		+		
Diurnal Birds			Opportunistic				
	Anthus novaeseelandiae	Australasian Pipit				+	
	Falco longipennis	Australian Hobby	+				
	Cracticus tibicen	Australian Magpie		+	+	+	
	Corvus coronoides	Australian Raven			+	+	
	Acrocephalus australis	Australian Reed-warbler				+	+
	Threskiornis molucca	Australian White Ibis				+	
	Coracina novaehollandiae	Black-faced Cuckoo-shrike			+		
	Elanus axillaris	Black-shouldered Kite				+	
	Acanthiza pusilla	Brown Thornbill			+		
M	*Ardea ibis*	Cattle Egret				+	
	Anas castanea	Chestnut Teal	+				
I	*Sturnus tristis*	Common Myna		+			
	Ocyphaps lophotes	Crested Pigeon				+	
	Platycercus eximius	Eastern Rosella		+	+		
	Petrochelidon ariel	Fairy Martin				+	+
	Cacomantis flabelliformis	Fan-tailed Cuckoo			+		
	Eulophus roseicapillus	Galah				+	
	Pachycephala pectoralis	Golden Whistler			+		
	Cisticola exilis	Golden-headed Cisticola				+	+
	Cracticus torquatus	Grey Butcherbird			+		
	Rhipidura albiscapa	Grey Fantail			+		
	Accipiter novaehollandiae	Grey Goshawk	+				
	Dacelo novaeguineae	Laughing Kookaburra		+	+		
	Egretta garzetta	Little Egret	+				

Status	Scientific Name	Common Name	Method	Area recorded			
Diurnal Birds cont.			Opportunistic	SMPSF	SORF	EG	FWC
	Megalurus gramineus	Little Grassbird				+	+
	Grallina cyanoleuca	Magpie-lark				+	
	Vanellus miles	Masked Lapwing				+	
	Dicaeum hirundinaceum	Mistletoebird			+		
	Falco cenchroides	Nankeen Kestrel				+	
	Oriolus sagittatus	Olive-backed Oriole			+		
	Centropus phasiananus	Pheasant Coucal				+	
	Strepera graculina	Pied Currawong			+		
	Neochmia temporalis	Red-browed Finch			+	+	
	Zosterops lateralis	Silvereye			+		
	Stipiturus malachurus	Southern Emu-wren			+	+	
	Plectorhyncha lanceolata	Striped Honeyeater			+		
	Malurus cyaneus	Superb Fairy-wren			+	+	
	Circus approximans	Swamp Harrier				+	+
	Megalurus timoriensis	Tawny Grassbird				+	+
	Malurus lamberti	Variegated Fairy-wren			+		
	Aquila audax	Wedge-tailed Eagle	+				
	Hirundo neoxena	Welcome Swallow				+	+
	Haliastur sphenurus	Whistling Kite	+				
	Haliaeetus leucogaster	White-bellied Sea-Eagle	+				
	Sericornis frontalis	White-browed Scrubwren			+		
	Egretta novaehollandiae	White-faced Heron	+				
	Cormobates leucophaea	White-throated Treecreeper			+		
	Rhipidura leucophrys	Willie Wagtail			+	+	
	Acanthiza nana	Yellow Thornbill			+		
	Lichenostomus chrysops	Yellow-faced Honeyeater			+		
	Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo	+				

Appendix 3: Survey efforts compared to OEH guidelines

Flora survey effort

Refer to Figure 6 which displays the flora survey effort over vegetation mapping.

Vegetation Community	Formation	Study area (ha)	No of Quads	Quadrats required (OEH)
Freshwater Wetland Complex	Freshwater Wetlands	70.59	6	3
Constructed Freshwater Wetland Complex	Freshwater Wetlands	6.07	See above	-
Swamp Oak Forest	Forested Wetlands	14.82	6	2
Swamp Oak Forest (regen)	Forested Wetlands	2.2	1	2 (however 4 additional quads completed in same mature community type)
Swamp Sclerophyll Forest	Forested Wetlands	1.47	2	1
Exotic grassland	N/A	141.66	5	3
Cleared	N/A	4.19	-	-
	Totals	**239.7**	**20**	**11**

Discussion: The appropriate number of flora quadrats in accordance with the OEH guidelines was undertaken (additional 9 quadrats undertaken). Random meanders were conducted across the site to target threatened species in Spring 2009, Spring 2010 and Spring 2011, totalling 16.75 person hrs. A map overlaying the flora survey effort over the vegetation / stratification units is provided in Figure 6. OEH recommend 30 minutes of meanders for each quadrat sampled within the same stratification unit as the quadrat; therefore, random meander time exceeds the guidelines (20 quads x 30 mins = 10 hrs).

Fauna survey effort

Refer to Figure 7 which displays the fauna survey effort over vegetation mapping.

