Appendix 3

Abel Underground Coalmine Dam Monitoring and Management Plan: 2008 Baseline Report

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Abel Underground Coalmine Dam Monitoring and Management Plan:
2008 Baseline Report.

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Report prepared for Donaldson Coal Pty Ltd.

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Executive Summary

Donaldson Coal Pty Ltd commenced operating Abel Underground Coalmine at Beresfield in the lower Hunter Valley, New South Wales, during 2008. To comply with part of the conditions of consent a Flora and Fauna Management Plan was prepared in late 2007 by EcoBiological. This plan identified the need to establish a Dam Monitoring and Management Plan (DMMP) for 175 dams located above the Abel underground mining area. It was determined in the Abel Environmental Assessment (EA) that these dams are vulnerable to subsidence impacts such as cracking or tilting with significant water loss resulting. The purpose of the DMMP is to make an initial assessment of the value of these dams for threatened and other species of flora and fauna, and to establish a long-term monitoring program to monitor and manage any environmental impacts that the mine might have on habitat associated with the dams.

This report provides an initial assessment of the value of the dams for target threatened flora and fauna species, as well as baseline information on the occurrence of threatened and other species against which any changes over time can be measured and evaluated. It has been estimated that it will take between 5 and 7 years before any impact on the dams is likely to occur from subsidence, which will allow enough time to gather suitable information on the presence and status of threatened species present in the dams. This information will then be available to inform best practice measures to be incorporated into the Subsidence Management Plan (SMP).

The Surface Ecological Monitoring Plan (SEMP), of which this plan forms a part of, will continue until one year after mining has passed the Long Gully and Blue Gum Creek catchments.

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1. Introduction

Donaldson Coal Pty Ltd (Donaldson) has commenced operations for a new underground mine (Abel), approximately 23 kilometres north-west of Newcastle. The mine will extract up to 4.5 million tonnes per year over 21 years using high productivity continuous miner based bord and pillar systems, and pillar extraction techniques. The seams to be mined are located under the Black Hill rural and adjoining forested areas. Mine access and associated surface infrastructure will be located within the existing Donaldson Coal mine open cut void at Beresfield, with transfer of coal to the existing Bloomfield Coal Handling and Preparation Plant (CHPP) immediately to the north for coal washing and rail transport to the Port of Newcastle.

Underground coal mining is often associated with adverse environmental impacts because of subsidence (Bell *et al.* 2000, Sidle *et al.* 2000). Subsidence can cause loss of productive land, damage to underground pipelines and above-ground structures, decreased stability of slopes and escarpments, contamination of groundwater by acid drainage and dewatering of streams and groundwater supplies (Sidle *et al.* 2000). Of these, one of the major environmental concerns arising from the Abel mine is the effect of subsidence on local and regional hydrology. Surface and sub-surface cracking associated with mining subsidence can alter and create preferential flow paths, thus causing dewatering and rerouting of surface water and groundwater (Sidle *et al.* 2000). Alterations in channel and drainage morphology may also affect channel erosion, sediment delivery, and routing in streams and riparian habitat.

Associated with development approval for the Abel coalmine were a number of conditions of consent. These conditions included a requirement for the preparation of a Flora and Fauna Management Plan (F & FMP) which was prepared by EcoBiological in 2007. The F & FMP, which forms part of a comprehensive Environmental Management System for the Abel mine, sets out a strategy to monitor the effectiveness of the conservation measures proposed in the Environmental Assessment (EA) Statement of Commitments for the overall operation of the mine. Part of this strategy was to establish a Surface Ecological Monitoring Plan (SEMP) to monitor the effectiveness of the conservation measures proposed in the EA to mitigate against subsidence impacts on three distinct habitat areas; farm dams that form a belt across the mine site; subtropical rainforest areas of Long Gully Creek; and Pambalong Nature Reserve. The SEMP outlines a

monitoring plan for each of these areas by which baseline and subsequent monitoring data are to be gathered to inform future management. This report forms the baseline report for the Dam Monitoring and Management Plan (DMMP) which forms part of the overall SEMP.

2. Location

The Abel Underground Mine is located within Newcastle, Cessnock and Maitland local government areas (LGAs). The majority of the underground mine and surface infrastructure area is within the Cessnock LGA.

The location of the underground mine area and surface facilities is shown in Figure 1. The underground mine area is bounded on the eastern side by the F3 Freeway; the western and southern sides by a tract of forest that extends south to the Central Coast and beyond to Hornsby, and the northern side by existing open cut coal mining activities within the Donaldson and Bloomfield mine leases.

The Abel underground mine area is approximately 2750 ha and consists of low undulating forested hills with patches of cleared land for 110 rural/residential properties. Approximately 175 farm dams are located above the underground mining area, scattered across these various properties. Large areas of land are owned by Donaldson, Coal and Allied and the Catholic Diocese of Maitland and Newcastle. Black Hill School, various local roads and other infrastructure are located in the area.

