

Dendrobium Area 3A and 3B TARP response
Littlejohn's Tree Frog tadpole surveys
DC13, SC10C and WC17

Final Report

Prepared for Illawarra Coal

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1 Introduction

Biosis was commissioned by Illawarra Coal to undertake monthly monitoring of Littlejohn's Tree Frog *Litoria littlejohni* tadpoles at three streams located within the Dendrobium mining area, DC13, SC10C and WC17 (Figure 1). Additional monitoring was recommended by Biosis following the annual monitoring of the species during the 2015 breeding season. Subsidence effects observed during this monitoring included fracturing of stream bedrock, diversion of surface flows and iron flocculent in known breeding pools.

1.1 Objective

The objective of the monitoring program was to determine if tadpoles were developing through to metamorphosis and adults, indicated by an overall decline in tadpole numbers coincident with an increase in later developmental stages for tadpoles over time. This hypothesis was deemed to represent metamorphosis and successful completion of this life stage, and thus negligible impact to the species during the monitoring period.

1.2 Background

1.2.1 Dendrobium Area 3A

Following the extraction of Longwalls 6-8 in Dendrobium Area 3A in 2012, 30 subsidence impacts were recorded including rock fracturing and flow diversion within WC17 and SC10C sub-catchments. A total of nine impacts were located along streams and have resulted in the draining and/or loss of water from Littlejohn's Tree Frog breeding pools. Both SC10C and WC17 are located above Longwall 7 and Longwall 8 in Dendrobium Area 3A.

During the 2015 monitoring period, Littlejohn's Tree Frog was not recorded within the WC17 transect for a second consecutive year. This followed a decline in adult and tadpole numbers for this species from 2011 to 2013 post-impact. Despite not detecting the species, Biosis found that the entire monitoring transect along WC17 was full of water following high rainfall events in the month prior to survey. This contrasts with observations made during 2014 during which time the entire length of the transect was dry. In addition, iron flocculent coverage was present throughout the entire monitoring transect in 2015.

Adult detection at SC10C increased in 2015 compared with previous post-mining years of monitoring. Previous declines in the presence of Littlejohn's Tree Frog adults at SC10C has correlated with reductions in pool water levels along the transect. Heavy rain during the monitoring season resulted in increased water levels along the transect at the time of year required to facilitate a breeding event however abundance remained below pre-mining values. No tadpoles were recorded at SC10C during 2015; a result which has not been recorded for this site since monitoring began in 2007.

The revised *Dendrobium Area 3A Trigger Action Response Plan* (TARP) (dated 18 October 2012) relating to ecology does not include triggers specific to threatened fauna and therefore do not stipulate specific actions to be undertaken following the detection of impacts to Littlejohn's Tree Frog habitat during Littlejohn's Tree Frog surveys. It is understood that Pool Water Level / Flow and Appearance triggers in the Dendrobium Area 3A Watercourse TARP have, however, been reached and Corrective Management Actions (CMAs) are being considered by Illawarra Coal to address observed impacts to threatened frog habitat.

1.2.2 Dendrobium Area 3B

The upper 300 metre section of DC13 is located above Longwall 9 in Dendrobium Area 3B. At the completion of extraction of Longwall 9 in Dendrobium Area 3B in 2014, twenty-eight impacts had been identified by the Illawarra Coal Environmental Field Team (Illawarra Coal 2014). A total of six pools were impacted in April 2013 along DC13, of which four were known to provide Littlejohn's Tree Frog breeding habitat prior to mining (Biosis 2013).

In 2015, Littlejohn's Tree Frog adults and egg mass were recorded at DC13 for the first time since 2012. One adult was recorded in Pool 12, and 30 egg mass were recorded across seven breeding pools from Pool 11 through to some potholes in the sandstone bedrock below Pool 17. Adult detection remained below that recorded pre-impact. Declines in water level remained evident during 2015 along the DC13 Littlejohn's Tree Frog monitoring transect with no water present upstream of Pool 18A and limited water present at 7 pools from Pool 13A to Pool 17.

Subsequently, DC13 was assessed against the Dendrobium Area 3B Watercourse TARP (dated 12 October 2015). The triggers for *terrestrial fauna - threatened frog species* state that:

- A Level 1 TARP is triggered if a reduction in habitat is observed for one year.
- A Level 2 TARP is triggered if a reduction in habitat is observed for two years following the active subsidence period.
- A Level 3 TARP is triggered if a reduction in habitat is observed for more than two years or a complete loss of habitat is observed following the active subsidence period.

To assist in the assessment of observations made at DC13 against the TARP, Biosis has defined a reduction in habitat as any of the following:

1. A reduction in threatened frog breeding habitat, shown by dry pools along a transect throughout the breeding season. This prevents adults from laying egg mass and is a reduction only if a portion of the habitat is affected and not others.
2. A reduction in habitat for threatened frog egg mass and tadpole life stages, as shown by breeding pools unable to hold water for a sufficient time to allow for full development to occur. This results in the unsuccessful hatching or incomplete metamorphosis.
3. A reduction in the presence of threatened frogs (all life stages) from a site where successful breeding occurred pre-mining when recorded at the same period at control sites.

A complete loss of habitat is defined as any of the following:

4. The loss of an entire transect of threatened frog breeding habitat along a stream, as indicated by dry pools during the breeding season. This prevents adults from laying egg mass.
5. The absence of the threatened frog species (all life stages) from a site where successful breeding occurred pre-mining when recorded at the same period at control sites.

Using these definitions and the TARP triggers Biosis determined that following the winter 2015 Littlejohn's Tree Frog targeted surveys a Level 2 TARP has been triggered for DC13. Further assessment has been provided below in Section 1.2.3.

No other threatened frogs were recorded along these transects during the winter survey.

1.2.3 Performance against the TARP

Table 1 below provides further details of the assessment of SC10C and WC17 against the Dendrobium Area 3A Watercourse TARP (dated 18 October 2012), while Table 2 provides an assessment of all three sites against the Dendrobium Area 3B Watercourse TARP (dated 12 October 2015).

Table 1 Assessment of Littlejohn's Tree Frog monitoring results at impacted sites within the Dendrobium Area 3A against Dendrobium Area 3A TARPs

Stream	Predicted impact	Results and TARP justification	TARP
SC10C	Significant impacts to the Littlejohn's Tree Frog.	No trigger relates specifically to threatened fauna species, therefore observed impacts to Littlejohn's Tree Frog habitat have not triggered a TARP. Level 3 Watercourse Monitoring relating to the following have been observed: <ul style="list-style-type: none"> Stream appearance at SC10C. Aquatic ecology including pool water level, interconnectivity between pools and loss of connectivity, noticeable alteration of habitat at SC10C. 	No threatened frog TARP triggered. Consider response in line with Area 3B Level 3 TARP trigger for Threatened Frogs.
WC17	Significant impacts to the Littlejohn's Tree Frog.	No trigger relates specifically to threatened fauna species, therefore observed impacts to Littlejohn's Tree Frog habitat have not triggered a TARP. A Level 2 Watercourse Monitoring trigger has been observed for WC17 as the majority of pools monitored showed water level or pool retention time lower than baseline.	No threatened frog TARP triggered. Consider response in line with Area 3B Level 3 TARP trigger for Threatened Frogs

Table 2 Assessment of Littlejohn's Tree Frog monitoring results at impact sites within the Dendrobium Area 3B against Dendrobium Area 3B TARPs

Stream	Predicted impact	Results and TARP justification	TARP
DC13	Significant impacts to the Littlejohn's Tree Frog.	Following the 2015 survey at DC13, pools that were previously utilised by the species to breed (Pools 18A through to the transect end) were recorded to have minimal to no water for three consecutive years (2013, 2014 and 2015). This represents a reduction in breeding habitat across three monitoring periods and two years following impacts; therefore a level 2 TARP has been triggered for DC13.	Level 2 trigger.

