CHAPTER 8

Terrestrial Ecology

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8 Terrestrial Ecology

This chapter assesses the impact of the Six Mile Creek Dam upgrade project on terrestrial ecology in and around the Project area.

8.1 Background

This chapter identifies:

- Existing terrestrial ecological values in the Project area and around Lake Macdonald
- The potential impacts on terrestrial ecological values associated with the Project
- Mitigation measures to be implemented to minimise the potential impacts on terrestrial ecological values.

To determine the broader impact of the Project on ecological values, the terrestrial ecological assessment assessed the Project area (primary impact area) and the wider study area, which encompasses all extents of Lake Macdonald. Assessment of the study area is important to identify impacts that may occur in shallow areas of the lake as a result of lowering the water levels during construction. The Project area and study area referred to throughout this chapter are illustrated in Figure 8-1.

The chapter is structured as follows:

- Section 8.2 describes the methods used to assess the terrestrial ecological values in the Project and study areas
- Section 8.3 describes the existing terrestrial ecology, including survey outcomes
- Section 8.4 provides an assessment of potential impacts to terrestrial ecological values from the Project
- Section 8.5 discusses management and mitigation measures that can be implemented to minimise impacts on terrestrial ecological values
- Section 8.6 provides recommendations regarding monitoring of aspects of terrestrial ecology during the Project
- Section 8.7 discusses potential environmental offset requirements associated with terrestrial ecology impacts.

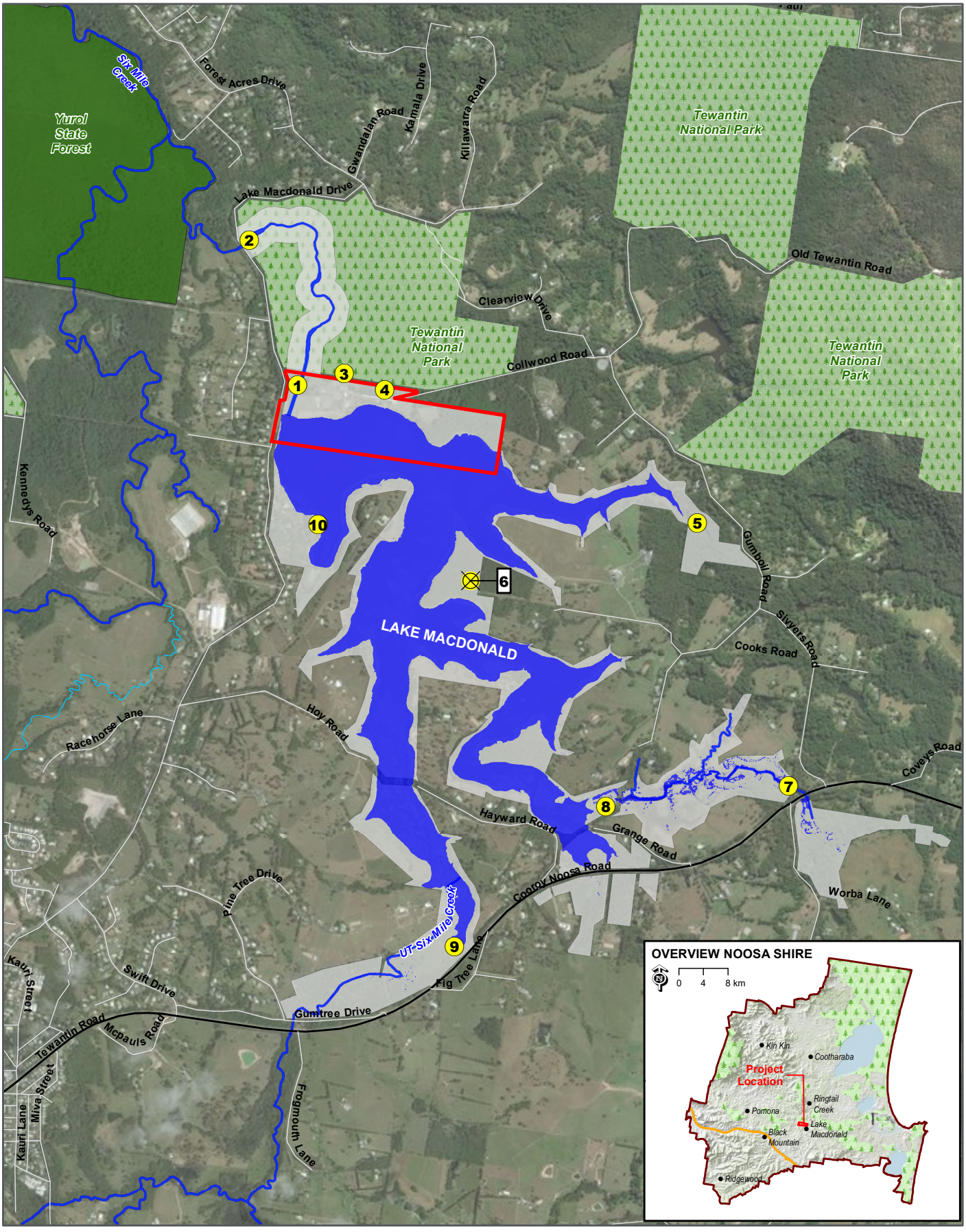
8.1.1 Nomenclature

Throughout this chapter, species are referred to by their common names with species names provided in brackets for the first reference. The exception to this is where technical descriptions are provided (e.g. for vegetation communities). Common names for flora are taken from the Department of Environment and Science (DES) wildlife online database where available. Where a common name is not provided in the wildlife online database, accepted common names were researched on government websites. If no alternative common name is available, the species is noted with its species name only.

Formal botanical nomenclature used was in accordance with that applied in the Census of Qld Queensland Flora 2017, (Bostock & Holland (eds), 2017).

FIGURE 8-1: PROJECT AREA AND STUDY AREA EXTENT

Six Mile Creek Dam Safety Upgrade Project



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seqwater WATER FOR LIFE

LEGEND

- Terrestrial Survey Sites
- Terrestrial Survey Site (not accessed)
- Bruce Highway
- Secondary Road
- Local Roads
- Watercourse
- Six Mile Creek and Upper Tributary
- Lake Macdonald
- Study Area
- Project Area
- Local Governmental Area

Protected Areas

- National Parks
- State Forest

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8.2 Methodology

8.2.1 Permits and Approvals

SMEC hold an animal ethics approval and are a registered scientific user with the Department of Agriculture and Fisheries (DAF). All works were conducted under this approval (CA 2017/05/1064) and Scientific Purposes Permit number WISP15252714.

8.2.2 Survey Timing and Conditions

Flora and fauna surveys were conducted over four nights and five days from 12-16 February 2018. During the survey week, weather conditions were hot and humid, with patchy evening thunderstorms each day. Weather data recorded by the Bureau of Meteorology (BOM) at Tewantin RSL Park (040908) is provided in Table 8-1. Temperatures in the 11 days before the survey had been cooler, with a total rainfall of 134.2 mm during this time. The study area therefore contained standing water suitable for the identification of fauna groups such as frogs, which rely on rainfall. The timing was also optimal for detection of migratory birds which were present at the time of survey.

Table 8-1: Weather conditions during the survey period and the week prior

DATE	RAINFALL (MM)*	TEMPERATURE (°C)*		HUMIDITY (%) AT 3PM*
		Minimum	Maximum	
01/02/18	8.2	21.8	24.4	82
02/02/18	29.4	19.9	22.7	99
03/02/18	31.6	18.9	24.8	99
04/02/18	43.4	17.9	26.7	60
05/02/18	7.6	19.5	27.1	54
06/02/18	2.0	19.5	27.2	53
07/02/18	0.2	19.9	27.3	52
08/02/18	9.4	19.1	26.7	57
09/02/18	2.4	19.2	27.4	53
10/02/18	0	19.5	30.3	66
11/02/18	0	21.3	33.3	71
12/02/18	**1.8**	**22.7**	**29.9**	**77**
13/02/18	**0.0**	**24.9**	**30.0**	**81**
14/02/18	**0.4**	**23.0**	**32.4**	**71**
15/02/18	**0.2**	**23.9**	**33.2**	**67**
16/02/18	**0.0**	**25.6**	**30.2**	**80**

* Data sourced from the BOM

Bold text indicates survey period.

8.2.3 Flora Assessment

Desktop Analysis

A desktop assessment was conducted to identify mapped vegetation communities, previous flora species records, and species protected under the EPBC Act and NC Act that have potential to occur in the study area based on habitat requirements, including vegetation type and land zone. This assessment determined key species to be targeted during the field survey. The review included interrogation of the following sources:

- EPBC Act Protected Matters Search Tool (10 km buffer from the approximate centre of the Project area)
- DES Wildlife Online Database (10 km buffer from the approximate centre of the Project area)
- DES Species Profile Search information on key species
- DES Protected Plants Flora Survey Trigger Map
- Atlas of Living Australia, including HERBRECs data
- DNRME's Regulated Vegetation Management mapping (Version 10.1)
- Published literature and research papers
- Lake Macdonald, Initial Advice Statement (Seqwater, 2017)
- Lake Macdonald, Ecology Review (URS, 2014)
- Protected plants flora survey guidelines (DES, 2016)
- Relevant legislation and supplementary guidance.

Field Survey

Field verification of desktop findings was undertaken in general accordance with the following methods:

- Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland (Neldner et al. 2017)
- Flora Survey Guidelines – Protected Plants - *Nature Conservation Act, 1992*. Conservation and Biodiversity Policy Unit, Department of Environment and Heritage Protection. State of Queensland, (2016)

Threatened Flora Survey

Targeted surveys for threatened flora were informed by the desktop search results, known habitat requirements, and the experience of the ecology survey team with the target species. These factors enabled a likelihood assessment to determine which species have the potential to occur in the Project area. Searches for flora species listed under the EPBC and/or NC Act were carried out across the study area, but particularly focused on areas that will be directly impacted during construction (Project area). This included random meanders (Cropper, 1993) of up to 250 m immediately downstream of the dam wall, at the intersection of Six Mile Creek and Lake Macdonald Drive (approximately 1.4 km downstream), within areas of existing vegetation inside the water treatment plant boundary, and across locations that correspond with the fauna survey sites. Transect locations are shown in Figure 8-2. Cumulative species lists were developed for each survey site. Species that could not be identified in the field were sampled and identified using relevant botanical references.

Regional Ecosystem and Threatened Ecological Community Assessment

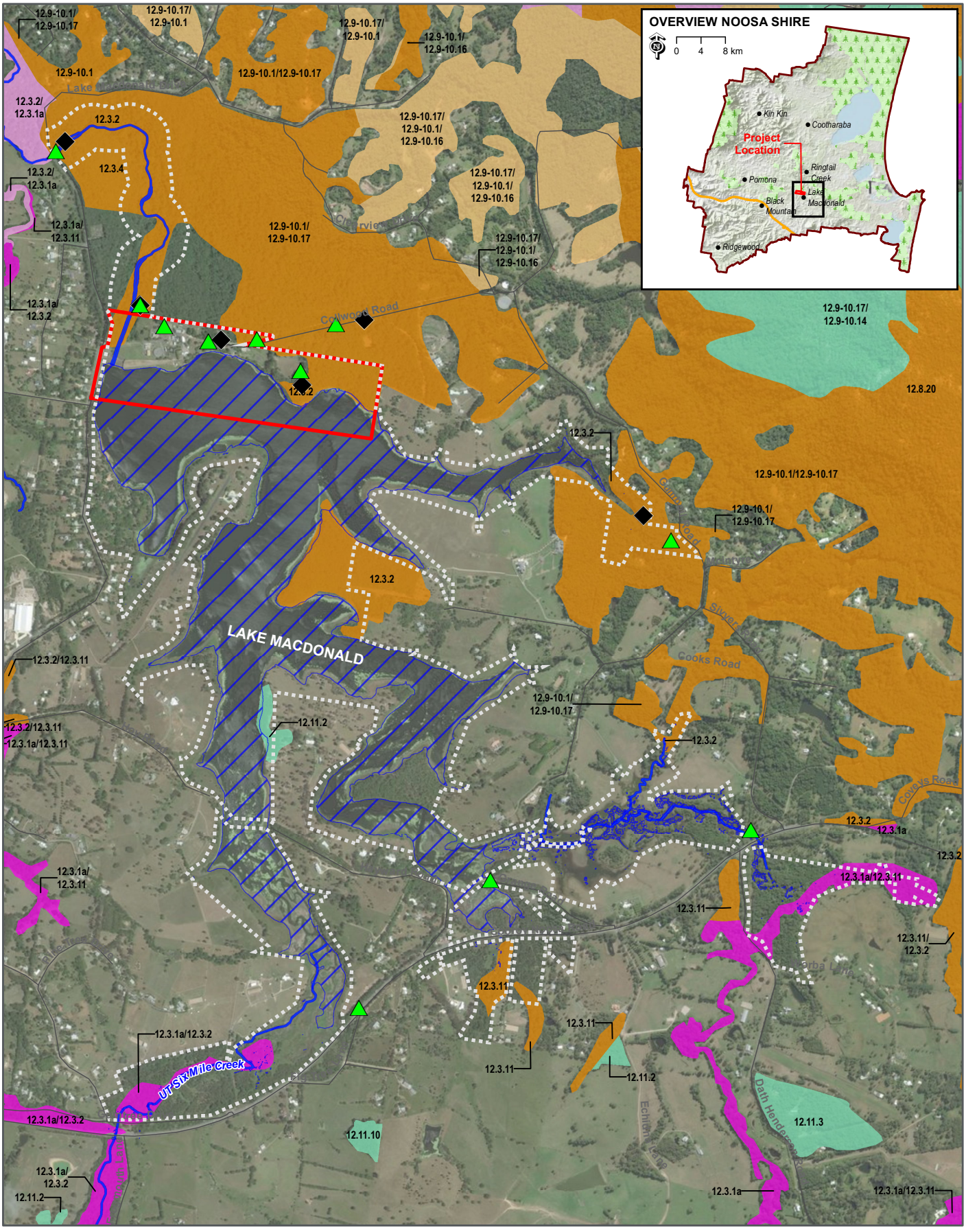
Ground-truthing of the regional ecosystem (RE) designation within the study area was undertaken using the quaternary level of data collection. Verification of the RE mapping was conducted at sites mapped as remnant vegetation on the Regulated Vegetation Management Map in accordance with the methodology for survey and mapping of REs and vegetation communities in Queensland, Version 4.0 May 2017 (Neldner et al 2017) (refer to Table 8-2). Quaternary data were collected as a record of field traverses to verify RE mapping (Neldner et al 2017). The characteristics used to refine or confirm vegetation communities are:

- Floristic and structural characteristics of each site including the following for each vegetation strata:
  - dominant flora species
  - height (m)
  - cover (%)
- Landform
- Underlying geology.

For the purpose of vegetation community mapping, polygons were verified in accordance with Queensland RE description and biodiversity status as per the Regional Ecosystem Description Database (REDD) and classified as remnant RE, vegetation consistent with RE, or non-remnant vegetation. For any areas of potential Threatened Ecological Community (TEC) encountered an assessment of vegetation survey data was made against TEC threshold criteria (DoEE 2017a, TSSC 2013). Vegetation community data was recorded in the field and entered into task specific datasheets. Representative photographs were taken at each vegetation survey site. Capture and delineation of RE and any TEC boundaries was undertaken using a combination of mobile GIS devices, GPS and delineation from imagery.

FIGURE 8-2:

MAPPED VEGETATION COMMUNITIES AND FLORA SURVEY SITES Six Mile Creek Dam Safety Upgrade Project



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seqwater WATER FOR LIFE

LEGEND

- Flora Survey Transect Start
- Quaternary Assessments
- Bruce Highway
- Road (secondary and local)
- Watercourse
- Six Mile Creek and Upper Tributary
- Lake Macdonald
- Study Area
- Project Area
- Local Governmental Area

Regional Ecosystems

- Endangered - Sub-dominant
- Endangered - Dominant
- Of Concern - Sub-dominant
- Of Concern - Dominant
- Not Of Concern

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8.2.4 Fauna Assessment

Desktop Analysis

A desktop assessment identified previous fauna species records and species protected under the EPBC Act and NC Act that have the potential to occur in the study area based on habitat requirements, including vegetation type and landzone. This assessment interrogated the same sources used for the flora assessment and determined key species that should be targeted during the field survey.

