APPENDIX 3

Abel Underground Coalmine Dam Monitoring and Management Plan: 2009 Monitoring Report

This appendices is presented on the CD included on the inside front cover this report

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Abel Underground Coalmine Dam Monitoring & Management Plan:
2009 Monitoring Report.

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2009 Monitoring 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 identified the need to establish a Surface Ecological Monitoring Plan (SEMP), comprising several monitoring programs, of which this Dam Monitoring and Management Plan (DMMP) is one.

In 2008, baseline ecological data was recorded at 156 dams in the Abel underground mine area (**ecobiological** 2008). As well, assessment of the habitat value of dam sites for threatened fauna and flora was undertaken so that future monitoring could target dams which exhibited habitat that may potentially support target threatened species. This report builds on the baseline information collected on the occurrence of threatened and non-threatened species against which changes over time can be measured and evaluated. Abundance, species diversity and composition data for all frog and water-dependent bird species at each of the targeted dams was also recorded.

While it may take between five and seven years before any impact on the dams is likely to occur from subsidence, some comparison with the first year's data was possible. In 2009, a much lower overall diversity of frog species was noted across the dams, only a few dams recorded more species in 2009 than what was recorded in 2008. Bird diversity did not differ to any large extent between the two years though numbers of ducks were higher in 2009 at Dam 14. No threatened frogs or birds were identified. No individuals of the threatened plant, *Maundia triglochinoides*, were identified.

Monitoring will continue until one year after mining has passed the Long Gully and Blue Gum Creek catchments. The information and management recommendations from these and other surface monitoring studies will then be available to inform best practice measures to be incorporated into the Subsidence Management Plan (SMP).

In order to differentiate between possible effects of the mine from other environmental impacts on changes in the composition and abundance of frog and water bird species at the target dams, it is recommended that future surveys include a water quality and condition assessment at each of the target dams.

Table of Contents

List of Figures

List of Tables

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

The Dam Monitoring and Monitoring Plan (DMMP) gathered data for 156 dams in 2008, all of which are located above the Abel underground mining area. In 2009, the number of dams identified for longer-term monitoring was reduced to 84, following assessment of their habitat suitability for the Green and Golden Bell Frog *Litoria aurea*, the Green-thighed Frog *Litoria brevipalmata*, the Blue-billed Duck *Oxyura australis* and the aquatic plant *Maundia triglochinoides*. Preferred habitat of each is detailed in Appendix 1.

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.

