

Woolgoolga to Ballina Pacific Highway upgrade

**Threatened Frog Monitoring Annual Report
2017/18**

Version 5.0



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...22 February 2019

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1.0 INTRODUCTION

1.1 Project Overview and Background to this Monitoring

The Woolgoolga to Ballina Pacific Highway Upgrade comprises approximately 155 km of highway to achieve a four-lane divided road extending north of Woolgoolga at the northern extent of Sapphire to Woolgoolga Upgrade to south of Ballina where it ties into the southern extent of the Ballina bypass. The project includes grade separated interchanges, service roads and upgrades to local road connections and has the potential to be staged in 11 sections.

The Threatened Frog Management Plan (RMS 2015) addresses the impacts of the upgrade and proposed mitigation on a number of threatened frog species including the Wallum Sedge Frog (*Litoria olongburensis*), Giant Barred Frog (*Mixophyes iteratus*) and Green-thighed Frog (*Litoria brevipalmata*). This management plan identifies both areas of known and potential habitat throughout the Project corridor and proposes a number of management actions to ensure the long-term survival of these species in the area of the project. In order to gauge the performance of these management actions, a pre-construction baseline monitoring survey was undertaken (Lewis 2014 a.b.c). The objective of these studies were to identify known threatened frog sites and to collect baseline data on the population and habitat condition. In summary, these studies along with some earlier construction monitoring have identified the following:

- The constructed carriageway bisects known Giant Barred Frog habitat at four locations and with this four reference sites have been selected;
- The constructed carriageway bisects numerous areas of known Green-thighed Frog habitat with 10 locations selected along with a further 10 paired reference sites for monitoring; and
- The constructed carriageway bisects five areas of known Wallum Sedge Frog habitat with a further five reference sites selected for monitoring.

With construction nearing completion in Section 1 (southern end – October 2017 and northern end December 2017) and 2 (October 2017) and the commencement of construction in Sections 3-11, Pacific Complete (PC) engaged Jacobs to implement the BACI population monitoring surveys. The following reports on these findings.

2.0 STATUS OF THE MONITORING PROGRAMS

This report covers the following monitoring periods:

- Giant Barred Frog monitoring program performed during the operational phase in Year 3 for Sections 1 and 2;
- Wallum Sedge Frog monitoring program in Year 1 of the construction phase in Sections 8, 9 and 10; and
- Green-thighed Frog monitoring program schedule for Year 3 of the construction phase in Sections 1 and 2 but only Year 2 of the construction phase in Sections 3, 6 and 7.

3.0 GIANT BARRED FROG – *MIXOPHYES ITERATUS*

3.1 Species Profile

3.1.1 Description of the Subject Species

The Giant Barred Frog (*Mixophyes iteratus*) is a large, dark-olive green to black coloured frog that grows to 115 mm. It has a pointed snout and a broad lateral band of dark spots dividing the dark dorsal surface from the white or pale yellow, ventral surface (underside). The limbs have dark crossbars. The hind side of the thighs are black with large yellow spots. Two joints of the fourth toe are free of web (Cogger 2000). The skin is finely granular above but smooth below. The call of the male Giant Barred Frog is a deep guttural grunt (OEH 2014).



Plate 3-1. Giant Barred Frog (ad) from Corindi Creek.

Giant Barred Frog tadpoles are large and grow to over 100 mm in length. They are deep-bodied and ovoid, with a tail length twice that of the body. The tadpole's eyes are dorsolateral.

The tadpoles are coloured yellow-brown above with dark spots and a dark patch at the base of tail. The underside is silver-white. The intestinal mass is obscured but the heart and lungs are visible from below (except near metamorphosis). The tail is thick and muscular (Anstis 2002). Fins are low and opaque with dark flecking (except the anterior half of the ventral fin; Meyer *et al.* 2001).

3.1.2 Distribution

The species is currently known from mid to low altitudes below 610 m above sea level (Hines *et al.* 2004), along the Coast and ranges from south-eastern Queensland to the Hawkesbury River in NSW. North-eastern NSW, particularly the Coffs Harbour-Dorrigo area, is now a stronghold whilst it appears to have disappeared south of the Hawkesbury and there are no recent records from the Blue Mountains (Hines and SEQTFRT 2002; DoE 2014).

3.1.3 Habitat and Ecology

Giant Barred Frog tends to forage and live amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest, at elevations below 1000 m (DoE 2014). Whilst it has been observed to prefer a closed forest canopy with a relatively light cover of vegetation at ground level (Aland and Wood 2013), they have been found in cleared or disturbed areas, for example agricultural landscapes with vegetated riparian strips and regenerated logged areas (Ingram

and McDonald 1993; Hero and Shoo n.d., cited in Hines *et al.* 2004; Lemckert and Brassil 2000; Lewis and Rohweder 2005). Giant Barred Frog are known from the lower reaches of streams which have been affected by major disturbances such as clearing, timber harvesting and urban development in their headwaters (Hines *et al.* 1999).

Giant Barred Frogs breed around shallow, flowing rocky streams and deeper slow moving rivers from late spring to summer. Females lay eggs onto moist creek banks or rocks above water level, from where tadpoles drop into the water when hatched (DoE 2014). Tadpoles grow to a length in excess of 100 mm and take up to 14 months before changing into frogs. They feed primarily on large insects and spiders, but have been known to consume small mammals (G. Madini pers. comm).

3.2 Survey Methods

Field surveys were performed in accordance with the Threatened Frog Species Management Plan (RMS 2015). The following details the areas surveyed along with the timing of field surveys and how the data were treated or analysed.

3.2.1 Site Selection and Treatment Design

All four sampling sites known as Site 1A, 1B, 2A, 2B, 3A, 3B, 4A and 4B occur within Sections 1 and 2 (Figure 2-1). Sampling accords with the BACI (Before-After-Control-Impact) approach which consists of the following:

- Impact sites which are identified in this instance with an 'A' and may be potentially impacted by construction works or once the newly constructed carriageway is completed. Potential impacts may include but are not necessarily limited to habitat removal, a reduction in habitat connectivity, increased road strike, facilitating the distribution and increasing densities of exotic predators;
- Reference or control sites which are identified in this instance with an 'B' and possess similar geographic landscape and habitat traits as the impact sites, but are located a sufficient distance (>200 m) and ideally upstream of the Upgrade. If this was not possible, a nearby sub catchment with similar attributes was also considered sufficient.

3.2.2 Timing of Surveys

Frog surveys were performed in a manner that was consistent with the Threatened Frog Management Plan (RMS 2015). Sampling occurred during the spring and summer period when there has been 10 mm of rainfall in 24 hours in the past 7 days and ambient air temperature was close to or ideally exceeding 18°C. The first round of sampling took place during late spring (7th – 14th November 2017), followed by summer sampling around 50 days later (5th-9th February 2018) to improve on temporal independence between the first and second survey (Table A1).

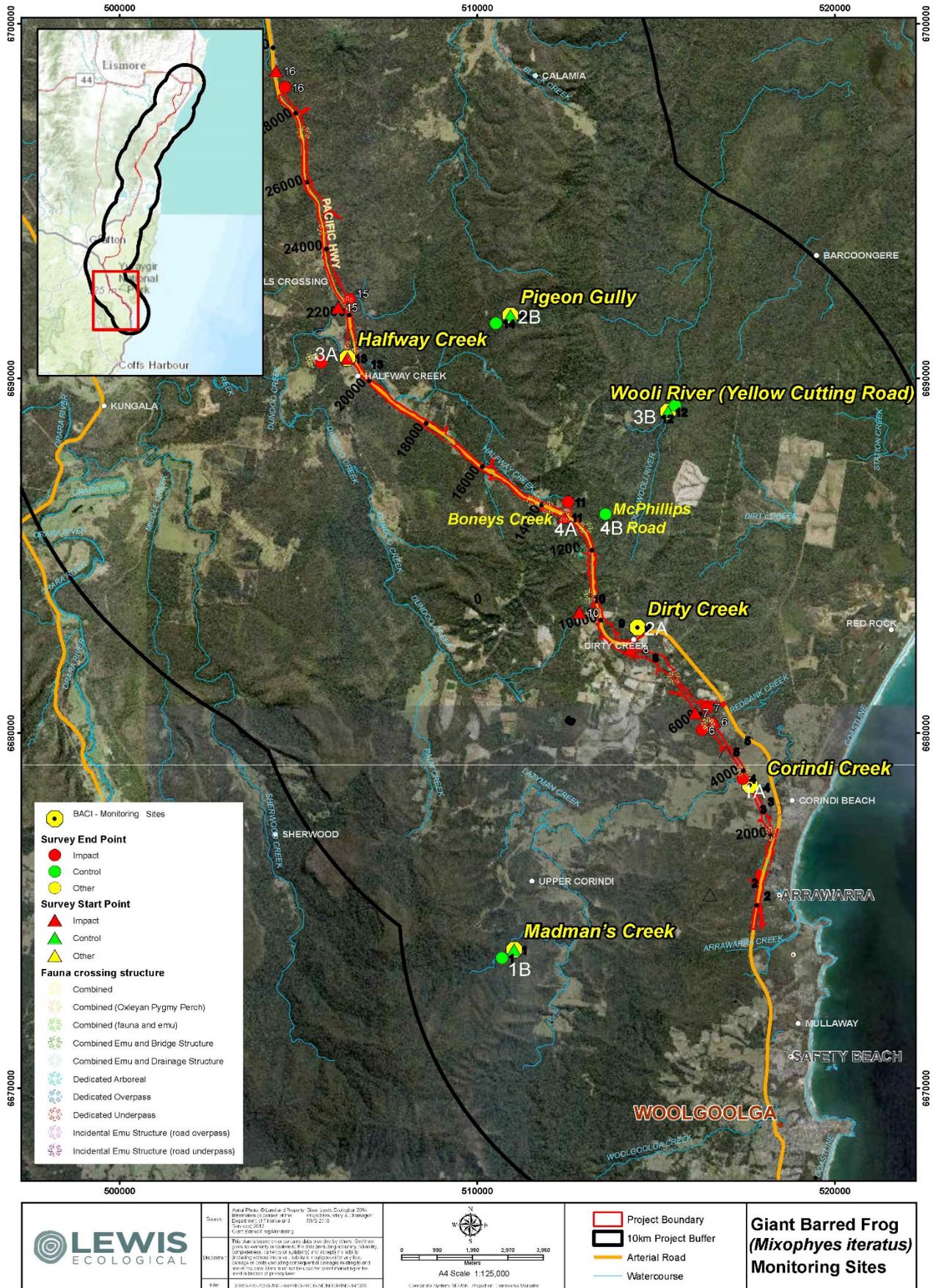


Figure 3-1. Locations of Giant Barred Frog BACI Monitoring Sites 1-4 in Sections 1 and 2 of Woolgoolga to Ballina Upgrade.

3.2.3 Frog Surveys

Frog surveys were performed in the manner outlined in the Threatened Frog Management Plan (RMS 2015). This involved:

- 500 m transect with 250 m either side of the Project corridor with the start and finish extent recorded using a hand held GPS in GDA94;
- Field surveys comprised spotlighting and call broadcast during the nocturnal transect;
- For each frog, the following information was collected:
 - Distance from the stream edge measured to the nearest 0.1 m;
 - Position within the microhabitat (i.e. under litter, above litter, exposed, on rock/log);
 - Sex (male, female, unknown) based on size of frog and inspection of nuptial pads present in male frogs;
 - Age class (adult = >60 mm; sub adult = 40-60 mm; juvenile = <40 mm)
 - Snout-vent length (mm);
 - Weight (grams); and
 - Breeding condition with:
 - males assessed on the colouration of their nuptial pads (i.e. no colour, light, moderate, dark) in accordance with a classification developed by Lewis Ecological Surveys (Table 2-1);
 - females based on whether they were gravid (i.e. typically adult weighing > 100 grams) or not gravid (egg bearing);
 - frogs with a snout vent length of <60 mm were classified as immature.
- Microchipped with Trovan™ nano transponders to individually mark frogs.

All handling procedures were undertaken in accordance with the *Hygiene Protocols for the Control of Disease in Frogs* (DECW 2008) and NSW Animal Care and Ethics Approval (Trim14/3786).

3.2.4 Abiotic Data

The following abiotic variables were collected during the survey:

- Air temperature (°C) measured with a thermometer at the start and finish of the frog survey and averaged;
- Relative humidity (%) measured with wet/dry bulb thermometer at the start and finish of the frog survey and averaged;
- Prevailing cloud cover was expressed as a percentage (%) coverage of the sky taken at the start and finish of the survey and averaged;
- Wind speed measured using a subjective scale (0 = no wind, 1 = light rustles of leaves on trees, 2 = leaves and branches moving and 3 = whole canopy moving); and
- Rain fall was also measured in a subjective scale (0 = no rain in past 24 hours, 1 = rain within 24 hours and 2 = rain during survey).

3.3 Year 3 Monitoring Results

Giant Barred Frogs were recorded at 6 (75%) of the 8 sites including Site 1A (Corindi Creek), 1B (Madmans Creek), 3A (Halfway Creek), 3B (Yellow Cutting Road), 4A (Boneys Creek) and 4B (McPhillips Road-Upper Halfway Creek; Figure 3-1). Frogs were not recorded from either of the Site 2 treatments, that being Dirty Creek (2A) and its paired reference Site 2B (Pigeon Gully; Table 3-1).

Sampling recorded 124 frogs with:

- Corindi Creek (Site 1A) - 24 frogs comprising 23 adults and sub adult. Nine of the frogs were recaptures from previous construction monitoring events in Years 1 and 2 and included recaptures from both upstream and downstream. None of the recaptured frogs were found on either side of the highway to demonstrate frogs had moved under the bridge;
- Madmans Creek (Site 1B) – 34 frogs comprising 20 adults, 13 sub adults and one juvenile. Two tadpoles were also recorded at this site. Twelve of the captures were recaptures from construction monitoring events performed in Years 1 and 2;



Plate 3-2. Giant Barred Frog with missing limb captured during monitoring surveys at Corindi Creek (Site 1A) in Feb 2018.

- Dirty Creek (Site 2A) – No frogs were recorded during Year 3;
- Pigeon Gully (Site 2B) - No frogs were recorded during Year 3;
- Halfway Creek (Site 3A) – 33 frogs comprising 18 adults, 16 sub adults and one juvenile with four of these being recaptures. One frog in particular (000735CB6F), a dominant male that occupies an area around 30 m upstream of the construction site has been recaptured now on four occasions;
- Yellow Cutting Road (Site 3B) – 19 frogs with 12 of these adults and seven sub adults. Two recaptures were recorded at this site with both of these occurring during the late spring sampling;
- Boney's Creek (Site 4A) – Four frogs comprising three adults and one sub adult. Interestingly, and for the first time, some large adult females are now present on the lower part of the monitoring transect. There were no recaptures at this site and no frogs recorded on the upstream side of the carriageway (i.e. the top half of the transect); and
- McPhillips Road (Site 4B) - Eight frogs, all of them adults. The young female frog (0007359B0C) originally captured from beside the road was recaptured at this site, but had moved a small distance of around 10 m upstream. It had grown around 10 mm since its last capture and was not gravid (egg bearing; Appendix A).

In accordance with recommendations outlined in the baseline surveys, captured frogs were microchipped for individual verification during later sampling. Seventy-eight (78) frogs were micro-chipped, whilst the remainder were either recaptures, had very obvious markings such as missing limb (Plate 3-1), had simply eluded capture or were too small to insert microchips (Appendix A).



Figure 3-2. The number of Giant Barred Frogs recorded between pre-construction monitoring and construction monitoring Year 1, 2 and 3 according to age class.

Table 3-1. Summary of the Giant Barred Frog Year 3 surveys for BACI Sites 1-4. Numbers in parentheses represent baseline abundance.

BACI Site	Year 3 (Surveys)			Frog Management Mitigation Observed or Recorded	General Comments	Presence of Giant Barred Frogs Confirmed in Baseline Survey
	Date	Total Number Frogs Captured	Calculated Mean No. of Frogs Per 500 m			
1A ch.3600 (Corindi Creek)	7 th November 2017 7 th February 2018	24	12 (10)	<ul style="list-style-type: none"> i. Permanent frog fence installed, however, number of potential breach points/defects. ii. Bridges installed to maintain habitat connectivity. iii. Revegetation and bank stabilisation works observed. iv. No frogs captured from within the rehabilitated works area. v. Numbers of frogs recorded is higher than the baseline surveys. 	<ul style="list-style-type: none"> i. Frogs recorded both upstream and downstream of the Upgrade. ii. Installed rehabilitation area has the potential to restore habitat connectivity. iii. Frog fence contains a number of breach points. Only likely to present a problem during flood flows that manage to breach the banks of the main channel as frogs would be pushed away from their normal occupation areas which as the data shows is <10 m from water's edge. 	Yes
1B (Madmans Creek)	8 th November 2017 6 th February 2018	34	17 (7)	Outside works footprint.	<ul style="list-style-type: none"> i. Frog counts are markedly higher than the baseline surveys which had been performed during largely dry seasonal conditions. As this site tends to periodically dry to a series of pools, some marked variability in the count data is expected. ii. Upper reaches of Corindi Creek catchment. Difficult to access, however, satisfies original brief to locate sites on public estate. 	Yes
2A ch. 8500 (Dirty Creek)	10 th November 2017 5 th February 2018	0	0 (5)	<ul style="list-style-type: none"> i. Temporary frog fencing observed. ii. No frogs captured during Year 3, a decline to absent. 	<ul style="list-style-type: none"> i. Habitat connectivity less of a concern as Project bisects edge of known habitat and may not isolate it. ii. Frogs are likely to still be present, numbers may undergo fluctuations similar to Boneys Creek which increased during Year 3. <u>Recommended</u> that transect length be increased to reconfirm presence. 	Yes
2B (Pigeon Gully)	10 th November 2017 5 th February 2018	0	0 (1.5)	Outside works footprint.	<ul style="list-style-type: none"> i. Ongoing absence at site during Year 3 monitoring. <u>Recommended</u> that transect length be increased to reconfirm presence and maintain consistency with Dirty Creek sampling. 	Yes
3A ch.20800 (Halfway Creek)	10 th November 2017 8 th February 2018	35	17.5 (0.5)	<ul style="list-style-type: none"> i. Permanent frog fencing installed and apart from some potential breach points it is considered functional. ii. No frogs captured within main construction works area, however, some frogs captured within powerline easement works zone and within retained main channel protected zone. iii. Bridges installed to maintain habitat connectivity. iv. Numbers of frogs recorded during Year 3 is far greater than the baseline survey. 	<ul style="list-style-type: none"> i. Frogs recorded on both sides of carriageway. ii. Successful rehabilitation efforts will assist in ensuring habitat connectivity. iii. Frog fence contains a number of breach points. Only likely to present a problem on south bound lanes. 	Yes

BACI Site	Year 3 (Surveys)			Frog Management Mitigation Observed or Recorded	General Comments	Presence of Giant Barred Frogs Confirmed in Baseline Survey
	Date	Total Number Frogs Captured	Calculated Mean No. of Frogs Per 500 m			
3B (Yellow Crossing Road)	11 th November 2017 7 th February 2018	19	9.5 (29.5)	Outside works footprint.	i. Far fewer frogs than recorded during the baseline survey. ii. Fire burnt through the transect during Year 1 (2016) and reduced amount of leaf litter and exposed a lot of the banks to bare soil.	Yes
4A ch.13300 (Boneys Creek)	14 th November 2017 8 th February 2018	4	2 (0)	i. Permanent frog fencing observed. ii. Two cell box culvert installed with base sitting at bed level of creek to maintain habitat connectivity for tadpoles. iii. Numbers of frogs far greater than during baseline surveys.	i. Captured adult frogs including large females suggest immigration of adult frogs into the transect. ii. No frogs recorded on upstream side to date and not previously mapped as known habitat.	No
4B (McPhillips Road)	14 th November 2017 8 th February 2018	8	4 (0)	Outside works footprint.	i. Far more frogs recorded along this transect than previous monitoring events and this mirrors the nearby impact site (Boneys Creek).	No

3.4 Discussion

Monitoring during Year 3 revealed a number of differing trends with frogs disappearing at some sites all together but there were notable increases at others. Different from other years, not all sites with frogs recorded recruitment in the form of tadpoles, juveniles or sub adults within the count data. Below is a discussion for each of the four BACI sites.

Site 1 - Corindi Creek (Impact) and Madmans Creek (control)

The numbers of adult frogs at the impact site along Corindi Creek has now slightly exceeded the pre construction baseline density of 10 frogs per 500 m of riparian habitat with a mean of 12 frogs per 500 m of riparian habitat. Importantly, a sub adult frog was also recorded, and with this, it demonstrates that frogs continue to breed and function in what appears to be a viable manner at this location. Frogs were more evenly distributed along this transect during Year 3 with individuals recorded from both upstream and downstream of the carriageway. This is an improvement from Year 1 monitoring when frogs were only recorded upstream of the construction works (Lewis 2017).