Field Survey

Nine survey sites were established for the fauna surveys. These were selected based on their proximity to the Project works, mapped vegetation communities, and accessibility (primarily targeting land owned by Seqwater). Sites were selected to ensure that different habitat types were surveyed and appropriate distribution around Lake Macdonald. Table 8-2 briefly describes the habitat at each survey site. The location of the survey sites is shown in Figure 8-2 with the mapped RE vegetation.

Survey techniques were chosen for specific locations based on the targeted species in that area. A variety of techniques were selected and, except for amphibians and the common death adder, carried out in accordance with the Terrestrial Vertebrate Fauna Survey Guidelines for Queensland Version 2.0 (Eyre et al. 2014). Surveys for amphibians were conducted in accordance with the Survey Guidelines for Australia's Threatened Frogs under the EPBC Act. The survey for the common death adder (*Acanthophis antarcticus*) was conducted in accordance with the Targeted Species Survey Guidlelines for the species (Rowland 2012). A summary of the methods conducted at each site is provided in Table 8-3. The location of specific fauna surveys is shown in Figure 8-3, Figure 8-4, and Figure 8-5. Where survey techniques are not specifically mapped, they were undertaken at the survey site location.

Table 8-2: Site descriptions

SITE NUMBER AND LOCATION	DESCRIPTION OF MAPPED VEGETATION COMMUNITY	SITE PHOTOGRAPH
Site 1	**Remnant RE 12.3.2** *Eucalyptus grandis* tall open forest on alluvial plains	
Site 2	**Remnant RE 12.3.2** *Eucalyptus grandis* tall open forest on alluvial plains	

SITE NUMBER AND LOCATION	DESCRIPTION OF MAPPED VEGETATION COMMUNITY	SITE PHOTOGRAPH
Site 3	**Regrowth RE 12.9-10.1 / RE 12.9-10.17** Tall open forest often with *Eucalyptus resinifera*, *E. grandis*, *E. robusta*, *Corymbia intermedia* on sedimentary rocks. *Eucalyptus acmenoides*, *E. major*, *E. siderophloia* +/- *Corymbia citriodora* subsp. *variegata* woodland on sedimentary rocks	
Site 4	**Remnant RE 12.9-10.1 / RE 12.9-10.17** Tall open forest often with *Eucalyptus resinifera*, *E. grandis*, *E. robusta*, *Corymbia intermedia* on sedimentary rocks. *Eucalyptus acmenoides*, *E. major*, *E. siderophloia* +/- *Corymbia citriodora* subsp. *variegata* woodland on sedimentary rocks	
Site 5	**Remnant RE 12.9-10.1 / RE 12.9-10.17 and 12.3.2** Tall open forest often with *Eucalyptus resinifera*, *E. grandis*, *E. robusta*, *Corymbia intermedia* on sedimentary rocks. *Eucalyptus acmenoides*, *E. major*, *E. siderophloia* +/- *Corymbia citriodora* subsp. *variegata* woodland on sedimentary rocks. *Eucalyptus grandis* tall open forest on alluvial plains.	
Site 6 – permission was not granted to access this site, so it was not surveyed.		
Site 7	Non-remnant vegetation (Acacia and Eucalypt regrowth) open water and fringing wetland vegetation	

SITE NUMBER AND LOCATION	DESCRIPTION OF MAPPED VEGETATION COMMUNITY	SITE PHOTOGRAPH
Site 8	Non-remnant vegetation (Acacia and Eucalypt regrowth), open water and fringing wetland vegetation	
Site 9	Non-remnant vegetation, open water and fringing wetland vegetation	
Site 10	Non-remnant vegetation, open water and fringing wetland vegetation	

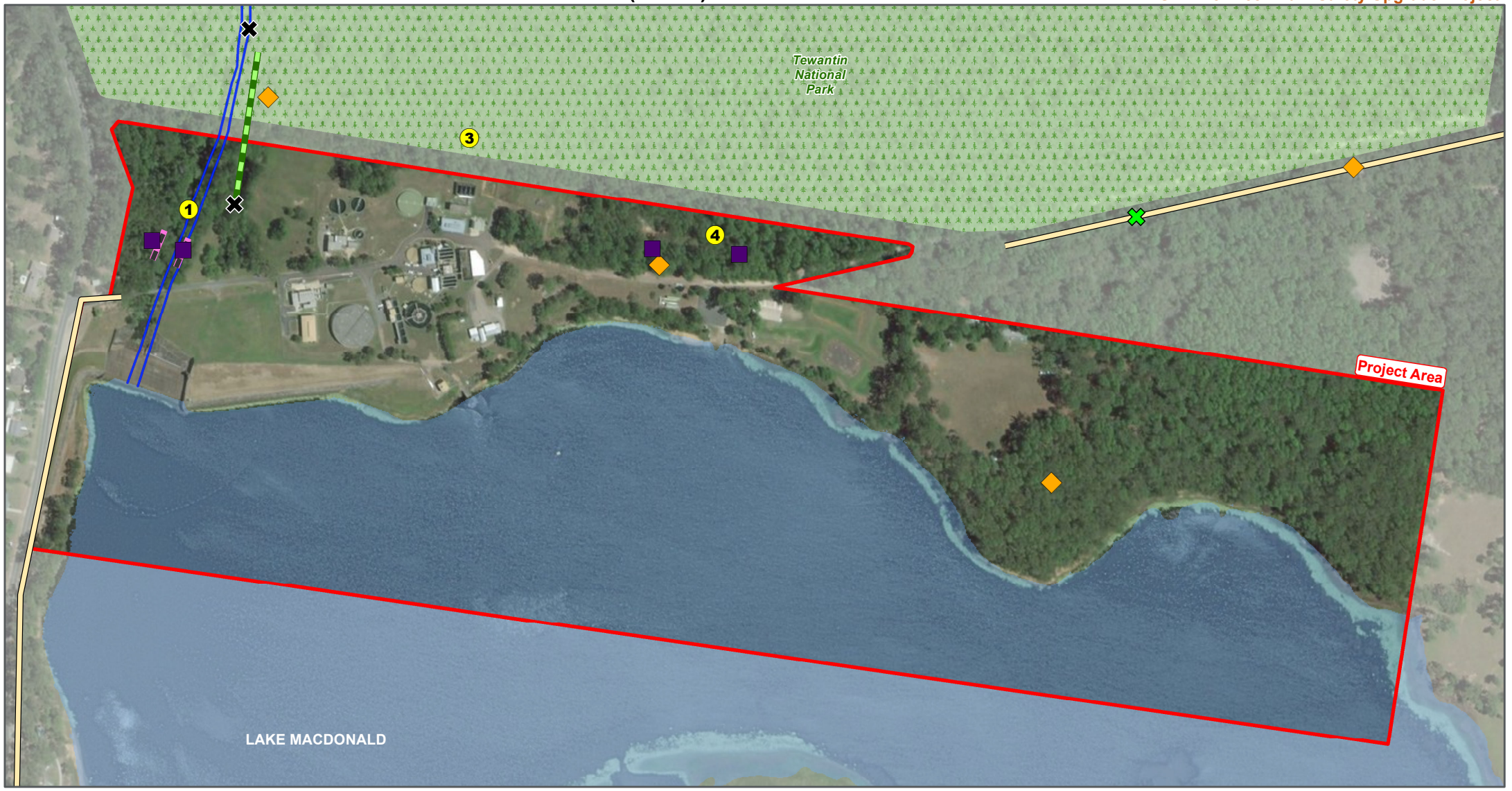
Table 8-3: Survey methods

SURVEY TECHNIQUE	DESCRIPTION	APPLICABLE SITES	SURVEY EFFORT
Pitfall traps	Two lines of five 20 L buckets spaced 5 m apart and connected by drift fence with steel pegs for support. 5 m of drift fence was installed at either end. Buckets were flush with the ground surface and filled with leaf litter, twigs and tiny holes for drainage. Traps were set for four nights. Pitfall traps targeted threatened amphibians and reptiles that had the potential to occur, including three-toed snake-tooth skink (*Saiphos reticulatus*), striped blind snake (*Anilios silvia*), giant barred frog (*Mixophyes iteratus*) and tusked frog (*Adelotus brevis*).	Site 1	40 trap nights
Spotlighting	Conducted for koala and greater glider along a 250 m transect over 15 minutes. Each site was surveyed twice over two nights.	Site 1, Site 2, Site 4 and Site 5	4 person hours
Call playback	Calls played for five-minutes, with a five-minute listening period before and after the calls. Calls were played for tusked frog and giant barred frog in suitable habitat.	Site 1, Site 2, Site 4 and Site 5	2 person hours
Anabat detection	Active sampling for microbats was undertaken using the Anabat hand-held during spotlighting for 15 minutes along a 250 m transect.	Site 1, Site 2, Site 4 and Site 5	4 person hours
Nocturnal vehicle transects	A vehicle was driven at a constant speed along sections of road surrounding Lake Macdonald to observe common death adders as they crossed the road. This was conducted when travelling to, from and between sites, over two nights of survey.	Driving between all sites	26km of survey
Amphibian active searches	In accordance with the Survey Guidelines for Australia's Threatened Frogs under the *EPBC Act,* two observers walked along a 200 m transect with spotlights searching for egg masses within leaf litter 20 m from Six Mile Creek, including inspection of overhanging banks. Low vegetation, debris, cavities and crevices were inspected. Each site was surveyed twice during the survey.	Site 1 and Site 2	2 person hours
Reptile active searches	Searches conducted for 15 minutes with two people between mid-morning and midday. Sites were searched around and under logs, decorticating bark, leaf litter and crevices in dead trees. Target species were primarily three-toed snake-tooth skink and striped blind snake.	Site 1 and Site 4	2 person hours
Diurnal and aquatic bird surveys	Six 10-minute surveys were conducted at each site, comprising two early mornings, two mid-mornings, and two late afternoons. Observers walked slowly and quietly through the site,	All sites	9 person hours

SURVEY TECHNIQUE	DESCRIPTION	APPLICABLE SITES	SURVEY EFFORT
	looking and listening for activity. Threatened and migratory bird species were the target of these surveys, but all bird species were recorded.		
Active search for evidence of Glossy Black-cockatoo	The ground was searched for evidence of glossy black-cockatoo (*Calyptorhynchus lathami*) foraging (chewed cones) and trees were inspected for nests.	Site 1, Site 3, Site 5, Site 7 and Site 8	2.5 person hours
Inspections for Platypus (*Ornithorhynchus anatinus*)	Visual inspections for individuals and burrows were conducted where suitable conditions were observed at the survey sites. Inspections were done in the early morning and late afternoon.	Site 1 and Site 2	1 person hour

FIGURE 8-3: FAUNA SURVEY LOCATIONS AND ANIMALS IDENTIFIED (PART 1)

Six Mile Creek Dam Safety Upgrade Project



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2. Basemap © Nearmap, 2018

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WATER FOR LIFE

LEGEND

- Terrestrial Survey Sites
- Reptile Searches
- Quaternary Assessments

Survey Records (identified during site visit)

- Tusked frog
- Giant barred frog

- Vehicle Transects
- Pitfall Trap Transect
- Frog Survey Transect
- Six Mile Creek and Upper Tributary
- Local Governmental Area
- Project Area
- Lake Macdonald

Protected Areas

- National Parks

OVERVIEW NOOSA SHIRE

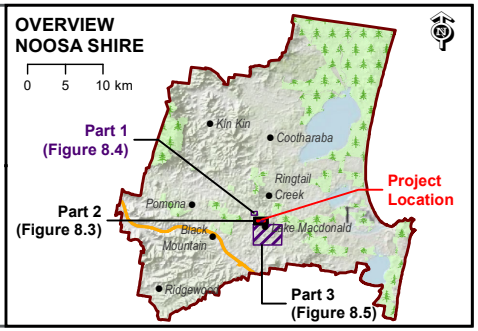

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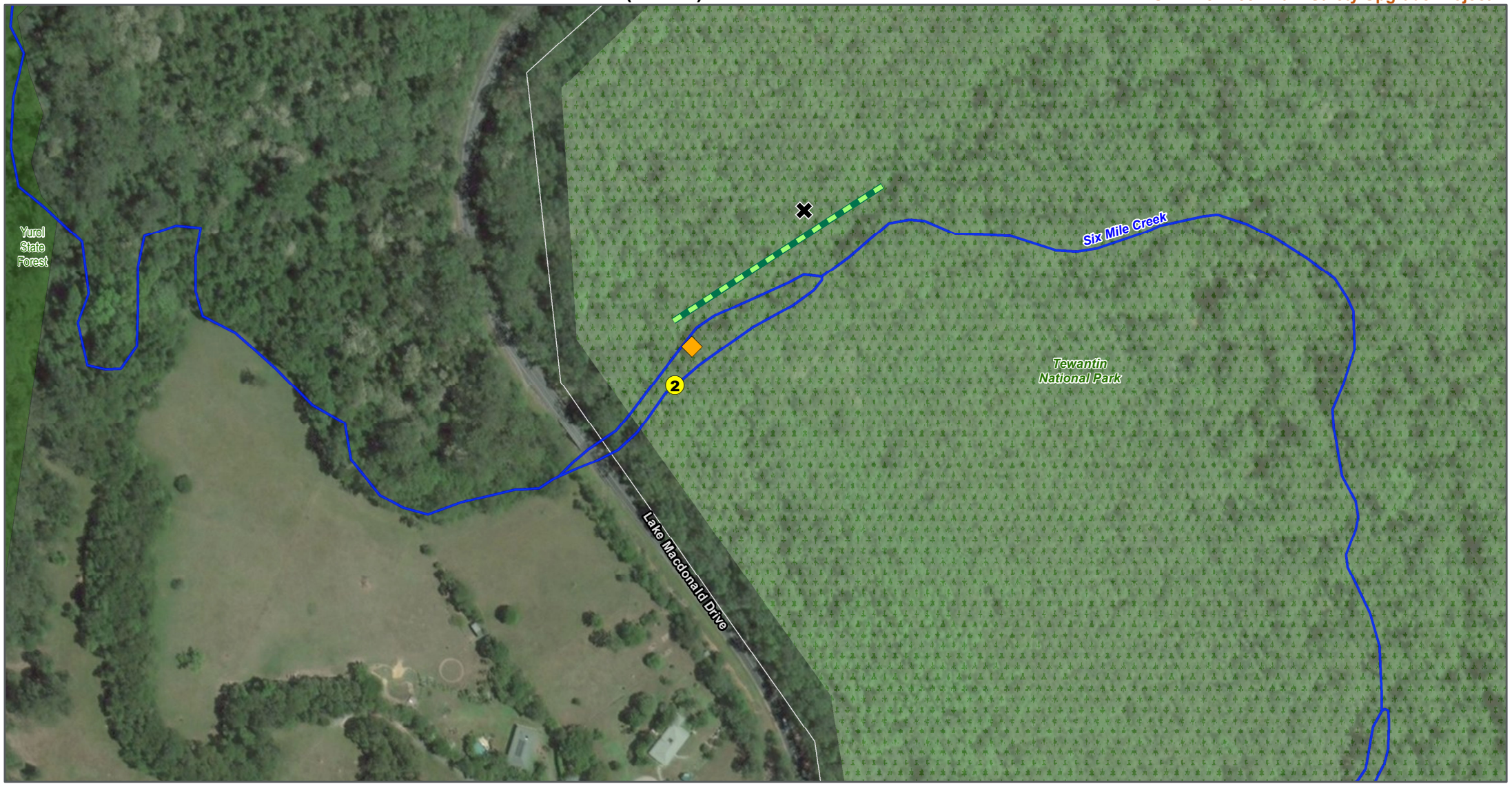
FIGURE 8-4: FAUNA SURVEY LOCATIONS AND ANIMALS IDENTIFIED (PART 2)