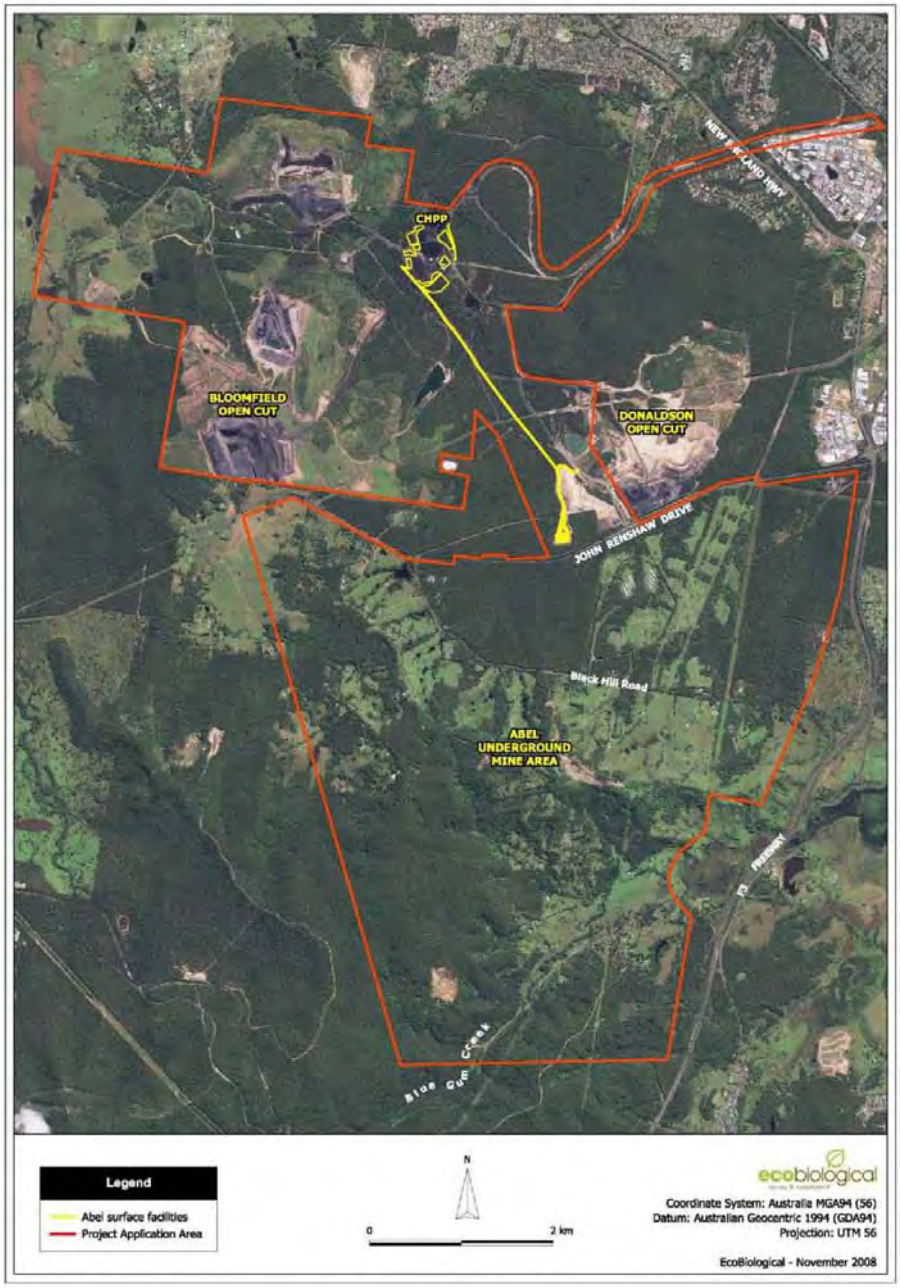

Figure 1: The location of the Abel Underground mine area and surface facilities.

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 84 of these dams (Appendix 2) focussing on sensitive flora and fauna (targeting threatened species) to inform the Subsidence Management Plan. Table 1 sets out the target threatened species, appropriate methods and monitoring times as outlined in the F & FMP. Figure 2 shows the location of the targeted dams across the mine area as well as other significant surface features.

Table 1: Species to be targeted by the DMMP.

Scientific name	Common Name	Method	No. of Dams	Monitoring Period
Litoria aurea	Green and Golden Bell Frog	Call playback and targeted search	64	Warm nights during or after rain October – February
Litoria brevipalmata	Green-thighed Frog	Targeted search	2	Warm nights during or after rain October – February
Oxyura australis	Blue-billed Duck	Targeted search	4	Summer
Maundia triglochinoides		Targeted search	63	Late spring to early autumn