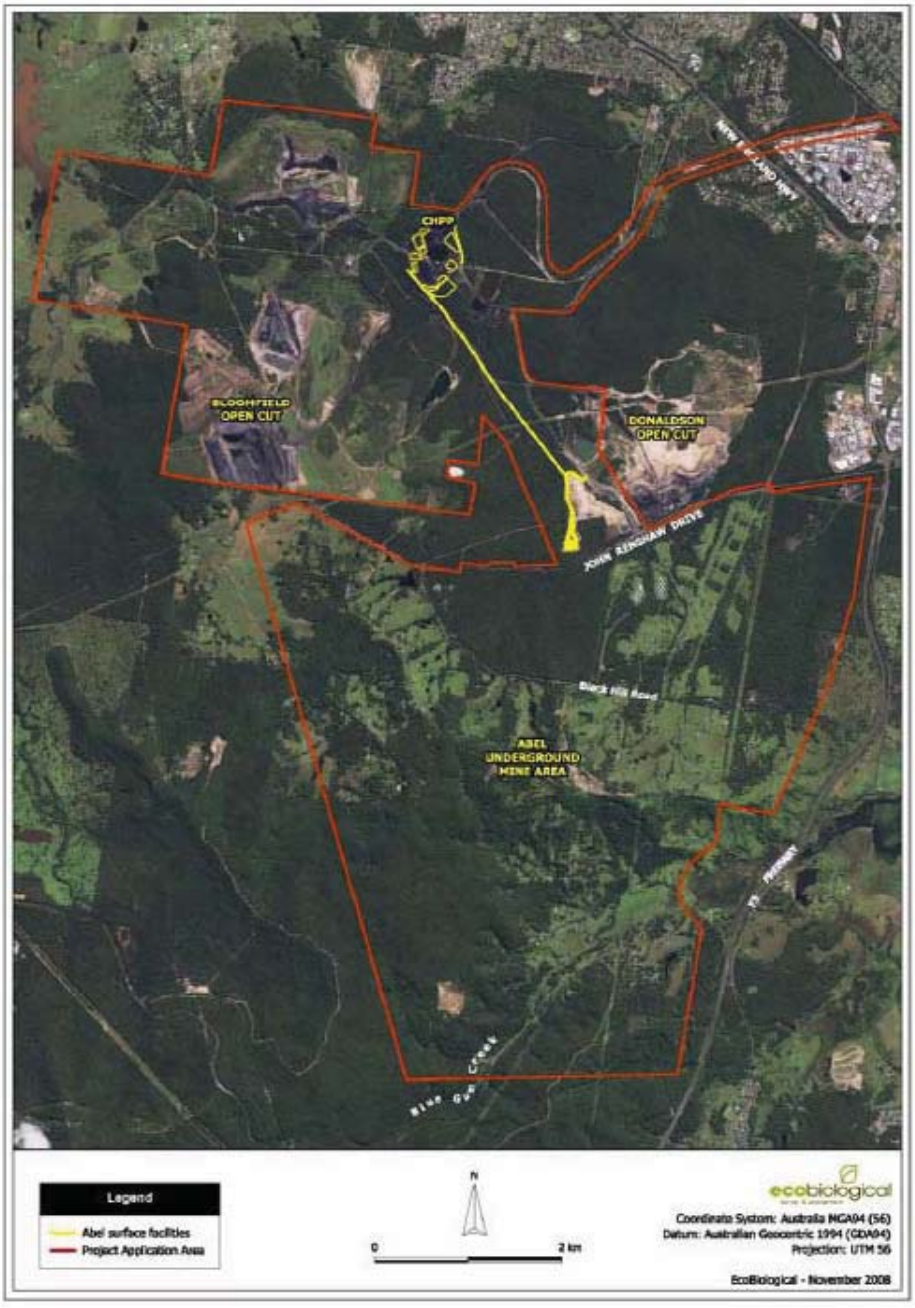

Figure 1: The location of the Abel Underground mine area and surface facilities.

3. Objectives

The Abel EA submission notes that the 175 dams located above the underground mining area are vulnerable to subsidence impacts such as cracking or tilting with significant water loss as a result. The DMMP aims to develop a set of data for these dams focussing on threatened flora and fauna which will then be available to inform the Subsidence Management Plan for the area containing the dams. Table 1 sets out the target species, appropriate methods and monitoring times as outlined in the F & FMP. Figure 2 shows the location of the dams across the mine area as well as other significant surface features.

Table 1: Species to be targeted by the DMMP.

Class	Species	Method	Monitoring Period
Amphibia	Green and Golden Bell Frog	Call playback and targeted search	Warm nights during or after rain October – February
Amphibia	Green-thighed Frog	Targeted search	Warm nights during or after rain October – February
Aves	Blue-billed Duck	Targeted search	Summer
Flora	*Maundia triglochinoides*	Targeted search	Late spring to early autumn

In addition, an assessment is to be conducted of all dams, after which each dam will be classified as to their future search priority based on the habitat quality of the dam for each of the target threatened species.

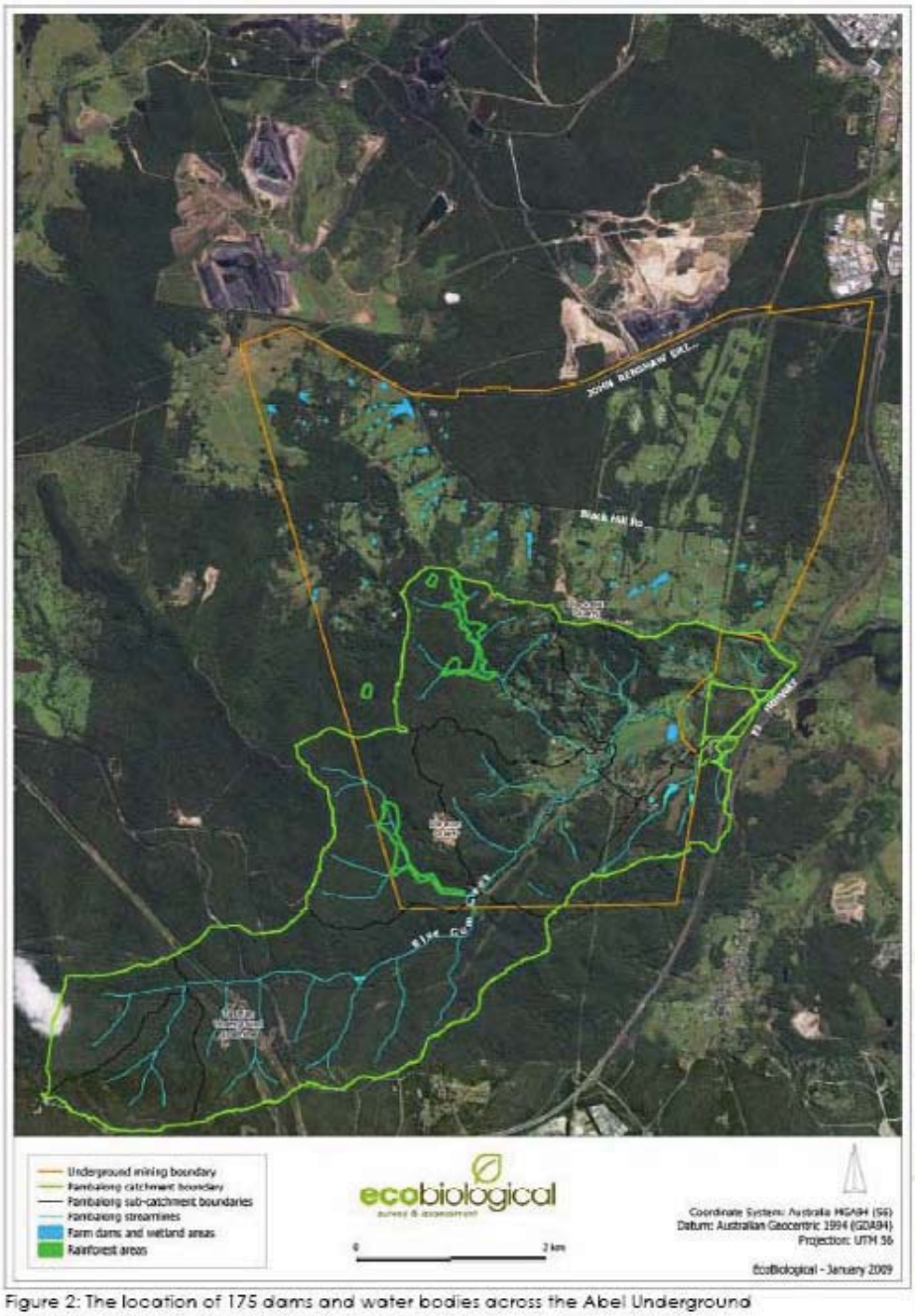

Figure 2: The location of 175 dams and water bodies across the Abel Underground Coalmine area and other significant surface features.

