

Woolgoolga to Ballina Pacific Highway Upgrade

Threatened Frog Monitoring Annual Report 2021/22

Version 3.0



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...21st March 2024.....

Date



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TABLE OF CONTENTS

1.0	INTRODUCTION	1
1.1	PROJECT OVERVIEW AND BACKGROUND TO THIS MONITORING.....	1
2.0	STATUS OF THE MONITORING PROGRAMS.....	2
3.0	WALLUM SEDGE FROG (<i>LITORIA OLONGBURENSIS</i>).....	3
3.1	SPECIES PROFILE	3
3.1.1	Description.....	3
3.1.2	Distribution.....	3
3.1.3	Habitat and Ecology.....	4
3.1.4	Conservation Status	4
3.2	SURVEY METHODS	4
3.2.1	Site Selection and Treatment Design	5
3.2.2	Timing of Surveys.....	5
3.2.3	Frog Surveys	5
3.2.4	Abiotic Data	8
3.2.5	Connectivity Structures & Permanent Frog Fence Monitoring.....	8
3.2.6	Compensatory Breeding Ponds.....	8
3.2.7	Cursory surveys of adjacent areas to Site 2A, 3A and 3B.	8
3.3	YEAR 5 (OPERATION YEAR 1) MONITORING RESULTS	9
3.3.1	Sedge Frog Abundance.....	9
3.3.2	Culvert and Frog Fencing	13
3.3.3	Sedge frogs Adjacent to Site 2A, 3A and 3B	14
3.4	DISCUSSION	15
3.5	PERFORMANCE INDICATORS AND CORRECTIVE ACTIONS.....	16
3.6	CONCLUSIONS AND RECOMMENDATIONS	25
4.0	GREEN-THIGHED FROG (<i>LITORIA BREVIPALMATA</i>)	26
4.1	SPECIES PROFILE	26
4.1.1	Description.....	26
4.1.2	Distribution.....	26
4.1.3	Habitat and Ecology.....	26
4.2	SURVEY METHODS	27
4.2.1	Site Selection.....	27
4.2.2	Timing of Surveys.....	27
4.2.3	Abiotic Data	30
4.2.4	Connectivity Structure Monitoring.....	30
4.3	MONITORING RESULTS	31
4.3.1	Stage 1 Surveys - Calling Intensity and Spotlighting	31
4.3.2	Stage 2 Surveys – Post Breeding Counts of Tadpoles and Froglets.....	35
4.3.3	Seasonal Rainfall and Associated Survey Conditions	35
4.3.4	Constructed Breeding Ponds.....	35
i.	Section 3 - Glenugie Site 7A (ch. 37400).....	35
ii.	Section 3 - Tyndale Site 8A (ch. 64700).....	36
ii.	Section 6 – Jackybulbin Site 9A (ch. 102250).....	36
ii.	Section 7 – Tabbimoble Site 10A (ch. 118500).....	38
4.3.5	Connectivity Structure Monitoring.....	38
4.3.6	Frog Fencing.....	38
4.4	DISCUSSION	42
4.5	PERFORMANCE MEASURES AND CORRECTIVE ACTIONS	43
4.5.1	Population Monitoring	43
4.5.2	Connectivity Structures and Permanent Frog fencing	43

4.5.3 Compensatory Breeding Ponds.....	43
4.5.4 Riparian Habitat Revegetation.....	44
4.6 CONCLUSIONS AND RECOMMENDATIONS	51
6.0 REFERENCES	53
7.0 APPENDIX A – RAW FROG SURVEY AND RAINFALL DATA.....	55

LIST OF TABLES

Table 3-1. Summary of the sites and mean Wallum Sedge Frog counts between baseline survey and Years 1-5.	11
Table 3-2. Performance indicators and corrective actions from the Threatened Frog Species Management Plan (RMS 2015) for Wallum Sedge Frog.	19
Table 3-3. Recommendations following Year 5 Wallum Sedge Frog population monitoring and Transport for NSW response.	25
Table 4-1. Summary of the connectivity structure monitored during the 2021/2022 Green-thighed Frog surveys	30
Table 4-1. Summary of the 2021/2022 Green-thighed Frog surveys for BACI Sites 6-10.	33
Table 4-2. Summary of compensatory frog pond monitoring during Year 6 in Sections 3, 6 and 7.	37
Table 4-3. Summary of connectivity structure monitoring performed during Year 6 at Sites 6-10.	38
Table 4-4. Summary of permanent frog exclusion fence monitoring during Year 6 at Sites 6-10.	39
Table 4-5. Performance indicators and corrective actions from the Threatened Frog Species Management Plan (RMS 2015).	45
Table 4-6. Recommendations following 2021/2022 Green-thighed Frog monitoring and Transport for NSW responses.	52
Table A1. Summary of Wallum Sedge Frog surveys during the 2021 monitoring season.	55
Table A2. Summary of Green-thighed Frog surveys during the 2021/2022 monitoring season.	56
Table A3. Rainfall data (Grafton Airport - Station 58161) with survey dates (shaded red) for Green-thighed Frog surveys at Sites 6-10 during the 2021/22 monitoring season.	57

LIST OF FIGURES

Figure 3-1. Locations of Wallum Sedge Frog BACI Monitoring Sites in Sections 8 and 9 of Woolgoolga to Ballina Upgrade.	6
Figure 3-2. Locations of Wallum Sedge Frog BACI Monitoring Sites in Section 10 of the Woolgoolga to Ballina Upgrade.	7
Figure 3-3. Total wallum sedge frog counts between baseline survey, Year 1-5 monitoring.	9
Figure 3-4. Wallum sedge frog counts across three age classes between baseline survey and subsequent monitoring in Year 1-510	
Figure 4-1. Locations of Green-thighed Frog BACI Sites 6 and 7 between ch.34000–40000.	28
Figure 4-2. Locations of Green-thighed Frog Control and Impact sites between ch. 57500–118500.	29
Figure 4-4. The number of Green-thighed Frogs spotlighted between the baseline survey, construction and operational monitoring in Years 1-6 at Sites 6-10.	32

LIST OF PLATES

Plate 3-1. Adult Wallum Sedge Frog at Site 2B in Broadwater National Park.....	3
Plate 3-2. Wallum Sedge Frog habitat along the W2B corridor (adjacent ch. 148550).....	4
Plate 4-1. Constructed ponds at Site 7A (ch.37330) in late February 2022.....	35
Plate 4-2. Example of maintenance being performed along frog exclusion fencing at Site 9A Jackybulbin ch.101250.....	40
Plate 4-3. Example of return flap wash out or holes beneath the mesh within 50 m of installed ponds at ch.118500 Site 10 A (Tabbimoble).....	41

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.

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 completed in late 2020, 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:

- Wallum Sedge Frog monitoring program in Year 5 of the construction phase in Sections 8, 9 and 10. This is the first year of operational monitoring; and
- Green-thighed Frog monitoring program schedule for Year 6 in Sections 3, 6 and 7. This is the second year of operational monitoring in Sections 3, 6 and 7.

3.0 WALLUM SEDGE FROG (*LITORIA OLONGBURENSIS*)

3.1 Species Profile

3.1.1 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).



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).

Plate 3-1. Adult Wallum Sedge Frog at Site 2B in Broadwater National Park.

3.1.2 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).

3.1.3 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 3-2. Wallum Sedge Frog habitat along the W2B corridor (adjacent ch. 148550).

3.1.4 Conservation Status

The Wallum Sedge Frog is currently listed as Vulnerable pursuant to the NSW *Biodiversity Conservation Act* (2016) and Commonwealth *Environment 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).

3.2 Survey Methods

Field surveys were performed in accordance with the 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.

3.2.1 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.

3.2.2 Timing of Surveys

Field surveys were comprised of two sampling periods with each event taking place generally 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 on the 17-18th February 2021 and a follow up post breeding survey to determine the level of breeding success was performed in late May 2021 (Appendix A). Both surveys coincided with adequate rainfall a week or two beforehand.

3.2.3 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) whilst the previous Woodburn station (58061) has ceased recording (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 0230 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.

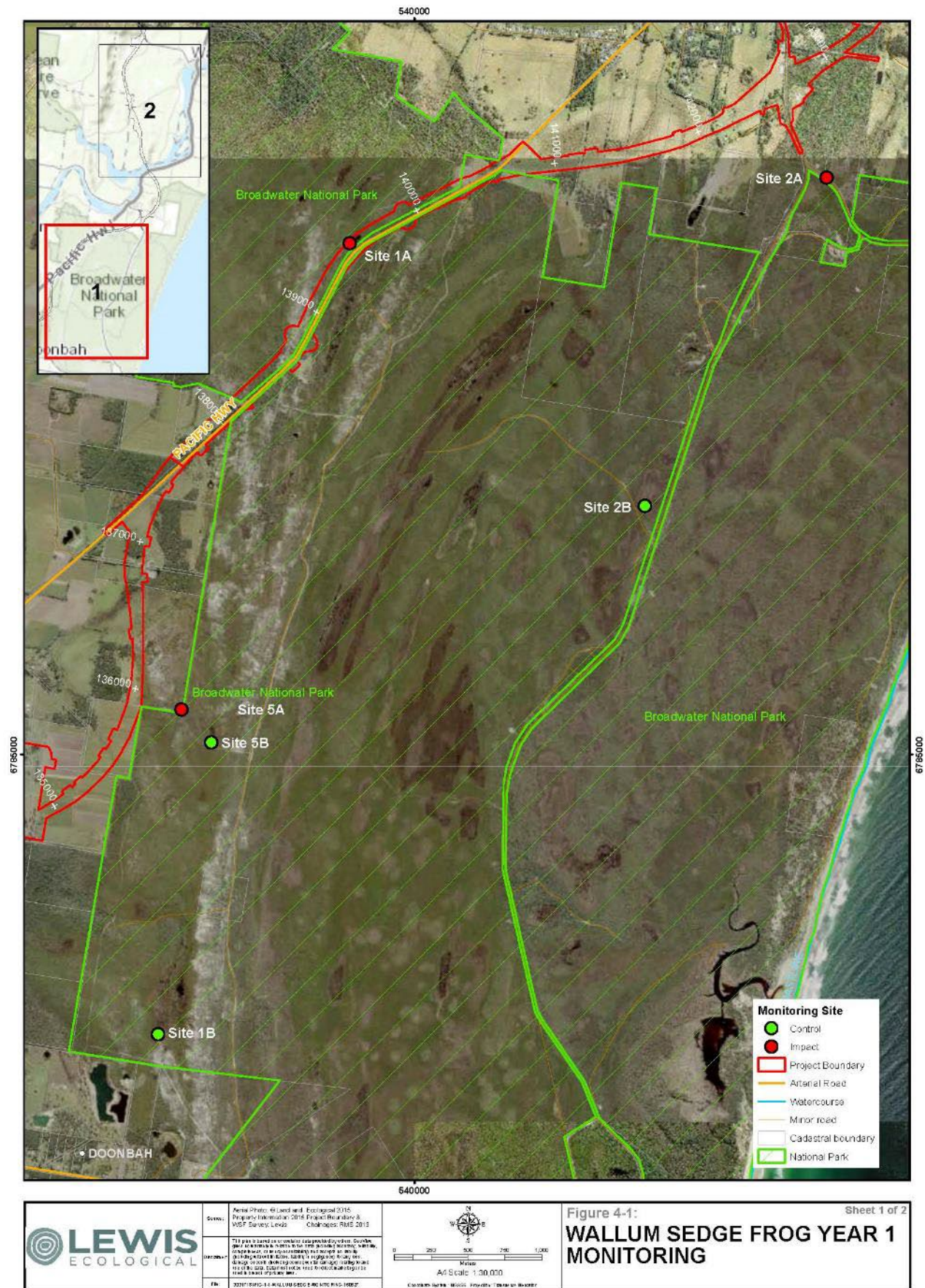


Figure 3-1. Locations of Wallum Sedge Frog BACI Monitoring Sites in Sections 8 and 9 of Woolgoolga to Ballina Upgrade.