The installed or operational mitigation at this site includes twin bridges, permanent frog fencing installed high on the batter of the carriageway formation and some strategic rehabilitation around the bridge abutments, along with some scour protection. Whilst nine of the frogs recorded were recaptures from previous monitoring events, none of them have moved to the extent of demonstrating habitat connectivity by moving from upstream reaches to the downstream side of the bridge, or vice versa. There are a number of individuals now microchipped and within 100 m of the carriageway on both sides of the bridges so future monitoring will prove useful in demonstrating how effective these mitigation tools have been in restoring habitat connectivity.

The control or reference site, Madmans Creek continues to show a more marked increase in the number of frogs compared to Corindi Creek with the same two to threefold increase from the earlier baseline surveys. Interestingly, this site tends to have a greater representation of age classes with adults, sub adults, juveniles and occasionally tadpoles compared to Corindi Creek. Importantly, both sites showed increases and the deviation hasn't exceeded 25% in terms of performance measures.

Site 2 – Dirty Creek (Impact) and Pigeon Gully (Control)

Both treatment classes have undergone declines. No frogs were recorded at the impact site along Dirty Creek compared to previous sampling events when frogs had not only been recorded but also evidence of breeding and successful recruitment into the population (Lewis 2014; Lewis 2017; Lewis 2018). Monitoring during Year 3 revealed a continued decline to the point where the monitoring transect now contains no frogs. In reality, multiple surveys over a number of years would be required before some confidence could be assigned to this current status. A similar trend has occurred at the assigned control site at Pigeon Gully. Here, some adult frogs were recorded during the baseline survey but no frogs have been found along the monitoring transect since. One remedy at this point is to extend the transect lengths at both of these sites to 1 km given this transect length has been able to adequately compensate for false negatives and

spatial absences of frogs over several hundred metres (see Lewis 2015). Put simply, surveys at other locations have found frogs absent over several hundred metres of riparian habitat before being located as a cluster of 2-8 individuals (Lewis 2014).

Site 3 – Halfway Creek and Yellow Crossing Road (Wooli River)

There was a mixed but positive result across both of the treatment classes at Halfway Creek and Yellow Crossing Road. At the Halfway Creek impact site, the same marked increase of both adult and sub adult frogs was recorded during Year 3 and consistent with Year 2 sampling. Frogs were consistently found along the full transect gradient and this included individuals close to the construction site which is in the early stages of rehabilitation. The same male frog (000735CB6F) continues to inhabit an area just upstream of the works area and supports the notion that there is perhaps little edge effect once temporary measures of effective frog fencing are installed. In other words, it is not like frogs retreat from the newly created forest edge but will continue to use all of the retained habitat.

In excess of 75 frogs have now been captured along this transect, yet just four frogs represent recaptures. This comparatively lower recapture rate is attributed to the higher number of sub adult frogs captured and as with r selected species, they have a lower rate of survival. A number of the recaptured frogs occur close to the newly constructed carriageway and with that, continued monitoring is likely to demonstrate the effectiveness of the installed mitigation in the near future. In fact, one male frog (000735B008) has been captured just inside the construction site where the construction contractor had protected the main channel during construction. This particular frog has the capacity to demonstrate the success of any assisted rehabilitation efforts beneath the bridges during Year 4 monitoring.

The reference site at Yellow Crossing Road in the upper Wooli River catchment continues to produce lower numbers of frogs than it did during the baseline surveys. There is still some representation of the sub adult age class during both the spring and summer sampling to indicate annual breeding is taking place indicating the population is probably functioning in a viable manner. The fire which had burnt out part of the transect in Year 1 may have impacted on the population causing not only some direct losses during the fire but also the reduction in foraging resources which accompany the litter and detritus loss notwithstanding the potential influence of Red Fox which is often seen in this area.

Site 4 – Boneys Creek and Upper Halfway Creek (McPhillips Road)

Continuing on from the positive findings in Year 2, Giant Barred Frogs were recorded at both of the treatment classes and this reflects a marked change from frogs being absent at both locations during the baseline survey or found at one and not the other site during Year 1. At Boneys Creek, this round of monitoring produced four frogs comprising adults and a sub adult, all from below the construction site, but none of these were recaptures. The fact that some larger adult frogs are now present along the transect suggests that frogs, particularly females probably travel hundreds of metres along a riparian zone. The continued absence of frogs in the upper half of this transect suggests this area still remains marginal habitat and that the provided mitigation may have been complimentary rather than mandatory as part of protecting Giant Barred Frog habitat along this watercourse.

The reference site of Upper Halfway Creek adjacent to McPhillips Road produced many more frogs than it has done so in the past. The baseline surveys were unable to locate frogs in this area as were the surveys in Year 1 when they were performed late in the sampling season. With the number of frogs increasing each year and the site itself being a reference site, it serves to demonstrate that fluctuations in frog numbers or density are normal, should be expected and this can vary within the same catchment. In other words construction related impacts must be considered along with broader seasonal effects and natural fluctuations therein.

The following section compares the Year 3 construction monitoring data against the prescriptions outlined in the Threatened Frog Species Management Plan.

3.5 Performance Indicators and Corrective Actions

A series of performance indicators and corrective actions have been outlined in Section 7.2.3 of the Threatened Frog Species Management Plan (RMS 2015). This plan states that *should it become clear that sites that were occupied prior to road construction (i.e. established impact monitoring sites) have become unoccupied, or abundance (estimated using the transect counts) has declined beyond the identified thresholds (i.e. 25%) relative to control/reference sites, corrective actions must be implemented in accordance with those provided in Table 7-1.*

Year 3 monitoring is mainly tied into the population monitoring component outlined in Table 5-1 as the culverts, bridges, ponds and revegetation works have only recently been completed. The performing factor for the population monitoring is the number of Giant Barred Frogs per 500 m of habitat, however, this unit of measure doesn't explicitly state if mean or cumulative data requires comparison. In the absence of this, mean data has been used and is considered the standardised format following two sampling events.

Both declines and increases were recorded across the monitoring sites and this has been summarised in Table 3-3. Increases were recorded at Corindi Creek (Site 1A), Madmans Creek (Site 1B), Halfway Creek (Site 3A), Boneys Creek (Site 4A) and McPhillips Road (Site 4B). Some of these increases were in the order of 30 times greater than the baseline survey (Halfway Creek) and in doing so it confirms the large scale variability expected for r selected species which undergo marked fluctuations in population size. What is probably more concerning at this stage of the monitoring program is the continuing decline at Dirty Creek which has now reached a point where frogs are absent at this impact site adjacent ch.8500. This decline has been consistent which started at 50% between the baseline and Year 1 before a further 20% decline at Year 2 and now a further 30% decline to absent at Year 3. Similarly, the paired control site at Pigeon Gully has continued to record an ongoing absence of Giant Barred Frogs. Both sites are small spring fed streams, and this combined with dry seasonal conditions probably results in populations retracting to isolated points or clusters along the creek which probably occur adjacent to the transect. An increase in transect length would address this question and provide a more definitive status at both sites.

Table 3-3. Mean number of Giant Barred Frogs (inclusive - adults, sub adults, juvenile) during the construction phase of Years 1-3.

Sampling Year	Corindi Creek (Impact)	Madmans Creek (Control)	Dirty Creek downstream (Impact)	Pigeon Gully (Control)	Halfway Creek (Impact)	Yellow Cutting Road (Control)	Boneys Creek (Impact)	McPhillips Road (Control)
	1A	1B	2A	2B	3A	3B	4A	4B
GBF Base	10	7	5	1.5	0.5	29.5	0	0
GBF Year 1 (mean count)	5	4.5	2.5	0	4	1.5	0	0
GBF Year 2 (mean count)	13	17	1.5	0	30.5	12.5	1	0.5
GBF Year 3 (mean count)	12	17	0	0	17.5	9.5	2	4
Increase (%)	17	150	-	-	3500	-	100	100
Decline (%)	-	-	absent	absent	-	68	-	-

In regard to other construction related mitigation goals and mitigation measures for threatened frog species, and their associated corrective actions as outlined in Table 5-4 of the TFMP they include:

- No injuries or mortality to threatened frogs during clearing works.
- No injuries to or mortality of threatened frogs during construction as a result of vehicle collisions.
- No injuries to frogs that need to be handled.
- No movement of chytrid fungus between sites.
- Low rate injuries or mortality of threatened frogs as a result of dewatering activities.
- No loss of habitat beyond what is identified in construction footprint as a result of dewatering activities
- No adverse effects to Giant Barred Frog and Green-thighed Frog populations resulting from impacts to water quality.

The performance of these management actions have been previously addressed in the post clearing reports for Sections 1 and 2 (EcoSure 2016; Sandpiper Ecological Surveys 2016).

Table 3-2. Performance indicators and corrective actions from the Threatened Frog Species Management Plan (RMS 2015).

Triggers for corrective actions	Corrective actions	Relevance to Year 3 Giant Barred Frog Monitoring	Results of Year 3 Giant Barred Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Population Monitoring					
<p>The absence of threatened frogs at impact sites identified as occupied in the baseline monitoring surveys.</p> <p>A relative decline in abundance of 25% or more at an impact site than its relative control site over 3 consecutive monitoring periods. Frog abundance determined by standardised transect counts:</p> <ul style="list-style-type: none"> • Number of Wallum Sedge Frogs per 100 m² of habitat; • Number of Giant Barred Frogs per 500 m of habitat; • Number of adult male Green-thighed Frog per Stage 1 survey (breeding survey) (as outlined in Section 4.3). 	<p>Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance.</p> <p>Investigate effectiveness of frog exclusion fencing immediately.</p> <p>Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation.</p> <p>Assess the requirement for additional offsets where a threatened frog population is no longer present in a previously occupied area, and this habitat is deemed unsuitable for the target species.</p>	Relevant	<p>Increased numbers of Giant Barred Frogs recorded from the following impact sites:</p> <ul style="list-style-type: none"> - 1A (Corindi Creek), - 3A (Halfway Creek); - 4A (Boneys Creek). <p>Absent from:</p> <ul style="list-style-type: none"> - 2A (Dirty Creek), <p>Dirty Creek declined by 50% in Year 1, further 20% in Year 2 and now the remaining 30% in Year 3 to zero. Frogs were originally recorded at the paired control site, Pigeon Gully during the baseline survey but not for the past three years of monitoring. Both impact and control site recorded declines to zero or absence in Year 3.</p>	<p>i. Natural fluctuations in population with some sites increasing and other decreasing.</p> <p>ii. Transect length too small to capture when populations retract to clusters as may be the case at Dirty Creek and Pigeon Gully.</p> <p>iii. Construction related impacts reported in Year 1 and Year 2 monitoring reports (Lewis 2017; 2018).</p>	<p>Monitoring method requires immediate review and decision made based on recommended increase in transect length at Dirty Creek (2A) and Pigeon Gully (2B).</p> <p>Note – Population is thought to still be present, just probably retracted to areas adjacent to monitoring transects as part of natural fluctuations.</p>
Underpass Structure Monitoring					
<p>The use of the structure by less than 1% of the estimated population size.</p> <p>Connectivity structures not maintained (i.e. culverts clogged with debris or sedimentation). Frog exclusion fencing damaged or ineffective.</p>	<p>Review monitoring methods where goals are not achieved, by increasing frequency, intensity and duration, to ensure individuals are identified.</p> <p>Survey habitat adjoining the connectivity structures and undertake Landscape improvement (planting, weed removal) to improve habitat functionality.</p> <p>Survey and monitor crossing structures and frog fencing to ensure they are functional (i.e. are adequately maintained, including fencing is not</p>	No relevant at this point in time. Structures are not operational.	Not Applicable	Not applicable	Not Applicable

Triggers for corrective actions	Corrective actions	Relevance to Year 3 Giant Barred Frog Monitoring	Results of Year 3 Giant Barred Frog Monitoring	Potential Contributing Factors	Corrective Action Required
	<p>damaged, and connectivity structure is operating correctly). Monitor twice per year.</p> <p>Assess the need for offsets if connectivity structures are identified as ineffective over three consecutive monitoring periods.</p>				
Riparian Habitat Revegetation					
<p>Greater than 10% of riparian plants have died after first 12 months of maintenance.</p> <p>Greater than 20% of riparian plants have died after three years of maintenance.</p> <p>Total weed coverage is more than 30% in revegetation areas.</p> <p>Bank erosion causes unforeseen revegetation area instability.</p>	<p>Review maintenance schedule for revegetated areas immediately after trigger.</p> <p>Replace dead plants within one month of issue being identified.</p> <p>Increase weed control if required as soon as practicable or review control methods being used.</p> <p>Install physical measures to halt bank erosion within one month of issue being identified.</p>	<p>Not relevant at this point in time. Landscape and habitat rehabilitation is expected to commence during Year 4 of the Giant Barred Frog monitoring program</p>	<p>Not Applicable</p>	<p>Not Applicable</p>	<p>Not Applicable</p>

3.6 Conclusions and Recommendations

Population monitoring during Year 3 continues to demonstrate the presence and viability of Giant Barred Frog populations bisected to accommodate the Woolgoolga to Ballina Upgrade. With this, populations in Corindi Creek, Halfway Creek and Boneys Creek have generally increased since the initial baseline surveys were performed in 2013 and 2014 (Lewis 2015). On the other hand, the population at Dirty Creek has continued to decline to the point where it is now absent from the monitoring transect. As the paired treatment at Pigeon Gully has also report the same similar decline, more widespread factors are likely to play a role in this decline and with that recommendations have been proposed as a means of demonstrating that frogs have probably just retracted to a series of clustered points which in this case occur beyond the monitoring transect.

At this stage of the monitoring program, more than 100 frogs have been micro chipped in and around where operational mitigation devices of bridges, culverts, permanent frog fencing and rehabilitation has been installed. Whilst a number of the frogs currently reside in close proximity (i.e. <50 m) to the newly constructed carriageway, none have ventured into the rehabilitated areas to denote the area is now frog friendly habitat and can assist in restoring habitat connectivity, nor has there been any demonstrated recaptures showing frogs have moved from upstream to the downstream side of the carriageway or vice versa. By the time monitoring commences in Year 4, more than 12 months of rehabilitation and settling in of the new structures will have occurred and it is then that such demonstrated crossings or effectiveness of the mitigation devices may start to occur.

Based on the Year 3 findings, the following recommendation is outlined in Table 3-4.

Table 3-4. Recommendations following Year 3 Giant barred Frog population monitoring and Roads and maritime response.

Recommendation No	Recommendation	Roads and Maritime Response
1.	Increase the transect length at Pigeon Gully and Dirty Creek from the existing 500m outlined in the Threatened Frog Management Plan to 1 km. This will assist in confirming the true status of frogs at both locations	Adopted – RMS agree with this recommendation to Increase the transect length at Pigeon Gully and Dirty Creek from the existing 500m outlined in the Threatened Frog Management Plan to 1 km. This will be implemented during the next monitoring event.

4.0 WALLUM SEDGE FROG (*LITORIA OLONGBURENSIS*)

4.1 Species Profile

4.1.1 Description

The Wallum Sedge Frog (*Litoria olongburensis*) is a small species that reaches a maximum length 30 mm. It is smooth light green or light brown above, cream and granular below. A dark brown streak runs from the nostril to the eye, then from behind the eye down the side of the body. From the eye, this streak is bordered below by a raised white stripe that breaks into a series of spots towards the flank. The snout is pointed and undercut and the call is a very rapid buzz, repeated several times (OEH 2014).



Plate 4-1. Adult Wallum Sedge Frog using *Lepironia* sedges growing in standing water to the east of ch. 146500.

Wallum Sedge Frog tadpoles are deep-bodied and high-finned (Anstis 2002). The snout is rounded in dorsal view and rounded to truncate in lateral view. The eyes are laterodorsal and the iris has a broad gold ring around the pupil. Nares open in the anterior direction with a very slight lateral tilt. The dorsum of the tadpole is a dark purple-brown or sooty grey colour with or without darker mottling. The tail, which terminates in a flagellum (long, lash-like appendage), is heavily mottled with dark brown or grey and sometimes orange. The flagellum is usually darkly pigmented and therefore conspicuous in the Wallum Sedge Frog tadpole. The venter is silver-white overlain with a copper sheen that continues halfway up the sides of the body, where it strongly contrasts with the dark dorsal pigmentation. Rolling blue sheen may be visible over the sides of the body. Best seen out of water, this blue sheen extends half-way along the tail. Tadpoles of the Wallum Sedge Frog reach a maximum total length of 37 mm (13 mm body length) and are found hovering in mid-water or, more commonly, resting or grazing on matted sedges (Anstis 2002; Meyer *et al.* 2006).

4.1.2 Distribution

Wallum Sedge Frog Frogs are found in coastal wallum swamps from Fraser Island in southern Queensland to Yuraygir National Park in northern NSW (OEH 2014). Within the W2B corridor they have been previously recorded from Sections 8-10 (Lewis 2014).

4.1.3 Habitat and Ecology

The Wallum Sedge Frog is an "acid" frog confined to the coastal sandplain wallum swamps. Their life-cycle is adapted to the acidic pH (2.8-5.5) of these wetlands. Frogs are highest in abundance in relatively undisturbed wallum swamps. Breeding habitat is characterised by the presence of emergent sedges, with upright species such as *Baumea* spp. and *Schoenus* spp. preferred by adult frogs for perching. Frogs can be found in breeding habitat throughout the year



although there appears to be some localised movements during or shortly after rainfall (Lewis and Goldingay 2005). Breeding occurs mainly in spring, summer and autumn after rain. Eggs are laid singly in water at the base of sedges (OEH 2014).

Plate 4-2. Wallum Sedge Frog habitat along the W2B corridor (adjacent ch. 148550).

4.1.4 Conservation Status

The Wallum Sedge Frog is currently listed as Vulnerable pursuant to the NSW *Threatened Species Conservation Act* (1995) and Commonwealth *Environmental Protection and Biodiversity Conservation Act* (1999; OEH 2014; DoE 2014). Threatening processes that have been identified include:

- Destruction and degradation of wallum habitat for coastal development;
- Reduction of water quantity and/or quality (including changes to pH) in coastal wetland habitat;
- Changes in average and extreme temperatures and the amount and timing of rainfall due to climate change;
- Severe fires in very dry periods that result in insufficient refuge remaining post-fire;
- Roadkill (it has been estimated that >10,000 Wallum Sedge Frogs are killed annually on one 4km stretch of road near Lennox Head; Goldingay and Taylor 2006); and
- Predation of tadpoles and eggs by the Plague Minnow (*Gambusia holbrooki*). While little is known of the extent of Plague Minnow predation on Wallum Sedge Frogs, it must be considered a potential threat (OEH 2014).

4.1.5 Previous Monitoring

Population monitoring of the Wallum Sedge Frog has previously been conducted in the broader Woolgoolga to Ballina study area by Lewis and Goldingay (2005). During this 5 year monitoring period, significant populations were recorded and monitored between Yuraygir National Park in the south, north through Bundjalung National Park and Broadwater National Park into parts of crown land around Wardell and Ballina. They found frog populations were rarely stable and fluctuated from year to year even when statistically controlling for rainfall (Lewis and Goldingay 2005). They concluded that Wallum Sedge Frog populations were not declining during a period when more upland and riverine species had reported declines (Lewis and Goldingay 2005). No chytrid monitoring is known for this species. More recent monitoring efforts have been centred on the development of a baseline monitoring program development for the Woolgoolga to Ballina Pacific Highway Upgrade. The site selection and data collection process taking place over 2014 and 2015 (Lewis and Smith 2014; Lewis 2015). Together, they form the baseline preconstruction data for which the following population monitoring is measured against.

4.2 Survey Methods

Field surveys were performed in accordance with the draft Threatened Frog Management Plan (RMS 2013). The following details the areas surveyed along with the timing of field surveys and how the data were treated or analysed.