4. Methods

4.1. Amphibians

4.1.1. Green and Golden Bell Frog (*Litoria aurea*)

One hundred and fifty nine dams were surveyed for the Green and Golden Bell Frog. The remaining dams were not surveyed due to private landholders preventing access to their land. The 159 dams that were surveyed spanned across the mine site. It is considered that the dams surveyed were suitably representative of the total dams present and that the surveys provided a reasonable chance of detecting the Green and Golden Bell Frog.

Both targeted habitat surveys and call playback surveys were conducted throughout the survey period. At each dam an initial 2 minute quiet listening period was carried out to see if any Green and Golden Bell Frogs were calling, and to record other common species that were calling. This was followed by 10 minutes of call playback and 10 minutes of habitat searching. During call playback, pre-recorded calls of the Green and Golden Bell Frog were broadcast over a megaphone to attempt to illicit a response from any males that may have been present. The call playback period generally consisted of around one minute of playing the calls followed by 20 seconds of quiet listening, repeated until the 10 minute period was complete. The habitat searches consisted of searching suitable habitat with the aid of a head-torch to locate any adults or juveniles by eye-shine or by physical sightings. All other amphibian species observed were also recorded.

Each dam was assessed as to its suitability to contain Green and Golden Bell Frogs based on habitat attributes such as the type, amount and complexity of aquatic and terrestrial vegetation present; amount of refuge and foraging habitat present; the proximity to other suitable dams or areas of habitat; and the general surrounds.

4.1.2. Green-thighed Frog (*Litoria brevipalmata*)

During surveys for the Green and Golden Bell Frog each dam and its surrounds was assessed for its suitability to provide Green-thighed Frog habitat. This assessment was based on the most recent information on the biology and habitat requirements for the species in the southern portion of its range, as it is thought that habitat requirements for the species may

differ slightly between the northern and southern ends of its range (Lemckert *et al.*, 2006). Approximately 95% of all breeding sites for the Green-thighed Frog at the southern end of its range occur in ephemeral pools, predominately occurring in wet forest types (~85% occurrence in wet forest) (Lemckert *et al*, 2006). The most common breeding sites are natural depressions, particularly when adjacent to streams (e.g. old billabongs), although males will also call and breed at artificial water bodies such as human excavated hollows and flooded road verges (almost half of recorded breeding sites in a study by Lemckert *et al* (2006) consisted of artificial water bodies). Almost all breeding sites recorded for the Green-thighed Frog occur in, or are immediately adjacent to, large tracts of forest. As such, consideration was given in the habitat assessment for the Green-thighed Frog to the type and amount of forest surrounding the dam and whether or not there were areas or sections adjoining the dam that would likely fill up or flood during heavy rainfall events.

Quiet listening was carried out for the Green-thighed Frog at each dam surveyed. The species only calls on a small number of nights (usually <5) in any given season. It does not readily respond to call playback.

4.2. Birds

4.2.1. Blue-billed Duck (*Oxyura australis*)

Six dams were surveyed for the Blue-billed Duck (dams 7, 14, 16, 19, 26 & 28; see Figure 3). The remaining dams were not surveyed either because an initial assessment determined that they did not contain suitable habitat for the species or due to private landholders preventing access to their land. The surveyed dams spanned across the mine site and were chosen based on their size (with only large dams usually being inhabited by the species); the amount of deep, open water; and the amount of fringing aquatic vegetation present (see species profile provided in Appendix 1).

Targeted surveys for the Blue-billed Duck were carried out at each selected dam which involved a 20-minute walking transect along the edge of each selected dam. This time period enabled the inspection of the entire surface of each dam for the target species. The surveys were carried out during clear and warm conditions. All other bird species observed utilising the surface of the water body or foraging either within the vegetated margins or aerially foraging over each dam was also recorded. Dams 16 and 28 are similar in size and are separated only by a narrow wall. These dams were

surveyed as if they were one dam due to their immediate proximity to each other and the likelihood that threatened and common bird species would occupy either water body.

Each dam surveyed was assessed as to its suitability to provide habitat for the Blue-billed Duck and other threatened waterbird species based on habitat attributes such as the amount of fringing aquatic vegetation present; the amount of deep, open water present and the proximity to other suitable dams or areas of habitat.

4.3. Flora

4.3.1. *Maundia triglochinoides*

One hundred and sixty one dams were surveyed for *Maundia triglochinoides*. Access to the remaining dams was not granted by the property owners and could not be included in the targeted threatened flora survey. During surveys the perimeter of all dams were walked and carefully searched around the shallow edges for *M. triglochinoides*. A habitat assessment of each dam was made by recording dominant flora species and whether or not shallow edges were present. Dams which contained a high diversity of native wetland species, contained species of the closely related plant genus *Triglochin*, and had shallow edges were assessed as containing suitable habitat for *M. triglochinoides*.

5. Results

5.1. Amphibians

5.1.1. Green and Golden Bell Frog (*Litoria aurea*)

No Green and Golden Bell Frogs were detected at any of the 159 dams surveyed. Eleven non-threatened species of frog were detected at the dams with between zero and seven species detected at any one individual dam (Appendix 2). All of these species are considered to be common dam or pond breeding species with the exception of the Red-backed Toadlet which is a terrestrial breeding species that inhabits drainage lines and soaks. This species was found in a small drainage line that fed into one of the dams. Several of the species detected are also known to breed in or along slow-moving streams, or in ephemeral pools (e.g. Dwarf Green Tree Frog, Emerald-spotted Tree Frog, Common Eastern Froglet).

Sixty four of the dams surveyed were considered to contain habitat suitable for the Green and Golden Bell Frog (Appendix 3). These dams occurred right across the Abel Mine site (Figure 3). Some dams contained some habitat attributes that are considered suitable for the Green and Golden Bell Frog but lacked others that led to the overall determination that these dams were unlikely to be inhabited by the species in the future.