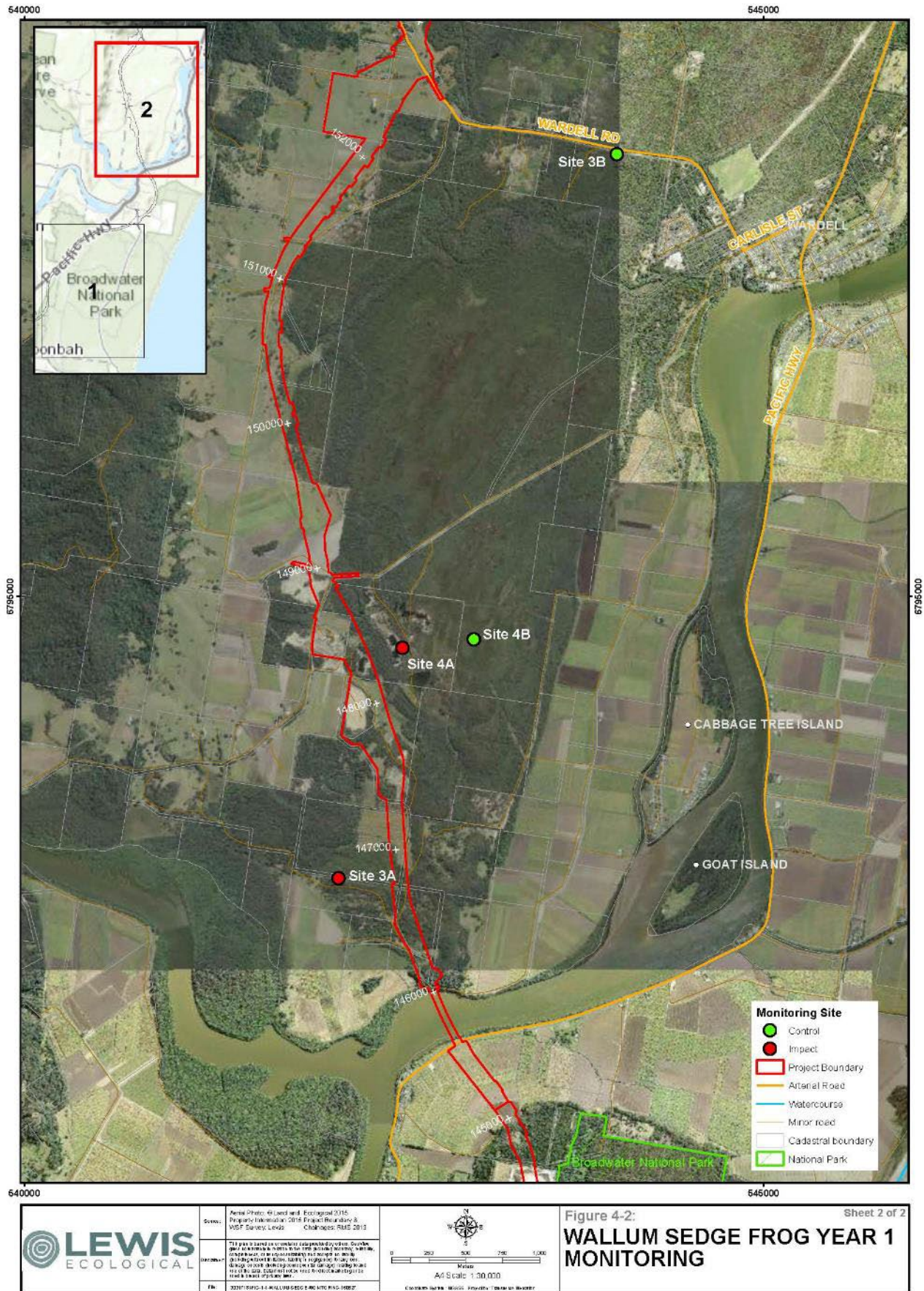


Figure 3-2. Locations of Wallum Sedge Frog BACI Monitoring Sites in Section 10 of the Woolgoolga to Ballina Upgrade.

3.2.4 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).

3.2.5 Connectivity Structures & Permanent Frog Fence Monitoring

Four connectivity and permanent frog fence areas have been nominated for monitoring. At the time of this monitoring, these structures were complete with regards to landscaping treatment, fencing and soft passage. They can be summarised as follows:

- ch. 139000 - Bridge Exc Fence Extent 138800-139200 (400m);
- ch. 139430 - RCP 1 Cell 68.32m x 1.5m Exc Fence Extent 139400 139600 (200m);
- ch. 140000 - Exc Fence Only - 139900 to 140100 (200 m) and
- ch. 148500 - Exc Fence Only - 148300 to 148750 (450 m)

3.2.6 Compensatory Breeding Ponds

No compensatory ponds have been installed for this species following a review of locations.

3.2.7 Cursory surveys of adjacent areas to Site 2A, 3A and 3B.

Some brief surveys were performed in some likely habitats adjacent to Site 2A (Broadwater Beach Road), Site 3A (Bagotville) and Site 3B (Wardell Road).

3.3 Year 5 (Operation Year 1) Monitoring Results

3.3.1 Sedge Frog Abundance

Wallum Sedge Frogs were recorded at 7 (70%) of the 10 monitoring sites during Year 5 (Table 3-1; Figure 3-3). No sedge frogs were recorded at Site 1A (Broadwater West) and this is the first time since monitoring commenced in 2014. No sedge frogs were again recorded at Site 2A (Broadwater Beach Road) and Site 3B (Wardell Road). The highest counts of sedge frogs continue to be recorded at the control sites located in Broadwater National Park with 36 and 22 frogs per 100m² of habitat at Site 2B and 5B respectively (Figure 3-3). Overall, sedge frog numbers have changed a little since the last round of monitoring with numbers declining to zero at Broadwater West (Site 1A) and increasing at six of the 10 sites including a return of frogs to Site 3A at Bagotville where they have remained absent for the past 4 consecutive years (Figure 3-3).

Adult frogs were recorded at seven sites, however, they were not recorded at Site 1A (Broadwater West) for the first time since monitoring commenced (Table 3-1). Meanwhile, an adult sedge frog was recorded from Site 3A (Bagotville), a site where monitoring had recorded an ongoing absence of sedge frogs for much of the monitoring program. Apart from the ever reliable Site 2B (Broadwater East) and Site 5B (Broadwater National Park) where 20 or more adults were recorded, the remaining sites recorded 1-2 adults along the monitoring transect (Figure 3-4; Table 3-1).

Sub adult frogs were recorded at six sites which is twice as many as the previous round of monitoring and the same as the baseline survey, albeit at differing densities (Table 3-1). Only two of these sites were impact sites, Site 4A (Ballina Shire Council Quarry) and Site 5A (McDonalds). Juvenile frogs were recorded at only three of the reference sites, all located within Broadwater National Park but interestingly during the first survey in February indicating that at least some breeding had taken place earlier in the season.

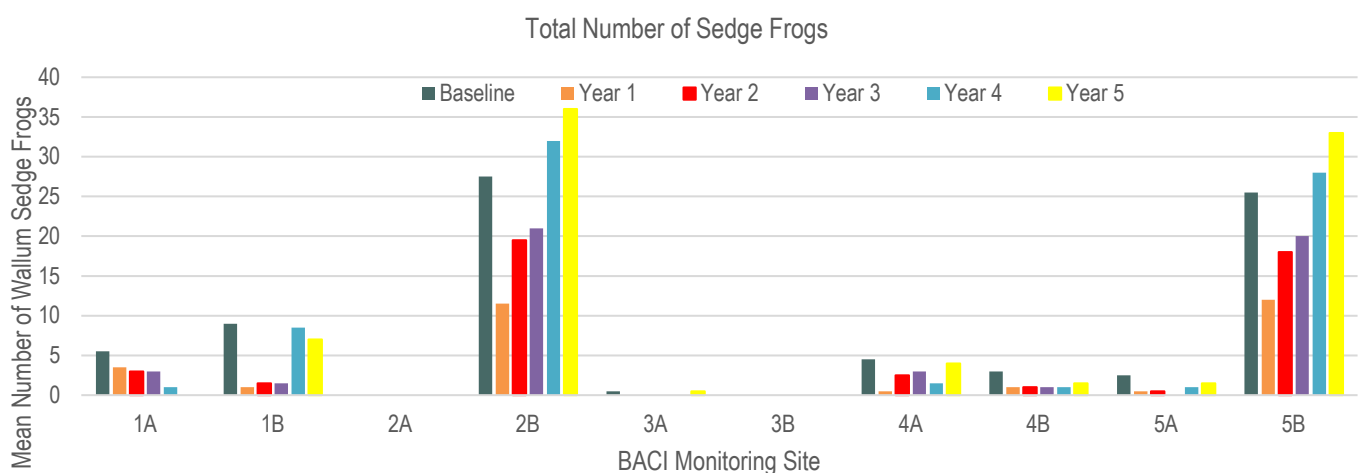


Figure 3-3. Total wallum sedge frog counts between the baseline survey and Years 1-5 with Year 5 being Operational Monitoring Year 1.

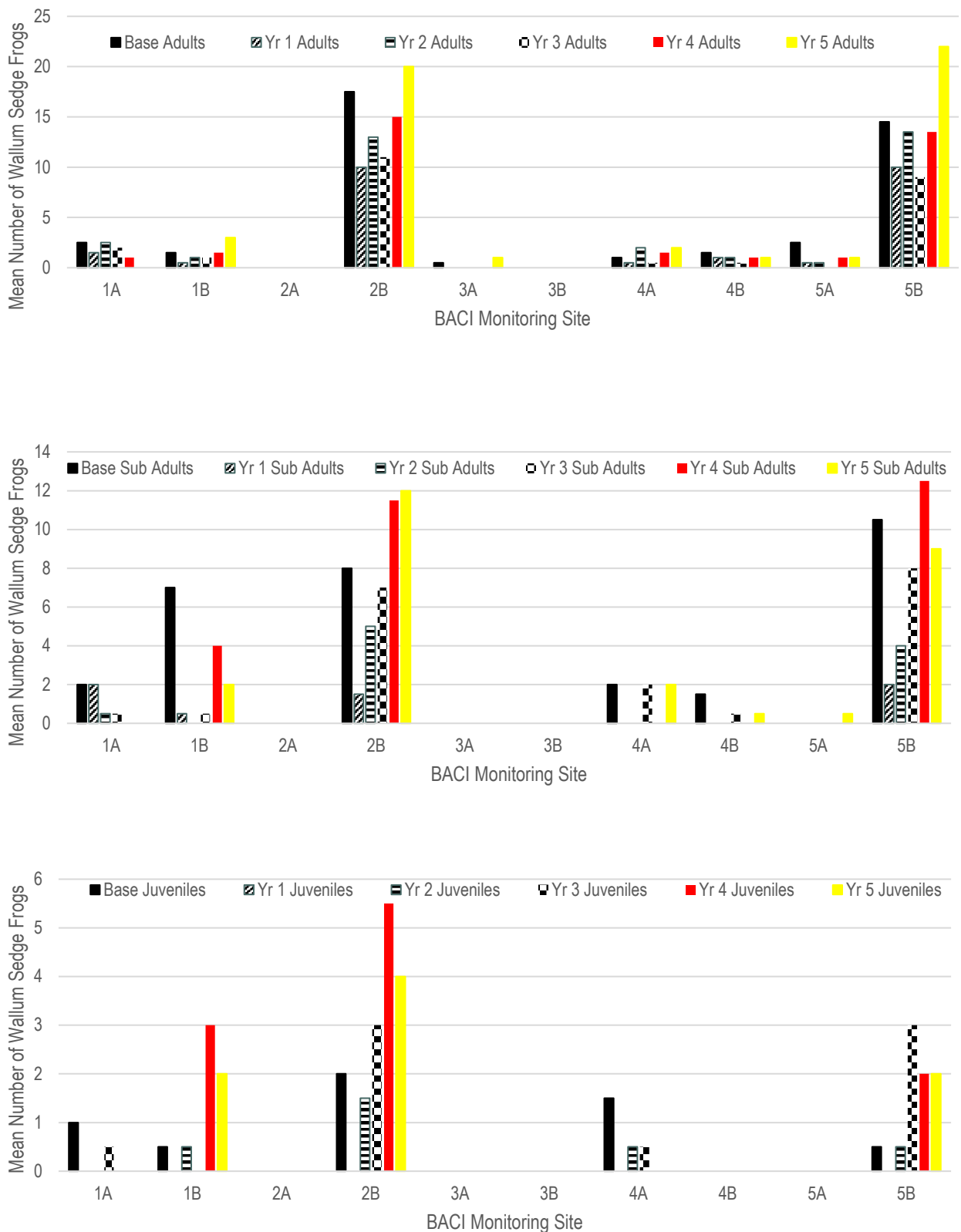


Figure 3-4. Wallum sedge frog counts across three age classes between baseline survey and subsequent monitoring in Year 1-5.

Table 3-1. Summary of the sites and mean Wallum Sedge Frog counts between baseline survey and Years 1-5.