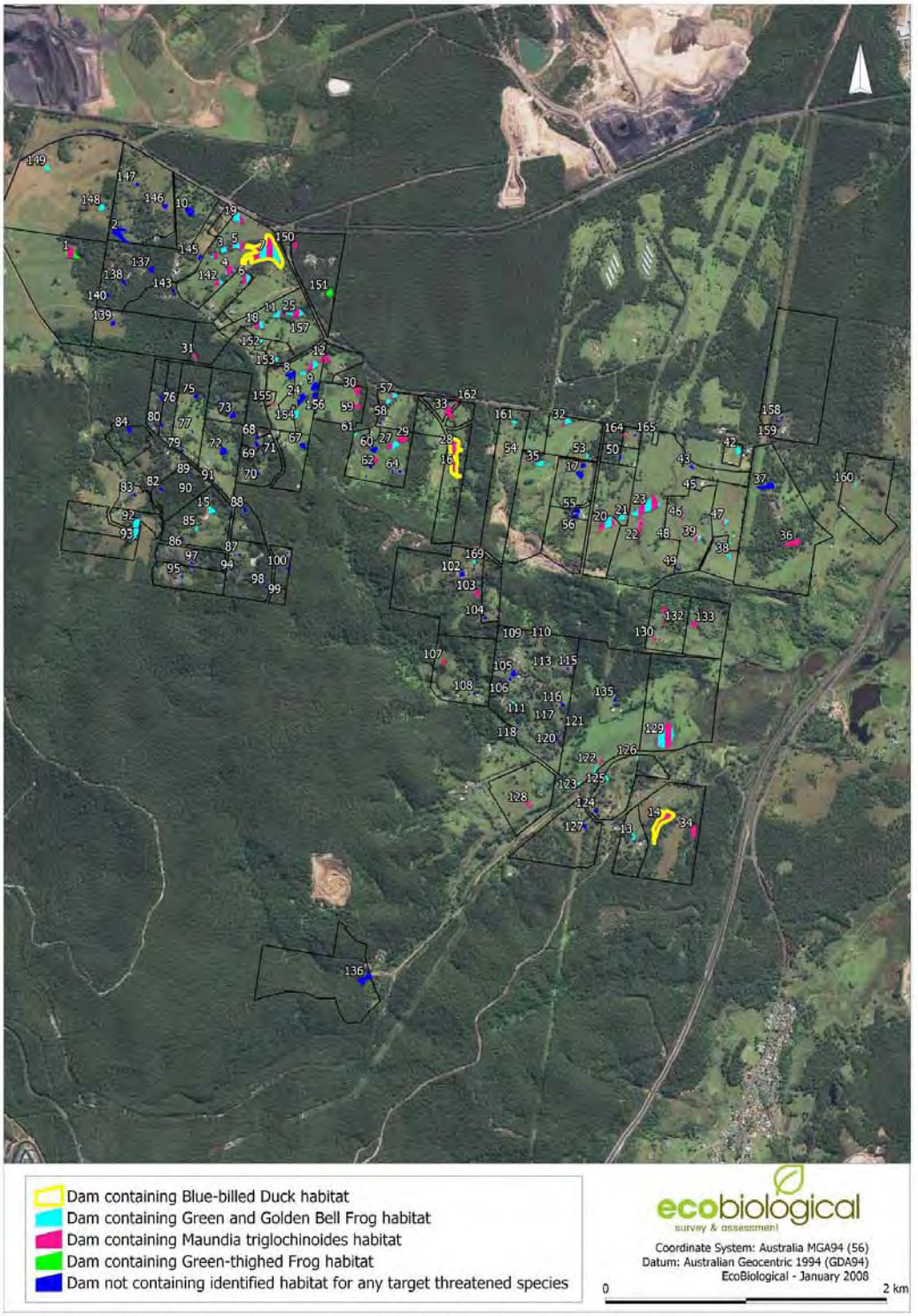

Figure 2: Aerial photograph of the Abel Mine area showing the layout of dams surveyed and the location of dams containing habitat suitable for each targeted threatened species.

4. Methods

4.1. Amphibians

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

Sixty-four dams with suitable Green and Golden Bell Frog habitat were surveyed for this species. The 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 two 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.

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

Two dams were deemed potentially suitable for the Green-thighed Frog in 2008 (Dams 1 and 151) and were surveyed for this species in 2009.

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*)

Four dams were surveyed for the Blue-billed Duck (Dams 7, 14, 16 & 28; see Figure 2, Appendix 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.

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

Sixty-three dams were assessed as containing suitable habitat for the aquatic plant *M. triglochinoides* (Figure 2, Appendix 2). Searches were conducted using a random meander methodology ensuring that all water edge environments were searched.

5. Results

5.1. Amphibians

No Green and Golden Bell Frogs were detected at any of the 64 dams surveyed. No Green-thighed Frogs were detected at any of the two dams surveyed that contained habitat for this species.