5.1.2. Green-thighed Frog (*Litoria brevipalmata*)

No Green-thighed Frogs were detected at any of the dams surveyed. Two dams were considered to potentially provide habitat suitable for the species (Appendix 3; Figure 3) based on the adjoining forest that they ran into and interconnecting areas that would likely fill up after heavy rain.

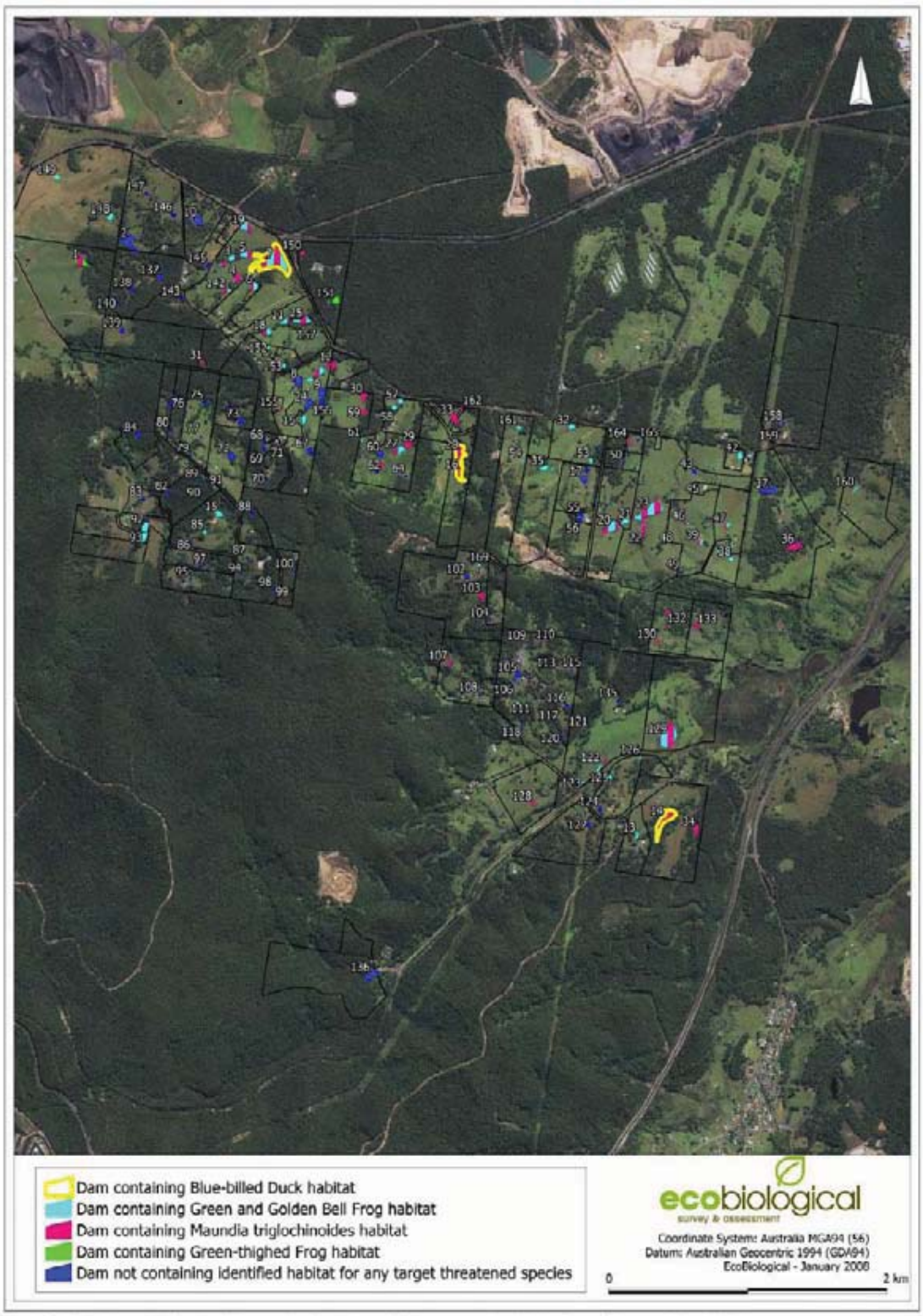

Figure 3: Aerial photograph of the Abel Mine area showing the layout of dams surveyed and the location of dams containing habitat suitable for each targeted threatened species.

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5.2. Birds

5.2.1. Blue-billed Duck (*Oxyura australis*)

The Blue-billed Duck was not detected at any of the six dams surveyed. No other bird species listed as threatened under State or Commonwealth legislation were recorded during field surveys. A total of 19 commonly occurring bird species were recorded utilising the surveyed dams with between 3 and 11 species detected at any one individual dam (Appendix 4).

Four of the six dams contained habitat suitable for the Blue-billed Duck (Appendix 3). These dams occur across the Abel Mine area (Figure 3).

5.3. Flora

5.3.1. Maundia triglochinoides

Maundia triglochinoides was not detected at any of the 161 surveyed dams. No other flora species listed as threatened under State or Commonwealth legislation or under the ROTAP (Rare or Threatened Australian Plant) scheme were recorded during field surveys.

Sixty three dams contained suitable habitat for *M. triglochinoides* (Appendix 3). These dams ranged across the Abel Mine area (Figure 3).

6. Discussion

While no threatened species were detected at any of the dams present within the Abel underground mine area, many were found to contain habitat suitable for at least one of the targeted threatened species. More than one third of the dams surveyed were considered to contain habitat suitable for the Green and Golden Bell Frog and *Maundia triglochinoides*, while only a small number of dams were considered to contain habitat suitable for the Blue-billed Duck and Green-thighed Frog. While the surveys carried out were considered robust, it always remains a possibility that a threatened species may have been overlooked, particularly after only one season of survey activity. This is particularly true of the more cryptic species such as the Green-thighed Frog, which may only call on one or two nights of the year and remains very difficult to detect on other nights. However, it is considered that as the annual surveys progress, the likelihood of detecting any threatened species that are present will increase; with a high probability of detecting all threatened species present before the first impacts from subsidence are likely to occur in 5-7 years time.