1.2.4 Response to TARP trigger

The Dendrobium Area 3A Watercourse TARP does not specifically consider threatened fauna in watercourses. CMAs required by related Dendrobium Area 3A Watercourse TARPs however are likely to address some impacts to threatened frog habitats.

In response to the impacts detected along DC13, the following response, in accordance with the Dendrobium Area 3B Watercourse TARP has been initiated. It should be noted that some of the following actions have commenced at SC10C and WC17, including the monitoring undertaken as part of this report by Biosis and Illawarra Coal.

Level 1

- Continue monitoring program.
 - Biosis will continue to monitoring SC10C, WC17 and DC13 as part of the 2016 threatened frog monitoring program.
- Submit an Impact Report to Office of Environment and Heritage (OEH), Department of Planning and Environment (DoPE), Trade and Investment: including Division of Resources and Energy, Office of Water, Fisheries (T&I), WaterNSW and other relevant resource managers.
 - As detailed herein.
- Report in the End of Panel Report.
 - End of Panel Terrestrial Ecology Reports have been prepared for Longwalls 7-10.
- Summarise actions and monitoring in AEMR.
 - Biosis recommends that the results detailed herein are included in the 2016 AEMR.

Level 2

- Review monitoring frequency.
 - Biosis conducted additional tadpole monitoring during summer 2015/2016 to determine tadpole success and metamorphosis. Methods and results have been further discussed herein.
- Notify relevant technical specialists and seek advice on any CMA required.
 - As detailed in Section 4 herein.
- Implement agreed CMAs as approved (subject to stakeholder feedback).
 - As detailed in Section 4 herein.

2 Survey methods

2.1 Increased monitoring of breeding pools

In response to the Level 2 and 3 triggers, Illawarra Coal increased the Environmental Field Team pool water level monitoring along DC13, SC10C and WC17. All pools along the three streams were monitored once per week during the monitoring program. A summary of pools is provided below in Table 3 and mapped in Figure 2.

Table 3 Summary of all pools along DC13, SC10C and WC17 with increased water level monitoring

Site	Pools
SC10C	Pool 1, Pool 2, Pool 2A, Pool 2B, Pool 3, Pool 4, Pool 5, Pool 6, Pool 7, Pool 8, Rockbar 9 and a pool on sandstone between Pool 8 and 8b.
WC17	Pool 20(S12), Pool 21(S12), Pool 22(S12), Pool 23(S12), Pool 24(S12), Pool 25(S12) and Pool 26(S12)
DC13	Pool 1, Pool 9, Pool 10, Pool 11, Pool 12, Pool 13B, Pool 13A, Pool 14, Pool 15, Pool 16A, Pool 16B, Pothole 1 between Pool 16A & 17, Pothole 2 between Pool 16A & 17, Pothole 3 between Pool 16A & 17 and Pool 17

Data was forwarded to Biosis on a monthly basis to review pool water levels and determine whether continued monthly monitoring was required through to the end of the metamorphosis period of Littlejohn's Tree Frog, being March 2016.

The pool monitoring data was then plotted by Biosis in Microsoft Excel to determine the extent of impact to Littlejohn's Tree Frog habitat at DC13, SC10C and WC17. For successful metamorphosis to occur at pools located along DC13, SC10C and WC17, pools must retain water for at least four months following a breeding event. Therefore if a key breeding pool was recorded as dry at any time during the four months from a breeding event (critical time for breeding and tadpole development), it was assumed that successful breeding was compromised and therefore an impact to a sub-population had occurred.

2.2 Monthly tadpole surveys

In addition to increased pool water level monitoring, Biosis also completed monthly tadpole surveys to confirm whether egg mass successfully hatched and if tadpoles were or were not surviving through to metamorphosis. Monitoring of egg mass and tadpoles assisted in determining the following:

- The success of hatching egg mass and survivorship of tadpoles where water persisted but only as very shallow pools.
 - Rationale: Low water levels have the potential to facilitate an increase in tadpole predation and reduce survivorship.
- Whether a breeding event occurred at impact sites where the species was not recorded during winter monitoring including WC17.
 - Rationale: Although the species was not recorded at WC17 when surveyed on 4 August 2015, due to water present in several pools along the transect, it was considered that a breeding event could have taken place following the original monitoring survey in August. An additional assessment to determine tadpole presence was undertaken.

- The success of egg mass hatching and survivorship of tadpoles during the first stages of development in locations where iron flock was present.
 - Rationale: It is unknown what effects iron flock may have on the early stages of development, therefore this information would allow confirmation of successful breeding in locations such as SC10C where many egg mass were coated in iron flock. Specifically, if water levels remained high enough in Pool 1 to allow for successful metamorphosis, it would be beneficial to confirm the successful hatching of egg mass and survival of tadpoles until the point that their lungs were sufficiently developed to gulp air.

Surveys were undertaken by a qualified Biosis zoologist and a member of the Illawarra Coal Environmental Field Team between November 2015 and March 2016. Weather observations for each survey date are shown in Table 4.

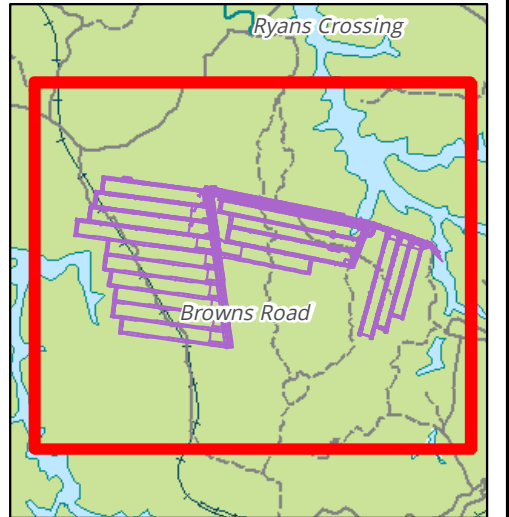
Table 4 Weather observations during tadpoles surveys (Source Moss Vale AWS and Dendrobium weather station)

Survey date	Temperature (°C) from Moss Vale AWS		Rain (mm) from Dendrobium weather station	
	Minimum	Maximum	On survey day	Cumulative over month prior
23 November 2015	10.4	24.9	0	69.5
24 November 2015	12.1	26.9	0	69.5
11 January 2016	16.7	33.0	0	167.5
12 January 2016	18.5	32.8	0	167.5
9 February 2016	14.2	23.7	0	156
10 March 2016	15.0	28.9	0	0.8

Surveys were undertaken at night and included counts of all tadpoles within pools. Counts were undertaken by a minimum of two people walking parallel to the creek and counting all tadpoles in each pool surveyed. Following these initial counts a representative sample of tadpoles were selected to identify the developmental stage (Gosner stage) to determine the overall trend in development of tadpoles in the pools.

During the first replicate, each pool was surveyed for tadpoles along the entire length of the monitoring transect. Subsequent surveys included those pools where tadpoles were recorded in the initial replicate and those downstream to ensure the survey covered any individuals that may have been flushed downstream in a high rainfall event or natural flow. Due to the location of pools and impacts, all pools along DC13 were surveyed in all four replicates.