Ten non-threatened species of frog were detected at the dams in 2009 with between zero and six species detected at any one individual dam (Appendix 2). All are considered to be common dam or pond breeding species with the exception of the Rocket Frog *Litoria nasuta* which was not detected in 2008. At most dams (47) there was a decline in frog diversity between 2008 to 2009. At ten dams there was an increase in diversity while five dams had the same number of species during both years.

The total number of known frog species identified from each dam (including both years) was tallied (Appendix 3). Eight dams recorded the highest diversity with seven species at each, however, at none of these were all seven recorded in the same year.

5.2. Birds

The Blue-billed Duck was not detected at any of the four targeted dams surveyed. No other bird species listed as threatened under State or Commonwealth legislation were recorded during field surveys. In 2009, a total of 17 commonly occurring water-dependent bird species were recorded utilising the surveyed dams with between three and 11 species detected at any one individual dam (Appendix 4).

5.3. Flora

Maundia triglochinoides was not detected at any of the 63 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.

6. Discussion

6.1. Amphibians

While a third of all the dams identified and surveyed in 2008 were considered to contain habitat suitable for the Green and Golden Bell Frog, this species were not detected in 2008 or in 2009.

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, a relatively mobile species that is known to be able to travel considerable distances and traverse hostile habitats to reach suitable ones (Daly 1995).

Currently there are two recognised key populations of Green and Golden Bell Frog at the opposite end of Hexham Swamp (known as the Sandgate and Kooragang Island populations). The species was also once known to be widespread right through the Hexham Swamp and adjoining areas. Old records of this species are known from within a 10 kilometre radius of the Black Hill area, however, these are thought to be now extinct (M. Mahoney pers. comm.). However, should this species recover in the near future it is highly conceivable that it may migrate back through this area towards Pambalong Nature Reserve and onto the adjoining belt of farm dams.

Only two dams were considered to contain habitat suitable for the 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 two seasons 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 (Lemckert *et al.* 2006) and remains very difficult to detect on other nights. The Green-thighed Frog is only known from two records some 13 km from the Blackhill area and is not known for its high mobility. However, it is considered that as the annual surveys progress, the likelihood of detecting this threatened species will increase.

The detection of numerous species of non-threatened frogs 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.

The dams with the highest frog diversity so far are Dam 1, 11, 40, 41, 42, 154 and 161 with seven species recorded over the two years. Most of these had fewer frog species in 2009 compared to 2008, though Dams 41 and 154 had more species this year than last year.

Some species of frog with a possible occurrence in the study area however have not been detected in the two years of surveys so far, particularly, the Green Tree Frog *Litoria caerulea*, Bleating Tree Frog *Litoria dentata*, Ornate Burrowing Frog *Platyplectrum ornatum*, Pobblebonk *Limnodynastes dumerilli*, Haswell's Frog *Paracrinia haswelli*, Bibron's Toadlet *Pseudophryne bibroni* and Tyler's Toadlet *Uperoleia tyleri*. One species, the Red-backed Toadlet, *Pseudophryne coriacea*, was detected in 2008 at one dam site that was not selected for further monitoring. Future surveys in following years may detect some of these species or confirm their absence.

The absence of the above species and the difference in the diversity and species composition at the dams in the two years so far may be due to a variety of factors, such as the health of the dam ecosystems (cattle disturbance is widespread), or the Chytrid virus (a pathogenic fungus that is considered largely responsible for the recent global amphibian decline, see Berger *et al.*, 1998), but may also be due to unsuitability of local habitat, changing weather conditions or just chance.

6.2. Birds

Only four dams were considered to contain habitat suitable for the Blue-billed Duck. While the surveys carried out were considered robust, it always remains a possibility that a threatened species may have been overlooked, particularly after only two seasons of survey activity. The Blue-billed Duck is a mobile species that may re-appear at suitable deep dams at any time provided conditions are suitable. This species is known from the Bloomfield Dam (NSW Wildlife Atlas 2010), to the north of the Abel mine area.

There was little change in the abundance and diversity of birds at the four dam sites surveyed this year compared to last year. However, Dam 14 recorded a greater number of ducks in 2009.