Regardless of the current status of occupancy of the dams by the targeted threatened species, the presence of a large number of dams with habitat suitable for these species (particularly those that interconnect and form habitat complexes) may be an important factor for their future recovery. This may be particularly true for the Green and Golden Bell Frog. The Green and Golden Bell Frog is a relatively mobile species that is known to be able to travel considerable distances and traverse hostile habitats to reach suitable ones. Two recognised key populations of Green and Golden Bell Frog currently exist at the opposite end of Hexham Swamp (known as the Sandgate and Kooragang Island populations) and the species was once known to be widespread right through the Hexham Swamp and adjoining areas. Should this species recover in the near future it is highly conceivable that it would rapidly migrate back through this area towards Pambalong Nature Reserve and onto the adjoining belt of farm dams, where it was anecdotally reported to have historically occurred. The Blue-billed Duck is another highly mobile species that may re appear at suitable dams should it undergo recovery in the area. Such recovery for either species (or indeed any other species of threatened flora and fauna) would likely be detected during future surveys for the DMMP, which are estimated to continue for another 20 years.

The detection of numerous species of non-threatened frogs and birds throughout the survey period is a promising sign of overall ecosystem health within the dams surveyed. Amphibian calling activity observed

throughout the survey period was high, resulting in a high level of confidence that the majority of species present were likely detected. One notable species that was absent however was the Green Tree Frog (*Litoria caerulea*), which was not detected at any of the dams surveyed. The Green Tree Frog is a wide-ranging species that breeds in variety of still-water habitats, and is commonly known to inhabit dams and swamps. While the species is listed as non-threatened it appears that it may be suffering decline in at least the southern portion of its range (based on anecdotal evidence and personal observation). While the absence of this species from all dams surveyed may potentially be a cause of alarm for the species itself, it is considered that it is not a reflection on the health of the dam ecosystems, but rather likely due to other factors such as a pathogenic fungus that is considered largely responsibly for the recent global amphibian decline (see for example Berger *et al.*, 1998).

The collection of data on non-threatened frog and bird species observed during the standardised surveys will be able to be used to make comment on the ongoing health of the dam ecosystems into the future. It is predicted that it will take between 5 and 7 years before potential impacts from subsidence will affect the dams. This will allow enough time to build a suitable dataset by which data collected after this period can be compared against. This will provide an indication of the health of the dams after potential impacts may have started to occur.

It is considered that the annual surveys of dams that contain suitable habitat for threatened species, as outlined in the F & FMP, will provide a suitable monitoring regime that will detect future changes in the dams related to mining activities. This information will then be able to be used to inform appropriate future management strategies. The requirement for future survey is outlined in the next section below.

7. Requirement for Future Survey, Reporting and Management

The F & FMP notes the importance of gathering as much pre-impact data as possible to inform the SEMP. It is predicted that it will take between 5 and 7 years before any potential impacts from subsidence on the dams will occur. It is considered that this timeframe is a long enough time period to provide a suitable dataset against which post-potential impact data can be compared against. The F & FMP notes that after 5 years of data collection, a thorough analysis of the data should be undertaken. This analysis will provide an insight into the dynamics of pre impact species diversity and abundance. Robust analyses will then be continued beyond this period which will allow for a proper evaluation of future impacts; such as significant shifts in species diversity or abundance beyond the normal parameters observed in the first 5 years of pre-impact data gathered.

The F & FMP sets out a requirement to survey the dams listed in the DMMP until one year after mining has passed the Long Gully and Blue Gum Creek catchments. However it is noted under the DMMP that not all dams will need to be surveyed for all target species, and that a future search priority should be assigned to each dam upon the undertaking of an initial assessment. Sixty four dams were found to be suitable for the Green and Golden Bell Frog, 63 were found to be suitable for *Mixophyes balbus*, 4 were found to be suitable for the Blue-billed Duck and 2 were found to be suitable for the Green-thighed Frog (refer to Figure 3; Appendix 3). These dams will be surveyed for the remainder of the DMMP as part of the overall SEMP i.e. until one year after mining has passed the Long Gully and Blue Gum Creek catchments, estimated to take around 21 years. Surveys are to be conducted annually at approximately the same time each year (between October and January). Any newly constructed dams are to be added into the monitoring schedule. This would initially involve a preliminary assessment of the suitability of habitat present at the dam for any threatened species, and if it was determined that suitable habitat is present, the dam would be incorporated into the monitoring schedule for the remainder of the DMMP.

Recent research on the biology of the highly cryptic Green-thighed Frog confirms that, in at least the southern part of their range, calling activity occurs on a very limited basis. In a study in 2006, Lemckert *et al.* showed that the duration of calling events for the species was brief, with calling lasting for a median of 1 night and a mean of only 1.4 nights. Furthermore, the species at the majority of sites was found to display only one calling

event in a season, with two calling events observed on four occasions, and three calling events in a season observed only once. The maximum total recorded number of nights of calling activity at any site in a season was five, with only one day or less per season recorded 80% of the time (Lemckert *et al,* 2006). Calling is likely to only occur after rainfall events that are significantly above the mean daily or three daily levels for the given time of year (when it is more likely that flooding will occur in breeding ponds), and greater than 90% of all calling activity occurs between November and February (Lemckert *et al,* 2006). Taken together these data indicate that the Green-thighed Frog has the lowest number of calling days of any temperate Australian anuran species, making it extremely difficult to detect. As such it is recommended that in order to increase the confidence level of detecting the species, future surveys at the 2 potential Green-thighed Frog sites are repeated on multiple occasions during the annual survey period (nominally 2-3 times), and that surveys are only conducted during or immediately after heavy rainfall events that are above the daily or three daily means. These surveys should be conducted between November and February.

The F & FMP sets out a requirement to report on survey findings on an annual basis. For the first 5 years this will involve outlining the data and making comments on general trends observed. At the end of the fifth year, and for subsequent years where appropriate, robust analyses will be carried out to determine if significant trends in the data are occurring. These analyses will utilise statistical methods where appropriate. The implications of these trends will then be evaluated to inform future management practices such as informing strategies for the Subsidence Management Plan. It is noted in the F & FMP that the presence of the Green and Golden Bell Frog would be of particular significance, and that specific management practices would need to be put in place utilising existing management and recovery plans, as well as the findings form current and future research.

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Appendix 1: Target species profiles

Green and Golden Bell Frog (Litoria aurea)

The Green and Golden Bell Frog is a large frog with a robust body form ranging from 45-110mm in size. This species was once one of the most common frog species on the east coast of Australia. It inhabited many lentic freshwater habitats throughout its distribution which occurred predominately along the coast but also extending as far inland as Bathurst and along the highlands in the north and south of the state (White and Pyke 1996). The Green and Golden Bell Frog has undergone a widespread and unexplained range contraction since the mid 1970's and the species is now listed as endangered under the NSW *Threatened Species Conservation Act* 1995, and as vulnerable under the federal *Environmental Protection and Biodiversity Conservation Act* 2000. Its distribution today is restricted to isolated pockets along the coast at various scattered locations throughout its former range with only one known remaining highland population at Queenbeyan.