Six Mile Creek Dam Safety Upgrade Project



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seqwater
WATER FOR LIFE

LEGEND

- Terrestrial Survey Sites
- Quaternary Assessments

Survey Records (identified during site visit)

- Giant barred frog
- Frog Survey Transect
- Six Mile Creek and Upper Tributary
- Local Roads
- Local Governmental Area

Protected Areas

- National Parks
- State Forest

OVERVIEW NOOSA SHIRE

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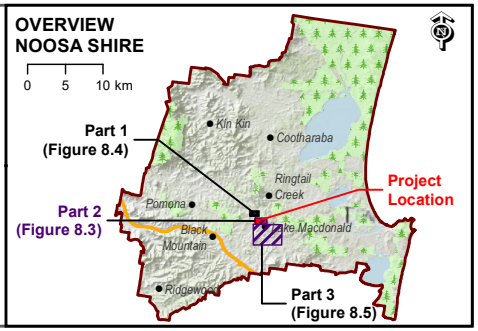

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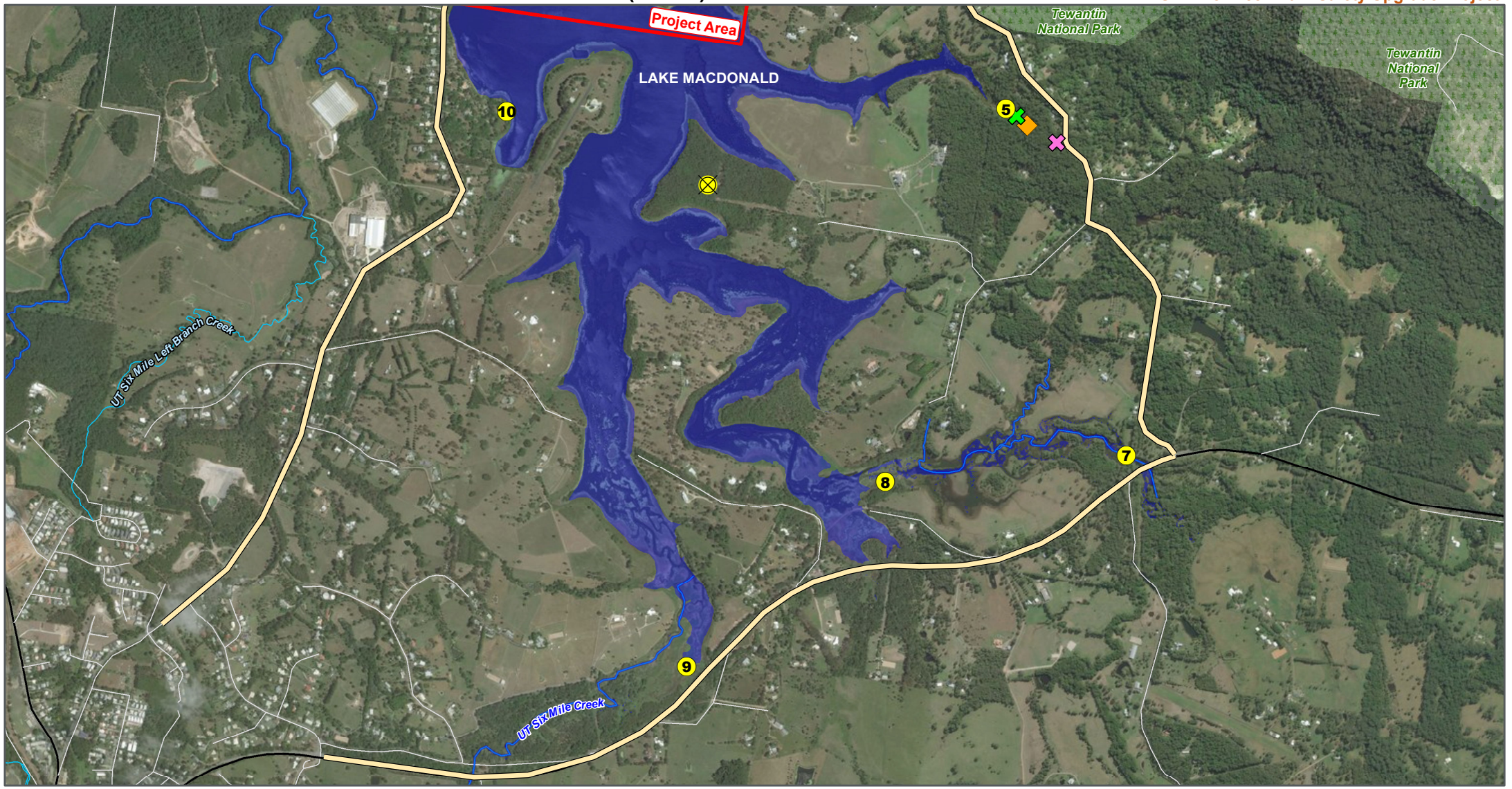
FIGURE 8-5: FAUNA SURVEY LOCATIONS AND ANIMALS IDENTIFIED (PART 3)

Six Mile Creek Dam Safety Upgrade Project



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WATER FOR LIFE

LEGEND

- Terrestrial Survey Sites
- Terrestrial Survey Site (not accessed)
- Quaternary Assessments

Survey Records (identified during site visit)

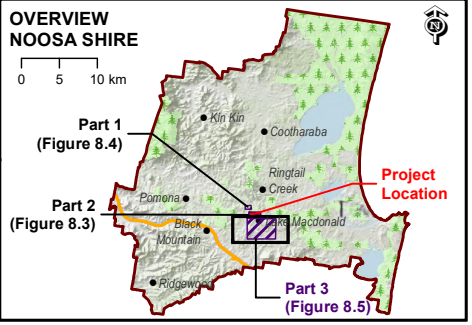
- Richmond birdwing butterfly
- Tusked frog

- Vehicle Transects
- Six Mile Creek and Upper Tributary
- Watercourse
- Secondary Road
- Local Roads
- Local Governmental Area
- Project Area
- Lake Macdonald

Protected Areas

- National Parks

OVERVIEW NOOSA SHIRE



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8.2.5 Survey Limitations

The terrestrial ecology survey results are an accurate and true representation of the site at the time of survey, limited by the area surveyed, site conditions and seasonal variation at the time of survey. The results do not guarantee the absence of threatened species listed under state or Commonwealth legislation. A summary of the survey limitations is provided below:

- The flora surveys utilised random meander methods and therefore only detect what is seen at that location. It is not a comprehensive list of all species that occur in the study area.
- Permission to conduct fauna surveys (e.g. trapping) within the National Park was not obtained. As a result, traps were located in sub-optimal habitat that was accessible during the survey.
- Permission to conduct surveys at Site 6 was not obtained, thereby preventing assessment of regional ecosystem vegetation in this area. Bird species could still be observed from other aspects around the lake.
- Many fauna species are highly mobile, seasonally variable, occur at low density, or may only utilise a site intermittently. For example, grey goshawk may occur at the site from time to time, but was not observed during the survey. The common death adder occurs at low density and its cryptic behaviour (a well-camouflaged ambush predator) makes it difficult to detect. Species such as these cannot be confirmed as permanently absent from the site, despite not being detected during the survey period.

8.3 Existing Environment and Survey Outcomes

8.3.1 Flora

Vegetation Communities

EPBC Act Threatened Ecological Communities

The EPBC Act Protected Matters Search lists three TECs that are likely to occur within 10 km of the dam wall:

- Subtropical and Temperate Coastal Saltmarsh – vulnerable under the EPBC Act
- Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community – endangered under the EPBC Act
- Lowland Rainforest of Subtropical Australia – critically endangered under the EPBC Act.

Subtropical and Temperate Coastal Saltmarsh occurs within a narrow margin of the coast in saline environments with regular tidal inundation. These environments do not exist as far inland as Lake Macdonald. This TEC was not observed during the field survey and will not occur in the study area.

The Coastal Swamp Oak community also occurs within coastal areas that have a saline influence. No swamp oak (*Casuarina glauca*) was observed during the field survey and this TEC does not occur in the study area.

Lowland Rainforest of Subtropical Australia is noted in the listing advice (TSSC, 2011) as occurring on basalt and alluvial soils between Maryborough in Queensland and the Clarence River in New South Wales. The community generally occurs below 300 m AHD where rainfall is higher. The listing advice (TSSC, 2011) notes this TEC as being equivalent to RE 12.3.1. Patches of this RE are mapped in upstream sections of Six Mile Creek near the intersection with Tewantin Road, in downstream sections of Six Mile Creek approximately 1.5 km from the dam wall, and within high value regrowth vegetation immediately west of Six Mile Creek, just outside the Project area. None of the REs in the proposed construction footprint [1] are listed as equivalent to this TEC. This TEC was not observed in the proposed construction footprint and is not likely to be directly impacted by the Project.

[1] Area proposed to be disturbed by construction activities for the Project.

***Vegetation Management Act 1999* Remnant and Regrowth Vegetation**

Seven remnant and regrowth REs are mapped within the study area. Three of these, RE 12.3.2 (of concern), RE 12.9-10.1 (of concern), and RE 12.9-10.17 (least concern) are mapped within the proposed construction footprint. The distribution of the mapped remnant and regrowth REs is illustrated in Figure 8-6 and Figure 8-7.

Quaternary level floristic assessments were conducted in representative sections of all mapped REs to confirm the mapping of these areas. In the Project area, the mapping for RE 12.3.2 and 12.9-10.1 was largely correct, though only a small patch of RE 12.9-10.17 was observed in the vicinity of Camp Cooroora where basalt derived soils were more prevalent. This vegetation is mapped as comprising 60% RE 12.9-10.1 and 40% RE 12.9-10.17. Therefore, it is likely this mapping is correct, though the remainder of the mapped vegetation in this location was not surveyed to confirm the extent of these REs outside the Project area (refer to Figure 8-3).

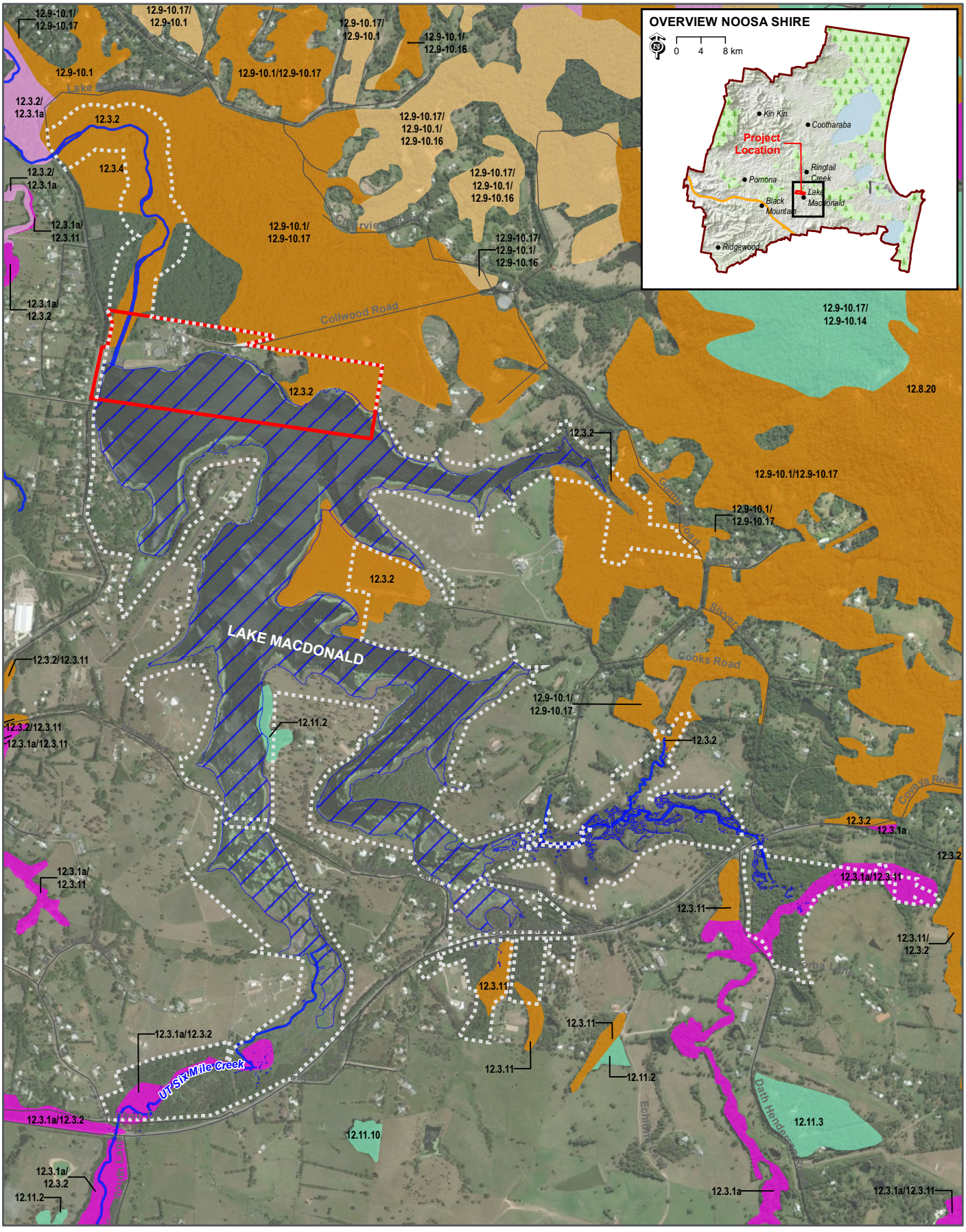
Descriptions of the remnant and regrowth REs present in the area are included in Table 8-4.

Non-remnant vegetation

The majority of the Seqwater water treatment plant land is mapped and verified as non-remnant vegetation. This area has been subject to significant previous disturbance and vegetation clearing. Two larger patches of vegetation are present within this land parcel; both contain selected species that are representative of the surrounding remnant vegetation, but have not reached a height, size or composition that achieves remnant status. The most eastern vegetation patch contains a large number of landscaping species that would not naturally occur in remnant vegetation communities.

Similarly, vegetation in the centre of Tewantin National Park is mapped and was verified as non-remnant vegetation. Historical aerial imagery indicates that in 1993, this area was almost entirely cleared. This area contains selected species that are representative of the surrounding regional ecosystems, but due to the historical clearing, canopy species have not reached a height, size or composition that achieves remnant status.