The collection of data on non-threatened bird species observed during the standardised surveys will be used to make comment on the ongoing health of the dam ecosystems into the future. It is predicted that it will take between five and seven 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.

6.3. Flora

While a third of all the dams identified and surveyed in 2008 were considered to contain habitat suitable for *Maundia triglochinoides*, this species was not detected in 2008 or in 2009.

Only three records of *Maundia triglochinoides* in close proximity to the study area exist, one from Kooragang Wetlands (pers. obs., D. Pedersen), Irrawang Wetlands (pers. obs., Dan Pedersen) and the Medowie area, some 25 km from the Abel Mine site (NSW Wildlife Atlas, 2010). However, a close inspection of suitable dams over the two year period has not recorded this species. As this species mainly disperses via stream flow, it is unlikely that it will appear at any of the dam sites which are not generally connected to natural stream flows, unless spread by duck faeces, which is a relatively unlikely occurrence.

7. Recommendations

It is recommended that in future amphibian surveys, water quality and aquatic habitat assessments of the relevant dams be made because any future changes in frog diversity or species composition at the dams may be explained by local environmental factors. An example proforma of the type of data that would be collected is provided in Appendix 4. Indices of water quality that can be collected with minimal cost and effort include temperature, pH and salinity (EC) as well as visual observations of water and aquatic vegetation health.

This will assist in the future to identify factors, such as eutrophication of dams from stock, recent fertiliser applications or nutrient runoff from farming practices which may contribute to local frog decline other than effects from mining.

8. Conclusion

While suitable habitat exists at 84 dams in the Abel mine area for targeted threatened species, none have been detected in two years of surveys (**ecobiological** 2008; this report). Abundance data has been collected for 11 frogs and 21 birds, though as this is the first monitoring report, a more detailed statistical analysis is not possible at this stage. An accompanying water quality and condition assessment at the target dams is recommended.

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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 Queanbeyan.

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 2005a). 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 2005a). 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, 2005b).

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, 2005b). 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: Suitability of habitat at target dams

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	✓	✓	✓	
3	✓	✓		
4	✓	✓		
5	✓	✓		
6	✓	✓		
7	✓	✓		✓
11	✓	✓		
12	✓			
13	✓	✓		
14	✓			✓
15		✓		
16	✓	✓		✓
18	✓	✓		
19	✓	✓		
20	✓	✓		
21	✓	✓		
22	✓	✓		
23	✓	✓		
25	✓	✓		
26	✓	✓		
27	✓	✓		
28	✓	✓		✓
29	✓			
31	✓			
32	✓	✓		
33	✓			
34	✓			
35		✓		
36	✓			
38	✓	✓		
39	✓	✓		
40	✓	✓		
41	✓	✓		
42		✓		
45	✓	✓		
46	✓	✓		
47	✓	✓		
48	✓	✓		
51	✓	✓		
53		✓		

Dam Number	M. triglochin	GGBF	GTF	BBD
54		✓		
57	✓	✓		
58		✓		
59	✓			
61		✓		
62	✓	✓		
85		✓		
91		✓		
92		✓		
99	✓			
103	✓			
107	✓			
112		✓		
121	✓			
122	✓	✓		
123		✓		
125	✓	✓		
126	✓	✓		
128	✓			
129	✓	✓		
130	✓	✓		
131	✓			
132	✓			
133	✓			
134	✓			
142	✓	✓		
144	✓	✓		
148		✓		
149		✓		
150	✓			
151	✓		✓	
152		✓		
153	✓	✓		
154		✓		
155	✓			
157		✓		
160		✓		
161		✓		
162	✓	✓		
163		✓		
164	✓			
167	✓	✓		
168	✓	✓		
169		✓		
Total	63	64	2	4

Appendix 3: Amphibian species recorded in each dam surveyed

Dam N° = 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. nasuta = Rocket Frog (*Litoria nasuta*); L. verr. = Whistling Tree Frog (*Litoria verreauxii*); Lim. per. = Striped Marsh Frog (*Limnodynastes peronii*); Lim. 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*); *n* = Total number of species known from site (both years); DIFF = difference in diversity between years