The habitat preference and requirements of the Green and Golden Bell Frog are not well understood and difficult to define (Mahony 1999) resulting in some disagreement and confusion between biologists studying the species. Some of the differing views on Green and Golden Bell Frog ecology between biologists may be due to a failure to take into account the role of disease (a pathogenic fungus) that is probably primarily responsible for changes in its distribution and abundance in the last two decades. The species uses different habitat components throughout the various stages of its life cycle including different breeding, foraging and refuge habitats and has been known to disperse distances of up to several kilometres between these various habitats. Generally large, permanent water bodies containing high levels of emergent vegetation such as *Typha*, *Baumea* and the introduced *Juncus acutus* are favourable for the detection of the Green and Golden Bell Frog, however it has been observed utilising a wide range of natural and man-made water bodies including coastal swamps, marshes, dune swales, lagoons, lakes, estuary wetlands, riverine floodplain wetlands, billabongs, storm water retention basins, farm dams, bounded areas, storage tanks, water troughs, drains, ditches and other excavation areas capable of capturing water such as quarries and brick pits (DEC 2005). Terrestrial habitat attributes that appear to favour the species include large grassy areas associated with adjacent cover from logs, rocks or tussock forming vegetation that provide shelter. There also appears to be a preference shown to habitat containing a complexity of terrestrial and aquatic vegetation structure (Hamer *et al.* 2002). The introduced mosquito fish, *Gambusia holbrooki*, is believed to feed on small tadpoles and habitat free of these fish is preferred (White & Pike 1996)

The Green and Golden Bell Frog is frequently active at day and night in the warmer months and can often be observed sitting in emergent vegetation well above the water level (0.5-1m). It has also been observed well away from water altogether. The breeding period generally occurs between September and March although reproductive behaviour has been noted to occur between late winter and early autumn (DEC 2005). Breeding events occur most often during, and just after, heavy rain events with a peak around January/February when summer storms are common. Males call while floating in the water or from pond-side vegetation mostly at night but will occasionally call during the day. Individuals or small groups of males often respond to call play back or call imitation.

Green Thighed Frog (Litoria brevipalmata)

The Green-thighed Frog was only discovered in 1970, originally at Wauchope, NSW and later in the Gosford area (Barker & Grigg 1977). It reaches around 40mm in length and is chocolate brown on the dorsum with yellowish lower flanks. A dark stripe runs from the snout, through the eye and tympanum and ends in the flank. The groin and backs of thighs are a distinct bright blue-green with black flecks throughout and the belly is pale cream (Robinson 1998).

It is distributed in forests and swamps of the coast and adjacent ranges from central New South Wales to south east Queensland (Cogger, 2000; Hines *et al*, 1999). Its habitat requirements have remained highly cryptic for a long time with breeding noted to take place after heavy summer rains in rainforest and wet sclerophyll forest but also around temporary and semi-permanent ponds, flooded ditches and swamps including areas such as roadsides and power easements. More recent research however has shed some light on the biology of this highly cryptic species, particularly in relation to its breeding habitat requirements and calling behaviour. In a study by Lemckert *et al* (2006) it was found that over 90% of breeding sites consisted of ephemeral pools, partly or wholly within rainforest or wet sclerophyll forest (84% of the time). There are however some records from around permanent, artificial ponds within dry sclerophyll forest, and a small number from coastal forests and swamps. Natural depressions adjacent to streams (e.g. old billabongs) are the most commonly used calling sites, although breeding also occurs in artificial water bodies such as human excavated hollows and flooded road verges (around half of sites recorded). These pools are usually either leaf and shrub filled depressions, or have significant amounts of grass in and around them (Lemckert *et al*, 2006).

The duration of calling events for the species is brief, with calling lasting for a median of only 1 night and a mean of 1.4 nights (Lemckert *et al*, 2006). Calling occurs between September and May, although greater than 90% of all calling activity occurs between November and February, with between 1 and >100 males calling (most commonly 2-10 individuals) (Lemckert *et al*, 2006). The species in the southern part of its range often displays only one calling event in a season, with two calling events observed on only four occasions in a study by Lemckert *et al* (2006), and three calling events in a season observed only once. The maximum total recorded number of nights of calling activity at any site in a season in the 2006 study was five, with only one day or less per season recorded 80% of the time, indicating that the Green-thighed Frog has the lowest number of calling days of any temperate Australian anuran species (Lemckert *et al*, 2006). Calling is likely to occur only after rainfall events that are significantly above the mean daily or three daily levels for the given time of year (when it is more likely that flooding will occur in breeding ponds), and it is believed that the flooding of the breeding pools is the significant factor in calling behaviour, rather than the intensity of the rain itself.

The majority of Green-thighed Frogs are found within 100m of a tract of natural vegetation >20ha in size and none were found in the 2006 study (Lemckert *et al*) to occur in largely cleared (>50%) grazing lands or within entirely urban areas. While habitat on a broad scale is a clear threat for this frog, it appears that partial clearing of vegetation within an area does not prevent Green-thighed Frogs from calling at a site, and that they may have some tolerance for disturbance (Lemckert *et al*, 2006). Fire, particularly high-intensity fire, is also listed as a potential threat to the Green-thighed Frog, particularly when associated with multiple disturbance events in rapid succession (Lemckert *et al*, 2006).

Blue Billed Duck (Oxyura australis)

The adult male Blue-billed Duck has a slate blue bill with a glossy black head and neck, a rich chestnut back and black-brown tail coverts. The adult female has a grey-brown bill with plumage darker than the male with each feather barred with narrow bands of light brown. Juveniles are similar to the adult female but paler with a grey-green bill (Marchant & Higgins 1990). Preferred habitat is in large, deep, well-vegetated swamps where they spend almost all of their time in the water often in large flocks. Occasionally the species can be found using creeks, rivers and farm dams for foraging and breeding (Frith 1982). The Blue-billed Duck feeds on the surface of the water or by diving, for aquatic insects such as chironomid larvae, caddis flies, dragonflies, damselflies, flies and water beetle larvae (Schodde and Tidemann 1986).