FIGURE 8-6: REMNANT REGIONAL ECOSYSTEMS



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seqwater WATER FOR LIFE

LEGEND

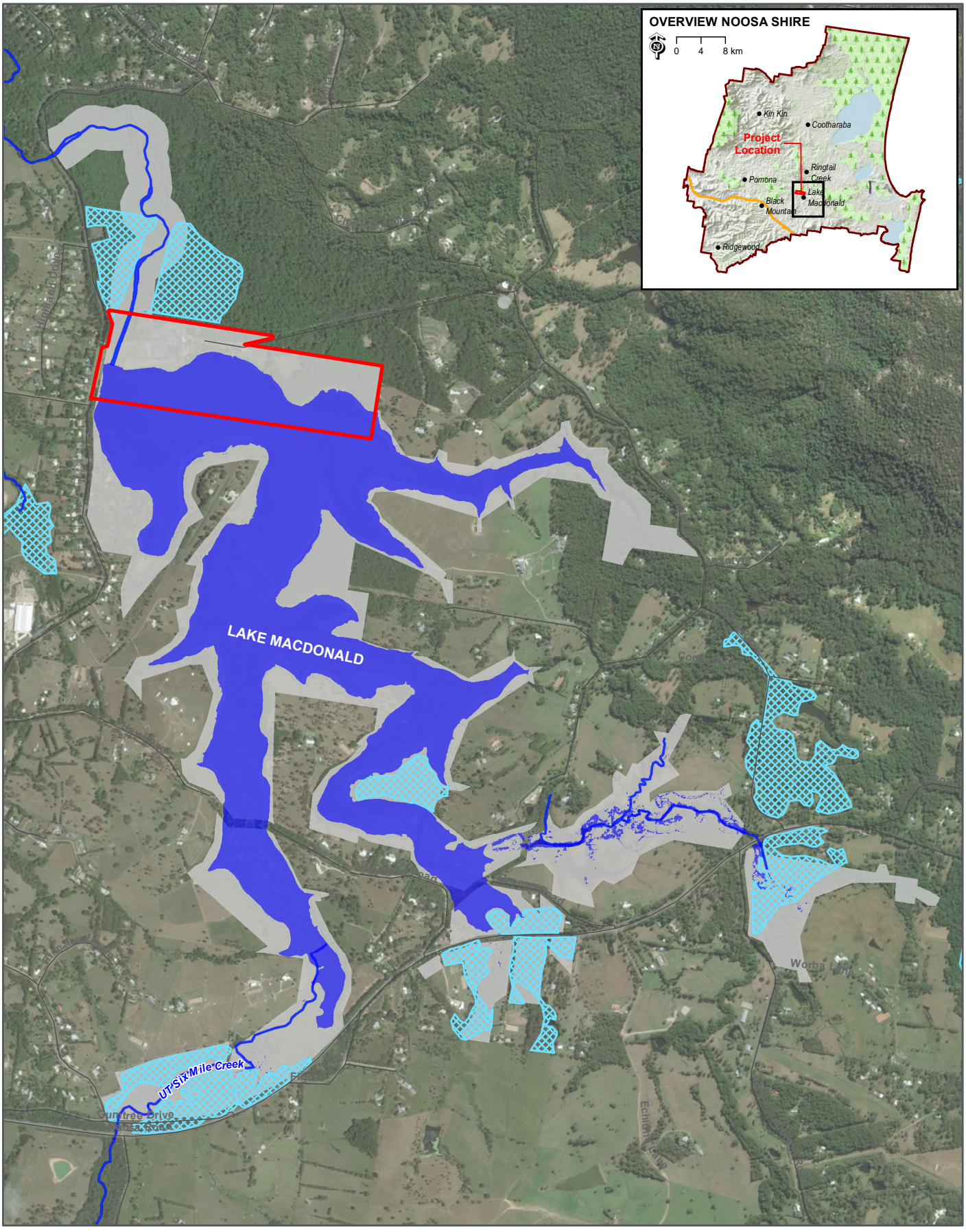
- Bruce Highway
- Road (secondary and local)
- Watercourse
- Six Mile Creek and Upper Tributary
- Lake Macdonald
- Study Area
- Project Area
- Local Governmental Area

Regional Ecosystems

- Endangered - Sub-dominant
- Endangered - Dominant
- Of Concern - Sub-dominant
- Of Concern - Dominant
- Not Of Concern

Path: R:\PROJECTS\30031970\MXD\IAS_ReportMaps\P30031970_Figure8_6_RemnantREs.mxd

FIGURE 8-7: REGROWTH REGIONAL ECOSYSTEMS



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seqwater WATER FOR LIFE

LEGEND

- Bruce Highway
- Road (secondary and local)
- Watercourse
- Six Mile Creek and Upper Tributary
- Lake Macdonald
- Study Area
- Project Area
- Local Governmental Area
- Category C (High-value regrowth on freehold land, Indigenous land, leases for agriculture and grazing and occupational licences)

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Table 8-4: Confirmed remnant and regrowth regional ecosystems

REGIONAL ECOSYSTEM	LOCATED WITHIN THE PROJECT AREA?	REGIONAL ECOSYSTEM STATUS	REGIONAL ECOSYSTEM DESCRIPTION
12.3.2	Yes - Adjacent to the lake, near the boat ramp (adjacent to the cod hatchery, north of the lake) and along Six Mile Creek. Mapped at site 6 but not able to be ground-truthed	Of concern	*Eucalyptus grandis +/- E. microcorys, Lophostemon confertus* tall open forest with vine forest understorey ('wet sclerophyll'). Patches of *Eucalyptus pilularis* sometimes present especially in vicinity of sedimentary rocks (e.g. around Palmwoods). Fringing streams and in narrow gullies in high rainfall areas. (BVG1M: 8a)
12.3.4	No – within the study area, located west of Six Mile Creek, 500 m downstream of the Project area	Of concern	Open forest to woodland of *Melaleuca quinquenervia* and *Eucalyptus robusta.* Occurs fringing drainage lines and on floodplains in coastal areas. (BVG1M: 22a)
12.11.2	No – mapped immediately adjacent to the lake, north of Cooroy Noosa Road	Least concern	Tall open forest with vine forest understorey ('wet sclerophyll'). Canopy species include *Eucalyptus saligna subsp. saligna or E. grandis, E. microcorys, Corymbia intermedia* and *Lophostemon confertus.* Characteristic understorey species include *Caldcluvia paniculosa, Pittosporum undulatum, Synoum glandulosum subsp. glandulosum and Cryptocarya microneura.* Occurs on Palaeozoic and older moderately to strongly deformed and metamorphosed sediments and interbedded volcanics. (BVG1M: 8a)
12.3.1	No – occurs at the south east and south west extents of the study area, also approximately 1.5 km downstream of Six Mile Creek dam	Endangered	Complex to simple notophyll vine forest. *Waterhousea floribunda* is predominant fringing stream channels. Other species can include *Cryptocarya hypospodia, C. obovata, C. triplinervis, Argyrodendron trifoliolatum, Ficus coronata, F. fraseri, F. macrophylla forma macrophylla, Aphananthe philippinensis, Elaeocarpus grandis, Grevillea robusta, Castanospermum australe* and *Syzygium francisii. Ficus racemosa* and *Nauclea orientalis* in north of bioregion. Eucalyptus spp. emergents (e.g. *E. grandis*) and *Araucaria cunninghamii;* less commonly *Agathis robusta* may also be present. Occurs on Quaternary alluvial plains and channels. (BVG1M: 4b)
12.3.11	No – mapped south of Lake Macdonald, on the southern side of Cooroy Noosa Road	Of concern	*Eucalyptus tereticornis +/- E. siderophloia and Corymbia intermedia* open forest to woodland. *Corymbia tessellaris, Lophostemon suaveolens and Melaleuca quinquenervia* frequently occur and often form a low tree layer. Other species present in scattered patches or low densities include *Angophora leiocarpa, E. exserta, E. grandis, C. trachyphloia, C. citriodora subsp. variegata, E. latisinensis, E. tindaliae, E. racemosa and Melaleuca sieberi. E. seeana* may be present south of Landsborough and *Livistona decora* may occur in scattered patches or low densities in the Glenbar SF and Wongi SF areas. Occurs on Quaternary alluvial plains and drainage lines along coastal lowlands. Rainfall usually exceeds 1000mm/y. (BVG1M: 16c)

REGIONAL ECOSYSTEM	LOCATED WITHIN THE PROJECT AREA?	REGIONAL ECOSYSTEM STATUS	REGIONAL ECOSYSTEM DESCRIPTION
12.9-10.1	Yes - adjacent to the lake at site 5 (eastern extent) and within the project area in the vicinity of site 4 (along Collwood Road)	Of concern	Tall open forest. Canopy species include *Eucalyptus resinifera, E. grandis, E. robusta, Corymbia intermedia +/- E. microcorys, Melaleuca quinquenervia, Syncarpia glomulifera subsp. glomulifera* and *Lophostemon confertus*. Occurs on Cainozoic and Mesozoic sediments. (BVG1M: 8a)
12.9-10.17	Yes - small patches of this RE were observed in the vicinity of Camp Cooroora. It was scattered throughout RE 12.9-10.1 and not specifically mapped during the field survey	Least concern	Open forest to woodland complex generally with a variety of stringybarks, grey gums, ironbarks and in some areas spotted gum. Canopy trees include *Eucalyptus siderophloia, E. propinqua* or *E. major, E. acmenoides* or *E. portuensis, E. carnea* and/or *E. microcorys* and/or *Corymbia citriodora subsp. variegata.* Other species that may be present locally include *Corymbia intermedia, C. trachyphloia, Eucalyptus tereticornis, E. biturbinata, E. moluccana, E. longirostrata, E. fibrosa subsp. fibrosa* and *Angophora leiocarpa. Lophostemon confertus* or Whipstick *Lophostemon confertus* often present in gullies and as a sub-canopy or understorey tree. Mixed understorey of grasses, shrubs and ferns. Hills and ranges of Cainozoic and Mesozoic sediments. (BVG1M: 9a)

Threatened Flora Species

The wildlife online search completed on 27 August 2018 identified 737 flora species that have been previously recorded within a 10 km radius of the dam wall. Of these species, 21 are listed as endangered, vulnerable or near threatened (EVNT) under Commonwealth or state legislation. The EPBC Act protected matters search identified 19 flora species that have the potential for the species or the species habitat to occur within 10 km of the dam wall (27 August 2018). Of the species identified in desktop searches, 12 were returned in both searches, resulting in 28 unique species with potential to occur in the study area. A likelihood of occurrence assessment was undertaken for all 28 threatened species listed in the search results (refer to Appendix I for the likelihood of occurrence assessment). Fourteen species were identified as having a moderate likelihood of occurrence within the study area (Table 8-5). The majority of these species grow on higher nutrient soils (basalt, alluvium) in rainforest and/or wet sclerophyll forest.

The flora survey recorded a total of 227 species from 85 families across the study area. This was made up of 172 native species and 55 exotic species. No species listed as threatened under the EPBC Act or NC Act were identified within the Project area. However, a number of threatened species have been recorded in the Lake Macdonald area, including a number of records of Southern penda (*Xanthostemon oppositifolius*), which is listed as vulnerable under both state and Commonwealth legislation. The closest of these is an individual on the eastern side of Six Mile Creek downstream of the dam wall and within one kilometre of the proposed construction footprint. Extensive targeted investigation in this area could not relocate this individual, but it should be assumed the record is correct and that a limited number of this species is present in that area. The record indicates that the specimen is probably located in the Tewantin National Park, north of the Project area. Other records for this species are generally to the east of the dam and all appear to be on private property.

The complete species list for each survey site is provided in Appendix I.

Table 8-5: Flora species with a moderate or high likelihood of occurrence in the study area

SPECIES NAME	COMMON NAME	EPBC ACT STATUS	NC ACT STATUS	LIKELIHOOD OF OCCURRENCE
Arthraxon hispidus	Hairy jointgrass	V	V	Moderate
Bosistoa transversa	Yellow satinheart	V	LC	Moderate
Cryptostylis hunteriana	Leafless tongue orchid	V	LC	Moderate
Gossia inophloia		-	NT	Moderate
Macadamia integrifolia	Macadamia nut	V	V	Moderate
Mallotus megadontus		-	V	Moderate
Pararistolochia praevenosa	Richmond birdwing vine	-	NT	Moderate
Phaius australis	Lesser swamp orchid	E	E	Moderate
Prostanthera spathulata		V	V	Moderate
Ricinocarpos speciosus		-	V	Moderate
Samadera bidwillii	Quassia	V	V	Moderate
Symplocos harroldii	Hairy hazelwood	-	NT	Moderate
Triunia robusta	Glossy spice bush	E	E	Moderate
Xanthostemon oppositifolius	Southern penda	V	V	Moderate

Pest Flora

A total of 55 exotic species were recorded within the study area during the flora survey. These are detailed in Appendix I.

Of the exotic species identified, two are classified as Weeds of National Significance, five are listed as category three biosecurity matters under the Queensland *Biosecurity Act 2014* and 11 are regarded as environmental weeds by Noosa Shire Council (refer to Table 8-6).

The listed weed species, with the exception of lantana (*Lantana camara*), were generally present in low abundance. Lantana was present at most sites and was occasionally dense in areas where significant disturbance had occurred. This was most notable in the area immediately north of the fish hatchery.

Recommendations for control of weed species are contained in Appendix I.

Table 8-6: Summary of significant pest species identified during the survey

SPECIES		WEED OF NATIONAL SIGNIFICANCE	ENVIRONMENTAL WEED (NOOSA COUNCIL)	QLD BIOSECURITY ACT CATEGORY
SCIENTIFIC NAME	COMMON NAME			
Agave americana	Century plant		✓	
Asparagus aethiopicus	Asparagus fern	✓	✓	3
Celtis sinensis	Chinese celtis			3
Cinnamomum camphora	Camphor laurel		✓	3
Lantana camara	Lantana	✓	✓	3
Macroptilium atropurpureum	Siratro		✓	
Neonotonia wightii	Glycine		✓	
Nephrolepis cordifolia	Fishbone fern		✓	
Schefflera actinophylla	Umbrella tree		✓	
Senna pendula	Easter cassia		✓	
Spagneticola trilobata	Singapore daisy		✓	3
Syagrus romanzoffiana	Cocos palm		✓	

8.3.2 Fauna

Essential Habitat

Essential habitat mapping identifies areas where habitat suitable for EVNT species occurs, as listed under the NC Act. The Vegetation Management Supporting Map Version 10.1 identifies essential habitat for the following species in the study area:

- Koala
- Giant barred frog
- Tusked frog
- Cascade tree frog (*Litoria pearsoniana*)
- Glossy black-cockatoo
- Hairy hazelwood (*Symplocos harroldii*).

The cascade tree frog is found in gullies associated with flowing streams in rainforest and wet sclerophyll forest (Rowland 2013) above 200 m in elevation. Vegetation along Six Mile Creek may provide suitable habitat for the cascade tree frog; however, no evidence of this species was detected during the field survey.

Essential habitat for glossy black-cockatoo is mapped across RE 12.9-10.1 within the Project area, but there were very low densities of *Allocasuarina* species (the seeds of which are the sole food resource for the glossy black-cockatoo) in this area and no feeding signs were observed during the field survey. Thus, glossy black-cockatoo are not considered likely to occur in the Project area.

The Project area contains actual or potential habitat for the remaining four species: koala, giant barred frog, tusked frog, and hairy hazelwood.

Essential habitat areas were generally located along the northern end of the lake where the highest concentration of remnant REs is mapped. The Project area contains significant areas of mapped essential habitat that may be cleared.

Habitat Features

The field survey revealed a general lack of hollow-bearing trees (live and dead) across the study area. The highest density of hollows was observed in the forested areas of Site 5 with three hollow bearing trees within a 25 m x 25 m area. Within the assessment area for Site 1, one hollow bearing tree was observed. No hollow bearing trees were observed within the remaining survey sites. Most hollow-bearing trees at Site 5 were dead trees.

During the field survey, fallen logs were observed at a moderate density across the forested sites, averaging one log per 25 m circular radius. No fallen logs were observed at the wetland sites. Similarly, leaf litter cover ranged from 50-90% and generally had a depth of 5 cm in the forested sites, including Six Mile Creek and Tewantin National Park, while the wetland sites had minimal to no leaf litter.

The survey noted the presence of key flora species that provide food or foraging habitat for target fauna species, such as Acacia species and winter flowering Eucalypts (e.g. forest red gum and grey ironbark for exudivorous gliders such as feathertail, sugar and squirrel gliders), black she-oak (*Allocasuarina littoralis*) for glossy black-cockatoo, and primary koala food trees. Primary koala food tree species across the study area comprised forest red gum, swamp mahogany and tallowood. Acacia species (primarily *Acacia disaparrima*) were observed at all sites except Site 2 and Site 8. Black she-oak was recorded in low densities at Site 1, Site 4, Site 5 and Site 7. However, no feeding signs attributable to the glossy black-cockatoo were observed.

Watercourse and Wetland Habitat

There are no Ramsar Wetlands of International Importance in the study area. The Great Sandy Strait is located 30-40 km downstream of the Project. There are no referable wetlands mapped in the study area.