Due to inclement weather and catchment access closures, the December replicate could not be completed. The survey was planned for 21-22 December 2015; however the catchment was closed due to high rainfall and remained closed until the early January survey. As a result, only two replicates were completed at WC17.



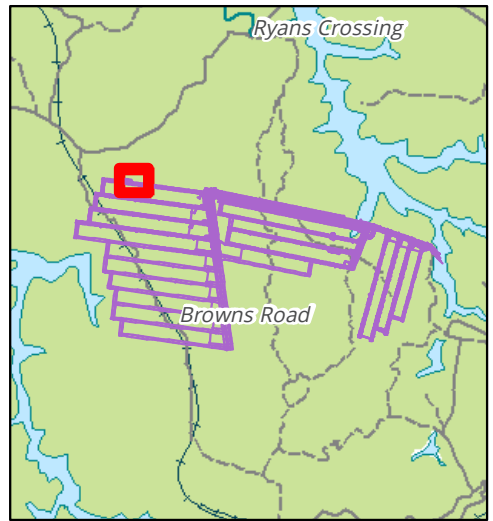
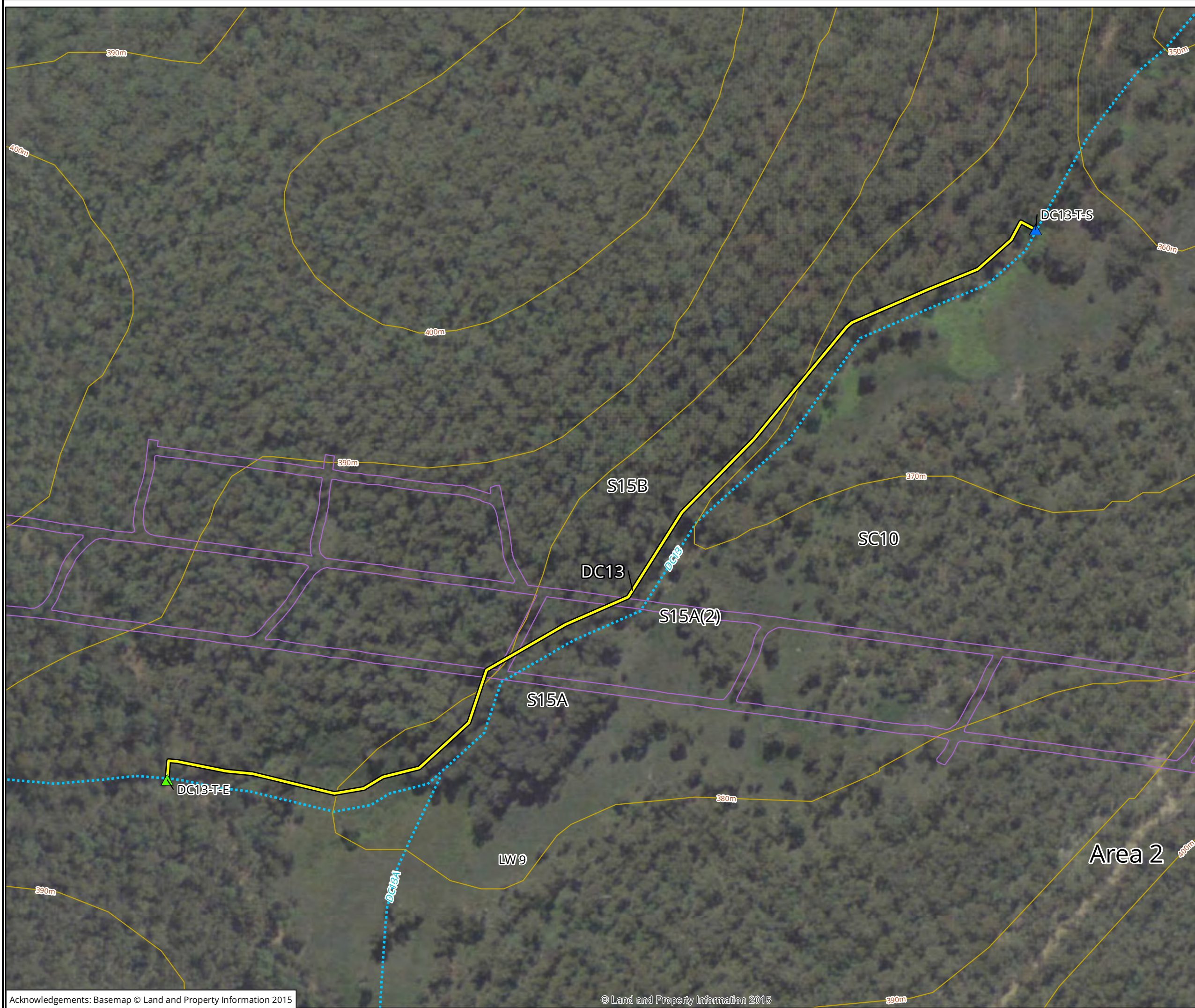
- Legend**
- Threatened frog monitoring impact transect
 - Survey Area
 - Longwall Layout
 - IC Creekline

Figure 1: Location of watercourses surveyed in Dendrobium Area 3A and Dendrobium Area 3B

0 300 600 900 1,200 1,500
 Metres
 Scale: 1:30,000 @ A3
 Coordinate System: GDA 1994 MGA Zone 56

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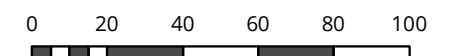
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 Date: 14 March 2016,
 Checked by: KJR, Drawn by: JMS, Last edited by: jshepherd
 Location: P:\21100s\21186\Mapping\21186 AR F1 DendArea3a3b_overview



Legend

- Threatened Frog Monitoring
 - ▲ Transect Start
 - ▲ Transect End
 - Threatened frog monitoring impact transect
- Survey Area
 - Longwall Layout
 - IC Creekline