BACI Site	Treatment Class	Site Name	Chainage Extent	Base Adults	Yr 1 Adults	Yr 2 Adults	Yr 3 Adults	Yr 4 Adults	Yr 5 Adults	Comments
1A	Impact	Broadwater West	139500	2.5	1.5	2.5	2	1	0	Numbers have now declined to zero. Also an increase in the number of competitor species including the native Eastern Dwarf Frog (<i>Litoria fallax</i>) and the introduced toad (<i>Rhinella marina</i>). <i>Azolla spp</i> present for the second year in a row.
1B	Control	Broadwater West	133000–132000	1.5	0.5	1	1	1.5	3	Numbers are the highest since the program starting, site has recovered progressively since the site was first monitored 25 years ago.
2A	Impact	Broadwater Beach Road	143000–142000	0	0	0	0	0	0	Frogs have remained absent from this site since monitoring program commenced. Suggest site provide temporal habitat but other wallum endemics like Wallum Froglet remain present at this site.
2B	Control	Broadwater East	137000-138000	17.5	10	13	11	15	20	Frog numbers relatively consistent. Site has been monitored by author for almost 25 years.
3A	Impact	Bagotville	146000-147000	0.5	0	0	0	0	1	Frogs have reappeared for the first time since the baseline survey. The ongoing wet seasons may have assisted recolonization of this site.
3B	Control	Wardell Road	151000-152000	0	0	0	0	0	0	Frogs have remained absent from this site since monitoring program commenced.
4A	Impact	Ballina Shire Council Quarry	148000-149000	1	0.5	2	0.5	1.5	2	Frog numbers slightly higher than baseline survey
4B	Control	Jali Land	148000-149000	1.5	1	1	0.5	1	1	Frog numbers relatively consistent since monitoring commenced.
5A	Impact	McDonalds	135900	2.5	0.5	0.5	0	1	1	Frog numbers have declined since baseline survey.
5B	Control	Broadwater National Park	135800	14.5	10	13.5	9	13.5	22	Frog numbers much higher than the baseline survey.

BACI Site	Treatment Class	Site Name	Chainage Extent	Base Sub Adults	Yr 1 Sub Adults	Yr 2 Sub Adults	Yr 3 Sub Adults	Yr 4 Sub Adults	Yr 5 Sub Adults	Comments
1A	Impact	Broadwater West	139500	2	2	0.5	0.5	0	0	Decline from earlier monitoring events.
1B	Control	Broadwater West	133000–132000	7	0.5	0	0.5	4	2	Decline from the baseline survey, however, age class still present and well represented by adult frogs.
2A	Impact	Broadwater Beach Road	143000–142000	0	0	0	0	0	0	No record of breeding at this location since monitoring began.
2B	Control	Broadwater East	137000-138000	8	1.5	5	7	11.5	12	Highest number of sub adults since monitoring began.

3A	Impact	Bagotville	146000-147000	0	0	0	0	0	0	No record of breeding.
3B	Control	Wardell Road	151000-152000	0	0	0	0	0	0	No record of breeding.
4A	Impact	Ballina Shire Council Quarry	148000-149000	2	0	0	2	0	2	Breeding confirmed.
4B	Control	Jali Land	148000-149000	1.5	0	0	0.5	0	0.5	Breeding confirmed.
5A	Impact	McDonalds	135900	0	0	0	0	0	0.5	First time breeding confirmed in this area, probably a reflection of ongoing wet conditions and major flooding in the area. In normal seasons, site would be too dry.
5B	Control	Broadwater National Park	135800	10.5	2	4	8	12.5	9	Evidence of long term ongoing breeding at this site, probably a source population for the surrounding landscape.

BACI Site	Treatment Class	Site Name	Chainage Extent	Base Juveniles	Yr 1 Juveniles	Yr 2 Juveniles	Yr 3 Juveniles	Yr 4 Juveniles	Yr 5 Juveniles	Comments
1A	Impact	Broadwater West	139500	1	0	0	0.5	0	0	No evidence of breeding during this round of monitoring.
1B	Control	Broadwater West	133000-132000	0.5	0	0.5	0	3	2	Last two rounds represent the highest number of juveniles since monitoring began. Probably reflection of ongoing wet seasons.
2A	Impact	Broadwater Beach Road	143000-142000	0	0	0	0	0	0	No juveniles recorded at this site since monitoring began.
2B	Control	Broadwater East	137000-138000	2	0	1.5	3	5.5	4	Last two rounds represent the highest number of juveniles since monitoring began. Probably reflection of ongoing wet seasons.
3A	Impact	Bagotville	146000-147000	0	0	0	0	0	0	No juveniles recorded at this site since monitoring began.
3B	Control	Wardell Road	151000-152000	0	0	0	0	0	0	No juveniles recorded at this site since monitoring began.
4A	Impact	Ballina Shire Council Quarry	148000-149000	1.5	0	0.5	0.5	0	0	Decline in number of juveniles recorded. Possibly just a reflection of survey timing as sub adults and breeding confirmed during this round of monitoring.
4B	Control	Jali Land	148000-149000	0	0	0	0	0	0	No juveniles recorded at this site since monitoring began.
5A	Impact	McDonalds	135900	0	0	0	0	0	0	No juveniles recorded at this site since monitoring began.
5B	Control	Broadwater National Park	135800	0.5	0	0.5	3	2	2	Still evidence of late summer breeding recorded at this site.

Yr – Year

3.3.2 Culvert and Frog Fencing

Permanent frog fencing was installed between the following three chainage extents:

- ch. 139000 - Bridge With Exclusion Fence Extent 138800-139200 (400m);
- ch. 139430 – Round Concrete Pipe 1 Cell 68.32m x 1.5m Exc Fence Extent 139400 139600 (200m);
- ch. 140000 - Exc Fence Only - 139900 to 140100 (200 m) and
- ch. 148500 - Exc Fence Only - 148300 to 148750 (450 m).

i. ch. 139000 - Bridge With Exclusion Fence Extent 138800-139200 (400m)

No sedge frogs were recorded on either side of the bridge nor on the road side of the frog exclusion fence.

ii. ch. 139430 – Round Concrete Pipe 1 Cell 68.32m x 1.5m Exc Fence Extent 139400 139600 (200m)

No sedge frogs were recorded in the vicinity (20 m) of the round concrete pipe. No sedge frogs were recorded on either the road side or the habitat side of the frog exclusion fence between ch. 139400-139600.

iii. ch. 140000 – Frog Exclusion Fence - 139900 to 140100 (200 m)

No sedge frogs were recorded on either the road side or the habitat side of the frog exclusion fence between ch. 139900-140100.

iv. ch. 148500 – Frog Exclusion Fence Only - 148300 to 148750 (450 m)

No sedge frogs were recorded on either the road side or the habitat side of the frog exclusion fence between ch. 148300-148750.



Plate 3-1. Evidence of herbicide treatment to contain or reduce the permeability of frog exclusion fence around ch. 140000 (left) and vegetation creating opportunities for frogs to move onto the roadway around ch.139000 (right).

3.3.3 Sedge frogs Adjacent to Site 2A, 3A and 3B

Sedge frogs were heard calling from around 300 m south west of Site 2A and to the west of Broadwater-Evans Head Road. At this location, a more prominent freshwater sedge swamp and wet heath association occurs. This is likely to be a source population from which individuals move into less suitable habitat during wet periods.

Sedge frogs were recorded at the monitoring transect at Site 3A and surveys of the surrounding habitat was subsequently abandoned.

At Site 3B, sedge frogs were heard calling 300 m north east of the monitoring site on the northern side of Wardell Road. This location appears less edge affected and whilst the surveys were brief in nature, there were far fewer Tyler's Tree Frog and Eastern Dwarf Frog calling.

3.4 Discussion

Monitoring during Year 5 found some variation in sedge frog density compared to the baseline surveys conducted in 2014. Some of the variation can be attributed to seasonal cues as broader climatic conditions have shifted from an El Niño weather pattern during years 2017-2020 to a La Niña pattern in 2020 onwards bringing with it, cooling conditions and a wet weather pattern. This best explains the higher overall numbers of sedge frogs from those source populations where monitoring transects are stationed in Broadwater National Park (i.e. Site 2B and 5B). Sedge frog numbers were 30% higher at these monitoring sites than the baseline survey and were represented by adults, sub adults and juvenile frogs. There was also evidence of some early season breeding at these locations with juvenile frogs detected during the first round of monitoring in late summer. Interestingly, with this weather pattern sedge frogs were again recorded at Site 3A (Bagotville) where they had not been recorded since the baseline survey were performed. For this to occur, there must be an unknown source population to the west of ch. 146000-147000.

The wet weather probably best explains the increased reporting rate of juvenile and sub adults sedge frogs when compared to more recent monitoring events. The number of sites and numbers of sedge frogs recorded were similar to the baseline survey indicating that where declines were previously apparent there may be some population recovery in process following those drier years associated with construction monitoring Year 1-4.

Despite the La Niña weather pattern, sedge frogs were not recorded for the first time at Site 1A (Broadwater West) where there has been a recorded gradual decline since the monitoring began in 2016. The paired reference site recorded sedge frog numbers similar to the baseline survey indicating other factors are likely to have contributed to their apparent disappearance. Site 1A was subject to some clearing that opened the area into an open corridor, wetland reclamation, construction water management and located beside an area where construction imported quantities of fill material. Some minor changes in water quality accompanied with increased exposure to common competitor or generalist species such as the Eastern Dwarf Frog (*Litoria fallax*), Tyler's tree Frog (*Litoria tyleri*) and the introduced Cane Toad (*Rhinella marina*) may be associated with this decline.

There was a continuing trend of absenteeism for Site 2A (Broadwater Beach Road) and the adoption of recommendation enabled some cursory surveys to be deployed, locating what is likely to be the local source population around 300 m to the south west on the western side of the Broadwater-Evans Head Road. A similar situation was discovered for Site 3B (Wardell Road) with sedge frogs heard calling around 300 m to the north east of the monitoring site in dense wet heath and Baumea sedge swamp. Sedge frogs are therefore present through the broader landscape but probably undergo changes in occupancy patterns depending on the availability and suitability of habitat which are influenced by seasonal conditions and competitor species, both native and introduced.

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

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 5 monitoring (operational Year 1) includes the population monitoring component, the connectivity structures, and the exclusion fencing as part of the Wallum Sedge Frog management (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 have been summarised below and in Table 3-2.

- Site 1 – **Broadwater West**

- Year 1 with 36% decline at impact treatment compared to an 89% decline at the control site.
- Year 2 with 45% decline at the impact treatment compared to the 83% decline at the control site.
- Year 3 with 45% decline at the impact treatment compared to the 83% decline at the control site.
- Year 4 with 82% decline at the impact treatment compared to the 6% decline at the control site.
- Year 5 with 100% decline at the impact treatment compared to the 22% decline at the control site

Both sites have declined with the impact treatment continuing to decline to the point of being absent whilst the control treatment has decline by 22%.

- Site 2 – **Broadwater North** where no sedge frogs have been recorded along the transect since monitoring began. Meanwhile, the control site continues to record relatively high densities of sedge frogs.

- Site 3 – **Bagotville and Wardell Road** where sedge frogs have been recorded again at the impact site whilst sedge frogs at the control site adjacent to Wardell Road remain absent. Interestingly, there is a similar frog assemblage at this control site to that recorded at Site 1A (Broadwater West). The Wardell Road sites used to support a sedge frog population back in 2013/2014.

- Site 4 – **Ballina Shire Council and Jali Land**

- Year 1 with an 89% decline at the impact treatment compared to a 67% decline at the control site.
- Year 2 with a 44% decline at the impact treatment compared to a 67% decline at the control site.
- Year 3 with a 33% decline at the impact treatment compared to a 67% decline at the control site
- Year 4 with a 67% decline at both the impact and control treatment sites.
- Year 5 with an 11% decline at the impact site compared to a 50% decline at the control site.

Both sites have declined, however, the decline is far less at the impact site and a little less at the control site indicating some level of population recovery.

- **Site 5 – *McDonalds and Broadwater National Park***

- Year 1 with an 80% decline at the impact treatment compared to a 53% decline at the control site.
- Year 2 with an 80% decline at the impact treatment compared to a 29% decline at the control site.
- Year 3 with a 100% decline at the impact treatment compared to a 22% decline at the control site.
- Year 4 with a 60% decline at the impact treatment compared to a 10% increase at the control site.
- Year 5 with a 40% decline at the impact treatment compared with a 29% increase at the control site.

As with other years, the decline has exceeded the 25% threshold relative to the two treatment types and corrective action in accordance with Table 3-2 is required.

Declines reported at Site 4 (Ballina Shire Council and Jali Land) and Site 5 (McDonalds and Broadwater National Park) probably represent normal population fluctuation from year to year. The increased decline at Site 4B is probably linked to the way surface water levels tend to fluctuate at this site, combined with some fires that have periodically burnt through this area and some mechanical intervention in the form of slashing sedges associated with a management trail (Plate 3-2). Meanwhile, fluctuating surface water levels probably explain the reported decline at Site 5A (McDonalds). When this area floods, sedge frogs are likely to disperse over a broader area as described by Lewis and Goldingay (2005) and similarly, during dry periods there is often no surface water at the monitoring site when adult sedge frogs move back to the east in to Broadwater National Park.



Plate 3-2. Part of the monitoring transect at Site 4B which is subject to periodic maintenance slashing (non project related).

The continuing downward trend of sedge frog numbers at Site 1 has culminated in no frogs being recorded during the current round of monitoring. This potential factors have been outlined elsewhere in this report and the disappearance was forecast during previous rounds of monitoring (Lewis 2022).

At Site 2 (Broadwater Beach Road), sedge frogs remain absent despite their past presence at this site whilst other wallum endemics remain, namely Wallum Froglet and Wallum Rocket Frog (*Litoria freycineti*). This pattern of occupancy is not thought to be project related but linked to source and recruitment sites for sedge frogs where small numbers have colonised this area in the past but ultimately not able to persist.