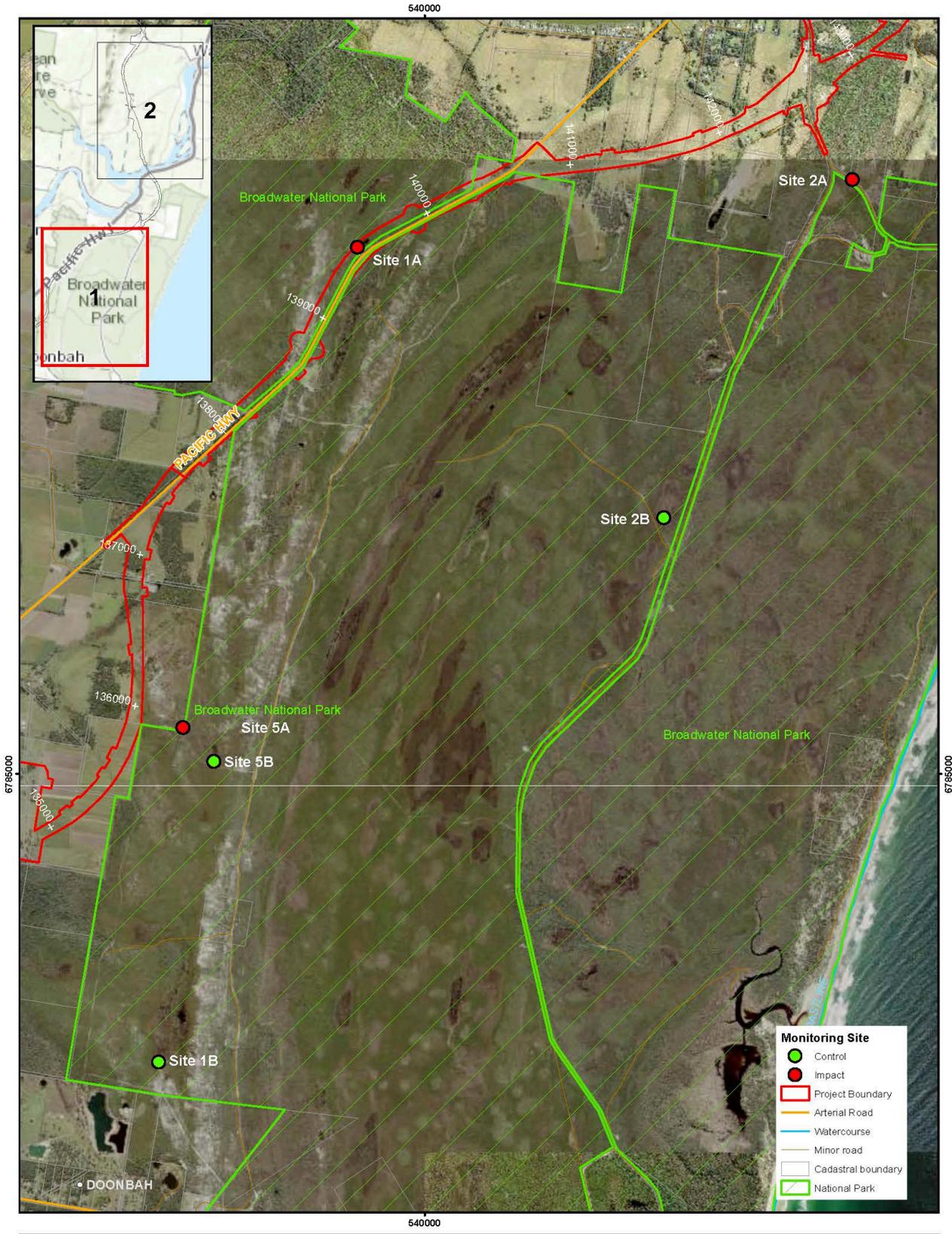
4.2.1 Site Selection and Treatment Design

All five sampling sites known as Site 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B, 5A and 5B occur within Section 8-10 (Figure 2-1). Sampling accords with the BACI (Before-After-Control-Impact) approach which consists of the following:

- Impact sites which are identified in this instance with an 'A' and may be potentially impacted by construction works or once the newly constructed carriageway is completed. Potential impacts may include but are not necessarily limited to habitat removal, a reduction in habitat connectivity, increased road strike, facilitating the distribution and increasing densities of exotic predators;
- Reference or control sites which are identified in this instance with an 'B' and possess similar geographic landscape and habitat traits as the impact sites, but are located a sufficient distance (>200 m) and ideally upstream of the Upgrade. If this was not possible, a nearby sub catchment with similar attributes was also considered sufficient.

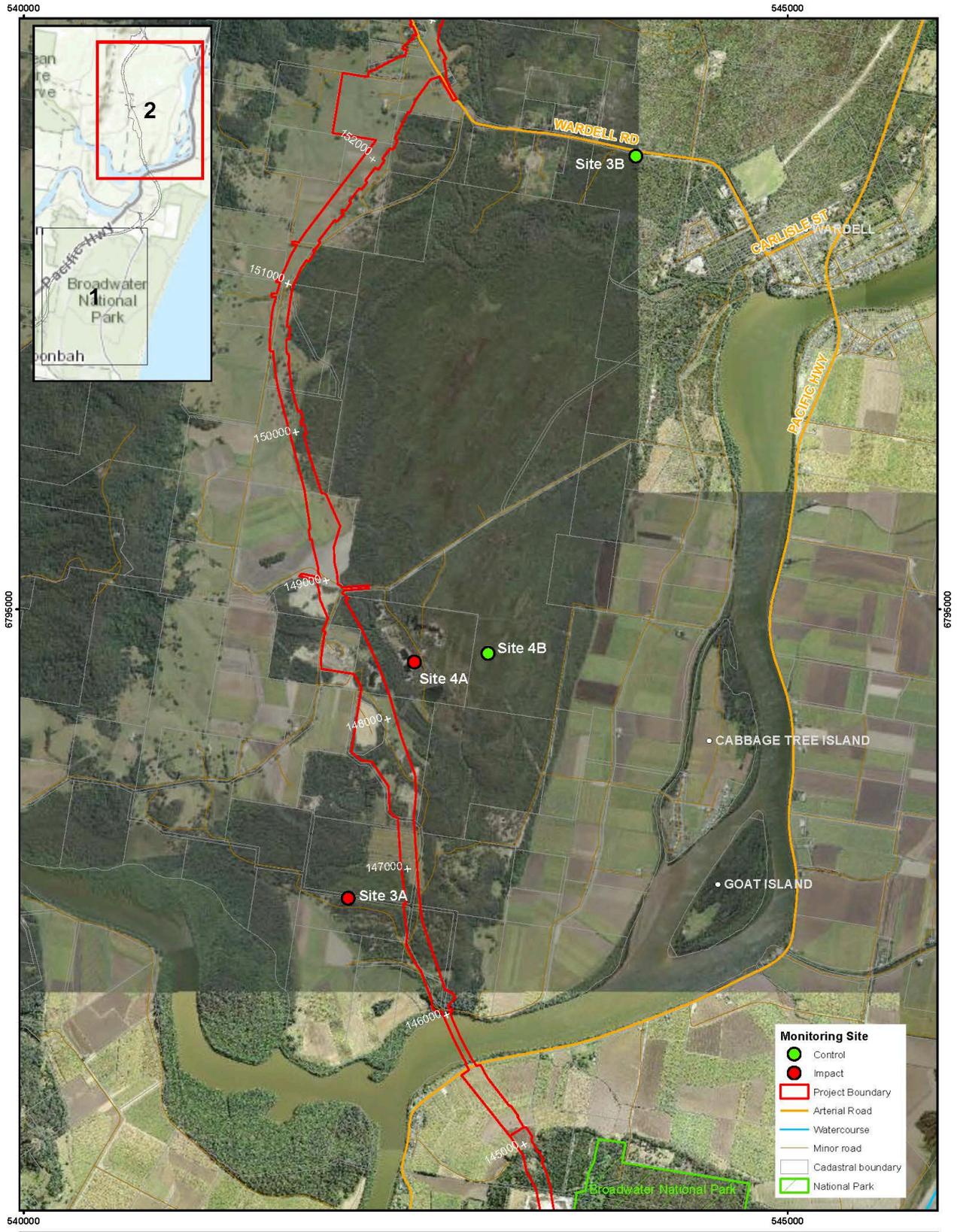
4.2.2 Timing of Surveys

Field surveys were comprised of two sampling periods with each event taking place within 7 days of a 10 mm rainfall event in the past 24 hours. This meant that the summer or calling breeding survey was performed in late February 2017 and a follow up post breeding survey to determine the level of breeding success was performed at the start of winter in June 2017 (Appendix A).



	SOURCE: Aerial Photo: © Land and Ecological 2015 Property Information 2015 Project Boundary & VSF Survey, Lewis, Chainages RMS 2013	 A4 Scale 1:30,000 Coordinate System: GDA94 Projected: Transverse Mercator	Figure 4-1: Sheet 1 of 2 WALLUM SEDGE FROG YEAR 1 MONITORING
	DATE: 11/11/2017 DRAWN BY: J. B. B. (J.B.B.) CHECKED BY: J. B. B. (J.B.B.) PROJECT: 3031718I-14 WALLUM SEDGE FROG MONITORING 15/07/17		

Figure 4-1. Locations of Wallum Sedge Frog BACI Monitoring Sites in Sections 8 and 9 of Woolgoolga to Ballina Upgrade.



	SOURCE: Aerial Photo. © Land and Ecological 2015 Property Information 2015 Project Boundary & VSF Survey, Lewis & Chalmers, RMS 2013	 A4 Scale 1:30,000 Coordinate System: GDA94 Projected: Transverse Mercator	Figure 4-2: Sheet 2 of 2 WALLUM SEDGE FROG YEAR 1 MONITORING
	DATE: 2017 DRAWN BY: [Name] CHECKED BY: [Name] FR: 20317181-14-WALLUM-SEDO-C-MON-INTO-RING-15027		

Figure 4-2. Locations of Wallum Sedge Frog BACI Monitoring Sites in Section 10 of the Woolgoolga to Ballina Upgrade.

4.2.3 Frog Surveys

Frog surveys were performed in the following manner and in accordance with the required hygiene protocols followed (DECC 2008):

- Surveys were performed generally within 7 days of a notable rainfall event (>10 mm in 24 hrs) using the Bureau of Meteorology (BoM) weather stations at Evans Head (058212; see Table A4 in Appendix 3). At other times the BoM website and radar images from Grafton were used to determine more fine scale survey requirements post rainfall;
- Surveys commenced at 30 minutes after dark with the latest surveys being performed up to around 0130 hrs;
- A 50 metre transect was installed at some sites whilst a timed 20 minute search was used at other sites where a 50 m transect could not be installed due to the small size of the habitat;
- All surveys involved the use of active search with a head lamp (Led Lensor H14R rated 850 lumens); and
- For all frogs that were detected, the age class was determined with:
 - Adults defined as being >16 mm;
 - Sub adult <16 mm; and
 - Juvenile showing some form of a tail tad from recent metamorphosis.

4.2.4 Abiotic Data

The following abiotic variables were collected during the survey:

- The amount of rain fall was calculated for the periods 24 hours, 48 hours and 7 days prior to each survey using the weather station at Evans Head (058212);
- Air temperature (°C) measured with a thermometer at the start and finish of the frog survey and averaged;
- Relative humidity (%) measured with wet/dry bulb thermometer at the start and finish of the frog survey and averaged;
- Water level measured with a tape measure generally at the start of the transect or alternatively at the deepest point along the transect;
- pH level measured using a hand held meter, if water was present;
- Prevailing cloud cover was expressed as a percentage (%) coverage of the sky;
- Wind speed measured using a subjective scale (0 = no wind, 1 = light rustles of leaves on trees, 2 = leaves and branches moving and 3 = whole canopy moving); and
- Rain fall was also measured in a subjective scale (0 = no rain in past 24 hours, 1 = rain within 24 hours and 2 = rain during survey).

4.3 Year 1 Construction Monitoring Results

4.3.1 Sedge Frog Abundance

Wallum Sedge Frogs were recorded at 7 (70%) of the 10 monitoring sites during Year 1 (Table 4-1). Sedge frogs were not recorded Site 2A (Broadwater Beach Road), 3A (Bagotville) and 3B (Wardell Road) whilst the highest counts of 12 frogs per 100m² of habitat were recorded at the control site 5B in Broadwater National Park (Figure 4-3). In fact, sedge frog numbers declined across all sites and treatments classes in Year 1 (Figure 4-3). No juvenile frogs nor tadpoles were recorded indicating that breeding may have taken place in March 2017 and by the time the follow up post breeding surveys were performed, the age class had advanced to sub adults (Figure 4-4). It nonetheless reflects a measure of breeding success for that year.

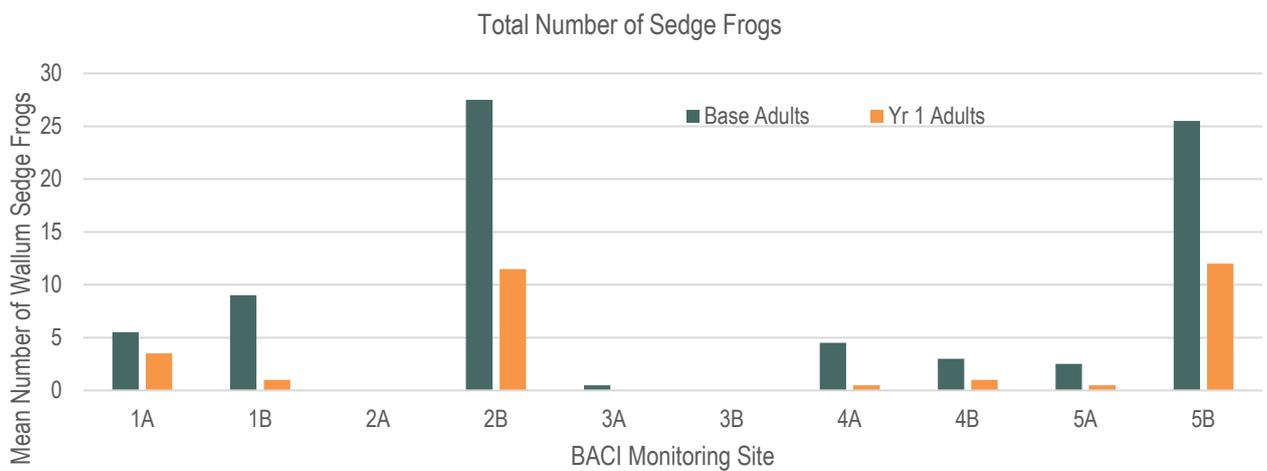


Figure 4-3. Wallum sedge frog counts between baseline survey and Year 1 monitoring.

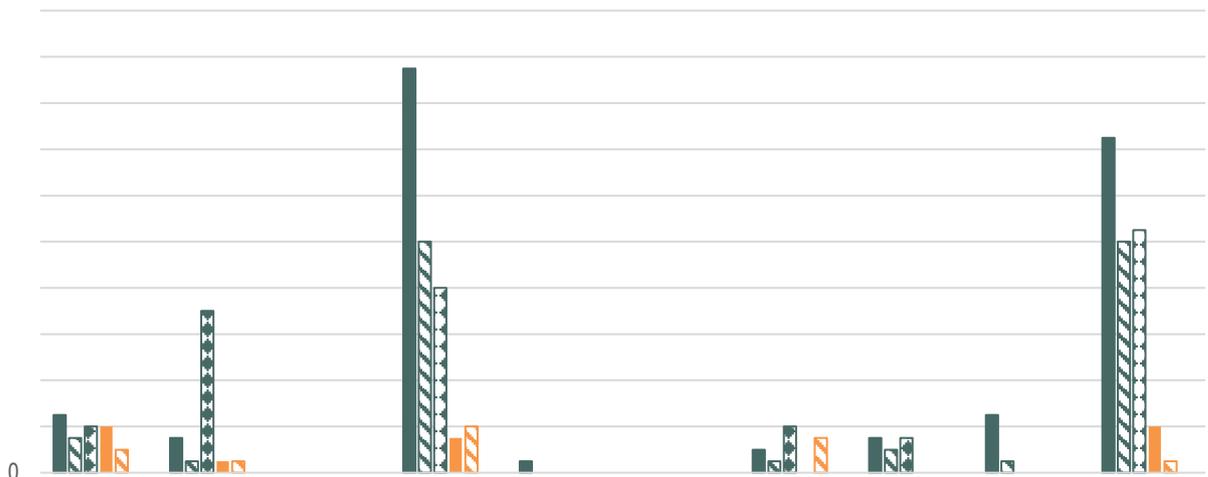


Figure 4-4. Wallum sedge frog counts across three age classes between baseline survey and Year 1 monitoring.

Table 4-1. Summary of the sites where Wallum Sedge Frogs were detected.

BACI Site	Treatment Class	Site Name	Chainage Extent	Base Adults	Yr 1 Adults	Base Sub Adults	Yr 1 Sub Adults	Base Juveniles	Yr 1 Juveniles
1A	Impact	Broadwater West	139500	2.5	1.5	2	2	1	0
1B	Control	Broadwater West	133000–132000	1.5	0.5	7	0.5	0.5	0
2A	Impact	Broadwater Beach Road	143000–142000	0	0	0	0	0	0
2B	Control	Broadwater East	137000–138000	17.5	10	8	1.5	2	0
3A	Impact	Bagotville	146000–147000	0.5	0	0	0	0	0
3B	Control	Wardell Road	151000–152000	0	0	0	0	0	0
4A	Impact	Ballina Shire Council Quarry	148000–149000	1	0.5	2	0	1.5	0
4B	Control	Jali Land	148000–149000	1.5	1	1.5	0	0	0
5A	Impact	McDonalds	135900	2.5	0.5	0	0	0	0
5B	Control	Broadwater National Park	135800	14.5	10	10.5	2	0.5	0

4.3.2 Constructed Breeding Ponds

At the time of monitoring, no compensatory breeding ponds had been constructed for sedge frogs.

4.3.3 Frog Fencing

At the time of monitoring, no permanent frog fencing had been installed at sedge frog locations. There was, however, some temporary fencing observed during the winter round of monitoring at Site 1A (Broadwater National Park ch. 139500W) constructed from silt fencing and without a top return lip (Plate 3-1). The frog counts performed at this time would suggest this design had little success at excluding frogs from the construction site, with both adults and sub adults within the construction works area where pre-clearing surveys should have removed individuals prior to clearing.

At Site 3B (Wardell Road), an extension of fauna fencing to preserve other threatened fauna, namely Koala, during the pre-construction phase resulted in the reference or control site being subject to temporary disturbance with minor clearing and associated mowing of grasses and sedges at this monitoring site. This small-scale and temporary disturbance has not resulted in a notable impact to the habitat and as such the site will be maintained as a reference for the purposes of the monitoring program, and the incident noted, where required, in any future analysis of Wallum Sedge Frog population data.



Plate 4-3. Location of Site 1A monitoring transect (red circles) and installed temporary frog exclusion fence with no return lip for hylid frogs.

4.4 Discussion

Far fewer sedge frogs were recorded during Year 1 construction monitoring with a decline in the count data across all sites and for all three age classes. This decline probably reflects the dry period when the first round of sampling was performed in February 2017. At this time, most of the sites were dry and as sedge frogs tend to perch on vegetation growing in free standing water (see Lewis and Goldingay 2005), far fewer frogs are to be expected. In fact, the dry state of Site 2B was the first time no water had been observed at this site in 22 years of monitoring. This presents as one of the problems when structuring field programs set around monitoring which focuses almost entirely on implementing surveys fixated on dates, as opposed to similar abiotic conditions. Sampling around three weeks later in mid March when the groundwater table had risen in response to heavy rainfall is likely to have yielded higher numbers of sedge frogs, however, the survey would not have been performed in summer as the program states.

One of the important aspects of monitoring r selected species is to ensure there are signs of different age classes to demonstrate population turnover, and with that, viability. Whilst sedge frog abundance was lower during Year 1, there was general consistency with the turnover of ratio of offspring to adults. This turnover or recruitment was recorded at four

of the monitoring sites and importantly it includes Site 1A where probably most of the immediate construction impacts on sedge frogs have taken place to date. During the baseline surveys, pH levels at Site 1A ranged from 4.34 to 4.47 and this has now increased to 6.52 in June 2017. This increase in pH may be attributed to the almost 400 mm of rainfall which had fallen across the study area just a week or two prior to monitoring. These natural fluctuations in pH may result in some increased competition from non-acid frogs should be considered during future monitoring events.

At the time field surveys were performed, construction in the form of habitat removal and associated disturbances had taken place at Site 1A, nearby to 2A and 5A, and unforeseen at 3B (Wardell Road). Wardell Road was selected as a reference site on the basis it has been subject to irregular long term monitoring since the late 1990's by Lewis Ecological Surveys and this could provide useful insights into sedge frog populations with smaller numbers of frogs already exposed to edge effects from roads, utility maintenance and competitor frog species that don't usually inhabit low pH waters. As the project has now encroached into the monitoring area, it does raise some concern about its validity as a reference site given it now lies closer to the project than the nominated impact site at Bagotville (3A). The micro habitat along the monitoring transect has remained the same.

No compensatory breeding ponds had been constructed at the time of monitoring. Work on these should be prioritised as compensatory frog ponds for this species can be difficult to construct and get right in relation to drying periods, correct vegetation type and acceptable pH which is an important attribute to reduce competitor interactions from non-acidic frog fauna including Eastern Sedge Frog (*Litoria fallax*) and Tylers Tree Frog (*Litoria tyleri*). Lessons from the Tugun Bypass should be applied in this instance.

How the data compares or performs against the prescriptions outlined in the Threatened Frog Management Plan is outlined in the following section.