Abundance ratings: 1=1; 2=2-5; 3=6-10; 4=11-20; 5=21-50; 6=51-100; 7=>100 'x' – indicates presence only

DAM	L. fallax		L. peronii		L. tyleri		L. lato.		L. nasuta		L. verr.		Lim. per.		Lim. tas.		U. fusca		U. laev.		C. signif.		*n*	DIFF
	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09		
1	x	4	x		x						x	1	x				x		x				7	-5
3	x	6		1									x						x	4		4	5	+1
4	x	6					x	2											x	4	x	4	4	0
5	x	6		1	x														x		x	4	4	-1
6	x	4									x	2		3					x		x	3	5	0
7	x	6			x						x	4	x								x	6	5	0
11	x	6	x	1	x						x			2	x				x	3	x		7	-4
13	x	6	x	2	x	2													x		x		5	-2
15	x	6	x	2			x	1					x	3					x		x	3	6	-1
16	x						x					2	x								x	2	5	-2
18	x	6	x	1	x							3							x		x	4	6	-1

DAM	L. fallax		L. peronii		L. tyleri		L. lato.		L. nasuta		L. verr.		Lim. per.		Lim. tas.		U. fusca		U. laev.		C. signif.		#	DIFF
	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09		
19	x	6										2										2	3	+2
20	x	5	x		x								x						x		x	2	6	-3
21	x	6	x	1	x	2							x						x		x	2	6	-2
22	x	5					x	2					x	2					x		x		5	-2
23	x	6		3			x	2					x								x	5	5	-1
25	x	6	x								x	4	x	2					x		x	4	6	-2
26	x		x																x	2	x	5	4	-2
27	x	4	x		x						x	2	x	3					x				6	-3
28	x						x						x								x	2	4	-3
32	x	1	x		x		x						x	1									5	-3
35	x						x												x			2	4	-3
38	x	6	x				x								x				x		x		6	-5
39	x	5	x	3	x		x															4	5	-1
40	x	4	x				x	2					x	2	x	2			x		x	4	7	-2
40B																3				3			2	0

DAM	L. fallax		L. peronii		L. tyleri		L. lato.		L. nasuta		L. verr.		Lim. per.		Lim. tas.		U. fusca		U. laev.		C. signif.		*n*	DIFF
	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09		
41	x	5		1			x	1						2					x	5	x	4	6	+2
42	x		x		x		x	1				1			x							2	7	-2
45	x	2	x		x	2	x	2					x		x	1			x				7	-3
46	x	2	x		x		x	1					x										5	-3
47																							0	0
48	x	6	x		x		x								x				x	1			6	-4
51	x	3					x														x	2	3	-1
53	x	1											x	1					x			1	4	0
54	x		x				x								x				x	1		2	6	-3
57	x														x							2	3	-2
58															x						x	2	2	-1
61	x	4			x														x	3	x	4	4	-1
62	x	5		1		4								2					x		x	3	6	+2
85	x	3	x																				2	-1
91													x										1	-1

DAM	L. fallax		L. peronii		L. tyleri		L. lato.		L. nasuta		L. verr.		Lim. per.		Lim. tas.		U. fusca		U. laev.		C. signif.		*n*	DIFF
	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09		
92	x	6	x	2	x							1		1					x			2	7	+1
112	x	6		2	x	2													x	4			4	+1
122	x	5											x		x				x			2	5	-2
123	x	6																					1	0
125	x												x		x				x		x		5	-5
126	x	2			x								x						x			2	5	-2
129	x	6			x														x			3	4	-1
130	x	5		1																	x	2	3	+1
142	x	5																	x				2	-1
144	x	6		1		2					x	2							x	4		3	6	+3
148	x	6					x	1					x									3	4	0
149	x	6																				2	2	+1
151	x	6		4						5	x		x								x		6	-1
152	x	5	x	3	x		x											4	x	3			6	-1
153	x		x				x									1		4		5	x	2	7	0