In accordance with Section 7.2.3 of the Threatened Frog Species Management Plan (RMS 2015) corrective action is required at Site 1. The corrective actions tabled in the Threatened Frog Species Management Plan (RMS 2015) include:

- *Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance.*

The monitoring method is considered an applicable survey technique and has been reliably used by the author for more than 25 years. It has been used to describe the patterns and densities of this species in scientific investigations (e.g. Lewis and Goldingay 2005) and has been endorsed by the Land and Environment Court.

- *Investigate effectiveness of frog exclusion fencing immediately.*

Frog exclusion fence monitoring was performed during this round of monitoring and found no sedge frogs on the road side of the fence.

- *Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation.*

Has been proposed as a recommendation in this report.

- *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.*

Review at the completion of operational Year 3 forecast to occur in 2024.

Table 3-2. 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 5 (Operational Year 1) Wallum Sedge Frog Monitoring	Results of Year 5 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 3.3). 	<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>Compared to the baseline survey, Wallum Sedge Frogs</p> <ul style="list-style-type: none"> • Site 1 – Broadwater West <ul style="list-style-type: none"> ○ Year 1 with 36% decline at impact treatment compared to an 89% decline at the control site. ○ Year 2 with 45% decline at the impact treatment compared to the 83% decline at the control site. ○ Year 3 with 45% decline at the impact treatment compared to the 83% decline at the control site. ○ Year 4 with 82% decline at the impact treatment compared to the 6% decline at the control site. ○ Year 5 with 100% decline at the impact treatment compared to the 22% decline at the control site <p>Both sites have declined with the impact treatment now at zero (i.e. absent) whilst the control treatment has virtually recovered to pre-construction baseline densities.</p> <ul style="list-style-type: none"> • Site 2 – Broadwater North where no sedge frogs have been recorded along the transect since monitoring began. Meanwhile, the control site continues to record relatively high densities of sedge frogs. 	<p>Eutrophication and competitor frog numbers increased at Site 1A.</p> <p>Fluctuating water levels at Site 5.</p>	<p>Site 1 – Adopt corrective action three:</p> <ul style="list-style-type: none"> • <i>Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation.</i> <p>Site 5 - declines recorded but these are linked to natural variation of water levels.</p>

Triggers for corrective actions	Corrective actions	Relevance to Year 5 (Operational Year 1) Wallum Sedge Frog Monitoring	Results of Year 5 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
			<ul style="list-style-type: none"> Site 3 – Bagotville and Wardell Road where sedge frogs have been detected at the impact site whilst sedge frogs have not been recorded at the control site adjacent to Wardell Road. Site 4 – Ballina Shire Council and Jali Land <ul style="list-style-type: none"> Year 1 with an 89% decline at the impact treatment compared to a 67% decline at the control site. Year 2 with a 44% decline at the impact treatment compared to a 67% decline at the control site. Year 3 with a 33% decline at the impact treatment compared to a 67% decline at the control site Year 4 with a 67% decline at both the impact and control treatment sites. Year 5 with an 11% decline at the impact site compared to a 50% decline at the control site. <p>Both sites have declined with the greater decline occurring at the control site where non project related factors have been identified (i.e. past wild fires, fluctuating surface water levels and periodic slashing on parts of the transect).</p> <ul style="list-style-type: none"> Site 5 – McDonalds and Broadwater National Park <ul style="list-style-type: none"> Year 1 with an 80% decline at the impact treatment compared to a 53% decline at the control site. 		

Triggers for corrective actions	Corrective actions	Relevance to Year 5 (Operational Year 1) Wallum Sedge Frog Monitoring	Results of Year 5 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
			<ul style="list-style-type: none"> Year 2 with an 80% decline at the impact treatment compared to a 29% decline at the control site. Year 3 with a 100% decline at the impact treatment compared to a 22% decline at the control site. Year 4 with a 60% decline at the impact treatment compared to a 10% increase at the control site. Year 5 with a 40% decline at the impact treatment compared with a 29% increase at the control site. <p>Decline exceeds 25% over three consecutive monitoring periods.</p> <p>Variation explained by other non project related factors associated with fluctuating water levels.</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>	Not relevant as sites have not been completed.	<ul style="list-style-type: none"> ch. 139000 - Bridge with Exclusion Fence Extent 138800-139200 (400m) – No sedge frogs recorded. ch. 139430 – Round Concrete Pipe 1 Cell 68.32m x 1.5m Exc Fence Extent 139400 139600 (200m) – No sedge frogs recorded. 	Refer to nearby BACI Monitoring Site 1A where frogs have disappeared.	Not relevant at this point in time.

Triggers for corrective actions	Corrective actions	Relevance to Year 5 (Operational Year 1) Wallum Sedge Frog Monitoring	Results of Year 5 Wallum Sedge 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>				
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>	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.

Triggers for corrective actions	Corrective actions	Relevance to Year 5 (Operational Year 1) Wallum Sedge Frog Monitoring	Results of Year 5 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Water pH exceeds 5.5 for Wallum Sedge Frog	Investigate ways to reduce pH of water.	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
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.	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
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	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
Mosquito Fish present and threatened frogs / tadpoles absent.	Draining pond to remove Mosquito Fish and allow pond fill at the next rain event.	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
Constructed habitat unsuitable for frogs (e.g. wetlands have unsuitable hydro-period (as determined from monitoring events), water quality or associated vegetation) as detailed in section 5.4.4.	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.	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
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.	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
Frog absence confirmed following monitoring surveys (it should be noted that a pond may be	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control.	No compensatory ponds have been constructed to date.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.

Triggers for corrective actions	Corrective actions	Relevance to Year 5 (Operational Year 1) Wallum Sedge Frog Monitoring	Results of Year 5 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
suitable for frogs, but not colonised).	Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.				
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 applicable as site not in riparian habitat.	Not Applicable	Not Applicable	Not Applicable


3.6 Conclusions and Recommendations

Year 5 monitoring during late summer and late autumn of 2021 found sedge frogs at seven of the 10 monitoring sites. This included the disappearance of sedge frogs from Site 1A (Broadwater West) which coincides with a downwards trends over the past few rounds of monitoring (see Lewis 2022). It had been previously proposed that increased nutrient loads combined with an increase of competitor species have rendered the site less suitable as sedge frog habitat. The corrective action *“Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation”* should now be adopted and corrective action *“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”* should only be adopted if sedge frogs remain absent at the cessation of the monitoring program, scheduled in 2024.

This round of monitoring was able to rediscover sedge frogs at Site 3A (Bagotville) where they had remained absent since the baseline surveys. This provides some opportunity for their rediscovery at Site 1A above, with increased opportunity following an extended period of wet seasons that improve the colonisation opportunities for sedge frogs. Meanwhile, sedge frogs remain absent from Site 2A (Broadwater Beach Road) and from the reference Site 3 adjacent to Wardell Road. It is interesting in that the frog assemblages at Site 3B (Wardell Road) are similar to that recorded now at Site 1A, so the competitor interactions could have been operating here several years earlier.

Based on the Year 5 findings, the following recommendation is outlined in Table 3-3.

Table 3-3. Recommendations following Year 5 Wallum Sedge Frog population monitoring and Transport for NSW response.

Recommendation No	Recommendation	Transport for NSW Response
1	<p>At Site 1A. 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> 	Adopted. Perform during next season of monitoring.
2	Perform some additional surveys adjacent to Site 1A to confirm the continued existence of sedge frogs on this side of the motorway.	Adopted. Perform during next season of monitoring.

4.0 GREEN-THIGHED FROG (*LITORIA BREVIPALMATA*)

4.1 Species Profile

4.1.1 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 4-1. Green-thighed Frog from Bald Knob Tick Gate Road (Site 3A).

4.1.2 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).

4.1.3 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).

4.2 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.

4.2.1 Site Selection

The location of BACI 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).

4.2.2 Timing of Surveys

Weather patterns were constantly monitored between September 2021 through to May 2022 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, stage one sampling took place on the 24-28th February 2022.

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. Searches of the adjacent permanent frog fence were also performed at this time. At each site, the following was 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. Some additional surveys were performed in accordance with the adoption of Recommendation 4 from the last round of monitoring (Lewis 2022). This included an additional survey adjacent to Redbank Creek in an attempt to qualify a breeding site where Green-thighed Frogs had been heard calling in the past, and secondly, survey an area to the east of Site 10A – Tabbimoble given that frogs have not been recorded in this area over a number of seasons.

The second round or post breeding surveys were used to measure the breeding success at each site and these were performed on the 16 and 17th April 2022. 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.

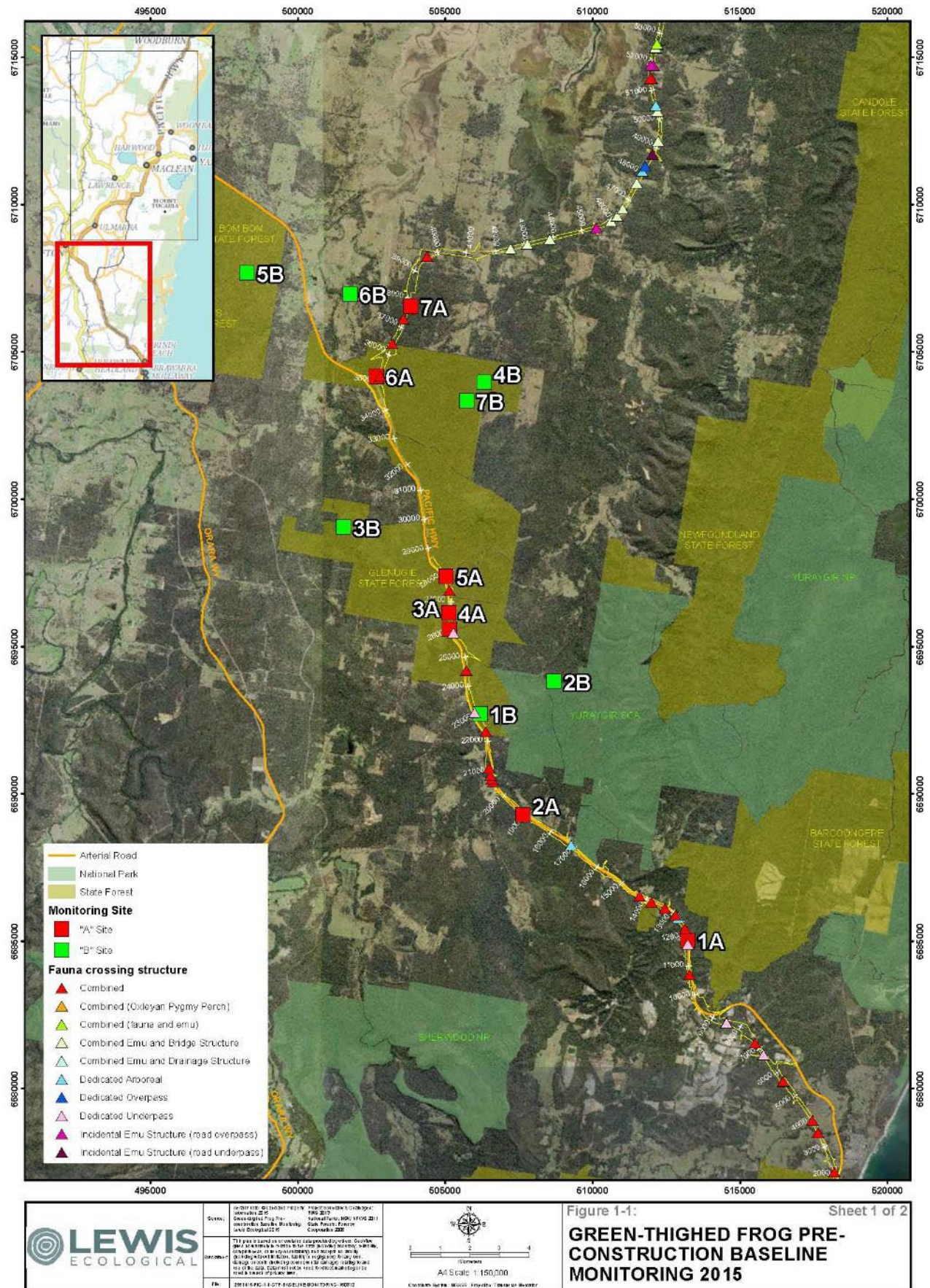


Figure 4-1. Locations of Green-thighed Frog BACI Sites 1-7 between ch.11800–40000.