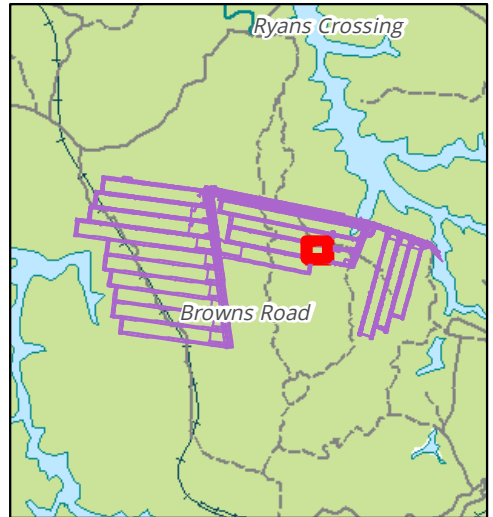
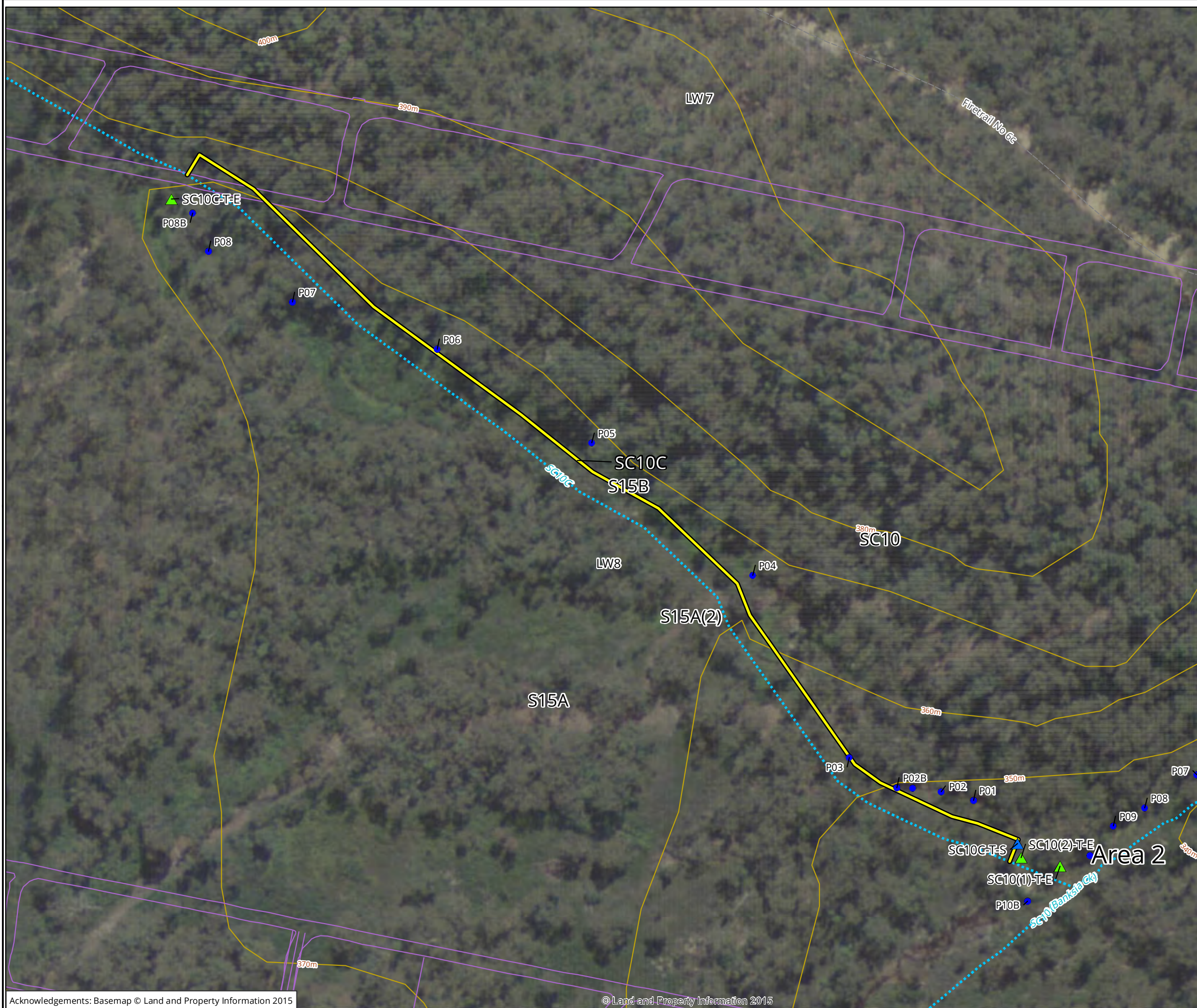
Figure 2: Location of pools along DC13



Metres
 Scale: 1:2,000 @ A3
 Coordinate System: GDA 1994 MGA Zone 56



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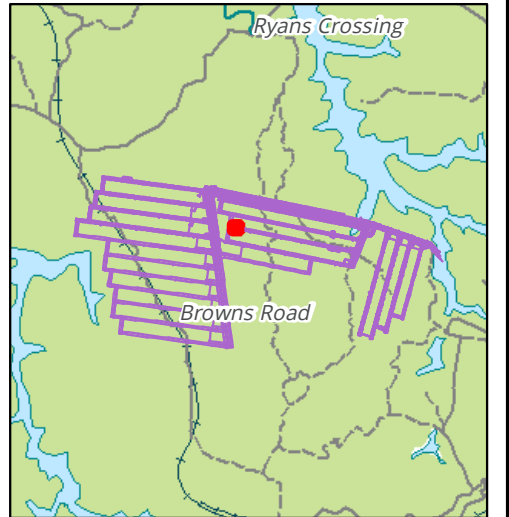
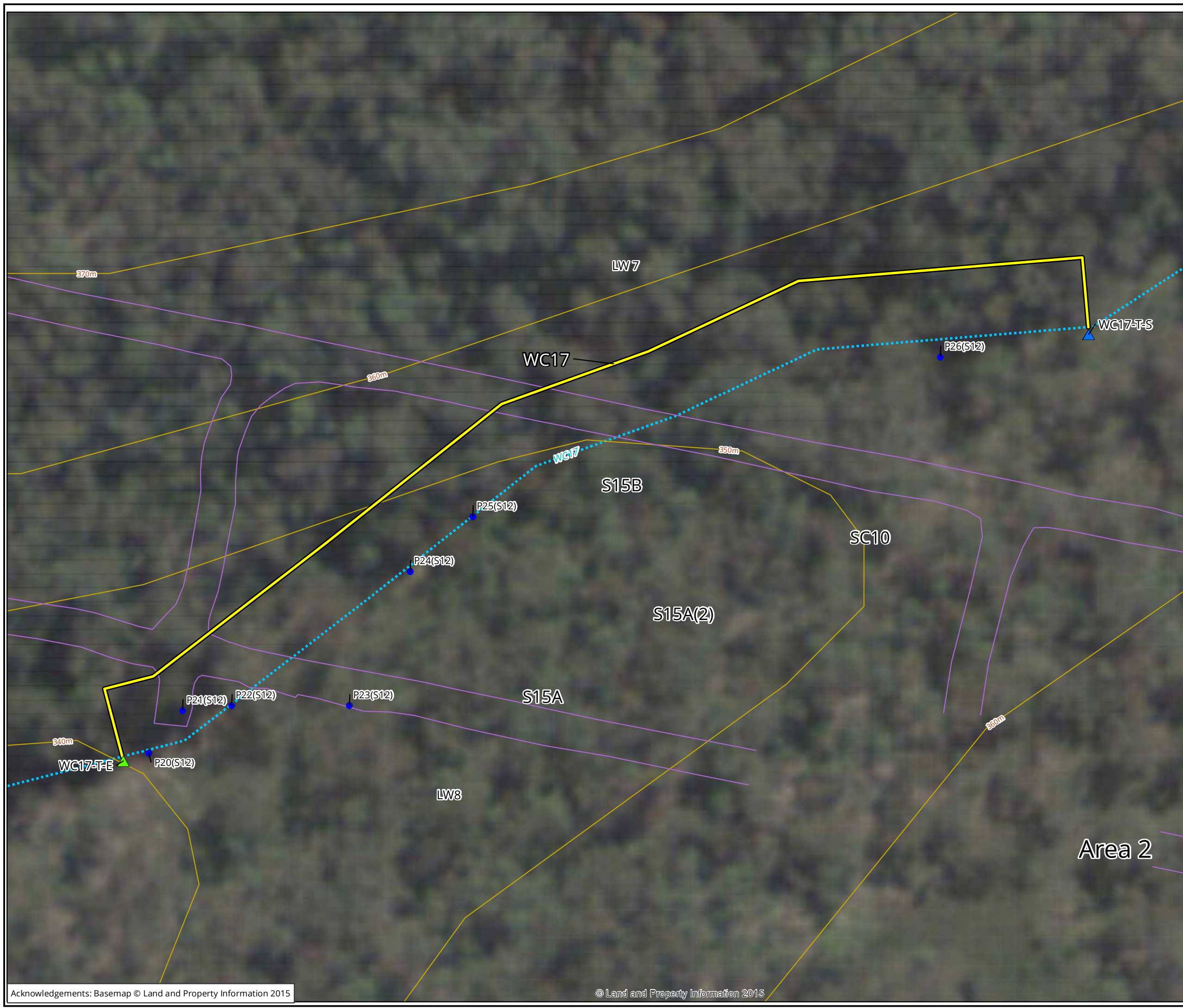
- Legend**
- Threatened Frog Monitoring
 - ▲ Transect Start
 - ▲ Transect End
 - Threatened frog monitoring breeding pool
 - Threatened frog monitoring impact transect
 - Survey Area
 - Longwall Layout
 - ⋯ IC Creekline