The Blue-billed Duck is endemic to Australia occurring mainly within temperate wetlands of the south-eastern and south-western parts of the continent (Marchant & Higgins 1990). The Blue-billed Duck has also been reported from central Australia and Tasmania with little change in reporting rate over the last 20 years (Barrett *et al.* 2003). The Blue-billed Duck is listed as vulnerable under the NSW *Threatened Species Conservation Act* 1995. Nationally the Blue-billed Duck is classed as of 'least concern' because of the very large flocks that inhabit large artificial wetlands (Garnett & Crowley 2000) although threats are noted as being the destruction or modification of habitat, particularly by drainage works, clearing, cropping or burning (Marchant & Higgins 1990).

Maundia triglochinoides

Maundia triglochinoides is a perennial plant with rhizomes about 5mm thick and emergent tufts of leaves arising along their length. Leaves are triangular in cross section, to 80 cm long, 5 - 10mm wide. Inflorescence is up to 10cm long and 2.5 cm wide. Carpels (female parts of flower) are 6 - 8mm long, sessile, each with a spreading beak (Harden, 1993). This species is found along the NSW coast and southern Queensland. There are old records of this species occurring as far south as Sydney, however it is presumed extinct from these sites, and Wyong in now thought to be the southern limit of its range (DECC, 2005).

Maundia triglochinoides grows in swamps, creeks or shallow freshwater 30 - 60 cm deep on heavy clay and low nutrients and it is often associated with wetland species e.g. *Triglochin procerum*. The flowering occurs during warmer months (November to January). The plant is likely to be wind pollinated. The long distance dispersal is the seed and root tubers, which are probably dispersed by water. The plant spreads vegetatively, with tufts of leaves arising along the rhizomes (DECC, 2005). The main threats to this species are further loss and fragmentation of habitat, changes in hydrology and water quality, and weed invasion (DECC, 2008).

Appendix 2: Frog species recorded in each dam surveyed

Dam Nº = Dam Number; L. fallax = Dwarf Green Tree Frog (*Litoria fallax*); L. peronii = Emerald-spotted Tree Frog (*Litoria peronii*); L. tyleri = Southern Laughing Frog (*Litoria tyleri*); L. lato. = Broad-palmed Frog (*Litoria latopalmata*); L. verr. = Whistling Tree Frog (*Litoria verreauxii*); Lim. per. = Striped Marsh Frog (*Limnodynastes peronii*); L. tas. = Spotted Grass Frog (*Limnodynastes tasmaniensis*); U. fusca = Dusky Toadlet (*Uperoleia fusca*); U. laev. = Smooth Toadlet (*Uperoleia laevigata*); C. sig. = Common Eastern Froglet (*Crinia signifera*); P. cor. = Red-backed Toadlet (*Pseudophryne coriacea*); Nº species = Total Number of Species.

Dam Nº	L. fallax	L. peronii	L. tyleri	L. lato.	L. verr.	Lim. per.	L. tas.	U. fusca	U. laev.	C. sig.	P. cor.	Nº species
1	x	x	x		x	x		x	x			7
2	x			x				x	x	x		5
3	x					x			x			3
4	x			x					x	x		4
5	x		x						x	x		4
6	x				x				x	x		4
7	x		x		x	x				x		5
8	x				x					x		3
9												0
11	x	x	x		x		x		x	x		7
12	x					x						2
13	x	x	x						x	x		5
14	x	x	x									3
15	x	x		x		x			x	x		6
16	x			x		x				x		4
17	x			x						x		3
18	x	x	x						x	x		5
19	x											1
20	x	x	x			x			x	x		6
21	x	x	x			x			x	x		6
22	x			x		x			x	x		5
23	x			x		x				x		4
24												0
25	x	x			x	x			x	x		6
26	x	x							x	x		4
27	x	x	x		x	x			x			6
28	x			x		x				x		4
29	x				x				x			3
30										x		1
31	x	x		x		x		x	x			6
32	x	x	x	x		x						5

Dam Nº	L. fallax	L. peronii	L. tyleri	L. lato.	L. verr.	Lim. per.	L. tas.	U. fusca	U. laev.	C. sig.	P. cor.	Nº species
33	x					x	x		x			4
34	x	x	x							x		4
35	x			x					x			3
36	x	x		x								3
37	x	x	x	x								4
38	x	x		x			x		x	x		6
39	x	x	x	x								4
40	x	x		x		x	x		x	x		7
41	x			x					x	x		4
42	x	x	x	x			x					5
43							x					1
44	x	x		x			x					4
45	x	x	x	x		x	x		x			7
46	x	x	x	x		x						5
47	x									x		2
48	x	x	x	x			x		x			6
49	x	x		x					x			4
50	x	x	x	x			x		x			6
51	x			x						x		3
52	x	x		x						x		4
53	x					x			x			3
54	x	x		x			x		x			5
55	x			x						x		3
56	x	x	x	x						x		5
57	x						x					2
58							x			x		2
59	x	x	x				x	x	x			6
60						x						1
61	x		x						x	x		4
62	x								x	x		3
63	x	x							x			3
64	x								x			2
65							x					1
66	x								x			2
67	x	x										2
68			x			x			x			3
69		x					x		x			3
70	x	x							x			3
71									x	x		2
72	x	x	x		x	x						5

Dam Nº	L. fallax	L. peronii	L. tyleri	L. lato.	L. verr.	Lim. per.	L. tas.	U. fusca	U. laev.	C. sig.	P. cor.	Nº species
73										x		1
74	x	x			x	x			x			5
75	x	x										2
76												0
77							x					1
78												0
79												0
80	x		x				x		x			4
81	x		x								x	3
83	x	x							x			3
84				x					x	x		3
85	x	x										2
86												0
87						x						1
91						x						1
92	x	x	x						x			4
93	x	x	x			x			x			5
94	x						x		x			3
95							x		x			2
96							x			x		2
97												0
98			x	x					x	x		4
102												0
103	x	x	x			x			x			5
104	x		x	x		x	x		x			6
105	x						x					2
106												0
107	x	x	x		x		x		x	x		7
108												0
109												0
110	x						x		x	x		4
111												0
112	x		x						x			3
113												0
114										x		1
115				x								1
116							x		x	x		3
117												0
118	x											1
119												0