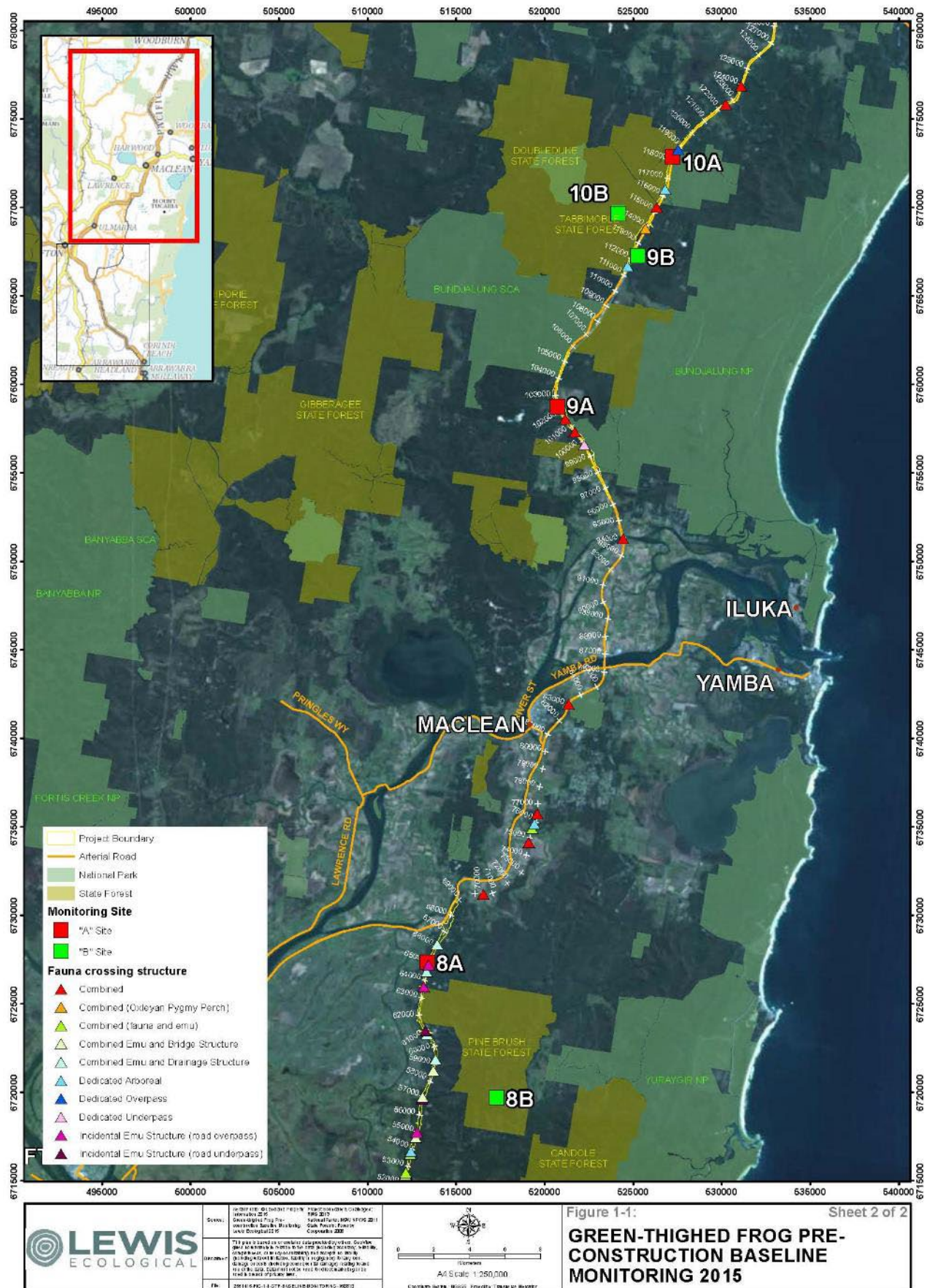


Figure 4-2. Locations of Green-thighed Frog Control and Impact sites between ch. 57500–118500.

4.2.3 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 2019 and the end of May 2021 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.

4.2.4 Connectivity Structure Monitoring

Eight connectivity structures have been nominated for Green-thighed Frog monitoring and extend from ch. 35075 (BACI Site 6A) to 118464 (BACI Site 10A; Table 4-1). At each site, a 20-25 min search was used to detect frogs within 100 m of the connectivity structure. Captured frogs were toe clipped with a single digit partially removed before the wound was dressed with Vetbond surgical adhesive. Frogs captured on the eastern side of the carriageway were marked on their left hand using the outer finger. Frogs captured on the western side of the carriageway were marked on their right hand using the outer finger.

Table 4-1. Summary of the connectivity structure monitored during the 2020/2021 Green-thighed Frog surveys for BACI Sites 1-10.

Chainage	Structure Type	Corresponding Frog Fence Extent
35075	RCBC	34200 to 35200 (1000m)
37330	RCBC	36100 to 38300 (2200 m)
64400	Arch	64200 to 65100 (900 m)
102500	Not applicable	102100 to 102600 (500 m)
102670	RCP	just outside
111750	RCP	111800 to 112100 (300m)
111756	RCP	111800 to 112100 (300m)
118464	Bridge - Tabbimoble floodway	118100 to 118600 (500m)

4.3 Monitoring Results

4.3.1 Stage 1 Surveys - Calling Intensity and Spotlighting

Green-thighed Frogs were recorded at 9 (90%) of the 10 sites as part of Year 6 monitoring in Sections 3-7 (Table 3-1; Figure 3-1). Frogs were recorded from four (80%) of the impact sites and from all five (100%) control sites. Counts and chorusing male frogs were regularly in the order of 2-9 frogs with some notable exceptions, in particular:

- Airport Road (Site 6B) where 14 males were heard and 15 frogs were spotlighted, several of these being females;
- Old Six Mile Lane (Site 7A) where 9 males were heard and 15 frogs spotlighted and
- Glenugie East (Site 7B) where 11 males were heard and 7 frogs spotlighted.

The implementation of recommendation 2 to survey an adjacent area to Redbank Creek in Section 1 was unsuccessful in detecting Green-thighed Frogs which had been heard from this site of the carriageway when conducting compensatory pond surveys on the eastern side of the carriageway. Similarly, additional surveys to the east of Site 10A (Tabbimoble) was unsuccessful in detecting Green-thighed Frog in this area.

No amplexing or mating frogs were recorded during this round of monitoring. Several choruses of male frogs and nearby females alluded to the fact that this would have taken place as suitable weather conditions prevailed over a number of days.

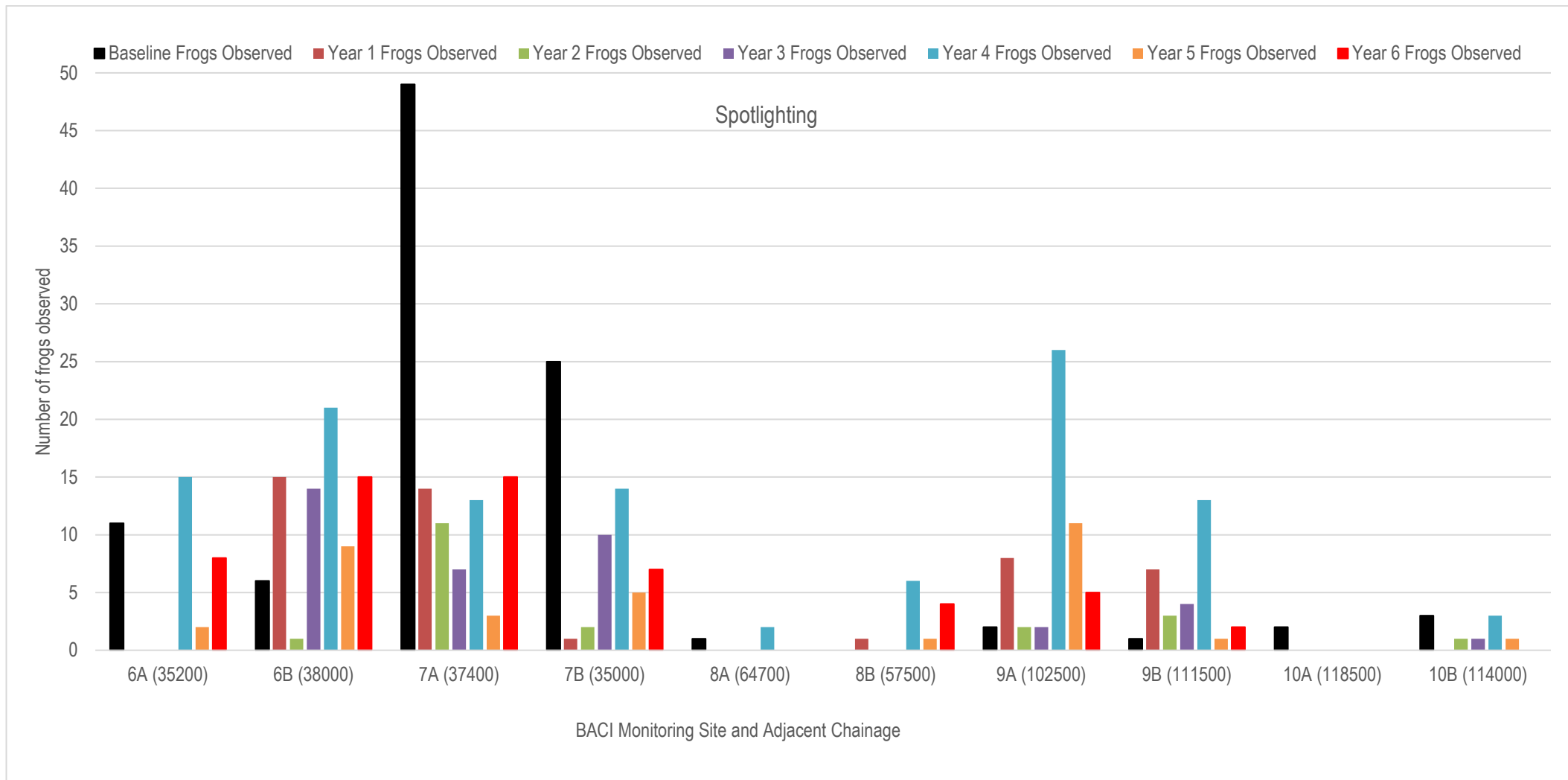


Figure 4-4. The number of Green-thighed Frogs spotlighted between the baseline survey, construction and operational monitoring in Years 1-6 at Sites 6-10.

Table 4-1. Summary of the 2020/2021 Green-thighed Frog surveys for BACI Sites 1-10.

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)
BACI Site	Date	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads			
6A (35200)	25.02.2022	6	8	16.04.2022	0	1	0	i. Permanent frog fence installed. ii. L3 Natural Pond (35400E) monitored as part of general site, not a compensatory pond. iii. Combined culvert installed.	Main breeding area removed by carriageway. No constructed breeding ponds due to no dig requirements associated with Aboriginal Heritage constraints. Two low lying natural pond formations were recorded within this area adjacent to the alignment.	Yes
6B (38000)	25.02.2022	14	15	16.04.2022	3	5	0	Outside of works footprint. Occurs close to bitumen roadway.	Frogs may have successfully bred on multiple occasions at this site following identification of both sub adults and juveniles in mid April 2022.	Yes
7A (37400)	25.02.2022	9	15	16.04.2022	0	2	0	i. Permanent frog fencing installed. ii. Compensatory frog ponds installed on both sides of the carriageway. iii. Combined culvert installed in general area.	L12-E, L6W and L7-W monitored with no frogs recorded using the compensatory ponds. This is expected to change in time based on observations on the way frogs breed at this site (i.e. move around and have bred in different depressions and stump holes since monitoring began).	Yes
7B (35000)	25.02.2022	11	7	16.04.2022	0	0	0	Outside works footprint.	No evidence of breeding recorded. Juveniles may quickly disperse from this site into the surrounding forest.	No
8A (64700)	26.02.2022	2	0	16.04.2022	0	0	0	i. Permanent frog fence installed. ii. Compensatory frog ponds constructed.	The mere fact that frogs are still calling in this general area eludes to an ongoing population. L8 ponds monitored but no frogs using. Tend to dry out rapidly.	No
8B (57500)	26.02.2022	3	4	16.04.2022	0	0	0	Outside works footprint.	Frogs continue to change their breeding site not unlike Site 7A. Calling frogs again recorded from the drainage line further to the north some 250m from the original calling site. The original calling site is often impacted by cattle whom may drink from the pond and make it more prone to drying out in a number of weeks.	No
9A (102500)	26.02.2022	9	5	17.04.2022	1	6	0	i. Permanent frog exclusion fencing observed.	Successful breeding documented at this location. Follow up rainfall post calling proved ideal to maintain water levels.	No

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)
BACI Site	Date	No. Calling Males (choring intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads			
								ii. The installed RCP culverts provide marginal opportunity at improving habitat connectivity. iii. Compensatory frog ponds provided.	Dip-netting for tadpoles proved difficult at this site with grasses and sedges. Ponds contained varying water levels.	
9B (111500)	26.02.2022	3	2	17.04.2022	0	0	0	Outside works footprint.	Calling frog numbers are likely to have been underestimated due to the intensity of other frog species calling. Juvenile were located at edge of leaf litter and sticks at the northern pond site.	No
10A (118500)	26.02.2022	0	0	17.04.2022	0	0	0	i. Permanent frog fence installed on the western side where the monitoring site was previously located. ii. Bridge structure completed. iii. Compensatory ponds observed on eastern side and opposite to the side where frog ponds were supposed to be constructed. iv. Additional surveys employed in accordance with recommendation 2 from last round of monitoring (Lewis 2022).	Numerous Cane Toad observed around drainage line. Frogs are proving difficult to locate at this site. Ponds contained varying water levels.	Yes
10B (114000)	27.02.2022	2	0	17.04.2022	0	0	0	Outside works footprint	Area has been altered following importation of rock and road works to improve drainage in this area. Frogs still heard broadly through the adjacent forest but none were spotlighted.	No

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

Juvenile and some sub adult frogs were recorded during this round of monitoring but no tadpoles (Table 4-1).