Figure 2: Location of pools along SC10C

0 10 20 30 40 50
Metres
Scale: 1:1,500 @ A3
Coordinate System: GDA 1994 MGA Zone 56



Matter: 21186
Date: 14 March 2016,
Checked by: KJR, Drawn by: JMS, Last edited by: jshepherd
Location: P:\21100s\21186\Mapping\21186 AR F2 Pools



- Legend**
- ▲ Transect Start
 - ▲ Transect End
 - Threatened frog monitoring breeding pool
 - Threatened frog monitoring impact transect
 - ⋯ IC Creekline

Figure 2: Location of pools along WC17



Scale: 1:500 @ A3
 Coordinate System: GDA 1994 MGA Zone 56



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 Date: 14 March 2016,
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 Location: P:\21100s\21186\Mapping\21186_AR_F2_Pools

Area 2

3 Results

3.1 SC10C

Tadpoles were detected within the SC10C transect at all surveys completed at this site between November 2015 and February 2016. During the annual monitoring completed at SC10C on 8 August 2015 a total of 28 tadpoles were detected at two breeding pools, Pool 1 and Pool 8B (Graph 1).

The initial survey undertaken during the current assessment detected tadpoles at the following locations along the DC13 transect in November 2015:

- Pool 1
- Pool on sandstone between Pool 8 and 8b

At Pool 1, the trend in tadpole counts was similar to that detected at DC13 and declined following a peak in November 2015. This overall trending decline combined with increased numbers of late stage tadpoles (see (Graph 1 and Plate 1) would suggest that this decline in numbers could be a result of sustained tadpole development through to metamorphosis to adult frogs.

No tadpoles were detected in other pools following the first survey in November 2015.

Graph 1 SC10C transect experiencing a decline in Littlejohn's Tree Frog tadpole counts and increased development of tadpoles (Date on x-axis, tadpole count on y-axis) despite high rainfall. Tadpole count (TC). Metamorphosis Development Stage (MDS)

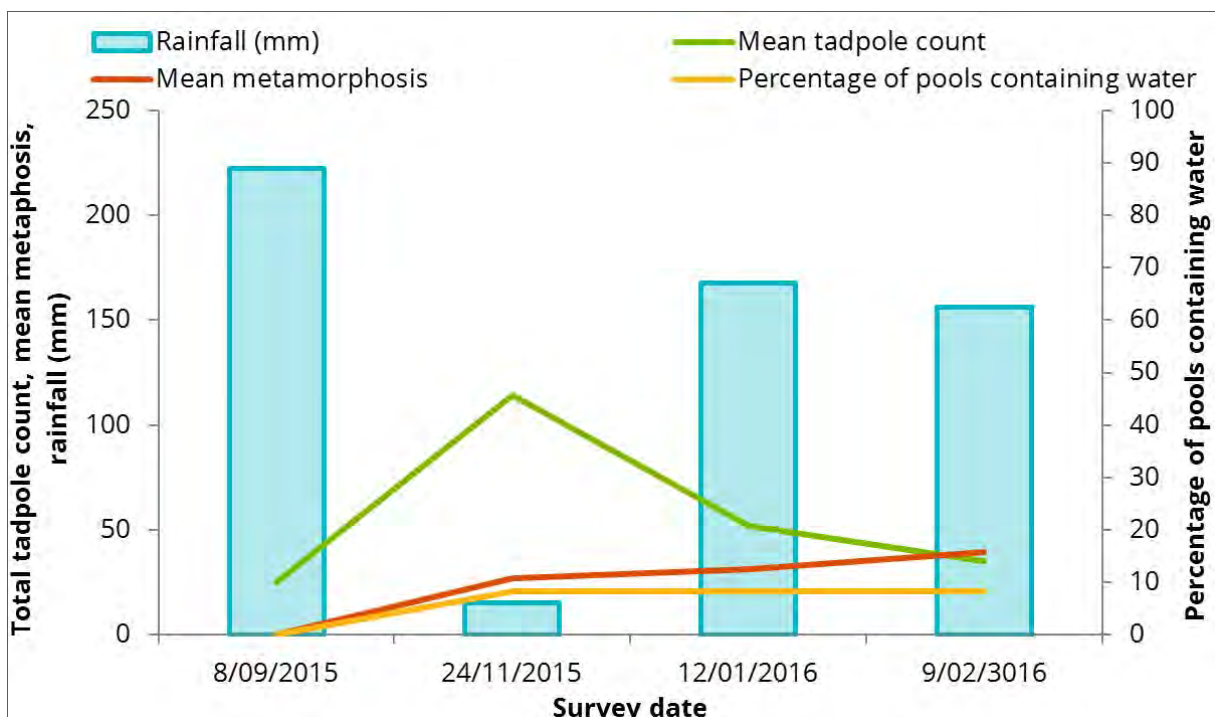


Plate 1: Littlejohn's Tree Frog *Litoria littlejohni* in Pool 1 at SC10C in metamorphosis (Stage 44)



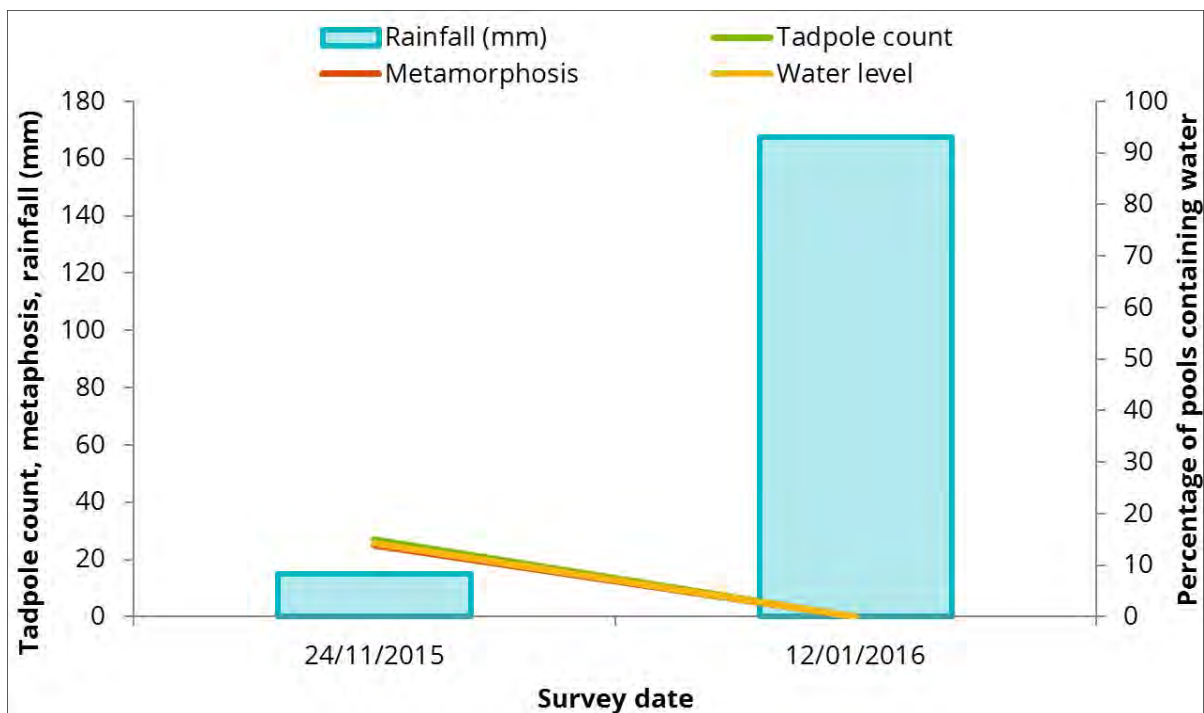
3.2 WC17

Tadpoles were only recorded in the first replicate at WC17. Surveys detected immature tadpoles in Pool 26 at the end of November however this pool was subsequently recorded to be dry in mid December by the Illawarra Coal Environmental Field Team. Following the drying of all pools except Pool 22 and Pool 26 during the December 2015 survey, no tadpoles were detected (Graph 2).