Lake Macdonald is located on Six Mile Creek and the upgrade works are to be undertaken at the northern end of the dam, discharging directly into the downstream section of Six Mile Creek. Six Mile Creek is mapped as a watercourse on the Vegetation Management Map and is partially mapped as Category R reef regrowth vegetation. Six Mile Creek is a gently flowing perennial stream with densely vegetated banks. Large woody debris is common along Six Mile Creek. Medium length pools less than 2 m deep, riffles and shallow glides over sand are also present (DNRME, 2004).

A number of additional drainage features are mapped on the Vegetation Management Map. This includes a drainage line along Collwood Road and a number of smaller channels that flow into the outer reaches of Lake Macdonald.

At approximately 700 m downstream of the dam wall, Six Mile Creek is mapped as a wetland on the Vegetation Management Wetlands Map. No additional areas in the study area are identified as wetland areas on this map, despite having wetland habitat values. The upper reaches of Lake Macdonald create shallow, open wetland habitat (refer to Figure 8-8). These areas provide habitat for a range of aquatic / wetland bird and amphibian species.

Several watercourses and wetlands in and around Lake Macdonald are mapped as MSES and are discussed in further detail in section 8.4.2.

Figure 8-8: Wetland habitat at Site 5

Previous disturbance

The proposed construction footprint is largely contained within previously disturbed areas associated with the Lake Macdonald dam wall, the water treatment plant, Camp Cooroora, and Collwood Road. Vegetation remaining within the treatment plant boundary has been subject to previous waste disposal, edge effects, and landscape planting.

Within Tewantin National Park, immediately adjacent to the proposed construction footprint, previous disturbance has been minimal. A very low level of weed disturbance was observed in the vicinity of Six Mile Creek. Horse riding, mountain biking and bushwalking are likely to result in weed disturbance in the vicinity of the pathways. Weed invasion was more significant to the north of Collwood Road, near the intersection with the Seqwater access road, where material has been dumped previously, vegetation has been cleared, and weeds have subsequently spread, particularly lantana.

Historical logging is evident in Tewantin National Park. The larger trees (e.g. more than 100 cm diameter at breast height (DBH)) have historically been ringbarked, logged and killed, but still remain as stags throughout the park. Figure 8-9 shows springboard notches associated with historical logging. The remaining vegetation communities are generally intact and representative of regional ecosystem communities.

Figure 8-9: Remains of historical logging

Fauna Species

The wildlife online search completed on 27 August 2018 identified a total of 320 fauna species within a 10 km radius. The EPBC Act protected matters and wildlife online searches identified a total of 61 threatened fauna species that have the potential for the species or species habitat to occur within 10 km of the site (27 August 2018). This comprised 53 fauna species on the protected matters search, and 15 on the wildlife online search, with seven species being returned on both searches. A likelihood of occurrence assessment was undertaken for all threatened species listed in the search results. In addition, the Mary River turtle and white-throated snapping turtle, which were not identified in the desktop searches, have the potential to occur. Of the 63 conservation significant species considered, sixteen have a moderate likelihood of occurrence, while a further five species had a high likelihood (refer to Table 8-7). The complete likelihood of occurrence assessment is contained within Appendix I . Detailed assessment of the aquatic species including Mary River Turtle and white-throated snapping turtle is provided in Chapter 7 – Aquatic Ecology.

The field survey identified a total of 105 species across 51 families. This comprised six amphibians, 83 birds, six reptiles, nine mammals (all bat species), and one significant invertebrate species. Three of these species are listed under either the EPBC Act or the NC Act and four are migratory under the EPBC Act (refer to Table 8-8). A summary of the observations for each fauna group is provided below Table 8-8. The complete list of fauna encountered during the survey is included as Appendix I.

Table 8-7: Fauna species with a moderate or high likelihood of occurrence in the study area

SPECIES NAME	COMMON NAME	EPBC ACT STATUS	NC ACT STATUS	LIKELIHOOD OF OCCURRENCE
Anthochaera phrygia	Regent honeyeater	CE	E	Moderate, occasional
Botaurus poiciloptilus	Australasian bittern	E	LC	Moderate
Calidris ferruginea	Curlew sandpiper	CE, M	E	Moderate
Calyptorhynchus lathami lathami	Glossy black-cockatoo	-	V	Moderate
Cyclopsitta diophthalma coxeni	Coxen's fig-parrot	E	E	Moderate
Erythrotriorchis radiatus	Red goshawk	V	E	Moderate
Lathamus discolor	Swift parrot	CE	E	Moderate, occasional
Rostratula australis	Australian painted snipe	E	V	Moderate
Turnix melanogaster	Black-breasted button-quail	V	V	Moderate
Maccullochella mariensis	Mary River cod	E	LC	High
Neoceratodus forsteri	Queensland lungfish	V	LC	High
Adelotus brevis	Tusked frog	-	V	High
Mixophyes iteratus	Giant barred frog	E	E	High
Chalinolobus dwyeri	Large-eared pied bat	V	V	Moderate
Dasyurus maculatus maculatus	Spotted-tail quoll (south-eastern mainland population)	E	V	Moderate
Phascolarctos cinereus	Koala	V	V	Moderate
Pteropus poliocephalus	Grey-headed flying-fox	V	LC	High
Anilios silvia	Striped blind snake	-	NT	Moderate
Saiphos reticulatus	Three-toed snake-tooth skink	V	LC	Moderate
Elseya albagula	White-throated snapping turtle	CE	E	Moderate
Elusor macrurus	Mary River turtle	E	E	Moderate

Note: LC = Least Concern, NT = Near Threatened, V = Vulnerable, E = Endangered, CE = Critically Endangered

Table 8-8: Conservation Significant fauna species identified during the field survey

FAMILY	SCIENTIFIC NAME	COMMON NAME	EPBC ACT STATUS	NC ACT STATUS
Limnodynastidae	*Adelotus brevis*	Tusked frog		V
Myobatrachidae	*Mixophyes iteratus*	Giant barred frog	E	E
Laridae	*Hydroprogne caspia*	Caspian tern	Migratory	SL
Rhipiduridae	*Rhipidura rufifrons*	Rufous fantail	Migratory	SL
Monarchidae	*Myiagra cyanoleuca*	Satin flycatcher	Migratory	SL
Monarchidae	*Symposiachrus trivirgatus*	Spectacled monarch	Migratory	SL
Papilionidae	*Ornithoptera richmondia*	Richmond birdwing		V

Note: SL = Special Least Concern, V = Vulnerable, E = Endangered

Amphibians

Six amphibian species were either seen or heard calling within the study area during the field survey. This included two threatened species and four least concern species. Giant barred frogs (*Mixophyes iteratus*) were heard calling at Site 1 on Six Mile Creek, and a single juvenile was observed at Site 2 downstream, with more adults calling near the transect. Six Mile Creek downstream of Lake Macdonald appears to provide suitable habitat for this species in the area surveyed, and potentially further downstream, though the results suggest a low density population is present in this area.

Tusked frogs (*Adelotus brevis*) were recorded by call at Site 4 (along Collwood Road) and Site 5 (eastern extent of Lake Macdonald). Along Collwood Road, tusked frogs were heard calling on the southern side of the road, near a drainage line that runs along the road. Thus, the identified frogs would cross Collwood Road to access breeding habitat.

At Site 5, in the shallow upper reaches of Lake Macdonald, tusked frogs were calling around the water's edge (Figure 8-8).

No evidence of tusked frog was detected at Six Mile Creek, however given the habitat requirements for this species and the vegetation communities / habitat features observed, Six Mile Creek is still considered potential habitat for tusked frog. Other species observed include eastern sedge-frog (*Litoria fallax*), graceful tree-frog (*Litoria gracilenta*) and striped marsh frog (*Limnodynastes peronii*). Cane toads (*Rhinella marina*) were also recorded in the study area.

Birds

A total of 83 bird species were observed across the study area. This included various forest and wetland bird species. The survey targeted species within forested areas that may be cleared or subject to construction disturbance and shallower areas of the dam that will be impacted by lowering of the water levels. Four species listed as migratory under the EPBC Act and special least concern under the NC Act were observed during the survey: Caspian tern (*Hydroprogne caspia*), rufous fantail (*Rhipidura rufifrons*), satin flycatcher (*Myiagra cyanoleuca*) and spectacled monarch (*Symposiachrus trivirgatus*). All other species observed are listed as least concern except Pekin duck (*Anas platyrhynchos domesticus*), which is an exotic species.

The forested areas of Sites 1 – 5 provide good quality habitat that is suitable for a variety of migratory forest birds, despite only the rufous fantail, satin flycatcher and spectacled monarch being observed. There is potential for many other significant species that were not observed during the week of field survey to occur.

Magpie goose (*Anseranas semipalmata*) and comb-crested jacana (*Irediparra gallinacea*) were observed in significant numbers at this site at Site 8, in the southern sections of the lake. There was evidence of breeding by the magpie goose at Site 9. While these species are not listed as threatened under Queensland legislation, they are listed as threatened under NSW legislation. The south east Queensland population could therefore be considered significant. There is also potential for white-bellied sea-eagle (*Haliaeetus leucogaster*), which is an EPBC migratory species, to use this area of the lake intermittently.

Reptiles

Four common reptile species were observed in the pitfall traps installed along both sides of Six Mile Creek and two additional species were seen during active searches. Species caught in the pitfalls were eastern water dragon (*Intellagama lesueurii*), dark bar-sided skink (*Concinnia martini*), water skink (*Eulamprus quoyii*), and pink-tongued lizard (*Cyclodomorphus gerrardii*). Additional species seen during active searches were the exotic Asian house gecko and an unidentified *Lampropholis* species. A pink-tongued lizard was also observed during spotlighting at Site 2.

No striped blind snakes or three-toed snake-tooth skink (the target EPBC species) were captured and these species are considered unlikely to occur in the Project area due to a lack of required microhabitat features (e.g. deep leaf litter and rotting logs). However, they may occur further downstream along Six Mile Creek, within Tewantin National Park, where required microhabitat features are more available.

Mammals

A platypus burrow was observed along the banks of Six Mile Creek in the vicinity of Site 2.

Nine microbat species were detected on the Anabat during Anabat surveys along Six Mile Creek and around Lake Macdonald. All of these recorded species are classified as least concern under the NC Act, and none are protected under the EPBC Act.

Six Mile Creek provides foraging habitat for species such as the fishing bat (*Myotis macropus*) and little bent-wing bat (*Miniopterus australis*). The Eastern tube-nosed bat (*Nyctimene robinsoni*) was recorded along Six Mile Creek by call. While this species is not listed as threatened, it is a specialised feeder in rainforest habitat where fruit is available and is listed as threatened under NSW legislation. Given the proximity to NSW, the south east Queensland populations could therefore be considered regionally significant.

Invertebrates

A male Richmond Birdwing butterfly was observed in the vicinity of Gumboil Road (Site 5) during midday bird surveys. This species is listed as vulnerable under the NC Act. No food plants for this species, birdwing butterfly vine (*Pararistolochia praevenosa*), were observed during the surveys, though some of the subtropical rainforest vegetation communities in the surrounding area are likely to provide suitable habitat for this species.

Pest Species

Three pest fauna species were observed during the field survey, namely cane toad (*Rhinella marina*), Pekin duck, and Asian house gecko (*Hemidactylus frenata*). All three species are commonly occurring fauna species across Queensland.

8.4 Impact Assessment

An assessment of the proposed works against the terrestrial ecological values of the Project area and study area, and the likely direct and indirect impacts, are discussed in the following sections. Impacts to Matters of National and State Environmental Significance are discussed separately. A detailed assessment of impacts to EPBC listed species against significant residual impact criteria is provided in Chapter 5– MNES.

The lake drawdown and construction phases of the Project may result in the following general impacts, which are discussed in further detail below:

- Changes in hydrology/environmental flows, which could impact threatened amphibian species, downstream mapped High Ecological Value (HEV) waters (wetlands and waterways), and identified areas of high ecological significance wetlands
- Direct impacts to remnant vegetation communities and species habitats
- Direct impacts to aquatic vegetation communities and aquatic fauna due to the lowering of the Lake which may therefore impact bird species that rely on aquatic flora and fauna for survival
- Reduction of water quality – water quality in the lake may be impacted by lowering of water levels, while Six Mile Creek downstream may be impacted by earthworks, causing increased erosion and sedimentation and associated impacts on amphibians
- Additional traffic – minor increases in vehicular traffic are likely to occur during construction resulting in an elevated risk of wildlife vehicle strike
- Weed invasion and edge effects as a result of additional vegetation clearing and vehicle movement during construction.

Operational phase impacts on terrestrial ecology values as a result of the Project are likely to be minor and similar in nature and intensity to the current operation.

8.4.1 Matters of National Environmental Significance

This section discusses the presence and potential impacts to MNES, including species and vegetation communities, in accordance with the *Matters of National Environmental Significance Significant Impact Guidelines 1.1.*

Listed Threatened Ecological Communities

No TEC occur within the Project area. Areas of Lowland Rainforest occur to the east of the project, but will not be directly impacted. Indirect impact on these areas also seem unlikely given their distance from the Project.

Listed Threatened Species

The Project has been referred as a controlled action under the EPBC Act. The referral discussed potential impacts to a number of threatened species listed under the EPBC Act, with the giant barred frog (*Mixophyes iteratus*) being the only terrestrial fauna species noted in the referral. Aquatic species are addressed in Chapter 7 – Aquatic Ecology.

Giant Barred Frog

Suitable habitat and presence of giant barred frogs were confirmed along Six Mile Creek downstream of the dam. The species occurs along shallow rocky streams in rainforest, wet sclerophyll forest and farmland between 100 m and 1000 m elevation (Covacevich & McDonald 1993) or deep, slow moving streams with steep banks in lowland areas. The downstream areas of Six Mile Creek meet the latter description. A short term study of the patterns of daily movement of this species during the breeding season showed that individuals moved up to 100 m in a night, but not more than 20 m from the stream (Lemckert & Brassil 2000). Therefore, habitat for the giant barred frog is confined to a long, narrow area of habitat along Six Mile Creek.

The Project has the potential to result in temporary and localised impacts to giant barred frog and its habitat within Six Mile Creek. During drawdown, construction and refilling of Lake Macdonald, this species could be negatively impacted by changes to water quality and hydrology. There may be increased sedimentation, and altered frequency and velocity of flows until the dam is recommissioned. These factors are more likely to affect breeding (altered water quality and flushing of tadpoles due to increased velocity during lake drawdown) than adult frogs, which have the capacity to avoid what is essentially a flood event. Through careful management of the drawdown and construction process, it is considered possible to mitigate any significant impacts to this species. This includes establishing water quality criteria, installing erosion and sediment controls, and maintaining flow rates as discussed in section 8.5. Flows will be managed during construction to ensure water levels downstream do not exceed the bankfull width, and the drawdown is proposed to be gradually undertaken over a period of three months to allow species to adjust. Should any heavy rainfall events occur during construction, the impacts to Six Mile Creek are not expected to substantially differ from impacts associated with storm flow or flood events under normal conditions.

Following the initial drawdown of Lake Macdonald, an increase in cane toad populations may occur due to the increase in shallow, still waters that are ideal for cane toad breeding. Female cane toads can lay anywhere between 8,000 and 30,000 eggs at a time (Cameron, 2016). Cane toads are known to feed on smaller frog species, therefore, an increase in toad individuals could potentially lead to a decrease in native frog species (Cameron, 2016) and other species that predate amphibians (e.g. red-bellied black snake *Pseudechis porphyriacus*).

Following completion of the Project and refilling of the dam, downstream flows will not differ from pre-existing conditions. No operational phase impacts are expected to occur to giant barred frog.

A Significant Impact Assessment for giant barred frog has been conducted in accordance with the *Significant Impact Guidelines 1.1* and is provided in the Chapter 5 – MNES.

Koala and Grey-headed Flying Fox

The field survey did not identify any evidence of koala or grey-headed flying fox within the study area. However, vegetation communities identified in the Project area provide suitable foraging habitat for both species, including within the proposed construction footprint. The vegetation communities identified are eucalypt dominated, containing species that flower in winter for flying foxes, and comprise secondary trees for koala. There is potential for both species to occur intermittently and for koala, likely in low density.