4.5 Performance Indicators and Corrective Actions

A series of performance indicators and corrective actions have been outlined in Section 7.2.3 of the Threatened Frog Species Management Plan (RMS 2015). This plan states that *should it become clear that sites that were occupied prior to road construction (i.e. established impact monitoring sites) have become unoccupied, or abundance (estimated using the transect counts) has declined beyond the identified thresholds (i.e. 25%) relative to control/reference sites, corrective actions must be implemented in accordance with those provided in Table 7-1.*

Year 1 monitoring is mainly tied into the population monitoring component outlined in Table 7-1 as the culverts, compensatory ponds and revegetation works are not yet complete (RMS 2015). The performing factor for the population monitoring is the number of Wallum Sedge Frogs per 100 m² of habitat. With this, the numbers or actual counts of sedge frogs has declined in a relative manner across both the impact and control sites. For example, no sedge frogs were recorded at either Site 3A (Bagotville) or Site 3B (Wardell Road) yet both historically contained small numbers of frogs. The corrective action itself is to be assessed at the completion of Year 3 monitoring.

Opportunities to investigate how effective some of the other frog mitigation tools including pre clearing surveys is not yet available but should be forthcoming as part of Year 2 monitoring and reporting. As for other mitigation and associated performance measures, they are similarly not relevant to sedge frog monitoring at this point in time. The underpass structures themselves are either partially installed, not yet installed or still yet to receive frog fencing treatments. The locations of compensatory ponds should now be finalised so that it accords with the commitments identified in the TFMP, that being “*where breeding habitat will be directly impacted by the project or changed hydrological patterns have the potential to affect the suitability of breeding habitat areas adjacent to the corridor*”. As the ponds nor monitoring sites occur in riparian areas, the riparian habitat revegetation parameters appear irrelevant at this time.

Table 4-2. Performance indicators and corrective actions from the Threatened Frog Species Management Plan (RMS 2015) for Wallum Sedge Frog.

Triggers for corrective actions	Corrective actions	Relevance to Year 1 Wallum Sedge Frog Monitoring	Results of Year 1 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Population Monitoring					
<p>The absence of threatened frogs at impact sites identified as occupied in the baseline monitoring surveys.</p> <p>A relative decline in abundance of 25% or more at an impact site than its relative control site over 3 consecutive monitoring periods. Frog abundance determined by standardised transect counts:</p> <ul style="list-style-type: none"> • Number of Wallum Sedge Frogs per 100 m² of habitat; • Number of Giant Barred Frogs per 500 m of habitat; • Number of adult male Green-thighed Frogs per Stage 1 survey (breeding survey) (as outlined in Section 4.3). 	<p>Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance.</p> <p>Investigate effectiveness of frog exclusion fencing immediately.</p> <p>Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation.</p> <p>Assess the requirement for additional offsets where a threatened frog population is no longer present in a previously occupied area, and this habitat is deemed unsuitable for the target species.</p>	<p>Relevant</p>	<p>Wallum Sedge Frogs absent from Site 2A, 3A and 3B.</p> <p>Compared to the baseline survey, Wallum Sedge Frogs declined across all three age classes at the remaining seven sites. Sedge frogs were absent from Site 2A and 3B in the pre-construction baseline surveys.</p> <p>No declines exceeded 25% when compared with respective control site and baseline results.</p>	<p>Surveys being performed during seasonally dry conditions when no surface water at the monitoring sites. Typically frogs occupy vegetated wetlands with freestanding water (see Lewis and Goldingay 2005).</p>	<p>Wait until Year 3.</p>
Underpass Structure Monitoring					
<p>The use of the structure by less than 1% of the estimated population size.</p> <p>Connectivity structures not maintained (i.e. culverts clogged with debris or sedimentation). Frog exclusion fencing damaged or ineffective.</p>	<p>Review monitoring methods where goals are not achieved, by increasing frequency, intensity and duration, to ensure individuals are identified.</p> <p>Survey habitat adjoining the connectivity structures and undertake Landscape improvement (planting, weed removal) to improve habitat functionality.</p> <p>Survey and monitor crossing structures and frog fencing to ensure they are functional (i.e. are adequately maintained, including fencing is not damaged, and connectivity structure is operating correctly). Monitor twice per year.</p>	<p>No relevant at this point in time. Structures are not operational.</p>	<p>Not Applicable</p>	<p>Not applicable</p>	<p>Not Applicable</p>

Triggers for corrective actions	Corrective actions	Relevance to Year 1 Wallum Sedge Frog Monitoring	Results of Year 1 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
	Assess the need for offsets if connectivity structures are identified as ineffective over three consecutive monitoring periods.				
Constructed Pond Monitoring					
Absence of threatened frogs and metamorphs at the compensatory ponds after three years since construction.	Investigation be undertaken to determine why there may be a lack of success and, as where recommended, changes be made to the habitat and monitored for effectiveness (i.e. 3 more years of monitoring) Review monitoring methods, considering timing and weather conditions to ensure individuals are identified. Review location of the compensatory pond and consider moving, and/or modifying or constructing additional ponds. Investigate habitat adjoining the upgraded highway and consider improving habitat condition and connectivity.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
Water pH exceeds 5.5 for Wallum Sedge Frog	Investigate ways to reduce pH of water.	Not relevant at this point in time.	Not Applicable	Not Applicable	Investigate ways to reduce pH of water at Site 1A where pH has increased from 4.34-4.47 in baseline survey to 6.52 in Year 1.
Visual water quality of the compensatory pond is not similar to nearby unimpacted and/or similar wetlands or is unsuitable for frog occupation.	Complete site specific investigation to identify the causes of the unsuitable hydrological conditions or water quality.	Not relevant at this point in time.	Not Applicable	Not Applicable	Not Applicable
No persistent water present in ponds (negative hydro period) despite recent rainfall.	Assess possible causes for water draining from the pond and apply physical corrective actions	Not relevant at this point in time.	Not Applicable	Not Applicable	Not Applicable
Mosquito Fish present and threatened frogs / tadpoles absent.	Draining pond to remove Mosquito Fish and allow pond fill at the next rain event.	Not relevant at this point in time.	Not Applicable	Not Applicable	Not Applicable
Constructed habitat un-suitable for frogs (e.g. wetlands have un-suitable hydro-period (as determined from	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control.	Not relevant at this point in time.	Not Applicable	Not Applicable	Not Applicable

Triggers for corrective actions	Corrective actions	Relevance to Year 1 Wallum Sedge Frog Monitoring	Results of Year 1 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
monitoring events), water quality or associated vegetation) as detailed in section 5.4.4.	Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.				
Revegetated native habitat in poor condition (e.g. >30% cover died, plant dieback).	<p>Undertake revegetation maintenance, i.e. replanting, erosion control, weed control.</p> <p>Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.</p>	Not relevant at this point in time.	Not Applicable	Not Applicable	Not Applicable
Frog absence confirmed following monitoring surveys (it should be noted that a pond may be suitable for frogs, but not colonised).	<p>Undertake revegetation maintenance, i.e. replanting, erosion control, weed control.</p> <p>Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.</p>	Not relevant at this point in time.	Not Applicable	Not Applicable	Not Applicable
Riparian Habitat Revegetation					
<p>Greater than 10% of riparian plants have died after first 12 months of maintenance.</p> <p>Greater than 20% of riparian plants have died after three years of maintenance.</p> <p>Total weed coverage is more than 30% in revegetation areas.</p> <p>Bank erosion causes unforeseen revegetation area instability.</p>	<p>Review maintenance schedule for revegetated areas immediately after trigger.</p> <p>Replace dead plants within one month of issue being identified.</p> <p>Increase weed control if required as soon as practicable or review control methods being used.</p> <p>Install physical measures to halt bank erosion within one month of issue being identified.</p>	Not relevant at this point in time.	Not Applicable	Not Applicable	Not Applicable

4.6 Conclusions and Recommendations

Construction monitoring during the summer and early winter of 2017 found sedge frogs at seven of the 10 monitoring sites. Their absence from Site 2A and both of the Site 3 treatments reflects small populations that rely on source populations from nearby locations. Whilst there has been a recorded overall decline in sedge frog numbers in Year 1, it is important to note that these declines are mirrored at the nearby reference sites. Furthermore, recruitment in the form of sub adult frogs was recorded at four of the sites and evidence of recruitment at other sites is likely to occur during Year 2.

Temporary frog fencing in the form of sediment barrier fencing was observed at Site 1A (ch. 139500) during the second round of sampling. The recording of frogs along the transect at this time reflects, one of two things, the pre-clearing surveys were ineffective at capturing and relocating frogs to areas beyond the clearing footprint, or secondly, the fence itself is ineffective at excluding frogs from the construction site. It was noted, the fence did not have a return lip to prevent tree frogs from scaling the fence. Without it, it is almost a pointless mitigation tool apart from providing additional protective measures for the threatened Wallum Froglet (*Crinia tinnula*).

No compensatory ponds have been constructed to date. Consideration should be given to establishing ponds early into the construction of the upgrade to avoid oversights recorded for other species on other sections of the upgrade. The difficulties associated with recreating habitat for sedge frogs has previously presented problems on other sections of the Pacific Highway Upgrade program (i.e. Tugun Bypass). At year 1, the performance indicators of the monitoring program are yet to be measured with corrective action and their consequences. This is required at Year 3 so that any seasonal or external effects are adequately considered.

Based on the Year 1 findings, the following recommendation is outlined in Table 4-3.

Table 4-3. Recommendations following Year 1 Wallum Sedge Frog population monitoring and Roads and Maritime response.

Recommendation No	Recommendation	Roads and Maritime Response
1.	Ensure construction of the compensatory breeding ponds commence early in the construction program in accordance with the Threatened Frog Management Plan.	Noted – Compensatory breeding ponds will be installed in accordance with the Threatened Frog Management Plan.

5.0 GREEN-THIGHED FROG (*LITORIA BREVIPALMATA*)

5.1 Species Profile

5.1.1 Description

The Green-thighed Frog is a small to medium sized (max. 47 mm) hylid frog (Barker *et al.* 1995; Cogger 1995; Murphy and Turnbull 1999; Lemckert *et al.* 2006). It is a relatively distinct species with a prominent white upper lip, armpits and groin marked in lime green or yellowish in some instances but always with black markings (Barker *et al.* 1995; Lemckert *et al.* 2006).



Plate 5-1. Green-thighed Frog.

5.1.2 Distribution

The Green-thighed Frog is distributed in coastal and sub coastal areas from near Bundaberg (Cordalba) in the north to Ourimbah (i.e. central coast NSW) in the south (Barker *et al.* 1995; Lemckert *et al.* 2006). Despite this relatively wide distribution, it is known from few areas (see Ehmann 1997).

5.1.3 Habitat and Ecology

The cryptic habits of the Green-thighed Frog ensured it remained unknown to science until 1972 (Tyler *et al.* 1972). The main habitat requirement of this species is warm temperate lowland forest, although more recent records have indicated other habitat types including dry sclerophyll forest, heathland and swamp forest are used (Natrass and Ingram 1993; Lemckert 1999; Murphy and Turnbull 1999; Lewis 2000; Lewis 2006). The Green-thighed Frog is most often detected during breeding events between October and April when males congregate

around flooded depressions and call from either the ground or low fallen branches or vegetation (Barker *et al.* 1995; Ehmann 1997; Lemckert *et al.* 2006). Typically, calling events occur when the breeding site has received at least 75 mm in 24 hours or around 150 mm over a 72 hour period (B. Lewis unpublished data).

5.2 Survey Methods

Field surveys were performed in accordance with the Threatened Frog Species Management Plan (RMS 2015). The following details the areas surveyed along with the timing of field surveys and how the data were treated or analysed.

5.2.1 Site Selection

The location of BACI sites 1-5 are located in Section 1 and 2 whilst sites 6 to 10 are located in Section 3-7 and were selected during follow up surveys and updating of baseline information in 2015 (Lewis 2015; Figure 5-1).

5.2.2 Timing of Surveys

Weather patterns were constantly monitored between October 2017 through to May 2018 for the suitability of implementing field surveys during or immediately after a rainfall event delivering >50-75 mm in 24 hours, or alternatively 150 mm over 72 hours (Table A1). Consequently, sampling took place on the 15th -17th October 2017 for Sites 8-10 and the 22nd and 23rd December for Sites 1-7. No sampling was performed at Site 6A due to ongoing access constraints.

During stage one calling surveys, each site was visited and an initial five minute listening survey was performed to identify calling individuals. This was followed by a search of any flooded habitat to visually identify any non-calling individuals present in and around the flooded areas. At each site, the following were recorded: time at start and end of survey for each survey site, conditions during the survey (including temperature, humidity, cloud cover, relative wind intensity and rainfall) and species of frogs calling.

The second round or post breeding surveys were used to measure the breeding success at each site and these were performed on the 7th December 2017, 10th and 15th February 2018 or around 50-57 days after the potential breeding event. During the post breeding surveys, a fine scale mesh net (400 mm diameter) was used to sweep any of the residual water body. In an attempt to standardise this method, a minimum of 10 sweeps was undertaken per 25m² of water body. Any tadpoles captured were examined to determine if they were hylids representative of Green-thighed Frog, and if so, a sample was taken for further identification. The bank area within 5-10 m was also traversed to visually search for metamorphosed froglets over a set 20 minutes per site and the number of frogs recorded.

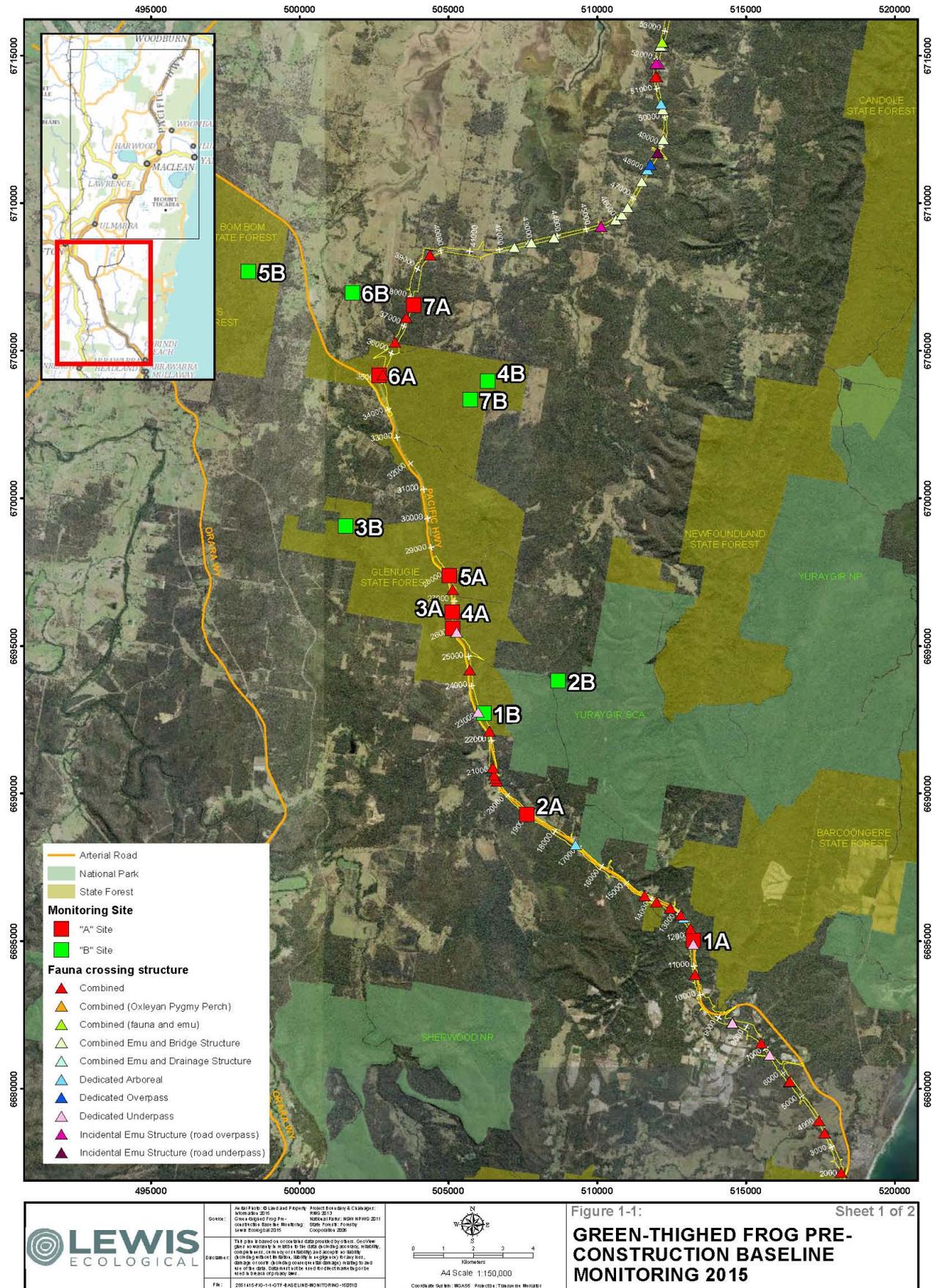


Figure 5-1. Locations of Green-thighed Frog BACI Sites 1-7 between ch.11800–40000.

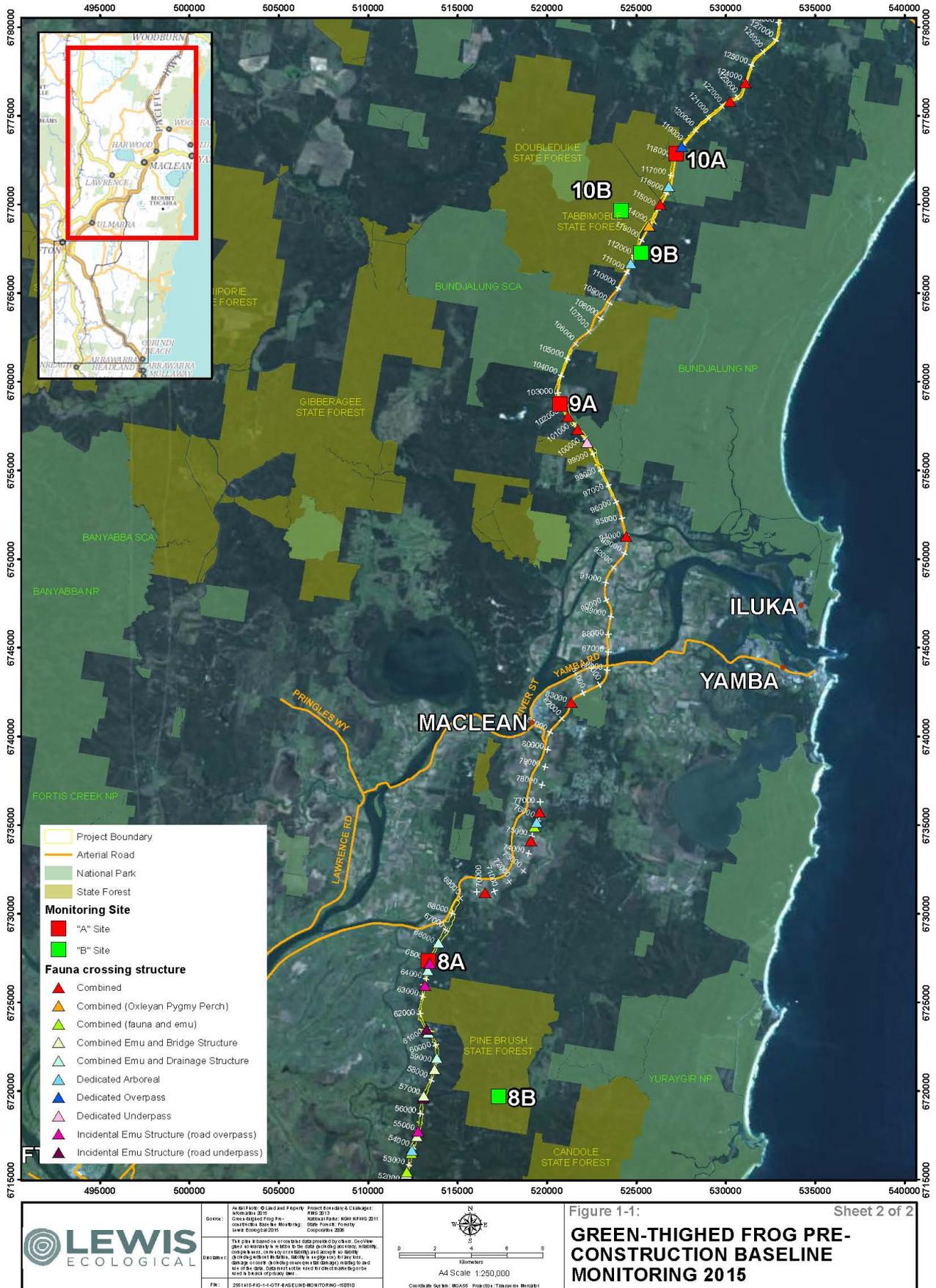


Figure 5-2. Locations of Green-thighed Frog Control and Impact sites between ch. 57500–118500.