Despite an increase in rainfall over the metamorphosis period, pools along WC17 contained little to no water and therefore suitable breeding habitat for Littlejohn's Tree Frog was largely absent from the transect.

As a result, full metamorphosis of the species into sub-adult and or adult frog form was not observed during the monitoring period (Graph 2).

Graph 2 WC17 transect experiencing a decline in Littlejohn’s Tree Frog tadpole counts to zero (Date on x-axis, tadpole count on y-axis) despite high rainfall. Tadpole count (TC). Metamorphosis Development Stage (MDS)



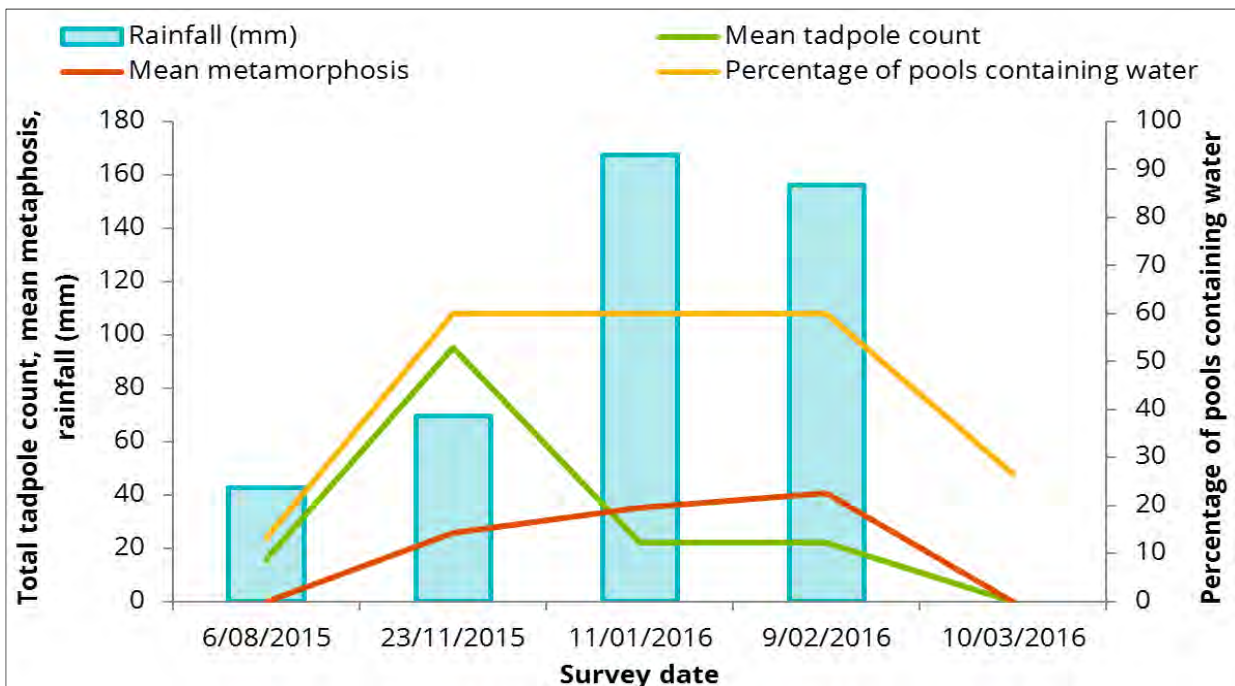
3.3 DC13

Tadpoles were detected within the DC13 transect at all surveys except for the last survey undertaken in March 2016. During the annual monitoring completed at DC13 on 6 August 2015 a total of 36 tadpoles were detected over three breeding pools and three potholes located between Pool 16A and Pool 17. The initial survey undertaken in November 2015 as part of the current assessment, detected at least one tadpole at the following six pools and two potholes along the DC13 transect:

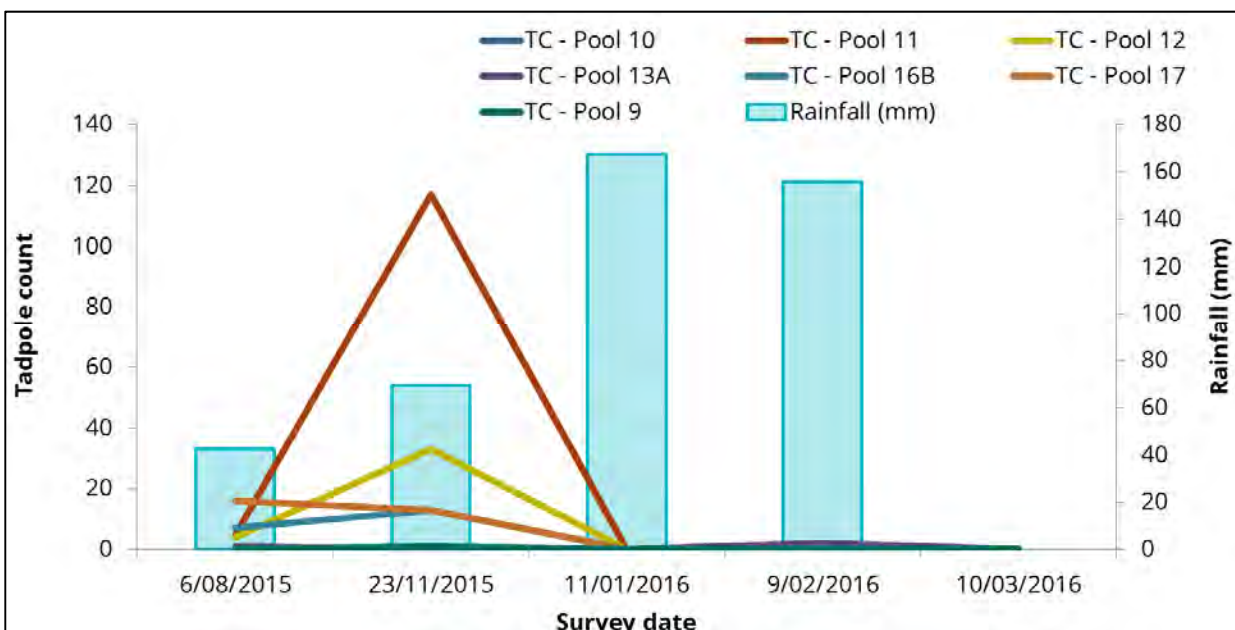
- Pool 9
- Pool 10
- Pool 11
- Pool 12
- Pool 16B
- Pool 17
- Pothole 1 (between Pool 16A & 17)
- Pothole 3 (between Pool 16A & 17)

Following the peak breeding season, a total of 284 tadpoles were recorded along the DC13 transect from 14 of the 15 (93%) mapped breeding pools. This is not surprising as the peak breeding season extends to mid-September (authors observations) within the region and Littlejohn's Tree Frog adults would have deposited egg mass following the survey in August. Between the late November survey and early January survey (seven weeks), the number of tadpoles decreased by 87% and were restricted to the three pothole sites (Graph 3 and Graph 4).