4.3.3 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 in late February 2022 with this event continuing into early March when the surveys were conducted (Table A-2). Another suitable rainfall period occurred in late March when the cumulative total didn't quite reach the required amount, however, more than 150 mm of rainfall fell over a week long period when the ground remained saturated from previous rainfall events.

4.3.4 Constructed Breeding Ponds

No Green-thighed Frogs were recorded breeding in the constructed ponds. A summary for each pond area is provided below and summarised in Table 4-2.

i. Section 3 - Glenugie Site 7A (ch. 37400)

Monitoring for the second time of these newly constructed ponds commenced on the 25th February 2022 where four ponds on the eastern side of the carriageway (L6 & L7 in GeoLINK 2019) and four ponds on the eastern side of the carriageway (L12 in GeoLINK 2019) had filled and over flowed following an estimated 125 mm of rainfall over the past few days (Plate 4-8). No Green-thighed Frogs were heard calling or observed around the ponds, although a number of other species were encountered, namely Bleating Tree Frog and Broad-palmed Frog.



Plate 4-1. Constructed ponds at Site 7A (ch.37330) in late February 2022.

A follow up survey on the 17th March found the ponds contained 50-80% of their capacity over the past 20 days although there had been around 50 mm of rainfall in the week leading up to the pond monitoring. Another inspection on the 5th

April found the ponds were almost full with between 80-100% capacity, again due to ongoing rainfall including close to 100mm of rainfall in the week leading up to the inspection. A final inspection was performed on the 16th April where all ponds still contained water to varying degrees, measured at this time at 30-80% some 50 days after the stage 1 surveys. Inspections around the pond edge found metamorphs of both Bleating Tree Frog and Broad-palmed Frog and a number of tadpoles belonging to the same species.

ii. Section 3 - Tyndale Site 8A (ch. 64700)

Monitoring for the second time of these newly constructed ponds commenced on the evening of the 26 February 2022 where the three ponds on either side of the carriageway had filled and over flowed following an estimated 150 mm of rainfall over the past few days (Plate 4-9). No Green-thighed Frogs were heard calling or observed around the ponds, although a number of other species were encountered, namely Ornate Burrowing Frog, Bleating Tree Frog, Dusky Toadlet and the occasional Scarlet-sided Pobblebonk and Rocket Frog (*Litoria nasuta*).

A follow up survey on the 17th March found the ponds had receded to between 10-50% of their capacity over the past 20 days. Another inspection on the 4th April found they contained more water than the past survey with 30-80% following heavy rainfall in the week prior to the survey. Inspections at day 50 found all ponds contained at least some water, measured here at 10-40% and despite a number of tadpoles being dip netted, none were identified as Green-thighed Frog. It is suspected without the follow up rainfall, these ponds would almost certainly dry out.

ii. Section 6 – Jackybulbin Site 9A (ch. 102250)

Monitoring of five ponds are scattered along the western side of the carriageway between approximate ch.102150 and ch.102375. Initial inspections on the 26th February found all of the ponds were flooded with around 280-380 mm of surface water. Follow up monitoring on the 18th March they were around half to three quarters full and had received recent inflow from ongoing rains in the previous week. When the site was again revisited on the 5th April, the ponds had received additional inflows and measured at 60-90% capacity. The final round of monitoring took place on the 17th April when the ponds contained between 30-70% of their capacity. The ponds did not appear to have dried out, due larger to the ongoing follow up rainfall, something that is probably required in this area for the ponds to retain water for 50 continuous days. Some dip-netting of these ponds revealed a range of tadpoles, but none of them were identified as Green-thighed Frog.

Table 4-2. Summary of compensatory frog pond monitoring during Year 6 in Sections 3, 6 and 7.

Site	Ch. + Side of Carriageway	Number of Constructed Ponds	First Survey	Second Survey	Third Survey	Fourth Survey	Comments
Section 3	Ch.37400 (both sides) West Side – L6 and L7 in GeoLink (2019)	12	25 th February 2022 All ponds filled to capacity i.e. 100%. Contain 250-400 mm of water. Visual Water Quality – same as adjacent flooded areas – turbid from surrounding sodic soils.	17 th March 2022 Ponds remain at 50-80% or around 160-290 mm in depth. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles.	5 th April 2022 Ponds 80-100% or around 250-420 mm in depth. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles.	16 th April 2022 Ponds at 30-80% or 100-290 mm in depth. Visual Water Quality – Similar to surrounding area. Still turbid but with some increased tannin content, still considered suitable for tadpoles.	Ponds have received timber and other habitat treatments including sedge plantings. Pond suitability likely to improve over time.
	64700 West	3	26 th February 2022 All ponds filled to capacity. Contain 350-400 mm of water. Visual Water Quality – same as adjacent flooded areas – turbid from surrounding sodic and sandy soils.	17 th March 2022 Ponds remain at 10-40% or around 50-150 mm in depth. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles.	5 th April 2022 Ponds at 30-80% capacity or 150-300 mm depth. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles.	16 th April 2022 Ponds remain at 10-40% or around 50-150 mm in depth. Visual Water Quality – Similar to surrounding area. Still turbid with some increasing tannins.	Without consistent follow up rain these ponds would dry out within the 50 day period. Ponds have received tube stock plantings.
Section 6	102250 West	5	26 th February 2022 All ponds filled to capacity. Contain 280-380 mm of water. Visual Water Quality – same as adjacent flooded areas – turbid from surrounding sodic and sandy soils.	18 th March 2022 Ponds remain at 40-80% or around 150-280 mm in depth. Been recent rain, so appear to have risen. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles.	5 th April 2022 Ponds at 60-90% capacity or 200-350 mm depth. Been significant recent rainfall in past week. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles.	17 th April 2022 Ponds remain at 30-70% or around 80-220 mm in depth. Visual Water Quality – Similar to surrounding area. Still turbid with some increasing tannins.	Ponds have fluctuated throughout monitoring period, appear to have retained water and would dry out to ensure they are fish free. Lots of competitor species here, particularly Tyler's Tree Frog.
Section 7	118500 East	4	26 th February 2022 All ponds filled to capacity. Contain 300-400 mm of water. Visual Water Quality – same as adjacent flooded areas – turbid from surrounding sodic and sandy soils.	18 th March 2022 Ponds remain at 60-80% or around 200-300 mm in depth. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles.	5 th April 2022 Ponds at 80-95% capacity or 250-375 mm depth. Been significant recent rainfall in past week. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles.	17 th April 2022 Ponds remain at 50-70% or around 180-280 mm in depth. Visual Water Quality – Similar to surrounding area. Still turbid with some increasing tannins.	Ponds installed on the wrong side of carriageway. Green-thighed Frog never recorded east of carriageway, however this was the recommendation from the project ecologist and agreed with EPA at the time (email 3/8/20). Ponds located too close to main drainage channel. A lot of Cane Toads congregate in this area.

ii. Section 7 – Tabbimoble Site 10A (ch. 118500)

Monitoring took place on the 26th February and coincided with stage 1 calling/breeding surveys. At this time, all four ponds were at 100% capacity or around 300-400mm in depth. The ponds were revisited on the 18th March and 5th April where on each occasion all ponds contained sufficient amounts of water, measured at 60-95% of their capacity following ongoing rainfall leading up to each of the surveys. A final visit on the 17th April recorded the ponds remained at 50-70% capacity. Some dip-netting of these ponds revealed a range of tadpoles, but none of them were identified as Green-thighed Frog.

4.3.5 Connectivity Structure Monitoring

Green-thighed Frogs were recorded adjacent to three of the seven structures with one female clipped on the western side of the carriageway at ~ch. 35020 (i.e. Site 6A) whilst two males were captured and clipped from the western side of the carriageway at Site 7A and two males were captured and clipped to the south of 102670 near Site 9A (Table 4-3). None of the captures showed evidence of past capture from the previous round of monitoring.

Table 4-3. Summary of connectivity structure monitoring performed during Year 6 at Sites 1-5 and for Year 5 at Sites 6-10.

Chainage	Structure Type	Length / specs	Frog Fence	Number of Green-thighed Frogs (finger-clip) Left outer finger is east side. Right outer finger is west side.	Comments
35075	RCBC		34200 to 35200 (1000m)	Female west side.	Away from culvert south side estimated 50 m.
37330	RCBC		36100 to 38300 (2200 m)	Two males west side	~40 and 60 m from culvert
64400	RCBC		64200 to 65100 (900 m)	No captures	
102670	RCP		102100 to 102600 (500 m)	Two males.	Frogs remain concentrated on western side.
111750	RCP		111800 to 112100 (300m)	No captures	
111756	RCP		111800 to 112100 (300m)	No captures	
118464	Bridge - Tabbimoble floodway	20 m span	118100 to 118600 (500m)	No captures	Toads around the crossing structure.

4.3.6 Frog Fencing

No Green-thighed Frogs were recorded on the road side of the installed permanent fencing at any of the monitored sites (Table 5-4). Although no Green-thighed Frogs were recorded on the road side of the fenced sections, some other frogs were, and they included both tree frogs (i.e. hylids) and ground dwelling frogs (i.e. myobatrachids). A number of minor breach point were recorded including those where vegetation tends to grow up and over the fence, however this has been maintained at a few of the monitoring location like Jackybulbin (Plate 4-2). Some of the ground mesh provide ample opportunity for frogs to move underneath the fence and is typically evident around structures that have scour protection installed (Plate 4-3).

Table 4-4. Summary of permanent frog exclusion fence monitoring during Year 6 at Sites 6-10.

Site	Ch. + Side of Carriageway	Status of Fencing	Fencing Extent Surveyed	Green-thighed Frogs Within 2 m Habitat Side of Fence	Green-thighed Frogs on Road Side of Fence	Comments
Pheasant Creek (Site 6A)	35200	Completed permanent fence	35050-35300	Nil	Nil	Some minor breach points in the fence associated with wash outs, tie ins and vegetation growing up against the fence. Overall, considered effective at reducing frog movements not eliminating them from accessing the carriageway.
Old Six Mile Lane (Site 7A)	38000	Completed permanent fence	37230-37500	1	Nil	Two males found around 3-4 m from fence and 40-60 m from culvert on the habitat side. Number of minor breach points observed including near wing walls of connectivity culvert ch. 37330, vegetation growing against fence and some minor wash outs or lifting of the pinned ground mesh.
Tyndale Crown Reserve (Site 8A)	64700	Completed permanent fence	64600-64750	Nil	Nil	Overall fence found to be in a functional state with some minor wash outs and vegetation growing against fence from habitat side.
Jackybulbin (Site 9A)	102500	Completed permanent fence	102100 to 102600	Nil	Nil	Large numbers of frogs in this area. Majority on habitat side of the fence. A lot of grasses and regenerating shrubs and annual weeds providing opportunities for frogs to move over the fence. Maintenance in the form of herbicide application observed.
Tabbimoble North (Site 10A)	118500	Completed permanent fence	118100 to 118600	Nil	Nil	Large numbers of frogs in this area. Majority on habitat side of the fence. Some washed out areas providing opportunities for frogs to move onto the roadway. No Green-thighed Frogs recorded in this area for a number of years now so the risk to them is considered minimal.



Plate 4-2. Example of maintenance being performed along frog exclusion fencing at Site 9A Jackybulbin ch.101250.



Plate 4-3. Example of return flap wash out or holes beneath the mesh within 50 m of installed ponds at ch.118500 Site 10 A (Tabbimoble).

4.4 Discussion

Monitoring in Sections 3, 6 and 7 has entered its sixth year over the 2021/2022 season and continues to record frogs using most of the sites. In Section 3, frog numbers have declined from the baseline surveys but still appear to function as a viable population with evidence of breeding being recorded at Site 6A (Pheasant Creek) and Site 7A (Old Six Mile Lane) but not at Site 8A (Tyndale Crown Reserve). Frogs appear to have shifted their breeding location at Site 8A from the public land to some private land around 100 m to the south. The installed mitigation measures of compensatory ponds and frog fencing may in time benefit that population. Further north, the population at Jackybulbin Creek appears to have responded well to the past couple of wet seasons where numbers of calling males and observed females tends to translate into successful breeding around 40-50 days later. Meanwhile the population at Site 10A (Tabbimoble) appears to have disappeared from this immediate area and despite a number of extended surveys on both sides of the carriageway it is yet to be found. The additional surveys performed during this round of monitoring found the vegetation was particularly dense and may not be well suited to this species based on localised observations which point to more open areas of forest.