5.2.3 Abiotic Data

The following abiotic variables were collected during the survey:

- Air temperature (°C) measured with a thermometer at the start and finish of the frog survey and averaged;
- Relative humidity (%) measured with wet/dry bulb thermometer at the start and finish of the frog survey and averaged;
- Prevailing cloud cover was expressed as a percentage (%) coverage of the sky;
- Wind speed measured using a subjective scale (0 = no wind, 1 = light rustles of leaves on trees, 2 = leaves and branches moving and 3 = whole canopy moving); and
- Rain fall was also measured in a subjective scale (0 = no rain in past 24 hours, 1 = rain within 24 hours and 2 = rain during survey).
- Seasonal rainfall data was also collated for the period between September 2017 and the start of May 2018 to assess when the surveys were performed and how they compared to other rainfall events within the perceived breeding period. The data were collated from Grafton Airport (058161) for the southern sites and from New Italy (058097) for the northern sites.

5.3 Monitoring Results

5.3.1 Stage 1 Surveys - Calling Intensity and Spotlighting

Green-thighed Frogs were recorded at 13 (68%) of the 19 sites as part of Year 3 monitoring in Sections 1 and 2 and Year 2 in Sections 3-7 (Table 3-1; Figure 3-1). Frogs were recorded from six (60%) of the impact sites including the newly relocated Site 3A (Bald Knob Tick Gate Road ch. 25000) where ponds are yet to be constructed. Frogs were recorded from seven (70%) of the control sites. No surveys were conducted at Site 6A due to continuing access restrictions. At Site 1A (Falconers ch. 11800), a single male frog was heard calling from private property adjacent to the road corridor, and again access constraints prevented a spotlight active search of this area. At six sites, frogs were observed and included males and females, but no males were heard calling.

Amplexing or mating frogs were recorded from Site 3A (Bald Knob Tick Gate Road) and 5A (Franklins Road) on the 22nd and 23rd December 2017. At these two sites, counts of 11 and 17 frogs were made following summer thunderstorm activity in this area. At the remaining sites, counts were generally of less than five frogs.



Plate 5-2. Green-thighed Frogs in amplexus (left) from Site 5A (Franklins Road) and a male calling (right) from Site 7A (Six Mile Lane).

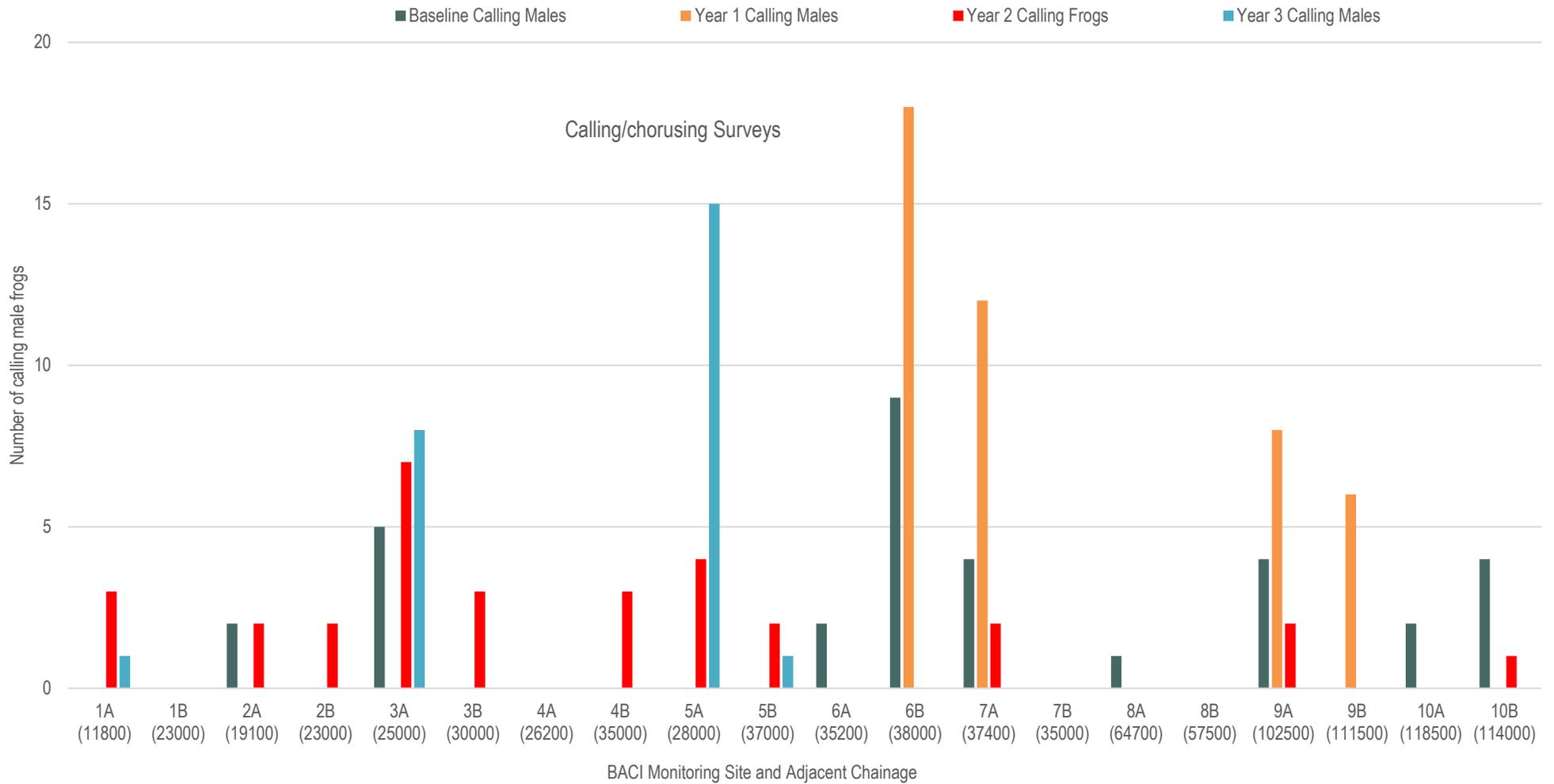


Figure 5-3. The number of calling male Green-thighed Frogs between the pre construction surveys and construction monitoring in Years 1, 2 and 3.

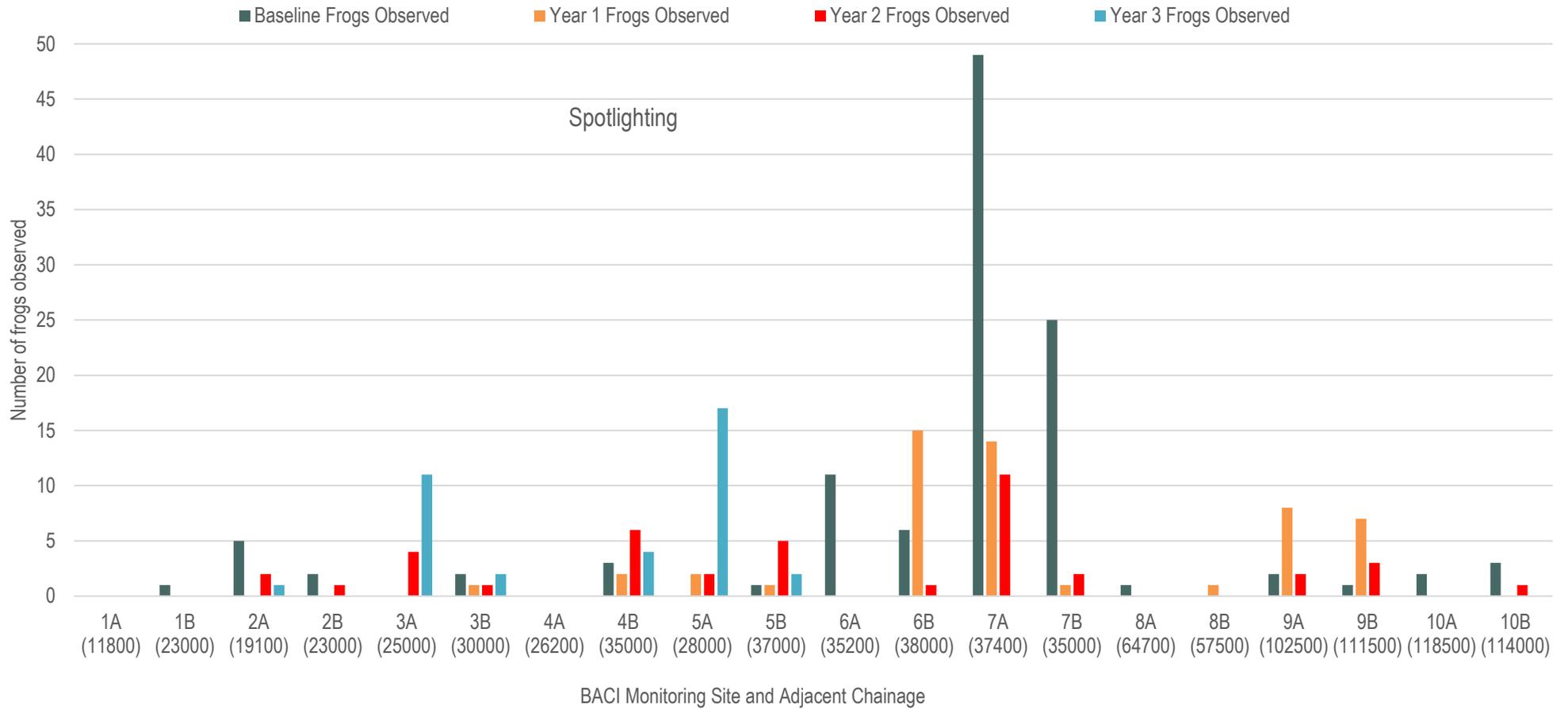


Figure 5-4. The number of Green-thighed Frogs observed between the pre construction surveys and construction monitoring in Years 1, 2 and 3.

Table 5-1. Summary of the 2017/2018 Green-thighed Frog surveys for BACI Sites 1-10.

BACI Site	Stage 1 – Calling/Breeding Surveys			Stage 2 – Post Breeding Follow-up Survey				Frog Management Mitigation Observed or Recorded	General Comments	Presence of Green-thighed Frogs Confirmed in 2015 (Baseline Surveys Lewis 2015)
	Date	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads			
1A ch.11800	23.12.2017	1	0	10.02.2018	0	0	0	<p>i. Permanent frog fencing installed adjacent to the compensatory breeding ponds.</p> <p>ii. Compensatory ponds constructed on western side. Most have filled with sediment.</p>	<p>Single male frog heard calling from adjacent private property which has been recently developed for intensive horticulture.</p> <p>Frogs are likely to opportunistically breed through the broader area so reliable and repeated sampling likely to remain difficult.</p>	No
1B ch.23000	23.12.2017	0	0	10.02.2018	0	0	0	<p>i. Site is impacted by works and not considered a control site.</p>	<p>Site not considered a control site. It is immediately adjacent to the clearing footprint for the Upgrade and therefore an impact site.</p> <p>Recommendation – Alternative site be identified and surveyed as part of Year 4 monitoring.</p>	No
2A ch.19100	23.12.2017	0	1	10.02.2018	0	0	0	<p>i. Frog fencing observed on both sides of the carriageway in both Giant Barred Frog and Green-thighed Frog configurations.</p> <p>ii. Compensatory ponds constructed on western side towards southern extent of frog exclusion fencing.</p>	<p>Consistent records of small numbers of frogs across the broader area.</p> <p>Area appears to dry more rapidly than previously. Adjacent table drains probably increased drainage in this area.</p> <p>Ponds tend to dry rapidly at this site and require ongoing follow up rainfall to ensure they retain water for at least 30-35 days.</p>	Yes
2B ch.23000	22.12.2017	0	0	10.02.2018	0	0	0	<p>Outside works footprint.</p>	<p>Site only appears to be occasionally used by frogs and more so during thunderstorms in dry seasons as the main monitoring pond fills up rapidly. Suspect other locations used nearby.</p>	Yes
3A ch.25000 (new)	23.12.2017	8	11	10.02.2018	0	0	0	<p>i. Constructed ponds identified in the TFMP not constructed at the time of monitoring</p>	<p>Roadside ponds currently serve as important breeding sites after the removal of similar ponds to accommodate the Upgrade.</p> <p>Constructed compensatory ponds not installed at Year 3 in the monitoring program.</p>	Yes

BACI Site	Stage 1 – Calling/Breeding Surveys			Stage 2 – Post Breeding Follow-up Survey				Frog Management Mitigation Observed or Recorded	General Comments	Presence of Green-thighed Frogs Confirmed in 2015 (Baseline Surveys Lewis 2015)
	Date	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads			
									Frog population still appears to be functioning in a viable manner with breeding frogs recorded in previous monitoring year.	
3B ch.30000	22.12.2017	0	2	10.02.2018	0	0	0	Outside works footprint.	Site burnt since initial 2013 surveys and likely to have influenced frog numbers. Difficult site to pin point breeding areas and likely to vary based on extent of seasonal heavy rains, depressions left from upturned trees and localised earthworks and associated drainage.	Yes
4A ch.26200	23.12.2017	0	0	10.02.2018	0	0	0	i. Permanent frog fencing partly installed.	Area prone to ongoing disturbance due to its proximity to road verge and routine maintenance or vehicles parking off the shoulder. The retained breeding area is now located in a vegetated median isolated by north bound and south bound carriageways.	No
4B ch.35000	22.12.2017	0	4	10.02.2018	0	2	0	Outside works footprint.	Frogs are generally scattered throughout this section of Glenugie State Forest. Frog counts influenced heavily by prevailing rainfall conditions and season as individuals are expected to breed at other nearby locations and not the monitoring site.	Yes
5A ch.28000	23.12.2017	15	17	15.02.2018	0	0	0	i. Permanent frog fence installed and appears to be functioning in an effective manner. ii. No compensatory ponds installed, however, number of retained areas which appear to function in the same manner and are currently used by frogs.	Highest number of frogs recorded here since the design input surveys of 2013 (Lewis 2013). No Green-thighed Frogs recorded on the roadside of frog fence although a number of common species were observed. Numbers of wild horses accessing the ponds to drink appears to have reduced the water holding period during this round of monitoring. Reduced substantive follow up rains.	Yes

BACI Site	Stage 1 – Calling/Breeding Surveys			Stage 2 – Post Breeding Follow-up Survey				Frog Management Mitigation Observed or Recorded	General Comments	Presence of Green-thighed Frogs Confirmed in 2015 (Baseline Surveys Lewis 2015)
	Date	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads			
									Breeding ponds may not be required as this location given frogs have successfully breed in the retained pools of which there are more than 10 located in an area where ponds would have had to of been constructed.	
6A (35200)	no data - site restrictions still in place			no data - site restrictions still in place				No access permitted to this area	No access permitted to this area. Likely to have successfully bred at this monitoring location given the results from the surrounding sites.	Yes
6B (38000)	23.12.2017	1	2	15.02.2018	0	0	0	Outside works footprint but close to Airport Road.	Site immediately adjacent to Airport Road which continuously provides a good barometer of local Green-thighed Frog activity. Breeding site probably runoff from adjacent bitumen road.	Yes
7A (37400)	23.12.2017	0	1	15.02.2018	0	3	0	i. Temporary frog fencing recorded in the form of geo textile fabric. ii. Clearing has extended to around 150 m south of Old Six Mile Lane Road	Potential breeding area is not well defined but numbers of frogs suggest this area as a 'hotspot' in 2015 (Lewis 2015). Insufficient follow up rainfall contributed to reduced breeding success.	Yes
7B (35000)	23.12.2017	2	11	15.02.2018	0	0	0	Outside works footprint.	Site logistically difficult to access during rainfall events.	No
8A (64700)	16.10.2017	0	2	07.12.2017	0	0	0	i. Permanent frog fence installed. ii. Access road graded which has reduced its suitability for Green-thighed Frogs based on past observations.	Frog fence appears to function in an effective manner. Frogs at this site appear to vary their breeding location based on extent of rainfall. Frogs were heard calling from adjacent private property during spotlighting surveys for Bettong and Phascogale in February 2018.	No
8B (57500)	16.10.2017	0	0	07.12.2017	0	0	0	Outside works footprint.	Site is seasonally grazed by cattle and with this the pond forms a watering source. Frogs appear to vary their breeding site and with drier seasons, the calling/breeding site now appears to occur in the drainage line around 300 m to north.	No
9A (102500)	16.10.2017	0	2	07.12.2017	0	0	0	i. Only temporary frog fencing observed.	Site was progressively cleared from February 2017 onwards.	No

BACI Site	Stage 1 – Calling/Breeding Surveys			Stage 2 – Post Breeding Follow-up Survey				Frog Management Mitigation Observed or Recorded	General Comments	Presence of Green-thighed Frogs Confirmed in 2015 (Baseline Surveys Lewis 2015)
	Date	No. Calling Males (choring intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads			
								ii. Pre-clearing surveys have been performed in the area but no post clearing report available as yet.	Some frog fencing noted during later stage 2 surveys and in months thereafter. Presence of frogs adjacent to the clearing indicates the population extends further to the west.	
9B (111500)	16.10.2017	2	3	07.12.2017	0	0	0	Outside works footprint.	Frogs are generally scattered throughout this section. Two breeding sites identified. Both barely contained surface water after almost 80 mm of rainfall in mid October and quickly dried thereafter.	No
10A (118500)	16.10.2017	0	2	07.12.2017	0	0	0	i. No mitigation recorded. ii. Apart from some minor geotechnical and access preliminary works no substantive clearing had commenced.	Not really considered Year 2 during construction survey when nothing has changed.	Yes
10B (114000)	16.10.2017	0	0	07.12.2017	0	0	0	Outside works footprint	Calling or breeding location varies markedly within this area. One male recorded on this occasion was perched on low vegetation calling from roadside drain.	No

5.3.2 Stage 2 Surveys – Post Breeding Counts of Tadpoles and Froglets

Tadpoles or juvenile frogs were recorded at 2 (11%) of the monitoring sites (Table 3-1). At Site 4B, two juvenile froglets were recorded during post breeding surveys on the 10th February 2018 which equates to around 50 days from the initial Stage 1 survey on the 23rd December. A neighbouring impact site, 7A (Six Mile Lane) also recorded froglets but interestingly, the paired treatment (7B – Glenugie East) did not, nor did the reference site off Airport Road a mere few kilometres to the west.

Although no Green-thighed Frog tadpoles were captured during the standardised 10 sweeps, other species of tadpole were identified including Broad-palmed Frog (*Litoria latapalmata*), Tyler's Tree Frog (*Litoria tyleri*) and/or Perons Tree Frog (*Litoria peronii*) and some ground dwelling species, presumably Common Eastern Froglet (*Crinia signifera*) or Eastern Sign-bearing Froglet (*Crinia parinsignifera*) and at some sites, the Ornate Burrowing Frog (*Platyplectrum ornatum*).

The breeding sites tended to dry out within 50 days of the calling event. Sites 8-10 sampled in mid October dried rapidly as did most of the sites sampled in Section 1 and 2 following a later rainfall event in December (Plate 3-2). At these northern sites (8-10), the ponds themselves didn't really fill with water after the 80 mm rainfall event so there was little chance the proceeding rainfall events would prevent them from drying out.

5.3.3 Seasonal Rainfall and Associated Survey Conditions

Suitable seasonal conditions in the form of heavy rainfall events exceeding 50 mm in 24 hours or cumulative tallies exceeding 150 mm in 72 hours occurred on a few occasions (Table A-2). Rainfall events exceeding 50 mm in 24 hours occurred on the 15/16th October (95 mm) for sites 8-10 and on the 22/23rd December 2017 for Sites 1-7 (74 mm). A follow up rainfall event on the 6th of November produced 69.2 mm at New Italy, however, it is likely to have yielded the same result as the surveys performed a few weeks earlier. Further south, no further substantive rainfall events occurred with monitoring occurring up until May 2018.



Plate 5-3. Breeding ponds at Site 10A (top left), 10B (top right), Site 9A (bottom left) and 9B (bottom right), 8A (Tyndale Crown) and 8B (Pine Brush State Forest) during the October to December monitoring.

5.3.4 Constructed Breeding Ponds

No Green-thighed Frogs were recorded breeding in the constructed ponds at Redbank Creek (ch. 5600 E) nor at Site 1A (ch.11800 W) or Site 2A (ch. 19100 W). At Site 3A (ch. 25000) where the new impact site has been relocated, no compensatory breeding ponds were constructed at the time this monitoring was undertaken (i.e. December 2017 – February 2018). A summary of the site inspections is presented below and in Table 5-2.

i. Redbank Creek Ponds (5600 E)

Monitoring commenced on the evening of 23rd December 2017 where all four ponds had filled to capacity following an estimated 80 mm of rainfall in the past 24 hrs. At this time, no Green-thighed Frogs were heard or observed around the ponds. Access constraints prevented any cursory surveys to the east of the constructed ponds, however, past approved access would indicate Green-thighed Frog is likely to inhabit that area.