DAM	L. fallax		L. peronii		L. tyleri		L. lato.		L. nasuta		L. verr.		Lim. per.		Lim. tas.		U. fusca		U. laev.		C. signif.		*n*	DIFF
	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09	08	09		
154	x	6									x	1	x						x	3	x	3	5	-1
157							x	1														2	2	+1
160	x	2	x				x	1							x	2			x				5	-2
161	x		x		x		x						x						x	7		3	7	-4
162					x						x		x						x	1	x	3	5	-3
163	x			1																	x	2	3	0
167	x		x											1					x	2	x	3	5	-1
168	x												x		x				x	2	x	3	5	-3
169																							0	0

Appendix 4: Bird species and abundance at target dams

Scientific Name	Common Name	Dam No. 7		Dam No. 14		Dam No. 16		Dam No. 28	
		08	09	08	09	08	09	08	09
Circus approximans	Swamp Harrier	2				1			
Acrocephalus australis	Australian Reed Warbler								h
Chenonetta jubata	Australian Wood Duck	6		6	4	10	4	26	3
Cygnus atratus	Black Swan	1							
Anas castanea	Chestnut Teal			4	40		10	2	
Anas gracilis	Grey Teal				60		6	5	
Aythya australis	Hardhead						1	3	
Anas superciliosa	Pacific Black Duck	1	4	16	72	5	5	2	10
Anhinga melanogaster	Darter					1			
Egretta novaehollandiae	White-faced Heron	2	1						
Nycticorax caledonicus	Nankeen Night heron								1
Vanellus miles	Masked Lapwing		1			2			
Todiramphus sanctus	Sacred Kingfisher	1			1				
Pelecanus conspicillatus	Australian Pelican								1
Phalacrocorax sulcirostris	Little Black Cormorant	4	2					2	3
Phalacrocorax melanoleucos	Little Pied Cormorant		1						1
Phalacrocorax varius	Pied Cormorant					1			
Tachybaptus novaehollandiae	Australasian Grebe				2		4	2	3
Gallinula tenebrosa	Dusky Moorhen		2			2	2	3	2
Fulica atra	Eurasian Coot	4	1				2	2	1
Porphyrio porphyrio	Purple Swamphen	2	10					2	2
Total individuals recorded on each dam		**23**	**22**	**26**	**179**	**22**	**34**	**49**	**28**
No. of species recorded on each dam		**9**	**8**	**3**	**6**	**7**	**8**	**10**	**11**

Key: h=heard

Appendix 5: Example Water Quality and Aquatic Habitat Proforma

CUS/JOB NO:	
CLIENT NAME:	
SITE ADDRESS:	

Water_Body_Habitat_Assessment_Proforma

Identifier: **Waypoint:** **Date:**

	Habitat characteristic	Score	Comments
1	**Site particulars**		
	Waterbody type	Dam/Natural	
		Permanent/Ephemeral	
	Approx. Size (m^2)		
	External connectivity		
2	**Water Condition**		
	Turbidity	None/Low/Moderate/High	
	Eutrophication	None/Low/Moderate/High	
	Pollutants	None/Low/Moderate/High	
	pH		
	EC		
	Temperature		
3	**Vegetation**		
	Main Species present (+ % cover)		
	Plant diversity	Low/Moderate/High	
	Vegetation type / EEC		
	Regeneration occurring	Low/Moderate/High	
4	**Other Signs of Life**		
	Invertebrate activity	None/Low/Moderate/High	
	Presence of *Gambusia*	None/Low/Moderate/High	
5	**Habitat quality/10**		

Appendix 6: Contributions and qualifications of ecobiological staff

Name	Qualification	Title	Contribution
David Paull	M.Res.Sc	Ecologist (Herpetologist)	Project management, amphibian surveys, report writing
Kristy Peters	B. ParkMgt.	Ecologist (Ornithologist)	Blue-billed Duck surveys, report review
Ryan Parsons	B. Env Sc.	Botanist	*M. triglochinoides* survey
Dan Pedersen	B. Sc.	Botanist	*M. triglochinoides* survey
Dianna Brettschneider	B. App Sc.	GIS Manager	Preparation of map layouts for report

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