Graph 3 Total Littlejohn's Tree Frog tadpole counts along DC13 (date on x-axis, tadpole count on right y-axis and percentage of pools containing water on left y-axis).



Graph 4 Pools along DC13 experiencing a decline in Littlejohn's Tree Frog tadpole counts to zero (Date on x-axis, tadpole count on y-axis) despite high rainfall. Tadpole count (TC).



The observed decrease in tadpoles at the remaining pools along DC13 can be attributed to several factors including:

- Pool 13B was dry at monitoring completed between 24 November 2015 and 20 January 2015.
- Water in Pool 13B, Pool 13A, Pool 14, Pool 15, Pool 16A and Pool 16B fluctuated between completely dry to slightly filling with a rapid transition from slightly filled to dry.
- Heavy rainfall may have flushed individuals' further downstream beyond the monitoring transect.

- Low water levels may have increased the rate of predation on tadpoles.

Over the period of monitoring, small potholes along DC13 provided stable waterbodies in which Littlejohn's Tree Frog tadpoles can metamorphose. During all surveys, the ponding water surface in Pothole 1 was approximately 100cm by 75cm in diameter and ranged from 30cm to 40cm deep (Plate 2). Heavy colouring resulting from natural plant tannins made it difficult to see the bottom of the pool and therefore difficult to survey during the first replicate. The survey time was extended to ensure the entire pothole was exhaustively searched and all tadpoles recorded. Subsequent surveys, in January and February, were much easier as heavy rainfall in the month prior had flushed out the water reducing tannins and greatly improving visibility.

The ponding water surface in Pothole 2 was 17 by 20cm in diameter and 25cm deep (Plate 3), while Pothole 3 was 130cm by 50cm in diameter and ranged from 30cm to 40cm deep (Plate 4).

During the last survey, in March 2016, water in all three potholes had again become highly coloured by plant tannins. No tadpoles were detected.



Plate 2: DC13 Pothole 1



Plate 3: DC13 Pothole 2



Plate 4: DC13 Pothole 3

During the period of monitoring between November 2015 and March 2016, development in tadpoles at DC13 progressed through to metamorphosis stages, albeit this was driven by the observations from only three potholes and did not include larger pools along the transect (Graph 3). Sustained growth and development of tadpoles within these potholes to late Gosner stage was detected throughout the monitoring period until the February 2016 survey. Resulting from a combination of growth and development of tadpoles to late Gosner

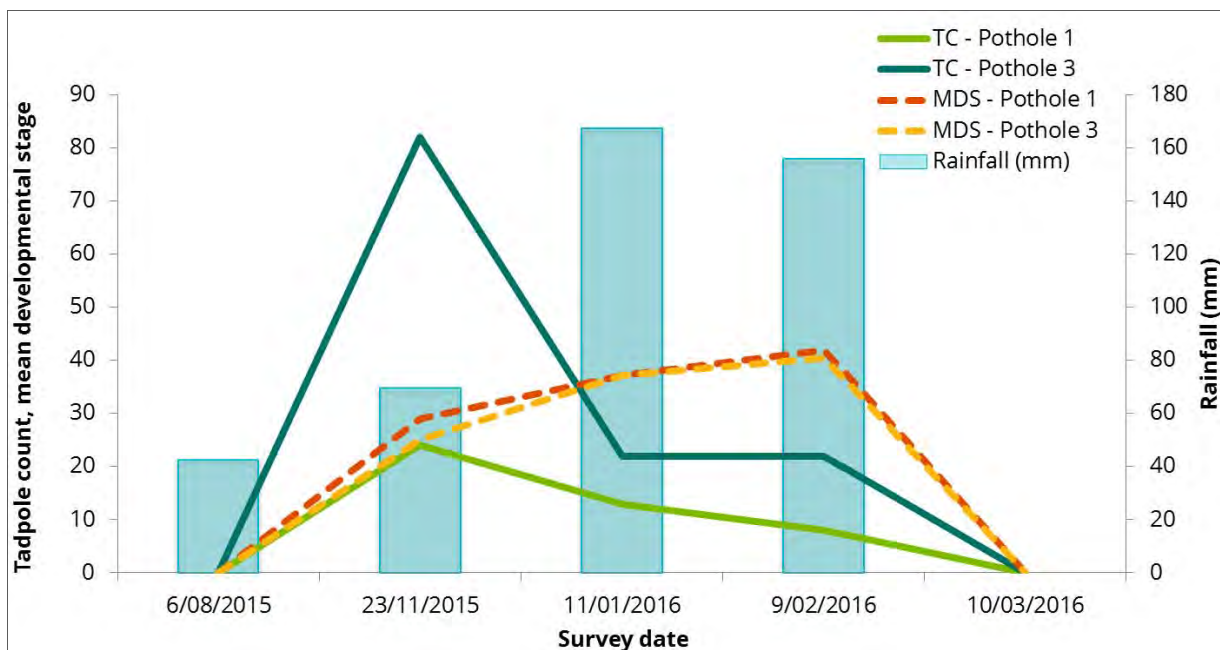
stage and environmental factors, the number of tadpoles in Potholes 1, 2 and 3 decreased consistently, from a peak in November 2015.

No rainfall was detected at the Dendrobium weather station between the February and March 2016 surveys. During this time, water levels at all pools along the transect declined (Biosis observations) and water within the three potholes became rich in tannins. No tadpoles were detected during March 2016 surveys. It is estimated that approximated half of the tadpoles sampled during the February 2016 survey were at Gosner Stage 42 or 43 and had therefore developed to the metamorphosis stage (between Stage 42 and Stage 46).

Completion of full metamorphosis of the species into sub-adult and or adult frog form was not observed during the monitoring period. Once frogs metamorphose and vacate the waterbody they are likely to be difficult to detect. As the final March 2016 survey did not detect any tadpoles, it cannot be determined whether successful metamorphosis from the tadpole life form to frog life form occurred.

Graph 5 shows numbers of Littlejohn's Tree Frog tadpoles detected during the monitoring period at the three potholes and the rate of development to metamorphosis.

Graph 5 Potholes along DC13 detecting development of Littlejohn's Tree Frog tadpole to metamorphosis and a decline in tadpole counts (Date on x-axis, tadpole count on y-axis) despite high rainfall. Tadpole Count (TC). Metamorphosis Development Stage (MDS)



4 Discussion and conclusions

4.1 Discussion

Although tadpole development through to metamorphosis was recorded at DC13, tadpoles were restricted to three small potholes located in the sandstone bedrock below Pool 17. Potholes and pools recorded in other locations along the transect did not retain water long enough to allow tadpole development through to later Gosner stages. Following the extraction of Longwall 9 and Longwall 10, habitat along this transect is now considered to be limited to the three potholes. This poses greater risk to the species through increased predation rates both from other tadpoles and other fauna that prey on tadpoles, risk to disease and increased risk to changes in water quality such as dissolved oxygen levels, foraging habitat and sheltering habitat. It is therefore recommended that CMAs are required along DC13.