Vegetation of importance for both species will be directly impacted by construction, around Camp Cooroora and north of Collwood Road. However, there are no flying-fox camps that are mapped or were observed in the study area. This species is also highly mobile. Removal of habitat suitable for flying-fox is therefore not expected to result in a significant impact to this species. An assessment against the significant impact criteria has been undertaken and is provided in Chapter 5 – MNES.

As koalas largely sleep during daylight hours, construction phase activities may disturb this species through increased noise and vibration; this is discussed further in section 8.4.3. Koalas are relatively sedentary and tend to stay within their home ranges. A significant impact assessment against the EPBC criteria has therefore been undertaken for koala, contained within Chapter 5 – MNES.

No additional flora or fauna species listed as threatened under the EPBC Act were detected during the terrestrial ecological assessment. This does not mean it is not possible for other threatened species to occur and the Construction Environmental Management Plan will need to contain procedures to be followed in the event any unexpected flora or fauna species listed under the NC Act or EPBC Act are encountered.

Migratory Species

Four bird species listed as migratory under the EPBC Act were recorded during the field survey, namely: Caspian tern, Spectacled monarch, Rufous fantail, and Satin flycatcher. All four of these species are relatively common and have a broad distribution and range. They were not observed within the proposed construction footprint, though they have the potential to occasionally occur in these areas.

Caspian tern forage in open wetlands, including lakes, and prefer shallow water along the margins. This species is therefore likely to feed in Lake Macdonald intermittently, though the study area does not contain suitable breeding habitat. Lowering of the lake will temporarily reduce and remove the shallow wetland areas that this species prefers for foraging.

The other three migratory species observed are likely to opportunistically utilise forested areas in the broader study area. Vegetation clearing is required within the Project area to allow for construction access and facilities. Removal of habitat suitable for these migratory species is likely to occur, though the extent will be minor and these species are likely to move into adjacent suitable habitat (i.e. RE connected to the Project area), throughout Tewantin National Park. It is therefore considered unlikely that the Project will have a significant impact on any of the migratory species observed in the study area. A more detailed assessment of the impacts to migratory species against the *Significant Impact Guidelines 1.1* is provided in the Chapter 5 – MNES.

A number of additional migratory species were considered in the EPBC referral, but were not detected during the survey (refer to Appendix I for the full list of migratory species). No nesting sites for migratory bird species or specific habitat features were observed during the survey.

8.4.2 Matters of State Environmental Significance

This section discusses the presence of and potential impacts to MSES as defined under the *Environmental Offsets Act 2014*.

Regulated Vegetation

The regulated vegetation MSES refers to the following:

- Endangered or of concern REs
- Remnant vegetation within the defined distance of a watercourse identified on the vegetation management watercourses map
- Remnant vegetation that intersects with an area shown as a wetland on the vegetation management wetlands map
- Essential habitat as identified on the essential habitat map.

These MSES, their relevance to the Project and potential impacts as a result of drawdown and construction are discussed in further detail below.

Regional Ecosystems

The Project will require clearing within the construction footprint to facilitate construction. Two REs with a vegetation management status of 'of concern' were identified in this area and are likely to be cleared, resulting in direct impacts

to this MSES. The areas directly affected by clearing are shown in Figure 2-8 and direct impacts are discussed in further detail below.

Indirect impacts to REs are also likely to occur as a result of edge effects. Edge effects is a term given to the physical and biotic impacts that can occur along natural and artifical boundaries of patches of vegetation communities. Artificial boundaries tend to be rapid and sharply-defined compared to natural edges. Impacts associated with edge effects can include altered microclimate, incursion of invasive flora and pest fauna species, reduced species richness, and increased risk of predation.

The proposed construction footprint is located within previously disturbed areas on land owned by Seqwater. The design extends into RE vegetation along Collwood Road and around Camp Cooroora. Additional clearing within RE communities has the potential to extend the area experiencing edge effects into previously undisturbed vegetation. The resulting impact of the Project is likely to be minor intrusion of pest flora species into adjacent vegetation.

RE 12.9-10.1 / RE 12.9-10.17

RE 12.9-10.1 and RE 12.9-10.17 are mapped as occurring at a ratio of 60% and 40% within Tewantin National Park, including the vegetation extending into the Project area. RE 12.9-10.1 has an of concern status under the *Vegetation Management Act 1999* (VM Act), while 12.9-10.17 has a status of least concern. Only RE 12.9-10.1 (mid-dense RE) was observed within the Project area. Approximately 1.2 ha of these REs may be directly impacted, if it is deemed necessary to clear the area north of Collwood Road and north of Camp Cooroora during construction. It has not been confirmed that clearing is necessary in these areas, but it may be required with further development of construction planning and has therefore been assume as such. This RE is also mapped as present along Collwood Road, which has been previously cleared.

For mid-dense REs, the clearing limits for a significant residual impact are 10 m in width or 0.5 ha in area. Clearing of more than 0.5 ha may trigger a significant residual impact and require offsets if no approval exemptions apply.

RE 12.3.2

RE 12.3.2 is a wetland RE that occurs along the fringe of Lake Macdonald in the vicinity of Camp Cooroora, north of the lake. Approximately 0.25 ha of this RE may be directly impacted if additional construction space is required.

This RE is also mapped as occurring in shallow wetland areas to the east of the lake such as Site 5. Lowering of the water level in the lake has the potential to temporarily impact this RE during construction by restricting water available to vegetation that typically fringes waterbodies. As the clearing of RE 12.9-10.1 exceeds the 0.5 ha threshold, offsets for this RE may be required if no approval exemptions apply.

Wetlands

As outlined in the Significant Residual Impact Guideline (December 2014), a project may have a significant residual impact on regulated vegetation where remnant vegetation intersects a wetland on the vegetation management wetlands map and is being cleared. For the Project, one wetland within the study area is mapped on the vegetation management wetlands map. This is located along Six Mile Creek, approximately 650 m downstream of the dam wall. This area will not be cleared or directly disturbed by the Project. As no clearing will occur in this area, the Project will not have a significant residual impact on this particular matter.

Watercourse

Permanent removal of remnant vegetation within the defined distance of a watercourse has the potential to result in a significant residual impact on regulated vegetation. Six Mile Creek upstream and downstream of Lake Macdonald is identified as a fourth order stream. As the site is within the coastal bioregion, the defined distance from a watercourse for Six Mile Creek is 25 m, as specified in Appendix 3 of the Queensland Environmental Offsets Policy Version 1.6. No permanent removal of remnant vegetation within this distance is currently proposed to occur for the Project. However, if clearing becomes necessary during future stages of the Project, clearing with no rehabilitation may trigger a significant residual impact and require offsets if no approval exemptions apply.

An additional minor, unnamed waterway with a stream order of 1 is mapped approximately 30 m north of Collwood Road, however vegetation clearing is not proposed to occur in this area. Clearing within a first order waterway is unlikely to trigger a significant residual impact.

Essential Habitat

Essential habitat is a category A, category B or category C area on the regulated vegetation management map that has at least three essential habitat factors stated as mandatory for the species e.g. landform, pollinator or RE, or in which the wildlife at any stage of its life cycle is located. Within the Project area, regulated vegetation is mapped as essential habitat for koala (addressed in the discussion of protected wildlife habitat below) and glossy black-cockatoo. Species records for giant barred frog and hairy hazelwood are mapped immediately north of the Project area, highlighting the potential for these species to occur within the clearing area, though hairy hazlewood was not observed within the Project area during the field survey.

Direct removal of approximately 1.2 ha of essential habitat for glossy black-cockatoo is likely to be required for the Project construction areas. However, while *Allocasuarina* species were observed throughout forested sections of the Project and study areas, no evidence of glossy black-cockatoo individuals or feeding on cones was detected. Vegetation surrounding Lake Macdonald provides some suitable habitat for this species, but suitable tree hollows for breeding are present at a very low density overall. Individuals may visit the Project area intermittently to forage. Removal of this essential habitat is unlikely constitute a significant residual impact as the 1.2 ha of clearing comprises less than 10% of the total essential habitat mapped on site.

Connectivity

Tewantin National Park and connecting vegetation within the Project area form part of a large vegetative corridor that stretches from Noosa North Shore to the east to Pomona in the west. This extends to Cooloola National Park north of Lake Macdonald. The Project area is predominantly contained within previously disturbed areas around the Noosa water treatment plant. Vegetation clearing may be required at the boundaries of the previously disturbed area around the treatment plant, and immediately east of this area. This will create a larger continuous patch of disturbed land, but will not result in creation of any additional barriers to fauna movement connectivity. The proposed construction footprint will not result in any significant fragmentation or isolation of habitats. Connectivity at a broad scale is unlikely to be significantly impacted by the Project. However, it is recommended that the connectivity tool be applied prior to construction to determine whether there will be a significant impact to connectivity.

Protected Wildlife Habitat

For the purposes of the *Environmental Offsets Regulation 2014*, protected wildlife is defined as:

- A high risk area on the flora survey trigger map that contains endangered or vulnerable plants
- A non-high risk area on the flora survey trigger map that contains endangered or vulnerable plants
- A non-juvenile koala habitat tree located in an area shown as bushland habitat, high value rehabilitation habitat or medium value rehabilitation habitat on the map called 'Map of Assessable Development Area Koala Habitat Values'
- A non-juvenile koala habitat tree in a bushland habitat area under the *Planning Regulation 2017* (low, medium or high bushland habitat on the 'SEQ Koala Protection Area Koala Habitat Values' Map) or a medium or high value rehabilitation habitat area
- Habitat for an animal that is endangered, vulnerable or special least concern.

Endangered or vulnerable plants

The study area is mapped as a high risk area on the flora survey trigger map, however no endangered or vulnerable plants were observed during the ecological assessment. However, given previous species records in the local area (e.g. hairy hazelwood), there is potential for these threatened species to be present within or immediately adjacent to the Project area. A flora survey in accordance with the Protected Plants Flora Survey Guidelines (DES, 2016) must be undertaken once the construction footprint and timeframes have been confirmed. In accordance with the *Nature Conservation (Wildlife Management) Regulation 2006,* the flora survey report must be submitted within 12 months of the date of survey, and clearing must be completed within 2 years of submission of the report. Due to uncertainty around construction timeframes, a detailed survey in accordance with these guidelines has not yet been undertaken. A Protected Plant Flora Survey will be conducted within 12 months of the Project commencing, once construction schedules are known.

Koalas

Review of the 'Map of Assessable Development Area Koala Habitat Values' indicates there are no areas of bushland habitat or rehabilitation habitat for koala within the study area. The 'SEQ Koala Protection Area Koala Habitat Values' Map identifies the majority of the Project area as containing either low or medium value koala bushland habitat. This

is reflected on the MSES Wildlife Habitat map which shows koala bushland. The vegetation communities within the Project area are eucalypt dominated and therefore contain non-juvenile koala habitat trees. Despite anecdotal reports of koalas within Tewantin National Park, no evidence of koalas was detected during the field survey. An assessment has been undertaken to determine whether the Project will result in a significant residual impact to koala in Chapter 5 – MNES. Chapter 5 also includes an assessment of the Project against the Koala Habitat Assessment Tool contained within the *EPBC Act referral guidelines for the vulnerable koala*. While the koala habitat assessment tool indicates that the Project area includes habitat critical to koala survival (achieving a score of 5), the area to be cleared borders an already highly modified environment and no evidence of koalas was found during the field survey. As such, it is considered that the Project is unlikely to adversely affect habitat critical to the survival of koalas.

Frogs

Essential habitat for the giant barred frog is also mapped within the Project area on the MSES Wildlife Habitat map. This extends along Six Mile Creek and in vegetation surrounding the Camp Cooroora (refer to Figure 8-10). Impacts to this species are addressed in the MNES section, as this takes precedence over state matters. A significant residual impact is not expected to occur to giant barred frog.

The field survey identified suitable habitat for tusked frog along the downstream section of Six Mile Creek, the tributary that runs through Tewantin National Park, and in the shallow upper reaches of Lake Macdonald near survey Site 5. This area is not currently mapped as protected wildlife habitat under the MSES mapping. The tusked frog is listed as vulnerable under the NC Act. Six Mile Creek and its tributary are likely to provide breeding habitat for tusked frog and may be temporarily impacted by hydrological changes during construction. Lowering of the water level will be undertaken over three months, therefore enabling fauna to adjust to changes within Six Mile Creek. Suitable habitat in the shallow wetland areas of Lake Macdonald will be temporarily impacted during construction as water currently present at areas such as Site 5 will be drained. However, it is likely that tusked frogs occur upstream of the lake's full supply level, in habitat areas that will not be impacted by the Project. These areas would provide a source population(s) for the recolonisation of affected habitat. An assessment of impacts to this species against the significant residual impact criteria prescribed for protected wildlife habitat under the Significant Residual Impact Guideline (DLGRMA, 2014) is provided in Table 8-9. An action is likely to have a significant residual impact on habitat for an animal that is endangered or vulnerable if the action will cause any of the criteria to occur. Based on the below assessment, the Project is not expected to have a significant residual impact on tusked frogs.

Table 8-9: Significant Residual Impact Assessment for tusked frog

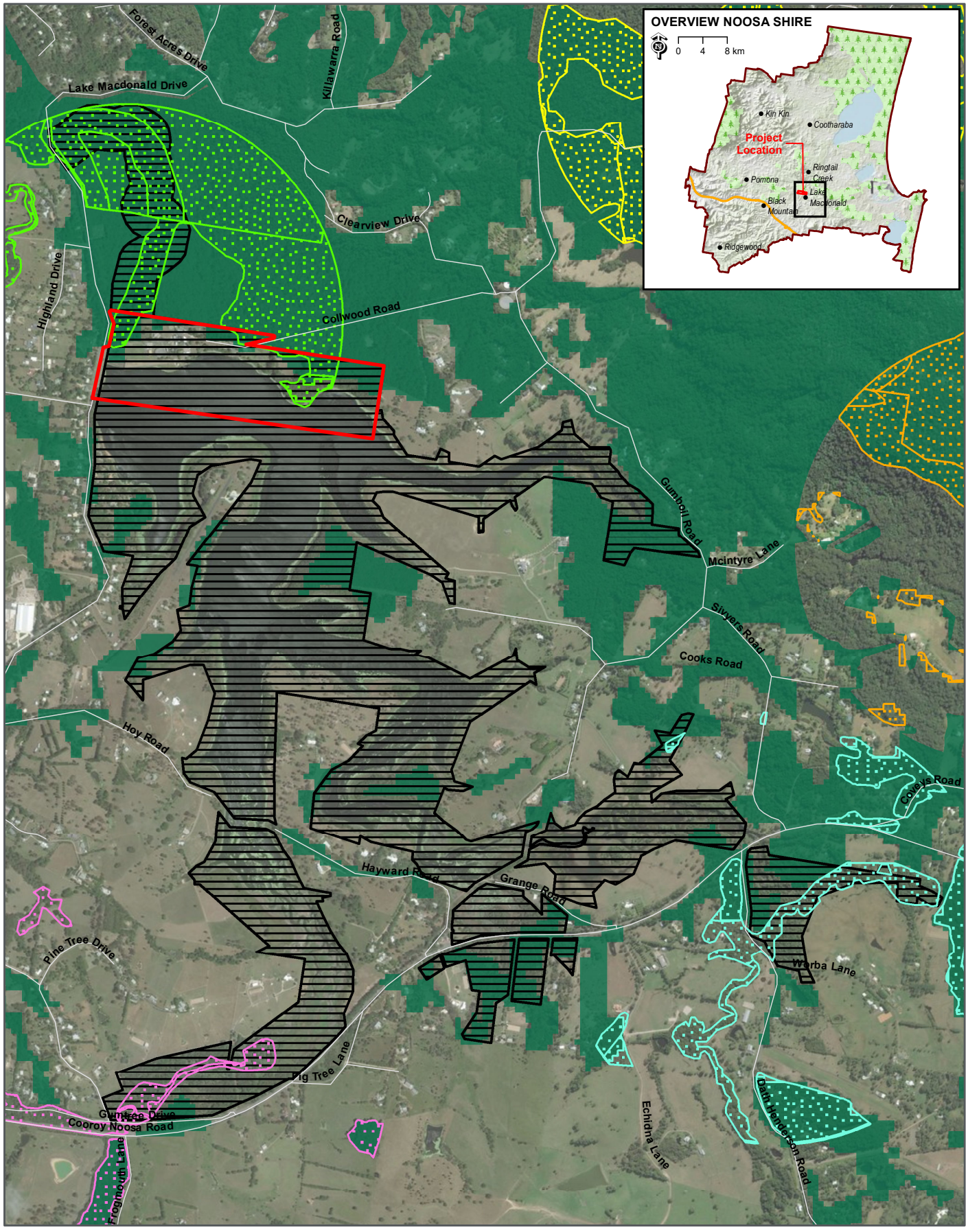
CRITERIA	RESPONSE FOR LAKE MACDONALD UPGRADE PROJECT
(a) lead to a long-term decrease in the size of a local population	Field surveys identified tusked frog individuals along Collwood Road and within shallow wetland areas near Site 5. Tusked frog is considered likely to breed along the drainage line that runs parallel to Collwood Road, however this channel is not expected to be directly impacted by the Project. No more than two individuals were detected at each of these sites, indicating a small population is likely to occur. While no evidence of tusked frog was detected along Six Mile Creek during the field survey, there is potential for this species to occur as suitable habitat is present. Tusked frogs are known to occur in highly disturbed and modified habitats and have a wide range of suitable habitat types. Lowering of Lake Macdonald will temporarily reduce the shallow wetland habitat available at sites such as Site 5. This could also temporarily reduce suitable breeding habitat around Lake Macdonald during the construction phase. However, mitigation measures will be put in place to monitor and manage the impacts associated with the Project. Following completion of construction and refilling, the water level within Lake Macdonald will return to pre-construction levels. The goal will be to return vegetation communities to the current quality. Construction traffic will utilise Collwood Road throughout the construction phase, resulting in an increase in vehicular traffic adjacent to tusked frog breeding habitat. No additional vegetation clearing will be required to enable vehicle use, though there may be temporary disturbance through noise, dust and vibrations.