A follow up survey 50 days later on the 10th February revealed all four ponds contained around 40 mm of water. In this context, they are considered functional for the purposes of providing breeding habitat for Green-thighed Frogs.

ii. Falconers (11800 W)

Monitoring commenced on the evening of 23rd December 2017 where only the fifth pond had filled with water whilst the remaining ponds had filled with sediment. Although no Green-thighed Frogs were heard calling from around the ponds, one male frog was heard calling from the adjacent private property.

The follow up post breeding survey found all of the constructed ponds had dried out and had been this way for some time. Four of the five ponds contained sediment, whilst the fifth pond probably retained some capacity to hold surface water to enable tadpole development.

iii. Halfway Creek (19100 W)

Monitoring commenced on the evening of 23rd December 2017 where all four ponds had only partly filled with water following a thunderstorm earlier that evening. Water depths of 30-150 mm were recorded during this initial survey. Some follow up surveys performed on the 11th January found these ponds were virtually dry, despite around 25-30 mm of follow up rainfall in early January. Further monitoring on the 10th February found all four ponds had dried out and had been this way for some time.

iv. Bald Knob Tick Gate Road (25000 E)

At the time monitoring was performed, no breeding ponds had been constructed.

v. Compensatory Ponds in Sections 3-7

At the time monitoring was performed, no breeding ponds had been constructed.

Table 5-2. Summary of compensatory frog pond monitoring during Year 2.

Site	Ch. + Side of Carriageway	Number of Constructed Ponds	First Survey	Second Survey	Third Survey	Comments
Redbank Creek	5600 East	4	23 rd December 2017 All ponds filled to capacity. Visual Water Quality – same as adjacent Redbank Creek and flooded depressions.	6 th January 2018 Ponds receded by about 30% which equates to 70% capacity. Visual Water Quality – same as adjacent Redbank Creek and flooded depressions.	10 th February 2018 Ponds receded to 5-10% capacity. Visual Water Quality – same as adjacent Redbank Creek and flooded depressions.	Without follow up rain, ponds likely to dry within 30 days. Sufficient follow up rain has enabled the ponds to provide suitable breeding habitat for Green-thighed Frog this season.
Falconers	11800 West	5	23 rd December 2017 Four upslope ponds filled with sediment and no longer considered functional. The fifth or lower pond can fill with water and was filled to capacity at around 200 mm depth. Visual Water Quality – Turbid and continuing to rain at time of inspection.	6 th January 2018 Fifth pond was dry during inspection despite around 30 mm of rainfall a few day earlier. Visual Water Quality – Dry.	10 th February 2018 Fifth pond dry. Remainder silted and no longer functional. Visual Water Quality – Dry.	Most ponds now filled with sediment and no longer considered functional. Follow up rainfall considered essential for pond five to retain water for more than 30 consecutive days. Frogs continue to call in adjacent area indicating some suitable breeding habitat may be retained on adjacent private property.
Halfway Creek	19100 West	4	23 rd December 2017 Ponds contained between 30-150 mm water. Visual Water Quality – same as adjacent flooded areas to the south with a slight tannin stain.	11 th January 2018 Ponds virtually dry despite 25-30 mm rainfall around a week earlier. Visual Water Quality – Dry.	10 th February 2018 Ponds dry and have been so for some time. Visual Water Quality – Dry.	Follow up rainfall required to ensure ponds retain water for more than 30 consecutive days. Ponds drying out too quickly. Adjacent table drains likely to increase drainage rates and reduce drying times of ponds.
Bald Knob Tick Gate Road	25000 East	Not constructed	Not applicable	Not applicable	Not applicable	Not constructed at the time of Year 3 monitoring.
Section 3	No compensatory ponds constructed to date					No compensatory ponds constructed to date
Section 6	No compensatory ponds constructed to date					No compensatory ponds constructed to date
Section 7	No compensatory ponds constructed to date					No compensatory ponds constructed to date

5.3.5 Frog Fencing

No Green-thighed Frogs were recorded on the road side of the installed permanent fencing. Other species of frog were recorded and include both tree frogs (i.e. hylids) and ground dwelling frogs (i.e. myobatrachids). Numbers of frogs were generally 2-7 times more likely to be found on the habitat side of the fence indicating the fence design is effective at reducing frogs accessing the carriageway. At Halfway Creek (Site 2A), a lower proportion of frogs were found on the habitat side and this being largely attributed to increased areas of surface water and suitability of breeding habitat actually found on the road side of the fence for pond dwelling frogs. In other words, the table drains act like a sump to the surrounding landscape. Counts were not performed at Site 4A, as the permanent fence divides the existing north and south bound carriageways and offers no protection. At Sites 7A and 9A, temporary frog fencing remains installed whilst Site 6 A and 10A, clearing is yet to commence.

Table 5-3. Summary of permanent frog exclusion fence monitoring during Year 3 at Sites 1-5 and for Year 2 at Sites 6-10.

Site	Ch. + Side of Carriageway	Status of Fencing	Fencing Extent Surveyed	Frogs Within 2 m Habitat Side of Fence	Frogs on Road Side of Fence	Comments
Redbank Creek	5600 East	Completed permanent fence	5500-5625	<i>Litoria latapalmata</i> x 4 <i>Litoria nasuta</i> x 1 <i>Litoria dentata</i> x 2 <i>Platyplectrum ornatum</i> x 4 <i>Limnodynastes peroni</i> x 1 <i>Crinia parinsignifera</i> (heard) Total = 12	<i>Litoria latapalmata</i> x 1 <i>Litoria dentata</i> x 1 <i>Platyplectrum ornatum</i> x 2 <i>Crinia parinsignifera</i> (heard) Total = 4	Some minor breaches and finishing attention at tie in to culvert and directional changes required. Majority of frogs found on habitat side indicating frog fence is effective with a ratio of one frog road side for every three frogs on the habitat side of the fence.
Falconers	11800 West	Completed permanent fence	11700-11850	<i>Litoria latapalmata</i> x 6 <i>Litoria nasuta</i> x 1 Total = 7	<i>Litoria latapalmata</i> x 1 Total = 1	Steep batter associated with this area probably improves the functionality of the fence. Ratio reduced to seven frogs on habitat side of fence to every frog on the road side of the fence.
Halfway Creek	19100 West	Completed permanent fence	19000-19500	<i>Litoria latapalmata</i> x 9 <i>Litoria nasuta</i> x 6 <i>Litoria dentata</i> x 4 <i>Platyplectrum ornatum</i> x 17 <i>Limnodynastes peroni</i> x 7 <i>Limnodynastes terraereginae</i> x 4 <i>Crinia parinsignifera</i> x 2 + numerous heard Total = 49	<i>Litoria latapalmata</i> x 3 <i>Litoria nasuta</i> x 3 <i>Litoria dentata</i> x 7 <i>Platyplectrum ornatum</i> x 9 <i>Limnodynastes terraereginae</i> x 3 <i>Crinia parinsignifera</i> x 8 + numerous heard Total = 33	Greater extent of frog fence walked than at other locations. Deep table drain appears to attract frog fauna. Around 50% more frogs are found on the habitat side of the frog fence.
Bald Knob Tick Gate Road	25000 East	Completed permanent fence	No counts performed	No counts performed	No counts performed	Perform surveys once compensatory ponds have been installed.

Site	Ch. + Side of Carriageway	Status of Fencing	Fencing Extent Surveyed	Frogs Within 2 m Habitat Side of Fence	Frogs on Road Side of Fence	Comments
Old Highway Heavy Vehicle Checking Station	26200 West	Completed permanent fence	26100-26250	No counts performed	No counts performed	The frog fence which borders the pond has the carriageway on both sides. With the use of the old carriageway for north bound traffic the fence is redundant with no functionality.
Franklins Road	28000 East	Completed permanent fence	27900-28050	<i>Litoria latapalmata</i> x 14 <i>Litoria nasuta</i> x 1 <i>Litoria dentata</i> x 9 <i>Platyplectrum ornatum</i> x 1 <i>Limnodynastes peroni</i> x 3 <i>Limnodynastes terraereginae</i> x 7 <i>Crinia parinsignifera</i> x numerous heard Total = 32	<i>Litoria latapalmata</i> x 3 <i>Litoria nasuta</i> x 3 <i>Litoria dentata</i> x 1 <i>Platyplectrum ornatum</i> x 4 <i>Crinia parinsignifera</i> x 2 + heard Total = 13	Reduced ratio of around 2.5 frogs for every frog found on the road side of the fence. Some minor breach points in the fence but based on frog counts it is functional with no Green-thighed Frogs accessing the carriageway as part of Year 3 monitoring. Access road with grid that still enables frogs to access roadway
Pheasant Creek	35200	Clearing had not commenced – restricted access				No surveys performed as site remains restricted access.
Old Six Mile Lane	38000					
Tyndale Crown Reserve	64700	Partly completed permanent fencing	64600-64750	<i>Litoria latapalmata</i> x 1 <i>Litoria nasuta</i> x 1 <i>Litoria dentata</i> x 2 <i>Platyplectrum ornatum</i> x 7 <i>Limnodynastes terraereginae</i> x 3 Total = 14	<i>Litoria latapalmata</i> x 1 <i>Platyplectrum ornatum</i> x 2	Reduced ratio of almost five frogs for every frog found on the road side of the fence. Some minor breach points including the existing construction access.

Site	Ch. + Side of Carriageway	Status of Fencing	Fencing Extent Surveyed	Frogs Within 2 m Habitat Side of Fence	Frogs on Road Side of Fence	Comments
					Total = 3	
Jackybulbin	102500	Temporary frog fencing only				Area has been cleared for 12 months.
Tabbimoble North	118500	Clearing had not commenced at the time of monitoring				Clearing had not commenced at the time of monitoring

5.4 Discussion

Monitoring between spring 2017 through to autumn 2018 resulted in Green-thighed Frogs being recorded at two thirds of the monitoring sites. The number of sites that recorded frogs is lower than the baseline survey when apart from Site 8B (Pine Brush State Forest), frogs were recorded at all monitoring sites. This year to year variability probably relates more to the prevailing conditions at the time surveys were performed as opposed to the direct consequences of construction and operation. Put simply, there were very few rainfall events which triggered sampling during the monitoring period with only a mid October rainfall event for the northern sites (8-10) and a thunderstorm event on the 22nd of December which provided marginal conditions for Sites 1-7. The difficulties associated with accurate monitoring of rainfall at the northern monitoring sites has been previously raised (see Lewis 2018). Sampling at most of the southern sites is reasonably accurate when relying on the Bureau of Meteorology station at Grafton Airport. This combined with survey staff being stationed in Grafton probably contributed to capturing the isolated pre Christmas thunderstorms and with that, breeding observations of frogs from two of the impact sites in Section 2 where construction had been recently completed.

Monitoring coincided with construction works being more or less completed at Sites 1-5 and with construction underway at Sites 7A, 8A and 9A. The installed permanent frog fence appears effective at reducing the number of frogs accessing the carriageway, but not prevent it. During this round of monitoring, no Green-thighed Frogs were recorded on the road side of the fence, however, the use of common frogs as a surrogate found they were two to seven times more likely to be found on the habitat side of the frog fence. At this stage of the monitoring, the permanent frog fencing appears to function in an effective manner.

During this round of monitoring, compensatory breeding ponds had been constructed at two sites in Section 1 (Redbank Creek and Falconers) and at one site in Section 2 (Halfway Creek). Ponds at the two remaining sites nominated in the Threatened Frog Management Plan are yet to be installed, and with this, they are discussed further in the performance measures in Section 5.0.

The four ponds constructed at Redbank Creek held water over a period that would have enabled tadpoles to develop into froglets. Although Green-thighed Frogs are yet to be recorded using these ponds, they are likely to in due time. The difficulty at this site is the access constraints which prevent some broader surveys of the area to confirm where Green-thighed Frogs are focusing their chorusing within any given rainfall event. What we have learnt in the past two seasons is that frogs are known from the western side of the carriageway and from around 1 km to the north, so future monitoring will prove an informative tool in demonstrating how threatened frogs may colonise compensatory habitat created during construction.

The ponds constructed at Falconers continue to prove problematic. The ponds themselves are constructed adjacent to a fill zone which does require some settling time from the bulk earthworks. This has resulted in four of the five ponds silting up and the fifth will do so if some form of rectification works are not undertaken. RMS are currently working on rectifying

this matter including the construction and desilting of the ponds following a meeting in June 2018. One other problem at this site is that access constraints prevent surveys from being performed on the nearby property where Green-thighed Frogs are often heard calling so there is a great reliance on aural surveys. Being able to obtain access to this locality would prove useful in understanding the long term viability of this breeding site.

The ponds at Halfway Creek present a different set of difficulties as without substantial follow up rainfall they tend to dry too quickly to enable the development of Green-thighed Frog tadpoles. Apart from the sandy soils, the positioning of the longitudinal drains probably increased drainage in this area. The added difficulty of positioning ponds in this area was the room between the drainage works, the project boundary and services including the optic fibre. Ameliorates such as bentonite are probably required to retard the rate of drying.

The remaining nominated pond areas at Bald Knob Tick Gate Road and Franklins Road are yet to be constructed. Some important breeding habitat was removed at the former site around ch.25000 and compensatory ponds are required. This has been the subject of some on site meetings and there is a commitment to construct some ponds to the east of the constructed carriageway. Meanwhile at Franklins Road (ch. 28000) where compensatory ponds were identified in the TFMP, there are enough retained ponds to have enabled successful breeding in the past and therefore, constructing additional compensatory ponds may now not be necessary.

For the remaining sites, the locations of compensatory ponds are yet to be determined and this will need to be addressed in the near future to ensure the commitments of the plan are met whilst ensuring important breeding habitat removed to accommodate the Upgrade has been adequately compensated.

How the data collected for Year 2 and 3 compares or performs against the prescriptions outlined in the Threatened Frog Management Plan is outlined in the following section.

5.5 Performance Measures and Corrective Actions

A series of performance indicators and corrective actions have been outlined in Section 7.2.3 of the Threatened Frog Species Management Plan (RMS 2015). This plan states that *should it become clear that sites that were occupied prior to road construction (i.e. established impact monitoring sites) have become unoccupied, or abundance (estimated using the transect counts) has declined beyond the identified thresholds (i.e. 25%) relative to control/reference sites, corrective actions must be implemented in accordance with those provided in Table 7-1.*

Monitoring during the 2017/18 season is tied into the population monitoring component outlined in Table 7-1 of the plan as well as some of the compensatory ponds at some but not all of the sites. The performing factor for the population monitoring is the number of male frogs during the Stage 1 survey, although recommendations in Lewis (2017) have allowed for this to be updated to the number of frogs recorded. With this, the numbers or actual counts of frogs had increased at Site 1A with a single male frog heard calling as opposed to no frogs being recorded at this site during the baseline sampling (Table 5-4). At Site 2A, the number of frogs had halved, down from two frogs in the baseline survey to a single frog in Year 3. At the newly installed Site 3A the numbers of frogs were approximately twice that recorded in the baseline survey whilst no frogs have been recorded at Site 4A over a number of monitoring periods now, including the baseline survey. A substantive increase in the number of frogs was recorded at Site 5A (Franklins Road) with the count data among the highest recorded for this site since it was initially discovered in January 2013. The continuing access constraints have prevented any surveys from being performed at Site 6A, however, the site a few kilometres further to the north declined sharply at Site 7A, down from 49 individuals to just 11 individuals yet they were similarly down at the paired treatment from 25 individuals in the baseline survey to just two individuals on this occasion (Table 5-4). At Site 8A (Tyndale Crown), frogs remain absent like Year 1. Conversely, one individual was observed at the paired treatment Site 8B (Pine Brush State Forest) compared to no frogs during the baseline survey. At Site 9A, frog numbers declined by half yet they had increased at the paired treatment of Site 9B. Site 10 recorded an absence of frogs from the impact treatment even though construction had not yet commenced. The reference site on the other hand recorded a 75% decline from the baseline survey, down from four frogs to just one on this occasion.

In regard to the compensatory ponds, they should now be finalised so that is accords with the commitments identified in the TFMP, that being “*where breeding habitat will be directly impacted by the project or changed hydrological patterns have the potential to affect the suitability of breeding habitat areas adjacent to the corridor*”. As the ponds nor monitoring sites occur in riparian areas, the riparian habitat revegetation parameters appear irrelevant at this time.

Table 5-4. Performance indicators and corrective actions from the Threatened Frog Species Management Plan (RMS 2015).

Triggers for corrective actions	Corrective actions	Relevance to 2017/18 Green-thighed Frog Construction Monitoring	Results of 2017/18 Green-thighed Frog Construction Monitoring	Potential Contributing Factors	Corrective Action Required
Population Monitoring					
<p>The absence of threatened frogs at impact sites identified as occupied in the baseline monitoring surveys.</p> <p>A relative decline in abundance of 25% or more at an impact site than its relative control site over 3 consecutive monitoring periods. Frog abundance determined by standardised transect counts:</p> <ul style="list-style-type: none"> • Number of Wallum Sedge Frogs per 100 m² of habitat; • Number of Giant Barred Frogs per 500 m of habitat; • Number of adult male Green-thighed Frogs per Stage 1 survey (breeding survey) (as outlined in Section 4.3). 	<p>Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance.</p> <p>Investigate effectiveness of frog exclusion fencing immediately.</p> <p>Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation.</p> <p>Assess the requirement for additional offsets where a threatened frog population is no longer present in a previously occupied area, and this habitat is deemed unsuitable for the target species.</p>	<p>Relevant</p>	<p>Green-thighed Frogs recorded from impact sites of 1A, 2A, 3A, 5A, 7A and 9A and from reference sites 3B, 4B, 5B, 6B, 7B, 9B and 10B.</p> <p>Green-thighed Frogs absent from impact sites of 4A, 8A, 10A, and control sites 1B and 10B.</p> <p>The recorded declines and absences reflect the variability in survey conditions than any real decline. For example, no works/habitat removal had occurred at the time surveys were undertaken at Site 10.</p>	<p>Variability in results influenced by prevailing weather conditions at the time of sampling.</p>	<p>Sites 1-5 have undergone their third year of monitoring. Frogs have declined by 60-80% at Site 2A yet this has been mirrored at the reference site with a decline to nil or absent at Year 3. Similar comparative declines have occurred at Site 7A, however, this is mirrored at the reference site (7B). At Site 8, the recorded declines and variability are reflected in the reference site. At Site 10A, the reported declines exceed the acceptable threshold yet no construction activity has taken place. This exemplifies variability tied to rainfall events.</p> <p>This round of monitoring represents the second year for Sites 6-10. The next round of monitoring is required before determining the requirements for any corrective actions.</p>
Underpass Structure Monitoring					
<p>The use of the structure by less than 1% of the estimated population size.</p> <p>Connectivity structures not maintained (i.e. culverts clogged with debris or sedimentation). Frog exclusion fencing damaged or ineffective.</p>	<p>Review monitoring methods where goals are not achieved, by increasing frequency, intensity and duration, to ensure individuals are identified.</p> <p>Survey habitat adjoining the connectivity structures and undertake Landscape improvement (planting, weed removal) to improve habitat functionality.</p> <p>Survey and monitor crossing structures and frog fencing to ensure they are functional (i.e. are adequately maintained, including fencing is not damaged, and connectivity structure is operating correctly). Monitor twice per year.</p>	<p>No relevant at this point in time. Structures are not operational.</p>	<p>Not Applicable</p>	<p>Not applicable</p>	<p>Not Applicable</p>