Trapping effort

Vegetation Community	Elliott A	Elliott B ground	Elliott B tree	Hair tube ground	Hair tube tree	Cage	Harp trap
Freshwater Wetland Complex	25	25	-	10	-	6	1
Swamp Oak Forest	25	25	5	10	5	6	1
Exotic grassland	25	25	-	10	-	6	1
Total number of traps	75	75	5	30	5	18	3
Trap nights	4	4	4	4	4	4	4
Total trap nights	**300**	**300**	**20**	**120**	**20**	**72**	**12**
Survey effort required (OEH)	100 trap nights per stratification unit	100 trap nights per stratification unit	24 trap nights per stratification unit	80 trap nights per stratification unit	12 nights (in every 10 trees) per stratification unit	24 trap nights per stratification unit	4 trap nights over 2 consecutive nights (with one trap placed outside the flyways for one night)

Discussion: The survey effort using Elliott A and Elliott B ground and cage traps meets the OEH guidelines and exceeds the harp trapping requirement. Trapping effort targeting arboreal mammals (Elliott B and Hair tubes in trees (optional method)) falls slightly short of the guidelines, however, there was only one stratification unit with potential habitat for arboreal mammals (Swamp Oak Forest) and was considered unlikely to support threatened arboreal mammal species. Trapping was not undertaken in the Swamp Sclerophyll Forest due to its small area (1.5 ha) and isolated, linear nature. It was considered unlikely that arboreal mammals would use this isolated patch. Spotlighting and Anabat recording were considered appropriate methods for detecting any arboreal mammals or insectivorous bats using the area.

Other fauna survey effort

Vegetation Community	Spotlighting	Anabat	Owl call playback	Bird survey	Reptile survey	Frog survey	Tracks, scats, signs	Targeted surveys
Freshwater Wetland Complex	Conducted across the site in all formations; driving transects along tracks were also conducted	2	3	3 area searches repeated (Dec 2010)	3 nocturnal searches	3	Conducted across the site in all formations and in the vicinity of the trapping transects; opportunistic observations were made by all field staff during other methods	AUSTRALASIAN BITTERN – 4 sites (2 nights in spring); 1 site (1 night in summer) GREEN AND GOLDEN BELL FROG – 3 sites (4 nights in summer 2010) THREATENED WATERBIRDS – plots and meanders on two separate mornings in summer 2010
Swamp Oak Forest		2	-	3 area searches repeated (Dec 2010)	1 nocturnal search	1		GREEN AND GOLDEN BELL FROG – 1 site (4 nights in summer 2010) THREATENED WATERBIRDS – plots and meanders on two separate mornings in summer 2010
Exotic grassland		3	2	1 area search repeated (Dec 2010)	1 nocturnal search	1		AUSTRALASIAN BITTERN – 2 sites (2 nights in spring) GREEN AND GOLDEN BELL FROG – 1 site (4 nights in summer 2010) MIGRATORY BIRDS – 200m transect along the Hunter River foreshore THREATENED WATERBIRDS – plots and meanders on two separate mornings in summer 2010
Swamp Sclerophyll Forest		2	-	1 area search repeated (Dec 2010)	-	-		-
Total number of locations	**Refer to Fig 7 for transect locations**	**9**	**5**	**8**	**5 plots plus diurnal and nocturnal meandering transects**	**5 plots plus meandering transects**	**Across site**	**Refer to Figure 7 for respective survey methods**

Vegetation Community	Spotlighting	Anabat	Owl call playback	Bird survey	Reptile survey	Frog survey	Tracks, scats, signs	Targeted surveys
Season in which surveys conducted	4 nights in winter; 4 nights in summer for a total of 9.5 person hrs	7 sites in winter over 3 nights; 2 sites in summer (two units left overnight)	5 nights in winter; 1 night in summer	4 x 2 ha plots repeated in winter plus 1 hr of meandering; 5 x 2 ha plots repeated in summer (one plot the same as in winter) plus 2 hrs meandering	Two days in late autumn; two nights in winter; four nights in summer; opportunistic observations collected during other survey methods	Two days in late autumn; two nights in winter; four nights in summer; opportunistic observations during other methods.	All seasons	Spring and summer
Comment on adequacy of effort compared with OEH guidelines	Complies	Complies	Complies for Grass Owl (no suitable habitat for other species)	Complies – no open water sources or wetlands in study area. Temporarily flooded areas were searched during meanders and by opportunistic sightings.	Diurnal searches conducted in May and June are outside OEH guidelines. Nocturnal searches comply. The site lacks habitat for any threatened reptile species.	Autumn /winter surveys outside OEH guidelines however, targeted amphibian searches comply with OEH 2009 guidelines	Complies	Call playback surveys conducted over two nights in spring and one night in summer which is within known breeding season for Australasian Bittern. Bird surveys within potential habitat also involved walking through reedy habitat in an attempt to flush birds. Additionally, many hours were spent walking through potential habitat by other field staff during flora surveys, spotlighting and targeted amphibian surveys. Targeted surveys for Green and Golden Bell Frog comply with OEH 2009 guidelines. Targeted searches for threatened / migratory waterbird and shorebird species are within the migratory periods for these species.