Dam N°	L. fallax	L. peronii	L. tyleri	L. lato.	L. verr.	Lim. per.	L. tas.	U. fusca	U. laev.	C. sig.	P. cor.	N° species
120												0
121									x	x		2
122	x					x	x		x			4
123	x											1
124												0
125	x					x	x		x	x		5
126	x		x			x			x			4
127										x		1
128	x						x					2
129	x		x						x			3
130	x									x		2
131	x					x				x		3
132	x		x			x			x			4
133												0
134	x		x						x	x		4
135	x									x		2
136	x									x		2
139												0
142	x								x			2
143	x		x	x			x		x	x		6
144	x				x				x			3
146												0
147							x					1
148	x			x		x						3
149	x											1
150	x					x		x		x		4
151	x				x	x				x		4
152	x	x	x	x					x			5
153	x	x		x						x		4
154	x				x	x			x	x		5
155	x	x		x			x		x			5
156												0
157				x								1
158	x			x			x			x		4
159	x			x			x			x		4
160	x	x		x			x		x			5
161	x	x	x	x		x			x			6
162			x		x	x			x	x		5
163	x									x		2
164	x	x	x	x					x	x		6

Dam Nº	L. fallax	L. peronii	L. tyleri	L. lato.	L. verr.	Lim. per.	L. tas.	U. fusca	U. laev.	C. sig.	P. cor.	Nº species
165												0
166						x						1
167	x	x							x	x		4
168	x					x	x		x	x		5
169	x						x		x			3

Appendix 3: Suitability of habitat for targeted threatened species in each dam surveyed

M. triglochin = *Maundia triglochinoides*; GGBF = Green and Golden Bell Frog (*Litoria aurea*); GTF = Green-thighed Frog (*Litoria brevipalmata*); BBD = Blue-billed Duck (*Oxyura australis*).

Dam Number	M. triglochin	GGBF	GTF	BBD
1	✓		✓	
2				
3	✓	✓		
4	✓	✓		
5	✓	✓		
6	✓	✓		
7	✓	✓		✓
8				
9				
10				
11	✓	✓		
12	✓			
13	✓	✓		
14	✓			✓
15		✓		
16	✓	✓		✓
17				
18	✓	✓		
19	✓	✓		
20	✓	✓		
21	✓	✓		
22	✓	✓		
23	✓	✓		
24				
25	✓	✓		
26	✓	✓		
27	✓	✓		
28	✓	✓		✓
29	✓			
30				
31	✓			
32	✓	✓		
33	✓			
34	✓			
35		✓		
36	✓			
37				
38	✓	✓		

Dam Number	M. triglochin	GGBF	GTF	BBD
39	✓	✓		
40	✓	✓		
41	✓	✓		
42		✓		
43				
44				
45	✓	✓		
46	✓	✓		
47	✓	✓		
48	✓	✓		
49				
50				
51	✓	✓		
52				
53		✓		
54		✓		
55				
56				
57	✓	✓		
58		✓		
59	✓			
60				
61		✓		
62	✓	✓		
63				
64				
65				
66				
67				
68				
69				
70				
71				
72				
73				
74				
75				
76				
77				
78				
79				
80				
81				
82				
83				
84				
85		✓		
86				
87			✓	
88				
89				

Dam Number	M. triglochin	CCBF	CTF	BBD
90				
91		✓		
92		✓		
93		✓		
94				
95				
96				
97				
98				
99	✓			
100				
101				
102				
103	✓			
104				
105				
106				
107	✓			
108				
109				
110				
111				
112		✓		
113				
114				
115				
116				
117				
118				
119				
120				
121	✓			
122	✓	✓		
123		✓		
124				
125	✓	✓		
126	✓	✓		
127				
128	✓			
129	✓	✓		
130	✓	✓		
131	✓	✓		
132	✓			
133	✓			
134	✓			
135				
136				
137				
138				
139				
140				
141				

Dam Number	M. triglochin	GG8F	GTF	BBD
142	✓	✓		
143				
144	✓	✓		
145				
146				
147				
148		✓		
149		✓		
150	✓			
151	✓			
152		✓		
153	✓	✓		
154		✓		
155	✓			
156				
157		✓		
158				
159				
160		✓		
161		✓		
162	✓	✓		
163		✓		
164	✓			
165				
166				
167	✓	✓		
168	✓	✓		
169		✓		
Total	**63**	**64**	**2**	**4**

Appendix 4: Bird species and abundance recorded in each dam surveyed

Family Name	Scientific Name	Common Name	Dam No. 7	Dam No. 14	Dam No. 19	Dam No. 26	Dam No. 16 & 28
Accipitridae	*Circus approximans*	Swamp Harrier	2			1	
Anatidae	*Chenonetta jubata*	Australian Wood Duck	6	6		10	26
Anatidae	*Cygnus atratus*	Black Swan	1		2		
Anatidae	*Anas castanea*	Chestnut Teal		4			2
Anatidae	*Anas gracilis*	Grey Teal					5
Anatidae	*Aythya australis*	Hardhead					3
Anatidae	*Anas superciliosa*	Pacific Black Duck	1	16		5	2
Anhingidae	*Anhinga melanogaster*	Darter				1	
Ardeidae	*Egretta novaehollandiae*	White-faced Heron	2		1		
Artamidae	*Artamus leucorynchus*	White-breasted Woodswallow					2
Charadriidae	*Vanellus miles*	Masked Lapwing				2	
Halcyonidae	*Todiramphus sanctus*	Sacred Kingfisher	1				
Phalacrocoracidae	*Phalacrocorax sulcirostris*	Little Black Cormorant	4				2
Phalacrocoracidae	*Phalacrocorax melanoleucos*	Little Pied Cormorant			1		
Phalacrocoracidae	*Phalacrocorax varius*	Pied Cormorant				1	
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian Grebe					2
Rallidae	*Gallinula tenebrosa*	Dusky Moorhen				2	3
Rallidae	*Fulica atra*	Eurasian Coot	4				2
Rallidae	*Porphyrio porphyrio*	Purple Swamphen	2				2
Total individuals recorded on each dam			23	26	4	22	51
No. of species recorded on each dam			9	3	3	7	11

Appendix 5: Contributions and qualifications of EcoBiological staff

Name	Qualification	Title	Contribution
Simon Clulow	B. Sc./B. Teach M. Philosophy candidate	Ecologist (Herpetologist)	Project management, amphibian surveys, report writing
Kristy Peters	B. ParkMgt.	Ecologist (Ornithologist)	Blue-billed Duck surveys
Ryan Parsons	B. Env Sc.	Botanist	*M. triglochinoides* survey
Dan Pedersen	B. Sc.	Botanist	*M. triglochinoides* survey
Colin Driscoll	B. Sc.	Botanist	Report review
Dianna Brettschneider	B. App Sc.	GIS Manager	Preparation of map layouts for report