CRITERIA	RESPONSE FOR LAKE MACDONALD UPGRADE PROJECT
	Impacts to the populations in the Project area and along Collwood Road are likely to be temporary, but are not expected to lead to a long-term decrease.
(b) reduce the extent of occurrence of the species	Given the wide variety of habitat types that tusked frog inhabit, the removal of small areas of vegetation and temporary lowering of the water levels in Lake Macdonald are not expected to reduce the extent of occurrence of the species.
(c) fragment an existing population	The specific locations of tusked frog populations in the Lake Macdonald region have not been quantified, though they are known to occur in several locations. Vegetation clearing proposed for the Project will extend existing disturbed areas, particularly in the vicinity of the water treatment plant, but will not result in fragmentation or isolation of vegetation patches or waterways. The Project is not expected to fragment an existing population of tusked frogs.
(d) avoid genetically distinct populations forming as a result of habitat isolation	As above, vegetation clearing proposed for the Project will extend existing disturbed areas, but will not result in fragmentation or isolation of vegetation patches or waterways. The Project is not expected to isolate habitat such that forming of populations is prevented.
(e) result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat	Several invasive flora and fauna species are known to or are likely to occur within Lake Macdonald. Significant invasive species include cabomba, mosquito fish and cane toad. With the water levels being reduced, a large volume of water will be released downstream into Six Mile Creek. During the release of water, it is highly likely that tadpoles, fish and aquatic weeds (e.g. cabomba) will be released downstream, thereby having the potential to result in increased populations of mosquito fish, tadpoles and aquatic weeds. These species currently exist within Six Mile Creek (downstream) in low abundance and are released from the dam during periods of high flow. Therefore, the Project is not expected to result in the establishment of any new invasive species within potential habitat for tusked frog. Mitigation measures will be implemented throughout the Project to manage invasive species within Lake Macdonald and downstream within Six Mile Creek.
(f) introduce disease that may cause the population to decline	Chytrid fungus is a known threat to tusked frogs. However, the Project will not result in changes that are likely to introduce or further spread this disease. If it is currently present in the vicinity of Lake Macdonald, tadpoles with the fungus would be transported downstream during flood events, which would not change during the drawdown or construction phases of the Project. It is therefore unlikely to introduce any diseases that may cause the population to decline.
(g) interfere with the recovery of the species	Tusked frogs are not currently listed as protected under Commonwealth legislation and therefore do not have a recovery plan. Key threats include habitat destruction, pest species (e.g. cane toads), and chytrid fungus. The Project will result in minor habitat destruction and has the potential to increase cane toad production during construction. Installation of cane toad tadpole traps is proposed to manage population growth throughout construction.
(h) cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species	There are no known ecologically significant locations for tusked frog in the vicinity of Lake Macdonald, however the drainage line along Collwood Road is a suspected breeding place. Additional surveys would be required to determine the likelihood and significance of breeding in this area. Construction traffic will utilise Collwood Road throughout the construction phase, thereby resulting in an increase in vehicular traffic adjacent to tusked frog breeding habitat. No additional vegetation clearing will be required to enable vehicle use, though there may be temporary disturbance to adjacent breeding habitat through noise, dust and vibrations.

CRITERIA	RESPONSE FOR LAKE MACDONALD UPGRADE PROJECT
	If breeding places are present in vegetation immediately surrounding Lake Macdonald, lowering of water levels may temporarily disrupt this breeding habitat for the duration of construction. Exclusion fencing is proposed to be installed to prevent construction activities entering known breeding places.

FIGURE 8-10: MAPPED PROTECTED WILDLIFE HABITAT

Six Mile Creek Dam Safety Upgrade Project



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seqwater WATER FOR LIFE

LEGEND

- Bruce Highway
- Road (secondary and local)
- Study Area
- Project Area
- Local Governmental Area

Mapped Protected Habitat

- Tusked frog
- Giant barred frog
- Platypus
- Native mint
- Ricinocarpos speciosus
- Koala

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Protected Areas

Tewantin National Park, located immediately north of the proposed construction footprint, is recognised as a protected area (estate). Surveys in this area were restricted to visual observations only. Vegetation within the National Park is predominantly remnant and high value regrowth tall open forest and woodland communities (RE 12.9-10.1 and RE 12.9-10.17). The Tewantin National Park boundary also encompasses Six Mile Creek, which contains a combination of riparian vegetation communities that are both remnant and high value regrowth (RE 12.3.11, RE 12.3.2 and RE 12.3.1).

No works are to be undertaken within the National Park, but will be immediately adjacent and upstream (refer to Figure 8-1). Indirect impacts may occur to this area during the construction and operational phases of the Project. This comprises potential degradation of the edges of the National Park through removal of adjacent vegetation which currently provides a buffer to the National Park. Edge effects, as discussed in section 8.4.2, may occur within the National Park. However, the Project will not have a significant residual impact on protected areas.

Waterways Providing Fish Passage

Waterways providing fish passage, likely impacts and offsets associated with the Project are addressed in Chapter 7 – Aquatic Ecology. A Development Approval for waterway barrier works will be required for the project and is further addressed in Chapter 3 Regulatory Approvals and Planning.

Wetlands and Watercourses

The Project area and study area contain wetlands and watercourses mapped as MSES (refer to Figure 8-11). These include the following:

- Wetland protection areas (WPA)
- Other High Ecological Significance Wetlands shown on the map of referable wetlands
- High Ecological Value (HEV) waters (wetland) – Mary River at the upstream end of Lake Macdonald
- High Ecological Value (HEV) waters (watercourse) – at the upstream end of Lake Macdonald

High ecological significance wetlands are mapped on the map of referable wetlands at Site 6, the southern extent of Lake Macdonald, along Six Mile Creek (upstream and downstream), and south of Camp Cooroora. There are no WPAs mapped in the study area.

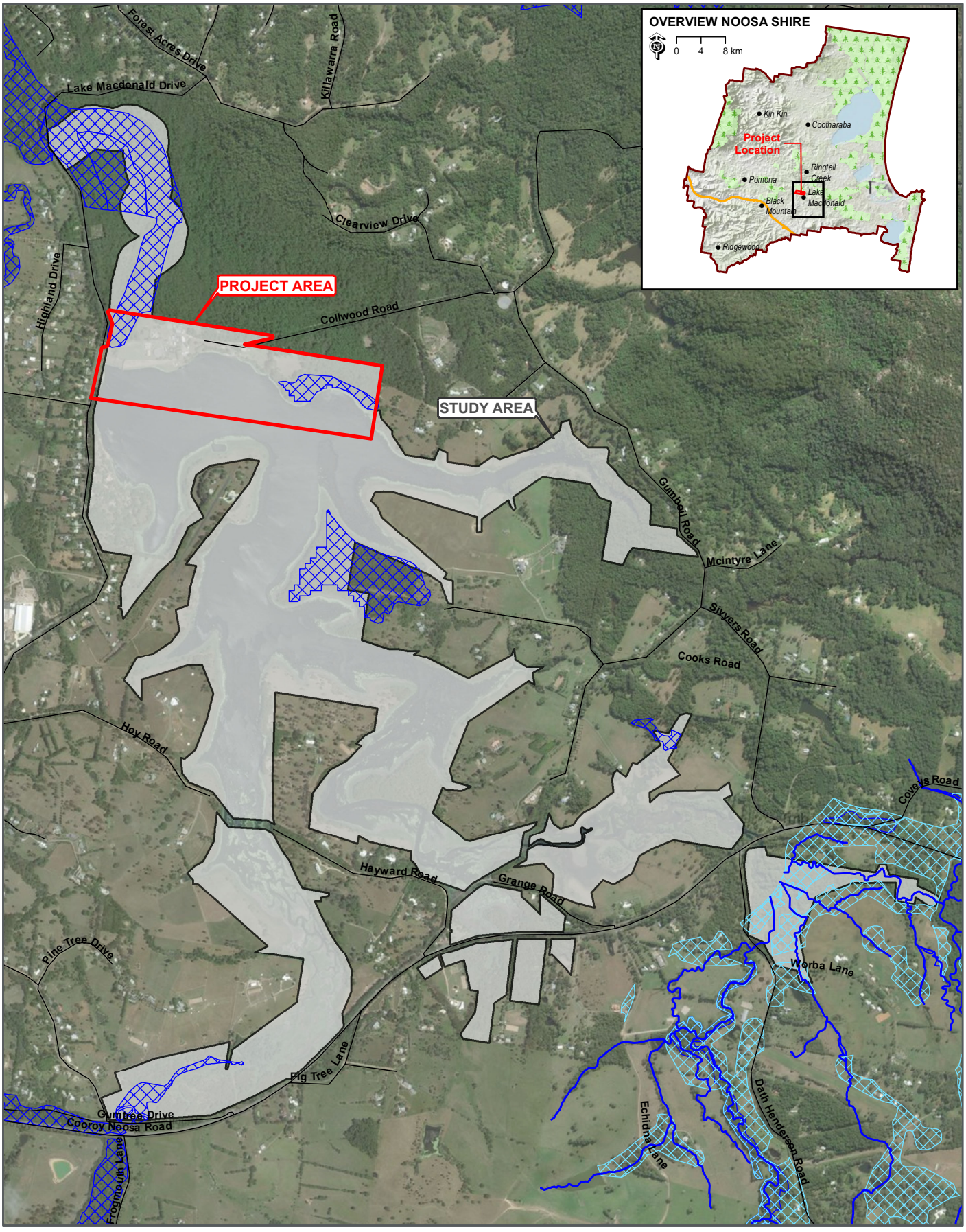
Declared high ecological value waters (wetland - Mary River) are mapped as occurring upstream of the lake near Site 7. High ecological value waters (watercourse), attributed to the Mary River, are also mapped as occurring upstream of the lake at Site 7 and surrounds, along the unmapped tributary of Six Mile Creek.

In the vegetation south of Camp Cooroora, high ecological significance wetlands will be directly impacted through vegetation clearing. Other wetland areas, including around Site 6 and along Six Mile Creek upstream, may be indirectly impacted temporarily as a result of the lake lowering. Under the Significant Residual Impact Guideline, activities that result in permanent degradation of landform, vegetation or water quality associated with the above wetlands may trigger a significant residual impact. Vegetation clearing in the vicinity of Camp Cooroora may therefore trigger a significant impact that requires offsets if no approval exemptions apply for the Project. If required, it is possible that for offset calculations, some of the mapped wetland impact areas will co-occur with other of concern RE areas proposed to be cleared.

Wetland areas are also vulnerable to changes in hydrology and water quality, which could potentially occur as a consequence of the construction of the project. An impact assessment, and discussion of management and mitigation measures, is included in section 8.5.

FIGURE 8-11: MSES WETLAND

Six Mile Creek Dam Safety Upgrade Project



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seqwater WATER FOR LIFE

LEGEND

- Bruce Highway
- Road (secondary and local)
- MSES High Ecological Value Water (watercourse)
- MSES High Ecological Value Water (wetlands)
- MSES High Ecological Significance (wetlands)
- Study Area
- Project Area
- Local Governmental Area

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8.4.3 Noise and Vibration

The construction will result in increased noise and vibration levels around Lake Macdonald. A detailed assessment of noise and vibration impacts and identification of mitigation measures is provided in Chapter 11 – Noise and Vibration. Potential impacts to terrestrial ecology as a result of noise and vibration are discussed here.

Increased noise and vibration levels have the potential to temporarily disturb local fauna species. A limited number of fauna species were identified in the Project area and Tewantin National Park during the field survey, however there is still potential for common and threatened species to occur. The forested areas of Tewantin National Park contain Eucalypt species that may provide foraging habitat for bat species, though no roosts were identified nearby. Nocturnal species, including possums and gliders, may be disturbed by daytime noise levels. Increases in construction noise can also impact on avian species who rely on the detection of calls for a range of functions, including breeding (Barber et.al 2011). Any impacts are likely to be short term and temporary, and therefore will not represent a significant impact on local fauna species.

8.4.4 Dust

During construction, additional disturbance areas will be created within the proposed construction footprint. Construction activities including vegetation clearing, movement of plant and equipment, and excavation are likely to generate localised increases in dust and suspended particulate matter. Given the importance of Tewantin National Park, consideration of dust impacts on vegetation is important for the Project. Chapter 10 – Air Quality discusses the potential impacts of dust generation and deposition on surrounding vegetation.

Dust deposition rates above 350 mg/m^2/day may occur along the boundary of Tewantin National Park during peak construction activities. The air quality assessment notes that dust deposition rates above this level have the potential to impact vegetation through smothering, therefore reducing photosynthesis processes. This does, however, vary from one species of plant to another. It is considered possible to manage this impact through implementation of suitable mitigation and management measures during the construction phase.

8.4.5 Traffic

The construction phase of the Project is expected to result in increased vehicular traffic to and from the construction footprint. Proposed Project transport routes are likely to utilise Lake Macdonald Drive from the west and Collwood Road / Gumboil Road from the east, as discussed in Chapter 9 – Traffic and Transport. The traffic assessment notes a conservative estimate of, on average, 49 staff vehicles and two heavy vehicles travelling to site during the construction period. This is likely to cause a temporary increase in noise levels along local roads that typically have light traffic and are adjacent to vegetation. The increase in traffic also has the potential to result in increased vehicle strike of wildlife, particularly if night works are required through the construction phase.

8.5 Impact Mitigation and Management

The upgrade of Six Mile Creek Dam presents a number of risks associated with the design, drawdown, construction and operation phases of the Project as discussed above. The mitigation and management measures proposed for each terrestrial ecology aspect and specific species are detailed in Table 8-10.

Table 8-10 also incorporates an assessment of the impact before and after the implementation of mitigation measures, thereby identifying where a significant residual impact is likely to occur.