Triggers for corrective actions	Corrective actions	Relevance to 2017/18 Green-thighed Frog Construction Monitoring	Results of 2017/18 Green-thighed Frog Construction Monitoring	Potential Contributing Factors	Corrective Action Required
	Assess the need for offsets if connectivity structures are identified as ineffective over three consecutive monitoring periods.				
Constructed Pond Monitoring					
Absence of threatened frogs and metamorphs at the compensatory ponds after three years since construction.	<p>Investigation be undertaken to determine why there may be a lack of success and, as where recommended, changes be made to the habitat and monitored for effectiveness (i.e. 3 more years of monitoring)</p> <p>Review monitoring methods, considering timing and weather conditions to ensure individuals are identified.</p> <p>Review location of the compensatory pond and consider moving, and/or modifying or constructing additional ponds.</p> <p>Investigate habitat adjoining the upgraded highway and consider improving habitat condition and connectivity.</p>	<p>Two rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at three of the five sites and monitoring performed over two seasons.</p> <p>At Sites 6-10 no ponds have been constructed to date.</p>	<p>No use of constructed ponds recorded at Redbank Creek, Falconers and Halfway Creek. Ponds have not been constructed at Bald Knob Tick Gate Road and Franklins Road.</p> <p>No ponds constructed in Sections 3-7 yet commitments identified in TFMP.</p>	<p>Ponds at Falconers have silted up and no longer provide frog breeding habitat.</p> <p>Ponds at Halfway Creek dry too quickly without regular follow up rain. Moreover, the adjacent longitudinal drainage probably increases drainage.</p> <p>Ponds not constructed at Bald Knob Tick Gate Road (ch. 25000). Although no compensatory ponds were constructed at Franklins Road (ch. 28000) there is probably sufficient retained breeding habitat.</p>	<ol style="list-style-type: none"> 1. Desilt and reconfigure ponds at Falconers 2. Use bentonite to reduce drying time of ponds at Halfway Creek 3. Construct ponds at Bald Knob Tick Gate Road 4. Highest counts at Site 5A - Franklins Road recorded in Year 3. Compensatory ponds not necessary given the retained areas of suitable breeding habitat. 5. Determine the locations for ponds in Sections 3, 6 and 7 so that they can be constructed.
Water pH exceeds 5.5 for Wallum Sedge Frog	Investigate ways to reduce pH of water.	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Visual water quality of the compensatory pond is not similar to nearby unimpacted and/or similar wetlands or is unsuitable for frog occupation.	Complete site specific investigation to identify the causes of the unsuitable hydrological conditions or water quality.	Not relevant at this point in time.	Not Applicable	Not Applicable	Not Applicable
No persistent water present in ponds (negative hydro period) despite recent rainfall.	Assess possible causes for water draining from the pond and apply physical corrective actions	Not relevant at this point in time.	Not Applicable	Not Applicable	Not Applicable
Mosquito Fish present and threatened frogs / tadpoles absent.	Draining pond to remove Mosquito Fish and allow pond fill at the next rain event.	Relevant	No Mosquito Fish recorded.	Ponds are drying out to ensure they remain fish free.	None required at this point.
Constructed habitat un-suitable for frogs (e.g. wetlands have un-suitable hydro-period (as determined from monitoring events), water quality or	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control.	Relevant	1. Ponds at Falconers silted up and not functioning as frog breeding habitat.	1. At Falconers, the settling time from bulk earthworks and associated erosion and sedimentation.	<ol style="list-style-type: none"> 1. Desilt ponds at Falconers so they can capture and retain water. 2. Add Bentonite or some similar product to retard drying times so they

Triggers for corrective actions	Corrective actions	Relevance to 2017/18 Green-thighed Frog Construction Monitoring	Results of 2017/18 Green-thighed Frog Construction Monitoring	Potential Contributing Factors	Corrective Action Required
associated vegetation) as detailed in section 5.4.4.	Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.		2. Ponds at Halfway Creek drying too quickly and require rectification works.	2. At Halfway Creek, longitudinal drains act as a sump to the surrounding area and increased drying times. Difficult area to position ponds away from other infrastructure and services.	accord more with larval development of Green-thighed Frog.
Revegetated native habitat in poor condition (e.g. >30% cover died, plant dieback).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	Not relevant at this point in time.	Not Applicable	Not Applicable	Not Applicable
Frog absence confirmed following monitoring surveys (it should be noted that a pond may be suitable for frogs, but not colonised).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	Partly relevant.	Redbank Creek – ponds are constructed in a suitable manner. Falconers – Most of ponds silted over. Halfway Creek – Ponds dried out too quickly.	1. At Falconers, the settling time from bulk earthworks and associated erosion and sedimentation. 2. At Halfway Creek, longitudinal drains act as a sump to the surrounding area and increased drying times. Difficult area to position ponds away from other infrastructure and services.	1. Desilt ponds at Falconers so they can capture and retain water. 2. Halfway Creek - add Bentonite or some similar product to retard drying times so they accord more with larval development of Green-thighed Frog.
Riparian Habitat Revegetation					
Greater than 10% of riparian plants have died after first 12 months of maintenance. Greater than 20% of riparian plants have died after three years of maintenance. Total weed coverage is more than 30% in revegetation areas. Bank erosion causes unforeseen revegetation area instability.	Review maintenance schedule for revegetated areas immediately after trigger. Replace dead plants within one month of issue being identified. Increase weed control if required as soon as practicable or review control methods being used. Install physical measures to halt bank erosion within one month of issue being identified.	Partly relevant.	Redbank Creek – Adequate planted native vegetation around ponds. Falconers – Very little vegetation around ponds. Halfway Creek – Adequate vegetation around ponds.	Falconers – Sedimentation filling up the ponds.	Falconers – Desilt and replant vegetation to accelerate ground cover and stability around ponds.

5.6 Conclusions and Recommendations

Monitoring during spring 2017 and into the summer and autumn of 2018 resulted in one suitable calling or breeding event in October for Sites 8-10 whilst a later thunderstorm event in December provided marginal, yet suitable sampling conditions at Sites 1-7. Continued monitoring for additional sampling events continued up until May 2018, after which the season concluded. Frogs were recorded at 13 of the monitoring sites including six impact sites and including some encouraging numbers of frogs from Site 5A (Franklins Road) where calling males were heard and amplexing frogs were observed in some small flooded retained areas adjacent to the permanent frog fencing. There is however, a continued absence of frogs from impact Site 4A where the reuse strategy of the old carriageway has created a monitoring site between the north and southbound lanes. Further north, frogs remain absent at Site 10 A (Tabbimoble North), yet construction hadn't started at the time of the monitoring and this best demonstrates that some year to year variation should be expected.

Monitoring of the constructed compensatory frog ponds found no evidence of Green-thighed Frogs using the ponds at Redbank Creek, Falconers and Halfway Creek. The ponds constructed at Redbank Creek appear to be functioning in their intended manner and don't require any rectification works. At Falconers, the ponds have largely silted over and with this, the ponds either don't hold water or for a reduced period of time numbering days, rather than weeks. Rectification works in the form of desilting and planting some stabilising ground covers would assist in improving their suitability as compensatory breeding habitat. A different problem exists at Halfway Creek with the ponds simply not holding water long enough and this has been attributed to the longitudinal drains acting like a sump combined with the sandy soil at this location. The application of bentonite or some other similar product could prove a useful cost effective corrective action at this location.

At the other locations, no ponds could be located at either Bald Knob Tick Gate Road (ch. 25000) or Franklins Road (ch. 28000), two locations identified in the Threatened Frog Management Plan. A site meeting in on the 29 June 2018 has confirmed RMS commitment to constructing a series of ponds at Bald Knob Tick Gate Road whilst there appears to be sufficient retained habitat at Franklins Road. Once this has been finalised the TFMP will need to be updated to reflect these changes. Similarly, the status of ponds further north in Sections 3, 6 and 7 of the Upgrade.

The performance indicators of the monitoring program were updated to reflect the actual number of frogs recorded rather than relying on the numbers of calling males (see Lewis 2017). Although the relative decline in abundance has not exceeded 25%, there are some reported declines but these tend to be consistent with the nearby reference sites. For example, frogs have declined by 60-80% at Site 2A (Halfway Creek) yet this has been mirrored at the reference site (Yuraygir SCA) with a decline to nil or absent at Year 3. Similar comparative declines have occurred further north at Site 7A (Old Six Mile Lane), however, this is mirrored at the reference site (7B) and this holds true at Site 8 (Tyndale Crown versus Pine Brush State Forest). The fact that Site 10A has recorded the greatest decline to date best demonstrates the

variability that must be taken into account when monitoring frog populations. At this location, the reported declines at Year 2 currently exceed the acceptable threshold, yet no construction activity has taken place. This will need to be taken into account in Year 3 as construction works will have only existed in that area for around 12-15 months.

Monitoring of the installed permanent frog fencing continues to demonstrate all of the recorded Green-thighed Frogs have been found on the habitat side of the fence. As their numbers tend to be low, the recording of other common frogs has found that between two to seven times more frogs remain on the habitat side of the fence as opposed to the road side. Whilst the fence may not completely exclude all frogs, the monitoring data to date suggests it is providing an effective form of mitigation in reducing frog mortality during the operational phase.

Based on the 2017/18 findings, the following recommendations and Roads and maritime responses have been presented in Table 5-5.

Table 5-5. Recommendations following 2017/18 Green-thighed Frog population monitoring and Roads and Maritime responses.

Recommendation No	Recommendation	Roads and Maritime Response
1.	Rectification works take place at: a. Falconers (ch. 11800W) in the form of desilting and establishing ground cover plants that will assist in stabilising the pond areas; b. Halfway Creek (ch. 19100W) with the application of bentonite or some other similar environmentally friendly produce increase the retention period of surface water in the ponds.	Adopted - RMS has undertaken a site visit with ecologist to identify corrective actions required to meet intent of the Threatened Frog Management Plan, including a combination of desilting and relocating frog ponds at Falconers. It is anticipated that these works will be undertaken in late 2018 / early 2019. Adopted – RMS will review these ponds to determine the works required to increase the water retention period of surface water and meet the intent of the Threatened Frog Management Plan. These works were completed in November 2018.
2.	Ponds be constructed at Bald Knob Tick Gate Road (ch. 25000E) and investigations into the requirement for frog ponds be performed at Franklins Road (ch. 28000E).	Adopted - RMS has undertaken a site visit with ecologist to investigate suitable locations to construct frog ponds at Ch. 25000 (Bald Knob Tick Gate Road). These works were completed in November 2018. Recent Monitoring has demonstrated that significant suitable breeding habitat remains at Franklins Road with the count data among the highest recorded for this site since it was initially discovered in January 2013. This report identifies that are enough retained ponds to have enabled successful breeding in the past. RMS does intend to construct frog ponds at this location given the quantity of suitable breeding habitat remaining.
3	The effectiveness of the installed frog fence be reviewed for ch. 26000-27500 as it is currently located in the incorrect position to provide protection from road strike.	This area of the W2B upgrade is still subject to construction sequencing as part of the approved project, with further upgrade works to be undertaken and completed.

Recommendation No	Recommendation	Roads and Maritime Response
4	The compensatory Green-thighed Frog breeding ponds be identified in Sections 3-8. The TFMP currently notes <i>“These will be constructed where breeding habitat will be directly impacted by the project (Figure 3-1 and Figure 3-3) or changed hydrological patterns have the potential to affect the suitability of breeding habitat areas adjacent to the corridor”</i> .	Noted – Compensatory breeding ponds will be installed in accordance with the Threatened Frog Management Plan.
5	Access be obtained for any construction related automated weather station located between the following chainages: a. Ch.55000-75000; and b. Ch. 95000-123000.	Adopted - RMS has provided the author with access to the projects automated weather stations
6	The calling/breeding survey should occur twice within any given season so that it can accommodate for localised rainfall events and improve the opportunity to records frogs.	Not Adopted – Monitoring to continue in accordance with the baseline surveys and approved Threatened Frog Management Plan.
7	Ensure Year 3 monitoring provides a review of the targeted pre clearing survey results for Green-thighed Frog surveys in Section 3, 6 and 7	Pre-clearing survey results form part of a separate report with associated review of results, and if required, recommendations for consideration for future pre-clearing surveys.

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7.0 APPENDIX A – RAW FROG SURVEY AND RAINFALL DATA

Table A1. Raw Year 3 Giant Barred Frog survey data (November 2017 and February 2018).

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing
1A	Corindi Creek	7/11/2017	2040	2317	18	16	40	74	0	1	shallow, little water trickling in some spots	11	Female	Adult	Not gravid	108	175	00073567C6	90 M DOWNSTREAM	5	Second time	Observed	Above litter	Downstream of bridge on southern bank. Location GPS		
1A	Corindi Creek	7/11/2017	2040	2317	18	16	40	74	0	1	shallow, little water trickling in some spots	11	Female	Adult	Not gravid	105	170	000735367D	150 m Downstream	8	First Time	Observed	Above litter	Downstream on southern bank		
1A	Corindi Creek	7/11/2017	2040	2317	18	16	40	74	0	1	shallow, little water trickling in some spots	11	Male	Adult	No Colour	70	50	000735C0EE	150 M DOWNSTREAM	3	Second time	Observed	Among Lomandra	Downstream on southern bank		
1A	Corindi Creek	7/11/2017	2040	2317	18	16	40	74	0	1	shallow, little water trickling in some spots	11	Female	Adult	Not gravid	103	135	000735B20F	100m upstream	7	Second time	Observed	On Exposed Tree Roots	Upstream on northern bank		
1A	Corindi Creek	7/11/2017	2040	2317	18	16	40	74	0	1	shallow, little water trickling in some spots	11	Male	Adult	Light colour	74	60	000735A0AF	50 m upstream	4	Second time	Observed	Bare ground	Upstream on northern bank		
1A	Corindi Creek	7/11/2017	2040	2317	18	16	40	74	0	1	shallow, little water trickling in some spots	11	Female	Adult	Not gravid	113	130	MISSING FRONT LEFT LEG	20m -ds	3	Second time	Observed	Above Litter	Missing entire left leg. Was tagged but tag number not recorded. Whoops.		
1A	Corindi Creek	7/11/2017	2040	2317	18	16	40	74	0	1	shallow, little water trickling in some spots	11	Unknown	Sub Adult	Immature	53	19	00073567T9	40 m -ds	5	First Time	Observed	Above litter	Downstream on southern bank		
												Missed 4 <i>M. iteratus</i> - 2 upstream 2 downstream on north bank														
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Male	Adult	dark grey	78	73	7352C37	70 m - us	2	First Time	Heard	Above litter	Northern side	517552	6678574
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Male	Adult	dark brown	73	53	735bec7	100 m - us	3	Second/third Time	Observed	Above litter	Northern side	517518	6678570
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Male	Adult	pale brown	81	77	7357972	180m - us	1	Second/third Time	Observed	Above litter	Northern side	517498	6678597
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Male	Adult	pale grey	79	56	73585AD	190m -us	3	First Time	Observed	Above litter	Northern side	517506	6678605
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Female	Adult	ng	80	52	73529a0	190m -us	5	First Time	Observed	Above litter	Northern side	517516	6678601
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Female	Adult	ng	110	144	7356F45	180m - us	9	Second/third Time	Observed	Above litter	Southern Side	517467	6678544
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Female	Adult	gravid	111	170	7352A54	70m - us	0	Second/third Time	Observed	Water's Edge	Southern Side	517527	6678552
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Female	Adult	gravid	110	173	735AFD5	220 m -ds	5	First Time	Observed	On Bare Ground	Southern Side	517837	6678477
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Female	Adult	ng	82	75	735D21b	80m - ds	4	First Time	Observed	Above litter	Northern side	517750	6678572
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Female	Adult	ng	113	135	MISSING FRONT LEFT LEG	20m -ds	1	First Time	Observed	Above litter	Northern side	517672	6678613
												Missed 3 <i>M. iteratus</i> . 2x SS DS, 1x SS US														
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Male	Adult	Moderate nuptials	78	53	000735C609	400m -DS	5	Second time	Observed	On sand	Southern bank - suspect recapture from RH 3rd Digit meaning captured three times to date		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Unknown	Sub Adult	Immature	55	22	000735C476	200m -DS	4	First time	Observed on litter	Above litter	Northern bank		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Unknown	Sub Adult	Immature	65	35	000735C453	175m -DS	4	Second time	Observed	Part buried sand and litter on	Southern bank. Previously captured as a sub adult during Year 2		

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing
																							scoured bank			
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Female	Adult	Not gravid	99	120	000735C1DE	20m - DS	8	Second time	Observed	On rock	Southern bank Left Hand 3rd finger - Captured in Year 2 at top of the transect		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Unknown	Sub Adult	Immature	49	16	000735C488	150m-DS	5	First time	Observed	On sand	Southern bank		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Male	Adult	Light Nuptials	76	50	00073535EB	70m - DS	3	Second time	Observed	Above litter	Southern Bank - captured during Year 2 in similar area		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Female	Adult	Not gravid	94	80	000735ACDB	20 m - DS	14	Second time	Observed	Above litter	Southern Bank - second time captured from Year 2		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Unknown	Sub Adult	Immature	48	16	0073539FD	50 m - DS	4	First time	Observed	Above litter	Northern bank		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Female	Adult	Not gravid	77	47	000735B047	250m - DS	8	Second time	Observed	Above litter	Northern bank - captured during Year 2 monitoring		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Female	Adult	Not gravid	90	98	000735AE73	350 m downstream	8	Second time	Observed	Above litter	Northern bank - captured in same general area during Year 2		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Male	Adult	Moderate nuptials	75	54	00735C2FD	160 m - DS	5	First time	Observed	Above litter	Southern bank		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Unknown	Sub adult	Immature	57	120	00735C611	450m - DS	4	First time	Observed	Above litter	Southern bank		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Female	Adult	Part Gravid	100	120	0007359BDC	350 m - DS	4	Second time	Observed	Above litter	Northern bank - second time capture from Year 2		
												Missed two M. iteratus - both Sub adult sized														
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Unknown	Sub Adult	Immature	48	9	7358CB6	DS	10	First Time	Observed	Above litter		nd	nd
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Male	Adult	Moderate nuptials	78	45	735B3EA	DS	1	First Time	Heard	Above litter		nd	nd
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Male	Adult	Light Nuptials	74	51.1	7359F9C	DS	1	First Time	Observed	Above litter		510937	6673721
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Male	Adult	Dark nuptials	85	65	73535eb	DS	2	Recapture	Heard	Above litter		510937	6673721
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Unknown	Juvenile	Immature	38	8.5	735978a	DS	4	First Time	Observed	Above litter		510937	6673688
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Unknown	Sub Adult	Immature	40	8	7357f63	ds		First Time	Observed	Above litter		510976	6673704
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Unknown	Sub Adult	Immature	45	5	7355468	ds	6	First Time	Observed	Above litter		511078	6673827
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Male	Adult	Dark nuptials	80	60	735BCF7	ds	2.5	Recapture	Heard	Above litter		511064	6673850
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Male	Adult	Dark nuptials	85	76	7352c0a	240m - DS	1.5	Recapture	Heard	Above litter		511055	6673823
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Female	Adult	Not gravid	83	68.5	73586A5	260m -DS	10	First Time	Observed	Above litter		511030	6673843
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Female	Adult	Not gravid	79	55	735bd31	260m -DS	8	First Time	Observed	Above litter		511030	6673843
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Female	Adult	Not gravid	84	60	735A413	300m -DS	0.5	First Time	Observed	Above litter		511024	6673889
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Unknown	Sub Adult	Immature	46	8	7359 e 30	390m -DS	2	First Time	Observed	Above litter		511024	6673889
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Unknown	Sub Adult	Immature	49	10	735b1bc	300m - DS	2	First Time	Observed	Above litter		511041	6673893
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Female	Adult	Gravid	102	136	735A2C7	350m - DS	2	First Time	Observed	Above litter		510999	6673920
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Female	Adult	Gravid	112	158.5	735b6f6	500m - DS	2	First Time	Observed	Above litter		511077	6674022
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Unknown	Sub Adult	Immature	56	18	7357802	450m - DS	5	First Time	Observed	Above litter		510988	6674011
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Female	Adult	Not gravid	112	138	73555c2	30m -DS	6	First Time	Observed	Above litter		510900	6673658
												Missed 1 Adult iteratus														
2A	Dirty Creek	10/11/2017	1958	2147	22	16	50	72	0	0		0														
2A	Dirty Creek	5/02/2018	2335	145	21	17	100	83	0	1		0														
2B	Pigeon Gully	10/11/2017	2221	7	17	14	40	86	0	0		0														
2B	Pigeon Gully	5/02/2018	2040	2220	19	17	100	85	0	1		0														

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Male	Adult	Light nuptials	65	13	000735C3E3	120m-DS	9	Second time recapture from Year 2	Observed	Above litter	Northern bank	Originally tagged as a sub adult in Year 2 so its Year adult male	
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	48	13.5	000735CF3H	120m -DS	6	First time	Observed	On sand	Northern bank		
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	49	12.5	000735BD8D	100m -DS	4	First time	Observed	On sand	Southern bank		
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	47	17.5	0007358D8F	120m - DS	4	First time	Observed	Above litter at base of Lomandra	Southern bank		
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	50	16	00073579D3	90m- DS	3	First time	Observed	On sand of scoured bank	Edge of powerline easement - Northern bank		
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	45	13	000735876C	50 m downstream	4	First time	Observed	Above litter on scoured bank	Northern bank		
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Male	Adult	Very Dark Nuptials	74	46	000735B008	construction site	3	Second time	Observed	On sand	Northern bank	Recapture from similar area during Year 2	
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Male	Adult	Dark Nuptial	81	65	000735CB6F	30m -US	4	Fourth time recapture	Observed	Above litter	Southern bank	Appears to be a dominate male frog recaptured for the fourth time	
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	53	17	000735CF3D	40m - US	5	First time	Observed	Above litter	Southern bank		
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	46	11.5	0007352C9F	10m -US	2	First time	Observed	On bare bank	Southern bank		
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	50	16	0007356376	100m - US	5	First time	Observed	Above litter	Southern bank		
												3 sub adults and 2 adults missed														
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Unknown	Juvenile	Immature	37	4	735AE69	40m - DS	1	First time	Observed	Above litter	Southern bank	506519	6690536
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Light Nuptials	82	64	735841E	30m - DS	2	Recapture	Heard	Part buried in litter and sand	Northern bank	506528	6690533
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Unknown	Sub Adult	Immature	48	47	735c72B	70m - DS	1	First time	Observed	Above litter	Northern bank	506509	6690554
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	82	47	735c02C	90m - DS	1	First time	Observed	Above litter	Northern bank	506492	6690654
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Unknown	Sub Adult	Immature	51	13	73593ED	90m - DS	3	First time	Observed	Above litter	Northern bank	506495	6690567
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	98	60	735b8F8	90m - DS	4	First time	Observed	Above litter	Northern bank	506495	6690567
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Unknown	Sub Adult	Immature	46	8	735A512	180m - DS	1.5	First time	Observed	Above litter	Southern bank	506412	6690540
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	81	54	7358DEB	120m -DS	3	First time	Observed	Above litter	Southern bank	506455	6690551
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	80	50	735C00A	50m -DS	10	First time	Observed	Above litter	Southern bank	506477	6690548
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Sub Adult	Immature	50	13	7355AB6	50m - DS	2	First time	Observed	On sand	Southern bank	506520	6690526
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle.	19	Male	Adult	Light Nuptials	78	52	7353DFE	65m - US	1	First time	Heard	On sand	Northern bank	506635	6690514