Grouting of rockbar and bedrock at key locations where water flow is diverting will be required to ensure water is retained in the following important habitat pools (at a minimum):

- Pool 16A
- Pool 16B
- Pool 17
- Pool 18A
- Pool 18B
- Pool 19

The above pools have been selected based on the location of impacts, historical records of tadpoles and egg mass along DC13 and the proximity to the two potholes in which metamorphosis was recorded during the current survey. If current conditions continue, it is likely a Level 3 trigger will be reached following the 2016 monitoring of DC13.

At SC10C, based on the results herein, we conclude that tadpoles were likely to have successfully metamorphosed to adults at Pool 1, located downstream of the impacted area of the transect. Impacts to the remaining upstream pools have resulted in a significant local decline in the detection of Littlejohn's Tree Frog, in all life forms. Pool 1 remains a stronghold for the species along this transect. As detailed above, the reliance of successful breeding at one pool increases the risk of predation rates, disease and susceptibility of individuals to changes in water quality. Even with high levels of rainfall occurring between November 2016 and March 2016, the availability of habitat along WC17 was not sustained sufficiently long to allow for any tadpole development along the transect. It has therefore been concluded that WC17 no longer contains the habitat components necessary for successful metamorphosis and development to adults for the species during typical weather patterns.

4.2 Recommendations

As a requirement of the Dendrobium Area 3B TARPs, the following actions have been recommended for DC13:

- Continue threatened frog monitoring program in 2016.

- Submit this report as an Impact Report to OEH, DoPE, T&I, WaterNSW and other relevant resource managers.
- Include the results and recommendations detailed herein in the Illawarra Coal 2016 AEMR.
- Notify relevant technical specialists and seek advice on CMAs discussed in Section 4.3 below.
- Implement agreed CMAs as approved, subject to stakeholder feedback, and as discussed below in Section 4.3 below.

4.3 Additional actions

4.3.1 Area 3A Watercourse TARPs for SC10C and WC17

Level 3 Dendrobium Area 3A Watercourse TARPs for stream appearance and aquatic ecology (as identified in Table 1) have resulted in the following actions:

- Site visits with OEH, DoPE, T&I, Water NSW and other resource managers.
- Additional monitoring.
- Review relevant TARP and Management Plans in consultation with key stakeholders.
- CMAs have been proposed for SC10C as part of the Dendrobium Swamp Rehabilitation Research Program, including grouting of rockbar and bedrock base at significant pools. CMAs are further discussed in Section 4.3.2 below.

4.3.2 Develop site CMAs

It is recommended that Illawarra Coal use surface sealing techniques, such as grouting, at key locations of water flow diversion in accordance with the techniques summarised in the Dendrobium Watercourse Impact Monitoring Management and Contingency Plan. Surface grouting, which can be mixed and placed by hand onsite, should be placed at strategic locations such as rock bars above breeding pools, rather than all fractures along the watercourse with the aim to create permeability membrane that allows for water retention in important breeding pools (as detailed above). Over time, natural infill of sediment may supplement grouting.

Following the installation of CMAs, ongoing monitoring would be required in accordance with adaptive management principles to ensure the ongoing effectiveness of the action. Consultation and approvals from the relevant agencies including WaterNSW would be required.

4.4 Conclusion

Tadpole development at SC10C, WC17 and DC13 varied based on the availability of sustained water levels within potholes and pools throughout the key development stages following the 2015 breeding season.

Due to a limited number of breeding pools that currently contain water long enough to allow for full development to metamorphosis and adults, the risk of losing a generation of a local population of Littlejohn's Tree Frogs at these sites has significantly increased following the detection of mining impacts.

It is recommended that CMAs in the form of grouting at key locations where water flow is diverting are undertaken.

Annual threatened frog monitoring will continue as a part of Illawarra Coal's ecological monitoring program. The monitoring program will determine whether adult frogs attempt to breed at DC13, WC17 and SC10C

following any CMAs. The monitoring will determine whether flows remain diverted and whether observed impacts are likely to have a long-term impact on the local population of this species.

5 References

Biosis 2013. *Dendrobium Colliery Ecological Monitoring Program Annual Monitoring Report Financial Year 2012/2013*. Biosis Pty Ltd, Wollongong.

Commonwealth of Australia 2014. *Temperate Highland Peat Swamps on Sandstone: evaluation of mitigation and remediation techniques*. Knowledge report. Prepared by the Water Research Laboratory. University of New South Wales, for the Department of the Environment, Commonwealth of Australia.

Illawarra Coal 2012. *Dendrobium Area 3A Trigger Action Response Plan*. Illawarra Coal 18 October 2012.

Illawarra Coal 2014. *Dendrobium Area 3B Longwall 9 Landscape Monitoring Report*. Report prepared by Illawarra Coal, May 2014.

Illawarra Coal 2015. *Dendrobium Area 3B Trigger Action Response Plan*. Illawarra Coal 12 October 2015.

Appendix

Pool data

Table 5 SC10C tadpole, metamorphosis and pool data

Lifeform and water level	Survey date	Pool 1	Pool on sandstone between Pool 8 and 8B	Mean tadpole count	Rainfall (mm)
Tadpole count	8/09/2015	25	0	25	222.5
	24/11/2015	72	42	114	15
	12/01/2016	52	0	52	167.5
	9/02/3016	35	-	35	156
Metamorphosis	8/09/2015	0	0	0	222.5
	24/11/2015	25.5	28	26.75	15
	12/01/2016	31	0	31	167.5
	9/02/3016	39.5	0	39.5	156
Water level	8/09/2015	-	-	0	222.5
	24/11/2015	1	-	8	15
	12/01/2016	1	-	8	167.5
	9/02/3016	1	-	8	156

Table 6 WC17 tadpole, metamorphosis and pool data (Pool 26 (S12))

Lifeform and water level	Survey date	Tadpole count	Rainfall (mm)
Tadpole count	24/11/2015	27	15
	12/01/2016	0	167.5
Metamorphosis	24/11/2015	25	15
	12/01/2016	0	167.5
Water level	24/11/2015	14	15
	12/01/2016	0	167.5

Table 7 DC13 tadpole, metamorphosis and pool data

Lifeform and water level	Survey date	Pool 9	Pool 10	Pool 11	Pool 12	Pool 16B	Pothole 1	Pothole 3	Pothole 3	Pool 17	Mean tadpole count	Rainfall (mm)
Tadpole count	6/08/2015	0	0	5	6	3	0	0	0	16	16	42.5
	23/11/2015	0	1	117	33	13	24	0	82	13	95	69.5
	11/01/2016	0	0	0	0	0	13	1	22	0	22	167.5
	9/02/2016	0	0	0	0	0	8	1	22	0	22	156
	10/03/2016	0	0	0	0	0	0	0	0	0	0	-
Metamorphosis	6/08/2015	-	-	-	-	-	-	-	-	-	0	42.5
	23/11/2015	0	31	25	30	38	29	0	25	29	26	69.5
	11/01/2016	0	0	0	0	0	37	31	37	0	35	167.5
	9/02/2016	0	0	0	0	0	42	40	40	0	41	156
	10/03/2016	0	0	0	0	0	0	0	0	0	0	42.5
Water level	6/08/2015	0	0	0	0	1	0	0	0	1	13	42.5
	23/11/2015	1	1	1	1	1	1	1	1	1	60	69.5
	11/01/2016	1	1	1	1	1	1	1	1	1	60	167.5
	9/02/2016	1	1	1	1	1	1	1	1	1	60	156
	10/03/2016	0	1	0	0	0	1	1	1	0	27	x