Vegetation Community	Spotlighting	Anabat	Owl call playback	Bird survey	Reptile survey	Frog survey	Tracks, scats, signs	Targeted surveys
Survey effort required (OEH 2004)	On foot with a handheld spotlight for at least two searches of one hour duration on two separate nights for at least 1 km (up to 200 ha of stratification unit); From vehicle – 2 x 1km of track at max speed of 5km/hr on two separate nights	Two sound activated recording devices utilised for the entire night (min 4 hrs) starting at dusk for two nights	One playback on two separate nights – FROGS; One or more call playbacks (depending on size of site) for NOCTURNAL BIRDS – at least 5 visits per site for Grass Owl; Two sites per stratification unit up to 200 ha conducted twice on two separate nights – KOALA, GLIDERS	No specific method detailed however, area search considered a widely used suitable method. One hour wetland and 20 min water source census for each identified wetland or water source.	Habitat search - 30 min search on two separate days; Spotlighting – 30 min search on two separate nights; Pitfall trapping – 24 trap nights (min 4 consecutive nights)	Diurnal survey - 1 hr per stratification unit; Nocturnal habitat search (30 mins on two separate nights per stratification unit) plus 2 hrs per 200m of water body edge	At least 30 minute search in appropriate habitat.	Australasian Bittern – no specific survey method recommended (surveys within the Spring / Summer breeding season including call playback on dusk and diurnal flushing surveys through wetland areas (R. Jaensch pers comm.) Grass Owl – call playback over a minimum of 5 nights Threatened and migratory waterbird and shorebirds - One hour wetland and 20 min water source census for each identified wetland or water source.
Seasonality required by OEH (2004)	All year	Oct - Mar	All year	All year (except for target species)	Nov - Mar	Depends on peak activity of target species	All year	AUSTRALASIAN BITTERN (Sept – Feb R. Jaensch pers. comm.) GRASS OWL (All year) MIGRATORY SHOREBIRDS (Oct – Mar)
Survey effort required by OEH 2009 (threatened amphibian survey guidelines)	-	-	-	-	-	-	-	WALLUM FROGLET - Tadpole surveys, call surveys and nocturnal searches in suitable weather and habitat; Min. of one 200m transect per water body / inundated area on min. of two separate nights. GREEN AND GOLDEN BELL FROG – Tadpole surveys, call surveys and diurnal and nocturnal searches. Larger areas require a min. of three separate 4 hr searches.

Vegetation Community	Spotlighting	Anabat	Owl call playback	Bird survey	Reptile survey	Frog survey	Tracks, scats, signs	Targeted surveys
Seasonality required by OEH (2009)								WALLUM FROGLET (Nov – Mar) although males known to call all year especially after heavy rain. GREEN AND GOLDEN BELL FROG (Aug – Feb)

Appendix 4: Contributions and qualifications of ecobiological staff

Name	Qualification	Title/Experience	Contribution
Kristy Peters	B. ParkMgt. (Hons)	Senior Ecologist (Ornithologist)	Bird surveys, trap checks, hollow-bearing tree survey, SAT test, Anabat recording and analysis, call playback, spotlighting, fauna report writing
Dan Pedersen	B. Sc.	Senior Botanist	Flora surveys, flora species ID, vegetation community mapping and flora data and report review
Adam Blundell	B. Env Sc. (Hons)	Senior Environmental Scientist	Trap layout design and checks, Anabat recording, call playback, spotlighting, report review
David Paull	M. Res. Sc.	Ecologist (Herpetologist)	Amphibian and reptile surveys, Anabat analysis
Ryan Parsons	B. Env Sc. (Hons)	Botanist	Flora surveys, flora species identification, vegetation community mapping, report writing
Aaron Mulcahy	B. EnvSc&Mgt.	Botanist	Targeted threatened flora searches
Luke Foster	B. EnvSc&Mgt.	Ecologist	Preparation of map layouts for report, report writing
Samara Schulz	B. EnvSc&Mgt. (Hons)	Botanist	Targeted threatened flora searches

Appendix 5: Licensing matters relating to the survey

ecobiological and employees involved in the current study are licensed or approved under the *National Parks and Wildlife Act* 1974 (License Number: S12398, Expiry: March 2013) and the *Animal Research Act* 1985 to harm/trap/release protected native fauna and to pick for identification purposes native flora and to undertake fauna surveys.