Monitoring at the constructed compensatory ponds was not able to confirm use by Green-thighed Frogs, however, it did demonstrate that they fluctuate and have the capacity to dry out and thus remain fish free. During this round of monitoring, ponds had little opportunity to recede with more than 12 days where rainfall exceeded 10 mm in 24 hrs over the 50 day monitoring period.

Frogs were successfully marked in the general proximity of crossing structures for the second consecutive year, however, there was no evidence to suggest frogs had crossed the carriageway. Sampling around this time tends to coincide with the underpass structures containing either a lot of water or fast flowing water, two things that Green-thighed Frogs don't tend to like. Sampling at another alternative time might prove more beneficial, for example, around the time when Stage 2 post breeding surveys are performed.

No Green-thighed Frogs were recorded on the road side of the frog exclusion fencing during this round of monitoring. It is worth noting that a number of other frog species including ground dwelling Myobatrachids and tree dwelling hylids were observed on the road side but a far fewer numbers than on the habitat side of the fence. Provided that some level of maintenance is provided, particularly where tall grasses and recolonising shrubs like wattles occur, the exclusion fencing is likely to remain in a functional state.

How the data collected for Year 6 compares or performs against the prescriptions outlined in the Threatened Frog Management Plan is outlined in the following section.

4.5 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 2021/2022 season includes the population monitoring component as well as the compensatory ponds in Sections 3, 6 and 7. Underpass structure monitoring and permanent frog fence monitoring also forms part of the performance related monitoring.

4.5.1 Population Monitoring

The performing factor for the population monitoring is the number of frogs observed following a recommendation from earlier surveys (Lewis 2017). Most sites recorded sufficient numbers of frogs with counts compared to the past baseline surveys (Table 4-5). Where there has been declines, in most cases these have not exceeded the threshold of >25% relative to the reference site over three consecutive monitoring events. This is not the case at Site 10A (Tabbimoble north) where frogs have declined by 100% at the impact site (ch.118500) since the area was cleared to accommodate the carriageway whilst the reference site records frogs more often than not. In the current round of monitoring, frogs were heard calling from the adjacent forest, they simply weren't spotlighted during the allotted time but nonetheless present. This is a similar situation at Site 8A (Tyndale Crown Reserve) where frogs are now not often spotlighted but heard calling on adjacent private land suggesting they have shifted where they choose to breed.

4.5.2 Connectivity Structures and Permanent Frog fencing

Surveys performed at the seven connectivity structures found no frogs had completed a passage from one side of the road to the other (Table 4-5). In reality, this was the second year of more intensive sampling where frogs were captured and marked at Pheasant Creek (Site 6A), Glenugie (Site 7A) and Jackybulbin (Site 9A). Monitoring during successive years will provide an opportunity for their recapture and assessment as to whether these frogs have moved across the carriageway.

Permanent frog exclusion fence surveys tied into this connectivity monitoring found no Green-thighed Frogs on the carriageway side of the fence, although a number of potential breach points were observed at Site's 6A, 7A, 9A and 10A (Plate 4-3).

4.5.3 Compensatory Breeding Ponds

Surveys were unable to detect Green-thighed Frogs using the constructed compensatory ponds at Glenugie (ch.37330E+W), Tyndale (ch.64700W), Jackybulbin (ch. 101250) and Tabbimoble (ch.118500) with monitoring spanning between 1 and 2 years.

Most of the ponds tends to work in a manner consistent with the requirements of the Threatened Frog Management Plan (RMS 2015). The location of constructed ponds at Tabbimoble (Site 10A) does not accord with previous records of Green-thighed Frog from the western side of the old and newly constructed motorway. If ponds have been constructed on the western side in this area, they should be monitored and the ones on the eastern side abandoned.

4.5.4 Riparian Habitat Revegetation

As the ponds nor monitoring sites occur in riparian areas, the riparian habitat revegetation parameters appear irrelevant at this time.

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

Triggers for corrective actions	Corrective actions	Relevance to 2021/2022 Green-thighed Frog Monitoring	Results of 2021/2022 Green-thighed 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>	Relevant	<p>Site 6 – Impact treatment has recently declined by 27% whilst control site has increased by 150%. Second consecutive year where decline has exceeded the 25% threshold.</p> <p>Site 7 – Both sites have declined since the baseline with 69% at the impact and 72% at the control site.</p> <p>Site 8 – The impact site has declined 100% to zero whilst the reference site has increased fourfold. Frogs heard calling in distance at impact site so not an actual decline to zero.</p> <p>Site 9 – The impact site has increased by 100% and the reference site by 150%.</p> <p>Site 10 – The impact site has decreased to zero or 100% over the past 6 years whilst the control site has declined to zero in frogs observed, individuals were heard in adjacent forest.</p>	<p>At Site 6A, improved drainage has reduced suitability as breeding site, after removing some broad open depressions considered ideal breeding habitat.</p> <p>At Site 7A – Frogs have dispersed from one large broad area now bisected by the motorway. Frogs still present but likely changes in breeding patterns not fully understood by this monitoring.</p> <p>At Site 8A, changes in drainage patterns have resulted in a shift in the way the residual frog population uses the site. Population still present, just reliant on listening for calling frogs on adjacent private land.</p> <p>At Site 9A there has been notable increases at both impact and reference treatments.</p> <p>At Site 10A, loss of breeding pond and some sub small ponds constructed on the eastern side of the motorway or the opposite side of where frogs were bred successfully.</p>	<p>Site 6A – Second year where threshold has been exceeded, reassess after next round of monitoring.</p> <p>Site 8A – Last season's monitoring suggested <i>“Perform second round of monitoring with newly constructed ponds before investigating a change in sampling strategy”</i>. Still no frogs at the original site, however, calling frogs confirm the Green-thighed Frog still present here, so the population hasn't disappeared. Recommended that calling frogs also need to be considered in the performance measure for this site (see Recommendation in this report).</p> <p>At Site 10A – Additional surveys have also failed to identify a local population of Green-thighed Frog. Apply the final season of monitoring before moving to corrective action 4 “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>

Triggers for corrective actions	Corrective actions	Relevance to 2021/2022 Green-thighed Frog Monitoring	Results of 2021/2022 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
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>Assess the need for offsets if connectivity structures are identified as ineffective over three consecutive monitoring periods.</p>	Relevant	Surveys marked frogs at Site 6A with 1 individual, 7A with 2 individuals at Site 9A, another two males.	<p>Connectivity structure provide sufficient openness for frogs to move through.</p> <p>Frog exclusion fencing remains largely in a fit for purpose or functional state.</p>	Nil
Constructed Pond Monitoring					
<p>Absence of threatened frogs and metamorphs at the compensatory ponds after three years since construction.</p>	<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>Section 3 – 2 rounds of pond monitoring now completed.</p> <p>Section 6 and 7 – 1 round of frog pond monitoring completed.</p>	<p>Section 3 – No confirmed use during second round of monitoring.</p> <p>Section 6 and 7 – No confirmed use during first round of monitoring.</p>	<p>Section 3 - At Site 7A, and given the prevailing conditions, there were numerous opportunities for Green-thighed Frogs to broad across the broader habitat.</p> <p>At Site 8A, frogs have shifted their breeding site from around the original access road to an adjacent private property. Ponds are located in an area where pre construction surveys found numerous Green-thighed Frogs.</p> <p>Section 6 – At Site 9A ponds were monitored for the first time. Depending on the rainfall and subsequent runoff there are a lot of available breeding sites so pond use may take some time.</p>	<p>Ponds have been monitored for 1-2 times so next round of monitoring required before corrective action. It is recommended that any ponds on the western site of ch.118500 be monitored in preference.</p>

Triggers for corrective actions	Corrective actions	Relevance to 2021/2022 Green-thighed Frog Monitoring	Results of 2021/2022 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
				Section 7 – At Site 10A, the constructed ponds for monitoring are located near a construction basin and drainage line where Cane Toads are common and the neighbouring vegetation is not consistent with observations of Green-thighed Frog habitat use elsewhere.	
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.	Relevant	Water quality at all ponds is comparable to surrounding habitat, often turbid from sodic soils and without ongoing rainfall, tannins tend to colour water in same manner as the surrounding habitat.	Comparable to surrounding habitat.	Nil
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	Five rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at four sites and monitoring performed over five seasons at three sites and three season at Site 3A. First round of monitoring at ponds in Section 3 (Site 7A, 8A). Notification of pond construction in Section 6 and 7	Section 3, 6 and 7 – Pond drying rates met the design requirements of holding water for 40-50 days.	Ongoing rainfall throughout the monitoring period ensured ponds remained with water.	Nil

Triggers for corrective actions	Corrective actions	Relevance to 2021/2022 Green-thighed Frog Monitoring	Results of 2021/2022 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
		provided on 28 th April 2021, after this round of monitoring was completed.			
Mosquito Fish present and threatened frogs / tadpoles absent.	Draining pond to remove Mosquito Fish and allow pond fill at the next rain event.	<p>Five rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at four sites and monitoring performed over five seasons at three sites and three season at Site 3A.</p> <p>First round of monitoring at ponds in Section 3 (Site 7A, 8A). Notification of pond construction in Section 6 and 7 provided on 28th April 2021, after this round of monitoring was completed.</p>	No Mosquito Fish recorded.	Ponds undoubtedly drying out during the course of the year. Monitoring is geared around a time when there has been large amounts of rainfall so it's difficult to assess if all ponds do in fact dry on an annual basis.	Nil.
Constructed habitat un-suitable for frogs (e.g. wetlands have un-suitable hydro-period (as determined from monitoring events), water quality or associated vegetation) as detailed in section 5.4.4.	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.	Five rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at four sites and monitoring performed over five seasons at three	<p>1. Ponds in Section 3 and 6 appear suitable with increased amounts of fringing vegetation.</p> <p>2. Ponds in Section 7 (Site 10A) occur on the opposite side of the carriageway to where frogs have been recorded in the past, even when sampling was</p>	Possible unsuitable habitat around ponds at Site 10A.	No a revegetation maintenance issue but more the fact that no evidence of Green-thighed Frogs ever occurring on this site of the carriageway. Even attempts to locate individuals to the east as reference sites has never recorded Green-thighed Frog. Suggested recommendation to re-establish monitoring at any ponds on western side and remove these ponds from the monitoring program.

Triggers for corrective actions	Corrective actions	Relevance to 2021/2022 Green-thighed Frog Monitoring	Results of 2021/2022 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
		<p>sites and three season at Site 3A.</p> <p>First round of monitoring at ponds in Section 3 (Site 7A, 8A). Notification of pond construction in Section 6 and 7 provided on 28th April 2021, after this round of monitoring was completed.</p>	performed along the old carriageway in 2006 by the author and during 2014 and 2015 (Lewis 2006; Lewis 2015).		
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.	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>	Relevant	<p>Section 3 Glenugie (Site 7A) – Ponds constructed in a suitable manner and considered function during their first round of monitoring.</p> <p>Tyndale (Site 8A) - Ponds constructed in a suitable manner and considered function during their first round of monitoring.</p> <p>Section 6 Jackybulbin (Site 9A) – Ponds well constructed and considered functional.</p>	<p>At Site 7A, ponds considered suitable and accord with past observations of breeding frogs in this area.</p> <p>At Site 8A, ponds are competing with a new breeding site on private land that cannot be accessed to assess population size and stability.</p> <p>At Site 9A, ponds are competing with other areas of suitable breeding habitat, particularly during extended periods of rainfall (i.e. east coast low pressure systems) versus isolated thunderstorms.</p> <p>At Site 10A, ponds positioned on opposite side of carriageway to where</p>	At Site 10A, survey any constructed breeding ponds on western side of ch.118500 area in preference to currently nominated ponds.

Triggers for corrective actions	Corrective actions	Relevance to 2021/2022 Green-thighed Frog Monitoring	Results of 2021/2022 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
			Section 7 Tabbimoble (Site 10A) – Ponds constructed on the opposite side of where Green-thighed Frogs were recorded in the past. Additional surveys failed to locate frogs in this area.	Green-thighed Frogs previously recorded, so in effect there are no known records. This includes broader surveys from recommendation in this program and attempts to locate reference sites here in 2014 and 2015 as well as targeted surveys in 2006.	
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 – locations are not within riparian zones.	Not relevant	Not relevant	Not relevant

4.6 Conclusions and Recommendations

Monitoring for the Green-thighed Frog in Sections 3, 6 and 7 was triggered by the first suitable rainfall in the 2021/2022 season which commenced on the 25th February 2022 and continued to the 1st March 2022. This rainfall event was a broad weather system which allowed surveys to be conducted over the entire study area in a manner similar to the last round of monitoring.