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing
											Some ponds stagnant															
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Light Nuptials	74	46	7359648	70m - US	0	First time	Heard	on water's edge	Northern bank	506639	6690515
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Light Nuptials	83	46	735A52f	70m -US	2	First time	Heard	on log	Northern bank	506663	6690520
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Dark Nuptials	72	41	7352F38	105m -US	4	First time	Observed	Above litter	Southern bank	506714	6690505
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Gravid	118	144	7353 e 11	200m -US	3	First time	Observed	under litter	Southern bank	506826	6690470
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Juvenile	Sub Adult	Immature	46	8.5	73586AB	115m-US	3.5	First time	Observed	Above litter	Southern bank	506749	6690502
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	60	17	735629b	80m-US	3	First time	Observed	on moss	Northern bank	506701	6690507
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Dark nuptials	75	38	735B701	80m-US	3	First time	Heard	Above litter	Northern bank	506701	6690507
												1 adult male heard calling but not often enough to be located														
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Moderate nuptials	82	58	0007357E1B	30m - DS	5	Second time	Observed	Above litter	Northern bank	Recapture from Year 2	
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Moderate Nuptials	75	47	0007352FFD	50m - DS	4	First time	Observed	Above litter	Northern bank		
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Light nuptials	73	55	00073577DF	120m - DS	3	First time	Observed	Above litter	Southern bank		
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Dark nuptials	80	46	0007352CCF	190m - DS	6	First time	Observed	On log	Southern bank		
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Unknown	Sub adult	Immature	52	19	0007358F95	190m - DS	5	First time	Observed	Above litter	Southern bank		
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Female	Adult	Not gravid	104	120	000735C4BF	220m - DS	7	Second time	Observed	Above litter	Northern bank		
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Light nuptials	74	55	0007358C90	100m - DS	5	First time	Observed	Above litter	Southern bank		

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing
	River Catchment)																									
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Female	Adult	Not Gravid	93	88	0007359C55	15 m - US	8	First time	Observed	Above litter	Northern bank		
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Moderate Nuptials	74	48	0007358944	40 m - US	5	First time	Observed	Above litter	Northern bank		
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Unknown	Sub adult	Immature	50	18	0007357CB3	100m -US	5	First time	Observed	Above litter	Southern bank		
												2 sub adults missed														
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Unknown	Sub adult	Immature	47	7.5	7356534	30m - US	5	First time	Observed	Above litter		515423	6689075
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Female	Adult	Gravid	110	159	7359AFD	150m - US	5	First time	Observed	Above litter		515325	6689070
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Female	Adult	Not Gravid	101	124	73530f8	220m -US	2	First time	Observed	Above litter		515300	6689097
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Female	Adult	Not Gravid	80	50	735BAFD	230m - US	4	First time	Observed	Above litter		515300	6689093
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Unknown	Sub adult	Immature	42	7	735b50e	50m - US	5	First time	Observed	Above litter		515390	6689088
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Unknown	Sub adult	Immature	48	8	735967f	30m - US	3	First time	Observed	Above litter		515411	6689083
													1 male calling upstream could not be located													
4A	Boneys Creek	14/11/2017	2113	2255	21	17	40	77	0	1	Series of pools	1	Unknown	Sub Adult	Immature	52	16	0007357BF9	60 m downstream of construction works	5	First time	Observed	Above litter	Southern bank		
4A	Boney's Creek	8/02/2014	23:00	2:00	20	17	0	90	0	0	Shallow, little water movement.	3	Male	Adult	Moderate nuptials	71	42	735C0E1	10m - DS	0.5	First time	Heard	in grass		512478	6686214

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing
4A	Boney's Creek	8/02/2014	23:00	2:00	20	17	0	90	0	0	Shallow, little water movement.	3	Female	Adult	Gravid	115	166	735B4E9	210m - DS	10	First time	Observed	Above litter		512445	6686351
4A	Boney's Creek	8/02/2014	23:00	2:00	20	17	0	90	0	0	Shallow, little water movement.	3	Female	Adult	Not gravid	101	124	73587CC	190m - DS	5	First time	Observed	Above litter		512424	6686355
4B	McPhillips Road	14/11/2017	23:17	1:11	19	17	50	86	0	1	Series of shallow pools	1	Female	Adult	Not gravid	70	52	0007359B0C	10 m upstream of McPhillips Road	5	Second time	Observed	On bare ground	Southern Bank		
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	Light nuptials	71	37.5	735BC4a	115m - US	1	First time	Observed	Above litter		513086	6686332
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Female	Adult	Not gravid	69	27	735B001	120m - US	1	First time	Observed	Above litter		513074	6686323
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Female	Adult	Not gravid	92	81	735A516	150m - US	1	First time	Observed	Above litter		513078	6686314
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	dark brown	84	64	735C3E4	170m - US	4	First time	Observed	Above litter		513091	6686298
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	dark brown	80	55	735AA6B	180m - US	5	First time	Observed	Above litter		513107	6686293
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	pale brown	82	55	735C3A2	210m - US	6	First time	Observed	Above litter		513111	6686294
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	pale brown	75	44	7354D0A	210m - US	4	First time	Observed	Above litter		513111	6686304

Table A2. Summary of Wallum Sedge Frog surveys during the 2017/18 monitoring season.

BACI Site	Status		25th to 28 th February 2017										Jun-17										Comments
	Present Year 1	Absent Year 1	Count 1	Count 1	Count 1	Count 1	Water Depth (mm)	Air Temp (°C)	Humidity (%)	Rainfall	Cloud Cover (%)	pH	Count 2	Count 2	Count 2	Count 2	Water Depth	Air Temp	Humidity	Rainfall	Cloud Cover	pH	
			Adults	Sub Adults	Juveniles	Tadpoles							Adults	Sub Adults	Juveniles	Tadpoles							
1A	1		3	0	0	0	0	22.5	75	0	0	nr	2	4	0	0	470	15	81	1	80	6.52	Area impacted by clearing, earthworks and pond reclamation which included dewatering, planned trenching utility works with frogs found inside the frog fence construction zone.
1B	1		1	0	0	0	0	22.9	75	0	0	nr	0	1	0	0	170	16	72	0	0	4.7	Site provides consistently low numbers
2A		1	0	0	0	0	0	23.1	70	0	0	nr	0	0	0	0	680	16.7	73	1	50	4.62	Site prone to drying rapidly
2B	1		11	0	0	0	0	23.1	70	0	0	nr	9	3	0	0	390	16.7	80	1	50	4.32	Occasional calls during summer survey when site was dry for the first recorded time in 22 years
3A		1	0	0	0	0	0	22	73	0	0	nr	0	0	0	0	300	14.3	98	1	100	5.16	Site prone to drying out rapidly and periodic mowing
3B		1	0	0	0	0	0	22.9	71	0	0	nr	0	0	0	0	260	16.5	85	1	65	5.2	Site impacted by fencing and mowing works associated with W2B project. Affects integrity as a control site
4A	1		0	0	0	0	0	22.5	72	0	0	nr	1	0	0	0	400	16	85	1	100	8.2	Strange elevated pH reading following heavy rainfall event leading up to the survey
4B	1		0	0	0	0	0	22	73	0	0	nr	2	0	0	0	150	16	85	1	100	5.85	
5A	1		0	0	0	0	0	22.3	73	0	0	nr	1	0	0	0	230	14	95	1	80	4.64	Site typically seasonally inundated but dries within weeks to months depending on groundwater levels
5B	1		9	0	0	0	60	22.1	72	0	0	4.43	11	4	0	0	410	14	95	1	80	4.63	Seems to be a resilient site and form part of core or source population

Table A3. Summary of Green-thighed Frog surveys during the 2017/18 monitoring season.

BACI Site	Adjacent Chainage	Site Name	Easting Northing	Stage 1 Survey Date	Time (24hr)	AT °C	Hum %	Wind	Rain	CC	No. Calling Males (choring intensity)	No. Frogs Spotlighted	Stage 2 Survey Date	Days After Choring	No. Sub Adults	No. Juv	No. Tads	Breeding Confirmed	Comments
Compensatory Breeding Pond - Redbank Creek	5600	Redbank Creek	E:516564 N:6680284	23.12.2017	2327-2350	22	78	0	1	15	0	0	10.02.2018	49	0	0	0	No	40 mm of water in ponds and some metamorph Broad-palmed Frogs found.
1A	11800	Dirty Creek Range / Falconers	E:503224 N:6685035	23.12.2017	0028-0057	20.5	90	0	1	100	1	0	10.02.2018	49	0	0	0	No	Whole area was generally dry and probably requires a very wet summer for breeding to be successful.
1A - Compensatory Breeding Pond - Dirty Creek Range	11800	Dirty Creek Range / Falconers	E:513172 N:6685262	23.12.2017	0028-0057	20.5	90	0	1	100	0	0	10.02.2018	49	0	0	0	No	Ponds were dry and most filled with sediment. Metamorph Broad-palmed Frog found in adjacent vegetation.
1A - Frog Fencing	11750-11880	Dirty Creek Range / Falconers	E:513190 N:6685262	23.12.2017	0028-0057	20.5	90	0	1	100	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fencing installed although a number of potential breaches (defects identified)
1B - Old (As per TFMP RMS 2015)	23000	Wells Crossing Beside Road	E:506185 N:6692721	23.12.2017	2055-2130	20	90	0	1	90	0	0	10.02.2018	49	0	0	0	No	Surveyed this area as a suitable alternative has not be identified to date.
2A	19100	Halfway Creek	E:507641 N:6689299	23.12.2017	0105-0129	20	90	0	1	90	0	1	10.02.2018	49	0	0	0	No	Area generally dry and without surface water. Adjacent table drains probably increased drainage in this area.
2A Compensatory Breeding Pond	19000	Halfway Creek	E:507644 N:6689255	23.12.2017	0105-0129	20	90	0	1	90	0	0	10.02.2018	49	0	0	0	No	Ponds were all dry and have been for some time (i.e. > 5 days).
2A - Frog Fencing	18900-19300	Halfway Creek	E:507644 N:6689255	23.12.2017	0105-0129	20	90	0	1	90	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fencing remains partially effective with frogs calling from both sides of the fence. Observations of frogs around the fence suggest it is functional.
2B	23000	Yuraygir SRA	E:508694 N:6693816	22.12.2017	2345-0015	21.3	92	0	2	100	0	0	10.02.2018	50	0	0	0	No	Frogs probably use this pond only in response to thunderstorms during dry summers.
3A	25800	Bald Knob Tick Gate Road	E:505801 N:6694708	22.12.2017	2309-2337	21.3	92	0	2	100	8	11	10.02.2018	50	0	0	0	No	New site 3B with main pond only one with water. Common Eastern Froglet, Ornate Burrowing Frog and Perons Tree Frog tadpoles captured
3B	30000	Glenugie West	E:501553 N:6699052	23.12.2017	2311-2340	22.3	95	0	2	100	0	2	10.02.2018	49	0	0	0	No	Pond areas were dry and unlikely to have been a successful breeding event this year.
4A	26200	Glenugie Heavy Vehicle Checking Station South	E:505127 N:6696150	22.12.2017	0136-0205	21	90	0	1	100	0	0	10.02.2018	50	0	0	0	No	Habitat is fragmented with old carriageway used as northbound. Essentially represents frog ponds in a traffic island or vegetated median at present. Pond areas were dry at time of survey.
4A - Frog Fencing	26100-26250	Glenugie Heavy Vehicle Checking Station South	E:505167 N:6696111	22.12.2017	0136-0205	21	90	0	1	100	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fencing installed, however, there are some potential breach points but overall functionality is present.
4B	35000	Glenugie East	E:506326 N:6703965	23.12.2017	2110-2144	23	76	0	1	25	0	4	10.02.2018	49	0	2	0	Yes	Juvenile frog indicate that pre Christmas rainfall event was suitable sampling period, however, marginal follow up rain has contributed to limited breeding success.
5A	28000	Franklins Road	E:505038 N:6697387	22.12.2017	2235-2303	21	92	0	1	100	15	17	10.02.2018	50	0	0	0	No	All ponds were dry, however, only in past few days indicating they are suitable with follow up rain. Numerous hoof marks indicate Horses rely on these pond area and reduce the hydro period such that they probably impact on the ability of tadpoles to reach metamorphosis in some seasons.
5A - Frog Fencing	27900-28050	Eastern side Franklins Road	E:505014 N:6697324	22.12.2017	2235-2303	21	92	0	1	100	0	0	10.02.2018	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fencing appear functional based on Stage 1 sampling with majority of frogs were found on the vegetated side of the fence.
6A	35200	Pheasant Creek	E:502672 N:6704172	no data - site restrictions still in place									no data - site restrictions still in place						No access permitted at this time
6B	38000	Airport Road	E:501766 N:6706969	23.12.2017	0214-0239	20.3	91	0	1	95	0	1	15.02.2018	54	0	3	0	Yes	Appears to be a reliable breeding site. Possibly receives increased runoff from adjacent bitumen road.
7A	38000	Old Six Mile Lane	E:503837 N:6706546	23.12.2017	0255-0318	21	83	0	1	90	2	11	15.02.2018	54	0	0	0	No	Depressions from stump holes etc. dried out too quickly between sampling periods.
7B	35000	Glenugie East	E:505733 N:6703338	23.12.2017	2159-2228	22	78	0	1	20	0	2	15.02.2018	54	0	0	0	No	Breeding likely to have been successful given the lack of follow up rain events
8A	64700	Tyndale Crown Reserve	E:513362 N:6727361	16.10.2017	2005-2037	21.2	82	0	1	90	0	0	07.12.2017	52	0	0	0	No	Pond areas were dry apart from small stock dam.

8A - Frog Fencing	64600-64800	Tyndale Crown Reserve	E:513362 N:6727361	16.10.2017	2005-2037	21.2	82	0	1	90	0	0	07.12.2017	52	0	0	0	No	Frog fence generally in good order, however, the access road provides obviously breach point and was historically a focal point for frogs to congregate in the drains
8B	57500	Pine Brush State Forest	E:517300 N:6719708	16.10.2017	2102-2137	19.8	80	0	1	80	0	2	07.12.2017	52	0	0	0	No	Ponds contained little water during the Stage 1 survey and were subsequently dry at the time post breeding survey was performed.
9A	102500	JackyBulbin	E:520731 N:6758742	16.10.2017	2140-2210	22	85	0	1	80	2	3	07.12.2017	52	0	0	0	No	Ponds were dry at the time of stage 2 sampling. The frog fence at this location is still a temporary fence with a number of breach points and occasionally fallen branches.
9B	111500	Tabbimobile East	E:525262 N:6767265	16.10.2017	2233-2306	22	85	0	1	90	0	2	07.12.2017	52	0	0	0	No	Ponds didn't fill much from rainfall event triggering the calling survey and were dry at time of post breeding survey.
10A	118500	Tabbimobile North	E:527238 N:6772864	16.10.2017	2348-0014	22.3	88	0	1	80	0	0	07.12.2017	52	0	0	0	No	Ponds didn't fill much from rainfall event triggering the calling survey and were dry at time of post breeding survey.
10B	114000	Glencoe Road	E:524143 N:6769665	16.10.2017	2317-2339	22.3	88	0	1	80	1	1	07.12.2017	52	0	0	0	No	Ponds were dry at time of post breeding survey

Table A4. Rainfall data (New Italy Station 58097) with survey dates (shaded red) for Green-thighed Frog surveys at Sites 8-10 during the 2017/18 monitoring season.

2017	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Graph							
1st	0	0	19.2	0	18	0	0
2nd	2.8	0	2.4	8.2	12	0	1.8
3rd	20.2	0	9	22	12	2.2	0.8
4th	8.4	0	0	0	12	0	0
5th	0	0	12	0	3.4	0.8	2.6
6th	1	69.2	7.8	0	0	37.6	0
7th	0.2	17	0	0	0	43.4	1.2
8th	0	4	0	0	0	1	0.6
9th	7.4	0	0	0	0	4.2	0.4
10th	0	10.2	2.4	0	0	4.4	0
11th	0	8.2	0	0	0.4	14.4	0.6
12th	2.6	10	0	0	1	1	0
13th	2.4	5	0	0	0.8	0	0
14th	0	0	0	0	0	7.6	0
15th	95	0	0	0	0	0	0
16th	8.4	0	0	0	0	0	0
17th	4	5.2	0	0	0	0	0
18th	15	5	0	0	0	0	28
19th	2	2.2	0	0	0	0	0.4
20th	0	0	0	0	8.8	0	0
21st	35	4	0	0	22.2	0.6	0
22nd	5	1.8	17.8	0	0	0	10.2
23rd	0	0	0	0	12	7	8.4
24th	0	0	0	0	30	3	5.6
25th	0	0	3.2	0	4	1.2	39
26th	0	4	43	0	0	0.8	0.6
27th	10.2	0	10.8	0	0	0.8	0
28th	0	0	2.2	0	0	3.6	0
29th	0	0.4	3.2	2.5		2	0
30th	3.4	5.2	0	2.6		3.8	0
31st	0		7			1.2	
Highest Daily	95	69.2	43	22	30	43.4	39
Monthly Total	223	151.4	140	35.3	136.6	140.6	100.2

Table A5. Rainfall data (Grafton Airport - Station 58161) with survey dates (shaded red) for Green-thighed Frog surveys at Sites 1-7 during the 2017/18 monitoring season.

2017	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Graph									
1st	0	0	0.2	21.8	0.2	9.6	0	4.8	0
2nd	0	0	0	22.8	0.6	6.4	0	0.2	0
3rd	0	12.6	0	1.6	30.6	4.6	0	0	0
4th	0	1	0	0.2	0.2	1.6	0	0	0
5th	0	0.2	0	1	0	2.4	0.2	5.8	0.2
6th	0	0	14.6	8.8	0	0.8	11.8	0.2	0
7th	0	6.6	15.6	0	0	0	35.2	0.4	0
8th	0	0	0.2	0	0	0.6	0.6	0.2	0
9th	0	12.2	0	0	0	0	4.8	0.4	3
10th	0	0.2	2	4.4	0.4	0.2	1.4	0	0.2
11th	0	0	1.4	0.6	0.2	0	2.2	0.2	0.2
12th	0	8.4	0.8	0	1	0	0	0	0
13th	0	1.6	1.8	0	0.2	7.6	0	0	0
14th	0.2	0.2	0.2	0	0	0.8	0	0	0
15th	0	44.2	0	0	0	0	0.2	8	0
16th	0	9.2	0	0	0	0	0.2	0	0
17th	0	1	0.2	0	0	9.6	0	0	0
18th	0	0	2.6	0	0	0	0		0.2
19th	0	0.2	0.4	0	0	0	0.2	0.6	0
20th	0	0.2	2.6	0	0	1.2	0	0.2	0
21st	0	13.6	4.2	0.6	0	16.8	0.6	6.6	0.2
22nd	0	4.8	0	74.2	0	0	27.4	0.2	0
23rd	0	0	0	0		1	24.6	0	0
24th	0	8.2	1.2	0	0	14.2	26.4	10.4	0
25th	0	0.2	0	5.4	0	2.4	0.4	7	
26th	0	0	0	24	0	0.2	0.2	2	
27th	0	0	0	31.2	1.2	9	0	0.2	
28th	0	0	0	1	0.8	0.4	0	0	
29th	0	0	0	0.2	3.8		0	0.2	
30th	0	0.2	1.8	0	0.8		0.8	0.2	
31st		0		5	0		0.2		
Highest Daily	0.2	44.2	15.6	74.2	30.6	16.8	35.2	10.4	3
Monthly Total	0.2	124.8	49.8	202.8	40	89.4	137.4		