Table 8-10: Mitigation and management measures proposed to manage ecological impacts

ECOLOGICAL ASPECT	PROJECT PHASE	POTENTIAL IMPACT	IMPACT RISK BEFORE MITIGATION	MITIGATION AND MANAGEMENT	RESIDUAL IMPACT RISK
Biosecurity (flora)	Construction Operation	Spread of weed species through vehicle movements across the site Edge effects, including invasion of weed species into adjacent undisturbed vegetation	Medium	Undertake weed management during the Project, including implementation of wash-down guidelines and procedures for vehicles. Rehabilitate disturbed areas following completion of construction to prevent pest species from becoming established. Implement a pest management plan for the Project that is consistent with Seqwater's Water Supply Scheme Pest Management Plan and Catchment Services Biosecurity Operational Plan. Continue to implement operational plans to address biosecurity matters, including regular treatment of declared matters under the *Biosecurity Act 2014*. All personnel should be responsible for managing biosecurity risks and: • Take all reasonable and practical steps to prevent or minimise each biosecurity risk • Minimise the likelihood of causing a biosecurity event and limit the consequences if such an event is caused • Prevent or minimise the harmful effects a risk could have, and not do anything that might make any harmful effects worse.	Low
Biosecurity (fauna)	Construction	Introduction and / or increase in cane toads through lowering of water levels in the lake (creating shallow pools)	Medium	Implement management measures for cane toads. The recommended management measure is setting cane toad tadpole traps	Low

ECOLOGICAL ASPECT	PROJECT PHASE	POTENTIAL IMPACT	IMPACT RISK BEFORE MITIGATION	MITIGATION AND MANAGEMENT	RESIDUAL IMPACT RISK
				around the edges of the lake to reduce tadpole populations.	
	Construction / Operation	Introduction and / or increase in other pest fauna	Low	Provide bins across the work site for food waste. These should be emptied on a regular basis to prevent overflow and attraction of rodents. Routinely inspect the edges of Lake Macdonald during construction to detect and address any increased pest fauna as a result of lake lowering.	Low
Dust management	Construction	Smothering of adjacent vegetation, resulting in impacts to photosynthesis	High	Prepare and implement a Construction Environmental Management Plan that includes measures to minimise and manage dust generation. This should include: • Dust suppression measures (e.g. water cart) • Avoiding undertaking earthworks activities during dry/ high wind weather	Low
Remnant vegetation	Design	Direct loss of RE vegetation and diversity in vegetation community	High	Locate infrastructure, laydown areas and construction access sites within areas of previous disturbance, wherever possible, to minimise vegetation removal. Preferentially select non-remnant vegetation over remnant vegetation for clearing.	Medium
	Construction		High	Minimise tree clearing to the greatest extent possible. Maximise use of existing disturbed areas on Seqwater land. Vegetation clearing should be conducted in a manner that minimises impact to surrounding	Medium

ECOLOGICAL ASPECT	PROJECT PHASE	POTENTIAL IMPACT	IMPACT RISK BEFORE MITIGATION	MITIGATION AND MANAGEMENT	RESIDUAL IMPACT RISK
				vegetation, including the use of suitably sized equipment. Installation of no go zones with flagging tape and signage to prevent disturbance of vegetation outside the construction footprint.	
Fuels and chemicals	Construction	Fuels and / or chemicals leaking into adjacent vegetation or Six Mile Creek, thereby temporarily impacting habitat quality	High	Undertake storage and transport of hazardous materials and dangerous goods according to relevant Australian standards, guidelines and legislation. Refuelling and maintenance activities should be undertaken in designated bunded areas to minimise the potential for soil and water contamination from these activities. Prepare and implement spill response measures.	Low
Water quality	Construction	Destruction of suitable breeding habitat for frog species (e.g. giant barred frog, tusked frog and cascade tree frog)	Medium	Discharge of water during the lake drawdown process should be controlled, including maintaining discharge rates and velocities in Six Mile Creek consistent with those typically experienced during high flow events. Further detail is provided in the lake lowering plan. The period of time between Project completion and restoration of the Project area should be minimised to prevent loss of soils and weed incursion. Implement erosion and sediment control measures in accordance with the International Erosion Control Association (IECA) best practise guidelines. Establish release criteria for management of 'construction contaminated water'. Base flow	Low

ECOLOGICAL ASPECT	PROJECT PHASE	POTENTIAL IMPACT	IMPACT RISK BEFORE MITIGATION	MITIGATION AND MANAGEMENT	RESIDUAL IMPACT RISK
				entering the construction zone is to be monitored and either held on site for treatment or discharged downstream under certain release criteria to prevent impacts to Six Mile Creek. Minimise sediment tracked offsite by construction vehicles and potentially washed into waterways through the use of wash down bays or similar.	
General fauna management	Construction	Fauna mortality as a result of increased vehicular traffic	Medium	Implement slow speed limits of 10 km per hour onsite to allow for animals to move out of the way and for drivers to have the ability to safely stop if an animal is identified within the vehicle path. Restrict construction hours to daylight hours, where practicable. Recommended construction hours are in accordance with Section 440R of the *Environmental Protection Act 1994*.	Low
	Construction	Temporary disturbance to fauna habitat (e.g. wetland areas of the lake)	High	Prevent fauna fatalities due to habitat loss by: • Minimising the period of time that the dam is lowered during construction. • Implementing the lake lowering plan, including salvage of aquatic species. • Engaging a suitably qualified and licenced fauna spotter catcher for the duration of clearing to relocate any fauna encountered. • Conducting clearing sequentially to enable fauna to move into adjacent habitats.	Medium

ECOLOGICAL ASPECT	PROJECT PHASE	POTENTIAL IMPACT	IMPACT RISK BEFORE MITIGATION	MITIGATION AND MANAGEMENT	RESIDUAL IMPACT RISK
				Site inductions should be delivered to all construction personnel to educate them on how to identify key threatened species, and implement a STOP, MANAGE AND NOTIFY process if encountered. The induction should include the following: • Physical attributes for platypus identification such as bubbles rising to the surface of the water and a quick re-surface of a dark brown object approximately the size of a forearm • Platypus burrows can be identified as a neat hole, approximately 25 cm wide, in the banks of a creek/dam with overhanging vegetation • Tusked frogs are identified by their black and dark brown blotches, a pointed ventral snout, 40 mm long and red colouring on the thighs and groin • Giant barred frogs are identified by their large size (up to 115 mm long) and distinctive eye colour which is a vertical pupil and golden iris. Limbs have dark crossbars • Richmond birdwing butterflies are most commonly identified by their size, with a wingspan of up to 16 cm. Males have a distinctive iridescent green with black spots and females are brown with extensive white, cream and yellow markings on the hindwing • Photographs of these key species	

ECOLOGICAL ASPECT	PROJECT PHASE	POTENTIAL IMPACT	IMPACT RISK BEFORE MITIGATION	MITIGATION AND MANAGEMENT	RESIDUAL IMPACT RISK
				Retain felled logs and branches in designated stockpile locations for reuse in site rehabilitation, where possible.	
	Construction	Light disturbance in fauna habitats from construction activities	Medium	All bright lights should be positioned as close to the ground as practical. Where possible, light should be shielded so that it is directed toward the ground, minimising light spill towards any surrounding habitat. Utilise lighting that does not attract insects. Use only the minimum amount of lighting needed for safety. Avoid the use of naked bulbs and use narrow spectrum bulbs where possible. Use motion sensor lights where possible to only illuminate areas in use.	Low
	Construction	Noise and vibration disturbance to adjacent fauna habitats	Medium	Construction works and consideration of quiet work practices should be carried out in accordance with Australian Standard 2436-2010, Guide to noise control on construction, maintenance and demolition sites (Standards Australia, 2010).	Low

ECOLOGICAL ASPECT	PROJECT PHASE	POTENTIAL IMPACT	IMPACT RISK BEFORE MITIGATION	MITIGATION AND MANAGEMENT	RESIDUAL IMPACT RISK
Giant barred frog	Construction	Direct impacts to giant barred frog habitat along Six Mile Creek (downstream)	High	Where possible, conduct the lake drawdown outside of giant barred frog breeding season (September to May) and manage discharge rates to minimise impact on breeding habitat Construction footprint avoids areas of dense overhanging riparian vegetation (suitable breeding places). Implement erosion control in Six Mile Creek downstream of the dam, where necessary, and manage drawdown rates during the Project to prevent bank degradation as a result of scouring. Engage an appropriately qualified fauna spotter catcher to conduct a pre-clearing survey and salvage all EPBC species and eggs within the direct impact area. Any unplanned bank disturbance should not be completed until a suitably qualified person has inspected the banks for giant barred frog. Locate stockpiles away from drainage lines and cover if exposed for a long period of time. Designated stockpile areas should be accurately communicated to all site personnel.	Low
	Post-construction	Direct impacts to giant barred frog habitat along Six Mile Creek (downstream)	Medium	Rehabilitate disturbed banks following completion of construction. This includes revegetating areas impacted by construction, and stabilising exposed soils using biodegradable matting or similar.	Low

ECOLOGICAL ASPECT	PROJECT PHASE	POTENTIAL IMPACT	IMPACT RISK BEFORE MITIGATION	MITIGATION AND MANAGEMENT	RESIDUAL IMPACT RISK
Tusked frog	Construction	Direct impacts to tusked frog habitat along Six Mile Creek (downstream)	High	Prevent bank degradation as a result of scouring through management of drawdown rates. Where possible, conduct the lake drawdown outside of tusked frog breeding season (October to December). An appropriately qualified fauna spotter catcher should be engaged to conduct a pre-clearing survey and salvage all EPBC species and eggs within the direct impact. Locate stockpiles away from drainage lines, where possible, and cover if exposed for a long period of time. Designated stockpile areas should be accurately communicated to all site personnel. Prevent disturbance of breeding places, where possible, for example by installing fencing with no go signage around breeding places (e.g. drainage line on Collwood Road) to prevent direct construction impacts.	Low

8.5.1 Site Rehabilitation

Once the project footprint is finalised and construction staging confirmed a Project rehabilitation and revegetation plan should be prepared and implemented to guide the rehabilitation of area affected by the construction footprint. This rehabilitation would be independent of rehabilitation planning associated with offset requirements for the Project.

8.6 Recommended Monitoring

In order to track and appropriately manage impacts through the drawdown and construction phases of the Project, implementation of a monitoring program is recommended. This should include upstream and downstream locations in Six Mile Creek and across the Lake Macdonald waterbody. The suggested monitoring plan is detailed in Table 8-11 and is intended to be indicative rather than prescriptive.

Table 8-11: Recommended monitoring program

MONITORING TECHNIQUE	AIM AND METHODOLOGY	FREQUENCY	LOCATIONS
Photo monitoring points	Establish a series of photo monitoring points within areas of direct and indirect impact. This would include identifying sites, taking pre-construction photos and recording GPS location, photo direction (north, east, etc.) at each point. Taking regular photographs at set locations would assist with monitoring impacts associated with construction.	Once prior to construction. Monthly throughout lowering and construction. Quarterly until the lake has refilled and vegetation communities have re-established.	Throughout direct and indirect impact areas. Six Mile Creek upstream, and across shallow wetland areas (e.g. Site 5, Site 7 and Site 7).
Visual inspections of creek banks along Six Mile Creek (downstream)	Visual inspections of creek banks to detect evidence of erosion or morphological changes to the waterway.	Quarterly during water lowering and construction.	Six Mile Creek downstream of the dam at strategic locations within the study area.
Bird surveys	Conduct surveys of the lake to monitor changes in species assemblages during construction.	Quarterly during construction.	Fauna survey sites used in this assessment are recommended as the surveys can be compared against the baseline.
Water quality monitoring	Monitoring of water quality parameters and flow to check impacts to threatened frog species. Key parameters should include turbidity, total suspended solids, and dissolved oxygen.	Weekly for four weeks prior to construction (baseline). Weekly throughout lowering. Monthly during construction, or event based (following significant rainfall).	Six Mile Creek downstream of the dam within the study area.
Giant barred frog surveys	Larval sampling and active searches for egg masses in accordance with the Survey Guidelines for Australia's Threatened Frogs to assess impacts on breeding activity.	Between September and May (larval period), before, during and immediately after the drawdown, if possible.	Six Mile Creek downstream of the dam.

8.7 Environmental Offsets

Environmental offsets may be required for the Project where approval exemptions do not apply (refer to Chapter 3). Under the Queensland environmental offsets framework there are a number of options available for delivery of these offsets.

A proponent-driven offset may take the form of a traditional land-based offset, be undertaken through actions under a Direct Benefit Management Plan (DBMP), or a combination of both. An offset delivery plan is required for all proponent-driven offsets. Generally, all proponent-driven offsets must be legally secured. A financial settlement offset is a payment for a significant residual impact on a prescribed environmental matter(s). It must be calculated in accordance with the Financial Settlement Offset Calculation Methodology, which is outlined in the Queensland Environmental Offsets Policy. It is also possible to deliver an offset through a combination of these two methods.

Once the construction footprint is confirmed, a significant residual impact assessment will need to be undertaken to determine if offsets are required and an offset strategy may need to be developed. A preliminary assessment for state matters has indicated that, if approval exemptions do not apply, offsets may be required for significant residual impacts to the following matters:

- Regulated vegetation – of concern RE and clearing within the defined distance of a watercourseProtected wildlife habitat
- Waterways providing fish passage
- Wetlands and watercourses

8.8 Summary

The terrestrial ecological assessment has been conducted based on a detailed desktop assessment and subsequent field investigation in the Lake Macdonald study area. The assessment considered threatened flora, fauna and ecological communities, migratory species, pest species, and vegetation communities.

The survey confirmed that mapping of remnant vegetation communities is largely correct within the study area, though where a combination of RE 12.9-10.1 and RE 12.9-10.17 are mapped, the community within the Project area is predominantly RE 12.9-10.1. The removal of approximately 1.45 ha of this vegetation is likely to be required for the Project. No TECs were identified during the survey and these are not expected to be directly or indirectly impacted by the Project.

No threatened flora species were identified within the study area or Project area. It is considered unlikely for any threatened flora species to occur within the Project area; however, the flora survey conducted was a random meander and cannot completely guarantee the absence of threatened flora species.

Lake Macdonald provides extensive open water habitats and shallow wetland habitats in the upper reaches and along the fringes of the lake. It is surrounded by a variety of different forest communities (wet and dry Eucalypt forest, swamp forest), which are mapped as various remnant RE vegetation communities. This variation enables a diversity of flora and fauna species to be supported. However, most forest areas lack important habitat features such as hollow-bearing trees and fallen logs, which limits the presence of species that require these mature forest elements.

Two threatened frogs were recorded during the survey: the giant barred frog and the tusked frog. The giant barred frog occurs along Six Mile Creek, downstream of the dam. This area is also potential habitat for the tusked frog, although it was not recorded in this location. The tusked frog was recorded at one site in the upper lake and also along Collwood Road, which is likely to be used for construction access. It is likely that the population in this location would occur on both sides of the road and individual frogs would cross between foraging and breeding habitat on opposite sides of the road. A significant impact assessment for tusked frog has been undertaken as part of this report, while the assessment for giant barred frog is contained within Chapter 5 – MNES. With implementation of appropriate mitigation and management measures, a significant impact is not expected to occur to either frog species.

A Richmond birdwing butterfly was observed within the forest at Site 5, but is not expected to be impacted by the Project. No food plants for this species were detected. No other threatened fauna species were recorded within the study area. There is potential for koala and grey-headed flying-fox to utilise the Project area despite no evidence of these species during the survey. A significant impact assessment for these species has been undertaken within the MNES Chapter and identified that a significant residual impact is not likely to occur.

Migratory aquatic and forest birds listed under the EPBC Act were recorded in the study area, including satin flycatcher, rufous fantail, Caspian tern and spectacled monarch. The aquatic species would use both the open waters

and fringing vegetation of Lake Macdonald. The forest migrants utilise moist forest habitats, including habitat within the proposed construction area and will be subject to minor habitat loss.