Frogs were recorded at nine monitoring sites summarised as four impact sites and all five control sites. Surveys in Section 3 recorded frogs from both treatments at Site 6 (Pheasant Creek), Site 7 (Glenugie) and Site 8 (Tyndale). Numbers of frogs were often higher than the last round of monitoring but often lower than the baseline surveys. This occurred for the second consecutive year at Pheasant Creek (Site 6A) indicating that some corrective action may be necessary if this trend continues into the next round of monitoring. At Site 7, both treatments showed a consistent pattern of decline indicating the overall effect may be linked to broader environmental cues rather than anything specifically related to the Upgrade. Further north in Section 3, Site 8A (Tyndale Crown Reserve) continues to show a reoccurring pattern of frogs calling from some adjacent private lands and the newly constructed ponds have not been able to entice them back into an area where they were regularly observed and heard calling back in 2013-2015.

Sampling in Section 6 and 7 continues to produce mixed results. Frog numbers at Site 9A (Jackybulbin) remain markedly higher than what was recorded in the baseline survey, and this trend continues at the neighbouring reference site so there does not need to be some cause for concern because the frogs aren't readily using the constructed breeding ponds. No Green-thighed Frogs were recorded on the road side of the fence, however, there were numbers of both ground dwelling and tree frogs that suggest the fence continues to act as a deterrent rather than a barrier. Vegetation was recorded growing up along the fence but often showed signs of maintenance so provided this continues it will remain in a functional state. Some surveys employed around the culvert on the eastern side of the carriageway failed to locate any frogs for marking whilst two frogs were clipped on the western side and increase the opportunity to assess the role of the culvert in maintaining habitat connectivity.

Site 10A (Tabbimoble) produced the same result as the previous rounds of monitoring with no Green-thighed Frogs recorded on either side of the carriageway, whether it was surveys in areas of suitable habitat, along the constructed frog exclusion fence or within and around the constructed compensatory ponds. This also included, some increased effort on the eastern side of the carriageway in recognition of adopting Recommendation 2 from the last round of monitoring.

The data obtained during this round of monitoring was assessed against the performance indicators and proposed that the calling number of frogs should be considered when interpreting the data from Site 8 as frog observations from spotlighting alone have more recently yielded no frogs when they are in fact calling nearby. The ongoing absence of frogs from Site 10A (Tabbimoble) suggests there is only one more round of monitoring before corrective action 4 may be

necessary, that being “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”

Based on the 2021/2022 findings, the following recommendations and Transport for NSW responses have been presented in Table 4-6.

Table 4-6. Recommendations following 2021/2022 Green-thighed Frog monitoring and Transport for NSW responses.

Recommendation No	Recommendation	Transport for NSW Response
1	Site 8A (Tyndale) - The number of calling frogs be considered in response to the fact that frogs are more often heard and cannot always be spotlighted due to access constraints on neighboring private land.	Adopted.
2	Site 10A (Tabbimoble) - Any constructed frog ponds on the western side of ch. 118500 (Tabbimoble) should be preferentially monitored ahead of those ponds constructed on the eastern side of the carriageway.	Adopted and noted monitoring is now being performed on both sides.

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7.0 APPENDIX A – RAW FROG SURVEY AND RAINFALL DATA

Table A1. Summary of Wallum Sedge Frog surveys during the 2021 monitoring season.

14 th and 15 th February 2021											18 th May 2021										
	Count 1	Count 1	Count 1	Count 1	Water Depth	Air Temp	Humidity	Rainfall	Cloud Cover	pH	Count 2	Count 2	Count 2	Count 2	Water Depth	Air Temp	Humidity	Rainfall	Cloud Cover	pH	
BACI Site	Adults	Sub Adults	Juveniles	Tadpoles							Adults	Sub Adults	Juveniles	Tadpoles							Comments
1A	0	0	0	0	270	24	76	1	75	5.5	0	0	0	0	230	15	81	0	25	5.3	A lot of Azolla, common competitor frogs and toads
1B	4	1	0	0	170	23	76	1	75	4.0	2	3	4	0	200	15	80	0	25	4.2	Site regenerating and getting denser
2A	0	0	0	0	230	21	77	1	90	4.2	0	0	0	0	190	15	79	0	30	4.3	Surface water but still no sedge frogs
2B	16	4	0	0	310	23	78	1	80	4.0	24	16	8	0	390	15	80	0	30	4.1	Most reliable site in the monitoring program
3A	1	0	0	0	230	20	81	1	65	3.9	1	0	0	0	220	14	87	0	25	4.0	Must be other sites nearby
3B	0	0	0	0	260	22	78	1	65	5.5	0	0	0	0	280	16	81	0	25	5.6	Site appears to have deteriorated in terms of acidic frog suitability
4A	3	1	0	0	265	22	66	1	40	4.7	1	3	0	0	370	16	81	0	0	4.9	Not much has changed
4B	2	0	0	0	130	19	70	1	50	4.2	0	2	0	0	150	16	81	0	0	4.4	Part of site periodically slashed
5A	2	0	0	0	200	22	77	1	70	4.1	0	1	0	0	130	15	81	0	0	4.4	Only has frogs when water level is up. Site has improved since the Upgrade.
5B	18	1	0	0	260	22	80	1	50	4.2	26	17	4	0	370	15	81	0	0	4.5	Site appears to be a source population.

Table A2. Summary of Green-thighed Frog surveys during the 2021/22 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 (chorusing intensity)	No. Frogs Spotlit	Stage 2 Survey Date	Days After Stage 1 Survey	No. Sub Adults	No. Juv	No. Tads	Breeding Confirmed	Comments
6A	35200	Pheasant Creek	E:502672 N:6704172	25.02.2022	2050-2120	24	100	0	2	98	6	8	16.04.2022	50	0	1	0	Yes	Found in same small offshoot of drainage line as previous monitoring
6B	38000	Airport Road	E:501766 N:6706969	25.02.2022	2135-2159	24	100	0	3	100	14	15	16.04.2022	50	3	5	0	Yes	Held more water given follow up rainfall between stage 1 and 2 surveys
7A	38000	Old Six Mile Lane	E:503837 N:6706546	25.02.2022	2248-2322	23	100	0	2	98	9	15	16.04.2022	50	0	2	0	Yes	Using pond from old stump hole
7B	35000	Glenugie East	E:505733 N:6703338	25.02.2022	2355-0027	22	100	0	3	100	11	7	16.04.2022	50	0	0	0	No	May have already dispersed
8A	64700	Tyndale Crown Reserve	E:513362 N:6727361	26.02.2022	0115-0147	20	100	0	2	100	2	0	16.04.2022	49	0	0	0	No	Difficult to determine as frogs now call from private property not accessible whilst adjacent drains dry too quickly and nearby borrow pit seldom has Green-thighed Frogs
8B	57500	Pine Brush State Forest	E:517300 N:6719708	26.02.2022	0228-0300	21	100	0	3	100	3	4	16.04.2022	49	0	0	0	No	Frogs now appear to favour drainage line to the north. No sign of use at original site.
9A	102500	JackyBulbin	E:520731 N:6758742	26.02.2022	2110-2139	23	100	0	2	100	9	5	17.04.2022	50	1	6	0	Yes	Frogs utilising same broad open flooded area
9B	111500	Tabbimobile East	E:525262 N:6767265	26.02.2022	2211-2239	23	100	0	2	100	3	2	17.04.2022	50	0	0	0	No	Unusual as juveniles can normally be found around the old borrow pit
10A	118500	Tabbimobile North	E:527238 N:6772864	26.02.2022	2317-2343	22	100	0	3	100	0	0	17.04.2022	50	0	0	0	No	Coincides with ongoing absence
10B	114000	Glencoe Road	E:524143 N:6769665	27.02.2022	0003-0029	21	100	0	2	100	2	0	17.04.2022	49	0	0	0	No	Original breeding area has received drainage works, frogs likely to have used other small areas such as stump holes but not detected during this round of monitoring.

Table A3. Rainfall data (Grafton Airport - Station 58161 New Italy – Station 58097) with survey dates (shaded red) for Green-thighed Frog surveys at Sites 6-10 during the 2021/22 monitoring season.

Grafton Airport - Station 58161	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2021	2021	2021	2021	2022	2022	2022	2022	2022
1st	0	3.8	0	35.6	2.2	0	41.2	0	6.2
2nd	2.6	2.2	0	2.0	29.2	29.4	4.2	0	0
3rd	0	0	0	0.2	0.6	28.0	1.2		0
4th	0.6	0	0	0	0.2	18.4	1.6	20.4	0
5th	0	0	0	7.8	4.8	1.6	6.0	2.2	0
6th	0.6	0	4.0	5.8	12.2	3.2	4.0	12.0	21.0
7th	0	0	0	6.0	15.6	4.2	29.0	0.2	2.4
8th	0	0	30.6	11.0	1.0	0.4	10.2	25.0	1.8
9th	0	0	11.4	3.8	3.2	0	0	1.6	0
10th	0	0	2.0	19.4	0.2	0	16.4	2.4	0
11th	0	0	15.8	0	0	0	0.4	0	3.6
12th	0	26.6	2.4	0	0	2.2	1.0	0	7.6
13th	0	28.0	0.2	0.2	0	0	0.4	0	6.4
14th	2.2	2.4	0	0	0	0.6	2.0	4.4	1.6
15th	1.4	7.6	0	0	0	7.2	0	4.2	4.0
16th	0	0	0	0	7.2	0	1.6	0.6	2.8
17th	0	0	0	13.8	0.2	0	3.8	3.0	22.6
18th	0	0	0	1.0	0	0	1.6	0.4	0
19th	0	7.8	0	0.2	0	2.0	0	0	0
20th	0	2.4	0.2	0	8.4	1.0	2.2	0	0
21st	0	31.8	9.4	0	6.0	0	0.2		3.8
22nd	0	11.6	20.2	0	7.0	6.6	0	5.2	10.2
23rd	0	0	0	0.6	12.2	43.8	0	23.0	8.4
24th	0	0	0.4	10.4	0	75.2	0.4	1.6	2.8
25th	0	0	8.0	0	0	49.4	35.4	1.2	11.6
26th	0	0	24.0	2.6	0	14.4	1.2	1.6	1.0
27th	0.6	0	4.4	0	0.4	55.2	4.0	2.0	0.2
28th	1.0		0	7.0	0	163.0	8.4	5.0	0
29th	0	25.2	0	1.6	1.2		22.2	0.2	6.0
30th	13.4	2.4	0	6.0	3.4		60.0	2.6	0.2
31st		6.0		2.0	0		25.0		3.2
Highest Daily	13.4	31.8	30.6	35.6	29.2	163.0	60.0	25.0	22.6
Monthly Total	22.4	157.8	133.0	137.0	115.2	505.8	283.6	118.8	127.4

New Italy – Station 58097	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	2021	2021	2021	2021	2022	2022	2022	2022	2022
1st	0	0	5.0	0	1.0	0	95.6	0	2.0
2nd	7.6	0	15.0	0	26.0	20.0	0	0	15.0
3rd	0	0	0	0	4.0	46.0	0	0	5.0
4th	0	0.4	0	0	3.6	40.0	0	10.6	0
5th	0	3.8	0	3.0	18.6	8.6	10.0	0.6	0
6th	0	0	0	3.0	18.2	8.6	1.0	0	0
7th	0	0	0	0	4.0	3.6	27.6	17.6	2.2
8th	0	0	0	2.0	2.0	2.6	0	15.0	21.0
9th	16.0	0	0	10.0	2.0	0	0	2.0	0
10th	0	0	0	0.2	0	0	0	10.0	1.0
11th	0	0	0	43.0	0	0	0	0	7.0
12th	0	0	23.0	1.0	0	7.0	9.0	0	7.0
13th	0	0	68.0	0	0	0	1.0	0	3.0
14th	0	0	6.0	0	0	6.0	2.0	7.0	0
15th	0	0	2.0	0	0	11.0	1.4	5.0	31.2
16th	0	0	0	0	21.0	0	0	0	0
17th	0	0	0	1.2	0	0	6.0	10.0	20.1
18th	0	0	0	0	0	0	0	0	0
19th	0	1.8	0	0	0	0	5.0	0	0
20th	0	0	18.0	0	36.6	0	0	0	0
21st	0	0.8	3.0	23.0	49.0	0	0	0	27.0
22nd	0	3.4	26.6	7.4	0	11.6	0	3.0	37.0
23rd	0	0	0	6.0	4.4	0	0	20.0	36.0
24th	0	0	0	1.0	0	146.6	0	6.0	9.7
25th	6.6	0	0	18.2	0	4.0	36.6	6.0	9.6
26th	0	0.2	0	1.0	8.8	0	36.0	0	3.6
27th	0	20.0	0	8.8	0	54.0	46.6	1.8	0
28th	0	1.8	0	0	0	385.0	38.4	0	4.2
29th	0	20.0	0	0	5.0		82.6	3.0	0
30th	0	17.6	0	6.0	0		285.0	2.2	0
31st	0		3.0		0		3.0		0
Highest Daily	16.0	20.0	68.0	43.0	49.0	385.0	285.0	20.0	37.0
Monthly Total	30.2	69.8	169.6	134.8	204.2	754.6	686.8	119.8	241.6